

Rapid colonization of the Polish Baltic coast by an Atlantic palaemonid shrimp *Palaemon elegans* Rathke, 1837

Michał Grabowski

Department of Invertebrate Zoology & Hydrobiology, University of Łódź, Banacha 12/16, 90-237 Łódź, Poland

E-mail: michalg@biol.uni.lodz.pl

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Abstract

The Baltic palaemonid fauna comprises four species: *Palaemonetes varians*, *Palaemon adspersus* and two newcomers, *P. elegans* and *P. longirostris*. The first three species have been reported from Polish waters. This paper presents the history of faunal change associated with *P. elegans* recent colonization along the Polish Baltic coast, its estuaries, coastal lakes and lagoons. The oldest record of *P. elegans* comes from the Vistula deltaic system collected in 2000. Presumably moving eastwards from the Atlantic, the species colonized and formed a vivid, reproducing population all along the studied part of the Baltic shores. In many places it has replaced the native *P. adspersus* and it has become an abundant element of the palaemonid community in the Gulf of Gdańsk and in the Vistula delta, still accompanied by the two other species.

Key words: *Palaemon elegans*, Baltic Sea, invasion, palaemonid shrimp, Vistula delta

Introduction

The Baltic Sea is a basin with a relatively poor fauna, being mainly an impoverished Atlantic set of species, as well as a system with a high share of resident alien species. In recent years there have been many examples of successful colonization of its coastal waters by various animal species, including crustaceans (Jażdżewski et al. 2002, 2004, Konopacka 2003, Leppäkoski 2004, Leppäkoski and Olenin 2000). Recently, a new successful colonization event is that of the decapod crustacean *Palaemon elegans* Rathke, 1837. According to literature data, the palaemonid fauna of the Baltic now comprises four species:

1) *Palaemonetes varians* (Leach, 1814) (Figure 1) is a brackishwater shrimp of Mediterranean-boreal distribution occupying vegetated habitats mostly in lagoons and estuaries. In the Baltic Sea, it was recorded only in Mecklenburger Bucht (Funde von Poel), Greifswalder Bodden (Engelmann 1964,

Köhn and Gosselck 1989) and in the Dead Vistula (Martwa Wisła) in the Vistula estuary (Jażdżewski and Konopacka 1995, Ławinski and Szudarski 1960). Some general information on its occurrence in the adjacent Gulf of Gdańsk was also given by Köhn and Gosselck (1989).



Figure 1. *Palaemonetes varians* (Leach, 1814). Identification and photograph – Cédric d'Udekem d'Acoz

2) *Palaemon adspersus* Rathke, 1837 (Figure 2) is an euryhaline species of wide Mediterranean-boreal distribution. In the 1930s and 1980s it was introduced into the Caspian Sea, and in 1950s into the Aral Sea (Holthuis 1980, Jażdżewski and Konopacka 1995, Zenkevich 1963). The species is known from almost the entire Baltic Sea, including the Gulf of Finland (Balss 1926, Knipowitsch 1909, Kotta et al. 2003, Köhn and Gosselck 1989, Silfverberg 1999), and the southern parts of the Gulf of Bothnia to 61°10' N (Väinola pers. comm.). It inhabits littoral, vegetated habitats, and is an omnivorous species (Jażdżewski and Konopacka 1995, Köhn and Gosselck 1989).



Figure 2. *Palaemon adspersus* Rathke, 1837.
Identification and photograph – Cédric d'Udekem d'Acoz

3) *Palaemon longirostris* (H. Milne Edwards, 1837) (Figure 3) is originally an East-Atlantic species, occurring usually in estuaries, in brackish-water conditions but also noted from adjacent freshwater bodies. Until the end of the last century the species was not recorded in the Baltic Sea (Köhn and Gosselck 1989). In 1999, Zettler (2002) found it in the brackish Darss-Zingster Bodden-



Figure 3. *Palaemon longirostris* H. Milne Edwards, 1837.
Identification and photograph – Cédric d'Udekem d'Acoz

kette (Mecklenburg-Vorpommern) and in freshwater conditions in the Elbe (North Sea basin). This species is recorded sporadically from the German Baltic coast (Zettler pers. comm.), but there are no data on its potential breeding in the area. Further, this species probably does not enter the eastern part of Baltic (Zettler 2002).

4) *Palaemon elegans* Rathke, 1837 (Figure 4) inhabits vegetated areas (Dalla Via 1985) and is widely distributed in European coastal waters from the Black Sea, Mediterranean Sea, North Sea, to the Atlantic shores of Norway. In the 1950s it was accidentally introduced to the Aral and Caspian Seas (Zenkevich 1963). However, its distribution in the Baltic Sea has remained unclear. In some publications (e.g. Janas et al. 2004) it was erroneously reported, based on data from Balss (1926), that this species has since the 1920's been



Figure 4. *Palaemon elegans* Rathke, 1837.
Identification and photograph – Cédric d'Udekem d'Acoz

known from the southern Baltic, ranging from Kiel to the Gulf of Gdańsk. Balss (1926), cites *P. elegans* under its old name *Leander squilla* (Linnaeus, 1758). According to Opinion 564 of the International Commission of Zoological Nomenclature (Holthuis 1988), the name *Cancer squilla* described by Linnaeus (1758: 632, 1761: 495-496) belongs in reality to *Palaemon adspersus* Rathke, 1837 (syn. *Leander adspersus*). The latter name is conserved by the Commission, through suppression of the specific name *squilla* Linnaeus. In fact, in the cited work of Balss (1926) the information on the species distribution in Baltic concerns only *Leander squilla* var. *typica*: “(...) ist bekannt von Norwegen, W-Küste südlich von Stät den Fjorden des Skagerrak und Kattegat, Öresund und der Ostsee (Kiel bis Danziger Bucht); vielleicht auch Schottland”. That taxon was later included in *P. adspersus*; the other variety mentioned by Balss

(1926), *L.s.* var. *elegans* Rathke, 1837 was later raised to species level as *Palaemon elegans*. Holthuis (1949, 1950) gives more detailed explanation behind the taxonomic changes. Concerning this taxon, Balss (1926) states: “var. *elegans* Rathke vom Mittel - und Schwarzen Meer, von den atlantischen, subtropischen Inseln”. Also Holthuis (1950) makes a solid statement that former reports of *P. elegans* (eg. Balls 1926, Schellenberg 1928) in the Baltic Sea were mistakes resulted from confusing this species with *P. adspersus*. Concluding, all the older data may be attributed to *P. adspersus* or, at least, the occurrence of *P. elegans* in the Baltic at that time is questionable and demands further studies, i.e., examining of old German and Scandinavian collections.

Thus, the distribution of *P. elegans* in the Baltic was probably, until recently, limited. In the past the species was reported sporadically only from Wismarer Bucht (Köhn and Gosselck 1989). In the eastern and southern Baltic the species was found first in 2002 from the offshore waters of the Arkona Basin (Zettler 2003) and in the Gulf of Gdańsk (Janas et al. 2004). According to the reasons given above, it was a species new to the fauna of Poland, but collections made by the author of the present study from the Dead Vistula allow the presence of the species in Polish waters to be dated back at least to 2000 (Grabowski et al. 2005). Recent morphometric studies on that population were performed by Janas (2005). In 2003 the species was found in the Gulf of Finland (Kekkonen 2003). Köhn and Gosselck (1989) supposed that the larval stages of *P. elegans* arrived occasionally in ballast water, and this species did not reproduce in the Baltic Sea. They found only specimens of similar size; no ovigerous females were recorded. However, recently Zettler (pers. comm.) observed that the species occurs permanently and even breeds in the German Baltic waters.

This paper is a first attempt to present and discuss the dramatic change in palaemonid fauna composition along the entire Polish Baltic coastline, after a recent colonization by *P. elegans*.

Methods

This study is based on the field observations and collections made by the author between 1998 and 2004 (ca. 1000 individuals of palaemonid shrimps). This included an extensive survey of palaemonid distribution performed in 2004 along the entire

Polish Baltic coast, between the Szczecin Lagoon and the Vistula Lagoon (450 km). The animals were collected in a semi-quantitative way. Littoral habitats were sampled with a benthic hand-net and a dredge, and material was sorted at a site by two people operating for 30 min at each station. This method proved to be efficient, giving reliable results in faunistic surveys performed on larger geographical scales (Jażdżewski et al. 2002, 2004). To track faunal changes, some older collections of palaemonids from the Polish Baltic coast (ca. 160 individuals), sampled by Krzysztof Jażdżewski (in 1959-1971) and by the author of this study during 1991, were carefully re-examined. All the shrimps were identified according to the available literature (Alvarez 1968, Ashelby et al. 2004, Hayward and Ryland 1996, Smaldon et al. 1993). All the material studied has been deposited in the Department of Invertebrate Zoology and Hydrobiology, University of Łódź. Since various collection methods were used over the years, only the relative abundance measure (percentage of all palaemonids collected at a site) was used in the figures. Field data was supplemented with a literature survey. All records until 1992 from the Polish territory, assembled in the “Catalogus faunae Poloniae”, are cited in the figures as Jażdżewski and Konopacka (1995). Abbreviations used: PSU = Practical Salinity Units. 1 PSU = 1‰.

Results and Discussion

Historical data

Jażdżewski and Konopacka (1995) gathered faunistic data on the distribution of palaemonid shrimps along the Polish Baltic coast up to 1992. Zoobenthos of the Gulf of Gdańsk was also studied extensively by Żmudziński (1967). According to the pooled data (Figure 5), only two palaemonids were present in the area. *Palaemon adspersus* was occurring along the open Baltic coast as well as in the Gulf of Gdańsk, Bay of Puck, and in the Vistula delta. In contrast, *Palaemonetes varians* was restricted to the Dead Vistula (Martwa Wisła) with only anecdotal information on its presence in the Gulf of Gdańsk by Köhn and Gosselck (1989). Neither of these two species occurred in the Vistula Lagoon (Żmudziński 1957). To check whether lack of *P. elegans* records was due to misidentification with the former species, the old collection (1959-1971) of palaemonids gathered by Jażdżewski, was carefully re-examined. However, no *P. elegans* was found. Further, the examination of collection made

by the author of this present study showed that the species was not present on the Polish Baltic coast in 1991.

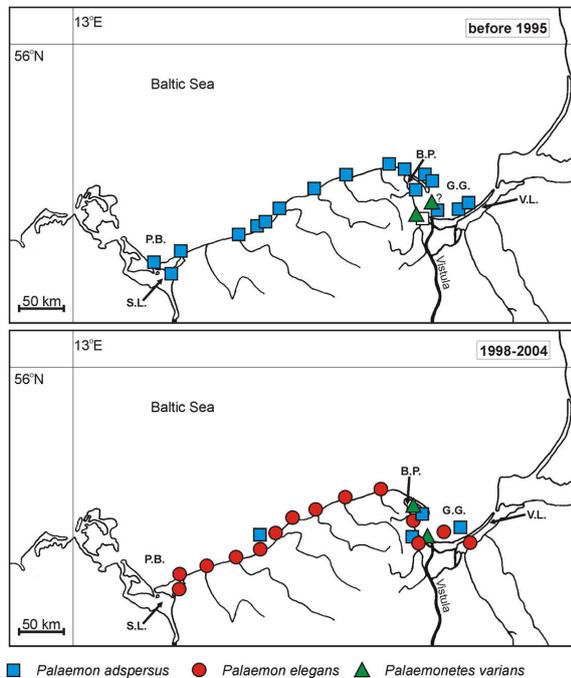


Figure 5. Distribution of palaemonid shrimps along the Southern Baltic Proper coast before 1995 (Jązdzewski and Konopacka 1995), and in 1998-2004 (own unpublished data). P.B. – Pomeranian Bay, S.L. – Szczecin Lagoon, B.P. – Bay of Puck, G.G. – Gulf of Gdańsk, V.L. – Vistula Lagoon

Summarising the old collection by Jązdzewski, only *P. adspersus* occurred in the Bay of Puck during 1959 and in 1971 it was the dominate species in the Dead Vistula (Martwa Wisła) with 96% of relative abundance when compared to *Palaemonetes varians* (Figure 6).

Present state

In 2004, forty locations along the Baltic coast between the Szczecin Lagoon and the Vistula Lagoon were surveyed. The presence of palaemonid shrimps was recorded at more than 20 sites (Annex). There were three species of Palaemonidae inhabiting the area: *Palaemon adspersus*, *P. elegans* and *Palaemonetes varians* (Figure 5). *Palaemon longirostris* was not found. In the summer 2004, the most common species was *P. elegans*. It occurred in the Wrzosowski Lagoon (part of the Szczecin Lagoon), in the Vistula deltaic area as well as all along the open Baltic coast in

between. It was found both in the Baltic itself, as well as in the mouths of the rivers, Rega, Piaśnica and Płutnica. This species was also recorded in the channels connecting the coastal lakes, Bukowo and Resko, to the sea. *Palaemon elegans* was usually found in relatively high numbers (Annex). In contrast, the occurrence of *P. adspersus* was restricted mostly to the Vistula delta and to the Gulf of Gdańsk. Outside this area it was found only at one open Baltic coast site (in Ustronie Morskie). The other species, *P. varians*, was recorded exclusively from the Dead Vistula and from the Bold Vistula (Wisła Śmiała) including the brackish part of the Vistula’s mouth, as well as from the Bay of Puck in the Gulf of Gdańsk. All species were found predominantly in brackish-water conditions. Salinity ranged from 0.9 PSU in the Wrzosowski Lagoon site to ca. 6 PSU in the open Baltic sites. The only exception was the mouth of the Rega River that, with salinity 0.3 PSU, may be defined as freshwater (Annex). However, conditions at this site range continuously between freshwater and brackish.

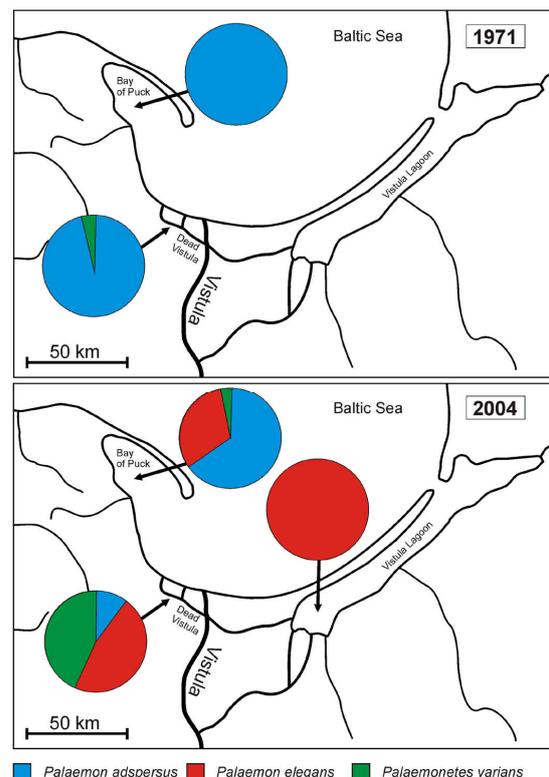


Figure 6. Change of relative species abundance in palaemonid communities of the Bay of Puck and the Vistula deltaic system since 1959 and 1971 (Jązdzewski unpublished), till 2004 (own data)

Palaemon elegans was definitely the most abundant shrimp in the whole area. Along the open Baltic coast, only one individual of *P. adspersus* was found (Figure 5). Relative abundances of palaemonids in the Bay of Puck and in the Vistula deltaic system are summarised in Figure 6. In the Bay of Puck, the dominant palaemonid was *P. adspersus* (66% in terms of relative abundance), followed by *P. elegans* (32%), with *Palaemonetes varians* having marginal contribution (2%). However, the situation was different in the Vistula deltaic system. The brackish section of the Vistula's mouth (Dead Vistula and Bold Vistula) was co-dominated by *Palaemon elegans* (47%) and *Palaemonetes varians* (43%), with *Palaemon adspersus* being much less abundant (10%). In the Vistula Lagoon, *P. elegans* was the only species recorded, either along its southern or northern coastline.

Change over the years

Based on the author's data, the appearance of *P. elegans* along the Polish Baltic coast dates back to at least 2000. In the sample from that year specimens of the species were found for the first time in the Dead Vistula (Grabowski et al. 2005). The year 2000 is probably a reasonable estimate of the starting date for colonization of *P. elegans* in the Vistula delta, since earlier samplings (1998-99) did not reveal presence of this species in the area. For the same reason 2004 is probably a realistic date of first colonization of *P. elegans* in the Vistula Lagoon. Therefore the species had probably reached the Polish coast some time earlier than 2000 although at present there is no data that may elucidate the exact time and way of colonization. At least with respect to the Gulf of Gdańsk, the species did not arrive earlier than 10 years ago. Intriguing is the problem of a drastic *P. adspersus* decline along the open Baltic coast. It is not known whether this is related to competition with the newcomer, *P. elegans*, or to other factors, e.g. habitat losses. The palaemonids are strongly associated with vegetated areas, especially with underwater *Zostera* meadows (Dalla Via 1985, Grabowski pers. obs., Jazdzewski 1971). Nowadays, this habitat typical for shallow bays and lagoons is generally declining. Along the open coast it is virtually not present due to wave action and the most common loose sand bottom. Thus, it seems that the most suitable, although relatively scarce surrogate is the artificial hard bottom - wooden or concrete constructions. Such structures offer food and shelter and they are usually densely

overgrown with filamentous green algae and inhabited by a variety of small invertebrates. Being limited in number and size, they have to be highly competitive resources. According to Jazdzewski and Konopacka (1995) those were the sites where *P. adspersus* was recorded. The present survey of these sites revealed an exclusive presence of *P. elegans* (Annex). However, no shrimp species were found in non-vegetated sites. This would suggest that *P. elegans* simply out-competed the former palaemonid in these island-type habitats. In the Bay of Puck and the Vistula's delta, vegetated areas are still capacious and they are presumably not habitats of such strong competition. This would explain the presence of a richer palaemonid community in the region. However, without well-designed experiments and detailed data on the ecology and life-histories of both species it is impossible to test this hypothesis. Anyway, following the observations by Zettler (pers. comm.), *P. elegans* now forms a stable and reproducing population along the Polish Baltic coast. In many of the sampled sites and particularly in the Bay of Puck, the author of this paper found individuals of all sizes, including very small post-larval juveniles, as well as mature and ovigerous females.

Mode of introduction

Palaemon elegans may be an addition to the long list of successful colonization events known from the Baltic Sea (Leppäkoski 2004, Leppäkoski and Olenin 2000). Without doubt the species has become a permanent and important element of the Baltic fauna. In many places it has replaced the native *P. adspersus*, and at some sites it even dominates the palaemonid assemblages. However, the question arises as to whether *P. elegans* should be regarded as an introduced invasive, non-native species threatening the local biodiversity, or simply as enriching the biodiversity through a natural range extension. The shrimp occurs along the Atlantic coasts of Europe and it may naturally penetrate into the brackish waters of the Baltic Sea as does the European shore crab, *Carcinus maenas* that is observed sporadically in the Eastern Baltic (unpublished data). On the other hand, Köhn and Gosselck (1989) hypothesised that *P. elegans* could be introduced through shipping via ballast water. This is highly probable as there are numerous cases of decapod crustaceans spread, enhanced and accelerated by human activity (Rodriguez and Suarez 2001). Decapod planktonic larvae are also known to migrate with ballast water (Chu et al. 1997) and examples of such kind of decapod

introductions are known from Europe (Rodriguez and Suarez 2001); in fact, these authors discuss this as a way of dispersal also for *C. maenas*. Furthermore, one should remember that *P. elegans* was introduced with mullet species to the seas of the former U.S.S.R (Zenkevich 1963), however this option is unlikely in the Baltic as there is no data on such fishery activity in the area.

To conclude, *P. elegans* has replaced the native *P. adspersus* in many places along the Polish Baltic coast however the true nature of this process remains unknown.

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Rapid colonization by *Palaemon elegans*

Annex

Distribution of palaemonid shrimps along the Polish Baltic coast in 2004*

Species: *P.a.* – *Palaemon adspersus*, *P.e.* – *Palaemon elegans*, *P.v.* – *Palaemonetes varians*. Abundance: L – low (<10 ind.), M – medium (10-100), H – high (>100). Habitat elements: Cb – concrete boulders, Cp – concrete pier, Fa – filamentous algae, Ma – macrophytes, Mu – mud, Sa – sand, St – stones, Wp – wooden poles

Sampling site	Geographic coordinates		Species/abundance			Salinity (PSU)	Habitat
	Latitude °N	Longitude °E	P. a.	P.e.	P.v.		
Szczecin Lagoon							
Wrzosowski Lagoon	54°01'	14°46'		L		0.90	Cp,St,Sa,Fa,Ma
Pomeranian Bay							
Dziwna canal mouth	54°01'	14°43'		H		1.50	Cp,St,Sa,Fa
Open Baltic coast							
Niechorze	54°05'	15°04'		M		0.50	Wp,Sa,Fa
Mrzeżyno	54°08'	15°17'		M		0.45	Cp,Wp,St,Sa,Wo,Fa
Rega River mouth	54°08'	15°17'		L		0.30	Cp,Wp,Sa,Wo,Fa
Dźwirzyno	54°09'	15°23'		M		0.45	Cb,St,Sa,Fa
Resko Lake canal mouth	54°09'	15°23'		L		2.05	Cp,St,Sa,Fa
Kołobrzeg	54°11'	15°33'		M		5.40	Cb,St,Sa,Fa
Ustronie Morskie	54°13'	15°47'	L	M		6.00	Wp,Sa,Fa
Dąbkowice	54°21'	16°16'		L		6.20	Wp,Sa,Fa
Bukowo Lake canal mouth	54°21'	16°16'		L		6.00	Wp,Sa,Fa
Darlówek	54°26'	16°22'		M		6.10	Wp,St,Sa,Fa
Ustka	54°35'	16°51'		L		6.50	Cb,St,Sa,Fa
Piaśnica River mouth	54°49'	18°03'		L		3.45	Wp,Sa,Fa
Gulf of Gdańsk							
Bay of Puck							
Swarzewo	54°45'	18°24'	L	L		6.00	Mu,Sa,Ma
Płutnica River mouth	54°44'	18°22'	L	L		5.60	St,Sa,Ma
Ośłonino	54°40'	18°27'	H	M	L	0.47	Mu,Sa,Fa.,Ma
Rewa	54°38'	18°30'	M	M	L	5.60	Sa,Ma
Vistula deltaic system							
Dead Vistula (many sites)	54°00'	18°00'	L	H	H	4.80	Mu,Fa.,Ma
Vistula Lagoon							
Krynica Morska	54°22'	19°26'		L		2.60	Mu,Sa,Fa,Ma
Tolkmicko	54°19'	19°31'		L		2.70	Cp,Cb,St,Sa,Fa,Ma

*Full reference to the data: Grabowski M (2006) Rapid colonization of the Polish Baltic coast by an Atlantic palaemonid shrimp *Palaemon elegans* Rathke, 1837. Aquatic Invasions 1(3): 116-123