A home away from home: a meiobenthic assemblage in a ship's ballast water tank sediment

OCEANOLOGIA, 48 (S), 2006.
pp. 259–265.

KEYWORDS
Ballast tank sediment
Dispersal
Meiobenthos

Teresa Radziejewska[1]
Piotr Gruszka[2]
Joanna Rokicka-Praxmajer[2]

[1] Department of Palaeoceanology,
University of Szczecin,
Wąska 13, PL–71–415 Szczecin, Poland;

e-mail: tera@univ.szczecin.pl

[2] Department of Marine Ecology and Environmental Protection,
Agricultural University of Szczecin,
Kazimierza Królewicza 4, PL–71–550 Szczecin, Poland

Received 12 December 2005, revised 14 April 2006, accepted 4 May 2006.

Abstract

The world-wide research on ship-aided dispersal of marine organisms and invasions of non-indigenous species focuses primarily on the plankters, which show the greatest potential for invading new areas and establishing viable populations in them, either in the water column (holoplankton) or on the bottom (meroplanktonic larvae of benthic species settling on the sea floor). As meiobenthic animals usually lack a pelagic larval stage in their life cycle, no biological invasion study has, to our knowledge, ever specifically targeted marine transport as a means of meiofaunal dispersal.

Here we present a set of data showing that the sediment deposited in a ship's ballast water tank does support a viable meiobenthic assemblage. We examined 0.015-dm^3 aliquots of a 1 dm^3 sample from a c. 1.5-cm thick layer of sediment residue in the ballast tank of MS Donnington, brought to the 'Gryfia' Repair Shipyard in Szczecin (Poland). The samples were found to contain representatives of calcareous Foraminifera, hydrozoans, nematodes, turbellarians, harpacticoid copepods and their nauplii, and cladocerans, as well as meiobenthic-sized bivalves and gastropods. Nematodes proved to be the most constant and most numerous component of the assemblage. The sediment portions examined revealed the presence of 1–11 individuals representing 11 marine nematode genera. The viability of the meiobenthic assemblage was evidenced by the presence of ovigerous females of both nematodes and harpacticoids.

Survival of the meiobenthos in shipborne ballast tank sediment residues may provide at least a partial explanation for the cosmopolitan distribution of meiobenthic taxa and may underlie the successful colonisation of new habitats by invasive meiofaunal species.

1. Introduction

Ship's ballast water is an established means by which numerous freshwater and marine organisms, including many invasive species, are dispersed (Gollasch et al. 2002, Minchin & Gollasch 2002). In addition to the water used for ballasting, which is discharged whenever necessary, ballast tanks also contain sediment introduced with the water pumped into the tanks, which accumulates as the various particles sink on to the ballast tank bottom. Regulations concerning ballast treatment and management (IMO 2004) require that when ballast water is discharged, the sediment be removed as well; however, unless the tank is cleaned thoroughly, a layer of residual sediment usually remains on the tank bottom.

Ballast water as a habitat for and dispersal vector of numerous planktonic and benthic organisms has been the focus of numerous studies (see Gollasch et al. 2002 and the references therein) and programmes for preventing the spread of non-indigenous species (see Taylor et al. 2002 and the references therein). Ballast tank sediment has recently been recognised as a means of dispersal for resting stages of bloom-forming phytoplankton (Hamer 2002, Hamer et al. 2000), microbial pathogens (Dobbs et al. 2003), and resting stages of zooplanktonic species (Bailey et al. 2003, 2005). In this study, we examined ballast tank residual sediment as a habitat supporting assemblages of meiobenthic organisms.

2. Material and methods

The study investigated sediment sampled from a ballast tank (tank 3C) of MS Donnington, a bulk carrier flying the Isle of Man flag, brought for repairs to the 'Gryfia' Repair Shipyard in Szczecin, Poland, in October 2004. Prior to docking, the ship's ballast tanks were emptied of water and sediment; about 50 m^3 of sediment were removed from all the tanks, including tank 3C. The tanks, however, retained a residual, c. 1.5-cm thick layer of sediment: this contained numerous coal particles, and its silt-clay content (< 0.063 mm fraction) was 46.37%.

The ballast tank sediment residue was sampled with a 1000-cm^3 glass jar inserted into the sediment and filled to the brim. The sediment sample was divided by means of a Folsom sample splitter into 32 sub-samples (31.25 cm^3 each); each sub-sample was treated with 10% formalin and stained with Rose Bengal. Half of the sub-samples (16, with a total sediment volume of 500 cm^3) were picked at random for meiofauna extraction.

The sub-sample sediment was passed through a set of 0.500 and 0.032 mm mesh size sieves; the sieving residues were examined under a stereomicroscope and the meiofaunal organisms encountered were manually picked out. The nematodes were mounted in glycerine and identified at the genus level.

3. Results

The sediment examined was found to contain foraminiferans (Foraminifera; only 'live', i.e. stained, individuals were taken into account), hydrozoans (Hydrozoa), nematodes (Nematoda), harpacticoid copepods (Copepoda Harpacticoida), turbellarians (Turbellaria), and meiofauna-sized bivalves (Bivalvia) and gastropods (Gastropoda). Judging by their appearance, prior to formaldehyde fixing and preservation, the animals had been in good condition and fully viable.

Based on the meiofaunal organism counts in the sub-samples, the total density was estimated at 314 indiv. per 1000 cm^3. Because only a single sample was collected, no confidence interval for the estimate can be given.

The assemblage was dominated by nematodes and foraminiferans (Fig. 1). Harpacticoid copepods, another important meiofaunal taxon, included gravid females.

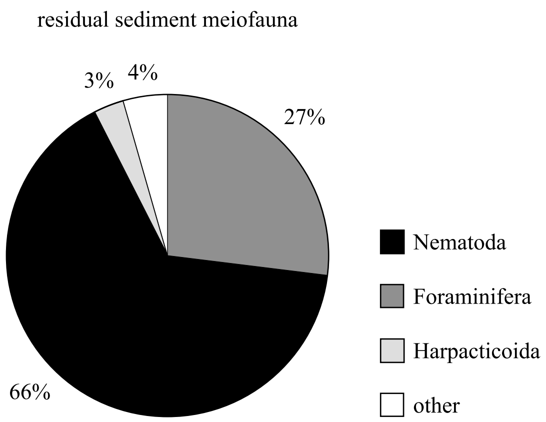

Fig. 1. Composition of MS Donnington's ballast tank sediment residue meiofauna

The nematodes, represented by 1–11 individuals per sediment aliquot, were identified as belonging to the following 11 marine genera: *Tripyloides, Daptonema, Desmodora, Antomicron, Dichromadora, Innocuonema, Sphaerolaimus, Paracanthonchus, Leptolaimus, Thalassomonhystera*, and *Anoplostoma*. Four genera – *Tripyloides, Dichromadora, Innocuonema*, and *Daptonema* – were represented most abundantly and, taken together, accounted for about 93% of all the nematodes collected (Fig. 2). Most, or in some cases all, individuals in each genus were females, many of them ovigerous.

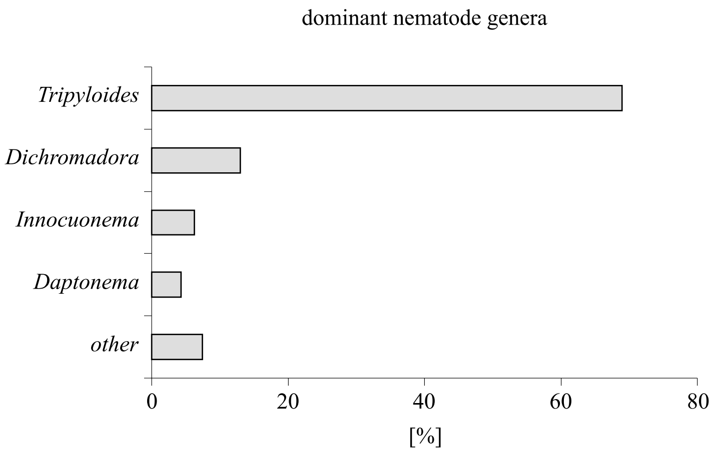

Fig. 2. Composition of the nematode assemblage in MS Donnington's ballast tank sediment residue meiofauna: dominant genera

4. Discussion

Until recently, ballast tank sediment, whether intact or a post-cleaning residue, has been considered primarily from the standpoint of its being a depository of microbial pathogens (Dobbs et al. 2003) or of resting stages of planktonic organisms (Bailey et al. 2003, 2005). Much less attention, let alone detailed research, has been focused on ballast tank sediment-dwelling invertebrates. And yet there is evidence that those sediments do indeed support a diverse array of benthic taxa, including meiobenthic ones (e.g. Hines & Ruiz 2000, Hamer 2002).

In this study, we found a viable meiobenthic community dwelling in the ship's ballast tank sediment residue. The density of the meiofauna (314 indiv. per 1000 cm^3) might seem low; however, the lack of any comparative data precludes concluding whether the level of abundance found was indeed low or typical of the type of habitat the animals were inhabiting. It has to be remembered that we were dealing with the sediment residue only, not with the entire bulk of sediment deposited on the ballast tank bottom.

The presence of the meiobenthic invertebrates in the ballast tank sediment residue and their active reproductive status (ovigerous females) may support the notion of the use of an anthropogenic vector by meiobenthic species for their dispersal, as already suggested by Gerlach (1977). It is also indicative of meiofaunal colonisation potential, as both gravid females or juveniles are transported by ships. Their colonisation of sediment in new locations may thus be facilitated because of their direct development (no need for metamorphosis, as opposed to the planktonic larvae of the macrobenthos). This has implications for the zoogeography of the meiobenthic species and also for the role of at least some of them as non-indigenous invasive species.

As opposed to the detailed knowledge of the macrobenthos in numerous localities, however, no all-taxa inventory of the meiobenthos in a locality has ever been attempted. On the other hand, inventories have been put together, taxonomic expertise permitting, of individual meiobenthic taxa, most notably the Nematoda (e.g. Vanreusel 1990), Copepoda Harpacticoida (e.g. Drzycimski 1993) and Gastrotricha (e.g. Todaro et al. 1995). Therefore, the appearance of a previously unrecorded meiobenthic species belonging to one of the better-known taxa in an inventoried locality may signal an invasion. An example has been recently furnished by Horvath et al. (2001), who recorded the establishment of two non-native harpacticoid species (*Schizopera borutzkyi* and *Heteropsyllus nunni*) in the nearshore sands of Lake Michigan. As shown by that study, native harpacticoids were eventually outnumbered by the invasive species, but, because the details of meiofaunal ecology are still scant, no further implications of these introductions could be offered.

The meiobenthic assemblage in the ballast tank sediment we studied was dominated by nematodes (Fig. 1), a typical feature of meiobenthic communities in most seafloor sedimentary environments (Giere 1993). The dominant nematode genera present (Fig. 2) are all marine and widely distributed, which explains their presence in the ship's ballast tank sediment on the one hand and may further facilitate their persistence in various localities worldwide on the other.

To sum up: the residual sediment in MS Donnington's ballast tank was a 'home' for an assemblage of viable and reproducing meiobenthic organisms. Thus, they apparently used it as a regular habitat, which, at the same time, serves as a depository of individuals and species physiologically and ontogenetically ready to colonise suitable seabed sedimentary environments. Survival in shipborne ballast residual sediment may provide at least a partial explanation for the cosmopolitan distribution of some meiobenthic taxa (e.g. Schmidt & Westheide 2000, Westheide & Schmidt 2002, Finlay & Fenchel 2004) and may underlie the successful establishment of some invasive meiofaunal species (Gerlach 1977, Horvath et al. 2001).

Acknowledgements

Our thanks go to Ms Halina Dworczak for performing the sediment grain size analysis. We are grateful to two anonymous reviewers for helping us to improve the manuscript.

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