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Effects of the invasive polychaete *Marenzelleria* spp. on benthic processes and meiobenthos of a species-poor brackish system

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ABSTRACT

The effects of the invasive polychaete *Marenzelleria* spp. on sediment processes and meiobenthos with an emphasis on free-living nematodes of the Vistula Lagoon (southern Baltic Sea) were investigated in a laboratory microcosm experiment. *Marenzelleria* occupies an open niche and its deep burying behaviour and feeding strategy represent a new function in the study area. Halos of oxidized sediment along *Marenzelleria* burrow walls indicated oxygen penetration into the burrows but the polychaete had no significant effect on porewater nutrient concentrations. The results showed, however, the density dependent effects of *Marenzelleria* on ammonium transport. An enhanced ammonium efflux was recorded at high polychaete densities (2000 ind. m^{-2}) but not at low polychaete densities (300 ind. m^{-2}).

There was no observable impact of the polychaete on total meiobenthic numbers. There was, therefore, no indication that *Marenzelleria* caused meiofauna mortality. On the contrary, the polychaete significantly affected vertical distribution of meiofauna facilitating the colonization of deeper sediment depths and thus extending the habitat to be used by meiobenthos. In addition, *Marenzelleria* had a positive impact on the survival of turbellarians.

Nevertheless, there was no effect of *Marenzelleria* on nematode assemblage structure and diversity, indicating that neither the physical presence nor the biological activity of the worm affected the nematode community. This suggests either 1. the limited impact of *Marenzelleria* on nematodes, resulting from the creation of simple, narrow and un-branched burrows, 2. poor response of nematode community resulting from their low abundance and diversity in the study area, or 3. the overriding role of the harsh chemical environment typical of sediments of the Vistula Lagoon, masking the effect of the bioturbator.

1. Introduction

The North American polychaetes of the genus *Marenzelleria* are recent newcomers to the Baltic Sea. They have colonized the whole Baltic area, including lagoons and other shallow water bodies on the Baltic coast (e.g. Ezhova and Spirido, 2005; Gruszka, 1991; Kotta and Kotta, 1998; Kube and Powilleit, 1997; Kube et al., 1996; Leppakoski et al., 2002; Maximov, 2011; Warzocha et al., 2005; Zettler, 1996; Zettler et al., 1995; Żmudzinski, 1996; Żmudziński, 2000) and became among the most successful invaders in this area. *Marenzelleria* lives in blind-ended tubes extending deeply into the sediment, can tolerate low oxygen and high sulphide concentrations (Schiedek, 1997) and may have a profound effect on sediment processes. Studies on the effects of *Marenzelleria* on sediment biogeochemistry performed in the central and northern Baltic Sea and Danish waters (Hedman et al., 2011; Hietanen et al., 2007; Karlson et al., 2005; Kristensen et al., 2011; Quintana et al., 2007, 2011, 2012; Viitasalo-Frosen et al., 2009) indicated that *Marenzelleria* stimulated porewater irrigation significantly enhancing transport of anoxic, nutrient and sulphide-rich porewater towards the sediment surface (Hietanen et al., 2007; Kristensen et al., 2011; Quintana et al., 2007, 2011, 2012). There is also an evidence on bioturbation-driven release of organic contaminants from the sediment mediated by this polychaete (Granberg et al., 2008; Hedman et al., 2008, 2009; Josefsson et al., 2011).

It is suggested, therefore, that changes in porewater chemistry due to *Marenzelleria* activity may influence the distribution of benthic biota, potentially having a detrimental effect on sediment dwelling organisms (Kristensen et al., 2011; Quintana et al., 2011). Unfortunately, the knowledge on the impact of *Marenzelleria* on indigenous fauna is limited to macrozoobenthos (Delefosse et al., 2012; Kotta et al., 2001, 2006; Zettler, 1996) while there is a lack of studies on the effect of this polychaete and also other invasive species on meiobenthos, both in the Baltic Sea and other invaded systems. Meiobenthos is a numerous and both taxonomically and functionally diverse group occupying all sediment types in all marine environments. Meiobenthic organisms directly or indirectly influence many processes associated with organic matter degradation in sediments (Heip et al., 1985; Nascimento et al., 2012; Rysgaard et al., 2000) and are an important structural and functional component of benthic systems. In addition, meiofauna, in

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particular nematodes, are known to be able to respond rapidly to alterations in environmental conditions; thus changes in their vertical distribution, community structure and diversity can be related to the changes in their environment (Heip et al., 1985; Platt and Warwick, 1980) making them a useful tool for environmental assessment.

Burying activity of macrobenthos that leads to sediment disturbance and cause modifications in the interstitial environment may substantially affect structure and composition of meiobenthic communities (Olafsson, 2003 for overview; Van Colen et al., 2009). There is an evidence both from the field and from laboratory experiments that various polychaetes in various ways affect nematode communities, their densities, vertical distribution, community structure and diversity (Braeckman et al., 2011; Maria et al., 2011; Pinto et al., 2006; Tita et al., 2000). It can be, therefore, hypothesized that the deep burying *Marenzelleria* affect meiobenthos and cause changes in nematode occurrence and community structure.

Lagoons, coastal lakes and semi-enclosed bays cover about 50% of the southern Baltic coast length. Most of them are shallow (mean depth of 2–4 m), brackish, eutrophied and heavily influenced by anthropogenic pressure (Witek et al., 2010 and Refs. therein). All of them are colonized by *Marenzelleria* but there is a general paucity of information on ecological effects of this polychaete in these specific ecosystems. Vistula Lagoon is one of the largest brackish water bodies of the southern Baltic. The macrobenthic composition and community structure have dramatically changed in this lagoon after the invasion of *Marenzelleria* spp. Prior to this invasion macrobenthos comprised almost exclusively of freshwater species dominated by oligochaetes and chironomid larvae, while the marine fauna has been recorded only sporadically (Willer, 1925; Żmudzinski, 1957). At present, the marine polychaete *Marenzelleria*, that reaches densities of up to 8000 ind. m^{-2} in the Polish part of the lagoon, is the dominant macrobenthic species (Żmudzinski, 1996, 2000; Warzocha et al., unpubl.) and its biomass, constituting up to 90–98% of the total macrobenthos (Warzocha et al., unpubl.), is responsible for enhancing the overall macrobenthic biomass by one order of magnitude in comparison with the pre-invasion levels. In the predominantly reduced sediments the polychaete is recorded down to depths of 20 cm, i.e. it penetrates much deeper than any resident macrobenthic species. In addition, *Marenzelleria* is a facultative (surface) deposit- and suspension feeder, collecting organic material suspended in the near-bottom water or deposited on the sediment surface (Dauer et al., 1981), while the resident macrofauna feed mainly on detritus deposited in the sediment. Thus, *Marenzelleria* appears to occupy an open niche and its deep burying behaviour and feeding strategy represent a new function in the invaded ecosystem.

The aim of this study was to investigate the effect of *Marenzelleria* spp. on meiobenthos, with a particular emphasis on free-living nematodes, the dominant meiobenthic group in the Vistula Lagoon. We performed a laboratory experiment to gain insight into the effects of *Marenzelleria* on the occurrence of meiobenthos and nematodes, and on selected sediment processes, to draw conclusions about the impact of this invasive polychaete on benthic system of the coastal shallow Baltic lagoon.

2. Materials and methods

2.1. Study area

The Vistula Lagoon (Fig. 1) extends along the Polish and Russian coast at a distance of 90 km. The lagoon has a limited connection with the sea through the 400 m wide Pilava Strait. Water salinity in the western (Polish) part of the lagoon ranges between 1.5 and 3.5 PSU and the average water depth is 2.7 m (Chubarenko and Margoński, 2008; Łazarienko and Majewski, 1975). The shallow and exposed character of the lagoon creates favourable conditions for sediment resuspension which is responsible for the low water transparency, usually not exceeding 0.3–0.4 m, that hampers primary production at depths exceeding 1–1.5 m (Witek et al., 2010). Muds dominate the deeper parts of the lagoon (>1.5–2 m) while sandy sediments are mostly found along the hydrodynamically active shallow coastal zone (to the depth of 1.5–2 m). Reduced grey or greyish-black sediments are covered by a thin (max. up to 2 cm) surface layer of light, oxidized sediment. The redox potential discontinuity (RPD) layer is usually recorded at depths of 2–5 cm in sandy sediments and at some distance above the mud surface (Warzocha et al., unpubl.). *Marenzelleria* spp. occur in the entire area of the lagoon, but with densities that are disproportionately higher in sandy sediments than in muds (on average 4000 vs. 200 ind. m^{-2}, respectively) (Warzocha et al., unpubl.).

2.2. Sediment and fauna sampling

The experiment was performed in October 2011. Sediment and fauna were collected from a site (54°22′ N, 19°27′ E) dominated by medium and fine sand (70 and 27%, respectively) at 1.7 m water depth. Water salinity at this site during the sampling period was 3.3 PSU. Contents of organic carbon and total nitrogen in the sediment averaged 0.07% and 0.012%, respectively. The sediment at this site is characterised by a clearly visible oxygenated surface layer (1–2 cm) and greyish-black reduced sediment underneath. Sediment was sampled by a hand-operated corer (HAPS) to a depth of 10 cm with a 145 cm^{-2} surface area. The upper layer of the oxidized sediment was separated from the reduced sediment and these two sediment types were further treated separately.

The sediment was immediately sieved over 1 mm mesh in a small amount of ambient water in order to exclude macrofauna, but retain all interstitial biota. In the laboratory, the sediment was gently homogenized by hand and put into plexiglass cores, 12.3 cm internal diameter and 33 cm long, to a depth of 18 cm. The reduced sediment was covered by 2 cm of light, oxidized sediment. These sediment cores were then placed into a water bath of a volume of 2000 l connected to an open-loop water pumping system. Water was distributed among cores via plastic tubes to facilitate the turnover of the overlying water (12 cm deep). Outflow water was recycled and replaced with fresh seawater once per week. Seawater of appropriate salinity was obtained by diluting water from the Gulf of Gdańsk with double-distilled water. The sediment was allowed to stabilize for 10 days before the experiment started at the constant temperature of 15 °C which corresponded to the field water temperature.

Marenzelleria spp. collected at the same study site and earlier acclimated to the laboratory conditions were added to the microcosms to obtain the following densities: 0 — Control (no *Marenzelleria*), low densities (4 ind. $core^{-1}$) and high densities (25 ind. $core^{-1}$), abbreviated in the text hereafter as Low and High treatments, corresponding respectively to the average low (300 ind. m^{-2}) and high (2000 ind. m^{-2}) densities of *Marenzelleria* most frequently recorded in the field (Warzocha et al., unpubl.) (Table 1). To obtain the worms we carefully washed the sediment with water over 1 mm sieve. Selected specimens were transferred using a plastic round stick to the Petri dish with water of a know weight and were weighed to estimate the biomass (live wet weight) to the nearest 0.1 g. Each damaged or broken specimen was replaced by another one. The whole amount of Petri dish was transferred to the microcosm. Each treatment was performed with four replicate cores.

Within half an hour of adding the specimens the majority had buried into the sediment. The microcosms were then incubated in the dark (to ensure the same light conditions as in the field) at 15 °C for five weeks. The experiment was monitored everyday over this period to control water temperature and the overlying water exchange rate. On the day of collection of sediment for the experiment, sediment samples were also taken for the determination of meiobenthic community abundance and structure in the field.