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Regeneration of artificial injuries on scleractinian corals and coral/algal competition for newly formed substrate

E.A. Titlyanov[a,b,*], T.V. Titlyanova[a,b], I.M. Yakovleva[a,c], Y. Nakano[b], R. Bhagooli[c]

[a]Institute of Marine Biology, Far East Branch of Russian Academy of Sciences, Vladivostok-41 690041, Russia
[b]Tropical Biosphere Research Center, University of the Ryukyus, Sesoko Island, Okinawa 905-0227, Japan
[c]Department of Chemistry, Biology and Marine Science, University of the Ryukyus, Nishihara, Okinawa 903-0213, Japan

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Abstract

Porites cylindrica and *Porites lutea* fragments of colonies were inflicted with five different injury types: chisel, file, Water Pik, osmotic and cement injuries. The fragments were maintained in outdoor aquaria for a period of 240 days under light intensities varying from 2–5% to 70–90% of incident surface photosynthetic active radiation (PAR_0). During the exposure, changes in weight of the fragments, the rates of regeneration of the injuries, abundance of algae and animals settled onto injured areas were monitored. The regeneration rate of the injuries depended on interspecific differences in corals, injury types, number and composition of algae and animals settled onto the lesions, and light and temperature conditions. Competitive interactions between polyps and settlers occurred after colonizers settled onto the damaged surface or the live tissue. It is noteworthy that recovered coral tissue generally overgrew about 100 algal species with or without inhibition of coral growth by algae. In the summer period, the cyanobacterium *Lyngbya majuscula* covered some lesions (osmotic and cement) by 100%, thus reducing dramatically the regeneration rate of the inflicted injuries and also caused coral bleaching when in direct contact.

Keywords: Coral/algal competition; Injury; Overgrowth; *Porites cylindrica*; *Porites lutea*; Regeneration

1. Introduction

Competition between scleractinian corals and benthic algae is considered fundamental to the overall status of coral reefs. Competition is an important process determining the structure, composition and the abundance of both coral and algal benthic communities on coral reefs (Littler and Littler, 1984; Lapointe, 1989; Hughes, 1994; Miller, 1998; McCook et al., 2001; Diaz-Pulido and McCook, 2002). McCook et al. (2001) have suggested six mechanisms of coral/algal competition: overgrowth, shading, abrasion, chemical, pre-emption/recruitment barrier, and epithelial sloughing. Corals and algae are

* Corresponding author. Institute of Marine Biology, Far East Branch of Russian Academy of Sciences, Vladivostok-41 690041, Russia. Tel.: +7 4232 310931; fax: +7 4232 310900.
E-mail addresses: etitlyanov@mail.ru, titlyanova@inbox.ru (E.A. Titlyanov).

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interspecific in competition for space, substrate and resources (McCook et al., 2001). In most cases, external factors, especially their sharp changes, determine not only the abundance and structure of both communities but also the superiority over the rest (McCook et al., 2001; Diaz-Pulido and McCook, 2002; Lapointe, 1989; Done, 1992).

The competition between coral polyps and algae for substratum, space and sources is a common and constant process on coral reefs with varying success for the competitors. However, for the past decades owing to global natural catastrophes, degradation of coral reefs and the so-called phase shifts from coral to plant dominance have been observed. Plant reefs consist mostly of algal and seagrasses grown on newly formed substrate due to dead and damaged colonies of hermatypic corals. The competition between corals and algae begins immediately after the formation of this substrate. Micro- and macro-algae, cyanobacteria and seagrasses as well as benthic invertebrate animals including settled planulae and survived coral polyps, participate in this competition. During the first 1–2 years after catastrophe, algae are the winners and occupy more than 90% of the newly formed substrate (Lapointe, 1989; Loya et al., 2001). It is known that during the first years, after the catastrophe, recovery of coral reef on the new substrate also occurs by the formation of new colonies (Sakai et al., 2004), by lesion healing and by spreading of polyps on the previously damaged colonies (Titlyanov, unpublished data).

The ability of many corals to recover from damage, depending on the position, size, shape and type of the damage, has been well documented (e.g., Bak and Steward-van Es, 1980; Bak, 1983; Wahle, 1983; Rinkevich and Loya, 1989; Meesters et al., 1992, 1994; Meesters and Bak, 1993, 1995; Hall, 1997, 2001; Oren et al., 1997; Marshall, 2000). However, to the best of our knowledge, the influence of the settled organisms (algae and animals) on the recovery of injuries, especially in relation to light intensity has largely been ignored (McCook et al., 2001).

In this paper, we show results of some experiments on the study of the dynamics and mechanisms of competition for newly formed substrate (injured surface of colonies) between communities of coral polyps and micro- or macro-algae or some animal organisms settled onto the damaged surface of scleractinian corals. In this study, we addressed the following hypothetical ideas:

1) Competitive success of coral for newly formed substrate (injured part of colony) depends on the physiological state of the coral, environmental conditions, especially light intensity, and also on the density and the structure of algal and animal communities colonizing the substrate.
2) Competitive success of the algae for newly formed substrate depends on the number of spores and thalli fragments settled onto the injury, the composition of algal community, the duration of the existence of the algal community, the physiological state and competitive abilities of coral polyps and environmental conditions.

The major objectives were to examine how scleractinian corals respond to different types of inflicted injuries and to investigate the impact of a given injury on species with different morphologies by monitoring their regenerative abilities to the respective injury under different light conditions. A second major objective was to monitor settlement on the injured areas by algae in various seasons and under different light and temperature conditions.

2. Materials and methods

2.1. Study site, time and conditions

All experiments were conducted in outdoor aquaria (50 L each) at the Sesoko Station of Tropical Biosphere Research Center of the University of the Ryukyus (Sesoko Island, Okinawa, Japan, 26°38′N, 127°52′ E) from November 2002 to August 2003. In the winter and spring periods, water temperature in the aquaria was 20–26 °C and 18–24 °C during the daytime and at night, respectively. In the summer season, the temperature was 28–31 °C and 26–28 °C during the daytime and at night, respectively. Mineral nutrition and zooplankton concentration in the aquaria and in the sea were close because the seawater was pumped from a depth of 2 m of the fringing reef and was not subjected to filtration or settling. The water in the aquaria was intensively