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Short Communication

Seasonal prevalence of white plague like disease on the endemic Brazilian reef coral *Mussismilia braziliensis*

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ABSTRACT. The reef coral *Mussismilia braziliensis* Verril, 1968 is endemic to the eastern Brazilian coast, representing a major reef-building species in the region. This coral is threatened by extinction due to the recent proliferation of a white-plague like (WPL) disease. Despite its severe impacts, the environmental factors leading to outbreaks of WPL disease are still poorly understood. This study describes the seasonal prevalence of WPL disease on *M. braziliensis* in the Abrolhos Bank, on the southern coast of Bahia Brazil. *In situ* estimates showed that WPL disease was about 4.5 times more prevalent in summer (January 2007, mean sea surface temperature 27.4°C) than in winter (July 2007, 25.0°C). This result suggests that the prevalence of WPL disease in *M. braziliensis* is temperature-dependent, supporting the hypothesis that warmer oceans are facilitating the proliferation of coral diseases worldwide.

Keywords: coral diseases, reef resilience, thermal stress, Abrolhos Bank, southwestern Atlantic, Brazil.

Prevalencia estacional de la enfermedad de la plaga blanca en el coral endémico de Brasil *Mussismilia braziliensis*

RESUMEN. El coral *Mussismilia braziliensis* Verril, 1968 es endémico de la costa este de Brasil y representa una de las principales especies constructoras de arrecifes coralinos en dicha región. Este coral se encuentra bajo la amenaza de extinción debido la reciente propagación de la enfermedad llamada la plaga blanca (PB). Pese los fuertes impactos, los factores ambientales responsables por epidemias de la PB aún son poco conocidos. En este estudio se describe la prevalencia estacional de la PB en *M. braziliensis* en el Banco de Abrolhos, ubicado en la costa sur de Bahia, Brasil. Estimaciones *in situ* comprueban que la prevalencia de esta molestia ha sido cerca de 4,5 veces mayor en verano (enero de 2007, temperatura media del agua superficial del mar 27,4°C), que en invierno (julio de 2007; 25,0°C). Este resultado sugiere que la prevalencia de la enfermedad PB en *M. braziliensis* es dependiente de la temperatura, reforzando la hipótesis de que los océanos mas cálidos estén facilitando la propagación de enfermedades coralígenas en todo el mundo.

Palabras clave: enfermedades de corales, resiliencia de los arrecifes, estrés térmico, Banco de Abrolhos, Atlántico sudoccidental, Brasil.

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The severity and distribution of coral diseases is increasing worldwide, currently representing a major threat to coral reef ecosystems (Harvell *et al.*, 1999; Rosenberg & Ben-Haim, 2002). In the tropical South Atlantic (Brazil), the occurrence of coral diseases was only recently described (Francini-Filho *et al.*, 2008). White-plague like (WPL) disease is the most common type of disease in the region, affecting primarily a major reef-building species, the Brazilian endemic coral *Mussismilia braziliensis* Verril, 1968. Progression rate of WPL disease on *M. braziliensis* during the summer was estimated at 0.18 ± 0.06 mm day^{-1} (Francini-Filho *et al.*, 2008). In addition, it has been demonstrated that the microbial assemblages associated with diseased versus healthy *M. braziliensis* colonies are different (Reis *et al.*, 2009). Despite these recent developments, environmental factors contributing to high prevalence of WPL disease in Brazilian reefs are still unknown. This study describes the seasonality in prevalence of WPL disease affecting *M. braziliensis*, thus allowing for the evaluation of the role of elevated sea surface temperature (SST) as a trigger for this disease.

Observations were undertaken on the Abrolhos Bank, eastern Brazil, where the largest and richest coral reefs in the South Atlantic are concentrated (Leão & Kikuchi, 2001). The Abrolhos region is a biodiversity hotspot and a priority area for conservation (Werner *et al.*, 2000; Moura, 2003). Depths in the region rarely exceed 30 m and reef structures display a characteristic form of mushroom-shaped pinnacles. Disease prevalence was determined in the austral summer (17-20 January 2007) and winter (3-6 July 2007) at two sites (Pedra de Leste and Timbebas) (Fig. 1), by using belt transects (1x10 m). Four replicate transects were laid randomly per site per season, in depths ranging 4-6 m. All colonies of *M. braziliensis* within each transect were counted, measured to its mean diameter (as calculated by averaging the smaller and larger diameters) and recorded as healthy or diseased. Differences in disease prevalence between sites and seasons were evaluated using two-way analysis of variance (ANOVA) (Zar, 1999). SST records for the sampling periods were obtained from NOAA AVHRR Pathfinder Version 5.0 satellite derived monthly data, with night time algorithm to avoid diurnal heat bias.

White-plague like disease prevalence during summer (mean SST = 27.4°C) was about 4.5 times greater than during winter (mean SST = 25.0°C), with a significant difference between seasons ($F = 8.66$, $P = 0.01$). The interaction between reef area and year was not significant ($F = 0.96$, $P = 0.34$), indicating that the temporal variation in disease prevalence was spatially consistent. No significant difference in WPL disease prevalence was recorded between the two sites ($F = 0.08$, $P = 0.78$; Fig. 2).

The positive relationship between SST and coral diseases is now a well established pattern (Rosenberg *et al.*, 1999; Rosenberg & Ben-Hain, 2002; Bruno *et al.*, 2007). Elevated SST may favor diseases by lowering coral resistance and/or by facilitating growth, virulence, and rates of transmission of pathogens (Ben-Haim *et al.*, 2003; Boyett *et al.*, 2007). For

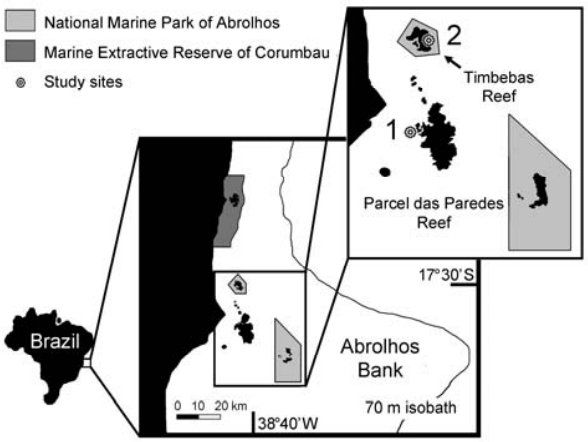

Figure 1. Map of the Abrolhos Bank, showing study sites and marine protected areas. Sites: 1. Pedra de Leste, 2. Timbebas.

Figura 1. Mapa del Banco de Abrolhos evidenciando los sitios de estudio y las áreas marinas protegidas. Sítios: 1. Pedra de Leste, 2. Timbebas.

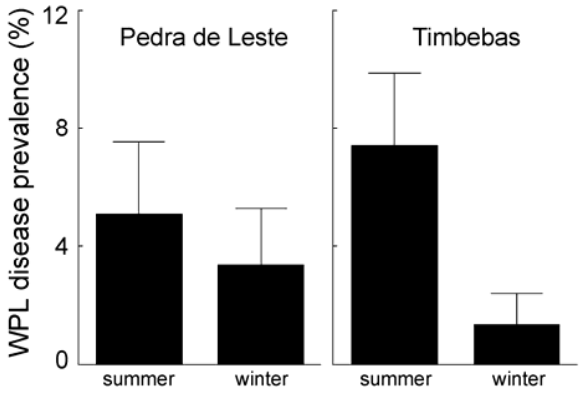

Figure 2. Prevalence (mean + standard error) of white-plague like (WPL) disease on the reef coral *Mussismilia braziliensis* during summer and winter of 2007 at two sites.

Figura 2. Prevalencia (media + error estándar) de la enfermedad de la plaga blanca (WPL) en el coral *Mussismilia braziliensis* durante el verano y el invierno de 2007 en los dos sitios de muestreo.

example, increased temperature leads to the expression of virulence genes in *Vibrio shiloi* and to the consequent production of toxins that inhibit photosynthesis and lyse zooxanthellae of the coral *Oculina patagonia* from the Mediterranean Sea (Toren *et al.*, 1998; Ben-Haim *et al.*, 1999). A similar mechanism was recorded for *V. corallilyticus* while infecting the reef coral *Pocillopora damicornis* (Ben-Haim *et al.*, 2003). Direct lysis and death of the coral tissue is caused by bacterial extracellular proteases produced during warmer conditions (Ben-Haim & Rosenberg, 2002; Ben-Haim *et al.*, 2003). Thus, higher SST is probably the most important factor leading to high prevalence levels of WPL disease during summer in the Abrolhos Bank. Similarly, relatively higher prevalence values were recorded for black band and other diseases during summer on the Great Barrier Reef (Willis *et al.*, 2004; Jones *et al.*, 2004) and Caribbean (Edmunds 1991; Kuta & Richardson, 1996; Porter *et al.*, 1999). Although the causative agents of WPL disease on *M. braziliensis* were not yet identified, its spreading and temperature-dependent nature strongly suggests an infectious disease (Ben-Haim & Rosenberg, 2002). Furthermore, although not significant, the higher prevalence recorded at Timbebas in comparison to Pedra de Leste may be due to the higher coral cover in this former site (see Fancini-Filho *et al.*, 2008). Bruno *et al.* (2007) found a positively relationship between coral cover and white syndrome on the Great Barrier Reef, a result that corroborates for a model of an infectious disease (Anderson & May, 1979).

The compromised-host hypothesis suggests that coral-hosts are more susceptible to diseases during periods of greater environmental stress (Lesser *et al.*, 2007). Following this hypothesis, corals are expected to be more stressed during summer than winter, as SST and irradiance levels (two widely recognized sources of stress to corals) are relatively higher in the former season. Coral reefs in the Abrolhos Bank experience strong seasonality in water turbidity, with higher turbidity values recorded in winter than summer (Leão & Kikuchi, 2001). This may lead to relatively low light levels during winter, thus mitigating the temperature/irradiance damage to corals and decreasing WPL disease prevalence.

Seasonality in zooxanthellae densities and chlorophyll-*a* and *c* concentrations was observed in the Caribbean (Fitt *et al.*, 2000), Indo-Pacific (Brown *et al.*, 1999) and northeastern Brazil (Costa *et al.*, 2005), with lower values recorded in summer than in winter. Several studies show that disease impacts are greater in bleached corals (i.e. corals showing lower densities of zooxanthellae and/or pigments) in comparison to healthy ones (Fitt *et al.*, 2001; Jones *et al.*, 2004; Miller *et al.*, 2006, 2008). Thus, it would be interesting to evaluate the possible relationship between bleaching incidence and disease susceptibility in *M. braziliensis*.

Because SST are expected to increase in the next decades, catastrophic coral cover declines due to bleaching and disease are predicted (Hoegh-Guldberg, 1999; Francini-Filho *et al.*, 2008). In fact, in some cases they have already occurred. For example, in the last three decades the corals *Acropora cervicornis* and *A. palmata* have suffered a massive and unprecedented decline due to white-band disease in the Caribbean, which was possibly triggered by elevated SST (Aronson *et al.*, 2002).

Not all bacteria are harmful to corals. Some of them may benefit the coral host by fixing nitrogen, degrading indigestible material and by serving as a direct source of food (Reshef *et al.*, 2006; Chimetto *et al.*, 2008). Most importantly, certain bacteria may produce antibiotics that are active against pathogenic bacteria, thus increasing coral resistance to disease (Reshef *et al.*, 2006; Reis *et al.*, 2009). Considering this latter fact Reshef *et al.* (2006) proposed that bacteria associated with corals may evolve rapidly in response to environmental disturbance, particularly elevated SST, thus allowing for the development of resistance against diseases (the so called Coral Probiotic Hypothesis). One example of such rapid adaptive response is that of *O. patagonia*, which has developed resistance to the once prevalent infectious disease caused by *V. shiloi*. Although the exact mechanisms are still unknown, it is likely that bacteria associated with *O. patagonia* are promoting lysis of *V. shiloi* (Reshef *et al.*, 2006).

A central question to the future of coral reefs is whether bacterial associated with reef corals are capable to adapt as fast as needed in face of rapid climate change and accelerated human impacts. To answer this question continued *in situ* monitoring efforts and the development of microbiological studies particularly designed to understand the adaptive capacity of bacteria associated to corals are urgently needed.

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