Ecological Indicators 69 (2016) 368–380

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Nematode biomass and morphometric attributes as biological indicators of local environmental conditions in Arctic fjords

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ARTICLE INFO

Article history:
Received 13 January 2016
Received in revised form 12 April 2016
Accepted 20 April 2016

Keywords:
Nematodes
Size spectra
Body shape
Arctic fjords
Spitsbergen

ABSTRACT

Kongsfjord and Hornsund are fjords located on the west coast of the island of Spitsbergen that differ in terms of hydrographical conditions and food source availability for benthic organisms. We studied the nematode communities of these two glacial fjords with respect to their morphometric attributes (body length, width, length/width ratio) and biomass (total and individual) to evaluate whether their differences reflect differences in hydrographical and biogeochemical conditions. Sediments collected from Kongsfjord, which contained enhanced marine organic material than sediments from Hornsund, supported nematode communities exhibiting higher biomass and morphological diversity. The roles that the biochemical properties of sediments and food availability play in structuring biological communities were reflected in the wider spectrum of length/width ratio (*L*/*W*) and size spectra, with biomass dominance in the higher weight-classes observed in Kongsfjord. In this respect, the appearance of short and plump nematodes in the Kongsfjord nematode assemblage (12% of all nematodes), characterised by a *L*/*W* ratio of <12, was striking. This morphotype, which is almost absent in the Hornsund fjord (4%), is considered to be an indicator of well-oxygenated sediments with favourable food sources and may further confirm that the organic material in the Kongsfjord sediments is of higher quality. Furthermore, the homogeneity of sediment composition suggests that the morphological landscape of nematode communities are not structured by granulometry per se, as has been suggested in other studies, but rather by other environmental factors that are indirectly connected with particle size. The results of the present study provide evidence that the morphometric characteristics of nematodes are suitable for detecting differences in sediments, particularly with regard to organic matter availability.

1. Introduction

The hydrographical regime is one of the key factors driving biodiversity patterns and ecological functioning in marine systems (Grebmeier and Barry, 1991). In particular, in fjords, which are ecosystems of a restricted geographical area, hydrodynamical complexity shapes the temporal and spatial variations of its physical and biological components (Syvitski and Shaw, 1995; Gilbert, 2000). The fjords of the west coast of Spitsbergen are representative of places with dynamic hydrographical conditions (Svendsen et al., 2002). Although located in close geographical proximity, the environmental conditions of the fjords along the west coast of Spitsbergen differ markedly due to the balance of the influx of Atlantic and Arctic waters, river run-off and glacial melt. For example, Kongsfjord, which is located in the northwest of the island, is influenced by the northern branch of the North Atlantic warm current (West Spitsbergen Current), whereas the Hornsund fjord, which is located in the south, is to a largely influenced by cold Arctic waters flowing from the Barents Sea via the Sørkapp Current (Swerpel, 1985; Weslawski et al., 1991). Differences in the cross-shelf water-mass exchanges, together with strong environmental gradients due to marine-terminating glaciers at the head of the fjords, are likely to affect the flux of organic matter and energy transport through the food web. Regulated by the interaction between hydrographical regimes, physical process, and the structure and function of the food web, organic carbon produced in the surface waters fuels the benthic system (Smetacek, 1984).

The magnitude and composition of the organic material exported to the fjords, along with the strong environmental gradient along the fjords' axis, influence a wide range of benthic patterns and processes (Piepenburg, 2005). The response of benthic communities to these processes and physical forces is reflected

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http://dx.doi.org/10.1016/j.ecolind.2016.04.036
1470-160X/

in their structural diversity, population densities and biomasses (Włodarska-Kowalczuk et al., 2005; Kędra et al., 2010a; Ronowicz et al., 2011), not only for macrofauna but also for meiobenthic and nematode communities (Kotwicki et al., 2004; Somerfield et al., 2006; Grzelak and Kotwicki, 2012). However, for the most part, research on the structural aspects of the nematode communities has not yielded a wealth of information about functional traits, such as trophic structure or body size, which are thought to be related to important ecological functions (Losi et al., 2013a,b; Norling et al., 2007; Vanaverbeke et al., 2003).

Due to their small body size (between 32 μm and 500 μm), nematodes are in intimate contact with the sediment and are therefore directly and indirectly influenced by the physical properties of the surrounding environment (e.g., granulometry, oxygen supply). Nematodes are regarded as suitable taxa for use in environmental monitoring (Kennedy and Jacoby, 1999; Semprucci et al., 2015a) and have already been implemented in many studies examining the impacts of anthropogenic and natural physical disturbances, environmental pollution and alterations in marine ecosystems (e.g., Sherman et al., 1983; Schratzberger et al., 2009; Alves et al., 2013; Semprucci et al., 2015b). However, the morphometrics of nematodes, despite being easier to study than taxonomical analyses, do not receive adequate attention in the context of environmental impact assessments. This is an unfortunate situation, since as a result of a wide range of morphological adaptations to an interstitial lifestyle, nematodes show significant differences in body size and shape (e.g., Tita et al., 1999; Soetaert et al., 2002; Losi et al., 2013a). As was shown by Schwinghamer (1981), variation in body size is a direct adaptation to sediment particle size, and interstitial pore size is a major influence on the size distribution of sediment dwelling organisms. Subsequent research (Duplisea and Drgas, 1999; Tita et al., 1999; Duplisea, 2000) has either failed to confirm this or has yielded inconsistent results, suggesting that other biotic and abiotic factors, such as sediment water content, oxygen concentration and organic content (as a proxy of food availability), are all important in determining body size and proportions. Nematode body length and width – as well as the length-to-width ratio, a quantitative measure of nematode shape – are also considered to be useful parameters reflecting the state of the ecosystem that they inhabit (Soetaert et al., 2002; Vanaverbeke et al., 2003, 2004; Vanhove et al., 2004; Losi et al., 2013a). Body size can be indicative of the environmental context of behavioural life histories, physiologies, and energy requirements and reflect the structural and functional aspects of the nematodes (Peters, 1983; Vanaverbeke et al., 2003; Losi et al., 2013a); that is, body size has important implications for community structure and is a useful descriptor of an ecosystem. Analysis of the biomass spectrum is an alternative but complementary approach to traditional taxonomical investigation, which can lead to a broader and more comprehensive understanding of the processes and ecological roles of species within an ecosystem than performing taxonomic distinctions and grouping organisms into taxonomical units (Kerr, 1974; Woodward et al., 2005). In addition, focusing on biomass distribution over size has the added advantage of being less time-consuming and does not require considerable expertise.

Here, we describe the morphometry of nematodes, their biomass and body shape, and characterise the length–width relationships of nematode assemblages in two Arctic fjords, the Kongsfjord and the Hornsund, with different environmental conditions. We hypothesised that the different hydrographical regimes of the Hornsund and Kongsfjord determine the quality and quantity of the organic matter flux to the seabed, which leads to differing biogeochemical properties in the sediments and, consequently, differences in the morphological characteristics of the nematodes inhabiting the two fjords.

2. Materials and methods

2.1. Study area

Sampling was undertaken in two fjords along the west coast of Spitsbergen. Kongsfjord is an open, 26-km-long fjord located on the northwestern coast of Spitsbergen, Svalbard (12° E 79° N; Fig. 1). The fjord is divided into the outer basin, with average depths of 200–300 m, and separated from the outer basin by a chain of islands (Lovénøyane), the inner basin, with average depths of 50–60 m. Landforms around Kongsfjord were and are shaped by glacial activity, with the active tidal glacier Kongsbreen situated at the head of

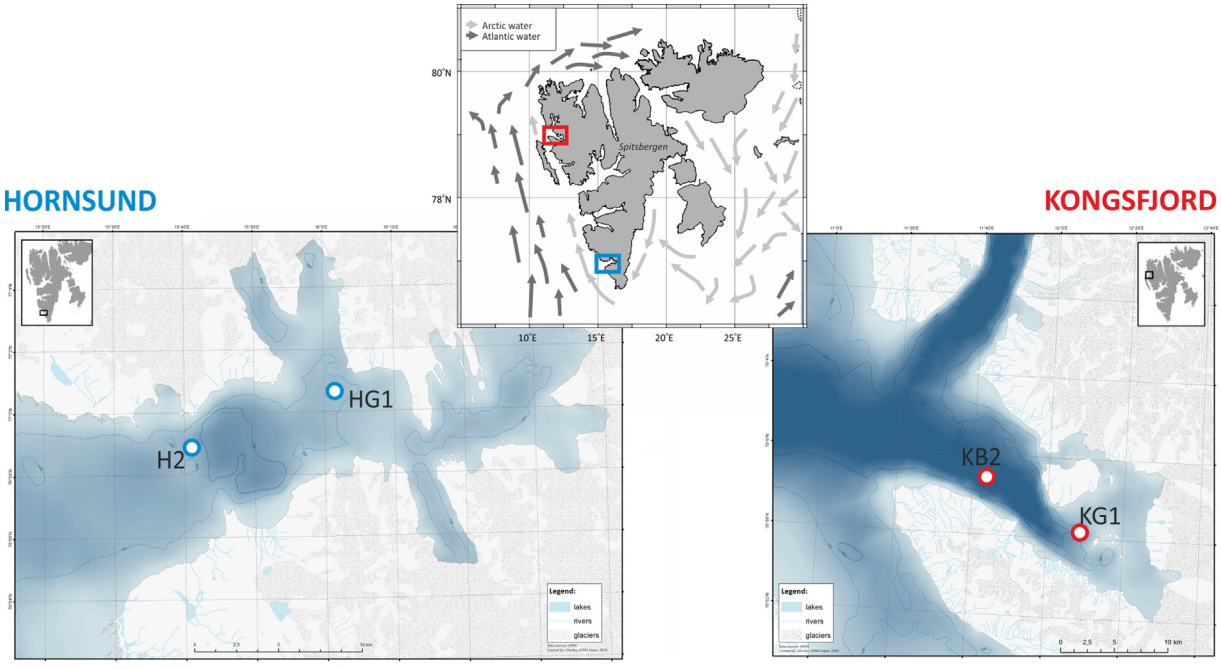

Fig. 1. Map of the Svalbard Archipelago showing the location of Hornsund and Kongsfjord and sampling stations.