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Biodiversity and distribution of the meiofaunal community in the reef slopes of the Maldivian archipelago (Indian Ocean)

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ABSTRACT

Marine biologists have progressively increased their consciousness of the importance of meiofauna for the benthic domain in both temperate and tropical regions. After the 1998 bleaching, Maldivian reefs (Indian Ocean) have been regarded as a vulnerable ecosystem that must be carefully monitored. Accordingly, an extensive investigation of meiofaunal distribution in the reef slopes of the Maldivian archipelago has been carried out, taking into account geographical position, type of habitat (inner *vs.* outer slope), inclination and depth gradient. Twenty-four taxa revealed the highest meiofaunal richness ever found in Maldivian reefs. Interestingly, Thermosbenacea and Syncarida were identified, which are two taxa that have only recently been documented in the marine ecosystem. Chaetognatha were also present, which is a group that was only considered to be planktonic until 2000, when they were also discovered in the benthos. The type of habitat, affected by different hydrodynamic conditions, was the main factor influencing the meiofaunal community's structure and diversity. In detail, the outer reefs were characterized by the highest level of diversity, confirming previous observations on the rate of coral reef growth and vitality and underlining the greater vulnerability of the inner slopes. In contrast, depth only significantly affected the community structure, but not its density or diversity. Accordingly, community structure seems to be more sensitive than abundance and diversity indices when it comes to detecting depth gradients. The 10° inclination of the inner slopes revealed the most different community structure and the greatest dominance of nematodes, leading to the lowest diversity levels.

1. Introduction

Meiofauna is a collective name for a size category (generally 500-42 μm) represented by eukaryotic organisms that share a distinctive lifestyle, ecological relations and common evolutionary traits (Giere, 2009). Due to their notable abundance and diversity in marine habitats, widespread distribution, rapid reproduction and high metabolic rate, meiofauna are fundamental contributors to ecosystem processes and functions, including nutrient cycling and the supply to higher trophic levels (see Zeppilli et al., 2015 for review). Their key role in benthic trophodynamics provides an excellent opportunity for testing ecological hypotheses and makes them very suitable for the assessment of the biodiversity and ecological status of marine ecosystems (Bianchelli et al., 2013; Boufahja et al., 2015).

Maldivian coral reefs (Indian Ocean) are known for their high biodiversity (Rosen, 1971; Andréfouët, 2012). Here, meiofauna have only been investigated irregularly after the qualitative pioneering studies carried out in 1958 during the 'Xarifa' expedition (Gerlach, 1961a, b; 1962, 1963a, b; 1964), although more recent quali-quantitative studies at the community level have documented a high species richness (see Semprucci and Balsamo, 2014 for review). The back-reef platforms created by dead coral material from the reef crest are one of the most studied Maldivian habitats for meiofauna (Semprucci et al., 2010, 2011). The degradation of these sediments is mainly due to wave and current actions that significantly influence the reef islands, causing them to change shape and possibly disappear in response to erosion by storm waves (Massel, 1997). Bio-erosion is also present and mainly due to the grazing of parrot- and surgeon-fish that release large quantities of loose sediment. Degraded corals are progressively broken down into small pieces. Sediments therefore become a combination composed of

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coral, mollusks, echinoids, alcyonarians, sponges and algae fragments (Semprucci et al., 2013). This combination of various elements produces a structurally complex sedimentary habitat that may host a very rich and even peculiar meiofaunal community (Giere, 2009).

Several geomorphological zones can be identified in a reef: outer slope, crest, back-reef platform, inner slope and lagoon. The energy gradients of the reef slopes control ecological, sedimentological and geomorphological processes. In particular, hydrodynamism has been recognized as the main factor influencing ecological zonation, long-term growth and the structure of coral reefs, as well as the distribution of the benthic fauna living within them (see Kench et al., 2006 and references therein).

The Maldivian archipelago was one of the coral reef environments most severely affected by the 1998 bleaching episode (Bianchi et al., 2003). The growth of tourism and coastal development have also threatened reef systems, leading some inner reefs to enter a regressive stage (Lasagna et al., 2010). Even though some recent studies have documented a positive sign of a slow recovery, reefs are still very vulnerable and require attention for protection and conservation purposes (Nepote et al., 2016).

Contrary to the overall good level of knowledge about the back-reef platforms of the Maldives, very little information is available on the meiofauna of the reef slopes, which are expected to host a different composition of the community (Semprucci et al., 2013; Sandulli et al., 2014). As reef communities are known to vary according to wave energy and water depth (Goreau, 1959; Ciarapica and Passeri, 1993; Bianchi et al., 1997; Kench et al., 2006), the meiofaunal community is analyzed in the present study by taking into account geographical position, topography (inner *vs*. outer slopes), current exposure and depth gradient. The following null hypotheses have been advanced: (1) H_0: the meiofaunal composition and diversity of the communities are not significantly affected by different geographical locations (i.e. between different atolls); (2) H_0: the different position on the outer or inner reefs, subject to different current expositions, does not affect meiofaunal composition and diversity; (3) H_0: the communities are not influenced by the different inclinations of the reef, or; (4) H_0: by the depth gradient. Furthermore, the present study is an important opportunity to collect information about the benthic status of these vulnerable habitats by means of the meiofaunal component that is increasing in relevance as a biological indicator group.

2. Materials and methods

2.1. Study area

The Maldives are situated in the central part of the Chagos-Maldives-Laccadive Ridge in the Indian Ocean (6°57′N to 0°34′S). More than 1200 reef islands are assembled in the 22 atolls, which are Mid-to Late Holocene in age (Kench et al., 2006). The archipelago (~750 km long) is formed by a single atoll chain in the northern and southern parts, and by a double atoll chain in the central area. Numerous studies have provided the baseline description of the morphology of the Maldivian reefs (Woodroffe, 1992; Ciarapica and Passeri, 1993; Morri et al., 1995; Bianchi et al., 1997; Colantoni et al., 2003).

Physical differences exist between the different reef types, with most atolls consisting of an annular reef rim that slopes steeply externally to a deep ocean basin, while internally enclosing a shallow lagoon. The outer reefs of the atolls are directly exposed to the breakers of the open ocean, while the inner lagoons are connected with the open sea by several channels that cross the reef rim in many places. Wave and current actions not only contribute to the physical erosion of the reef, but also have several functions such as the supply of nutrients, the renewal of water and oxygen, dispersal, and the recruitment of larvae (see Kench et al., 2009 for details). The climate in the Maldives is dominated by monsoons, with southwest to northwestern winds (~225–315°) from April to November (westerly monsoon, mean wind speed 5.0 m/s), and northeast–eastern winds (~45–90°) from November to March (northeastern monsoon, mean wind speed of 4.8 m/s) (Kench et al., 2006).

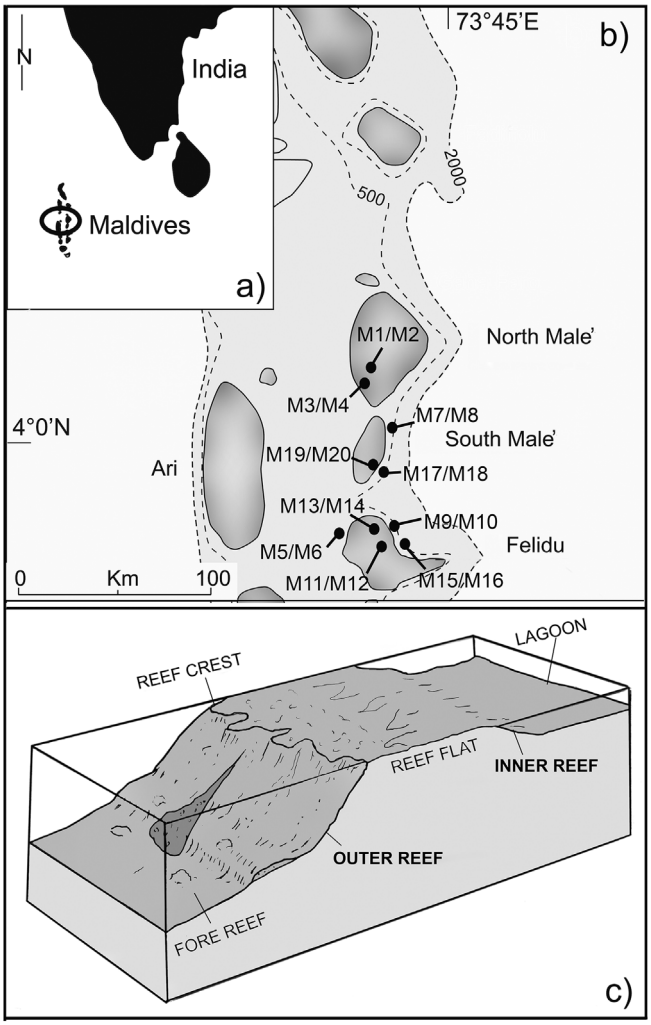

Fig. 1. Study area: a) Maldivian archipelago; b) location of the sampling stations; c) scheme of the two habitats investigated (inner and outer reef slopes).

The Felidhoo and Malé atolls situated on the central eastern part of the double chain were the focus of this study (Fig. 1). Felidhoo is represented by a single atoll, while Malé consists of two separate ones: North and South Malé. The former is the largest and hosts the capital of the Maldives - Malé.

2.2. Sample collection

The sampling was carried out from 15 to 20 May 2013 in the South and North Malé and Felidhoo atolls (Fig. 1, Table 1). Twenty sites were investigated: 10 outer (ocean-facing sides of faros: ring-shaped reefs situated on the atoll rim) and 10 inner (lagoon faros or lagoon-facing sides of the atoll rim) reefs. In order to collect undisturbed portions of the sediments, scuba divers carried out the sample collection using a manual corer (Danovaro et al., 2004). Samples were collected in the selected sites at stations located at different depths and inclinations on the reefs. The inclinations were measured using a clinometer. As reported in Table 1, the greatest inclinations were in the shallow depths in both the outer and inner reefs, while the minor inclinations were at the deepest stations. The outer oceanic reefs had the greatest wall inclinations.

Three independent replicate samples for the meiofauna and one for