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Adapting Coral Culture to Climate Change: The Mauritian Experience

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Abstract—Survival and growth rates of ten coral species were compared between a land-based nursery (LBN) and ocean-based nursery (OBN) in 2008-2010 at Albion, Mauritius. Survival of *Acropora formosa, Acropora austera, Acropora selago* and *Pocillopora damicornis* cultured in the first year was 100%. After the 2009 bleaching, most of the *A. selago* and *A. austera* died while >50% of the *A. formosa* and *P. damicornis* survived. However in 2010, survival and growth rates of *A. formosa* and *P. damicornis* declined with predation by *Drupella* snails at the OBN. Among the species that were cultured after the 2009 bleaching, >70% *Pavona decussata* and *Galaxea fascicularis* survived but survival in *Montipora digitata*, *Porites palmata, Pavona danai* and *Pavona cactus* ranged from 0-18%. Between 50-84% of bleaching-resistant genotypes of *A. austera, A. formosa* and *P. damicornis* survived. While growth rates differed significantly for some species between nurseries, there were no significant differences in species such as *P. damicornis* and *G. fascicularis*. Overall, the results of the pilot study indicated that *ex situ* coral culture was possible for various species and these could be used for conservation initiatives as well as in maintaining a sustainable marine aquarium trade.

INTRODUCTION

Corals are under peril worldwide from climate-induced threats such as increased Sea Surface Temperature (SST; Brown, 1997; Hoegh-Guldberg, 1999), increases in intensity and severity of tropical storms (Webster *et al*., 2005), and outbreaks of disease (Harvell *et al*., 1999). Moreover, increases in levels of atmospheric carbon dioxide with subsequent acidification of the ocean could cause a reduction in coral accretion and growth (Hoegh-Guldberg *et al*., 2007; De'ath *et al*., 2009). It is believed that 20% of the world's coral reefs have been destroyed, with no hope of recovery, and that 24% are under imminent risk of collapse from human activities (Wilkinson, 2004). Hence, the global loss of coral reefs could cost billions of dollars in lost revenue from tourism and fisheries (Hoegh-Guldberg, 1999).

The reefs of Mauritius, besides being at risk from local disturbances, are seriously threatened by climate-induced bleaching. In recent years, there has been an increase in both the extent and severity of bleaching around the island, mainly due to warm-water anomalies (Moothien Pillay *et al*., 2002; McClanahan *et a*l., 2005). Bleaching has increased from 10% in 1998 (Moothien Pillay *et al*., 2002) to 24% in 2004 (McClanahan *et al*., 2005). Moreover, it has been observed that, in 2009, more than

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50% of corals had bleached and died in some lagoons where temperatures exceeded the local seasonal temperature of 29°C by 1.5-2.0°C (R. Moothien Pillay, unpubl. data). The recurrent bleaching episodes which Mauritius has experienced over the past decade, combined with other factors such as agricultural runoff, overfishing, excessive boating activities and coastal development, have resulted in a high mortality rate amongst lagoon corals. There has been a dramatic decline in live coral cover, e.g. in Anse La Raie where the mean coral cover decreased from 60% in 2004 (McClanahan *et al*., 2005) to less than 5% in 2009 (R. Moothien Pillay, unpubl. data). The continuing deterioration of Mauritian reefs is reducing their recreational appeal and could be one of the main causes of a decrease in local fish abundance and fisheries production through habitat disturbance rather than fisheries exploitation (Wilson *et al*., 2008). Moreover, some coral species have become scarce (R. Moothien Pillay, unpubl. data) and could face total local extinction. Safeguarding the reefs for coastal protection, fisheries, tourism and the preservation of biodiversity is therefore a national priority.

Previous studies have proposed a 'gardening concept' for the mass culture of corals *in situ* for reef mitigation and restoration (Epstein *et al*., 2001; Rinkevich, 2006). Since climate change-related bleaching events are recurring in Mauritius and impact seriously on coral abundance and diversity, we applied the coral gardening concept to the culture of corals *ex situ*. We predicted that, if corals grew well in *ex situ* nurseries because they would not be influenced by warm water anomalies, pollution, cyclones, predators and other sea-based threats, farmed corals could eventually be used for various conservation initiatives such as the rehabilitation of degraded reefs sites and the creation of coral gardens for hotel resorts. Moreover, this would allow for the creation of a land-based sanctuary for the preservation of coral diversity and for the establishment of a marine aquarium industry. Currently, Mauritius does not have a coral culture industry although there is increased interest to start one. Successful coral culture and subsequent harvesting on land can be made sustainable while wild harvesting (Ross, 1984; Delbeek, 2001) for export, without adequate monitoring, would prove detrimental to reefs and exacerbate the effects of global warming. This pilot project was initiated with this background in mind, to establish the feasibility of land-based coral culture in Mauritius using a variety of local coral taxa.

MATERIALS and METHODS

Study site and nursery set-up

A land-based nursery (LBN) and an ocean-based nursery (OBN) were established at Albion on the west coast of Mauritius (20°12'37.22" S; 57°24'15.29" E; Fig.1a). The lagoon of Albion is fringed by coral reefs approximately 400 m offshore. The reef encloses a shallow lagoon with depths varying between 1-2 m (See Moothien Pillay *et al*., 2006). The sea surface temperature (SST) varies seasonally, with a low of 23°C in August and a high of 27°C in February. However, at times, the SST rises close to 29°C in summer and may drop to 22°C in winter (Ragoonaden, 1997). The LBN was constructed in an area of approximately 200 m^2 on the premises of the Albion Fisheries Research Centre (AFRC) adjacent to the lagoon (Fig. 1b). The centre has aquaculture facilities and a seawater pump station which extracts water from approximately 1.6 m below the sea surface. The OBN, which served as control for the experiment, was established at a depth of ~1.5 m near the fringing reef.

The LBN consisted of three circular culture tanks of 4000 l capacity (Fig.1b). Each culture tank was initially fitted with a flow-through water system and two siphon-surge generators of approximately 72 litres, each producing a 1.9 $l.s^{-1}$ surge for 23 sec at 3-minute intervals (modified from Forsman *et al*., 2006). In addition, two submersible 750 W pumps (75 $l.min^{-1}$ capacity) were placed together with an air flow system in each tank to create continuous water movement. Each tank had eight 45 x 25 cm trays (modified from Shafir *et al*., 2006) but could accommodate

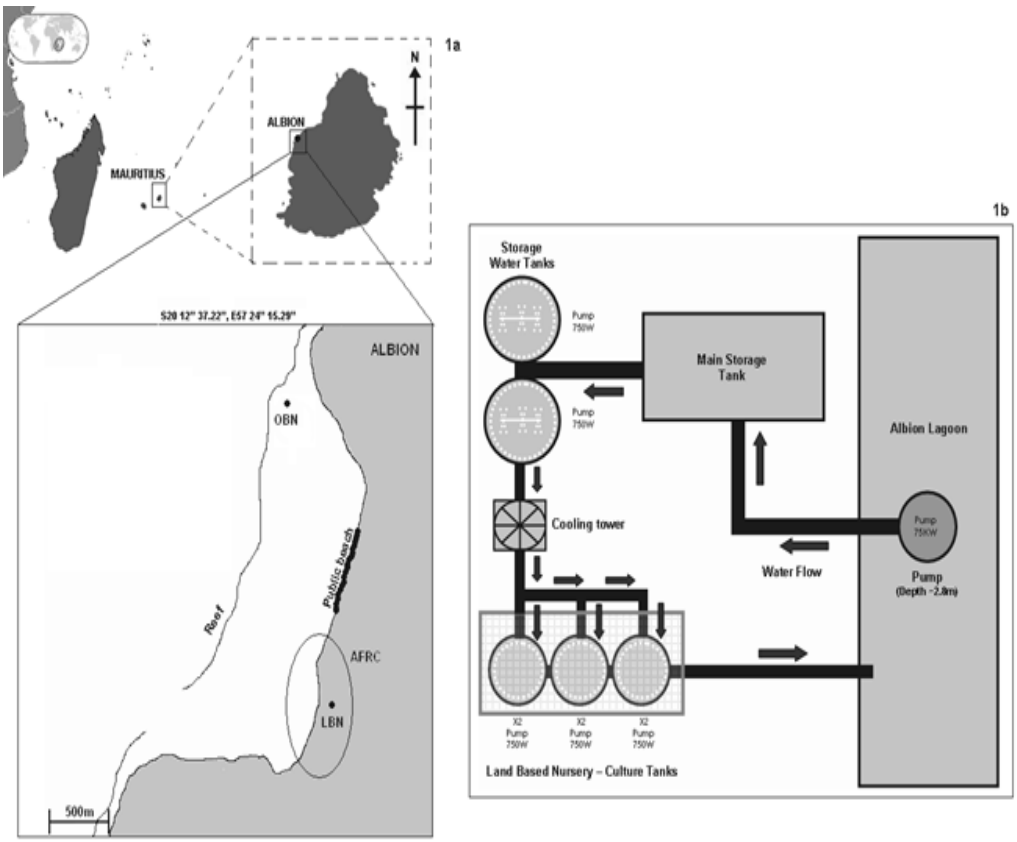

Figure 1. a) Site location of the Land-Based (LBN) and Ocean-Based Nurseries (OBN) in Mauritius and b) schematic representation of the LBN set up at Albion.

up to 24 trays, and each tray could hold up to ~40 coral fragments depending on the coral species. The trays were suspended at a depth of 60 cm below the water surface. They comprised a mesh grid supported by a PVC pipe frame for maximum flow of water between coral fragments. The tanks were housed under 50% shade cloth in summer and 85% shade cloth in winter, allowing adequate light to reach the cultured corals.

Seawater was pumped from the lagoon to the main storage tank of the research centre and from there to two header tanks at the coral nursery (Fig.1b). The latter were covered with white vinyl and water from the storage tank was introduced through a circular sprinkler system consisting of a PVC pipe with numerous holes, before being supplied to the culture tanks. After the severe bleaching of 2009, six shower heads were added to the header tanks, circular sprinkler systems to the culture tanks and a cooling water tower to the overall coral culture operation to cool down the water (Fig. 1b). This was fitted above the culture tanks and water passing through it was cooled by a fan before being gravity-fed into the surge generators. In addition, water recycled continuously through each culture tank via a circular PVC pipe with nozzles for further cooling.

The OBN comprised three galvanised metal tables (each table: 1.0 x 1.2 x 0.5 m), each with eight 50 cm x 25 cm metal trays fitted with metal doors to prevent poaching. One tray could accommodate up to 40 fragments. The metal tables were covered with galvanised chicken mesh to prevent grazing by fish. The water surface was 50-60 cm above the culture tables, depending on tidal variation. Each table was fixed to 4-5 150 kg concrete blocks to prevent it being dislodged during rough seas. The tanks at LBN and tables at OBN were cleaned weekly to control algal growth.

Study species, sampling design and growth measurement

During the first year, three species of fast growing corals, viz. *Acropora formosa*, *A. selago, A. austera* and one bleaching-resistant coral, *Pocillopora damicornis*, were cultured in the OBN and LBN. During the second year, the growth potential of six species known to be bleaching-resistant in Mauritius, *Montipora digitata, Porites palmata, Pavona decussata, P. cactus, P. danai* and *Galaxea fascicularis,* was investigated. Fragments of *A. formosa, A. austera* and *P. damicornis* were collected in the field after the 2009 bleaching event (bleaching-resistant genotypes) to monitor their survival and growth potential.

Most species were collected from the lagoon of Albion, except *P. cactus, P. danai* and *P. decussata* (Table 1). These were collected within similar habitats from other lagoons as they were unavailable at the study site. Fragments of 2 - 3 cm were clipped with a bone cutter from donor colonies of each species (See Table 1 for sample size). Donor colonies were randomly selected to increase genetic diversity among the fragments (Shaish *et al*. 2010). Each fragment was glued with either epoxy cement (Holdfast, Aquarium Systems, France) to small cement blocks, or with cyanoacrylate glue (super glue, MAGPOW, Japan) to plastic nails (Shafir *et al.* 2006) and then tagged. Initially, 10 fragments of each species were placed in each of the three culture tanks in the LBN and each of the tables in the OBN.

The nursery-reared fragments were monitored by digital photography for their survival and growth rate. Each fragment was photographed on the lateral side soon after culture, after the lag phase of three months, and thereafter every six months. The time series images were always taken on the same side (marked with marine paint). Image analysis software (Scion Image Alpha 4.0.3.2) was used to calculate the surface area of the lateral side of each fragment (henceforth known as the planar area) and its linear extension. Even though the 2-D image did not give absolute values, it provided a good indication of growth over time and was useful for this study.

Table 1. Coral species, sampling site (SS) where collected, sampling month (SM), sample size (n) and percentage mortality due to elevated temperature (T), predation by *Drupella* (D) or other causes in the OBN and LBN.

Species	SS	SM	n	% mortality			n	% mortality		
				T	D	Other		T	D	Other
				OBN				LBN		
Acropora austera	Albion	Jan-08	32	94	-	-	32	100	-	
Acropora formosa	Albion	May-08	32	18.5	15.5	-	32	41	-	-
Acropora selago	Albion	May-08	32	75	-	-	32	100	-	-
Pocillopora damicornis	Albion	Jan-08	33	15	6	-	33	30	-	-
Bleaching resistant species										
Pavona cactus	GRSE*	Jul-09	26	-	-	92	26	-	-	100
Pavona danai	GRSE*	Sep-09	28	-	-	82	28	-	-	100
Pavona decussata	Mahébourg	Aug-09	25	-	-	20	26	-	-	19
Galaxea fascicularis	Albion	Aug-09	45	-	-	27	45	-	-	27
Montipora digitata	Albion	Jul-09	30	-	-	100	30	-	-	100
Porites palmata	Albion	Jul-09	30	-	-	87	30	-	-	100
Bleaching resistant genotypes										
Acropora austera	Albion	Oct-09	31	-	-	16	31	-	-	16
Acropora formosa	Albion	Oct-09	30	-	-	20	30	-	-	40
Pocillopora damicornis	Albion	Oct-09	32	-	-	50	31	-	-	26

*GRSE: Grande Rivière Sud-Est

Environmental parameters

Submersible temperature data loggers (Onset HOBO® Pendant Light/Temperature Data Logger) and Photosynthetic Active Radiation meters (ODYSSEY Dataflow system PAR sensor) were deployed at the LBN and OBN to monitor water temperature (°C) and PAR (µM $m^{-2}s^{-1}$) every 15 min. Water samples at LBN and OBN were analysed on a weekly basis for nutrient levels (calcium, nitrate and phosphate (ppm); Palintest 7100 Photometer kit), as well as pH and salinity (SensIon 156 pH-salinity-dissolved oxygen Multiparameter meter). These physico-chemical variables were initially recorded in each culture tank. However, data collected over the first year revealed no significant difference in these variables in the tanks and, consequently, monitoring of these parameters was carried out in only one tank.

Data analysis

The temporal increase in planar and linear growth of each fragment was calculated by subtracting the initial growth from the final growth. The planar and linear growth rate (mm^2/month and mm/month respectively) of each fragment in the LBN and OBN were calculated using the following formula:

$$\overline{R} = \frac{\sum (F - I)}{n} * \frac{1}{t}$$

F = Final growth
I = Initial growth
n = Total no. of fragments
t = Total no. of months under culture
$\overline{R}$ = mean growth rate

Survival rate was calculated as the percentage of fragments that survived at each nursery. The Mann-Whitney *U* test was used (SPSS 15.0) to compare the growth rates in the OBN and LBN, as the data were not normally distributed (Shapiro-Wilk test). T-tests were used to compare physico-chemical variables between LBN and OBN. All values are expressed as means ± standard error.

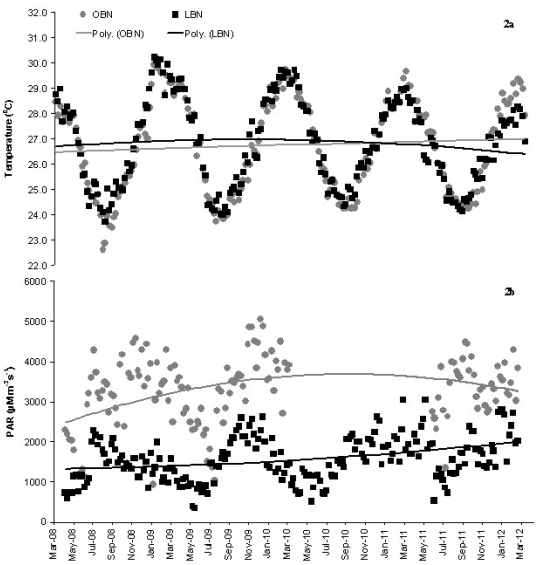

Figure 2. Average weekly a) Temperature (°C) and b) Photosynthetic Active Radiation (µM $m^{-2}s^{-1}$) during daytime at the OBN and LBN from March 2008 to March 2012 (sampling frequency: 15 mins). PAR data were not available for OBN from March 2010 to May 2011.

RESULTS and DISCUSSION

Coral Survival

First year of culture

The survival rate of *A. selago, A. austera, A. formosa* and *P. damicornis*, was 100% in both the nurseries during the first year until the end of December 2008 (Table 1). In January 2009, the seawater temperature in the lagoon rose by ~1.5-2°C above the seasonal maximum of 29°C. The average temperatures in the LBN and OBN were 28.9±1.2°C and 28.5±1.4°C respectively (t-test, $p<0.05$). Moreover, the maximum temperature recorded in the LBN was 31.04°C and in the OBN 31°C. By the end of the bleaching event in April 2009, survival rates for *A. austera* and *A. selago* were 6.3% and 25% in the OBN; none survived in the LBN. *A. formosa* survival was 59% and 66% in the LBN and OBN respectively. *P. damicornis* proved more resilient, with above 70% survival in both nurseries (Table 1). Although the coral culture facility was housed in a shed, and hence had reduced PAR levels (Fig. 2b), and a circular sprinkler system was used to cool the incoming water, the temperature

remained slightly higher in the LBN (Fig. 2a). This was due mainly to heating of the water through the distribution system (main storage tank and pipes). Even though the slightly higher temperatures recorded in the LBN would explain the higher mortality in *A. selago, A. austera* and *A. formosa*, various other factors including reduced water flow in the culture tanks and the interacting effects of reduced water flow with temperature may have exacerbated this. Although high temperature is known to initiate bleaching in various coral taxa (Hoegh-Guldberg, 1999; Yee & Barron, 2010), the effect of reduced water flow on temperature stressed corals is not well documented. In an experimental study, Nakamura and van Woesik (2001) demonstrated that the survival rate of *A. digitifera* was low when removed from a high flow environment to a low flow tank environment and exposed to light stress. Corals exposed to high water flow would hence be less susceptible to bleaching stress (Nakamura & van Woesik, 2001, 2003; McClanahan *et al*., 2005). Furthermore, a differential susceptibility between coral taxa to bleaching noted in this study has been previously observed and widely documented (e.g. Baird and Marshall 2002; McClanahan *et al*., 2004). For example, during the 1998 bleaching event, the genus *Acropora* was found to be more susceptible to bleaching than *Pocillopora* in the lagoon of Mauritius (Moothien Pillay *et al*., 2002). Similarly, a recent study by Guest *et al*. (2012) revealed that *Acropora* and *Pocillopora* were more susceptible to bleaching in Sumatra, Indonesia but were the least affected in Singapore, this being attributed to coral adaptation and/or acclimatization to thermal stress.

Bleaching resistance

After the bleaching event of 2009, cooling systems were added to lower the water temperature and increase circulation in the culture tanks in anticipation of further warm water anomalies. From July 2009, bleaching-resistant species and genotypes were cultured. Of the six bleaching-resistant species selected for the study, only two adapted well to nursery conditions. *P. decussata* and *G. fascicularis* survived the best: 73% of the *G. fascicularis* survived in both nurseries and 81% of the *P. decussata* in the LBN and 80% in the OBN (Table 1). The low survival of the *M. digitata*, *P. palmata, P. cactus* and *P. danai* (Table 1) may have been due to the high temperature stress that they had experienced during the 2009 bleaching event, or the culture technique we used, although Shaish *et al*. (2010) obtained high survival in *M. digitata* in the Philippines using a similar culture technique. However, it is known that survival rates differ among species and environmental conditions (Shaish *et al*., 2010). Survival of the bleaching resistant genotypes of *A. austera, A. formosa* and *P. damicornis* after one year were 84%, 80% and 50% in the OBN, and 84%, 60% and 74% in the LBN respectively. While survival rates did not differ for *A. austera* in either nursery, *A. formosa* genotypes survived better in the OBN and *P. damicornis* in the LBN.

***Drupella* predation at OBN**

From May 2010, we noticed large numbers of *Drupella* snails at various sites around Mauritius, including the OBN. Adult snails were either solitary or aggregated (1-3 adults) on the two-year old cultured *A. formosa* with less on the 2.3-year old *P. damicornis* colonies. In June 2010 we observed numerous juvenile *Drupella* among their branches. These coral species are known to be the preferred prey of *Drupella* snails (Cumming, 1999) and, when in abundance, are known to cause high mortality in corals, especially the acroporids and the pocilloporids (Turner, 1994; Cumming, 1999). The snails were removed manually from each of the affected corals during our weekly visits to the OBN. By July, *Drupella* densities had decreased substantially in the OBN with the majority of the corals harbouring none or only one snail per colony. After the *Drupella* attack, the survival of *A. formosa* was reduced to 66% (of 38% affected colonies, 16% died and 22% suffered partial mortality; Table 1). The survival of *P. damicornis* dropped to 79% (of 42% affected colonies, 6% died and 36% suffered partial mortality; Table 1). The one-

year old bleaching-resistant fragments of *A. austera*, *A. formosa* and *P. damicornis* were not preyed upon by *Drupella*, possibly due to their smaller colony size. The maximum colony diameter of the two-year old *A. formosa* was 12.8±0.7 cm and 6.4±0.2 cm for the 2.3-year old *P. damicornis*. The bleaching-resistant genotypes of *A. austera*, *A. formosa* and *P. damicornis* were 4.4±0.2 cm, 5.1±0.2 cm and 3.4±0.1 cm in diameter respectively. These results are in accordance with results reported for the Great Barrier Reef where large colonies were more vulnerable to *Drupella* predation than small colonies <10cm in diameter (Cumming, 2009).

Coral growth

Culture in the first year

Before succumbing to bleaching in 2009, the average linear (±SE) growth rate of *A. austera* was faster in the LBN (Fig.3d) but similar growth rates were recorded for *A. selago* under the two culture conditions (Fig.3c). However, the planar growth of these two species did not differ significantly between the LBN or OBN (Figs. 3a, 3b). Growth of *A. formosa* and *P. damicornis* was variable over the study period but, overall, the data collected for *P. damicornis* over 32-months showed no significant difference in growth rates between the nurseries but the planar growth of *A. formosa* was significantly faster at OBN (Fig.4a - 4d).

Bleaching resistant species and genotypes

Linear and planar growths of *G. fascicularis* were not significantly different between LBN and OBN (Fig.5c, d). In contrast, linear growth in *P. decussata* differed significantly between LBN and OBN. For the bleaching resistant genotypes, the linear growth of *A. austera* in the LBN was not significantly different from that in the OBN, though its planar growth rate was significantly faster in this nursery (Fig.5a, b). No significant differences were detected between nurseries for the other bleaching-resistant genotypes. Analyses of the nutrient levels showed that they were well within threshold values in both the LBN and OBN (Table 2) and were not significantly different between the nurseries, indicating that LBN water quality was similar to that in the ocean-based nursery. Temperature and PAR were the only environmental factors studied that varied significantly between the nurseries (Fig.2a, b).The differing growth pattern in some of the cultured species between nurseries could have been due to one or many variables such as temperature (Loya, 1985), PAR (Torres *et al*., 2007), plankton availability (Sebens *et al*., 1998) and water flow (Jokiel, 1978), though, in the latter case, Sebens *et al*. (2003) found no differences in growth rate of *Agaricia tenuifolia* in Belize across a range of water flow rates in different habitats.

Drupella predation at OBN

Apart from the aforementioned mortality caused by *Drupella* on *A. formosa* and *P. damicornis* in the OBN, these gastropods also negatively affected their growth rates (Table 1, Fig. 4a-4d) which decreased with predation in this nursery. Colonies injured by *Drupella* direct their energy to tissue regeneration at

Table 2. Weekly pH, salinity and nutrient levels (ppm) recorded in the OBN and LBN from Mar-08 to Oct-10.

	OBN	LBN	T-test (n= 124)	Threshold	Source reference
pH	8.2	8.2	p>0.05	7.5 - 8.5	MGG*, 1999
Salinity	33	33	p>0.05	32 - 35	MGG*, 1999
Nutrient level (ppm)					
Calcium	404	405	p>0.05	380-450	Reefkeeping, 2008
Phosphate	0.045	0.046	p>0.05	< 0.05	MGG*, 1999
Nitrate	0.41	0.43	p>0.05	< 0.50	Reefkeeping, 2008

*MGG: Mauritius Government Gazette

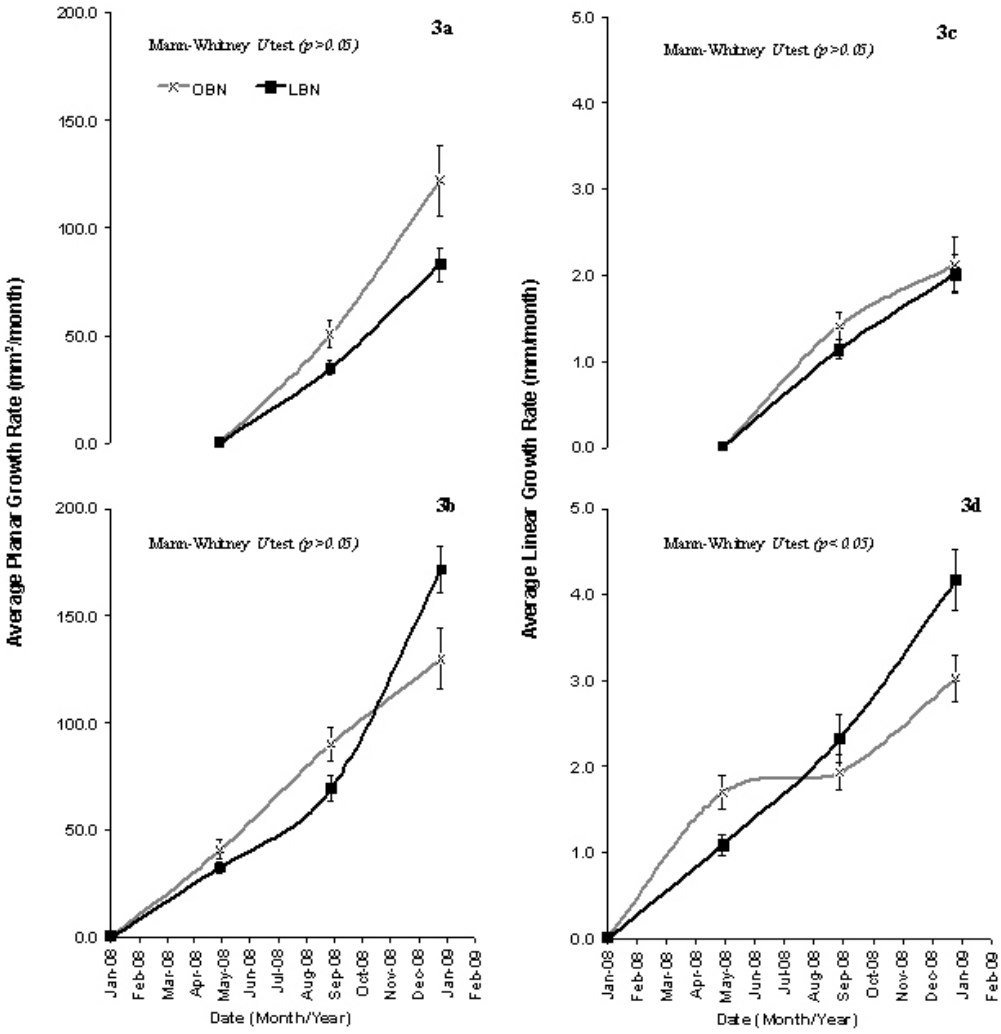

Figure 3. Average planar (mm^2/month ± SE) and linear (mm/month ± SE) growth rate of (a, c) *Acropora selago* from May 2008 to January 2009 and (b, d) *Acropora austera* from January 2008 to January 2009 at both nurseries.

the expense of colony growth and chronic or repeated injuries can lead to colony mortality (Rotjan and Lewis, 2008; Cumming, 2009).

Annual growth rates

Linear growth rates of the LBN *A. austera*, *A. formosa* and *P. damicornis* were comparable to the growth rates of the same species reported from elsewhere, despite their manipulation during culture and the bleaching event of 2009. That of *A. formosa* was 43.4±5.9 mm yr^{-1} and in India its growth ranged from 38-49 mm yr^{-1} (Suresh & Mathew, 1995); growth in *P. damicornis* was 13.1±1.5 mm yr^{-1} compared to 12.4-16.1 mm yr^{-1} in Eastern Australia (Harriott, 1999); and in *A. austera* growth was 30.3±3 mm yr^{-1} which ranged between 16.9-34.1 mm yr^{-1} in Rodrigues (Hardman, 2004). This suggests that the culture conditions at the nursery were appropriate for coral growth, though each species had its own specific requirements. Addition of live or artificial feed can accelerate growth in some farmed species (Sawall, 2011; Forsman *et al*., 2011) and this would be an option to consider, particularly by those whose prime interest is the farming of corals for export.

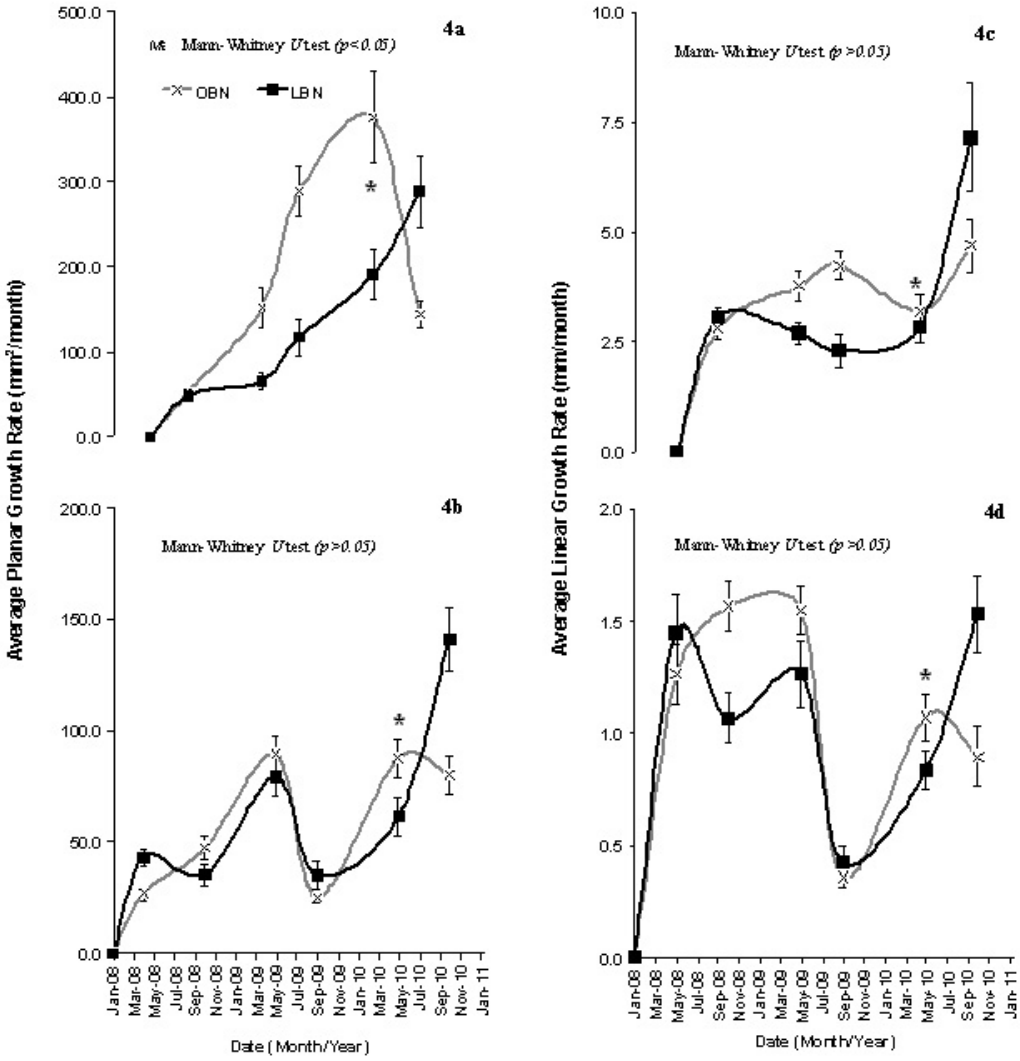

Figure 4. Average planar (mm^2/month ± SE) and linear (mm/month ± SE) growth rate of (a, c) *Acropora formosa* from May 2008 to October 2010 and (b, d) *Pocillopora damicornis* from January 2008 to October 2010 at both nurseries.*Predation by *Drupella* snails.

The variability observed in the survival and growth rates of the LBN coral species was most probably due to species-specific physical and biological requirements. Forsman *et al*. (2011) experimentally demonstrated that the growth rate of cultured *Porites compressa* was greatest in conditions of high-light, low-flow conditions, while *Montipora capitata* did not fare well under these conditions. Additionally, while artificial feeds did not significantly accelerate the growth of *P. compressa*, they positively influenced the growth rate of *M. capitata*. Observed differences were attributed to phototrophy in the former and heterotrophic ability in the latter species (Forsman *et al*., 2011). It has been suggested that dedicated studies would be needed to elaborate the specific requirements of individual species for their successful cultivation (Forsman *et al*., 2011). However, the culture conditions should eventually be optimised for multi-species culture to ensure the environmental as well as economic sustainability of any *ex situ* coral farming project. The successful culture

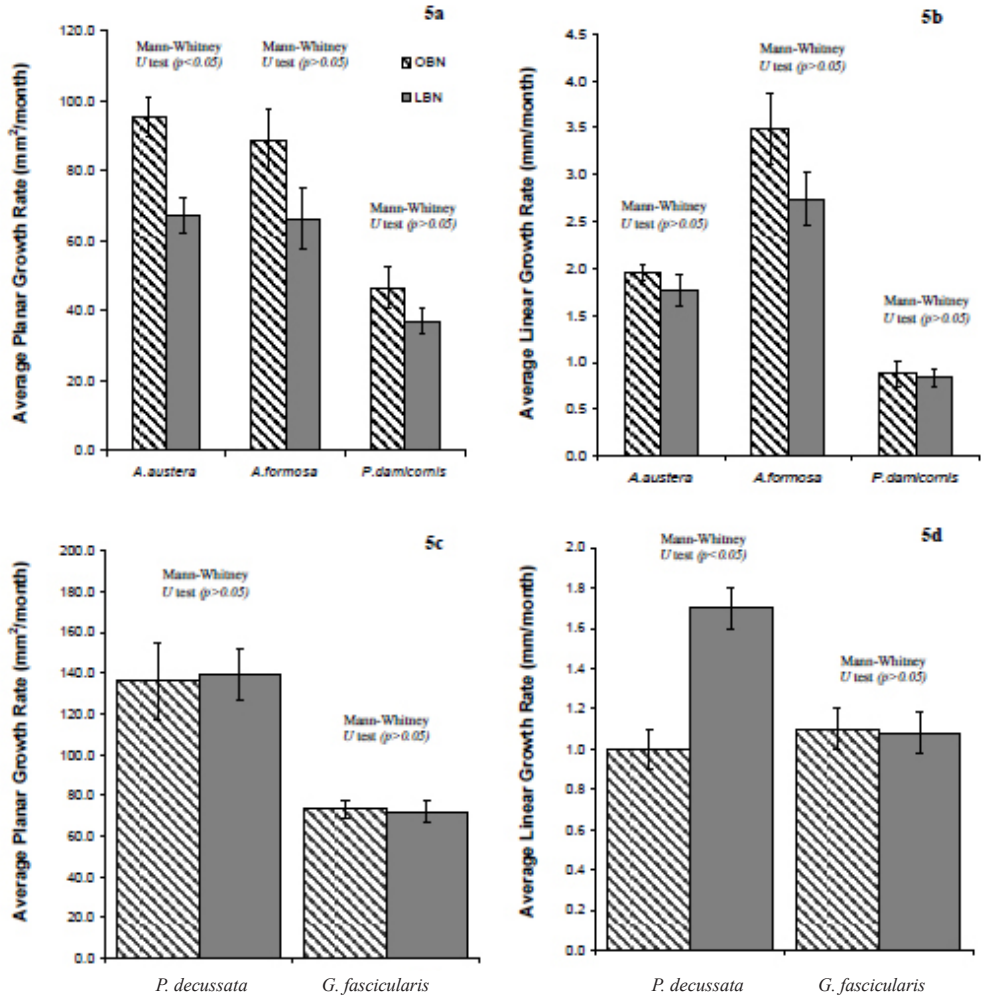

Figure 5. Average planar (mm²/month ± SE) and linear (mm/month ± SE) growth rates of bleaching-resistant genotypes of (a, b) *A. austera*, *A. formosa* and *P. damicornis* from October 2009 to October 2010 and (c, d) of bleaching-resistant *Pavona decussata* and *Galaxea fascicularis* from August 2009 to December 2010 at both nurseries.

of various species *ex situ*, as demonstrated in this study, will be advantageous in an era when bleaching events are becoming common. Furthermore, land-based farming of corals would be protected from marine impacts, e.g. predation by corallivorous gastropods.

In Mauritius, recent surveys have shown that some coral species are threatened with local extinction (R.Moothien Pillay, unpubl. data) and our land based facility is now being used to propagate these species. *Ex situ* coral culture may prove useful in maintaining brood stock to retain the overall coral diversity but it will not necessarily be a panacea to save all species from local extinction. Nevertheless, it may play an important role in restoring degraded reefs, enhancing the ecosystem services they provide for tourism, fisheries and coastline protection. Tourist visits of such culture facilities as well as their commercialisation for the aquarium industry could possibly make them self-sustainable for conservation initiatives. This is an avenue worth considering as it would benefit countries already involved in the harvest of corals from the wild for the international aquarium trade.

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