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NOTE

On the occurrence of the hydrocoral *Millepora* (Hydrozoa: Milleporidae) in the subtropical eastern Atlantic (Canary Islands): is the colonization related to climatic events?

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Abstract The occurrence of a hydrocoral of the genus *Millepora* has been recorded for the first time in the eastern subtropical Atlantic (Tenerife, Canary Islands), at a latitude of 11° N of its previously known northernmost limit of distribution in the Cape Verde Islands. The moderate development of the colonies, their fast growth rate and very restricted location indicate a recent colonization process, possibly related to an extreme climatic event that took place in the summer of 2004, adding to the rising seawater temperatures in the region during recent years.

Keywords *Millepora* sp · Hydrocoral · First record · Canary Islands · Extreme climatic event

Introduction

The occurrence of marine species in regions beyond their usual geographic range is a worldwide phenomenon (Bianchi 1997; Fine et al. 2005) with relevant ecological consequences to ecosystem diversity and structure (Sala et al. 2000). The calcareous hydrozoans of the genus *Millepora* have a circumtropical distribution, living in shallow waters. Their colonies are a regular conspicuous component of coral reefs and are important as reef builders (e.g., Lewis 1989, 2006). *Millepora* has been recorded in the tropical eastern Atlantic in various studies (Laborel 1974; Boekschoten and Best 1988; Morri and Bianchi 1995; Morri et al. 2000). Particularly in the Cape Verde Islands, it has been identified as *M. alcicornis* Linnaeus, 1758, or as *Millepora* sp. in the most recent study (Morri et al. 2000), indicating a possible new species or a morph of *M. alcicornis*. In Cape Verde Islands, at its northern distribution limit, it plays an extremely important role in the organization of coastal benthic communities (Morri and Bianchi 1995; Morri et al. 2000; Brito pers. obs.), being also evident in Pleistocene and Holocene paleontological deposits (Boekschoten and Best 1988).

Up to the present, hydrocorals had never been recorded in the Canary Islands, even as fossils. Two species of hermatypic corals inhabited the islands, both scleractinians of the genus *Madracis* (Brito and Ocaña 2004). Only one other tropical hermatypic coral appears in Pleistocene deposits, the scleractinian *Siderastrea radians* (Pallas 1766), whose current northern limit is also Cape Verde Islands (Zibrowius and Brito 1986; Brito and Ocaña 2004) where it is very common and plays an important role in the development of coastal benthic communities (Morri and Bianchi 1996; Moses et al. 2003).

In September 2008, three colonies of *Millepora* were discovered at a location in southeast Tenerife (Canary Islands). They were studied and monitored annually in order to describe their ongoing process of development and colonization. The results of an initial study are presented

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here, comparing data gathered in September 2008 with those obtained a year later in September 2009. Hypotheses are put forward about the colonization process.

Materials and methods

In September 2008, a sub-aqua fisherman reported finding a hydrocoral colony (Fig. 1) while snorkelling at Porís de Abona (South-East Tenerife, 28° 10′ 24.12″N, 16° 25′ 47.12″W) (see Fig. 2). We have conducted an exhaustive search in the vicinity, between 3 and 10 m deep on the rocky reef, locating two extra colonies. Each colony was measured with callipers at six fixed points at the edges to record its size and branching development, and then photographed. Images were analyzed using image-treatment software (Image J) to estimate surface cover of each colony.

The AVHRR/NOAA-derived Sea Surface Temperature (SST) data for previous years 2003, 2004 and 2005 were obtained from the Jet Propulsion Laboratory (JPL) POD-AAC Pathfinder. SST data have a cylindrical equidistant projection that corresponds to Standard Mapped Image products (SMI) and a spatial resolution of 0.0439453125°.

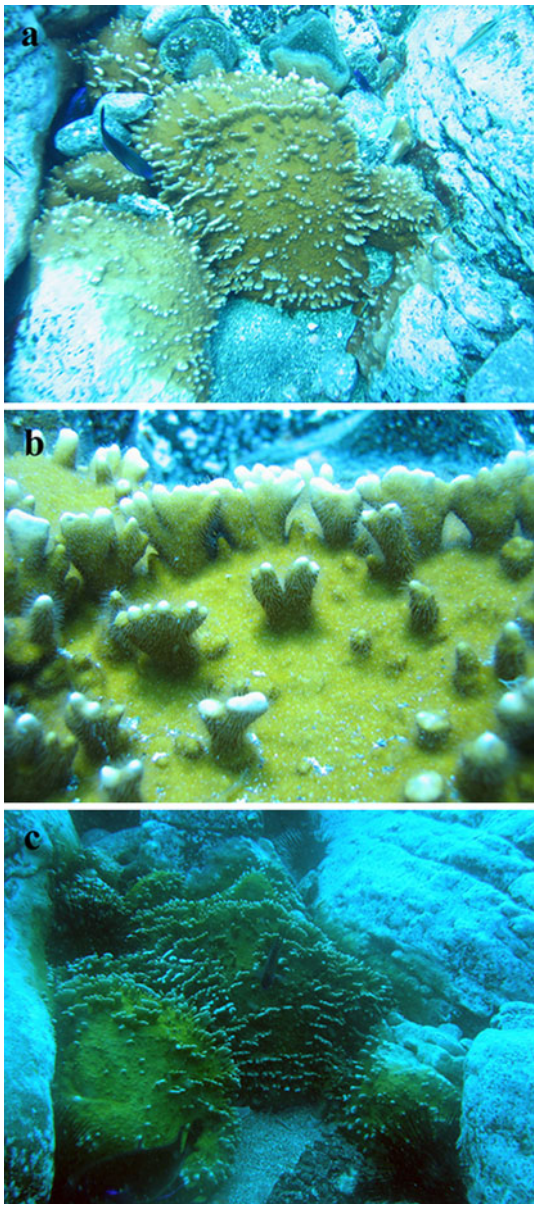

Fig. 1 **a** The largest colony of *Millepora* sp. (colony A) in September 2008 and **b** detail of branching. **c** The same colony in September 2009

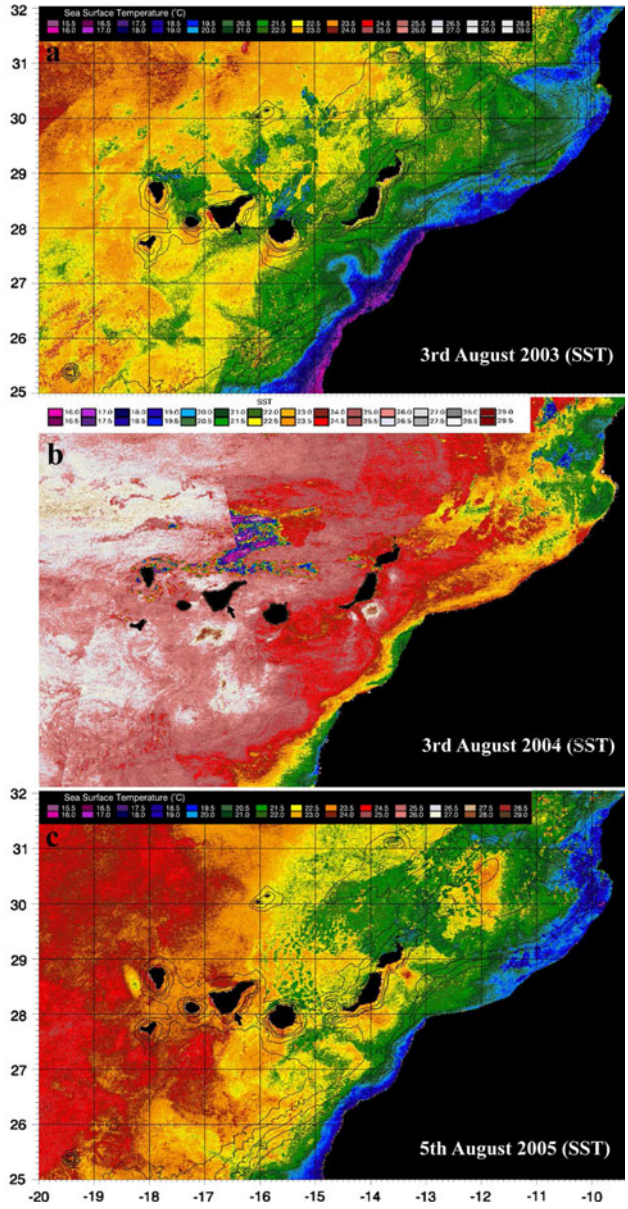

Fig. 2 Images of sea surface temperatures (SST) around the Canary Islands, generated by satellites AVHRR/NOAA, during the same period of the year (August) in **a** 2003, **b** 2004 and **c** 2005. The location of the hydrocoral *Millepora* sp. within the Archipelago is marked with an arrow in each image

Results and discussion

The three colonies of the hydrocoral *Millepora* were found in a very small area (maximum 3 m apart), and just at one site (Porís de Abona) (see Fig. 2), between 6 and 8 m deep on the rocky bottom. The habitat where specimens were found consisted on a typical algae-denuded barren ground community generated by the grazing activity of the sea urchin *Diadema* aff. *antillarum* (Hernández et al. 2008).

In September 2008, the largest colony (colony A, Fig. 1) covered an area of 633 cm^2 and the longest branches measured 2 cm long. The other two colonies were situated at about 3 and 1.80 m from the first one and were much smaller, measuring 343 cm^2 (colony B) and 133 cm^2 (colony C), with the longest branches of 1 and 0.5 cm, respectively.

Measurements of each colony a year later, in September 2009, indicated significant growth of the two larger ones (A and B). Colony A reached 2,610 cm^2 with a maximum branch length of 3 cm. Colony B grew up to 910 cm^2 with a maximum length of branches of 2.4 cm. The smallest colony (C) reached an area of 168 cm^2 and its longest branches measured 1.8 cm. A new colony (colony D) of 56 cm^2 and with branches of 0.2 cm of maximum length was recorded during the annual monitoring surveys, located at a distance of 10 cm from colony C. The growth at the edges varied according to colony, ranging between 4.59 and 27.67 cm (mean ± SD: 16.24 ± 3.32 cm) for colony A, between 0.39 and 16.01 cm (mean ± SD: 6.17 ± 2.21 cm) for colony B, and from 0.00 to 0.40 cm (mean ± SD: 0.20 ± 0.08 cm) for colony C.

The colonies showed morphological characteristics that may be attributable to *M. alcicornis*, but the complex taxonomy of this group, largely due to phenotypic plasticity in response to different environmental conditions (Amaral et al. 2008; Ruiz-Ramos 2009), supports identifying them as *Millepora* sp. Other authors have done the same in a recent work on the tropical eastern Atlantic, awaiting comparative studies with material from the western Atlantic (Morri et al. 2000).

The biometric measurements indicate that these specimens are only a few years old and show the remarkable growth rate of the two largest colonies (colonies A and B) in only a year, faster than rates recorded in the literature (e.g., Lewis 1991, 2006). Results also suggest that growth varies according to the characteristics of the substrate, since the fact that colony C is growing on an apparently unstable rock seems to have affected its development. Given the proximity of colonies, it is possible that the smaller specimens have appeared through regeneration and proliferation from fragments detached from the larger colony, a well-known phenomenon in these organisms (Lewis 2006).

Current weather conditions around the Canary Islands seem to favor the development of colonies of this important reef-building species of tropical origin, although its spatial spread throughout the coast off Tenerife has so far been minimal. The water temperature in the region currently ranges from about 18 to 25°C. However, the islands have undergone a recent warming trend with a mean increase of about one degree over the past 20 years (NCEP reanalysis, Kalnay et al. 1996). Clear evidence of a tropicalization process in the marine ecosystem of the Canary Islands has been shown for fish (Brito et al. 2005) and echinoids (Hernández et al. 2010), as a result of the increasing seawater temperatures.

The appearance of *Millepora* colonies at the latitude of the Canary Islands represents a new record of the species at 11° N of its previously known northernmost limit of distribution. Considering the reproductive cycle of hydrocorals and the short life span attributed to the medusa stage of these organisms (Lewis 2006), this new find can only be explained by the arrival of hydromedusae from the nearest tropical areas through a rapid movement of water masses. Along with the limited development of the largest colony, the rapid growth rate and restricted spatial location of the specimens supports a probable recent random colonization event. This process may well be related to extreme weather events such as that registered during the summer of 2004 (Ramos et al. 2005). In July–August 2004, the warmest heat-wave so far recorded in the NW African upwelling was reported. The meteo-oceanic data series, modelled dust deposition and concentration outputs, and in situ data sets confirmed a rare picoplankton bloom of the diazotrophic N2-fixing cyanobacter *Trichodesmium erythraeum* Ehrenberg, never described before in this area (Ramos et al. 2005). AVHRR/NOAA SST images showed a convergence of the warmest waters ever registered by satellite (27.5°C) drifting from the SW toward the Canary Islands (Fig. 2). A clear interannual variation in SST around the Archipelago related to the strength of the Saharan upwelling (maximal in 2003) and the unusually intense warming event of 2004 is evident in satellite images (Fig. 2).

The hydrocoral colonization process from tropical areas is not easy to explain, considering the brief life span of the medusa stage (Lewis 2006). However, the scarce knowledge of the sexual reproduction of many species of calcareous hydrozoans is also noted in the literature (Lewis 2006). Alternatively, the arrival of the hydromedusae could be due to transportation in ballast waters of large vessels or produced by hydrocorals developed during the fouling of vessel hulls (ships or oil platforms). This hypothesis would be more tenable if the colonies' location were nearer to the main ports of Tenerife. Instead, they have appeared for the first time in the Canary Islands in a fairly remote area, away from commercial or fishing ports.

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