

## Macroalgae of Puerto Morelos Reef System, Mexican Caribbean

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### ABSTRACT

A total of 113 species was found in Puerto Morelos reef system at four sampling sites in April 1995. Phycological differences were found between rear reef and reef lagoon as the Jaccard index accounts for only 28% of similarity between both habitats. It is evident that both habitats have different general conditions such as substrate and water motion, and they might some of the causes that produce quite different algal communities. A list of 245 species has been registered by 9 studies and our results for Puerto Morelos reef system. A wide difference in the number of reported species by different authors was found (158 to 23 species). Those results reflect different methods and sampling intensities used at each work. The species found in each sampling time can also be different because seasonal floristic changes and the occurrence of environmental disturbances such as hurricanes. Floristic differences found between authors, as well as differences at habitat level suggest that a continuous study is needed in all habitats of Puerto Morelos (rear and front reef, reef lagoon and deep waters) in order to have a better knowledge of this area.

**Key words:** Benthic algae, floristic affinity, reef system, mexican Caribbean, Puerto Morelos, Quintana Roo.

### RESUMEN

Se encontró un total de 113 especies en el sistema arrecifal de Puerto en cuatro estaciones de colecta en el mes de abril de 1995. Se encontraron diferencias ficológicas entre el arrecife y la laguna arrecifal dado que el Índice de Jaccard dió solamente un 28% de similitud entre ambos ambientes. Fue evidente que las condiciones generales de los dos ambientes, tales como substrato y movimiento de agua pueden estar relacionadas con la producción de comunidades algales completamente diferentes. Un total de 245 especies han sido registradas para el sistema arrecifal de Puerto Morelos en 9 trabajos y los resultados de este estudio. Se encontró una amplia diferencia en el número de especies registradas por los autores (158 a 23 especies). Estos resultados reflejan diferentes métodos de colecta e intensidades de trabajo de cada estudio, además que las especies encontradas en cada momento de colecta pueden ser diferentes en función de cambios estacionales o cambios debidos a disturbios ambientales tales como huracanes. Las diferencias florísticas encontradas entre los autores, así como las diferencias a nivel de ambiente encontradas en este estudio, sugieren que se requiere de un estudio continuo en todos los ambientes de Puerto Morelos (arrecife posterior y frontal, laguna arrecifal y aguas profundas), para tener un mejor conocimiento de las algas de ésta región.

**Palabras clave:** Algas bentónicas, sistema arrecifal, Caribe mexicano, afinidad florística, Puerto Morelos, Quintana Roo.

## INTRODUCTION

Coral reef systems are constructed mainly by corals and algae, particularly coralline and crustose algae due to their carbonate contents. Fleshy and filamentous algae have important ecological roles playing part in complex herbivory relations (Littler & Littler 1988). Phycological studies in the Caribbean began in 1707, revised by Diaz-Piferrer (1969). Taylor (1960) described in a monograph the material collected during the Allan Hancock expedition to the Caribbean, and a recent revision of the nomenclatural status of the species was realized by Wynne (1998). A field guide with a wide number of species for the Caribbean was prepared by Littler *et al.* (1990).

Phycological studies carried out in the Mexican Caribbean include those of Garza-Barrientos (1976), Mateo-Cid & Mendoza-González (1986, 1987a, b, c), Huerta *et al.* (1987), Mendoza-González & Mateo-Cid (1987), Mateo-Cid & Mendoza-González (1991), Aguilar-Rosas *et al.* (1992) all are basically floristic lists resulting from short visits to different places of the area. Jordán *et al.* (1978) mention the presence of some algae in a general study of the Nichupte Lagoon. More recently Collado-Vides (1992), Serviere *et al.* (1992), and Collado-Vides & González-González (1993), studied the algae of the Nichupte lagoon system, and with special interest on the floating masses of algae is the work of Collado-Vides *et al.* (1994) and those associated to mangrove roots Collado-Vides *et al.* (1995). Castillo-Arenas & Dreckmann (1995) studied drift algae particularly in Puerto Morelos. Specimens of *Laurencia* from Nichupte lagoon were analyzed by Fujii *et al.* (1996) and Comba (1996) studied the genus *Udotea* in Puerto Morelos and some other areas of the Mexican and Cuban Caribbean. Suárez *et al.* (1996) made a comparison between the flora of Cuba and Mexican Caribbean, and Dreckmann *et al.* (1996) give an actualized list of species for Puerto Morelos.

In this study a phycological characterization of the Puerto Morelos reef system is presented, together with a compilation of all the work done in this system in order to evaluate the phycological knowledge of the Puerto Morelos reef system.

## STUDY AREA

Puerto Morelos includes a barrier reef system with a north-south orientation. Jordán *et al.* (1981) suggest a division of the reef system in: reef lagoon, front and rear reef, and crest. The front reef forms a barrier against the open sea and protects the lagoon reef and rear reef from

direct wave action. The depth of the rear reef varies according to the size of the reef growth, a maximum of 6 m is reported in the mouth (Bocana) at the north of the reef and a minimum depth of 1 m at the south site (Ceiba). Substrate is essentially hard and carbonated, formed by corals such as *Acropora palmata* covered by algae and some patches of *Thalassia testudinum* Banks ex Koenig grow in depressions with accumulated sediments.

The lagoon reef is the area between the coast and the reef. Its width varies between 1.5 km at the north and 200-300 m close to Puerto Morelos village. Maximum depth is 4 m in the central lagoon. Substrate is characterized by sandy bottoms with little coral growth; algae and seagrasses are found growing in continuous fields with rare dense patches.

## MATERIAL AND METHODS

A general survey was done in physically contrasting habitats in April 1995 at Puerto Morelos reef system. Two sampling stations in the reef lagoon habitat and two in the rear reef habitat were selected (Fig. 1). Stations differ mainly in depth, substrate and water movement. At each sampling station algae were collected using SCUBA diving. Collected material was fixed in formaldehyde marine solution 4%, and deposited in the herbarium of the Facultad de Ciencias (FCME) of the Universidad Nacional Autónoma de México. Jaccard index was used to evaluate floristic differences between habitats, comparing both stations of reef lagoon against the two of the rear reef.

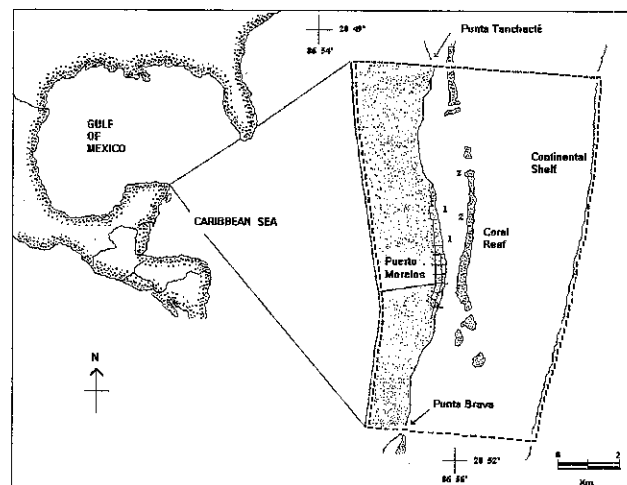


Figure 1. Study area. 1 = Lagoon sample stations; 2 = Reef sample stations.

Table 1.- Total number of species reported by author

1= This study; 2= Aguilar-Rosas, (1990); 3= Aguilar-Rosas (1992); 4= Garza-Barrientos, (1976); 5= Gómez-Pedroso, (1987); 6= Huerta-Muzquiz *et al.* (1987); 7= León-Tejera, (1980); 8= Torres-Mejía, (1991); 9= Castillo-Arenas y Dreckmann, (1995); 10= Dreckmann *et al.* (1996).

Species by author/Division	1	2	3	4	5	6	7	8	9	10	Total
Chlorophyta	50	48	5	34	52	32	26	32	8	29	92
Phaeophyta	16	19	1	10	19	13	7	7	10	9	34
Rhodophyta	40	56	17	41	87	22	13	15	11	22	119
Total	106	113	23	85	158	67	46	54	29	60	245

A bibliographic view on the records of algae for Puerto Morelos to date was registered. The nomenclatural status was actualized for all the species, based on: Dreckmann (1998); Wynne (1986, 1998) and Littler and Littler (1997).

## RESULTS AND DISCUSSION

### Habitat characterization

A total of 106 species was found, 50 belonging to Chlorophyta, 16 to Phaeophyta and 40 to Rhodophyta (Table 1).

The reef was found to have 62 species and the lagoon 72 (Fig. 2), the two areas also differ in the proportion of species per algal division: a higher number of species of Rhodophyta (20). In contrast more species of Chlorophyta (38) were found in the lagoon (Fig. 2).

Jaccard index showed a 28% of similarity between the two habitats. This data suggest that the reef and lagoon should be treated as two different habitats from the phycofloristic point of view.

The lagoon is characterized by green coenocytic algae of large size (up to 30 cm), with good rhizoidal systems that allow them to root in sand, such as *Penicillus capitatus*, *Avrainvillea nigricans*, *Udotea* spp. *Halimeda* spp. and stoloniferous algae such as *Caulerpa prolifera*. These species grow in patches of different densities, intermingled with seagrasses. Shrubby algae with basal discs, such as *Liagora farinosa* or *Laurencia intricata* can be found on corals or rocks haphazardly distributed on the lagoon. *Dictyota dichotoma* can grow prostrated covering different extensions of hard substratum. It is very common to find floating groups of algae in the lagoon, composed by species of *Lobophora variegata*, *Laurencia intricata*, *Codium decorticatum*, and others. These mats can be found close to the reef, in the middle lagoon or on the coast, depending on the direction and strength of the winds.

The reef is characterized by its high environmental heterogeneity, mainly due to the irregularity of the substratum and depth. A variety of microhabitats can be found such as highly illuminated platforms close to the crest, to shady places deeper in the reef or in caves formed by the irregular growth of corals, some protected from light. In this environmental diversity, algae are small (less than 10 cm high) with strong structures of fixation to the substratum, such as basal discs in *Laurencia papillosa* and *Halimeda discoidea*, or short strong cellular prolongations such as *Caulerpa racemosa* and *C. verticillata*. Some shrubby thalli are found growing above the corals such as *Gelidiella acerosa* which is an stoloniferous algae, always smaller than those of the lagoon. *Turbinaria turbinata* and *T. tricostata* are exceptions in size, since they can reach more than 10 cm in size but their thallus are flexible, and have strong haptera to fix to the substratum. However, both species were also found unattached in the lagoon and coast.

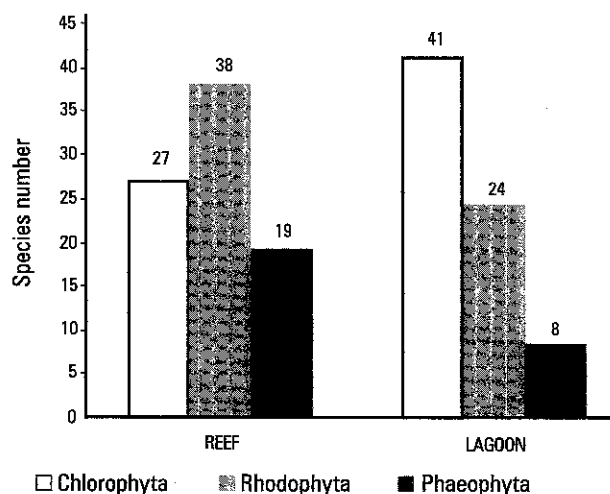


Figure 2. Number of species per division and per habitat.

Table 2.- List of species recorded for Puerto Morelos per habitat and author.

L= lagoon, R= Reef; \* = New record for the Mexican Caribbean, \*\* = New record for Puerto Morelos, Quintana Roo, México. See Table 1 for details of references.

TAXON	HABITAT	REFERENCES									
		1	2	3	4	5	6	7	8	9	10
<i>Acetabularia calyculus</i>	Lamouroux								X		
<i>A. crenulata</i>	Lamouroux		X	X	X						
<i>A. polyphysoides</i>	P. Crouan & H. Crouan in Mazé & Schramm				X						
<i>Anadyomene stellata</i>	(Wulfen in Jacquin) C. Agardh	L	X	X	X		X	X		X	
<i>Avrainvillea asarifolia</i>	BÆrgesen		X		X						
<i>A. longicaulis</i>	(Kützing) Murray & Boodle	L	X		X	X	X		X	X	
<i>A. nigricans</i>	Decaisne	L	X		X	X	X		X	X	
<i>A. rawsoni</i>	(Dickie) M. Howe	L	X		X	X			X	X	
<i>Batophora oerstedii</i>	J. Agardh	L	X			X				X	
<i>Bryopsis plumosa</i>	(Hudson) C. Agardh	R/L							X	X	
<i>B. pennata</i>	Lamouroux								X		
<i>Caulerpa cupressoides</i>	(West in Vahl) C. Agardh	L	X		X	X	X	X	X	X	
<i>C. cupressoides</i> var. <i>mamillosa</i>	(Montagne) Weber-Van Bosse						X	X			
<i>C. lanuginosa</i>	J. Agardh	L		X	X					X	
<i>C. mexicana</i>	Sonder ex Kützing	L	X		X	X				X	
<i>C. mexicana</i> f. <i>laxior</i>	(Weber-Van Bosse) W.R. Taylor						X				
<i>C. microphysa</i>	(Weber-Van Bosse) J. Feldmann	R			X						
<i>C. paspaloides</i>	(Bory) Greville	L	X		X				X	X	
<i>C. paspaloides</i> var. <i>compresa</i>	(Weber-Van Bosse) Howe				X						
<i>C. paspaloides</i> var. <i>wurdemanni</i>	Weber-Van Bosse						X				
<i>C. prolifera</i>	(Forsskål) Lamouroux	L	X		X	X		X	X	X	
<i>C. prolifera</i> f. <i>obovata</i>	J. Agardh				X						
<i>C. prolifera</i> f. <i>zosterifolia</i>	Bfrgesen						X				
<i>C. pusilla</i>	(Kützing) J. Agardh							X			
<i>C. racemosa</i>	(Forsskål) J. Agardh	R	X		X	X		X	X	X	
<i>C. racemosa</i> var. <i>macrophysa</i>	(Sonder ex Kützing) W. Taylor				X						
<i>C. racemosa</i> var. <i>occidentalis</i>	(J. Agardh) Bfrgesen				X						
<i>C. sertularoides</i>	(S. G. Gmelin) Howe		X		X	X					
<i>C. verticillata</i>	J. Agardh	R	X		X	X	X	X			
<i>Caulerpella ambigua</i>	(Okamura) Prud'Homme & Lokhorst		X				X	X			
<i>Chaetomorpha aerea</i>	(Dillwyn) Kützing				X				X		
<i>C. anteninna</i>	(Bory) Kützing						X				
<i>C. linum</i>	(O.F. Müller) Kützing				X						
<i>Cladocephalus luteofuscus</i>	(P. Crouan & H. Crouan) Bfrgesen		X		X						
<i>Cladophora brasiliiana</i>	Martens				X						
<i>C. catenata</i>	(Linnaeus) Kützing	L	X		X			X		X	
<i>C. montagneana</i>	Kützing				X						
<i>C. prolifera</i>	(Roth) Kützing									X	
<i>C. vagabunda</i>	(Linnaeus) van den Hoek		X		X	X	X				
<i>Cladophoropsis macromeres</i>	W.R. Taylor		X		X						
<i>C. membranacea</i>	(C. Agardh) Bfrgesen	L	X		X	X	X		X	X	
<i>Codium decorticatum</i>	(Woodward) M. Howe	R	X		X						
<i>C. isthmocladum</i>	Vickers	R/L			X	X	X			X	
<i>C. taylori</i>	P.C. Silva				X	X					
<i>Cymopolia barbata</i>	(Linnaeus) Lamouroux							X			
<b>CHLOROPHYTA</b>											
<i>Dasycladus vermicularis</i>	(Scopoli) Krasser		X		X	X					
<i>Derbesia osterhoutii</i> **	(L. Blinks & A.H. Blinks) Page	L									
<i>Dictyosphaeria cavernosa</i>	(Forsskål) Bfrgesen	R/L	X		X	X	X	X	X	X	X

Table 2. Continuation.

TAXON	HABITAT	REFERENCES									
		1	2	3	4	5	6	7	8	9	10
<i>D. ocellata</i> **	(Howe) Olsen – Stojkovich	R	X		X	X				X	
<i>D. versluysii</i> **	Weber - Van Bosse	L									
<i>Enteromorpha flexuosa</i>	(Wulfen) J. Agardh		X	X		X					
<i>Ernodesmis verticillata</i>	(Kützing) Bfrgesen		X		X						
<i>Halimeda copiosa</i> **	Goreau & Graham	R									
<i>H. discoidea</i>	Decaisne	R/L			X		X	X		X	
<i>H. favulosa</i> **	M. Howe	L									
<i>H. goreauii</i>	W.R. Taylor				X						
<i>H. gracilis</i> **	Harvey ex J. Agardh	L									
<i>H. incrassata</i>	(Ellis) Lamouroux	R/L	X	X	X	X	X	X	X		X
<i>H. lacrimosa</i>	Howe			X		X		X			
<i>H. monile</i>	(Ellis & Solander) Lamouroux	R/L	X	X	X	X	X	X			
<i>H. opuntia</i>	(Linnaeus) Lamouroux	R	X	X	X	X	X	X			X
<i>H. scabra</i>	M. Howe	R	X		X						
<i>H. simulans</i>	M. Howe	L			X		X	X			
<i>H. tuna</i>	(Ellis & Solander) Lamouroux	L	X		X	X	X	X			
<i>Neomeris annulata</i>	Dickie	L	X		X		X	X			X
<i>Penicillus capitatus</i>	Lamouroux	L			X	X		X	X		X
<i>P. dumetosus</i>	(Lamouroux) Blainville	R/L	X	X	X	X	X	X			X
<i>P. lamourouxii</i>	Decaisne	L	X	X	X	X					
<i>P. pyriformis</i>	A. Gepp & E. S. Gepp	L	X	X	X	X	X				X
<i>Rhipilia tomentosa</i>	Kützing		X		X						
<i>Rhipocephalus oblongus</i>	(Decaisne) Kützing	R	X		X		X	X			X
<i>R. phoenix</i>	(Ellis & Solander) Kützing	R/L	X		X	X	X	X			X
<i>R. phoenix</i> f. <i>brevifolius</i>	A. Gepp & E.S. Gepp				X						
<i>Rhizoclonium riparium</i>	(Roth) Kützing ex. Harvey		X			X					
<i>Siphonocladus rigidus</i>	M. Howe		X	X		X	X				
<i>Udotea abbottiorum</i> *	M. Littler, D. Littler & Reed	L									
<i>U. caribaea</i> *	D. Littler & M. Littler	L									
<i>U. conglutinata</i>	(Ellis & Solander) Lamouroux	R	X	X	X	X	X	X			
<i>U. cyathiformis</i>	Decaisne	R			X			X			
<i>U. cyathiformis</i> f. <i>sublittoralis</i>	(W.Taylor) Littler & Littler in Gepp & Gepp		X								
<i>U. dixoni</i> *	D. Littler & M. Littler	R/L									
<i>U. flabellum</i>	(Ellis & Solander) M. Howe	R/L	X		X		X	X	X	X	X
<i>U. loeensis</i> *	D. Littler & M. Littler,	L									
<i>U. luna</i> *	D. Littler & M. Littler	R/L									
<i>U. occidentalis</i>	A. Gepp & E. S. Gepp				X						
<i>U. spinulosa</i>	Howe								X		X
<i>U. wilsonii</i>	A. Gepp & E. S. Gepp & Howe	R/L			X		X	X			
<i>Ulva lactuca</i>	Linnaeus		X			X					
<i>U. rigida</i>	C. Agardh		X			X					
<i>Valonia macrophysa</i>	Kützing		X		X		X			X	
<i>V. utricularis</i>	(Roth) C. Agardh	R	X	X	X			X		X	
<i>Ventricaria ventricosa</i>	(J. Agardh) Olsen & J. West	R/L	X		X	X	X		X	X	
<b>PHAEOPHYTA</b>											
<i>Asteronema rhodoortonoides</i>	(Börgeesen) D. Müller & Parodi				X						
<i>Cladosiphon occidentalis</i>	Kylin		X	X		X					
<i>Dictyopteris delicatula</i>	Lamouroux				X	X	X				
<i>D. jamaicensis</i> **	W.R. Taylor	R									
<i>D. justii</i>	Lamouroux		X		X						
<i>Dictyota bartayresiana</i>	Lamouroux	R	X	X	X		X	X			

Table 2. Continuation.

TAXON	HABITAT	REFERENCES									
		1	2	3	4	5	6	7	8	9	10
<i>D. cervicornis</i>	Kützing	R	X		X			X		X	
<i>D. ciliolata</i>	Sonder ex Kützing		X		X						
<i>D. dichotoma</i>	(Hudson) Lamouroux	R/L	X		X					X	
<i>D. divaricata</i>	Lamouroux	R	X	X	X					X	
<i>D. guineensis</i>	(J. Agardh) P.Crouan & H. Crouan		X		X	X					
<i>D. jamaicensis</i>	W. R. Taylor		X		X						
<i>D. linearis*</i>	(C. Agardh) Greville	L									
<i>D. mertensii</i>	(Martius) Kützing	R/L	X		X						X
<i>D. pinnatifida</i>	Kützing		X		X		X				
<i>Lobophora variegata</i>	(Lamouroux) Womersley ex Oliveira	R/L	X		X	X	X	X	X	X	X
<i>Padina gymnospora</i>	(Kützing) Sonder.		X		X						
<i>P. pavonica</i>	(Linnaeus) Thivy in W. R. Taylor				X	X	X	X	X		
<i>P. sanctae crucis</i>	Bfrgesen		X		X						
<i>Ralfsia expansa</i>	(J. Agardh) J. Agardh				X						
<i>Sargassum cymosum</i>	C. Agardh					X				X	
<i>S. filipendula</i>	C. Agardh					X				X	
<i>S. fluitans</i>	(Börgeesen) Börgeesen	R/L	X			X				X	X
<i>S. furcatum</i>	Kützing									X	
<i>S. hystrix</i>	J. Agardh	R				X					
<i>S. hystrix</i> var. <i>buxifolium</i>	Chauvin in J. Agardh									X	X
<i>S. natans</i>	(Linnaeus) Gaillon	L				X					
<i>S. platycarpum</i>	Montagne	R									X
<i>S. polyceratium</i>	Montagne	R	X			X		X	X	X	
<i>S. vulgare</i>	C. Agardh					X					
<i>Spatoglossum schroederi</i>	(C. Agardh) Kützing.				X						
<i>Styopodium zonale</i>	(Lamouroux) Papenfuss	R	X		X	X	X	X	X		
<i>Turbinaria tricostata</i>	Barton	R/L	X		X	X	X	X		X	X
<i>T. turbinata</i>	(Linnaeus) Kuntze	R	X		X	X			X	X	X
<b>RHODOPHYTA</b>											
<i>Acanthophora spicifera</i>	(Vahl) Bfrgesen	R/L	X		X	X	X		X		
<i>Aglaothamnion cordatum</i>	(Börgeesen) Feldmann-Mazoyer		X	X		X					
<i>A. halliae</i>	(Collins) Aponte, Ballantine & J. Norris					X					
<i>Amphiroa beauvoisii</i>	Lamouroux						X	X			
<i>A. fragilissima</i>	(Linnaeus) Lamouroux	R	X		X	X	X	X	X		X
<i>A. rigida</i>	Lamouroux	R	X		X	X					X
<i>A. tribulus</i>	(Ellis & Solander) Lamouroux	R	X		X		X	X			X
<i>Anotrichum tenue</i>	(C. Agardh) Nägeli			X		X					
<i>Antithamnion cruciatum</i>	(C. Agardh) Nägeli			X		X					
<i>Asparagopsis taxiformis</i>	(Delile) Trevisan		X			X					
<i>Botryocladia pyriformis</i>	(Bfrgesen) Kylin							X			
<i>Bryothamnion seafortii</i>	(Turner) Kützing				X						
<i>B. triquetrum</i>	(S. G. Gmelin) Howe	R/L	X		X	X					X
<i>Centroceras clavulatum</i>	(Ag. In Kunth) Montagne in Durieu Maisonneuve	R	X		X	X	X			X	
<i>Ceramium diaphanum</i>	(Lighthfoot) Roth	R	X			X					
<i>C. flaccidum</i>	(Kützing) Ardisson	R			X						
<i>C. nitens</i>	(C. Agardh) J. Agardh	R/L	X			X	X				X
<i>C. rubrum**</i>	C. Agardh	R									
<i>Champia parvula</i>	(C. Agardh) Harvey	R/L	X		X	X					
<i>C. salicornoides</i>	Harvey					X	X	X	X		
<i>Chondracanthus teedii</i>	(Mertens ex Roth) Fredericq										X
<i>Chondria atropurpurea</i>	Harvey					X					
<i>C. baileyana</i>	(Montagne) Harvey		X			X					

Table 2. Continuation.

TAXON	HABITAT	REFERENCES									
		1	2	3	4	5	6	7	8	9	10
<i>C. capilaris</i>	(Hudson) Wynne	L			X	X	X	X	X		X
<i>C. cnicophylla</i>	(Melvill) De Toni	L								X	
<i>C. curvilineata</i>	Collins & Harvey										
<i>C. littoralis</i>	Harvey					X					
<i>C. platyramea</i>	Joly & Ugadim		X		X	X					
<i>C. polyrhiza</i>	Collins & Harvey		X	X		X					
<i>C. sedifolia</i>	Harvey		X		X	X					
<i>Coelothrix irregularis</i>	(Harvey) Brgesen					X					
<i>Crouania attenuata</i>	(C. Agardh) J. Agardh	R						X			
<i>Dasya antillarum</i>	(Howe) Millar	R	X								X
<i>D. baillouviana</i>	(S. G. Gmelin) Montagne			X							
<i>D. caraibica</i>	Brgesen		X			X					X
<i>D. collinsiana</i>	M. Howe		X			X					
<i>D. corymbifera</i>	J. Agardh		X			X					
<i>D. mollis</i>	Harvey		X			X					
<i>D. rigidula</i>	(Kützing) Ardissonne		X			X					
<i>Digenea simplex</i>	(Wulfen) C. Agardh		X		X	X					
<i>Dipterosiphonia dendritica</i>	(C. Agardh) Schmitz in Engler & Prantl	R/L	X		X	X	X	X		X	X
<i>Dohmiella antillarum</i>	(W.R. Taylor) Feldman-Mazoyer		X			X					
<i>Erythrotrichia carnea</i>	(Dillwyn) J. Agardh					X					
<i>Euchema isiforme</i>	(C. Agardh) J. Agardh			X				X			
<i>Galaxaura marginata**</i>	(Ellis & Solander) Lamouroux	R/L						X			
<i>G. obtusata**</i>	(Ellis & Solander) Lamouroux	R									
<i>G. rugosa</i>	(Ellis & Solander) Lamouroux	R									
<i>G. subverticillata</i>	Kjellman	R				X					
<i>Ganonema farinosum</i>	(Lamouroux) Fan & Wang	R					X	X	X		
<i>Gastroclonium parvum</i>	(Hollenberg) Chang & Xia	L	X			X	X				X
<i>Gelidiella acerosa</i>	(Forsskål) J. Feldmann & Hamel		X	X		X					
<i>G. trinitatensis</i>	W. R. Taylor	R/L	X			X	X	X	X		
<i>Gelidiopsis intricata</i>	(C. Agardh) Vickers			X							
<i>Gelidium americanum</i>	(Taylor) Santelices			X							
<i>G. pusillum</i>	(Stackhouse) Le Jolis					X					
<i>Gracilaria blodgettii</i>	Harvey		X		X		X				
<i>G. cervicornis</i>	(Turner) J. Agardh				X	X					
<i>G. multipartita</i>	(Clemente) Harvey		X			X					
<i>Gracillariopsis lemaneiformis**</i>	(Bory) Dawson, Acleto & Foldvik				X						
<i>Grallatoria reptans</i>	Howe	R									
<i>Griffitsia globulifera</i>	Harvey ex. Kützing	R	X	X		X					
<i>Gymnogongrus tenuis</i>	(J. Agardh) J. Agardh		X			X	X				
<i>Haliptilon cubense</i>	(Montagne ex Kützing) Garbary & Johansen				X						
<i>H. subulatum</i>	(Ellis & Solander) Johansen	R	X		X	X					
<i>Herposiphonia pecten - veneris</i>	(Harvey) Falkenberg			X		X					
<i>H. secunda</i>	(C. Agardh) Ambronn		X	X		X					
<i>H. secunda f. tenella</i>	(C. Agardh) Wynne	R	X			X	X				
<i>Heterosiphonia crispella</i>	(C. Agardh) Wynne	R/L			X	X				X	X
<i>H. gibbesii</i>	(Harvey) Falkenberg	L	X	X		X				X	X
<i>Hydropuntia cornea</i>	(J. Agardh) Wynne	L	X			X				X	
<i>H. crassissima</i>	(P. Crouan & H. Crouan in Schramm & Mazé) Wynne	L			X		X			X	X
<i>Hypnea musciformis</i>	(Wulfen in Jacquin) Lamouroux		X			X	X			X	
<i>H. spinella</i>	(J. Agardh) Kützing		X			X		X	X		
<i>Hypoglossum tenuifolium</i>	(Harvey) J. Agardh	R	X			X					
<i>Jania adherens</i>	Lamouroux	R	X		X	X	X	X	X		

Table 2. Continuation.

TAXON	HABITAT	REFERENCES									
		1	2	3	4	5	6	7	8	9	10
<i>J. pumila</i>	(Linnaeus) Lamouroux				X						
<i>Laurencia caraibica</i>	Silva				X						
<i>L. filiformis</i>	(C. Agardh) Montagne		X	X	X						
<i>L. flagellifera</i>	J. Agardh		X		X						
<i>L. intricata</i>	Lamouroux	R/L	X		X						X
<i>L. microcladia</i>	Kützing		X	X	X						
<i>L. obtusa</i>	(Hudson) Lamouroux	R/L			X	X		X			
<i>L. papillosa</i>	(C. Agardh) Greville	R	X	X	X	X					X
<i>L. poiteaui</i>	(Lamouroux) M. Howe	L	X		X					X	X
<i>Liagora ceranoides</i>	Lamouroux				X						
<i>L. dendroidea</i>	(P.Crouan & H. Crouan in Mazé & Schramm) I. A. Abbot				X	X					
<i>L. valida</i>	Harvey				X						
<i>Lithothamnion occidentale</i>	(Foslie) Foslie				X						
<i>Lophocladia trichoclados</i>	(J. Agardh) Schmitz		X	X	X						
<i>Lophosiphonia cristata</i>	Falkenberg		X	X	X						
<i>Mesophyllum mesomorphum</i>	(Foslie) Adey									X	
<i>Meristiella gelidium</i>	(J. Agardh) Cheney & Gabrielson				X			X			
<i>Micropeuce feredayae</i>	(Harvey) Kylin ex Silva		X		X						
<i>Neogoniolithon strictum</i>	(Foslie) Setchell & Mason		X							X	
<i>Polysiphonia breviarticulata</i>	(J. Agardh) Zanardini		X	X	X						
<i>P. ferulacea</i>	Suhringar ex. J. Agardh		X		X	X					
RHODOPHYTA											
<i>P. gorgoniae</i>	Harvey		X		X						
<i>P. howei</i>	Hellenberg in Taylor				X						X
<i>P. mollis</i>	Hooker & Harvey				X						
<i>P. scopulorum</i>	Harvey		X		X						
<i>P. scopulorum</i> var. <i>villum</i>	(J. Agardh) Holleberg			X							
<i>P. sertularoides</i>	(Grateloup) J. Agardh				X						
<i>P. sphaerocarpa</i>	Bfrgesen				X	X					
<i>P. tongatensis</i>	Harvey ex Kützing		X	X	X						
<i>Pneophyllum fragile</i>	Kützing				X						
<i>Pterocladia capillacea</i>	(S. G. Gmelin) Santelices & Hommersand	R			X		X				X
<i>Spermothamnium gymnocarpum</i>	M. Howe				X						
<i>Spyridia filamentosa</i>	(Wulfen) Harvey in Hooker	R/L	X	X	X						X
<i>S. hypnoides</i>	(Bory in Belanger) Papenfuss		X		X	X					
<i>Stylonema alsidii</i>	(Zanardini) Drew		X		X						
<i>Taenioma nanum</i>	(Kützing) Papenfuss		X	X	X						
<i>T. perpusillum</i>	(J. Agardh) J. Agardh								X		X
<i>Trichogloeopsis pedicelata</i>	(M. Howe) I. A. Abbott & Doty				X						
<i>Tricleocarpa cylindrica</i>	(Ellis & Solander) Huisman & Borowitzka								X		
<i>Wrangelia argus</i>	(Montagne) Montagne		X	X	X			X			
<i>W. bicuspidata</i>	Börgessen	L	X		X						X
<i>W. penicillata</i>	(C. Agardh) C. Agardh		X	X	X	X					
<i>Wurdemannia miniata</i>	(Sprengel) J. Fedelmann & Hamel				X						



The reef and lagoon are under similar general physical conditions, such as temperature, salinity, currents, and do not have any kind of physical barrier between them. Nevertheless, our results show that, from the phycological point of view, they are quite different.

### Bibliographic analysis

From the 10 phycological studies carried-out at Puerto Morelos (including the present one), a total of 245 species has been registered, of which, 92 species belong to Chlorophyta, 34 to Phaeophyta and 119 to Rhodophyta (Table 1).

It is noteworthy that 85 (32%) species have been reported only once (Table 2). There are great discrepancies between authors: Gómez-Pedroso (1987) reported the highest number of species (158), the rest of papers and theses recorded between 113 to 23 species (Table 1). Differences can be explained by several reasons: some species were probably misidentified, for example in the case of taxonomically difficult taxa such as *Polysiphonia*, *Laurencia* or *Halimeda*. Misidentification becomes a general problem when the work is done by unexperienced authors, particularly in some undergraduate students which results must be taken with caution or not to be used. Another important difference is the intensity of the identification work done by authors. In some studies, (Torres 1991), only conspicuous algae, higher than 3 cm, were identified in contrast others include small species of difficult determination giving an unreal high number of species.

The inclusion of new records by recent authors (Comba 1996), as in the case of species of the genus *Udotea* that has been recently revised by Littler & Littler (1990), is another cause of different results.

The objectives of the study were found to be another cause of differences found on results of the works consulted, for example Castillo-Arenas & Dreckman (1995) studied coast ashore algae, founding 28 species, León (1980) who focused her work on the reef found 50 species.

In our study, which includes only one date and four sampling stations, 106 species were found, from those, 11 are new records for the locality and 6 are new for the Mexican Caribbean (Table 2). It is also important to mention that sampling was done two days after Hurricane Roxanne and the species which were found are those that survived its effects.

Differences can also be explained by the season and/or year of sampling of each work. Puerto Morelos is localized in a geographical position characterized by eventual disturbances of different magnitude, from light constant

north winds to hurricanes as strong as Gilbert (1988). This kind of disturbances certainly have an effect on the phycological dynamics which still unknown for the area.

From our results and the literature analyzed we can conclude that we have a good knowledge of the phycoflora of Puerto Morelos reef system. Nevertheless there are taxonomic and ecological problems to be solved.

In the Chlorophyta, genera such as *Penicillus* and *Ripocephalus* have a morphological variation that has not yet been studied; *Udotea*, recently revised by Littler & Littler (1990) for the Caribbean, and by Comba (1996) for Puerto Morelos, still have problems in the morphological delimitation of several species, particularly *U. dixonii*, *U. doty* and *U. flabellum*. In the Rhodophyta, species of *Laurencia* are particularly difficult; it is a controversial genus world wide, and also at Puerto Morelos. Other example are the species of the genus *Gracilaria* Greville, that has taxonomical problems, and is also in need of evaluation as an important source of phycocolloids. In the Phaeophyta, the genus *Sargassum*, that has a high number of species and morphological diversity, is abundant and widely distributed at the locality, and has many taxonomical difficulties.

Ecological studies at the community and population level are important to carry out in order to understand the processes that are regulating the distributional patterns of algal species. Particularly, Puerto Morelos reef system is an interesting place to study the effect of disturbances on the community structure (Connell & Sousa 1983). It is a place under constant climatic disturbances, such as strong north winds and hurricanes. From our results, it is evident that the composition of algae species differs in lagoon and reef habitats, regardless of their proximity and gives basic knowledge to design future ecological studies.

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