# American Harris mud crab *Rhithropanopeus harrisii* (Gould, 1841) in the Gulf of Gdańsk (southern Baltic Sea): distribution, population structure and basic physiological processes

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Alien species are one of the main threats to native biodiversity and human economy. Unfortunately, the effects of their introduction to new ecosystems are often difficult to predict as the same alien species can be invasive in one environment and non-invasive in another one. Although introductions of alien species are now a worldwide problem, some of the water bodies in the world are particularly susceptible to this process, e.g. the Baltic Sea. Due to specific hydrological and physicochemical conditions, relatively young age (in geological terms) and low biodiversity, the Baltic Sea is characterised by a large number of adventive alien species. For this reason, researchers refer to this sea area as a "sea of aliens". The marine transport plays the major role in the process of introduction – alien species are transported in ballast tanks or on ships' hulls, sometimes from very remote regions, and they settle first in estuaries and bays where large harbours are located. Organisms coming from North America represent a large percentage among the species introduced into the Baltic Sea. One of them is the Harris mud crab *Rhithropanopeus harrisii* which originally occurs in salt and brackish waters of the south-western part of the Atlantic Ocean, from Canada to the Gulf of Mexico. In Europe, the species was first described in the 17th century, in Zuidersee in the Netherlands. In the 1950s, the Harris mud crab was observed in the Polish coastal zone of the Baltic Sea. Since that time, a stable population of this species occurred only in the Vistula Lagoon and the Dead Vistula River. Since the 2000s, the increasingly large numbers of *R. harrisii* have also been observed in the Gulf of Gdańsk, i.e. in the sea area where previously the species had not occurred. In recent years, the Harris mud crab suddenly appeared also in other regions of the Baltic Sea, i.a. in the Curonian Lagoon, the Odra estuary, the Gulf of Riga and on the coast of Finland.

Once an alien species is introduced into a given ecosystem, it is extremely important to monitor its spreading, abundance and structure of a population, as well as to determine its impact on the environment and human economy. This information not only contributes to the knowledge about a given species but also, in accordance with the European Union's policy, is required to assess the risk involved in the introduction of a new species, and to select the

appropriate management methods. Furthermore, according to the Marine Strategy Framework Directive, alien species are one of the several descriptors used in the assessment of seawater, where one of the criteria applied is their abundance and the status of a population in a new environment. It should be added that many alien species, including the Harris mud crab, often colonize habitats which are significantly different from their native habitats in terms of abiotic and biotic factors. This may lead to specific adaptations resulting in the development of phenotypic and genotypic diversity within a species. In *R. harrisii*, which according to the literature is characterised by a patchy distribution, a limited gene flow between the isolated populations may additionally support such diversity. On the other hand, in some regions, e.g. in the Gulf of Gdańsk where two large transhipment harbours are located, this process may be reduced by further introductions of new individuals by means of sea transport. Additional information on this subject comes from molecular studies, which become an essential tool providing answers to many questions related to e.g. species distribution, genetic diversity or even the source of species introduction. As a result of phenotypic and genotypic plasticity, different kinds of adaptation are observed, e.g. morphological adaptations manifested in crustaceans in the size and shape (proportions) of the carapace and claws. Because of different abiotic and biotic factors prevailing in the colonized regions, individuals of the same species may also be characterized by a varying condition and a varying rate of physiological processes, which consequently may affect the amount of energy available for the growth and reproduction.

Although the Harris mud crab *R. harrisii* has been successfully colonizing the Gulf of Gdańsk for over ten years now, there is no information in the available literature on the functioning of the species in this region. Thus, the objective of the presented dissertation was to determine the distribution, the population structure and basic physiological processes of this species in the Gulf of Gdańsk, based on the long-term and multidimensional research. The research began with the determination of spatial distribution, seasonal occurrence and the abundance of *R. harrisii*, as well as the identification of benthic species co-occurring with the Harris mud crab [1]. Next, the age and sex structure of the population, morphometric characteristics of the carapace and claws, as well as the wet and dry weights of *R. harrisii* were determined [2]. Subsequently, the rate of basic physiological processes was determined (consumption of food, excretion of faeces and ammonia, metabolism), as well as the energy balance in respect of temperature, which is one of the main factors determining the rate of life processes in poikilotermic organisms [3]. As the last step, the genetic diversity and the gene flow between individuals of *R. harrisii* coming from two assemblages occurring in the Gulf of

Gdańsk (the regions of Puck Bay, Gdynia and Sopot), and two assemblages in the Dead Vistula River and the Vistula Lagoon were determined [4].

It appears from the conducted research that the Harris mud crab is relatively widespread in the Gulf of Gdańsk where it occurs down to a depth of 20 m. Distribution of the species' population has a patchy pattern, like e.g. along the Iberian Peninsula, which is confirmed by the occurrence of two clusters − one in Puck Bay and the other one in Gulf of Gdańsk (the region of Gdynia and Sopot). In the former region, *R. harrisii* usually co-occurs with crustaceans *Gammarus* spp. and *Crangon crangon*, and its maximum density is almost four times higher than in the latter region where *Mytilus edulis trossulus* overgrown with *Balanus improvisus* and *Cerastoderma glaucum* were the most frequently accompanying organisms. Just as e.g. in Dead Vistula River and in the Odra estuary, also in the Gulf of Gdańsk seasonal changes were observed in the occurrence of *R. harrisii* whose abundance was increasing with the increasing temperature, and the number of specimens was increasing in the summer months and decreasing in the winter months [1].

Furthermore, the research has shown that *R. harrisii* established a stable population in the Gulf of Gdańsk, and the occurrence of a large number of juvenile individuals may indicate the reproductive success, probably resulting from favourable abiotic (e.g. a wide spectrum of temperature or stable salinity) and biotic factors (e.g. food resources) in this region. The population from the Gulf of Gdańsk is characterised by a similar age structure and sex ratio – with a slight dominance of males over females – like other non-indigenous populations of this species. Although a similar sex ratio is often observed in crabs occurring in the natural environment, the predominance of females over males is more favourable to the breeding success. Furthermore, males were characterised by larger dimensions of both the carapace and claws, and the higher wet weight compared to females. Such differences in the majority of crabs result from sexual dimorphism. Individuals occurring in the Gulf of Gdańsk are characterised by a similar size of the carapace and claws as well as similar proportions of the body compared to individuals coming from other European populations of the species. On the other hand, they are larger than individuals coming from native regions, probably due to lack of parasites. The study also showed that *R. harrisii* from the Gulf of Gdańsk has a similar weight gain in relation to the width of the carapace compared to specimens from e.g the Dead Vistula River. On the other hand, however, the weight gain in relation to the carapace is smaller in crabs from the Vistula Lagoon and the Odra estuary compared to crabs from the Gulf of Gdańsk. These differences probably result from better trophic conditions, which cause a faster weight gain in *R. harrisii* from the Gulf of Gdańsk [2].

As evidenced by the research on seasonal distribution [1] and contrary to other water bodies (e.g. the Vistula Lagoon or the Dead Vistula River), the Harris mud crab from the Gulf of Gdańsk is able to occur at varying depths and hence it may occur in the range of preferred temperatures for a longer period, thereby extending e.g. the period of reproduction. The laboratory analysis demonstrated that *R. harrisii* at a temperature typical of its abundant occurrence in the Gulf of Gdańsk is characterised by a high rate of food consumption and assimilation in relation to the rate of metabolic processes, and hence the amount of energy available for individual production is high. An increase in water temperature by a few degrees, to a value of thermal minimum for the reproduction of the species, involves an increase in the locomotor activity of crabs and over a two-and-a-half increase in the rate of physiological processes. Nevertheless, these changes do not reduce the amount of energy available for individual production. The low rate of metabolism and the high value of individual production lead to the conclusion that the analysed temperatures are favourable to the Harris mud crab, both in terms of physiology and bioenergy what might have influence on specimen`s condition as well as population abundance [3].

Genetic studies have shown that individuals of *R. harrisii* from the Gulf of Gdańsk (the region of Gdynia and Sopot) are characterised by the highest number of haplotypes and the highest genetic diversity (both in terms of haplotypes and nucleotides) among all analysed assemblages, which may be associated with the presence of two large harbours in the Gulf of Gdańsk, and consequently the repeated introduction of this species through marine transport of its individuals from other native and non-native regions. On the other hand, two common haplotypes have been identified in all four assemblages, which combined with the lack of distant haplotypes in the analysed assemblages permits the assumption that the process of colonization of the Gulf of Gdańsk may have occurred locally as a result of range expansion by previously settled populations. Furthermore, despite small (on the geographical scale) distances between the regions which were the source of the analysed *R. harrisii* assemblages, a limited gene flow was evidenced, which may contribute to the genetic diversification between individuals from the Bay of Puck and the Vistula Lagoon as well as from the Vistula Lagoon and the Dead Vistula River. This may be related to both the presence of ecological and geographical barriers, as well as the phenomenon of larval retention mechanism observed in this species [4].

The presented research is the first of this type dealing with the functioning of *R. harrisii* in the Gulf of Gdańsk. It has provided the evidence that the Harris mud crab is a well-established component of benthic communities in the Gulf of Gdańsk, with a stable

population of high reproductive potential. The population is characterised by similar morphometric characteristics like other non-indigenous populations established e.g. several dozen years ago in the sea areas adjacent to the Gulf of Gdańsk. Furthermore, *R. harrisii* seems to be well adapted to relatively high temperatures occurring in the summer months in the Gulf of Gdańsk, as evidenced by both, high abundances as well as the high individual production, and consequently a large amount of energy available for the growth and reproduction. The occurrence of the Harris mud crab population in the Gulf of Gdańsk might be potentially the result of range expansion by populations established in the adjacent regions a few decades ago. The close proximity of two large harbours, however, provides the possibility of new introductions, which additionally contributes to high genetic diversity. The complexity of the conducted research and innovative approaches to the issue of alien species and their functioning in a new environment should be emphasized. So far, no other papers have provided information on the distribution and structure of the Harris mud crab population in the Gulf of Gdańsk. The worldwide literature includes papers on the osmoregulation and the rate of metabolism, but there are no reports on the rate of basic physiological processes and the energy balance in this species. More and more often, knowledge about the functioning of alien species in non-native regions results in the need for interdisciplinary research based on different methods, e.g. ecological and molecular ones, the combination of which enables us to answer many more questions compared to separate analyses. Thus, combining the research on the biology, ecology, physiology and genetics of *R. harrisii*, as in the presented thesis, seems to be an original solution to the analysed scientific problem, which represents an important addition to the world literature.

## References


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