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REPLY COMMENT

Feeding activity by the blenny *Exallias brevis* causes multifocal bleaching in corals: Reply to Carlson (2012)

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ABSTRACT: We previously reported the sudden emergence of a disease-like syndrome in which numerous circular white spots were observed in *Millepora dichotoma* colonies in the Gulf of Aqaba (Zvuloni et al. 2011; Mar Ecol Prog Ser 441:25–32) and termed this phenomenon Multifocal Bleaching (MFB). Carlson (2012; Mar Ecol Prog Ser 463:297–299), based on his observations from Hawaiian coral reefs, suggests that the MFB is caused through foraging by the blenny *Exallias brevis*. Carlson's suggestion led us to perform new field and laboratory studies to confirm or discount this possibility. We were unable to document biting of the hydrocorals by *E. brevis* in the field, but our aquarium experiment demonstrated that the white spots are indeed a direct result of the blenny's biting. In addition, we found a strong linkage between the presence of *E. brevis* and the presence of MFB in *M. dichotoma* colonies. We accept Carlson's suggestion, which leads to the following questions: (1) Is the sudden emergence of MFB in the Red Sea caused by a sudden surge in the population of *E. brevis*? (2) Has a change in environmental conditions prompted *E. brevis* to suddenly begin feeding on *M. dichotoma*? (3) What will be the long-term impact of *E. brevis* on populations of *M. dichotoma*, an important component of shallow reefs in the Red Sea?

KEY WORDS: *Exallias brevis* · Multifocal bleaching · Feeding scars · Red Sea · Eilat

INTRODUCTION

Since February 2010 we have observed a sudden widespread emergence of circular white spots on many *Millepora dichotoma* colonies in the Gulf of Aqaba (see Zvuloni et al. 2011). Following the framework provided by Work & Aeby (2006) to systematically describe and name diseases in corals, this peculiar pattern in which colonies seem to lose their symbiotic algae in discrete focal points was termed Multifocal Bleaching (MFB). We characterized its occurrence, prevalence and spatial pattern, and suggested that MFB 'behaves' in a way reminiscent of coral diseases, but concluded that it is not possible to identify the nature of these bleached spots without further investigation into their character and microbiological attributes.

After publication, a photo of a similar observation from Marsa Shagra (Egyptian Red Sea) was posted by S. Moldzio on the 'Coral-List' (www.coralreef.noaa.gov). This led to contact between B.A. Carlson and A.Z. Based on his observations at Hawaiian coral reefs, Carlson (2012, this volume) suggests that bites by the blenny *Exallias brevis* are the cause of the

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bleached spots (MFB) observed on *Millepora dichotoma* in the Red Sea by Zvuloni et al. (2011; see their Fig. 1 and supplementary video at www.int-res.com/articles/suppl/m441p025_supp/). Following Carlson's comment we set out to verify or discount the suggestion that MFB in the Red Sea is caused by *E. brevis*.

MATERIALS AND METHODS

In February 2012 (before receiving Carlson's Comment) we re-surveyed the prevalence of MFB in a follow-up study to Zvuloni et al. (2011). Then, following Carlson's Comment, we adopted 3 approaches for verifying his suggestion:

(1) Surveys: We surveyed 102 randomly selected *Millepora dichotoma* colonies for the presence or absence of MFB, and presence or absence of a resident *Exallias brevis*.

(2) Field videography: A video camera was placed *in situ* in front of 3 *Millepora dichotoma* colonies that host *Exallias brevis*, for ca. 40 min at each location, in an attempt to document biting of the hydrocorals by the blenny.

(3) Aquarium experiments: One *Exallias brevis* was placed in a tank with 3 ca. 100 cm^2 fragments of *Millepora dichotoma* lacking any signs of MFB, and a control group of 4 fragments was placed out of reach of the blenny; we filmed this continuously for 10 d.

RESULTS

(1) Surveys: The prevalence of MFB on *Millepora dichotoma* decreased significantly between 2011 and 2012 (Fig. 1). The link between the presence of *Exallias brevis* and MFB is strong (χ^2 = 22.91, df = 1, p < 0.0001). Of 102 *M. dichotoma* examined, 27 had a resident individual of *E. brevis*, and 23 (85%) of these had MFB. Of the 75 hydrocorals that did not host *E. brevis*, only 22 (29%) had MFB.

(2) Field videography: Our attempt to document biting of *Millepora dichotoma* by *Exallias brevis* using a video camera did not succeed. Most of the time, the blennies were out of the camera's frame of vision, resting or moving among the branches of the hydrocoral, or hidden among its lower branches, and we could not observe the blenny feeding on *M. dichotoma* or corals in its vicinity.

(3) Aquarium experiments: After 8 d, *Exallias brevis* began biting the hydrocorals, and bleached spots appeared on the colonies within the reach of the blenny, but not on those that were out of reach. After

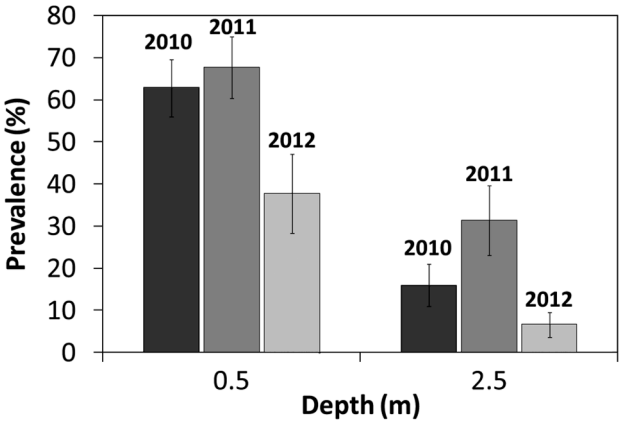

Fig. 1. *Millepora dichotoma*. Prevalence (%; mean ± SD, n = 6 transects) of multifocal bleaching (MFB) in colonies at the Coral Nature Reserve of Eilat, Israel. Surveys conducted in February 2010 and February 2011 are described in Zvuloni et al. (2011). The follow-up survey was conducted in the present study in February 2012. Differences between 2011 and 2012 are significant at 0.5 and 2.5 m (p = 0.016 and p = 0.014, respectively). The difference between 0.5 and 2.5 m depth is significant (p < 0.001)

that, and until the end of the experiment (Day 10), many more spots appeared, but only on the corals that were placed with the blenny. The spots were identical to those observed *in situ* (Zvuloni et al. 2011). Four acts of biting by *E. brevis* followed by immediate appearance of bleached spots were documented by video (www.int-res.com/articles/suppl/m463p301_supp/).

DISCUSSION

Our aquarium experiment showed that the white spots on *Millepora dichotoma* were a direct result of biting by *Exallias brevis*. Together with the results of the presence/absence survey, this confirms that the MFB disease-like syndrome in Red Sea *M. dichotoma* is caused by *E. brevis*, as suggested by Carlson (2012). Both coral diseases and predation adversely affect coral health and tissue integrity. While feeding scars on corals are well known and easily recognized, some scars caused by corallivores (e.g. fish, snails, sea stars) are similar to symptoms caused by pathogens. The bleached spots caused by *E. brevis* are unique. Unlike common feeding scars (e.g. by parrotfish), in the case of MFB the hydrocoral does not exhibit mortality due to the bites, the zooids within the bleached spot are intact and the skeleton is not eroded.

In a recent study of MFB spots on *M. dichotoma* in the Red Sea, using transmission electron microscopy,

Paramasivam et al. (2012) showed that, while the gross morphology of the white spots is characterized by seemingly bleached tissue, the spots underwent some tissue necrosis, release of zooxanthellae, and symbiophagy (e.g. digestion of the zooxanthellae by their host; see Downs et al. 2009). Paramasivam et al. (2012) also found a shift in microbial population within the bleached spots, as compared to undamaged tissue. The tissue within the bleached spots was populated by Alphaproteobacteria, which are widely associated with diseased scleractinian corals (Denner et al. 2003, Bourne 2005).

The MFB disease-like syndrome was first noticed by us in the Gulf of Aqaba in February 2010, at which time 63% of the *Millepora dichotoma* colonies at 0.5 m depth in the Eilat Coral Nature Reserve were affected. Sudden appearance of MFB occurred at other locations in the Red Sea as well: in July 2012, S. Moldzio, who surveyed Marsa Shagra (500 km south of Eilat), reported: 'We have conducted Reef Check surveys in that area for 4 years, but this was the first year we observed these circular patches' (www.reefcheck.org/newsletter/072012/). The sudden emergence of MFB in the Red Sea remains mysterious. Was there a sudden surge of *Exallias brevis* populations? Did environmental conditions prompt *E. brevis* to suddenly begin feeding on *M. dichotoma*, which had previously been ignored by the blenny in this region? The subsequent sharp decrease of the prevalence of MFB over the last year is also mysterious. In addition, Carlson (2012) describes vigorous biting activity of *E. brevis* on various corals at the Hawaiian coral reefs, while we were not able to observe biting *in situ*, and did not find the bite marks on corals other than *M. dichotoma* and *M. platyphylla.*

It is also unclear how the biting act of the blenny causes bleached spots. A possible explanation is that during the biting act, the zooids retract and the blenny damages only the coenosarc tissues. Then, if the regeneration of the coenosarc tissue within the spots is faster than regeneration of the population of symbiotic algae, the spots would seem bleached.

In summary, we accept Carlson's (2012) suggestion that the MFB disease-like syndrome in *Millepora dichotoma* in the Red Sea is caused by *Exallias brevis*. Given an apparent increased foraging of *E. brevis* on *M. dichotoma*, an effort should be made to establish the potential long-term impact of *E. brevis* on *Millepora dichotoma*, an important component of shallow reefs in the Red Sea (Loya & Slobodkin 1971).

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