

White plague disease outbreak in a coral reef at Los Roques National Park, Venezuela

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Abstract: Coral diseases have been reported as a major problem affecting Caribbean coral reefs. During August 2000, a coral mortality event of White Plague Disease-II (WPD-II) was observed at Madrizqui Reef in Los Roques National Park, Venezuela. This disease was identified as the major cause of coral mortality, affecting 24% of all colonies surveyed (n = 1 439). Other diseases such as Black Band Disease (BBD), Yellow Blotch Disease (YBD), Dark Spots Disease (DSD) and White Band Disease (WBD) were also recorded, but showed a lower incidence (0.14-0.97%). Two depth intervals, D1 (5.5-6.5 m) and D2 (9-9.5 m) were surveyed with two sets of three band transects 50 x 2 m long, placed parallel to the long axis of the reef. All healthy and injured corals, along each band transect, were counted and identified to species level. Additionally, all diseases and recent mortality that were still identifiable on each colony also were recorded. The incidence of colonies affected by WPD-II ranged from 12.8 to 33% among transects, where thirteen species of scleractinian corals showed several degrees of mortality. The species most affected were *Montastraea annularis* (39.13%), *M. faveolata* (26.67%), *M. franksi* (9.86%), *Stephanocoenia intersepta* (7.25%), *Colpophyllia natans* (6.96%), *Diploria labyrinthiformis* (2.99%), *Mycetophyllia aliciae* (2.03%), *M. cavernosa* (1.74%), and *D. strigosa* (1.45%). WPD-II was more common in the deeper strata (9-9.5 m), where 63% of the surveyed colonies were affected, although the disease was present along the entire reef. Presently, it is imperative to determine how fast the disease is spreading across the reef, how the disease spreads across the affected colonies and what the long-term effects on the reef will be.

Key words: White plague disease, coral diseases, coral reef, Los Roques, Venezuela.

Diseases of corals and other marine organisms are having significant deleterious impacts on the structure and function of coral reefs (ISRS 1999). For corals, marine mammals and other marine organisms, reports on the frequency of epidemics and the number of emergent diseases have increased recently (Gladfelter 1982, Edmunds 1991, Richardson *et al.* 1998a, Harvell *et al.* 1999, Green and Bruckner 2000). White Plague Disease (WPD) is a syndrome which mainly affects massive coral species; the disease was first described by Dustan (1977)

in the Florida Keys and later confirmed by Richardson *et al.* (1998 a, b) as WPD type II (WPD-II). Bruckner and Bruckner (1997) documented an outbreak of WPD in Puerto Rico, and more recently Green and Bruckner (2000) have extended their studies to the Bahamas, Puerto Rico and Florida. The rapid loss of tissue from the base of the colony upwards and leaving behind the coral skeleton bare is the main feature showed by infected colonies. The rates of tissue loss range from 3 mm to 2 cm day⁻¹ (Goreau *et al.* 1998, Richardson 1998).

Recently, different coral species showing WPD-II symptoms were detected at Madrizqui reef at Los Roques National Park. This park represents one of the most pristine marine environments of Venezuela, having a high coverage of living corals and extensive reefs. Only two studies examining coral diseases have been performed at the Los Roques Archipelago. Weil *et al.* (2000) carried out a survey at Key Dos Mosquises Sur and Boca de Cote Reef, while García (2001) conducted similar surveys around the Archipelago at seven localities. In both studies, the incidence of this disease seemed low; ranging from 1 to 6%. The main goal of this work was to assess and quantify the presence of colonies showing signs of WPD-II mortality and determine the coral species affected by the disease at Madrizqui Key.

MATERIALS AND METHODS

The Los Roques Archipelago is located 160 km north of the Venezuelan coast ($11^{\circ}44'26''$ - $11^{\circ}58'36''$ N, $66^{\circ}32'42''$ - $66^{\circ}57'26''$ W). The Archipelago has more than 40 coralline keys and over 200 sandy banks. The Keys form an irregular oval around a shallow lagoon, which is surrounded by two large barrier reefs; the eastern barrier is 20 km long, and the southern barrier is 30 km long. The reef site surveyed is located east of Madrizqui Key, which is oriented SE-NW close to Gran Roque Island. The reef forms a windward barrier, which is separated from the coast by a sandy lagoon, 50 to 100 m wide and 0.5-1.0 m depth. A shallow terrace of dead *Acropora palmata* followed by scattered colonies on a sandy substrate fringes colonize this sloping reef to a depth of 5 to 6 m. The lower slope, which descends to 6-12 m, is the largest reef zone and has the greatest coral abundance and diversity compared to reef platform.

The field study was conducted during August 22-31, 2000. Two sets of three transects, 50 m long, were placed parallel to the long axis of the reef. The first three transects were placed at 5.5-6.5 m depth, while the other three were at 9.0-9.5 m. Any healthy or diseased coral within the 2 m belt along each transect line, was identified to species level

and counted. All diseases and recent mortality that were still identifiable on each colony were also recorded. A set of bilingual underwater – laminated cards with descriptions and photographs of the diseases (published by Bruckner, Bruckner and Weil) was used as a guide to standardize identification of the different diseases and other causes of coral mortality. The proportion of colonies in each category (healthy, injured, and affected by each of the diseases) was calculated for all transects as a single pool. The percent of “x” species affected with “y” disease was calculated as follows: # colonies of “x” species affected with “y” disease /total number of colonies counted.

To test for significant differences between the occurrence of affected and healthy colonies and between depths, a Kruskal–Wallis Anova was performed. This analysis was applied because the data did not fulfill the assumptions for ANOVA test.

RESULTS

The reef was dominated by species of the genus *Montastraea* (*M. annularis*, *M. faveolata*, *M. franksi* and *M. cavernosa*), which represented more than 40% of the surveyed colonies. A total of 23 species were identified during the survey; 13 species showed signs of WPD-II and 23.97% of the coral colonies surveyed ($n=1\ 439$) were affected by WPD (Table 1). However, other diseases such as Black Band Disease (BBD), Dark Spots Disease (DSD), White Band Disease (WBD) and Yellow Blotch Disease (YBD) were also present, although with a lower incidence (Table 1). All the colonies affected by WPD had similar pattern of mortality, as the tissue destruction progressed from the base upward, it left behind a bare skeleton. The lack of algae overgrowth on the colonies suggests a rapid loss of tissue. Colonies with WPD-II in progress also were observed spreading over zones between healthy and affected colonies at both depths examined (Fig. 1).

Neither the incidence of WPD-II (Kruskal–Wallis $p>0.05$) nor the numbers of healthy colonies (Kruskal–Wallis $p>0.05$), were statistically different when comparing depth, cor-

TABLE 1

Percent of diseases on all coral species observed (n=1 439 colonies) at Madrizqui Reef, Los Roques, Venezuela

Species	Healthy col.	BBD	DSD	WBD	YBD	WPD	Dead	Total
<i>Acropora cervicornis</i>	4.17	0	0	0.97	0	0	0	5.14
<i>Agaricia agaricites</i>	8.06	0	0	0	0	0.14	0	8.20
<i>A. agaricites f. carinata</i>	2.29	0	0	0	0	0	0	2.29
<i>A. agaricites f. danai</i>	5.00	0	0	0	0	0.07	0	5.07
<i>Colpophyllia breviserialis</i>	0.07	0	0	0	0	0.07	0	0.14
<i>C. natans</i>	3.41	0.07	0	0	0	1.67	0	5.14
<i>Dendrogyra cylindrus</i>	0.07	0	0	0	0	0	0	0.07
<i>Diploria labyrinthiformis</i>	0.69	0	0	0	0	0.69	0.35	1.74
<i>D. strigosa</i>	0.63	0	0	0	0	0.35	0.07	1.04
<i>Eusmilia fastigiata</i>	0.83	0	0	0	0	0	0	0.83
<i>Madracis decactis</i>	0.28	0	0	0	0	0.07	0	0.35
<i>M. mirabilis</i>	2.02	0	0	0	0	0	0	2.02
<i>Meandrina meandrites</i>	0.42	0	0	0	0	0	0	0.42
<i>Montastraea annularis</i>	8.83	0	0	0	0.14	9.38	3.20	21.54
<i>M. cavernosa</i>	0.90	0	0	0	0	0.42	0	1.32
<i>M. faveolata</i>	5.00	0.07	0	0	0.97	6.39	0.49	12.02
<i>M. franksi</i>	5.91	0	0	0	0	2.36	0	8.27
<i>Mycetophyllia aliciae</i>	1.81	0	0	0	0	0.49	0	2.29
<i>Porites asteroides</i>	6.05	0	0	0	0	0	0.14	6.18
<i>P. porites</i>	3.27	0	0	0	0	0	0	3.27
<i>Siderastrea siderea</i>	1.04	0	0.14	0	0	0.14	0	1.32
<i>Stephanocoenia intersepta</i>	1.95	0	0	0	0	1.74	0	3.68
<i>Millepora alcicornis</i>	7.64	0	0	0	0	0	0	7.64
TOTAL	70.33	0.14	0.14	0.97	0.21	23.97	4.24	100.00

Black Band Disease (BBD), Dark Spots Disease (DSD), White Band Disease (WBD), Yellow Blotch Disease (YBD) and White Plague Disease (WPD).

TABLE 2

Kruskall–Wallis ANOVA results, for number of healthy colonies, number of colonies affected by WPD-II and depth

Dependent Variable	K-W Test (H)	N	P-level
Healthy colonies	1.1904	6	0.2723 n.s.
Colonies affected by WPD	2.3333	6	0.1266 n.s.

Independent variable is depth. n.s = not significant.

roborating the wide distribution of this disease across the reef (Table 2). The occurrence of colonies partially affected by WPD-II was high in comparison with the number of colonies showing total mortality (Table 3). The species *M. faveolata* showed similar percentages of affected colonies at both depth intervals, whereas the relative proportion of affected colonies of *M. annularis* increased from 3.87% (5.5-6.5

m) to 9.18% (9-9.5 m) (Table 4). The species *Montastraea annularis* (39.13%), *M. faveolata* (26.67%), *M. franksi* (9.86%), *Stephanocoenia intersepta* (7.25%), *Colpophyllia natans* (6.96%), *Diploria labyrinthiformis* (2.99%), *Mycetophyllia aliciae* (2.03%), *M. cavernosa* (1.74%), *D. strigosa* (1.45%), *Agaricia agaricites* (0.58%), and *Madracis decactis* (0.29%) appeared to be the more susceptible (Table 4).

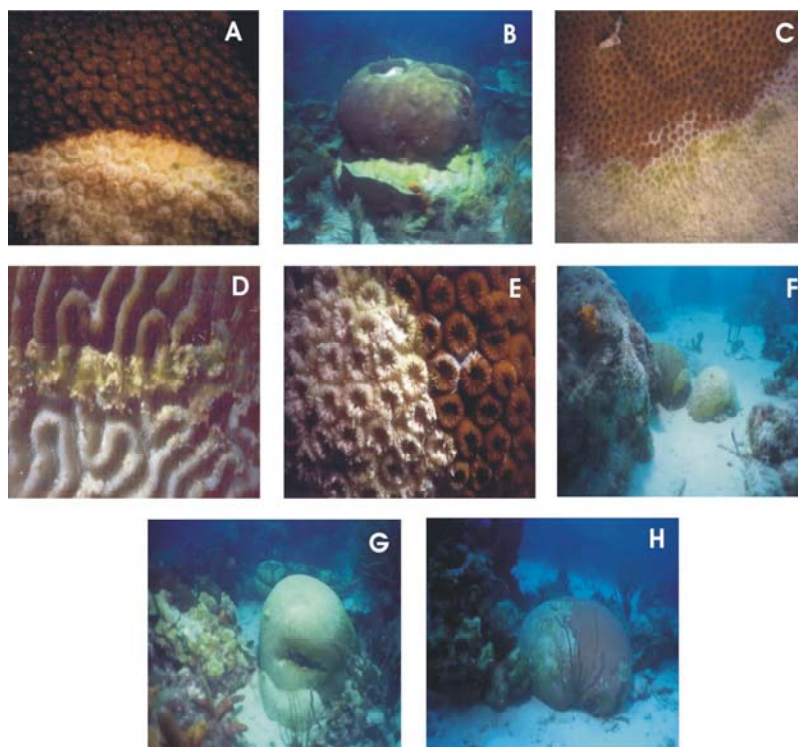


Fig. 1. Main coral species affected by White Plague Disease and general patterns of coral mortality at Madrizqui Coral Reef, Los Roques National Park. A. Close-up of *M. faveolata* showing the sharp line between healthy tissue and bare skeleton. B. Typical pattern of WPD on *M. faveolata*, notice the loss of tissue from the base upwards the colony. C. Close-up of *S. intersepta*. D. Close-up of *D. strigosa*, notice the bare skeleton. E. Close-up of *M. cavernosa*, notice no algae overgrowing on the bare skeleton. F. Two colonies of *D. strigosa*, one completely dead (right) and the other partially infected (left). G. *D. strigosa* showing typical pattern of infection. H. *S. siderea* showing the same pattern.

TABLE 3

Relative percent of diseased colonies at two depth intervals and total percent of all coral colonies (n=1 439) at Madrizqui Reef (August 2000)

Colonies	5.5 – 6.5 m		9 – 9.5 m		Total
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	
Black Band Disease	0.02	0.04	0.02	0.04	0.14
Dark Spots Disease	0.02	0.04	0.02	0.04	0.14
White Band Disease	0.32	0.30	0.00	0.00	0.97
White Plague Disease	2.97	1.70	5.03	1.95	23.97
Yellow Blotch Disease	0.00	0.00	0.07	0.07	0.21
Healthy colonies	9.47	2.66	13.97	3.76	70.33
Dead colonies	1.07	1.55	0.35	0.25	4.24

$\bar{x}$ = mean, S.D. = standard deviation

TABLE 4

Relative percent of coral species affected by White Plague Disease II at both depth intervals (n=345) on Madrizqui Reef (August 2000)

Species	5.5 – 6.5 m		9 – 9.5 m		Total
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	
<i>Agaricia agaricites</i>	0.10	0.17	0.10	0.17	0.58
<i>A. agaricites f. danai</i>	0.00	0.00	0.10	0.17	0.29
<i>Colpophyllia breviserialis</i>	0.00	0.00	0.10	0.17	0.29
<i>C. natans</i>	0.19	0.17	2.13	1.02	6.96
<i>Diploria labyrinthiformis</i>	0.77	1.10	0.19	0.17	2.99
<i>D. strigosa</i>	0.48	0.17	0.00	0.00	1.45
<i>Madracis decactis</i>	0.00	0.00	0.10	0.17	0.29
<i>Montastraea annularis</i>	3.87	5.94	9.18	4.70	39.13
<i>M. cavernosa</i>	0.19	0.17	0.39	0.44	1.74
<i>M. faveolata</i>	4.64	1.76	4.25	1.21	26.67
<i>M. franksi</i>	1.06	0.34	2.22	1.75	9.86
<i>Mycetophyllia aliciae</i>	0.00	0.00	0.68	0.17	2.03
<i>Siderastrea siderea</i>	0.10	0.17	0.10	0.17	0.58
<i>Stephanocoenia intersepta</i>	1.00	0.44	1.45	1.51	7.25
TOTAL	37.10		62.90		100.00

$\bar{x}$ = mean. S.D. = standard deviation.

DISCUSSION

Coral diseases have been identified as one of the major problems affecting coral reef health and decline (ISRS 1999). In spite of the growing number of reports of new diseases and coral mortality around the Caribbean, only a few quantitative studies have demonstrated important effects on reef communities (Green and Bruckner 2000). The most important reports on coral disease outbreaks have been made by Gladfelter (1982), Porter and Meier (1992), Bythell and Sheppard (1993), Garzón-Ferreira and Kielman (1993) and Richardson *et al.* (1998a). The Los Roques National Park Archipelago is one of the most important coralline areas in the Caribbean, due to its high living-coral abundance and reef extension. Previous reports have shown a low incidence (1-5%) of coral diseases on these reefs (Weil *et al.* 2000, García 2001), probably because Los Roques is located far from the mainland and has a relatively small human population. However, our results suggest that coral diseases might reach higher incidence in this Archipelago. The occurrence of infected colonies by WPD reported at Madrizqui (24%, this study), was comparable to the values reported

by Richardson *et al.* (1998a) affecting *Dichocoenia stockesii* populations in the Florida Keys. This syndrome had been observed in 18 coral species (Richardson *et al.* 1998b), dominant among *M. annularis*, *M. faveolata* and *C. natans*, which are the main reef builders in the Caribbean. Green and Bruckner (2000) published a similar list of species affected by WPD-II in the wider Caribbean.

The Madrizqui Key is located in close proximity to Gran Roque Island, the area where most of the human population of Los Roques is established. Moreover, this key is inside the Recreational Areas of the park, where tourists are allowed to stay overnight and major recreational activities take place (Zubillaga 2001). The widespread occurrence of WPD-II at Madrizqui Reef is likely to be a consequence of human activities and associated developments around this area, as already stated by Green and Bruckner (2000), who found a good correlation between coral disease reports and proximity to human settlements.

Although the significance and impact of this mortality event remains unclear and need to be studied further, our survey provides a basis as foundation for future work that could provide additional data to answer questions

such as: How rapidly does the disease kill the host? How fast it is spreading across the reefs? Is there any seasonal pattern? Which, if any, environmental factors (both natural and anthropogenic) are related to disease occurrence? And finally, what the ecology of the putative pathogens involved are, and the possible relationship between anthropogenic activities and reef health, which will require a better understanding of the overall reef ecology.

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RESUMEN

Las enfermedades que afectan a los corales han sido reportadas como uno de los principales problemas que afectan a los arrecifes del Caribe. Durante agosto de 2000, un evento de mortandad de Enfermedad de Plaga Blanca II (WPD-II) fue observado en el arrecife de Madrizquí en el Parque Nacional Los Roques, Venezuela. Esta enfermedad fue identificada como la principal causa de mortandad, afectando a 24% de todas las colonias muestreadas ($n = 1\,439$). Otras enfermedades como la banda negra (BBD), la banda amarilla (YBD), los lunares oscuros (DSD) y la banda blanca también se observaron pero con una menor incidencia (0.14-0.97%). Se muestrearon dos intervalos de profundidad: D1 (5.5-6.5 m) y D2 (9-9.5 m) con dos grupos de tres transectos de banda de 50 x 2 m de longitud, colocados paralelamente a la costa. Todas las colonias sanas y lesionadas dentro de estas bandas fueron identificadas y contabilizadas. Adicionalmente, las colonias afectadas por enfermedades y mortalidad reciente fueron contabilizadas e identificadas a nivel de especies. La incidencia de colonias afectadas por WPD-II varió entre

12.8 a 33% entre transectos, donde trece especies de corales escleractínidos mostraron diferentes grados de mortandad. Las especies más afectadas fueron *Montastraea annularis* (39.13%), *M. faveolata* (26.67%), *M. franksi* (9.86%), *Stephanocoenia intersepta* (7.25%), *Colpophyllia natans* (6.96%), *Diploria labyrinthiformis* (2.99%), *Mycetophyllia aliciae* (2.03%), *M. cavernosa* (1.74%) y *D. strigosa* (1.45%). La WPD-II fue mucho más común en los estratos más profundos (9-9.5 m), donde 63% de las colonias observadas estaban infectadas; aunque la enfermedad se distribuyó por todo el arrecife. Actualmente, es imperativo cuán rápido se está dispersando la enfermedad en el arrecife, la tasa de transmisión entre colonias enfermas y finalmente, qué efectos de largo plazo podrán presentarse.

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