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Coral reefs of Mauritius in a changing global climate

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Aims and scope: The *Western Indian Ocean Journal of Marine Science* provides an avenue for the wide dissemination of high quality research generated in the Western Indian Ocean (WIO) region, in particular on the sustainable use of coastal and marine resources. This is central to the goal of supporting and promoting sustainable coastal development in the region, as well as contributing to the global base of marine science. The journal publishes original research articles dealing with all aspects of marine science and coastal management. Topics include, but are not limited to: theoretical studies, oceanography, marine biology and ecology, fisheries, recovery and restoration processes, legal and institutional frameworks, and interactions/relationships between humans and the coastal and marine environment. In addition, *Western Indian Ocean Journal of Marine Science* features state-of-the-art review articles and short communications. The journal will, from time to time, consist of special issues on major events or important thematic issues. Submitted articles are subjected to standard peer-review prior to publication.

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Word from the Editor

The last couple of years have been a time of change for the Western Indian Ocean Journal of Marine Science. The journal has a new and more modern layout, published online only, and the editorial Board was increased to include more disciplines pertaining to marine sciences. While important challenges still lie ahead, we are steadily advancing our standard to increase visibility and dissemination throughout the global scientific community. The central objective of the journal continues focused on the Western Indian Ocean region and serving its growing scientific community.

We are pleased to start the publication of special issues of the journal, launched here with the publication of manuscripts from the University of Mauritius Research Week 2016. The special issues aim to contribute for advancing marine science in the WIO by focusing on specific themes, geographical areas or assembling contributions from scientific meetings. The editorial processes are exactly the same as for regular issues, with double peer-review, and guest editors are considered.

José Paula
Chief Editor

Editorial Note · Coral reefs of Mauritius in a changing global climate

The University of Mauritius Research Week (UoM RW) has been held on an annual basis since 2007 and was organized for the 9th time from 19-23 September 2016. The Research Week is geared towards dissemination of knowledge generated through research activities at the University and by relevant stakeholders in accordance with the UoM's vision of "*Excellence in Research and Innovation*". In line with national priorities, the UoM organizes this event to provide insightful research outcomes not only for the advancement of academic knowledge, but for the benefit of the community at large, through robust policy recommendations.

Out of the multiple submissions made during the UoM RW 2016, a number of manuscripts in the field of ocean/marine sciences were selected to be published in the Western Indian Ocean Journal of Marine Science (WIOJMS), as a special issue entitled "Coral reefs of Mauritius in a changing global climate". This issue is presented in the context of Mauritius being surrounded by a beautiful but delicate coral reef ecosystem, which provides ample ecosystem services contributing to the national economy, but which is subjected to extreme climatic events. Hence, in this special issue several contributions advancing our scientific understanding for sustainable use and management of marine resources in a globally changing marine environment are articulated. The original article by Mattan-Moorgawa *et al.* investigates the photo-physiology of diseased and non-diseased corals. Coral diseases are becoming more common on reefs worldwide due to both local and global stressors. Ramah *et al.* then present a short communication related to substrate affinity by two giant clam species found on the Mauritian coral reefs. Giant clams are under threat worldwide and information on their substrate affinity and habitat aims at providing insightful information towards their sustainable management. In addition, Nandoo *et al.*, in an effort to optimize nucleic acid extraction protocols from marine gastropods, present an original article based on a comparative study using the gastropod genera *Planaxis*, *Cypraea* and *Drupella*. These marine gastropods are ecologically important for coral reefs, especially the coral-eating *Drupella*. Moreover, given the importance of intertidal molluscs, Kaullysing *et al.* document the density and diversity of the benthic molluscs while comparing sheltered and exposed coastal habitats. Appadoo & Beeltah report on the biology of *Platorchestia* sp. (Crustacea, Amphipoda) at Poste La Fayette, Mauritius. Studies on Amphipod diversity and distribution are important especially since studies on marine biodiversity are scarce around Mauritius. Another original article by Ragoonaden *et al*. analyses the recent acceleration of sea level rise in Mauritius and Rodrigues. Such studies are more important than ever in the light of a globally changing marine environment with small island states faced with issues related to rising sea level. Two field notes, based on field observations, are presented by Bhagooli *et al.*, documenting a variety of coral diseases, and *Stylophora pistillata*-like morphotypes occurring around Mauritius Island, respectively. Kaullysing *et al.* also present a field note on coral-eating gastropods observed around Mauritius.

Apart from the local contributors, international collaborators also contribute two original articles in this special issue. Casareto *et al.* characterize the chemical and biological aspects of a coral reef of Mauritius focusing on benthic carbon and nitrogen fixation. These studies related to benthic productivity are important for understanding sustainability of coral reefs and/or lagoonal fisheries. On the other hand, Tokumoto *et al.* document the first detection of membrane progestin receptor (mPR)-interacting compounds from Mauritian coral reef and lagoonal seawater. They used cutting-edge technology to detect key regulators of reproduction in seawater. These contributions in terms of original articles, short communications, and field notes generate new scientific knowledge that may better inform policy and decision making in the field of coral reef studies and management in Mauritius, while contributing to the understanding of coral reefs in the wider Western Indian Ocean region.

Prof. Sanjeev K. Sobhee
Pro-Vice Chancellor (Academia)
The University of Mauritius

Photophysiology of *in hospite* zooxanthellae in diseased and non-diseased scleractinian corals from Belle Mare, Mauritius

Sushma Mattan-Moorgawa*[1], Deepeeka Kaullysing[1], Nawsheen Taleb-Hossenkhan[2], Soonil DDV Rughooputh[3], Ranjeet Bhagooli[1]

[1] Department of Marine & Ocean Science, Fisheries & Mariculture, Faculty of Ocean Studies, University of Mauritius, Réduit 80837, Republic of Mauritius

[2] Department of Biosciences, Faculty of Science, Réduit 80837, Republic of Mauritius

[3] Department of Physics, Faculty of Science, University of Mauritius, Réduit 80837, Republic of Mauritius

* Corresponding author: s.moorgawa@uom.ac.mu;

Abstract

This study investigated the occurrence of white band disease (WBD, tissue sloughing) and white plague (WP, complete whitening) among six scleractinian corals at Belle Mare, Mauritius. Photosynthetic responses of *in hospite* zooxanthellae in diseased and non-diseased/ healthy corals were characterised via effective quantum yield (Φ_{PSII} or $\Delta F/Fm$, light-adapted), relative maximum electron transport rate ($rETR_{max}$), and non-photochemical quenching (NPQ), using a Diving Pulse-Amplitude Modulated (D-PAM) fluorometer. Coral disease occurrence survey (n=20 colonies) and sampling for diseased and non-diseased/ healthy corals were carried out at 9 stations along 3 transects across the lagoon from coast to reef, for the November 2013 to February 2014 summer non-bleaching months. A higher percentage (90%) of disease occurrence was observed in *Acropora muricata* (WBD 45%; WP 55%) than in *Pocillopora damicornis* (WBD only 10%). *Pocillopora eydouxi, Galaxea fascicularis*, *Acropora cytherea,* and *Fungia repanda* exhibited no diseases. Φ_{PSII} was normal (0.60±0.01) in all non-diseased/ healthy corals, but was significantly low (<0.20) in diseased corals in healthy-looking tissues adjacent to disease lesions. Low Φ_{PSII} was accompanied by low $rETR_{max}$ and NPQ, indicating damage to photosynthetic apparatus in WBD-affected *A. muricata*. The findings indicated a higher susceptibility of *A. muricata* to the two diseases and may have implications for coral reef management and conservation.

Keywords: coral disease, Mauritius, photophysiology, scleractinian corals

Introduction

Coral reefs around the globe have been declining at an alarming rate during the past decade (Szmant, 2002; Gardner *et al.*, 2003; Pandolfi *et al.*, 2003; Hu *et al.*, 2003; Wilkinson, 2004; Bellwood *et al.*, 2004; Hoegh-Guldberg *et al.*, 2007; Bruno & Selig, 2007; Baker *et al.*, 2008; Miller *et al.*, 2009; De'ath *et al.*, 2012; Hooidonk *et al.*, 2013; Jackson *et al.*, 2014). This decline is happening due to a number of anthropogenic activities and environmental phenomena such as eutrophication, sedimentation, over-exploitation or physical destruction by reef users (Sebens, 1994), overfishing, habitat degradation, climate change, and coral bleaching (Brown, 1997; Hoegh-Guldberg, 1999), and more recently coral disease (Carpenter *et al.*, 2008).

Emerging coral diseases play a major role in the degradation of hard corals that provide the physical structure for the building of coral reefs (Harvell *et al.*, 2007) and support an enormous marine biodiversity. Coral diseases, especially those affecting hard corals, were observed in the 1970s (Garrett & Ducklow, 1975; Antonius, 1997). Harvell *et al.* (2007) reported that coral diseases have been observed in some 100 coral species (mostly hard corals and a few soft corals) on coral reefs of some 50 countries around the globe. In the early 1990s some detailed quantitative studies were carried out mostly on black band disease (Edmunds, 1991; Kuta & Richardson, 1996). The rate of discovery of new diseases has since increased drastically (Green & Bruckner, 2000; Weil, 2004). Coral diseases have been reported in many places around the world's coral reefs, for example, the Caribbean (Goreau *et al.*, 1998; Porter *et al.*, 2001; Weil *et al.*, 2002; Weil, 2004; Weil *et al.*, 2006), Gulf of Mexico (Jordan-Dahlgen, 2002), South Florida (Borger *et al.*, 2005), Australian Great Barrier Reef (Willis *et al.*, 2004; Haapkylä *et al.*, 2013), Mediterranean Seas (Harvell *et al.*, 2007), Phillipines (Raymundo *et al.*, 2004), Maldives (Montano *et al.*, 2012; 2016) and Western Indian Ocean (McClanahan *et al.*, 2004; Séré *et al.*, 2012; 2013; 2016).

The increased occurrence of coral disease outbreaks worldwide can be explained by the fact that the natural environmental conditions of the corals have been altered mainly through the impacts of anthropogenic activities. This has in turn altered the host/pathogen interaction either by impairing the resistance of the host or by increasing virulence of the pathogen(s) (Hayes *et al.*, 2001; Harvell *et al.*, 2002; Ben Haim *et al.*, 2003a; 2003b). Sea surface temperature anomalies have been observed to drive outbreaks of diseases in several regions, for example, outbreaks of white plague and yellow blotch in the Caribbean reefs following the thermal anomaly of 2005 (Miller *et al.*, 2006) and similarly in the Great Barrier Reefs (Willis *et al.*, 2004). Rosenberg & Ben-Haim (2002) also reported that increased temperatures may affect the basic biological and physiological properties of corals such as immunity against disease infection. Other stressors, for example, high nutrient levels and sedimentation can also contribute to altering the balance between the coral host and its resident microbial flora. Nutrient enrichment affects the dynamics of coral diseases by enhancing the fitness and virulence of the pathogen (Kim & Harvell, 2002).

The plethora of microbes that thrive within the mucus layer of the coral may confer protection against invasion of pathogens, and any disturbance in this normal microbial flora could lead to disease (Ricthie, 2006). Infectious diseases in corals can be caused by a number of agents, namely, bacteria, viruses, protozoa or fungi (Harvell *et al.*, 2007). So far, potential pathogens for coral diseases have only been identified for seven of the commonly found coral diseases (Harvell *et al.*, 2007). Disease outbreaks have been reported to result in coral tissue loss, changes in coral reproduction, decreased coral growth rates as well as declines in the coral community structure, species diversity and its reef-associated organisms (Loya *et al.*, 2001; Carpenter *et al.*, 2008). Growth anomalies (GA) can alter the structure of coral tissue, skeletal morphology and density (Burns *et al.*, 2013). Consequently, coral tissue and skeletal changes can, in turn, modify the light micro-environment of the coral tissue and this has been reported to have a direct impact on the photosynthetic potential of *Symbiodinium* spp. and the physiological interactions within the symbiosis (Burns *et al.*, 2013). Pulse-Amplitude-Modulated (PAM) fluorometry can be a useful tool to characterise the photo-physiological efficiency of diseased and non-diseased corals. However, limited studies have linked photophysiology of *Symbiodinium* spp. and coral diseases (Roff *et al.*, 2008a; 2008b; Burns *et al.*, 2013).

The aim of this study was to investigate the occurrence of coral diseases, namely tissue sloughing (White Band Disease, WBD) and complete whitening (White Plague, WP), among six hard corals commonly found in Mauritius, and to determine the effect of the two diseases on photosynthetic functioning in diseased and non-diseased/ healthy corals.

Materials and Methods

Site of Study

The island of Mauritius has an area of 1865 km^2 (Mauritius Environment Outlook Report, 2011) and is geographically situated at approximately 20.34°S and 57.55°E on the Mascarene Plateau in the Indian Ocean. It has a diverse marine environment surrounded by 150 km of fringing reefs except for a few breaks on the south/south-east and western coasts. A total of 159 species of scleractinian corals have been recorded around the island with the most common ones belonging to the genus *Acropora*. The study site, Belle Mare (Fig. 1) is located on the east coast of the island and is characterized by a long and curved beach situated between two basalt headlands and a reef more than 500 m offshore. It has a wide lagoon with a fringing reef, reef flat and patch reefs over wide expanses of the lagoon. The fringing reef at Belle Mare is between 0.85 km – 1 km from the coastline and depths within the lagoon ranges from 1 – 3 m. It has a high percentage of coral cover which is evenly distributed in the lagoon from the coast to the reef, and the bottom type consists of sand, rock and boulders, live and dead coral patches, coral rubble patches and also some macroalgae patches (Bhagooli & Taleb-Hossenkhan, 2012). The site is exposed to the South-East Trade Winds, onshore and longshore currents and has an average tidal range of 0.5 m. The study site is relatively less developed with a fairly low hotel density as compared to other coastal zones of the island of Mauritius (Sadally *et al.*, 2014). The vicinity of the site is characterized mainly by agricultural plantations.

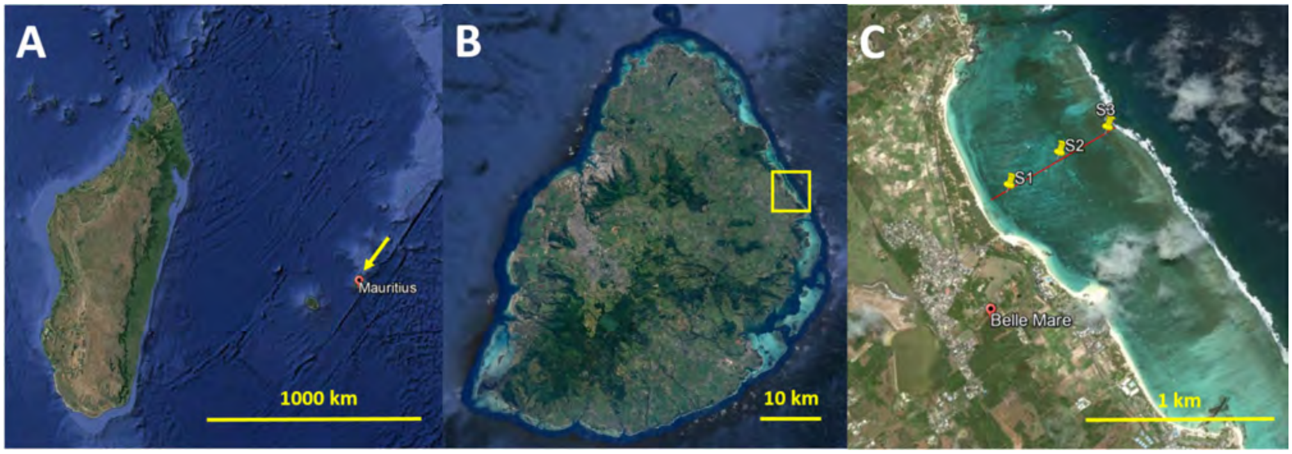

Figure 1. Site of Study: A. Geographical location of Mauritius in the Western Indian Ocean; B. The island of Mauritius and Belle Mare study site located on the east coast of the island; C. Aerial map of Belle Mare site showing location of stations at near coast, lagoon and reef. (Source: Google Earth, 2017)

Field survey of disease occurrence

The study was conducted over the summer months of November 2013 to February 2014. Six species of scleractinian corals in the lagoon of Belle Mare, namely *Acropora muricata* (Linnaeus 1758), *Acropora cytherea* (Dana 1846), *Pocillopora damicornis* (Linnaeus 1758), *Pocillopora eydouxi* (Milne-Edwards & Haime 1860), *Galaxea fascicularis* (Linnaeus 1767) and *Fungia repanda* (Dana 1846) were studied. The first part of the study consisted of a survey to record the percentage occurrence of coral diseases affecting the six species of corals. The survey was done along three transects running from the coast to the reef, with three stations per transect: coast, lagoon and reef. (Fig. 1c). An average of 20 coral colonies were surveyed per species at each station as follows: *A. muricata* (total of 180 colonies at coast, lagoon and reef stations); *P. eydouxi* (total of 60 colonies at reef stations only); *P. damicornis* (total of 120 colonies at lagoon and reef stations only); *G. fascicularis* (total of 60 colonies at reef stations only); *A. cytherea* (total of 60 colonies at reef stations only); and *F. repanda* (total of 120 colonies at lagoon and reef stations).

Bhagooli *et al.* (2017) reported a high prevalence of multiple coral diseases, namely, white plague-like, white band-like, brown band, skeletal eroding band, growth anomalies, and pink pigmentation diseases around Mauritius Island. For the purpose of this study, only two coral diseases were surveyed and studied, namely White Band Disease (WBD) and White Plague (WP), at Belle Mare site. The Underwater Cards for Assessing the Coral Health on Caribbean Reefs (www.gefcoral.org) were used for the identification of the diseases (Weil & Hooten, 2008). WBD is characterised by a wide band of white, clean, exposed skeleton which separates the healthy coral tissue from the algal-colonized skeleton, and sometimes with tissue strings or pieces sloughing off at the interface. The white band can range from a few millimetres to several centimetres wide (Raymundo *et al.*, 2008). WP is characterised by a wide band of white, exposed skeleton which borders the sharp edge of healthy coral tissue (with no tissue sloughing). Normally, WP starts at the base of the colony moving upwards over the colony (Raymundo *et al.*, 2008). Predators of corals such as gastropods were not observed on the coral species studied, and their absence on diseased corals or nearby colonies confirmed the occurrence of disease rather than simply scars resulting from coral predation.

Chlorophyll *a* fluorescence

Chlorophyll *a* fluorescence of the diseased and non-diseased (healthy) corals was measured using PAM fluorometry (D-PAM, Walz GmbH), which has been employed to study coral symbionts' photo-physiological health (Genty *et al.*, 1989; Warner *et al.*, 1996; Beer *et al.*, 1998; Jones *et al.*, 1998; Hoegh-Guldberg & Jones, 1999; Ralph *et al.*, 1999; Winters *et al.*, 2003; Bhagooli & Hidaka, 2006; Bhagooli *et al.*, 2008; Chauka *et al.*, 2015). Chlorophyll *a* fluorescence measurements, using a D-PAM, were recorded under ambient light conditions between 10h00 to 12h00 on the following: (a) diseased tissue of coral, within a distance of 1 cm from the healthy-looking portion (on same coral branch); (b) healthy-looking, non-affected coral tissue, within a distance of 1 cm from diseased tissue (on same coral branch); (c) a healthy-looking coral branch from another healthy/ non-diseased colony (as control) (Fig. 2 and 3). The effective quantum yield, Φ_{PSII}, was expressed by $(F_m'-F_o)/ F_m'$ or $\Delta F/$

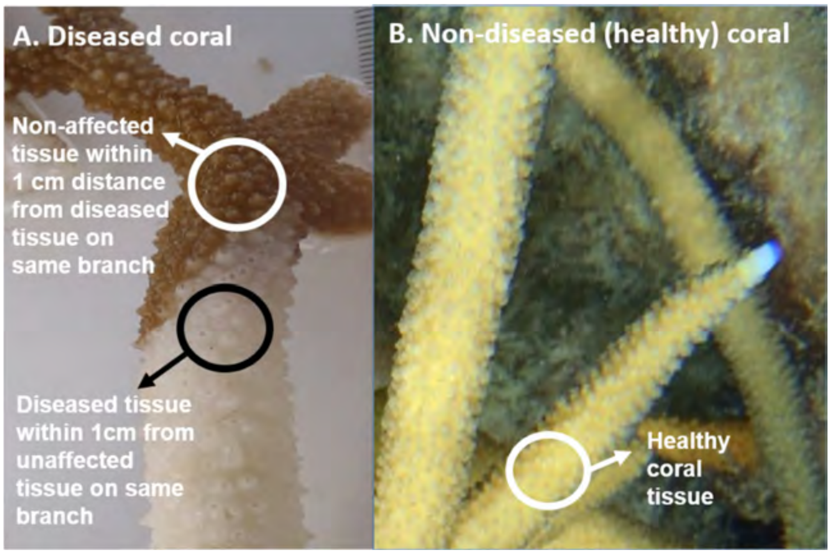

Figure 2. A. diseased coral branch of *A. muricata* (January 2014); B. Non- diseased/ healthy coral branch of *A. muricata* (January 2014), indicating the locations where PAM measurements were taken.

Fm where F_o is the initial fluorescence measured by applying weak pulses of red light, and F'_m is the fluorescence obtained by applying a saturated pulse in a light-adapted sample. Relative Electron Transport Rate, rETR, was determined by $[(F_m'-F_o)/ F_m']$ x Photosynthetically Active Radiation (PAR). Curve fitting of rapid light curves (RLCs) for relative ETR versus irradiance curves was done by the function of Platt *et al*. (1980). Relative ETR_{max} is the saturated relative ETR and is determined as the highest plateau region of the RLCs. Non-Photochemical Quenching, NPQ, is expressed as $(F_m - F_m')/ F_m'$, where F_m was determined in 20-min dark-adapted samples. NPQ_{max} was determined from the rapid light curves.

Sea Surface Temperature

Sea surface temperatures were recorded on the day of sampling and on a monthly basis from November 2013 to February 2014, using portable multiprobes (HANNA HI 991001). Several studies have reported a positive correlation between emerging coral diseases and thermal stress or high temperature anomalies (Kushmaro *et al.*, 1998; Harvell *et al.*, 1999; Rosenberg & Ben-Haim, 2002; Bruno *et al.*, 2007; Miller & Richardson, 2014).

Statistical analyses

The photo-physiological data for Φ_{PSII}, $rETR_{max}$ and NPQ was arc-sine, square-root transformed prior to running the one-way ANOVA, two-way ANOVA,

Table 1. Percentage disease occurrence affecting the six corals surveyed (January 2014).

Species of coral	Species distribution at study site (near coast, lagoon and reef stations)	Total number of coral colonies surveyed, per species	Percentage (%) occurrence of diseased coral colonies, per species (Jan 2014)
Acropora muricata	Coast, lagoon and reef	180	90
Pocillopora eydouxi	Mainly encountered on reef	60	0
Pocillopora damicornis	Mainly encountered in lagoon and reef	120	10
Galaxea fascicularis	Near reef only	60	0
Acropora cytherea	Near reef only	60	0
Fungia repanda	Lagoon and reef	120	0

Table 2. Photosynthetic functioning in healthy corals showing no signs of disease: *A. cytherea, P. eydouxi, G. fascicularis* and *F. repanda*. (Mean ± SD, n=3/species).

Coral species	Φ_{PSII}	$rETR_{max}$	NPQ
Acropora cytherea	0.585 ± 0.031	92.592 ± 14.364	0.840 ± 0.065
Pocillopora eydouxi	0.604 ± 0.015	143.817 ± 11.031	0.810 ± 0.053
Galaxea fascicularis	0.646 ± 0.033	66.872 ± 1.701	0.793 ± 0.076
Fungia repanda	0.659 ± 0.011	78.232 ± 10.96	0.746 ± 0.093

followed by the Post-Hoc Tukey test on SPSS (IBM version 16.0) software to test for any significant differences among the three coral conditions (healthy coral; WP-affected coral; WBD-affected coral) for the two species (*A. muricata* and *P. damicornis*). P-values less than 0.05 were considered as statistically significant.

Results

Disease occurrence

The results for the coral disease survey (Table 1) indicated that only two corals species out of the six species investigated were affected by diseases: *A. muricata* at 90% occurrence of disease as compared to *P. damicornis* which showed 10% of disease occurrence while *P. eydouxi*, *G. fascicularis*, *A. cytherea* and *F. repanda* did not show any sign of the two diseases and were observed as healthy. Diseased *A. muricata* colonies indicated visual signs of both diseases (90% disease occurrence with 45% WP and 55% WBD) while diseased *P. damicornis* showed one type of disease (10% disease occurrence, WBD only).

PSII functioning in diseased versus non-diseased corals and in healthy corals

The PSII functioning (Φ_{PSII}) ranged between 0.5 - 0.6 in coral species that did not exhibit any disease: *A. cytherea*, *P. eydouxi*, *G. fascicularis* and *F. repanda*. (Table 2). These colonies were all healthy looking and did not show any visual sign of disease and/or bleaching, as determined using the CoralWatch Coral Health Chart (www.coralwatch.org).

PSII functioning in diseased corals *A. muricata* and *P. damicornis* was photosynthetically compromised (Fig. 3 and Table 3) in tissues adjacent to the disease in both WP-affected and WBD-affected tissues, as compared to healthy colonies. Both Φ_{PSII} and $rETR_{max}$ were significantly lower in tissues adjacent to WP-affected

Table 3. Summary of statistical analyses: two-way ANOVA for the effects between the two coral species (*A. muricata* and *P. damicornis*) and among the coral conditions (healthy tissue; WP-affected tissue and WBD-affected tissue) for the Effective Quantum Yield (Φ_{PSII}), the relative maximum electron transport rate ($rETR_{max}$) and the Non-Photochemical Quenching (NPQ). n=3 for each photo-physiological parameter per condition per species of coral. Asterisks indicate significant differences in photo-physiological performance between coral condition and species.

	Dependent variables	Source of variation	df	MS	F	*p-value*
Photophysiology of *in hospite* *Symbiodinium* sp.	Φ_{PSII}	Species	1	0.003	5.898	0.036*
		Condition	2	0.069	147.070	0.000***
		Species*Condition	1	0.00001070	0.023	0.883 NS
	$rETR_{max}$	Species	1	0.003	3.477	0.092*
		Condition	2	0.166	108.689	0.000***
		Species*Condition	1	0.00002349	0.031	0.864 NS
	NPQ	Species	1	187.515	2.816	0.124 NS
		Condition	2	6253.284	93.894	0.000***
		Species*Condition	1	15.870	0.238	0.636 NS

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; NS = Not Significant

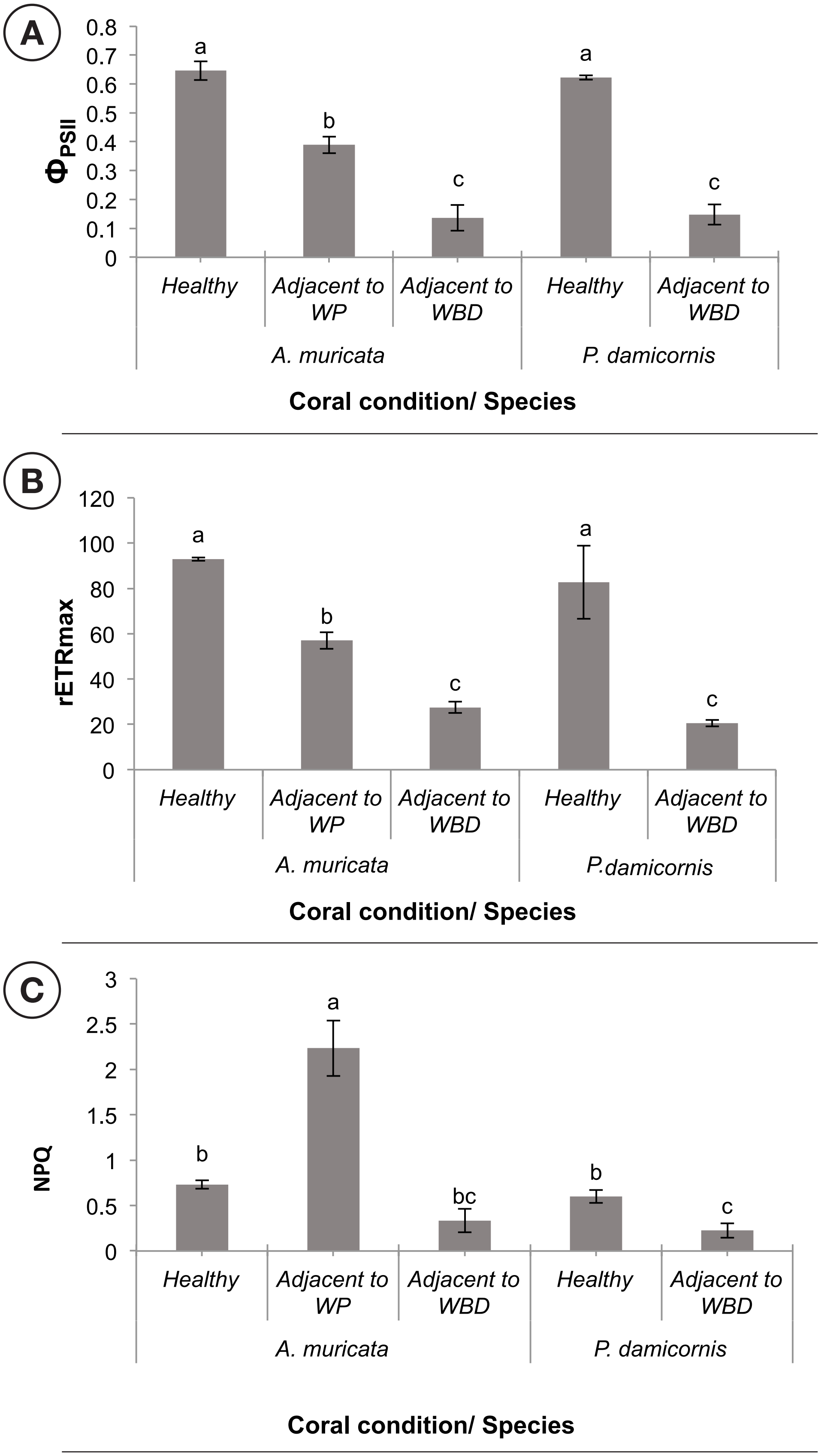

Figure 3. Photosystem II functioning in *A. muricata* (n=3) and *P. damicornis* (n=4) expressed as A. Effective Quantum Yield (Φ_{PSII}), B. relative maximum electron transport rate ($rETR_{max}$) and C. Non-Photochemical Quenching (NPQ). (Mean ± SD). The alphabet letters (a, b and c) indicate significant statistical differences between means (Post Hoc Tukey Test, $p < 0.05$).

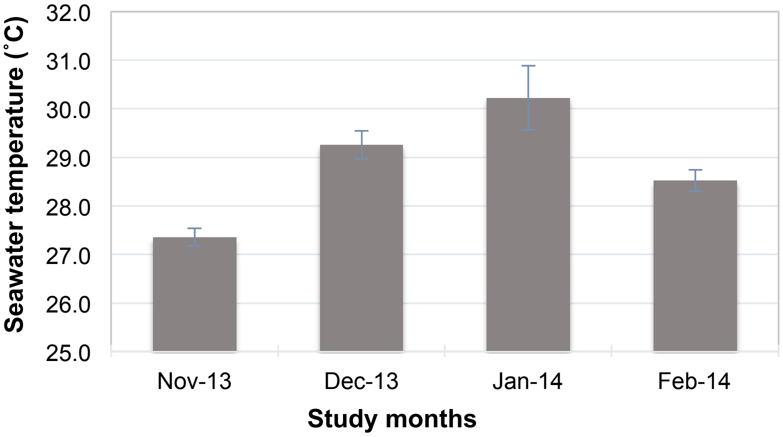

Figure 4. Sea surface temperature records for the summer months of November 2013 – February 2014.

(only in *A. muricata*) and WBD-affected corals (in both *A. muricata* and *P. damicornis*) as compared to healthy tissues from healthy colonies. NPQ was low (< 1.0) in healthy as well as WBD-affected tissues in both *A. muricata* and *P. damicornis*, except in tissues adjacent to WP-affected *A. muricata* indicating some form of photosynthetic quenching.

Sea surface temperatures

A peak in sea surface temperature (> 30°C) was recorded in January 2014 (Fig. 4) when the coral disease survey was carried out.

Discussion

This study investigated the occurrence of two commonly encountered diseases, namely White Band Disease (WBD) and White Plague (WP), among six scleractinian corals from the lagoon of Belle Mare, Mauritius.

It has indicated a susceptibility of *A. muricata* and *P. damicornis* to the diseases (WBD and WP) as compared to *A. cytherea*, *P. eydouxi*, *F. repanda* and *G. fascicularis*. Mattan-Moorgawa *et al.* (2012) reported a higher susceptibility of *A. muricata* to bleaching and mortality in comparison to *P. damicornis* and other species such as *F. repanda*. Likewise, Montano *et al.* (2015) reported that the most dominant coral genus in the Maldives, *Acropora*, was also the most affected genus in terms of diversity of disease-causing pathogens. The Acroporids have been reported in other studies to be most affected by a range of diseases such as white syndrome (also called the Acroporid White Syndrome), growth anomalies, and brown band disease (Roff *et al.*, 2011; Weil *et al.*, 2012; Burns *et al.*, 2013). Our observations may also be supported by past studies which reported a susceptibility of *A. muricata* to high sea surface temperatures with a lethal temperature limit of 30°C (Bhagooli & Sheppard, 2012; Mattan-Moorgawa *et al.*, 2012), and also its higher host coral density.

There is scientific evidence that differences exist in the bacterial communities associated with healthy corals and bleached or diseased ones. It has been reported that coral host- bacterial associations are sensitive to the effects of climate-driven temperature stress (Mouchka *et al.*, 2010) that can cause a shift from a healthy to unhealthy bacterial assemblage (Ritchie, 2006) and thus lead to a higher occurrence of coral diseases in vulnerable hosts. In certain cases, algal contact (Nugues *et al.*, 2007), reef fishes (Raymundo *et al.*, 2009), or coral predators such as *Drupella* sp. (Antonius & Riegl, 1997) may act as vectors or triggers for the onset and spread of coral diseases (Raymundo *et al.*, 2009). However, the effect of algal contact and corallivores as vectors were not investigated in this study, but it was observed that the studied coral colonies at the study site of Belle Mare were free from algal contact and signs of predation by corallivorous gastropods.

Moreover, there are scientific reports that physiologically distinct lines of *Symbiodinium* sp. can influence the thermal tolerance thresholds of their host corals (Oliver & Palumbi, 2011; Schoepf *et al.*, 2015). Most scleractinian corals (Acroporidae, Pocilloporidae, Uculinidae, Poridae and Agariciidae) in Mauritius have been reported to contain *Symbiodinium* Clade C (McClanahan *et al.*, 2005). Recently, Louis *et al.* (2016) reported to have detected only Clade A-like *Symbiodinium* sp. variants in *A. muricata* colonies at Belle Mare. Future investigations are warranted in order to determine the zooxanthellae clade, size and density in diseased and non-diseased corals.

The loss of the zooxanthellae or photosynthetic pigments can lead to the visual paling or whitening of coral tissue (Hoegh-Guldberg & Smith, 1989; Roff *et al.*, 2008b), as a consequence of bleaching or disease in corals. The photophysiological performance of *Symbiodinium* can be an important measure of the metabolic health of the coral holobiont and is even critical for its function (Burns *et al.*, 2013), and the study of the impacts of disease on *Symbiodinium* can help to characterise the dynamics of the disease in question. The results of this study indicated that *in hospite* zooxanthellae in healthy, disease-unaffected corals showed normal photosynthetic functioning (Φ_{PSII} 0.5 – 0.6) while for zooxanthellae in healthy-looking, non-affected tissues adjacent to (within a distance of 1 cm from) diseased tissue, photosynthetic functioning (PSII) was significantly affected ($p<0.05$). More specifically, in healthy-looking, non-affected tissue adjacent to (within a distance of 1 cm from) WP – affected *A. muricata*, Φ_{PSII} (light-adapted) and $rETR_{max}$ were low, while NPQ was relatively higher indicating photosynthetic stress or a form of protection mechanism such as heat dissipation in a non-harmful way. In healthy-looking, non-affected tissue adjacent to (within a distance of 1 cm from) WBD-affected *A. muricata*, Φ_{PSII}, $rETR_{max}$ and NPQ decreased as compared to the healthy tissue, indicating that the photosynthetic apparatus was damaged. In coral tissues adjacent to (within a distance of 1 cm from) WBD-affected *P. damicornis*, Φ_{PSII}, $rETR_{max}$ and NPQ were lower as compared to healthy corals, again indicating damage to the photosynthetic system. This study corroborated the findings of Burns *et al.* (2013) where endosymbionts within Growth Anomaly (GA)-affected tissue exhibited a reduced photochemical efficiency in comparison to healthy and disease-unaffected tissues, which implied that the GA-affected tissue were photo-physiologically compromised. However, Roff *et al.* (2008b) found no significant difference in the photosynthetic functioning of border tissue in Acroporid White Syndrome, namely in *A. cytherea*, as compared to healthy colonies, and also reported that there was no significant change in the symbiont density, chlorophyll *a* and mitotic cell division when comparing border tissue with healthy tissue.

In conclusion, the findings of the study indicated that among the six coral species that were studied, *A. muricata* and *P. damicornis* were vulnerable to the two diseases with higher disease occurrence in *A. muricata* (90% disease occurrence with 45% WP and 55% WBD) as compared to *P. damicornis* (10% disease occurence, WBD only). *P. eydouxi, A. cytherea, F. repanda* and *G. fascicularis* did not show any sign of disease and were found to be healthy. PSII data, in terms of effective quantum yield, relative electron transport rate and non-photochemical quenching, indicated that the symbiotic dinoflagellates in healthy tissue adjacent to (within a distance of 1 cm from) diseased parts were photosynthetically compromised as compared to healthy/ disease-unaffected corals, and in *A. muricata* there was more photosynthetic damage in adjacent tissues from WBD-affected corals than from WP-affected corals. The outcomes of this study provide further understanding of the dynamics of the two coral diseases, namely white band disease and white plague, on the Mauritian reef.

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