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Rapid Communication

Rangia cuneata (G. B. Sowerby I, 1831) continues its invasion in the Baltic Sea: the first record in Pärnu Bay, Estonia

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Abstract

This paper documents the arrival of the non-native bivalve *Rangia cuneata* in a shallow-water basin of Pärnu Bay, north-eastern Gulf of Riga, Baltic Sea, Estonia. The bivalve was collected for the first time in October 2016. The species occurred at low densities along a 25-km stretch of coastline. The size distribution suggests *R. cuneata* is established in the study area. This species represents the first obligatory suspension-feeding soft bottom bivalve in this low salinity area. Consequently, *R. cuneata* has a potential to intensify benthic-pelagic coupling as well as to improve the overall water quality of the bay. As Pärnu Bay is the northernmost location of the species' geographic range, winter temperature likely controls the species survival and further spread in the region.

Key words: nonindigenous, bivalve, range expansion, temperate, brackish water

Introduction

The brackish-water, burrowing, suspension-feeding bivalve *Rangia cuneata* (G. B. Sowerby I, 1832) is native to the Gulf of Mexico but it may not be native to the east coast of North America (Foltz et al. 1995) where it has been found in estuaries as far north as Chesapeake Bay (Hopkins and Andrews 1970) and the Hudson River (Carlton 1992).

In 2005, *R. cuneata* was first detected in Europe, most likely introduced as larvae in ballast water. It was first found in the Antwerp harbour, Belgium, within the pipes of the cooling water system of an industrial plant (Verween et al. 2006). Because individuals up to 6-years old were collected, the first settlers would have arrived in 1999 (Kerckhof et al. 2007). The species has expanded its range in the Netherlands and currently inhabits Rotterdam harbour and several other locations (Gittenberger et al. 2015). In the Baltic Sea, *R. cuneata* was first found in 2010 in the eastern part of Vistula Lagoon (Russia) (Rudinskaya and Gusiev 2012) and in 2011 in the western part of the lagoon (Poland) (Warzocha and Drgas 2013). In both parts, the presence of adult individuals (30–40 mm) suggests the introductions occurred 2–3 years earlier. In 2013, species was discovered in Lithuania, Curonian Lagoon (Solovjeva 2014). *R. cuneata* was reported from German waters in 2013 (Nord-Ostsee Kanal, Brunsbüttel, North Sea, Bock et al. 2015) and in 2015 (near Lübeck, Baltic Sea, Wiese et al. 2016).

In 2014, first dead shells of *R. cuneata* were observed in Pärnu Bay, Gulf of Riga, Estonia and the first living individuals collected in October 2016. In this communication, we report the range expansion of *R. cuneata* into Estonian coastal waters. In addition, as the bivalve can be potentially harvested for food, we also provide some morphometric information on the species.

Material and methods

Pärnu Bay is a small, shallow, semi-enclosed basin in the north-eastern part of the Gulf of Riga. Due to strong river discharge, the salinity is 0.5 to 5. Pärnu Bay is highly eutrophic; the main sources of

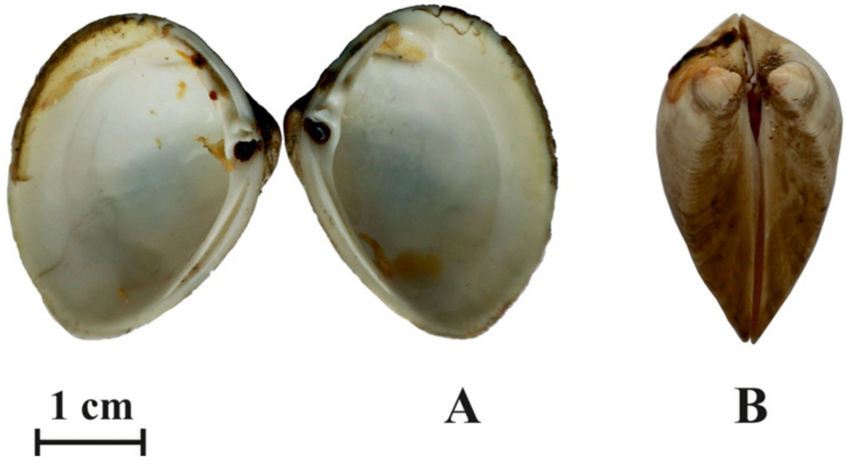

Figure 1. *Rangia cuneata* inside (A) and dorsal view (B). Photograph by Jonne Kotta.

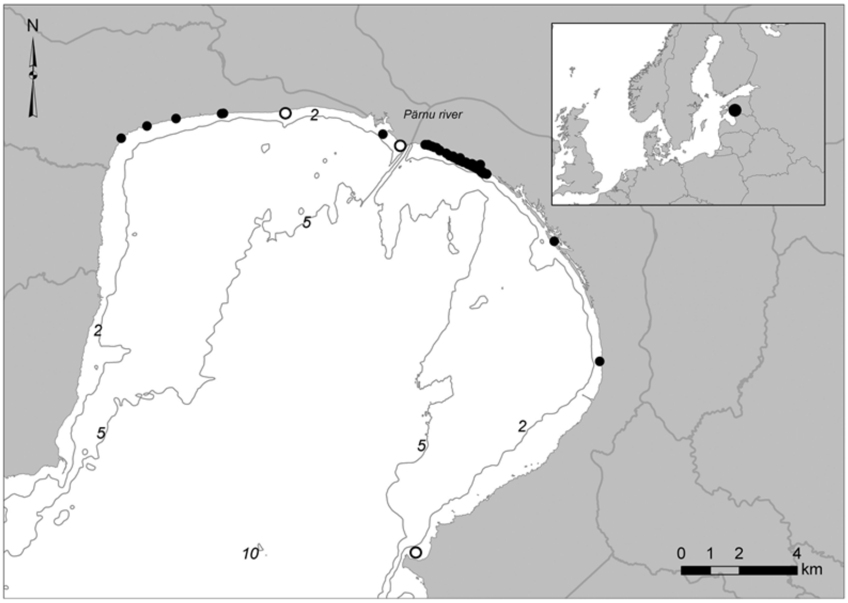

Figure 2. Map of the study area in Pärnu Bay. Each location represents an approximately 500 m transect walked by the author. Empty circles indicate locations where *Rangia cuneata* were not found and filled circles locations where the species was found. Depth isolines and rivers are also shown.

pollution are the town of Pärnu and the Pärnu River. The area lacks regular tides and water level fluctuations are irregular depending on wind conditions. Benthic species richness is very low with crustaceans, oligochaetes, polychaetes, and burrowing bivalves being the dominant taxa (Kotta et al. 2008).

Pärnu Bay is monitored regularly; the benthic invertebrate communities at depths below 5 m are sampled monthly. In shallower areas, sampling is done irregularly. In 2015–2016 extensive field work was carried out in relation to different experimental studies and targeted mapping of the non-indigenous *Rhithropanopeus harrisii* (Gould, 1841) and *Laonome* sp. Although the sampling grid covered all depth ranges and habitat types, none of these studies detected living specimens of *R. cuneata*.

On 4–5 October 2016, the sea level dropped to about 1 m below chart datum and remained exceptionally low until 27 October. *R. cuneata* was discovered accidentally and random sampling plots (5 times 50 × 50 cm shovelled through quadrats) in the areas where clams were picked from the surface revealed no other specimens of *R. cuneata*. This suggests that bivalve density was very low and traditional benthic invertebrate sampling methods could not detect the species. In order to map the current distribution of *R. cuneata,* we used conspicuous feeding activity of birds that were feeding on clams and took georeferenced photographs of every visible clam on a walking trajectory. In the west coast of the bay, semi-exposed sandy beaches are replaced with the stands of *Phragmites australis* (Cav.)

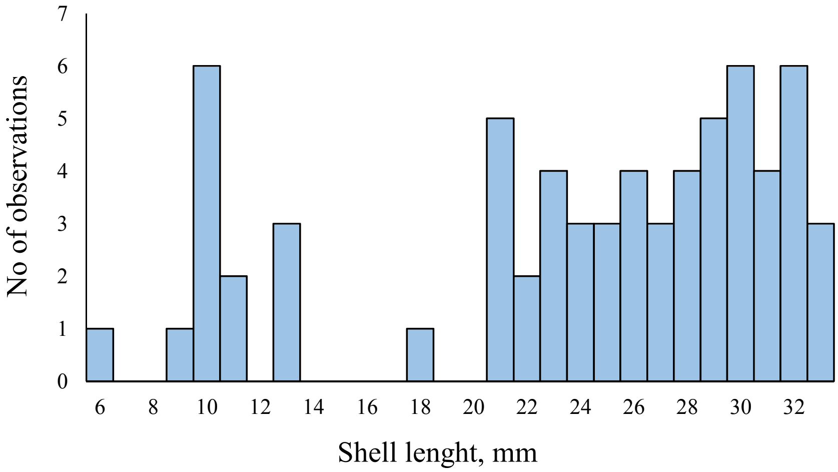

Figure 3. Length-frequency distribution of *Rangia cuneata* collected in Pärnu Bay, October 2016.

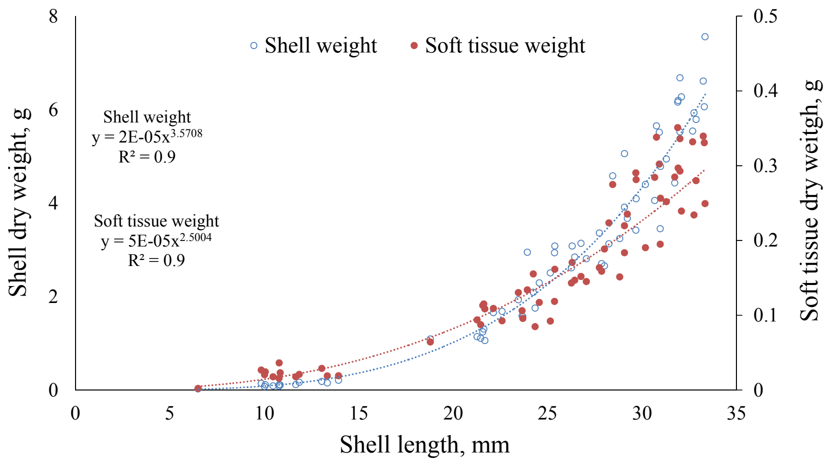

Figure 4. Relationships between shell length, shell (without soft tissue) and soft tissue dry weight of *Rangia cuneata* in the Pärnu Bay area.

Trin. ex Steud, and sampling was not conducted in this very silty habitat. We haphazardly collected 66 specimens of *R. cuneata* for examination in the laboratory. In the laboratory, shell length (nearest mm), shell weight (without soft tissue, 0.1 g), and soft tissue dry weight (0.1 g) of all clam individuals were quantified. The dry weight was obtained by drying the individuals at 60 °C for two weeks.

Results and discussion

The morphometric characters of the specimens of *R. cuneata* from this study (Figure 1) matched those provided by Verween et al. (2006).

The first living *R. cuneata* was found in Pärnu Bay in October 2016. On 7 October, the first large living specimens of *R. cuneata* were found on sand at wind induced low tide where a local population of the hooded crows *Corvus cornix* (Linnaeus, 1758) had picked out the clams from the sediment. In the first days of collection, the clams were found closed and whole, but the crows soon learned to break the shells and extract the meat. *R. cuneata* typically was buried in sediment about 1 cm depth and a small hole in the sediment potentially revealed its location.

R. cuneata was most abundant in area east of the Pärnu River and harbour area (Figure 2) where over 100 clams were recorded along a transect of 2.5 km. Visits to nearby sandy coasts revealed only the occasional, isolated, specimens, suggesting density was low along most of a 25-km stretch of the coastline.

Along the studied coastline, *R. cuneata* occurred mainly on fine sand sediment with small amounts of silt. The macrophytes *Stuckenia pectinata* (L.) Börner, 1912 and *Zannichellia palustris* L. were found at some locations where *R. cuneata* occurred. Sandy sediments rich in organic matter and phosphate are known to be favourable to *R. cuneata* but the species avoids the clay-silt sediments (Tenore at al. 1968) that prevail in deeper waters in the Pärnu Bay area.

Thus, it is likely that the distribution of *R. cuneata* from our visual survey is reasonably accurate, as exceptionally low sea level made the process of finding specimens relatively easy.

The majority of the clams collected were between 20 and 34 mm long (Figure 3). Smaller individuals likely were present but overlooked due to the qualitative nature of our sampling method. Nonetheless, the size-frequency distribution suggests that the Pärnu Bay population is established with production new cohorts having occurred in the preceeding 2–3 years. Thus, the actual arrival of *R. cuneata* likely dates to 2014 when the first small (≤5 mm) empty shells of *R. cuneata* were found on the Pärnu Bay beach. The species most likely arrived in ballast water because the Port of Pärnu (one of the most active commercial ports in Estonia) is located in the mouth of the Pärnu River.

The relationships between shell length and weight of *R. cuneata* approximated a power function (Figure 4). Allometric constants of the established regressions were very similar to those of the most common native clam *Limecola balthica* (Linnaeus, 1758) (based on J. Kotta unpublished data). Nevertheless, due to the much larger shell size, the edible flesh production of *R. cuneata* exceeds that of any native clams in the Estonian coastal sea.

The introduction of *R. cuneata* to the Baltic Sea raises the possibility of cultivation and harvesting of the species. According to Wakida-Kusunoki and MacKenzie (2004), *R. cuneata* has long history of being harvested (by scrape net or by hand picking) in the Gulf of Mexico where landings are about 1,000 tons per year. In harvested areas, the density of clams varies from 15 to 29 individuals m^{-2}. The clam has slightly muddy taste and is often used in soups. The preferred shell length for consumption is 2–5 cm. The Baltic Sea hosts few edible marine invertebrates. Although mussel farming has gained interest in recent years, presently only *Mytilus edulis* Linnaeus, 1758 is cultivated in the region. Currently, the potential for harvesting *R. cuneata* in the (northeastern) Baltic Sea is nil due to the low population density. Nevertheless, under changing environmental conditions, the population(s) may grow quickly and spread as has been seen for some other invasive species (e.g. Leppäkoski and Olenin 2000; Kornis et al. 2012; Kotta and Ojaveer 2012) and become economically important (e.g. Pienkowski et al. 2015).

At present, the presence of *R. cuneata* in Pärnu Bay, the Gulf of Riga, represents the most northern location for the species. Salinity and temperature are critical factors for the species growth, survival and reproduction. Gametogenesis is initiated at water temperatures above 15 °C and a change in salinity is needed to trigger spawning, i.e., clams in low-salinity areas (upstream) require a rise in salinity to spawn, while high-salinity area (down-stream) populations require a reduction in salinity (Cain 1973, 1974; LaSalle and de la Cruz 1985). The embryonal development is optimal at 18–29 °C and at salinity between 6 and 10. Larvae tolerate higher ranges of temperature and salinity, 8–32 °C and 2–20, respectively. After the settlement, salinity does not affect the survival of *R. cuneata* (Cain 1973, 1974). Mortality increases with lower temperatures; nevertheless, some *R. cuneata* can tolerate temperatures as low as 1 °C (Cain 1972).

Pärnu Bay is a very hostile environment for *R. cuneata*. Even in mild winters, the ice coverage exists for about 80 days in Pärnu Bay (Siitam et al. 2017) and ice-formation begins earlier than in other areas in the Gulf of Riga due to fresh water discharge from the Pärnu River, shelters from wind and waves, and weak water exchange with the Gulf (Jaagus 2006). When the ice forms in low sea level conditions, the sediment inhabited by *R. cuneata* freezes. Salinity varies from 0 (river mouth) to 5.3 (middle of the bay) (Kotta et al. 2015) and summer temperatures reach 24 °C (the Estonian Weather Service data). Thus, salinity conditions for embryonal development of *R. cuneata* are seldom met and periods of lethal temperatures are not uncommon during winter months. And yet, conditions suitable for growth and reproduction clearly occur in Pärnu Bay; however, the low winter temperatures may explain low abundance of the species in the area. Most probably the density of *R. cuneata* will remain low and population dynamics will reflect harsh winter conditions of the Pärnu Bay area with high interannual variability in density and population size structure expected, similar to the case for the Vistula Lagoon (Rudinskaya and Gusev 2012; Warzocha et al. 2016). Under some predicted climate change scenarios, however, conditions can improve (IPCC 2013) and allow the species to flourish.

The current distribution suggests *R. cuneata* will continue to expand within Pärnu Bay and in the Baltic Sea region. Pärnu Bay is the invasion hot spot of the Baltic Sea region with multiple non-indigenous species being established in recent years (e.g. Kotta and Ojaveer 2012; Kotta et al. 2015). Nevertheless, *R. cuneata* represents the first obligatory suspension feeding soft bottom bivalve in the local environment—thereby filling a partially empty niche. Other suspension feeders commonly found in the northeastern Baltic Sea, *Cerastoderma glaucum* (Bruguière, 1789) and *Mya arenaria* Linnaeus, 1758, inhabit areas with salinity above 5 and are rarely found in the inner parts of Pärnu Bay. *L. balthica* is known for both surface deposit feeding and suspension feeding but the species switches to suspension feeding only in food-limited sediments (Hummel 1985; Ólafsson 1986). Thus, considering large nutrient loads in the Pärnu Bay area, *L. balthica* is mostly the surface deposit feeder in shallow sandy and silty habitats of the study area. Moreover, the presence of *R. cuneata* has been shown to force *L. balthica* into deposit feeding (Skilleter and Peterson 1994). This suggests that *R. cuneata* has a potential to intensify benthic-pelagic coupling as well as to improve the overall water quality of the bay if abundance increases substantially. With a significant increase in population size, the invasion of *R. cuneata* is expected to have measurable effects on the Pärnu Bay ecosystem as it represents a novel ecosystem function as well as it is a valuable food item for many predators. Moreover, its heavy shells may provide extra substrate for algae and invertebrates, especially for the invasive *Dreissena polymorpha* (Pallas, 1771) (Warzocha et al. 2016), whose distribution is currently limited by the lack of available hard substrate in Pärnu Bay.

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Supplementary material

The following supplementary material is available for this article:

Table S1. Details of surveys conducted in October 2016 in Pärnu Bay, Estonia.

This material is available as part of online article from:
http://www.reabic.net/journals/bir/2017/Supplements/BIR_2017_Moller_Kotta_TableS1.xls