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SHORT COMMUNICATION

The first report on the establishment and spread of the alien clam *Rangia cuneata* (Mactridae) in the Polish part of the Vistula Lagoon (southern Baltic)☆

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Summary Information on distribution of the bivalve *Rangia cuneata* in the Polish part of the Vistula Lagoon is presented. The species, first recorded in the Lagoon in 2010, has since rapidly colonized almost the entire basin. The distribution and population structure of the species have been studied in the Polish part of the Lagoon since 2012. Preliminary results on distribution and size structure of the population highlight extensive fluctuations in 2012—2014. A drastic reduction in the abundance following the relatively long winter of 2012/2013 suggests that the winter oxygen deficiency associated with the ice cover could be critical for the population development. Potential effects of the new invasive bivalve on the structure of benthic habitats and macrozoobenthos communities are discussed.
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1. Introduction

The Vistula Lagoon is situated in the south-eastern Baltic and extends for about 91 km along the Polish and Russian coast of the Gulf of Gdańsk (Fig. 1). After the Curonian Lagoon, the Vistula Lagoon is the second largest coastal lagoon in the southern Baltic. At present, the Lagoon is connected with the Baltic via the Pilawska Strait in the eastern, Russian, part of the Lagoon. The Lagoon's total surface area, maximum and mean depths are 833 km^2, 5.1 m, and 2.6 m, respectively. The state border between Poland and Russian Federation divides the Lagoon into the eastern part (64% of the area)

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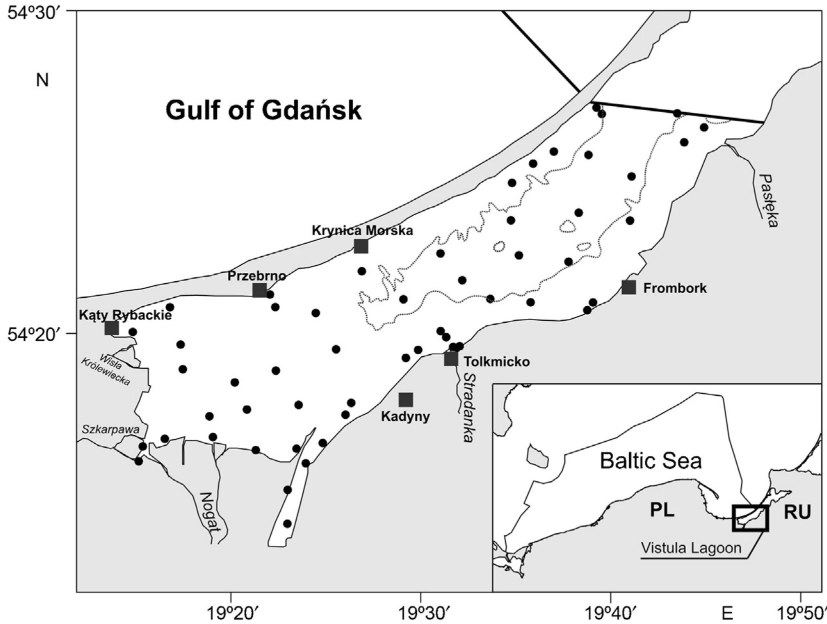

Figure 1 Map of the study area and the grid of stations sampled in 2012—2014.

belonging to Russia and called the Kaliningrad Lagoon, and the western part (36% of the area) belonging to Poland. The Lagoon's bottom is primarily muddy; sands are found only in a narrow belt close to the shore and on shallows, down to the depth of about 1.0—2.0 m. The Lagoon's water typically warms up rapidly in spring. In winter, the Lagoon may become ice-bound. The Lagoon's salinity is variable and ranges, within the Polish part, from about 0.5 to about 4.8 psu (Czubarenko and Margoński, 2008). At present, the Lagoon is classified as a eutrophic (and even hypereutrophic in the Polish part) water body (Aleksandrov, 2010; Nawrocka and Kobos, 2011). The western (Polish) part of the Lagoon is a protected area within the NATURA 2000 network (PLB 280010).

It is a species native to the Gulf of Mexico. In the 1960s, the species colonized coastal Atlantic waters (the Chesapeake Bay) to spread north up to the mouth of the Hudson River, New York (e.g. Pfitzenmeyer and Drobeck, 1964). According to some authors, it could have occurred along the Atlantic coast of North America earlier, and became extinct in the Pleistocene to reappear in the 1960s (Hopkins and Andrews, 1970). Other authors are of the opinion that the species has continued to be present there since the Pleistocene, but was rare and therefore not spotted (Pfitzenmeyer and Drobeck, 1964). In the European waters, it was first recorded in 2005 in the Belgian harbour of Antwerp (Verween et al., 2006). In the Vistula Lagoon, *R. cuneata* was first reported from the eastern, Russian, part in 2010 (Ezhova, 2012; Rudinskaya and Gusev, 2012), the first record from the western, Polish, part dating to 2011 (Warzocha and Drgas, 2013). In both cases, the presence of individuals up to 30—40 mm long suggests the introductions to have occurred 2—3 years earlier. *Rangia cuneata* is the first mactrid species in the fauna of Poland. The species is regarded (e.g. Tarver, 1972) as preferring low-salinity heavily turbid water and a soft bottom (mud or sand).

This report is aimed at presenting preliminary results of research, carried out since 2012, on the establishment, spread, and spatial distribution of *R. cuneata* in the Polish part of the Vistula Lagoon. The survey covered the bottom area beyond the inshore belt of reeds and bulrush, known as the Mid-lagoon (Klimowicz, 1958; Żmudziński, 1957). The sampling station grid is shown in Fig. 1. In total 55 stations were visited in summer seasons (July—September) from 2012 to 2014. The sediment was sampled with a 225 cm^2 Ekman grab weighing 7 kg and sieved with a 1 mm mesh sieves. A minimum of five replicate samples was taken at each station.

2. Results and discussion

The occurrence of *R. cuneata* in the Polish part of the Vistula Lagoon in 2012—2014 is shown in Fig. 2. In terms of the species' distribution in summer 2012, the area surveyed was divided into two distinct parts: one was the western part, including also areas off river mouths, supported no *R. cuneata*, the other being the remaining part of the Polish section of the Lagoon, where the bivalve was present at most stations (Fig. 2A). The area colonized by the species supported both juveniles and adults (from 2 to 48 mm). The absence of *R. cuneata* off river mouths could be explained by the prevalent low salinity (usually not more than 0.5 psu) which is too low for the survival of veliger larvae. *R. cuneata* can adapt to salinities varying from nearly 0 to 33 psu, but the young of the species have a much lower salinity tolerance than adults (Cooper, 1981; LaSalle and de la Cruz, 1985). Moreover, the interactions between temperature and salinity may increase the mortality of young stages (Cain, 1973). In 2013, following winter, there were almost no *R. cuneata* present (Fig. 2B) except for numerous live individuals found on the sandy bottom in the southern part of the Lagoon, close to the mouth of River Stradanka (Fig. 2B). Stations in the remaining part of the area yielded very few live individuals. As shown by the data collected by the Institute of

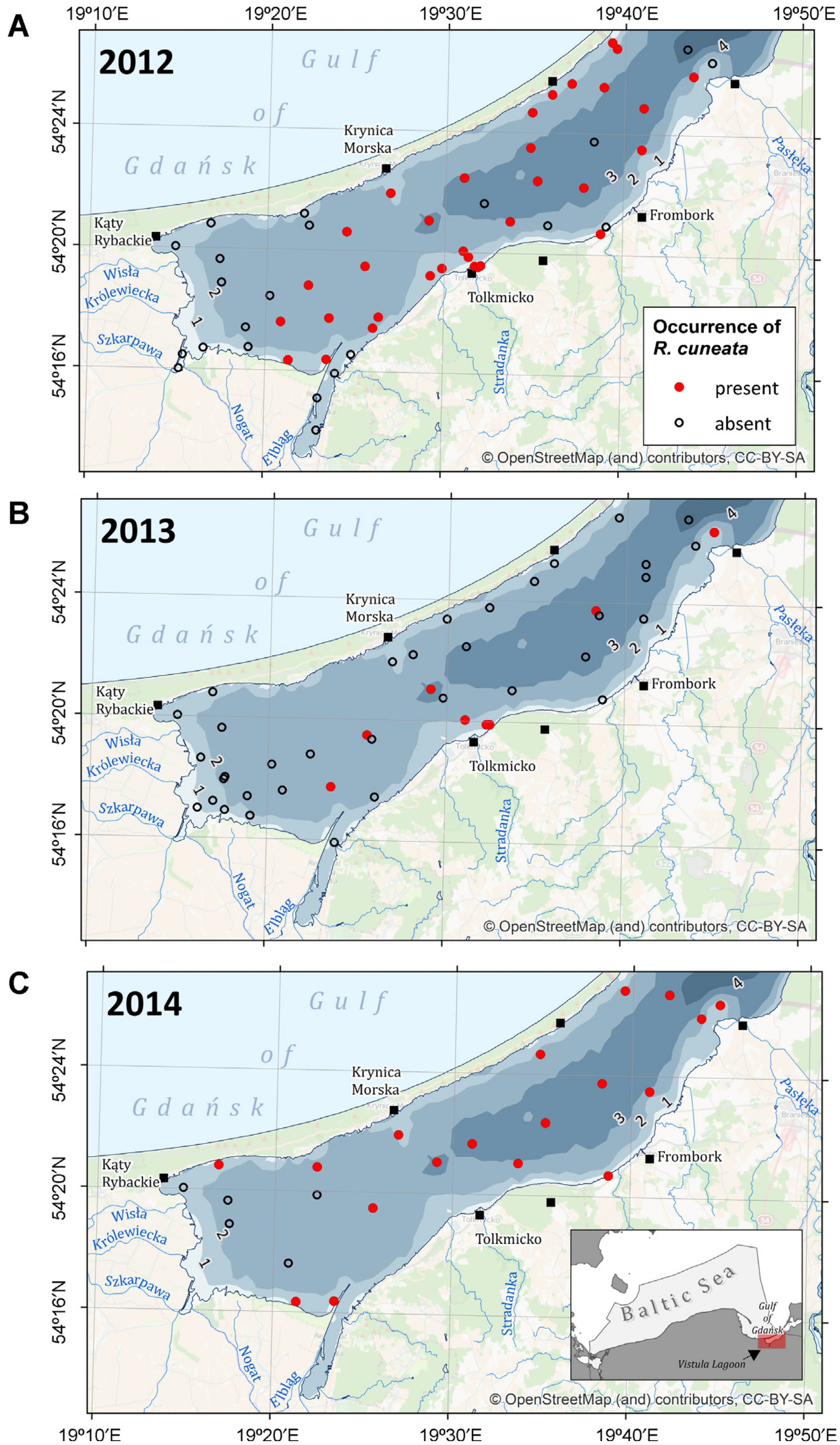

Figure 2 The occurrence of *Rangia cuneata* in the Polish part of the Vistula Lagoon in 2012—2014.

Meteorology and Water Management (IMWM), the winter of 2012/2013 in the Lagoon was characterized by the ice cover persisting longer than in the winter of 2011/2012 and 2013/2014. This may indicate an effect of winter severity on the survival of *R. cuneata*, oxygen deficiency resulting from the absence of seawater inflows via the Pilawska Strait (e.g. Lazarienko and Majewski, 1975; Łomniewski, 1958) being a potential stress factor acting during the ice cover persistence. Klimowicz (1958) suggested winter oxygen deficiency to be a potential factor affecting mollusc survival, while Rychter et al. (2011) found the abundance of the crab *Rhithropanopeus harrisii* to be substantially reduced after long, severe winters in the Vistula Lagoon. Gallagher and Wells (1969) observed high mortality of *R. cuneata* after the strong winter in Chesapeake Bay suggesting low winter temperature as a limiting factor. As the duration of ice cover

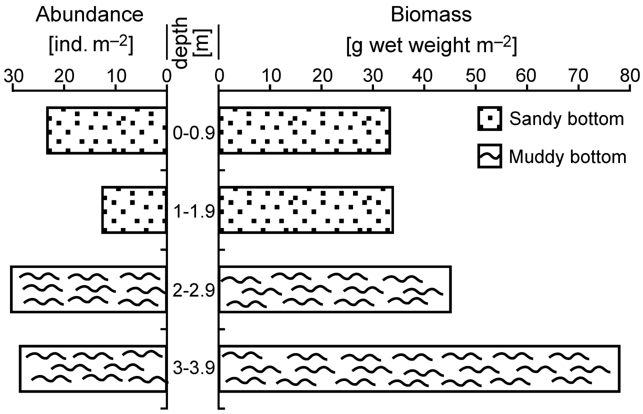

Figure 3 The mean abundance and biomass (formalin wet weight, including shells) of *Rangia cuneata* in 2012, in different depth strata.

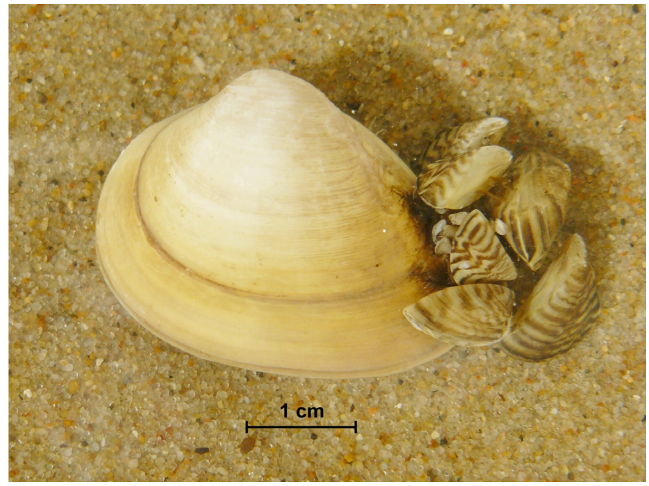

Figure 4 Settlement of *Dreissena polymorpha* on *Rangia cuneata* shells in the Vistula Lagoon.
Photographed by Katarzyna Horbowa.

persistence in the Lagoon has been observed to decrease in the recent years (IMWM data) compared to earlier years (e.g. Łomniewski, 1958), the *R. cuneata* population dynamics in the Lagoon may be greatly affected by climate changes. Preliminary data collected in 2014 point to the presence of *R. cuneata* (mainly young specimens; 0+ and 1+) throughout almost the entire Polish part of the Lagoon (Fig. 2C). Fig. 3 shows the mean abundance and biomass, as calculated from the 2012 data, in the function of depth and sediment type. Although the plot disregards horizontal variability, these preliminary data suggest the absence of any significant effect of depth and sediment type on the presence of *R. cuneata*. However, some studies (e.g. Wong et al., 2010) have revealed that sediment may be the important determinant of the distribution of this species. As deeper (>3 m) areas with the highest biomass found so far occur only in the eastern part of the Lagoon, higher biomasses recorded in the 3—4 m depth range (Fig. 3) may reflect also an effect of a closer distance to the Pilawska Strait, and hence better oxygen conditions, e.g. during winter time.

The *R. cuneata* invasion in the Vistula Lagoon gives rise to questions as to potential effects of the bivalve on benthic habitats and macrozoobenthos structure in the Lagoon. There is no doubt that the total macrozoobenthos biomass will change, particularly on the muddy bottom. The maximum biomass of *R. cuneata*, found in the study area reaches about 160 g m^{-2}. So far, there has been no bivalve that could have occurred throughout the Mid-lagoon and would have produced such a high biomass (Klimowicz, 1958). The bivalve has a relatively large, thick shell and lives on the sediment surface. It is then capable of modifying benthic habitats by acting as a substratum for other species. Settlement of *Dreissena polymorpha* on *R. cuneata* shells has already been observed (Fig. 4). To sum up, regardless of the preliminary nature of the results obtained so far, they indicate that *R. cuneata* may become a permanent component of the macrozoobenthos community in the Polish part of the Vistula Lagoon. Even though the size structure, abundance, and biomass of *R. cuneata* may vary widely, the habitat conditions fit the species' preference very well allowing a very high colonization rate and a rapid population recovery after drastic disturbances.

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