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MORPHOMETRIC AND TAPHONOMIC ANALYSIS OF *ACROPORA PROLIFERA* AT CORAL GARDENS, BELIZE

SHANNON DILLON, Colgate University

Research Advisor: Constance M. Soja

INTRODUCTION

In recent decades, a hybrid coral, *Acropora prolifera*, has been observed thriving in certain Caribbean areas, including Coral Gardens, Belize (Vollmer & Palumbi, 2002; Fogarty, 2007). Genetic analysis indicates that *A. prolifera* colonies are composed of first generation hybrids (i.e. offspring of two different species) (Vollmer & Palumbi, 2002; Fogarty, 2007). However, a study conducted by Fogarty (2007) yielded second generation hybrids (i.e. *A. prolifera* sexually reproducing with other *A. prolifera* corals), suggesting that the coral may be able to produce viable offspring of its own. In fact, *A. prolifera* spawning was observed in Belize in 2006, so perhaps second generation hybrids exist but have yet to be sampled (Fogarty et al., 2012).

There is debate about whether this hybrid is present but unidentified in the fossil record. To help answer this question, I investigated the preservational potential of *A. prolifera* by comparing the physical traits of the hybrid's skeleton to those of the two parent species (*Acropora cervicornis* and *Acropora palmata*), which are abundant in fossil reefs (Aronson & Precht, 2001; Greer et al., 2009).

Coral colonies are composed of many individual animals that secrete calcium carbonate cups, or corallites. These cups are interconnected and form the many branches of the colony. How likely the coral skeleton is to be preserved in the fossil record is influenced by several factors, including bioerosion, wave strength, water depth, skeletal growth rate, and skeleton strength (Greenstein, 2006). Skeletal properties that resist erosion, such as fewer exposed

surfaces, higher density, or lower porosity, increase the chances of skeletal preservation.

The recent expansion of *A. prolifera* during a time of environmental change suggests that there may be natural processes selecting for this hybrid's traits, possibly as a result of hybrid vigor. Another idea, proposed by Fogarty (2007), is that *A. prolifera* may be more apparent in reef communities today due to a reduction in parent species populations. Dwindling numbers of healthy, sexually mature adults of *A. cervicornis* and *A. palmata* limit the chances of conspecific fertilization because there are fewer gametes being released in a given area. Therefore, it is harder for sperm and egg from the same species to meet, and the number of cross-fertilizations between *A. cervicornis* and *A. palmata* increases as gametes must drift farther before encountering each other. Since there are few barriers to hybrid viability after fertilization (Fogarty et al., 2012), the number of hybrid *A. prolifera* corals is increasing as the instances of cross-fertilization increases.

Branching, fast growing corals that live in shallow, high energy environments (i.e. acroporids) generally are best preserved in the fossil record. This is because sediment is moved around more in high energy environments, so skeletons can be buried quickly and protected from degrading processes. Preservation is also enhanced by greater skeletal strength (Greenstein, 2006). Typically, slender, finger-like corals are not as well preserved because their skeletons are less resistant to strong waves and bioerosion, and are destroyed before becoming fossilized. Thicker branches are better preserved because they can

withstand destructive processes long enough to become fossilized (Greenstein, 2006).

In this study I examine *A. prolifera*'s branch morphology, including branch angle, corallite height, corallite diameter, corallites per cm², and skeleton porosity. The goal of this study is to test two hypotheses. The first is that *A. prolifera* is similar enough to the two parent species to have similar preservational potential. The second is that *A. prolifera*'s physical characteristics are different enough from the parents' that it can be distinguished in the fossil record.

MATERIALS AND METHODS

Caribbean Acroporid Corals

The corals examined belong to the genus *Acropora*, a group of branching corals that have a hard skeletal framework. *A. cervicornis*, *A. palmata*, and the hybrid, *A. prolifera*, are the only forms within this genus that live in the Caribbean (Wallace, 1999; Aronson & Precht, 2001). *A. cervicornis* ("staghorn coral") has a branching form similar to deer antlers. Colonies range from small bushes to large stands reaching nearly two meters in height. Branches are cylindrical and can be up to 1.1 meters long and 10-22 centimeters in diameter (Wallace, 1999).

A. palmata ("elkhorn coral") has a branching form similar to elk antlers. Its branches are flatter than *A. cervicornis*, resembling sheets rather than cylinders. The branches extend from a thicker base which provides support for the overlying skeleton. Colonies can grow a few meters in height with branches up to 25 centimeters wide, three meters long, and three centimeters thick (Wallace, 1999; De Kluijver et al., 2014).

Genetic analysis shows that the colony shape of *A. prolifera* more closely resembles whichever species contributes the male gamete during fertilization (Vollmer & Palumbi, 2002). *A. prolifera* has therefore been subdivided into two categories depending on colony appearance. Following terminology established by Vollmer and Palumbi (2002), one subgroup is termed "bushy" and looks like the slender branches of its father species, *A. cervicornis*,

but with a greater number of small branches. The other subgroup is termed "palmate" and looks like shorter, narrower branches of its father species, *A. palmata*. In this study, the two hybrid subgroups are examined independently to determine if there are differences between their physical characteristics. This subdivision produced a total of four groups (*A. cervicornis*, *A. palmata*, bushy *A. prolifera*, and palmate *A. prolifera*) for comparison.

Field Methods

Samples were collected from three areas within Coral Gardens (Figure 1, Greer et al., this volume) and two additional areas, Manatee Channel and Rocky Point. These locations were chosen because of their populations of healthy *A. prolifera* and because they were generally separate from patches of either parent species, making collection and photography of the hybrid easier.

Photographs were taken at Manatee Channel, Rocky Point, and transects one (T1), three (T3), and five (T5) at Coral Gardens. Photographs were consistently oriented towards the east (towards the reef crest). Floating above the coral patches, I photographed the top of the colonies. I also collected bleached pieces of *A. prolifera* at Coral Gardens; well-preserved pieces used in this analysis were taken from collections of Lisa Greer and Halard Lescinsky (Table 1). To remove tissue, destroy encrusting algae, and expose the underlying coral skeleton, all specimens were bleached before analysis.

Lab Methods

To examine internal characteristics, sections of coral were cut perpendicular to and parallel to the direction of growth. To analyze external characteristics, uncut pieces of recently bleached coral were examined in the SEM. Uncut pieces of coral were also examined using a stereomicroscope.

Horizontal branch angle was measured between primary and secondary branches and between secondary and tertiary branches (Fig. 1). Primary branches originate from the sediment base, while secondary branches grow from the primary branch but deviate from the primary branch's growth direction.

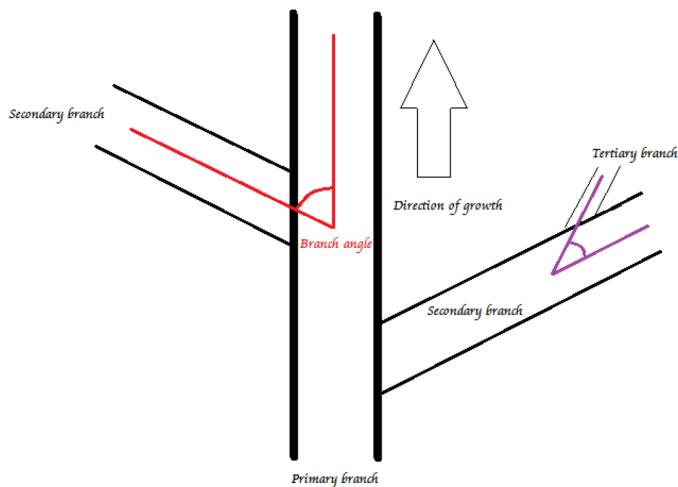


Figure 1. Diagram showing how horizontal branch angles were measured. Primary to secondary angles are in red, secondary to tertiary is in purple.

Tertiary branches grow from the secondary branch but deviate from the secondary branch's growth direction (NOAA, 2012).

Digital calipers were used to measure corallite height. Corallite heights were measured from where the corallite connected with the main branch to the corallite tip. Corallite diameter was measured using photo analysis on images collected on the

stereomicroscope. Photographs taken using the SEM and stereomicroscope were also used to determine number of corallites per cm^2 . Grid boxes of known dimensions were placed over photographs, and the number of corallites within the box was counted manually. The number of corallites per cm^2 was then extrapolated by estimating how many of the measured grids would fit into a one square centimeter grid.

To measure porosity, cut samples were examined using the SEM, and the photographs taken were analyzed using analySIS. This program calculated the number of pixels of each grayscale value, and I visually determined the threshold pixel value of pore compared to skeleton material. Percent porosity was calculated by dividing the number of pore pixel values by the number of total pixels (skeleton and pore combined).

RESULTS

Branch Angle

Branch angle was only measured for *A. cervicornis* and bushy *A. prolifera*, since no suitable top-down photographs of *A. prolifera* and palmate *A. prolifera* could be taken at any of the localities. Both secondary and tertiary angles are higher on average for *A.*

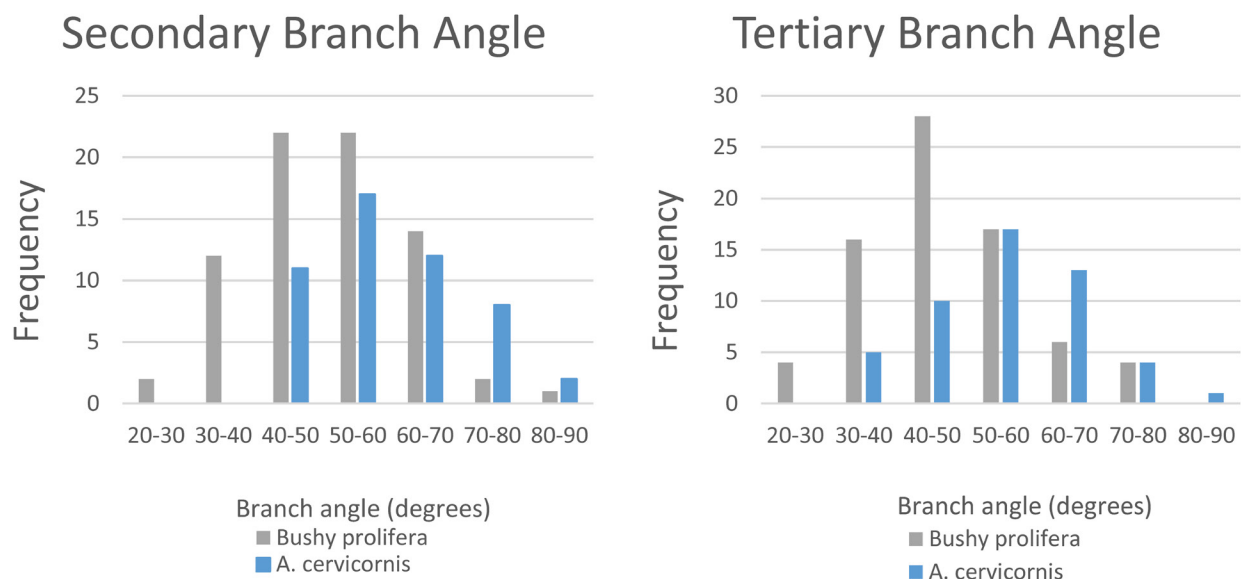


Figure 2. Raw data for secondary and tertiary branch angles measured for *A. cervicornis* and bushy *prolifera*.

cervicornis than for bushy type *A. prolifera* (Fig. 2). Secondary branch angles are greater than tertiary angles on average for both *A. cervicornis* and *A. prolifera*, but both secondary and tertiary angles are mainly between 45° and 60°.

Corallite Height

Of the four groups, *A. cervicornis* has the shortest average corallite height (2.3 mm) and *A. palmata* has the greatest average corallite height (3.7 mm) (Fig. 3). The two hybrid subgroups, bushy *A. prolifera* and palmate *A. prolifera*, both have approximately the same average corallite height (3.2 mm) and are closer to *A. palmata* than *A. cervicornis*. Bushy *A. prolifera* has the widest distribution of heights (Table 1), while palmate *A. prolifera* has the narrowest (Table 1). Kruskal Wallis and one way ANOVA tests showed differences between groups were significant for all comparisons except comparison of bushy *A. prolifera* to palmate *A. prolifera*, which makes sense since they have the same average height.

Corallite Diameter

A. cervicornis has the largest average corallite diameter (0.114 mm), while *A. palmata* has the lowest average corallite diameter (0.080 mm) (Fig. 3). Bushy *A. prolifera* is intermediate (0.081 mm) but is surprisingly more like *A. palmata*. Palmate *A. prolifera* shows the opposite trend and is closer to *A. cervicornis*'s average diameter (0.0973 mm). All differences were significant except for the comparison of *A. palmata* to bushy *A. prolifera*.

Corallites per cm²

Bushy *A. prolifera* has the greatest average number of corallites per cm² (28.8), though *A. palmata* has a very similar value (27.3) (Fig. 3). These two groups also have the greatest distribution of values (Table 1). *A. cervicornis* has the fewest average corallites per cm² (13.3), and palmate *A. prolifera* is intermediate between the two extremes (18.2). Differences

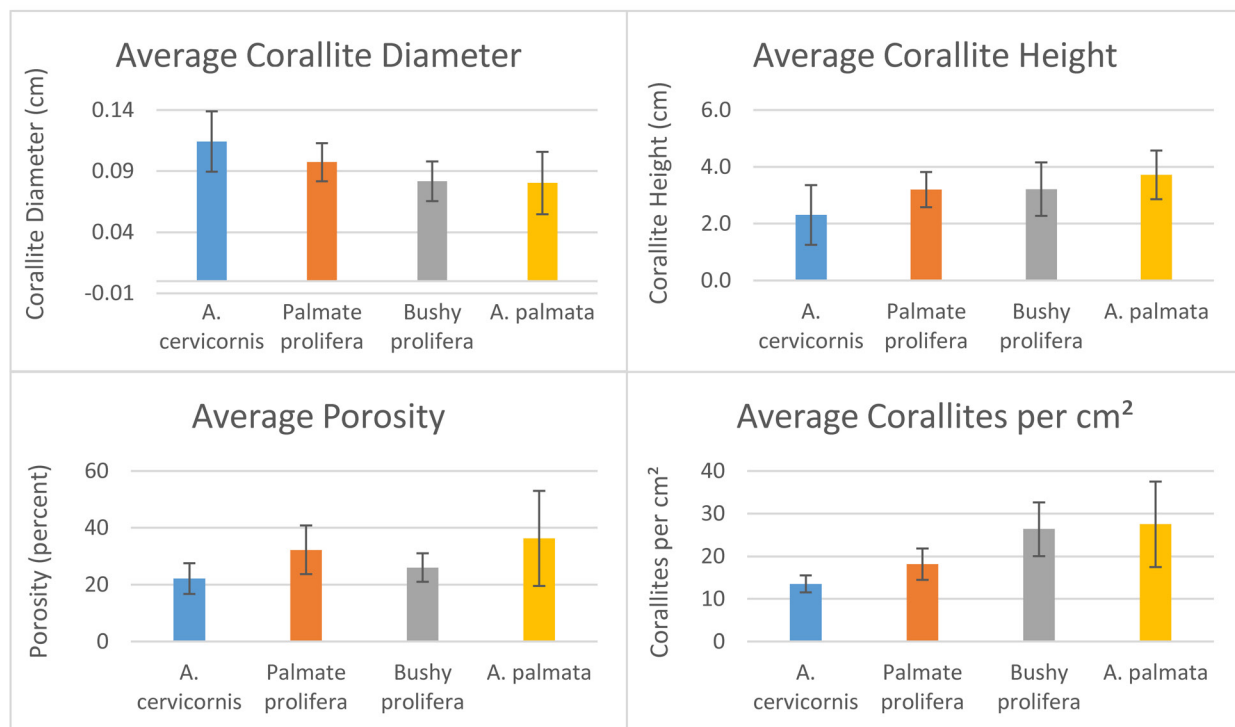


Figure 3. Graphs showing the averages for the four morphological characteristics examined. For average porosity and corallite height, the hybrid subgroups show greater similarity to their paternal species. For average corallites/cm² and corallite diameter, the hybrid subgroups show greater similarity to their maternal species.

	<i>Acropora cervicornis</i>	<i>Bushy prolifera</i>	<i>Palmate prolifera</i>	<i>Acropora palmata</i>
Height (mm)				
Average	2.3	3.2	3.2	3.7
N	45	45	30	55
SD	1.0543	0.94643	0.62501	0.85982
n	4	2	3	4
Diameter (mm)				
Average	0.114276102	0.081613296	0.097321421	0.080299195
N	29	27	42	92
SD	0.02478	0.01634	0.01573	0.02563
n	3	2	4	3
Corallites/cm²				
Average	13.52793	26.34554	18.17852699	27.51471269
N	20	9	24	10
SD	1.99412	6.27147	3.69514	10.00296
n	3	2	4	3
Porosity (percent)				
Average	22.13249126	26.5180199	32.24852702	30.93357747
N	19	7	10	5
SD	5.3959	5.04873	8.55255	16.72146
n	3	2	3	2

Table 1. Data collected for *A. cervicornis*, *A. palmata*, and the two hybrid subgroups, *bushy prolifera* and *palmate prolifera*. N indicates the number of data collected, SD indicates standard deviation, and n represents the number of unique branches examined.

were statistically significant for comparison of *A. cervicornis* to both hybrid subgroups, and comparison of the hybrid subgroups to each other. Differences between *A. palmata* and the two hybrid subgroups were not statistically significant.

Porosity

A. cervicornis has the lowest average porosity (22%) of the acroporid groups studied, while *A. palmata* has the highest average porosity (36%) (Fig. 3). However, *A. palmata* also has the largest spread of data, with a bimodal distribution between 15-25% and 45-55% porosity (Fig. 4). *Bushy A. prolifera* and *palmate A. prolifera* are intermediate, although *palmate A. prolifera* has the higher average porosity (32%) of the two (26% for *bushy A. prolifera*). Differences were only significant for comparison of *A. cervicornis* to *palmate A. prolifera*.

DISCUSSION

For most of the characteristics, the hybrids are intermediate and the parent species are the end members (Fig. 3). This may not be surprising, since the hybrids share the genetics of both parents and so it may be assumed that their physical traits should be a compromise between the two phenotypes. While *bushy A. prolifera* has the highest number of corallites per cm², the large standard deviation of both it and

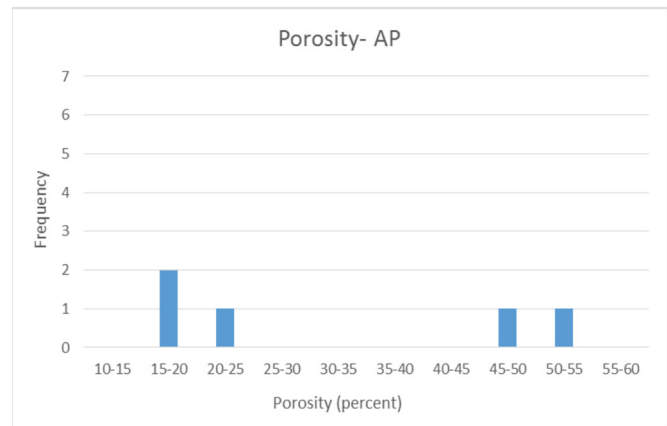


Figure 4. Graph showing the bimodal distribution of porosity for *A. palmata*.

A. palmata suggests that this may be an inaccurate reflection of their differences. This is reflected in the ANOVA test, which shows differences are not significant. It is possible that *A. palmata* has the highest number of corallites, but the two groups are too similar to draw clear conclusions.

When examining porosity, using averages glosses over the bimodal distribution of *A. palmata* (Fig. 4). The bimodal distribution may reflect differences between older and newly developing branch porosity, since samples were taken from both small, newly budding branches and older, more established branches. The newer branch showed higher porosity values, while the base sample showed much lower porosity. This could be related to observations that acroporids generally have two stages of branch development. The initial stage establishes a relatively low density skeleton framework. A second stage of skeletal infilling increases density (Roche et al., 2011). It is possible the older branch has already undergone infilling while the younger has not.

As noted above, hybrid colony morphology reflects paternal genetics. For example, hybrids with *A. palmata* as the father more closely resemble *A. palmata* (*palmate A. prolifera*), and those with *A. cervicornis* as the father resemble *A. cervicornis*

(bushy *A. prolifera*). Interestingly, the hybrid subgroups only follow paternal phenotypes for half of the characteristics when using averaged values. For both corallites per cm² and corallite diameter, the two hybrid subgroups have traits more like the maternal species than the paternal species.

Considering that the hybrid subgroups generally show intermediate physical properties compared to the two parent species, and that both parents appear in the fossil record (Aronson & Precht, 2001), *A. prolifera*, as a hybrid, should be incorporated into fossil assemblages as well. Based on branch angle, corallite height, corallite diameter, and corallites per cm², it should be possible to distinguish bushy *A. prolifera* from *A. cervicornis* in the field and also in the fossil record. Corallite height may also be useful, since there are significant differences between bushy *A. prolifera* and *A. palmata*. Due to the similarity between bushy *A. prolifera* and *A. palmata* for the other traits, overall colony or branch shape should be used to differentiate between the groups.

When distinguishing between *A. palmata* and palmate *A. prolifera*, corallite height and corallite diameter may be useful indicators. When comparing *A. cervicornis* to palmate *A. prolifera*, corallite height, diameter, and corallites per cm², along with branch morphology, could be used to discriminate between the two taxa.

Overall, results suggest that the hybrids fall between *A. cervicornis* and *A. palmata* for most of the characteristics examined. My data show that *A. prolifera*'s morphology is distinct enough that it can be differentiated from its parent species. Yet it is similar enough to the parents that it could be found in fossil reefs, due to its comparable preservational potential to the parent species which are fossilized (Aronson & Precht, 1997; Greenstein, 2006; Greer et al., 2009). Based on the conclusion that *A. prolifera* skeletons can be preserved, the fossil record should be reexamined to see if *A. prolifera* has been overlooked. If *A. prolifera* is not found in the fossil record, my data suggest that it is a new hybrid and may be indicative of the effects of climate change on reef ecosystems. However, the results presented here are preliminary findings, due to the small number of samples of protected coral species which could be obtained.

Future studies should be conducted using larger sample sizes of each subgroup. Additionally, branch density and permeability should be examined, as these skeletal characteristics can affect preservational potential (Greenstein, 2006).

CONCLUSION

In recent decades, the number of healthy *A. cervicornis* and *A. palmata* populations has been drastically declining in the Caribbean and Atlantic. At the same time, two hybrid subgroups of *Acropora prolifera* have been noted in the Caribbean. My results indicate that both subgroups of *A. prolifera* have preservational potentials that are equal to their parent species, *A. cervicornis* and *A. palmata*, and so should appear in the fossil record. Therefore, if *A. prolifera* has not been overlooked and is truly absent from the geologic record, *A. prolifera* likely represents a newly emerged hybrid and may be an indication of the effects of climate change on ocean ecosystems.

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REFERENCES

- Aronson, R.B., & Precht, W.F. (1997). Stasis, biological disturbance, and community structure of a Holocene coral reef. *Paleobiology*, 23(3), 326-346.
- Aronson, R.B., & Precht, W.F. (2001). White-band disease and the changing face of Caribbean corals. *Hydrobiologia*, 460, 25-38.
- De Kluijver, Gijswijt, M.G., De Leon, R., & Da Cunda, I. (2014). *Interactive guide to Caribbean diving*. Retrieved from http://species-identification.org/species.php?species_group=caribbean_diving_guide&id=294.
- Fogarty, N.D. (2007). Reproductive isolation and hybridization dynamics in threatened Caribbean

- acroporid corals. Retrieved from *Electronic Theses, Treatises and Dissertations*. Paper 4429.
- Fogarty, N.D., Vollmer, S.V., & Levitan, D.R. (2012). Weak prezygotic isolating mechanisms in threatened Caribbean *Acropora* corals. *PlosOne*, 7(2), e30486.
- Greenstein, B. (2006). Taphonomy: Detecting Critical Events in Fossil Reef Coral Assemblages. *Geological Approaches to Coral Reef Ecology*, 192, 31-60.
- Greer, L., Jackson, J.E., Curran, H.A., Guilderson, T., & Teneva, L. (2009). How vulnerable is *Acropora cervicornis* to environmental change? Lessons from the early to middle Holocene. *Geology*, 37 (3), 263-266.
- NOAA (2012). *Corals*. Retrieved from http://oceanservice.noaa.gov/education/tutorial_corals/welcome.html
- Roche, R.C., Abel, R.L., Johnson, K.G., & Perry, C.T. (2011). Spatial variation in porosity and skeletal element characteristics in apical tips of the branching coral *Acropora pulchra*. *Coral Reefs*, 30, (195-201).
- Vollmer, S.V., & S.R. (2002). Hybridization and the evolution of reef coral diversity. *Science*, 296 (5575), 2023-2025.
- Wallace, C.C. (1999). *Staghorn Corals of the World: A Revision of the Genus Acropora*. Collingwood, Australia: CSIRO Publishing.