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Note

Rafting in Zoantharia: a hitchhiker's guide to dispersal?

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ABSTRACT

The increasing availability of human-made structure in the oceans coupled with climate changes may lead to the range expansion of species able to disperse by rafting. In this study, we report on zoantharian species of genera *Isaurus*, *Palythoa*, *Umimayanthus* and *Zoanthus* covering artificial substrates in locations in both the Atlantic and Pacific oceans. Moreover, we reviewed observations of additional zoantharians as macrofouling organisms, and discuss the possible role of rafting in the dispersal of this cosmopolitan group. Traits reported to some zoantharian species, such as hermaphroditism and resistance to desiccation, support their dispersal potential by drifting attached to floating objects. Further reports of zoantharian species covering floating artificial structures and natural debris are needed to increase our knowledge of dispersal mechanisms in the oceans. Additionally, this information is essential to monitor and manage possible exotic species invasions, especially for zoantharian species that are common in the aquarium trade.

1. Introduction

Rafting has been reported in many marine taxa that are able to disperse by attaching to floating drifting objects (Thiel and Gutow, 2005), for example, reef fishes with seaweed flotsam (Luiz et al., 2015), and sea anemones and hydrocorals attached to volcanic pumice (Jokiel, 1990; Bryan et al., 2012). Artificial floating structures, such as plastic and glass litter, are nowadays much more available than natural debris, in addition to having slower decomposition times (Derraik, 2002; Kiessling et al., 2015; Carlton et al., 2017). As a consequence, rafting on human-made structures has led to the introduction of non-native species and become a major environmental problem (Barnes, 2002; Kiessling et al., 2015; Rech et al., 2016, 2018).

Zoantharians (Cnidaria: Anthozoa: Zoantharia) are benthic animals found in all oceans (Haddon and Shackleton, 1891; Burnett et al., 1997; Ryland et al., 2000). Species of genera *Palythoa* and *Zoanthus* are a common component of shallow-water subtropical and tropical reefs and can cover large portions of the substrate (Karlson, 1983; Oigman-pszczol et al., 2004; Irei et al., 2011). This widespread distribution is likely associated with a high dispersal capability, due to a long pelagic larval duration (Ryland et al., 2000; Polak et al., 2011) and several asexual reproduction strategies, including polyp ball production (Acosta et al., 2005) and relatively rapid growth of fragments (Karlson, 1988). In addition, there is the possible role of rafting, although this potential has not been examined or discussed for zoantharians.

In this study, we report on zoantharian colonies covering portions of artificial substrates (bottle, mooring line, shipwreck). Furthermore, we link these reports to previous biofouling records of species of Zoantharia, and discuss the potential for dispersal of zoantharians via rafting.

2. Methods

2.1. Specimens on artificial substrates

Zoantharian polyps were observed growing on a glass fragment of a bottle in October 2014, during an expedition to Rocas Atoll (3° 86′S, 33° 80′ W), 270 km off northeast Brazil, in the Atlantic Ocean. The atoll is approximately 3 km in diameter (Gherardi and Bosence, 2001) and the glass piece was collected from a sandy beach during low tide, where it had washed up.

In addition, zoantharian colonies were noticed covering large portions of the sunken Japanese tanker *Iro* (7°17′57″N, 134°24′56″E), and on a mooring line in Turtle Cove (7°05′13″N, 134°15′33″E), during field work in the Republic of Palau between 2016 and 2018. Zoantharian specimens were identified via examination of external morphology (Pax, 1910; Reimer, 2010; Reimer et al., 2012a; Montenegro et al., 2015). We also compiled previous published biofouling records of zoantharian species.

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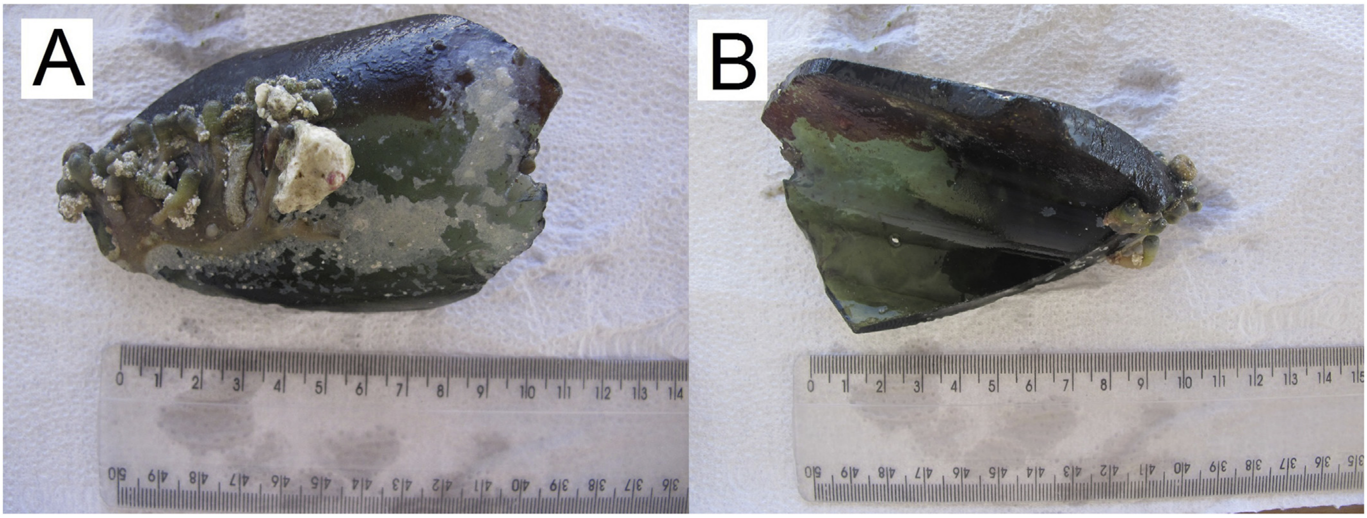

Fig. 1. Glass fragment covered with *Palythoa grandiflora* and *Zoanthus sociatus* polyps collected from Rocas Atoll, northeast Brazil. The fragment was approximately 10 cm in length and had polyps on both external (A) and internal (B) sides.

3. Results

Colonies of the species *Palythoa grandiflora* (family Sphenopidae) and *Zoanthus sociatus* (family Zoanthidae) were found on a glass fragment from Rocas Atoll (Fig. 1A-B). The fragment was from a bottle and was approximately 10 cm in length, partially covered on both sides by approximately 35 zoantharian polyps. It is unknown if the species settled after or before the glass was broken. Moreover, several colonies of *Zoanthus sansibaricus* were observed on the external wall of the sunken tanker *Iro* in Palau, as well as numerous polyps of *Umimayanthus chanpuru* (family Parazoanthidae). In addition, a colony of *Isaurus tuberculatus* (family Zoanthidae) and *Palythoa* cf. *mutuki* were also noted in a mooring line in Palau. The line was made of nylon and was in midwater, attached to a fixed float. The zoantharian polyps were observed growing on surfaces already covered by other encrusting organisms such as encrusting coralline algae, both on the bottle fragment from Rocas and on the artificial substrates in Palau. Moreover, species of *Umimayanthus* have an obligatory epizoic relationship with Porifera hosts, and *U. chanpuru* colonies were associated with encrusting sponges.

Additionally, species of *Palythoa*, *Zoanthus* and *Microzoanthus* (family Microzoanthidae) have been noted as biofouling in previous literature (Table 1). Genera *Isaurus*, *Palythoa* and *Zoanthus* belong to suborder Brachycnemina, while *Microzoanthus* and *Umimayanthus* belong to suborder Macrocnemina.

Table 1
Records of zoantharian species growing on artificial substrates.

Artificial substrate type	Species	Location(s)	Reference(s)
Concrete	*Palythoa caribaeorum*	Brazil, Mexico	Brandini and Silva, 2011; Silva et al., 2016
Fiberglass	*Zoanthus* sp.	Bahrain	Naser, 2017
Glass	*Palythoa grandiflora*	Brazil	This study
	Zoanthus sociatus	Brazil	This study
Jetty pilings	*Palythoa* sp.	Singapore	Ong and Tan, 2012
	Zoanthus sp.	Singapore	Ong and Tan, 2012
Limestone boulder	*Palythoa mammillosa*	USA	Cummings, 1994
Nylon mooring line	*Isaurus tuberculatus*	Palau	This study
	Palythoa cf. *mutuki*	Palau	This study
Shipwreck	*Palythoa caribaeorum*	Brazil	Vieira et al. 2012
	Umimayanthus chanpuru	Palau	This study
	Zoanthus sansibaricus	Palau	This study
Outflow pipes	*Microzoanthus kagareou*	Palau	Reimer and Fujii, 2013

4. Discussion

We observed zoantharian colonies attached to a glass surface, a plastic mooring line, and an artificial iron reef. The polyps were growing upon other encrusting organisms, which may have facilitated their initial settlement. Cases of zoantharians covering artificial structures are not rare (Table 1), and previous reports from the Atlantic Ocean include colonies of *Palythoa caribaeorum* on a wreck (Vieira et al., 2012), on concrete blocks (Brandini and Silva, 2011), and on reefs (Silva et al., 2016), as well as *P. mammillosa* on a limestone boulder (Cummings, 1994). In the Indo-Pacific, species of *Palythoa* and *Zoanthus* have been noted as macrofouling organisms on jetty pilings in Singapore (Ong and Tan, 2012), and *Zoanthus* has been reported on a fiberglass experimental panel in the Persian Gulf (Naser, 2017). Furthermore, polyps of the zoantharian *Microzoanthus kagareou* were observed attached to sea water outflow pipes of an aquaculture center (Reimer and Fujii, 2013). There is no information available to determine in these above cases if polyps were growing upon other organisms or not, and such data should be included in future observations. In summary, the current and previous reports demonstrate the ability of zoantharians to settle on substrates of several types and sizes, likely including floating objects. It is possible that zoantharians are also able to grow on natural debris, similar to as seen in other benthic cnidarians such as sea anemones (Bryan et al., 2012), hydrocorals (Jokiel, 1989, 1990), and scleractinian corals (Bryan et al., 2004, 2012), that have been reported on volcanic sea-rafting pumice. Moreover, the scleractinian coral *Astrangia poculata* has been reported to cross long distances on metal flotsam (Hoeksema et al., 2012, 2015). Likewise, genetic data indicate that rafting may be the main dispersal mode of the ascidian *Symplegma rubra*, which can be found on both natural and anthropogenic floating objects (Dias et al., 2006). Rafting may also drive gene flow among long distant areas for some marine invertebrates (Nikula et al., 2012), which could be a key dispersal strategy in species that do not have a long pelagic larval stage. For instance, the wide distribution and the occurrence of *Millepora alcicornis* in remote areas is probably due to successful raft dispersal, as although this hydrocoral may have a short pelagic phase, it shows generalist