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ORIGINAL ARTICLE

Microbial–meiofaunal interrelationships in coastal sediments of the Red Sea

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Abstract Population density and biomass of bacteria and meiofauna were investigated seasonally in the sediments of the north-western bank of Red Sea. Samples of sediments were collected seasonally from three different stations to determine microphytobenthic biomass (chlorophyll *a*), protein, lipid, carbohydrate, and total organic matter concentrations. These investigations revealed that microbial components tended to increase their dominancy, whereas sensitive meiofauna were extremely reduced during the entire study period. Thus a very low density of the total meiofauna (with an annual average of 109 ± 26 ind./10 cm^2) was recorded whilst the benthic microbial population densities exhibited higher values (ranging from 0.31 ± 0.02 × 10^8 to 43.67 ± 18.62 × 10^8/g dry sediment). These changes in the relative importance analysis of benthic microbial components versus meiofaunal ones seem to be based on the impact of organic matter accumulation on the function and structure of these benthic communities. Proteins, lipids and carbohydrates showed very low concentration values, and the organic matter mostly consisted of carbohydrates, reflecting lower nutritional values for benthic fauna in general and meiofauna in particular. The distribution of microbial and meiofaunal communities seems to be dependent on the quality of the organic matter rather than on its quantity. Total organic matter concentrations varied between 5.8 and 7.6 mg/g, with organic carbon accounting for only 32% of the total organic matter. Chlorophyll *a* attained very low values, fluctuating between 0.11 and 0.56 μg/g, indicating the oligotrophy of the studied area. The very low concentration of chlorophyll *a* in the Red Sea sediment suggests that the sedimentary organic matter, heterotrophic bacteria and/or protozoa constitute an alternative resource

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that is consumed by meiofauna when algae are less abundant. Protozoa, therefore, represent the "missing link in bacteria–meiofauna interaction in the Red Sea marine sediment ecosystem.

1. Introduction

The health of the sedimentary ecosystem can be assessed using data concerning the structure and abundance of its biological communities (Maher et al., 1999). Since the early 1980s biologists have been increasingly interested in studying benthic meiofauna started. This work presents obstacles, however, due to their small size, and the difficulties of isolating the benthic communities from the sediments and identifying species belonging to different taxa (Austen et al., 1994; Harguinteguy et al., 2012).

Meiofaunal organisms play an important ecological role in the aquatic ecosystem and are well suited for environmental impact assessment studies. Their short life spans, continuous reproduction and direct development in situ mean that meiofauna have a high potential to respond rapidly to both natural and anthropogenic environmental changes (Giere, 1993; Mirto and Danovaro, 2004; Fraschetti et al., 2006; Gyedu-Ababio and Baird, 2006; Moreno et al., 2008; Harguinteguy et al., 2012). Moreover, beaches may function as naturalfilters responsible for the remineralisation of substances, which then return to the sea as nutrients (Coull and Chandler, 2001). The interstitial system of beaches, in particular the system protected by muddy sediments, is formed by long and intricate food chains of bacteria, protists (unicellular algae & protozoa), and meiofauna at the first levels. Marine biological systems are therefore dependent on the productivity of coastal areas (Higgins and Thiel, 1988; Leguerrier et al., 2003).

Measuring carbohydrate, lipid and protein contents in marine sediments is usually very important to evaluate the availability of food (Fabiano et al., 1995; Pusceddu et al., 1996). Meanwhile, benthic microbes, in the form of bacteria, play an effective role in converting this organic matter into living biomass in the sediment, which in its turn can be utilised by benthic protozoa (Fenchel, 1967; Sleigh et al., 1992; Danovaro et al., 1999; Foissner, 2012), and meiofauna (Danovaro, 1996). This allows the transfer of feeding materials and energy to the higher trophic levels (Hondeveld et al., 1994; Mirto et al., 2004). Currently, however, no study has provided quantitative information on the trophic interaction between the three important sedimentary groups (bacteria/protozoa/meiofauna) and sedimentary organic matter within the Red Sea benthic ecosystem (El-Serehy et al., 2015).

In this research, population fluctuations of meiofauna and benthic heterotrophic bacteria were studied in relation to the seasonal fluctuation of sedimentary chlorophyll *a* and organic matter biochemical constituents at three different sites along the northern part of the Red Sea. The present work aims to investigate the microbial–meiofaunal population dynamics with relation to chlorophyll *a*, the organic matter content, biochemical composition and granulometric structure of the sediment.

Figure 1 Location of the study sites (with red colour) along the north-western bank of the Red Sea.

2. Material and methods

Three stations were chosen along the north-western bank of the Red Sea for this study (Fig. 1). The three stations were selected based on their proximity to mangrove. Safaga (lat 26° 36′ 56″N, long 34° 00′ 43″E) and Al-Qulaan (lat 24° 21′ 28″N, long 35° 18′ 23″E) were closer to mangrove vegetation than Gabal El-Zeit (27° 48′ 10″N, long 33° 33′ 59″E). Station I (Gabal El-Zeit) is located in a triangular bay at the entrance of the Gulf of Suez, 70 km to the north of Hurghada city. This site is surrounded by an extensive oily land area used by the GABCO Company for oil production services. Sediments have a red colour and are dominated by coarse and median sand particles. In addition, vegetation consists of *Padaina* sp. (Phaeophyceae) and *Caulerpa racemosa* (Chlorophyceae). Station II (Safaga) is sheltered by mangrove trees (*Avicennia marina*). The sediment texture is composed mainly of fine sand