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Research Article

Hypania invalida (Grube, 1960), a polychaete species new for the southern Baltic estuarine area: the Szczecin Lagoon and the River Odra mouth

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Abstract

During a study carried out in spring-summer 2010, the invasive Ponto-Caspian polychaete *Hypania invalida* (Grube, 1960) was recorded for the first time in the southern part of the River Odra estuary (southern Baltic). This is the first record of this species in Poland or in any a Baltic estuary. The appearance of *H. invalida* in the Odra estuary coincided with flood water descent in the Odra, suggesting that floods can aid in dispersal of this polychaete.

Key words: invasive species, freshwater polychaete, Szczecin Lagoon, *Hypania invalida*

Introduction

Hypania invalida (Grube, 1860), is one of the few polychaete species inhabiting fresh waters. Those habitats, non-typical of polychaetes, support less than 2% of all polychaete species (Glasby and Timm 2008). However, in the native Ponto-Caspian range *H. invalida* settles in both fresh and brackish waters, tolerating a wide range of salinity (0-12 psu), temperature (2-25°C), and depth (from the shore line up to more than 400 meters depth) (Mordukhai-Boltovskoi 1964; Norff et al. 2010; Parr et al. 2007). *H. invalida* belongs to a speciose group of Ponto-Caspian invasive species which have, in recent years, colonised numerous areas in Europe and North America (Bij de Vaate et al. 2002; Ojaveer et al. 2002; Gruszka 1999, see also Appendix 1). *H. invalida* penetrates European waters from three directions, using corridors described by Bij de Vaate et al. (2002): Northern (the Volga catchment), Central (Dnepr and Vistula catchments) and Southern (the Danube catchment). The spread of *H. invalida* in the Volga and the Dnepr catchments was initiated once the polychaete was purposefully introduced into newly constructed dam reservoirs on the Volga an the Dnepr in the 1960s (Mordukhai-Boltovskoi 1964; Filinova et al. 2008; Yakovlev and Yakovleva 2010). At present, the species occurs almost throughout the entire Volga catchment (Filinova et al. 2008; Yakovlev and Yakovleva 2010). Recently, *H. invalida* has begun spreading via the Central corridor to reach, most probably via the Dnepr catchment, the waters of Belarus (Karatayev et al. 2008; Semenchenko et al. 2009). The westernmost Belorussian records of the polychaete are in the vicinity of the town of Brest on the River Bug, in the section where the Bug constitutes the Polish-Belorussian border, and also in the River Muchawiec (Mukhovetz), Bug's right bank tributary (Semenchenko et al. 2009). Invasion via the Southern corridor awarded the polychaete its widest range, extending along the Danube and Rhine and eastwards via the Northern-Meridian corridor described by Panov et al. (2009). The first specimens of *H. invalida* were found in 1958-1959, in samples collected from the German and Austrian sections of the Danube (Kothé 1968; Weber 1964, in Tittizer et al. 2000). However, further spread of the species upstream in the Danube was observed as late as the 1980s (Tittizer et al. 2000). The initially slow dispersal of the species changed to a rapid invasion once the Rhine–Main–Danube Canal was opened in 1992. *H. invalida* rapidly colonised the Rhine catchment and almost immediately appeared in the Main (Schmidt et

al. 1998); as early as in 1995, the species was recorded in the Dutch section of the Rhine (Klink and Bij de Vaate 1996). In 1996–1997, numerous records of *H. invalida* were reported along the entire Rhine and in some sections of the Main; in 1999, the polychaete was for the first time found in the Mittellandkanal connecting the Rhine and Elbe catchments (Tittizer et al. 2000). Although *H. invalida* was for the first time recorded in the mid-stream Elbe in 2007 (Eggers and Anlauf 2008), the polychaete had earlier, in 2005, been found farther east, in Oder-Spree Canal connecting the catchments of the Elbe and the Odra (Müller et al. 2006). In 2005, too, the presence of *H. invalida* was recorded the Peene, a river discharging directly (the Peenestrom) into the Odra estuary (Meissner pers. inf. in Müller et al. 2006). At the same time, *H. invalida* was spreading westward: early in the 21st century the polychaete was present in the River Meuse in Belgium (Vanden Bossche et al. 2001) and in the Moselle in France (Devin et al. 2005) (Appendix 1).

So far, *H. invalida* has neither been reported from the Odra catchment nor from those of other Polish river; the species is also absent from the Polish database of alien species (*http://www.iop.krakow.pl/ias*), although – as already indicated– it has been found in the Polish-Belorussian stretch of the River Bug and in Bug's direct tributary, the Muchawiec (Mukhovetz) (Karatayev et al. 2008; Semenchenko et al. 2009). In addition, *H. invalida* is a species new for Baltic estuaries, and has not been placed in the Baltic database of non-indigenous species (*http://www.corpi.ku.lt/nemo/*).

H. invalida prefers a muddy bottom with reduced flow velocity and turbulence (Filinova et al. 2008; Norf et al. 2010), although it may also inhabit sandy bottomed areas covered by zebra mussel beds, and even stones, but its aggregations on those substrates are not as dense as those on muddy substrates (Yakovlev and Yakovleva 2010; Norf et al. 2010). *H. invalida* lacks a planktonic larval stage; however, juveniles that just emerging from the maternal dwelling tube are for some time moved around by the current, which ensures successful dispersal (Norf et al. 2010). In addition, Norf et al. (2010) demonstrated *H. invalida* are capable of establishing dense populations exclusively via settlement of the drifting juveniles. This way, using relatively small refuges, the species can rapidly colonize new areas and recolonize those it had to abandon (e.g., as a result of drying-out). Although this way of dispersal facilitates easy down-stream colonization *H. invalida* is capable of colonizing, albeit less intensively, upstream areas by taking advantage of inland shipping as a vector of spread (e.g. ballast water) (Norf et al. 2010).

Materials and methods

The main part of the Odra estuary is the brackish-water Szczecin Lagoon (Polish: Zalew Szczeciński; German: Oderhaff), geographically and politically divided into two parts: the Kleines Haff in Germany and the Wielki Zalew belonging to Poland (Figure 1). The Szczecin Lagoon is fed from the south by the River Odra water which, before it is discharged into the Wielki Zalew, rolls through a shallow embayment-like area of the so-called Roztoka Odrzańska. In addition, the estuary receives direct discharges of a few smaller rivers the most important of which are the Ina, Gowienica, Uecker, and Peene.

In its northern part, the Lagoon connects, via three straits (the Peenestrom, the Świna, and the Dziwna) with the Pomeranian Bay in the southern part of the Baltic Sea. The Szczecin Lagoon is a typical brackish-water transition area, its salinity varying from 0.3 to 4.5 psu (mean 1.4 psu; Radziejewska and Schernewski 2008). The southern part of the Lagoon resembles a freshwater reservoir affected by the riverine water of the Odra, whereas intrusions of Baltic water in the north increase the salinity there and create a horizontal salinity gradient. The Roztoka Odrzańska differs significantly from the Lagoon: its water is fresh (salinity lower than 0.3 psu, as recorded during the study described) and the flow is fairly fast, which makes the area similar to a downstream section of a river.

The Szczecin Lagoon depth averages 3.8 m, the maximum depth being 8.5 m (except for 10.5 m depth of the artificially dredged canal leading to the port in Szczecin (Radziejewska and Schernewski 2008). The substrate in the central part of the Wielki Zalew and, to some extent, the Kleines Haff, is composed of muddy sediments, usually occurring at depths exceeding 4.5 m. The bottom of more shallow areas and close to the shores feature sandy muds and sands; whereas in some other areas, the substrate is comprised of numerous aggregations of zebra mussel (*Dreissena polymorpha* Pallas, 1771) and/or

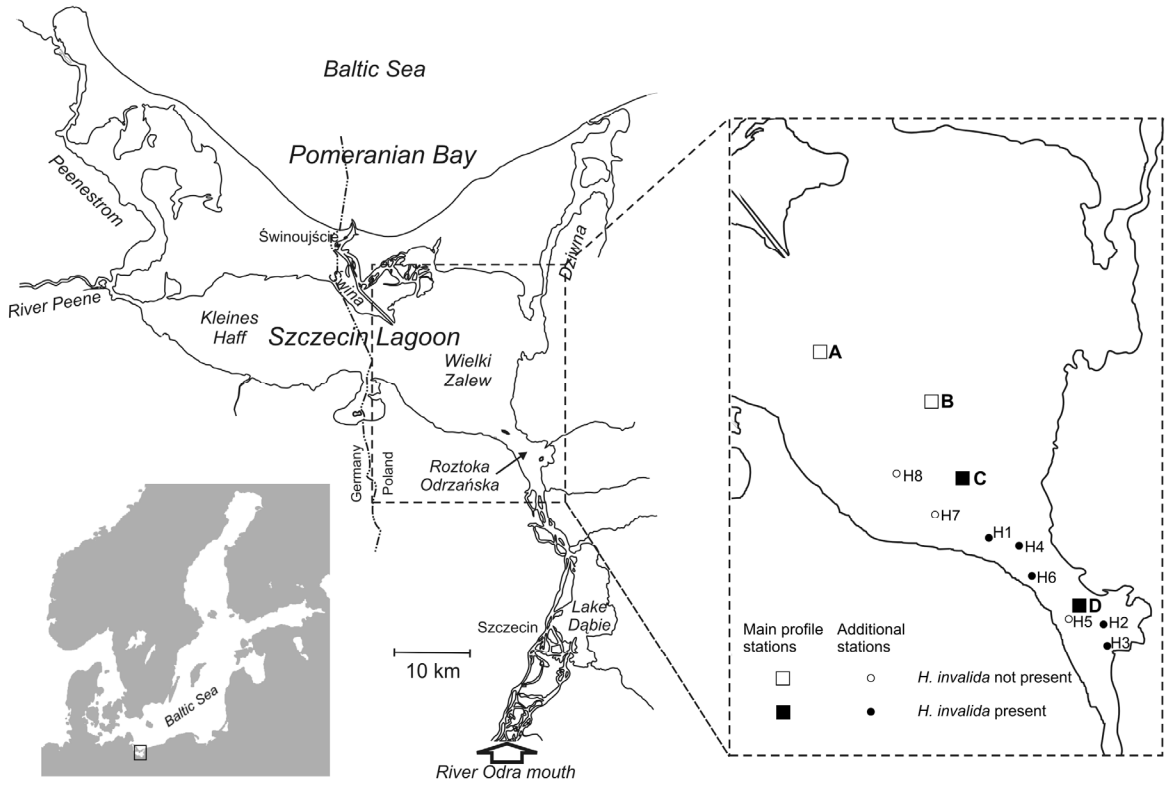

Figure 1. River Odra estuary and sampling stations location.

deposits consisting primarily of zebra mussel shell debris. The Roztoka Odrzańska substrate is also heterogeneous: the deepest, central part is covered by mud highly enriched with organic detritus, the remaining areas being covered by sand with varying proportions of silty fractions (Masłowski 1992; Wolnomiejski 1994). Typical of the Roztoka is the patchy distribution of different sediment types, the patchiness being additionally increased by the presence of zebra mussel aggregations of various sizes.

The Odra estuary is affected by strong anthropogenic pressure reflected by the high degree of eutrophication and subsequent impacts (Radziejewska and Schernewski 2008). The area is also intensively used for navigation with hubs in the harbours of Szczecin and Świnoujście; the Wielki Zalew is bisected by the dredged waterway leading to the harbour of Szczecin. The estuary is also an important area used for inland shipping; in addition to the Odra and the main navigation channel across the Lagoon, the routes used by the inland vessels lead through the Kleines Haff and Peenestrom. Inland vessels may also travel several tens of kilometres upstream in the River Peene.

In addition, the Odra estuary system is connected, via the River Odra and a network of canals, with the European system of inland waterways, including those in the Vistula and Elbe catchments, and indirectly also with the Rhine and Danube catchments (Bij de Vaate et al. 2002; Nehring 2005; Panov et al. 2009).

The presence of *Hypania invalida* in the Odra estuary was recorded during a study aimed to identify the effects of flood water descending down the Odra on the functioning of biota and habitats of the estuary. The project involved sampling at four stations (A, B, C, and D, Figure 1) forming a transect running along the major route of the flow from the Odra mouth to the southern end of the Świna strait, the latter forming a major conduit for the estuarine discharge into the Baltic Sea (Radziejewska and

Table 1. Sampling stations and the presence of *Hypania invalida* in samples in 2010: (+) *H. invalida* present in samples, (-) not present, (n.s.) station not sampled.

Coordinates					*Hypania invalida* presence			
Station	Latitude, N	Longitude, E	Depth	Sediment	31 May	7 June	29 June	21 July
A	53°45.9'	14°22.5'	6.2	Mud	-	-	-	-
B	53°44.2'	14°26.3'	6.0	Mud	-	-	-	-
C	53°44.2'	14°25.5'	5.6	Mud	-	-	+	+
D	53°39.4'	14°33.1'	4.3	Mud	-	+	+	+
H1	53°41.4'	14°29.5'	5.5	Mud	n.s.	n.s.	+	n.s.
H2	53°38.5'	14°35.0'	4.2	Mud	n.s.	n.s.	+	n.s.
H3	53°37.7'	14°35.5'	4.2	Mud	n.s.	n.s.	+	n.s.
H4	53°41.0'	14°31.0'	5,5	Mud	n.s.	n.s.	+	n.s.
H5	53°38.9'	14°32.9'	3.0	Shell debris	n.s.	n.s.	n.s.	-
H6	53°39.2'	14°32.2'	2.5	Sand	n.s.	n.s.	n.s.	+
H7	53°41.7'	14°27.8'	4.9	Mud	n.s.	n.s.	n.s.	-
H8	53°42.7'	14°25.2'	5,2	Mud	n.s.	n.s.	n.s.	-

Schernewski 2008). All the stations were located on muddy bottom. The samples were taken at 31 May, 7 and 29 June, and 21 July 2010 (Table 1). Three samples from each station were collected with a modified 0.0225 m^2 (15×15cm) Ekman-Birge grab with extra weights attached (7.5 kg). The grab content was sieved on a 0.5 mm sieve. Sampling was performed before, during, and after the major flood water entered the Lagoon. When *H. invalida* was first found in the samples, another series of samples was collected, on one occasion, from additional stations (H1 – H8) to determine the polychaete's range in the estuary.

Results and discussion

The first sampling occasion took place on 31 May 2010 from the four basic stations (A – D). At that time, the flood water had begun to enter the southern part of the estuary, but most of the flood was still upstream of Szczecin. All the samples collected on that date were analysed in detail: all showed the presence of a macrobenthic assemblage typical of the muddy bottom of the Szczecin Lagoon, consisting of larval *Chironomus* spp. (Diptera, Insecta) and oligochaetes which, taken together, contribute at least 90% of the macrobenthic abundance and biomass (Masłowski 1992; Wolnomiejski 1994). *H. invalida* was not detected in these samples.

The next sampling took place a week later (7 June 2010) when the flood wave crest entered the Roztoka Odrzańska and moved further into the Szczecin Lagoon. About two days earlier, the major flood water passed Szczecin and entered the estuary. Similar to the first sampling occasion, the samples were collected from the basic stations; inclement weather precluded sampling at Station B. The sediment collected at Station D (the Roztoka Odrzańska) showed, in all three samples, the presence of abundant tubes visible on the samples surface (Figure 2), such tubes being previously unknown from the Odra estuary sediments. When examined under the stereomicroscope during sorting, the tubes turned out to contain small polychaetes of unknown species. Consultations with specialists and reference to the "Macrobenthos of the North Sea" (de Kluijver et al. 2000) allowed us to identify the polychaetes as belonging to a single species, *Hypania invalida* (Figure 3).

Samples collected on the next sampling occasion (29 June 2010) confirmed the presence of *H. invalida* at Station D at a mean abundance of 4 933 ind. m^{-2} (maximum 11 466 ind. m^{-2} in one sample). Single individuals of the species were found also at Station C. As already mentioned, samples were collected from four additional stations (H1 – H4; Figure 1): each was found to support *H. invalida* (Table 1).

The samples collected on the final sampling occasion (21 July 2010) showed abundant *H. invalida* at Station D and single individuals at Station C. Of the additional sites sampled (H5 – H8; Figure 1), *H. invalida* was recorded only at H6 (Table 1).

Figure 2. *Hypania invalida* tubes on muddy bottom surface. Station D, 29 June 2010.

Figure 3. *Hypania invalida* individuals sampled in the River Odra estuary. Station D, 29 June 2010.

Thus the study revealed the occurrence – locally of a mass character (abundances on the order of 5 - 10 thou. ind. m^{-2}) - of *H. invalida*, a species new to the fauna of Poland. The samples provided an initial outline for the range of this polychaete's distribution in the Odra estuary, presently limited to the Roztoka Odrzańska and the southern part of the Szczecin Lagoon to which it is adjacent. The range is almost identical with that of another non-indigenous benthic species, the oligochaete *Branchiura sowerbyi* Beddard, 1892, (Masłowski 1992;

Wolnomiejski 1994, own observations). The scope of this study precluded finding *H. invalida* in the Odra estuary areas located south of the Roztoka Odrzańska (Lake Dąbie, the Lower Odra delta). Judging from the environmental conditions of those areas and habitat preferences of *H. invalida* as well as possible invasion vectors, it can be expected that the species may inhabit the Odra from the Roztoka Odrzańska to, at least, the mouth of the Odra (Oder)-Spree canal, one of two closest sites so far known to be supporting this species (Müller et al. 2006). At the same time, this polychaete may be expected to spread up the River Odra and its tributaries.

At the present stage, the invasion vector cannot be unambiguously pinpointed. Most likely, the species disperses from one of the two closest sites: in the Spree-Odra Canal or in the River Peene. The direct dispersal from the Peene is, however, not very probable, because the drifting stages would have to negotiate the virtually stagnant waters of the Szczecin Lagoon, which is only possible with the aid of shipping vessels. It hardly seems probable that the number of drifting individuals brought in this way would be sufficient to establish such dense aggregations as those observed in this study. However, the emergence of a small local population this formed cannot be ruled out; such a population could have subsequently dispersed further, particularly if the starting point was located in the upper reaches of the Odra. The fact that the sites showing the presence of *H. invalida* were clustered in the Odra mouth, and that the polychaete tends to disperse with the current (Norf et al. 2010) suggest the arrival of the polychaete from the upstream reaches of the river. It is possible that the polychaete arrived directly from the sites in the Odra-Spree Canal (Müller et al. 2006), although gradual dispersal based on non-detected, but probable, sites in the Odra seems a more plausible explanation. Disregarding the unknown origin of the Peene site, arrival of *H. invalida* to the Odra catchment must have occurred via the Odra-Spree Canal, and thus – indirectly – from the Rhein and Danube via the Elbe catchment. This is at present the major corridor of Ponto-Caspian species' migrations into the Odra estuary, as exemplified by some species of Ponto-Caspian gammarids (Gruszka 1999; Wawrzyniak-Wydrowska and Gruszka 2005; Gruszka and Woźniczka 2008). However, a route from Belarus, from the known sites in the Bug catchment (Karatayev et al. 2008; Semenchenko et al. 2009) along the so-called Central corridor (Bij de Vaate et al. 2002), via the Vistula catchment, cannot be ruled out. However, that route is less probable because it would require time and colonisation of most Polish rivers by the species, which probably would not thus far have escaped the attention of other researchers.

One week-long intervals between the sampling occasions, from the first with no *H. invalida* record to the next when numerous tubes with the polychaete were visible on the surface sediments may be indicative of a rapid spread of the polychaete in the Roztoka Odrzańska. This rapidity may be confirmed by the average length of *H. invalida* individuals found in the samples collected on 7 and 29 June, 3.3 and 7 mm, respectively, indicative of colonisation by young, growing individuals. This can indirectly explain the absence of *H. invalida* in the samples collected on 31 May. No tubes were spotted in the sediment at that time, hence the samples could possibly have contained still younger individuals, too small to have been retained by the sieve used. In addition, due to the lack of similarly small benthic animals found in previous studies, the authors cannot rule out the possibility of missing young, very small individuals of *H. invalida* during processing of the 31 May samples.

The appearance of *H. invalida* during flood water descent may suggest this event may have aided the polychaete in its dispersal. The increased flow during the flood facilitates transport of drifting organisms (including juvenile stages of *H. invalida*), making it possible for them to disperse over areas wider than those colonisable during lower flow levels. The lack of direct evidence, however, makes it necessary to consider this suggestion as a working hypothesis only. At the same time, the large distance between the Odra-Spree Canal mouth, not directly affected by the flood, and the lower Odra allows to infer that the *H. invalida* individuals descend to the Odra mouth from unknown sites that must have existed in the Odra catchment. Thus, colonisation of the Odra catchment by *H. invalida* could have occurred earlier, but went unnoticed and was not reported.

Despite the fact that this species has so far invaded only fresh waters beyond its native Ponto-Caspian range, *H. invalida*, due to its wide range of environmental tolerance (salinity, temperature, depth) can in the future, potentially inhabit the entire River Odra estuary, as well as the Baltic Sea.

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Supplementary material

The following supplementary material is available for this article.

Appendix 1. Records of *Hypania invalida* in Europe.

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_Wozniczka_etal_Supplement.pdf