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inventory

Inventory of benthic marine and estuarine algae and Cyanobacteria for Tabasco, México

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Abstract: Studies of benthic marine and estuarine algae as well as Cyanobacteria are in their early stages in the littoral of the state of Tabasco. Sixty seven taxa of seaweeds are currently known from Tabasco. The inventory of these organisms was made based on samples obtained in six localities, three of them in marine and three in estuarine environments. We found 147 species and subspecific taxa with Rhodophyta having the greatest number with 84, followed by Chlorophyta 44, and finally Phaeophyceae 19. In addition, the 26 species of Cyanobacteria collected are recorded for the first time for the coast of Tabasco since there are no previous reports. The presence of 115 species of benthic marine and estuarine algae is reported for the first time for Tabasco. Most of the new records are Rhodophyta (53.9%), followed by Chlorophyta (29.5%) and Phaeophyceae (16.6%). Of the 115 new records of algae for Tabasco, *Gayliella fimbriata* and *Grateloupia subpectinata* are new records also for the Mexican Atlantic. The highest number of species was recorded for Sanchez Magallanes breakwater, while the lowest number of taxa was recorded for Mecoacan Lagoon. According to the Feldmann and Cheney indexes the algal flora of the coast of Tabasco is tropical. The greatest diversity was found during the rainy season.

Keywords: *Tabasco, Mexico, new records, marine, estuarine, algae, Cyanobacteria.*

Inventário de algas bentônicas marinhas e estuarinas e cianobactérias para Tabasco, México

Resumo: Estudos sobre algas marinhas, estuarinas e cianobactérias para o litoral do estado de Tabasco encontram-se apenas nos estágios iniciais. Neste estudo, um inventário desses organismos foi feito com base em amostras obtidas em seis localidades, três delas marinhas e três em ambientes estuarinos. Os resultados indicaram a presença de 147 táxons, com Rhodophyta apresentando maior diversidade (84), seguido de Chlorophyta (44) e, finalmente, Phaeophyceae (19). Além disso, 26 espécies de Cyanobacteria são registradas pela primeira vez para a costa de Tabasco. A presença de 115 espécies de algas marinhas e estuarinas bentônicas é relatada peloa primeira vez para Tabasco. A maioria dos novos registros são de Rhodophyta (53.9%), seguido por Chlorophyta (25.9%), e Phaeophyceae (16.6%). Dos 115 novos registros de algas para Tabasco, *Gayliella fimbriata* e *Grateloupia subpectinata* são novos registros para a costa atlântica do México. O maior número de espécies foi localizado no paredão de Sanchez Magallanes, enquanto o menos número de táxons foi localizado na Lagoa Mecoacán. De acordo com os índices de Feldmann e Cheney, a flora de algas da costa de Tabasco é tropical, e a maior diversidade foi encontrada durante a estação chuvosa.

Palavras-chave: *Tabasco, México, registros novos, marinhos, estuarinos, algas, cianobactérias.*

Introduction

The Gulf of México is characterized by a relatively shallow but well developed continental shelf with an extensive system of generally deep, hard banks of varying origin and composition (Fredericq et al. 2009). In spite of the extension of the Gulf of Mexico coast, in the Mexican portion it has been scarcely studied from the phycological point of view. The phycological literature (Ortega et al. 2001; Wynne 2017) highlights the limited records for the coast of Tabasco. Orozco-Vega & Dreckmann (1995) reported six taxa for the Laguna Mecoacan, an estuarine environment; and Ramirez (1996) recorded 24 species of red algae (Rhodophyta) for the Sanchez-Magallanes breakwater. On the other hand, Dreckmann & De Lara (2000) described the vegetative and reproductive structures of *Gracilaria caudata* (Rhodophyta) for Laguna Mecoacan. Sentíes & Dreckmann (2013) updated information about the marine and estuarine algae for Tabasco, and recorded 50 taxa of algae for the Tabasco littoral. Recently, Quiroz-González et al. (2017) reported 17 Chlorophyta as new records for this coast. Of the five publications mentioned above, the most complete is that of Senties & Dreckmann (2015), who published an inventory of marine and estuarine algae recorded until 2000 for the coast of Tabasco; also sampled in four localities: Playa El Bellote, Playa El Cangrejo, Laguna Mecoacan and

Sánchez Magallanes breakwater, recording 50 taxa of algae, of which Rhodophyta had the highest number (38), followed by Phaeophyceae (7) and Chlorophyta (5). Quiroz-González et al (2017) carried out several collections in seven localities: Playa Miramar, Pico de Oro, Playa Paraiso, Poblado Chiltepec, Playa de Dos Bocas, Playa Las Brisas and Sanchez Magallanes breakwater; their study was based exclusively on Chlorophyta and the authors reported 17 new records of this group for the coast of Tabasco. In conclusion, it is evident that the length of the coast of Tabasco has not been equally inventoried and there are even portions which have not been studied at all, and the different groups of marine and estuarine algae have not been equally studied either.

Collectively, our knowledge about the cyanobacteria of the Tabasco coast is also limited. Cyanobacteria have been omitted in most studies conducted on the Mexican Atlantic benthic algae. Among the few reports that have been published is that of Mateo-Cid et al. (2013).

The aims of this study are to provide an updated revision of the diversity and distribution of the benthic marine and estuarine algae and Cyanobacteria of three new localities of the coast of Tabasco (San Pedro Centla, Laguna La Machona, La Machona), besides Sánchez Magallanes breakwater, Playa Paraíso breakwater and Laguna Mecoacan. We include records of new algae and cyanobacteria for Tabasco, as well as data about their distribution and temporal variation during the dry, rainy summer and rainy winter seasons (nortes). Using the Feldmann and Cheney indexes, the phycoflora of the coast of Tabasco will be classified as a function of the latitudinal gradient, and thus establish the basis for future taxonomic, ecological and biogeographic studies.

Materials and methods

1. Study site and collections

The shoreline of the state of Tabasco is between 092˚ 28 'and 094˚ 10' W, and 17˚15' and 18˚ 39' N, located in the southeast meso-region of Mexico, bounded on the north by the Gulf of Mexico (Figure 1); the south by the coastline of Tabasco; to the east northeast by the state of Campeche; and to the west by the state of Veracruz (Hernández-Santana et al., 2008). The Tabasco coastline presents a morphological predominance of low sandy beaches. The coast of Tabasco has a warm humid weather type Am (f): one with a higher annual average temperature of 22 ° C. Rains occur in the summer months and the precipitation of the driest month is less than 60 mm; the percentage of winter rain is higher than 10.2% of the annual total (García y Vidal-Zepeda, 1990a), with minimum extreme values between 20 and 22 ° C in January, and maximum between 30 and 34 ° C in May (García y Vidal-Zepeda, 1990b). Sampling was carried out in the littoral of Tabasco in August and November 2015 and in April and June 2016. The collections were made in the intertidal zone, 0.5 to 1.5 meters deep for sampling sites were chosen by the type of substrate and of access to the localities. A total of 120 samples was collected at six localities: Sanchez Magallanes breakwater (marine environment), La Machona (marine environment), Playa Paraiso breakwater (marine environment), Laguna La Machona, Laguna Mecoacan and Pedro Centla (these three localities of estuarine environment) (Figure 1). Data on the GPS coordinates, type of substrate, depth and date of collection in which organisms were obtained are shown in Table 1. Algae were preserved in a 5% formalin/sea water solution. Small fragments were cut manually with a double-edged blade, and stained with aniline blue and hematoxilin-eosine for anatomical observations and measurements. All specimens of red and brown macroalgae were carefully checked under the microscope for epiphytes. Using a stereoscopic microscope Zeigen HG571405 and an optical microscope OLYMPUS CX3 epiphytic algae were found growing on macroalgae as *Gracilaria, Grateloupia, Cladophora* and *Chnoospora*, among others. Thalli were thoroughly reviewed from the base to the apical portion locating filamentous epiphytes and articulated or fleshy macrophytes. After that using a double- edged blade, longitudinal scrapings of 2 cm of each thallus were performed in order to locate microscopic algae (Mateo-Cid et al., 2013).

Semi-permanent slides were prepared using corn syrup/water 1:1 with a trace of phenol added to prevent fungal growth. The identification at the

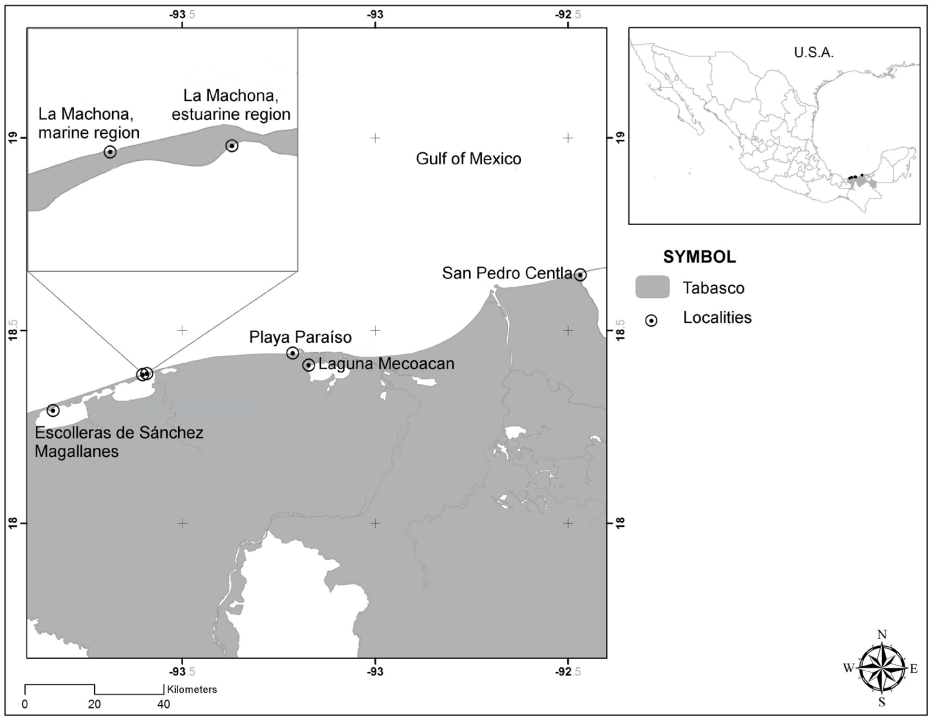

Figure 1. Map of the study area and sampling stations.

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Table 1. Location of sampling sites, substrate, environment, depth and collection dates.

Locality	GPS Coordinates	Substrate	Environment	Depth of collection	Collection dates
1. Sanchez Magallanes breakwater	18º17'26" N, 93º50'03" W	Rocks and artificial substrates	Marine	0-1 m	August and November, 2015; April and June 2016
2. La Machona	18º38'51" N, 93º60'61" W	Rocks	Marine	0 m	November 2015, April and June 2016
3. Laguna La Machona	18º17'56" N, 93º51'03" W	Aquatic vascular plants and artificial substrates	Estuarine	0-1 m	November 2015, April and June 2016
4. Playa Paraíso breakwater	18º23'33" N, 93º12'52" W	Rocks	Marine	0 m	August and November, 2015; April and June 2016
5. Laguna Mecoacan	18º24'37" N, 93º10'21" W	Rocks and artificial substrates	Estuarine	0-2 m	November 2015, April and June 2016
6. San Pedro Centla	18º38'41" N, 92º28'07" W	Cement floor and artificial substrates	Estuarine	0-1 m	November 2015, April and June 2016

specific level was based mainly on Taylor (1960), Schneider & Searles (1991), Littler & Littler (2000), Cho et al. (2008), Dawes & Mathieson (2008) and Won et al. (2009). For the determination of Cyanobacteria Gomont (1892), Anagnostidis & Komárek (1988), Komárek & Anagnostidis (1995), and Komárek et al. (2014) were used. The sequence of the floristic list follows the order proposed by Komárek (2010) for Cyanobacteria, Wynne (2017) and Guiry & Guiry (2017) for red, brown and green algae. Most of the material analyzed is deposited and available for study in the phycological section of "Herbario Escuela Nacional de Ciencias Biológicas at the Instituto Politécnico Nacional, Mexico".

For the study of descriptive phytogeography, Feldmann (1937) proposed the R / P index (number of Rhodophyta species divided by the number of Phaeophyceae species) useful for classifying the flora of a given region as a function of the latitudinal gradient. Thus, a value of the ratio R / P> 4 is characteristically found in tropical regions, while R / P <2 corresponds with a phycoflora of cool temperate regions. On the other hand, Cheney (1977) included the Chlorophyta (C) based on the one previously mentioned: (R + C) / P and verified that values of the ratio (R + C) / P> 6 are obtained in tropical floras, while those in temperate-cold seas are <3.

Results

1. New records of algae and cyanobacteria for Tabasco

A total of 173 taxa was identified, 84 of them are Rhodophyta, 44 Chlorophyta, 19 Phaeophyceae as well as 26 Cyanobacteria. The taxa identified from our collections are listed in Table 2 with sampling sites, seasonality, marine or estuarine environment and type of substrate where the organisms were collected, where the reference comes from, either from bibliography or collected by the authors, observations on new records for Tabasco and the Atlantic coast of Mexico and herbarium number. Many of the new algae records located in this study are epiphytes and they are not reported frequently in the floristic lists of Mexican coast of Gulf of Mexico (Ortega et al. 2001, Mateo-Cid et al. 2013, Senties & Dreckmann 2013, Wynne 2017).

Two red algae, *Gayliella fimbriata* (Setchell & N.L. Gardner) T.O. Cho & S.M. Boo and *Grateloupia subpectinata* Holmes are new records for the Atlantic coast of Mexico. Twenty six Cyanobacteria, 62 Rhodophyta, 18 Phaeophyceae and 34 Chlorophyta are new records for Tabasco. These new records are indicated in Table 2. The following families were the best represented in number of species in the study area: Rhodomelaceae (14), Ceramiaceae (12), Gracilariaceae (7), Cladophoraceae (19), Bryopsidaceae (8) and Ulvaceae (7). These families collectively include 45.57% of the total floristic diversity registered. The highest species richness was recorded in sampling sites with rocky substrate. The locality with the greatest diversity of species and subspecific taxa corresponds to the Sanchez Magallanes breakwater with 123 species, followed by the Playa Paraíso breakwater with 75, Laguna La Machona 35, La Machona 31, San Pedro Centla 26 and finally Laguna Mecoacan with 20 species (Figure 2).

Species and subspecific taxa such as *Jania ungulata* f. *brevior* Yendo, *Centroceras gasparrinii* (Meneghini) Kützing, *Spyridia clavata* Kützing, *Polysiphonia scopolorum* var. *villum* (J. Agardh) Hollenberg, *Peyssonnelia armorica* (P.L. Crouan & H.M. Crouan) Weber-van Bosse, *Hecatonema floridanum* (W.R. Taylor) W.R. Taylor, *Herponema tortugense* (W.R. Taylor) W.R. Taylor, *Rosenvingea orientalis* (J. Agardh) Børgesen, *Blidingia minima* (Nägeli ex Kützing) Kylin, *Cladophora crispula* Vickers and *Pseudobryopsis blomquistii* Diaz-Piferrer are considered unusual because few records are in the floristic lists of the Mexican coast of the Gulf of Mexico (Ortega et al. 2001, Mateo-Cid et al. 2013, Senties & Dreckmann 2013, Wynne 2017).

Thirty of the 67 species previously recorded for Tabasco (Orozco-Vega & Dreckmann 1995, Ramirez 1996, Dreckmann & De Lara-Isassi 2000, Senties & Dreckmann 2013, Quiroz-González et al., 2017) were found in this study. The other 115 species (table 2) are considered new records for Tabasco.

New records for the Atlantic coast of Mexico

Gayliella fimbriata and *Grateloupia subpectinata* of the coast of Tabasco, Mexico were recorded for the first time.

Description

Gayliella fimbriata (Setchell & N.L. Gardner) T.O. Cho & S.M. Boo (Figures 3a-d)

Type locality: Eureka, near La Paz, Lower California Mexico (Setchell & Gardner 1924: 777).

Basionym: *Ceramium fimbriatum* Setchell & N.L. Gardner 1924

Representative specimens examined: Sánchez Magallanes (Mendoza González & García López, 26.viii.2015, ENCB 22091, Vegetative).

Habit and anatomy: Thalli are 0.5–1.0 cm high, consisting of prostrate axes giving rise to erect axes (Figure 2). Erect axes bear forcipate incurved and complanate apical regions, main filaments 85-95 µm diameter at the nodes. Axial cells are spherical to cylindrical. The acropetal corticating filaments are 3–4 cells long, while the basipetal ones are 2–3 cells long. Branches are regularly alternate. Gland cells usually develop from cortical cells of acropetally and rarely basipetally corticating filaments, becoming strongly protruding, and are clavate, 60-65 µm x 30-34 µm.

Reproductive thalli were not found in our collections.

Comments: A particularly interesting case is the finding of *Gayliella fimbriata*, because this species was first described by Setchell and Gardner (1924) for the Bay of La Paz (Gulf of California, Mexico) as *Ceramium fimbriatum* and was subsequently transferred by Cho et al. (2008) to *G. fimbriata*. The presence of characteristic gland cells on the cortical cells and the dimensions of thalli agree with those recorded in specimens from La Paz, BCS, Mexico (Setchell & Gardner, 1924, Dawson, 1962).

Table 2. Marine and estuarine algae and Cyanobacteria of the coast of Tabasco (The abbreviations are explained at the end of the table).

DIVISION/SPECIES	LOCALITIES	SEASONALITY	ENVIRONMENT	SUBSTRATE	REFERENCE	OBS.	ENCB Herbarium number
CYANOBACTERIA							
Cyanophyceae							
Oscillatoriales							
Oscillatoriaceae							
1. *Blennothrix lyngbyacea* (Kützing ex Gomont) Anagnostidis et Komárek	1,6	W, S, R	M,E	Epi, As	A	NRT	21883
2. *Lyngbya confervoides* C. Agardh ex Gomont	1,4,6	W,S, R	M,E	As	A	NRT	21769 21963 21992
3. *L. majuscula* Harvey ex Gomont	1,3	R	M,E	Epi, Avp	A	NRT	21937 21962
4. *L. salina* Kützing ex Gomont	1	W, R	M	Epi	A	NRT	21968
5. *L. semiplena* J. Agardh ex Gomont	1,6	W, R	M,E	Epi	A	NRT	22010 22014
Homoeotrichaceae							
6. *Ammatoidea aegaea* Anagnostidis & Pantazidou	1	R	M	Epi	A	NRT	22014
Phormidiaceae							
7. *Coleofasciculus chthonoplastes* (Thuret ex Gomont) M. Siegesmund, J.R. Johansen & T. Friedl	5, 6	W	E	R, Epi	A	NRT	22173
Nostocales							
Aphanizomenonaceae							
8. *Nodularia harveyana* Thuret ex Bornet & Flahault	1	R	M	Epi	A	NRT	22014
Rivulariaceae							
9. *Calothrix confervicola* C. Agardh ex Bornet & Flahault	1	R	M	R, Epi	A	NRT	21880
10. *C. parietina* Thuret ex Bornet & Flahault	1,2,4	S, R	M	Epi	A	NRT	21921
Scytonemataceae							
11. *Scytonematopsis crustacea* (Thuret ex Bornet & Flahault) Kováli & Komárek	1,4	R	M	Epi	A	NRT	21910
Pseudanabaenales							
Pseudanabaenaceae							
12. *Leptolyngbya marina* (N.L. Gardner) Anagnostidis	1,2,3,4,6	W, R	M,E	Epi	A	NRT	21875 22111
Chroococcales							
Chroococcaceae							
13. *Chroococcus ercegovicii* Komárek & Anagnostidis	6	W	E	Epi	A	NRT	22173
14. *C. turgidus* (Kützing) Nägeli	1	S, R	M	Epi	A	NRT	22014
15. *Pseudocapsa maritima* Komárek	6	W	E	Epi	A	NRT	22173
Pleurocapsales							
Dermocarpellaceae							
16. *Cyanocystis hemisphaerica* (Setchell & N.L. Gardner) Kaas	1	R	M	Epi	A	NRT	21991
17. *Stanieria sublitoralis* (A. Lindstedt) Anagnostidis & Pantazidou	1,2	S, R	M	Epi	A	NRT	21921
Entophysalidaceae							
18. *Entophysalis conferta* (Kützing) F.E. Drouet & W.A. Daily	1,2,3,4,6	W, S, R	M,E	Epi	A	NRT	21772 21922
Xenococcaceae							
19. *Xenococcus cladophorae* (Tilden) Setchell & N.L. Gardner	3,5	W	E	Epi	A	NRT	22160
20. *X. minimus* Geitler	1	R	M	Epi	A	NRT	22311
21. *X. gilkeyae* Setchell & N.L .Gardner	1	W, R	M	Epi	A	NRT	21906
22. *X. pyriformis* Setchell & N.L. Gardner	5	W	E	Epi	A	NRT	21995

SIMBOLS: Localities: 1. Sánchez Magallanes 2. La Machona 3. Laguna La Machona 4. Playa Paraíso 5. Laguna Mecoacan 6. San Pedro Centla Seasonality: W (Winter rains) S (Dry) R (Summer rains) Environment: M: Marine E: Estuarine References (Data source) A. This study B. Senties & Dreckmann (2013) C. Quiroz-González, et al. (2017) OBS. (Observations) NRA: New record for Atlantic coast of Mexico NRT: New record for littoral of Tabasco Substrate: R: Rocky As: Artificial Substrate Cm: Cement floor Avp: Aquatic vascular plants Epi: Epiphytic on other algae

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Table 2. Continued...

DIVISION/SPECIES	LOCALITIES	SEASONALITY	ENVIRONMENT	SUBSTRATE	REFERENCE	OBS.	ENCB Herbarium number
Synechococcales							
Chamaesiphonaceae							
23. *Chamaesiphon rostafinskii* Hansgirg	1	R	M	Epi	A	NRT	22111
Merismopediaceae							
24. *Aphanocapsa litoralis* Hansgirg	1	S, R	M	Epi	A	NRT	22152
25. *A. marina* Hansgirg	6	R	E	Epi	A	NRT	22117
26. *Synechocystis minuscula* Woronichin	1,6	W, R	M,E	Epi	A	NRT	21998
RHODOPHYTA							
Bangiophyceae							
Bangiales							21906
Bangiaceae							21996 22133
27. *Bangia atropurpurea* (Mertens ex Roth) C. Agardh	1,3,5	W, R	M,E	As, R	A	NRT	
28. *B. fuscopurpurea* (Dillwyn) Lyngbye	6	W, S	E	As	A	NRT	21766 21848 22071
Compsopogonophyceae							
Erythropeltales							
Erythrotrichiaceae							
29. *Erythrotrichia carnea* (Dillwyn) J. Agardh	1,2,3,4,5	W, R	M,E	Epi	A, B		21770
30. *Sahlingia subintegra* (Rosenvinge) Kornmann	2,4	S, R	M	Epi	A	NRT	21913 22072
Stylonematophyceae							
Stylonematales							
Stylonemataceae							
31. *Chroodactylon ornatum* (C. Agardh) Basson	1,4	R	M	Epi	A	NRT	21970
32. *Stylonema alsidii* (Zanardini) K.M. Drew	1,4	S, R	M	Epi	A	NRT	21875 22062
Florideophyceae							
Acrochaetiales							
Acrochaetiaceae							
33. *Acrochaetium flexuosum* Vickers	1,3	W, R	M,E	Epi	A	NRT	21766 22063
34. *A. microscopicum* (Nägeli ex Kützing) Nägeli	1,2,4,6	W, S, R	M,E	Epi	A	NRT	21772 21849 22072
35. *Acrochaetium sancti-thomae* Børgesen	1	S	M	Epi	A	NRT	22093
36. *A. sagraeanum* (Montagne) Bornet	4	S	M	Epi	A	NRT	TAB-ENCB/A2
37. *A. secundatum* (Lyngbye) Nägeli	4	S	M	Epi	A	NRT	TAB-17/A1
Colaconematales							
Coleconemataceae							
38. *Colaconema dasyae* (Collins) Stegenga, I. Mol, Prud'homme van Reine & Lokhorst	1	R	M	Epi	A	NRT	21948 22064
39. *C. daviesii* (Dillwyn) Stegenga	1	S	M	Epi	A	NRT	22152
40. *C. hallandicum* (Kylin) Afonso-Carillo, Sanson, Sangil & Diaz-Villa	3	R	E	As	A	NRT	TAB-ENCB-C3
41. *C. hypneae* (Børgesen) A.A. Santos & W.N. Moura	1,2,3,4	S, R	M,E	Epi	A	NRT	21769 21898 21913 22082 21934
42. *C. savianum* (Meneghini) R. Nielsen	5	W	E	Epi	A	NRT	21995
Corallinales							
Corallinaceae							
43. *Hydrolithon farinosum* (J.V. Lamouroux) D.L. Penrose & Y.M. Chamberlain	4	S, R	M	Epi	A	NRT	21922
44. *Jania adhaerens* J.V. Lamouroux	1	R	M	R	A	NRT	22459

SIMBOLS: Localities: 1. Sánchez Magallanes 2. La Machona 3. Laguna La Machona 4. Playa Paraíso 5. Laguna Mecoacan 6. San Pedro Centla Seasonality: W (Winter rains) S (Dry) R (Summer rains) Environment: M: Marine E: Estuarine References (Data source) A. This study B. Senties & Dreckmann (2013) C. Quiroz-González, et al. (2017) OBS. (Observations) NRA: New record for Atlantic coast of Mexico NRT: New record for littoral of Tabasco Substrate: R: Rocky As: Artificial Substrate Cm: Cement floor Avp: Aquatic vascular plants Epi: Epiphytic on other algae

Table 2. Continued...

DIVISION/SPECIES	LOCALITIES	SEASONALITY	ENVIRONMENT	SUBSTRATE	REFERENCE	OBS.	ENCB Herbarium number
45. *J. capillacea* Harvey	4	R	M	R	A	NRT	22457
46. *J. ungulata* f. *brevior* Yendo	4	R	M	Epi	A	NRT	21206
47. *J. rubens* (Linnaeus) J.V. Lamouroux	4	S, R	M	R	A	NRT	22458
48. *Lithophyllum prototypum* (Foslie) Foslie	4	S	M	R	A	NRT	21621
49. *L. stictiforme* (Areschoug) Hauck	4	S, R	M	R	A	NRT	21620
Ceramiales							
Callithamniaceae							
50. *Aglaothamnion boergesenii* (Aponte & D.L. Ballantine) L'Hardy-Halos & Rueness	1	R	M	R	A	NRT	TAB-15-49/06
51. *Callithamnion corymbosum* (J.E. Smith) Lyngbye	1	S, R	M	Epi, R	A, B		22011 22042
Ceramiaceae							
52. *Antithamnionella boergesenii* (Cormaci & G.Furnari) Athanasiadis	1	R	M	Epi	A	NRT	22088
53. *An. elegans* (Berthold) J.H. Price & D.M. John	1	R	M	Epi	A	NRT	21929 22042
54. *Callithamniella tingitana* (Schousboe ex Bornet) Feldmann-Mazoyer	1	R	M	Epi	A	NRT	22138
55. *Centroceras gasparrinii* (Meneghini) Kützing	1,4	S, R	M	R, Cm	A	NRT	22043 22044 22045
56. *Cn. hyalacanthum* Kützing	1,4	R	M	Epi	A	NRT	21874 22047
57. *Cn. micracanthum* Kützing	1,4	W, S, R	M	R	A	NRT	22039
58. *Ceramium brevizonatum* var. *caraibicum* H.E. Petersen & Børgesen	4	R	M	R	A	NRT	22038
59. *C. cruciatum* F.S. Collins & Hervey	1,4	R	M	R	A	NRT	21883 22056
60. *C. leutzelburgii* Schmidt	5	S, R	E	Epi	A	NRT	22040
61. *Gayliella flaccida* (Harvey) T. O. Cho & L. J. McIvor	1,4	S, R	M	Epi	A	NRT	21874 22037
62. *G. fimbriata* (Setchell & N.L. Gardner) T.O. Cho & S.M. Boo	1	R	M	Epi	A	NRA	22091
63. *G. mazoyerae* T.O. Cho, Fredericq & Hommersand	1	R	M	Epi	A	NRT	22025
64. *G. transversalis* (Collins & Hervey) T.O. Cho & Fredericq	1	R	M	Epi	A	NRT	22111
Spyridiaceae							
65. *Spyridia clavata* Kützing	1	S	M	R	A	NRT	21977 21978
66. *S. hypnoides* (Bory de Saint-Vincent) Papenfuss	1	S	M	R	A, B		22090 22091
Wrangeliaceae							
67. *Wrangelia argus* (Montagne) Montagne	1,2,4	W, S, R	M	Epi, R, As	A	NRT	21973 21974 21975
Dasyaceae							
68. *Dasya pedicellata* (C. Agardh) C. Agardh	5	S	E	Cm	A, B		22034
69. *Heterosiphonia crispella* (C. Agardh) M.J. Wynne	4	R	M	Epi	A	NRT	22009
Delesseriaceae							
70. *Caloglossa leprieurii* (Montagne) G. Martens	6	W, S	E	Cm	A	NRT	22075
Rhodomelaceae							
71. *Acanthophora muscoides* (Linnaeus) Bory	1	W	M	R	A	NRT	21767
72. *A. spicifera* (Vahl) Børgesen	1,2,3,4	W, S, R	M,E	R	A, B		21769 21999 22000
73. *Bostrychia radicans (*Montagne) Montagne	6	S	E	As	A	NRT	TAB-15-D/11

SIMBOLS: Localities: 1. Sánchez Magallanes 2. La Machona 3. Laguna La Machona 4. Playa Paraíso 5. Laguna Mecoacan 6. San Pedro Centla Seasonality: W (Winter rains) S (Dry) R (Summer rains) Environment: M: Marine E: Estuarine References (Data source) A. This study B. Senties & Dreckmann (2013) C. Quiroz-González, et al. (2017) OBS. (Observations) NRA: New record for Atlantic coast of Mexico NRT: New record for littoral of Tabasco Substrate: R: Rocky As: Artificial Substrate Cm: Cement floor Avp: Aquatic vascular plants Epi: Epiphytic on other algae

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Table 2. Continued...

DIVISION/SPECIES	LOCALITIES	SEASONALITY	ENVIRONMENT	SUBSTRATE	REFERENCE	OBS.	ENCB Herbarium number
74. *Bryocladia cuspidata* (J. Agardh) De Toni	1,2,4	W, S, R	M	R	A, B		21990 22013
75. *B. thyrsigera* (J. Agardh) F. Schimtz	1,2,3,4	S, R	M,E	R	A	NRT	21906 22010 22012
76. *Chondria collinsiana* M. Howe	1	R	M	R	A	NRT	22140
77. *Melanothamnus ferulaceus* (Suhr ex J. Agardh) Díaz-Tapia & Maggs	1,2	S, R	M	R, Epi	A, B		21981 21983
78. *M. sphaerocarpus* (Børgesen) Díaz-Tapia & Maggs	4,5	W, R	M,E	As, Epi	A, B		21980 22005
79. *Polysiphonia atlantica* Kapraun & J.N. Norris	4,5	W, R	M,E	Epi	A	NRT	22005 22115
80. *P. havanensis* Montagne	1,4,6	W, S, R	M, E	Epi, As	A, B		22015 22114 22117
81. *P. schneideri* B. Stuercke & D.W. Freshwater	1	W	M	As	A	NRT	22140
82. *P. scopolorum* var. *villum* (J. Agardh) Hollenberg	1	R	M	Epi	A	NRT	22147
83. *P. subtilissima* Montagne	1,4,5	W, S, R	M,E	Cm, As	A, B		22002 22003 22113
84. *Yuzurua poiteauii* var. *gemmifera* (Harvey) M.J. Wynne	3	W	E	As	A	NRT	22120
Gelidiales							
Gelidiaceae							
85. *Gelidium americanum* (W.R. Taylor) Santelices	2,4,5	W, R	M,E	Cm, R	A	NRT	22023 22025 22032
86. *G. corneum* (Hudson) J.V. Lamouroux	1,2	W	M	R	A	NRT	22026 22027
87. *G. pusillum* (Stackhouse) Le Jolis	1,4	W, S, R	M	R	A, B		22007 22008
Pterocladiaceae							
88. *Pterocladiella sanctarum* (Feldmann & Hamel) Santelices	1	W	M	R	A	NRT	22061
Hildenbrandiales							
Hildenbrandiaceae							
89. *Hildenbrandia rubra* (Sommerfelt) Meneghini	1	R	M	R	A	NRT	21272
Peyssonneliales							
Peyssonneliaceae							
90. *Peyssonnelia armorica* (P.L. Crouan & H.M. Crouan) Weber-van Bosse	4	R	M	Epi	A	NRT	21620
91. *P. rubra* (Greville) J. Agardh	1,4	R	M	R	A	NRT	21348
Gigartinales							
Cystocloniaceae							
92. *Hypnea cornuta* (Kützing) J. Agardh	1	R	M	R	A	NRT	22049
93. *H. musciformis* (Wulfen in Jacquin) J. V. Lamouroux	1,2,4	S, R	M	Epi, R, As	A, B		22076 22078 22081
94. *H. spinella* (C. Agardh) Kützing	1,2,3,4	W, S, R	M,E	R, Epi	A, B		21875 22051 22052
95. *H. valentiae* (Turner) Montagne	1,2	S, R	M	R	A	NRT	22050
Gigartinaceae							
96. *Chondracanthus acicularis* (Roth) Fredericq	1	S	M	R	A	NRT	22108
Phyllophoraceae							
97. *Gymnogongrus griffithsiae* (Turner) Martius	1	W	M	R	A	NRT	22070
98. *G. tenuis* J. Agardh	1	W, R	M	R	A	NRT	21876 22103
Gracilariales							
Gracilariaceae							
99. *Gracilaria blodgettii* Harvey	1,3	W, S	M,E	R	A, B		22121 22122 22130
100. *G. bursa-pastoris* (S.G. Gmelin) P.C. Silva	3	R	E	As, Cm	A	NRT	22123
101. *G. caudata* J. Agardh	1,2,3,5	W, R	M,E	R, Cm	A, B		22068 22069

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Table 2. Continued...

DIVISION/SPECIES	LOCALITIES	SEASONALITY	ENVIRONMENT	SUBSTRATE	REFERENCE	OBS.	ENCB Herbarium number
102. *G. cervicornis* (Turner) J. Agardh	1	R	M	R	A, B		22110 22112
103. *G. damaecornis* J. Agardh	1,2	R	M	R	A, B		21852 21997
104. *G. flabelliformis* (P. Crouan & H. Crouan) Fredericq & Gurgel	1,3	S, R	M,E	R, Cm	A	NRT	21874 21875 22109
105. *Gracilariopsis longissima* (S.G. Gmelin) M. Steentoft, L.M. Irvine & W.F. Farnham	1,3	S, R	M,E	R, Cm	A	NRT	22085 22089
Halymeniales							
Halymeniaceae							21766 21995 21996
106. *Grateloupia filiformis* Kützing	1,2,3	W, S, R	M,E	R, Cm	A, B		
107. *G. gibbesii* Harvey	1	S	M	R	A	NRT	22094 22107
108. *G. subpectinata* Holmes	1.3	W,S,R	M, E	R, As	A	NRA	220021 22031
109. *Prionitis pterocladina* M.J. Wynne	1	R	M	R	A	NRT	22065 22067
Rhodymeniales							
Lomentariaceae							
110. *Ceratodictyon variabile* (J. Agardh) R.E. Norris	1,4	R	M	R	A	NRT	22086 22088
OCHROPHYTA							
Phaeophyceae							
Dictyotales							
Dictyotaceae							
111. *Dictyopteris delicatula* J.V. Lamouroux	4	R	M	R, Epi	A	NRT	21996
112. *Dictyota crenulata* J. Agardh	4	S, R	M	R	A	NRT	21958 22148
Asterocladales							
Asterocladaceae							
113. *Asterocladon rhodochortonoides* (Børgesen) S. Uwai, C. Nagasato, T. Motomura & K. Kogame	4	S	M	Epi	A	NRT	21947 22146
Scytothamnales							
Asteronemataceae							
114. *Asteronema breviarticulatum* (J. Agardh) Ouriques & Bouzon	4	R	M	R	A	NRT	21959 21960 21971
Bachelotiaceae							
115. *Bachelotia antillarum* (Grunow) Gerloff	1	R	M	R	A	NRT	21933 21954
Ectocarpales							
Acinetosporaceae							
116. *Feldmannia duchassaingiana* (Grunow) Aisha & Shameel	1,4	R	M	R	A	NRT	22481
117. *F. irregularis* (Kützing) Hamel	1	R	M	R	A	NRT	22482
118. *F. mitchelliae* (Harvey) H.S. Kim	1,2,3,4	S, R	M,E	Epi, Cm	A	NRT	21946 21948 21949 22144
119. *Herponema tortugense* (W.R. Taylor) W.R. Taylor	3	S	E	As	A	NRT	TAB-16-B/01
Chordariaceae							
120. *Hecatonema floridanum* (W.R. Taylor) W.R. Taylor	1	R	M	Epi	A	NRT	21853
121. *Kuetzingiella elachistaeformis* (Heydrich) M. Balakrishnan & Kinkar	1,4	S, R	M	Epi	A	NRT	21935
Ectocarpaceae							
122. *Ectocarpus siliculosus* (Dillwyn) Lyngbye	1,2,3,4	S, R	M,E	R, Cm	A	NRT	21938 21945 21950
Scytosiphonaceae							
123. *Chnoospora minima* (Hering) Papenfuss	1,2,4	S, R	M	R	A	NRT	21956 21961 21970

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Table 2. Continued...

DIVISION/SPECIES	LOCALITIES	SEASONALITY	ENVIRONMENT	SUBSTRATE	REFERENCE	OBS.	ENCB Herbarium number
124. *Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier	1,2,4	S, R	M	R	A	NRT	21942 22136
125. *Rosenvingea floridana* (W.R. Taylor) W.R. Taylor	1	S	M	R	A	NRT	22143
126. *R. intricata* (J. Agardh) Børgesen	1	S, R	M,E	R	A, B		22155
127. *R. orientalis* (J. Agardh) Børgesen	1	S	M	R	A	NRT	22135
Sphacelariales							
Sphacelariaceae							
128. *Sphacelaria rigidula* Kützing	1,2,3	W, R	M,E	Epi, Cm, As	A	NRT	21914 21965 21967
129. *S. tribuloides* Meneghini	1,2,3	R	M,E	R, Cm	A	NRT	21952 22150
CHLOROPHYTA							
Ulvophyceae							
Phaeophilales							
Phaeophilaceae							
130. *Phaeophila dendroides* (P.L. Crouan & H.M. Crouan) Batters	1,2,4,5	W, S, R	M,E	Epi	A	NRT	21863
Ulvales							
Kornmanniaceae							
131. *Blidingia marginata* (J. Agardh) P.J.L. Dangeard ex Bliding	1,6	W, S	M,E	Avp	A, C		21920 21944
132. *Bl. minima* (Nägeli ex Kützing) Kylin	1,4,5,6	W, S	M,E	Epi, Avp	A	NRT	21878 21896 21916 21969
Ulvaceae							
133. *Ulva clathrata* (Roth) C. Agardh.	3	W	E	As	A	NRT	21864
134. *U. compressa* Linnaeus	1,3,4,5,6	W, S, R	M,E	R, Epi, Cm	A, C		21775
135. *U. fasciata* Delile	1,4	S, R	M	R	A, C		21842 21894
136. *U. flexuosa* Wulfen	3,4,6	W, S, R	M,E	R, As	A, C		21778 21845 21882
137. *U. flexuosa* subsp. *paradoxa* (C. Agardh) M.J. Wynne	6	W, S	E	Cm	A, C	NRT	21873 21928
138. *U. intestinalis* Linnaeus	1,4,6	W, S, R	M,E	R, Cm	A, C		21915 21932
139. *U. rigida* C. Agardh	1,4	W, S, R	M	R	A, C		21856 21868
Ulvellaceae							
140. *Ulvella lens* P.L. Crouan & H.M. Crouan	1,2	R	M	Epi	A	NRT	21770
141. *Ul. scutata* (Reinke) R. Nielsen, C.J. O'Kelly & B. Wysor	3	S	E	As	A	NRT	TAB-ENCB/A
142. *Ul. viridis* (Reinke) R. Nielsen, C.J. O'Kelly & B. Wysor	1,4,5	W, R	M,E	Epi	A	NRT	21770 22073
Boodleaceae							
143. *Boodlea composita* (Harvey) F. Brand	4	W	M	R	A	NRT	21901
144. *Cladophoropsis membranacea* (Hofman Bang ex C. Agardh) Børgesen	4	S	M	R	A	NRT	21890
145. *C. sundanensis* Reinbold	1	R	M	R	A	NRT	TAB-ENCB/B1
Cladophoraceae							
146. *Chaetomorpha aerea* (Dillwyn) Kützing	1	S	M	R	A	NRT	21914
147. *Ch. antennina* (Bory) Kützing	1,2,4	W, S, R	M	R	A, C		21771 21855
148. *Ch. linum* (O.F. Müller) Kützing	3.5	W, S	M,E	Epi, Avp	A	NRT	21777 21860
149. *Ch. minima* Collins & Hervey	3	S	E	Epi	A	NRT	21924
150. *Ch. nodosa* Kützing	1,4	W, R	M	R	A, C		21839 21910
151. *Cladophora coelothrix* Kützing	1	R	M	R	A	NRT	21883
152. *Cl. crispula* Vickers	3,6	R	E	As, Cm	A	NRT	21937
153. *Cl. crystallina* (Roth) Kützing	1	R	M	R	A	NRT	TAB/15-54/04
154. *Cl. dalmatica* Kützing	4	S	M	R	A	NRT	21779
155. *Cl. flexuosa* (O.F. Müller) Kützing	1	R	M	R	A	NRT	TAB-15-54/02

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Table 2. Continued...

DIVISION/SPECIES	LOCALITIES	SEASONALITY	ENVIRONMENT	SUBSTRATE	REFERENCE	OBS.	ENCB Herbarium number
156. *Cl. fracta* (O.F. Müller ex Vahl) Kützing	1	S	M	R	A	NRT	21858
157. *Cl. glomerata* var. *crassior* (C. Agardh) Hoek	1	R	M	R	A	NRT	TAB-16-A/01
158. *Cl. hutchinsiae* (Dillwyn) Kützing	1,4	S	M	R	A	NRT	22137
159. *Cl. sericea* (Hudson) Kützing	1,4,6	S, R	M,E	R, Cm	A	NRT	21884 21887 21891
160. *Cl. submarina* P. Crouan & H. Crouan	1	R	M	Cm	A	NRT	21897
161. *C. vagabunda* (Linnaeus) van den Hoek	1,2,4,6	W, S, R	M,E	R, Cm	A, C		21770 21772 21904 21918
162. *Pseudorhizoclonium africanum* (Kützing) Boedeker	1,2,3	W, S	M,E	Epi, As	A	NRT	21860 21886 21926
163. *Rhizoclonium riparium* (Roth) Harvey	1,3,4,5,6	W, S, R	M,E	Epi	A, C		21840 21861
164. *Willeella brachyclados* (Montagne) M.J. Wynne	1,5,6	W, R	M,E	R, Cm	A	NRT	21773 22311
Bryopsidales							
Bryopsidaceae							
165. *Bryopsis halliae* W.R. Taylor	4	R	M	R	A	NRT	21843
166. *B, hypnoides* J.V. Lamouroux	1,4	R	M	R	A	NRT	21895 21919
167. *B. pennata* (Kützing) Collins & Hervey	1,4	R	M	R	A	NRT	21846 21877
168. *B. pennata* var. *leprieurii* (Kützing) Collins & Hervey	1,4	R	M	R	A	NRT	21776 21841
169. *B. pennata* var. *secunda* (Harvey) Collins & Hervey	1	R	M	R	A	NRT	21847 21863 22145
170. *B. plumosa* (Hudson) C. Agardh.	1,4	S, R	M	R	A	NRT	21774 21844
171. *Pseudobryopsis blomquistii* Díaz-Piferrer	4	S	M	R	A	NRT	22149
172. *Trichosolen duchassaingii* (J. Agardh) W.R. Taylor	4	R	M	R	A	NRT	21866 21867
Ulotrichales							
Ulotrichaceae							
173. *Urospora penicilliformis* (Roth) Areschoug	3	W	E	Avp	A	NRT	21848

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This species has been reported from Korea, Vietnam, Japan, China, India, Australia, New Zealand, Hawaii, Mariana Islands, Solomon Islands and Galapagos Islands (Guiry & Guiry, 2017). Therefore this is the first record of *Gayliella fimbriata* for Tabasco and moreover, for the Atlantic coast of America.

Grateloupia subpectinata Holmes (Figures 3 d-j)

Type locality: Japan.

Heterotypic synonyms:

Grateloupia luxurians (A. Gepp & E.S. Gepp) R.J. Wilkes, L.M. McIvor & Guiry 2005: 58

Grateloupia filicina var. *luxurians* A. Gepp & E.S. Gepp 1906: 259

Representative specimens examined: Sánchez Magallanes Breakwater (Mateo Cid, Mendoza González & Valencia Torres, 10.iv.2016, ENCB 22996, female thalli and tetrasporangial thalli); Laguna La Machona (Mateo Cid & Mendoza González, 10.iv.2016, ENCB 22006, female).

Habit and anatomy: The thallus arising from a discoid holdfast is formed by simple or pinnate erect fronds tapering at the ends, mainly compressed, mucilaginous but firm, reddish to blackish purple, sometimes greenish. Thalli are 2.0–7.0 cm high, simple linear compressed and 375-450 µm diameter; cortex 3-5 layers, the cells moniliform or rounded to stellate in

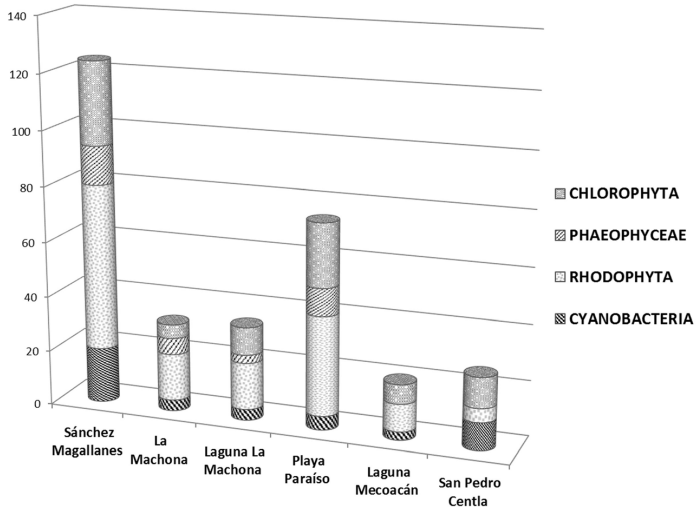

Figure 2. Number of species per division per locality

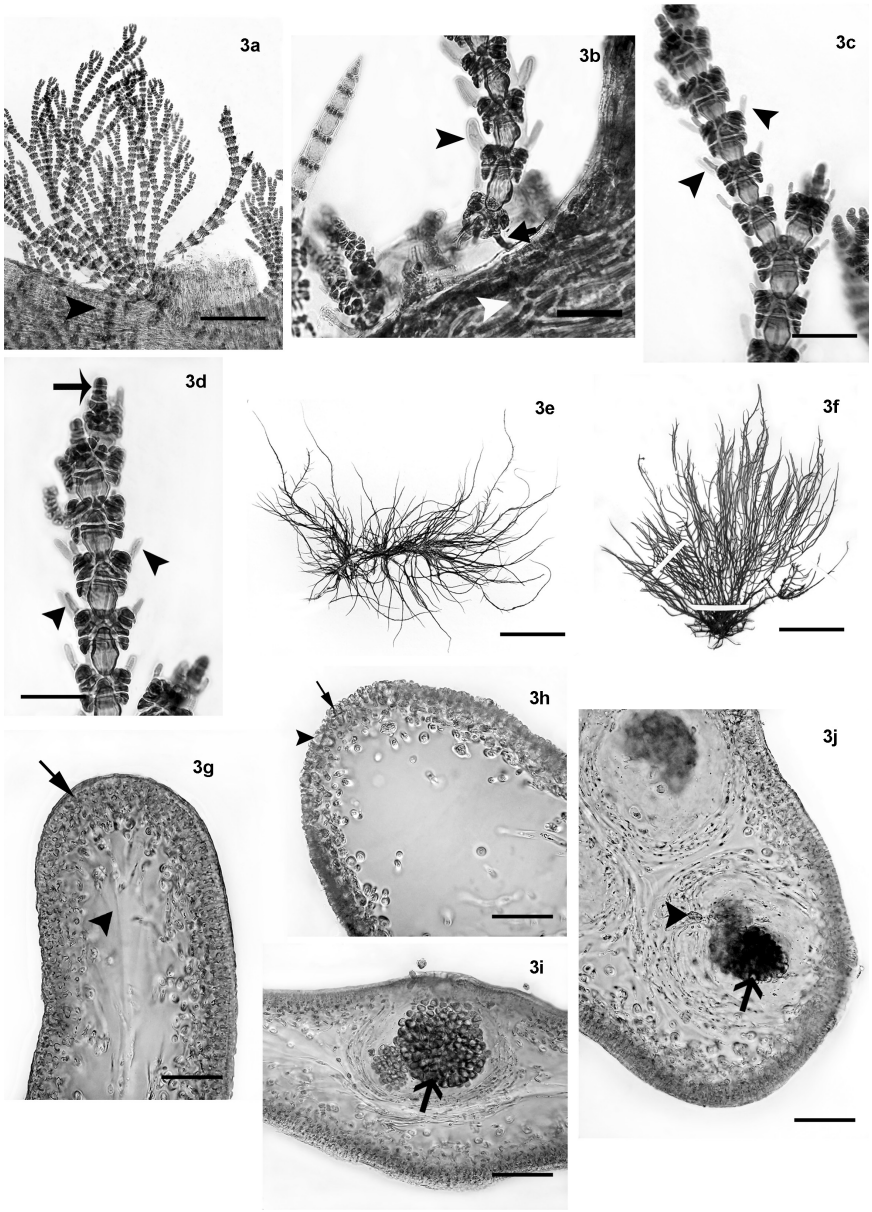

Figure 3. *Gayliella fimbriata:* Sánchez Magallanes (ENCB 22091). 3a. General appearance of the filamentous thallus growing on *Spyridia* sp (arrowhead). Scale 200 µm. 3b: Base of the thallus on the host (white arrowhead). Note rhizoid (arrow), and the prominent gland cells (black arrowhead) on the cortical bands. Scale 135 µm. 3c*:* Detail of verticilar arrangement of gland cells (arrowheads). Scale 25µm. 3d*:* Detail of an apical branch without forcipates apices. Note the apical cell (arrow) and gland cells (arrowheads). Scale 20 µm. 3e. *Grateloupia subpectinata:* Sanchez Magallanes (ENCB 22031), a: tetrasporangial thallus. Scale 1.6 cm. 3f: G. *subpectinata:* Sanchez Magallanes (ENCB 22016), Female thallus. Scale 1.8 cm. 3g: Cross-section through a blade showing cortex (arrow) and developing medulla. (Arrowhead). Scale 150 µm. 3h: Cross-section through a blade showing an immature tetrasporangium (arrowhead) and a mature, cruciately divided tetrasporangium. (Arrow) Scale 95 µm. 3i: Close-up of mature gonimoblast (arrow). Scale 80 µm. 3j: Cross-section through a blade showing the gonimoblasts (arrow) borne on an expanded fusion cell. Note the elongated ampullar filaments (arrowhead). Scale 60 µm.

shape 7-8 µm x 7.5-8.5 µm; medulla filamentous with lax filaments of 3-4 µm in diameter.

Tetrasporophytes and gametophytes isomorphic, the gametophytes dioecious with reproductive structures scattered over the entire thallus except the basal parts.

Tetrasporangia initiated from inner cortical cells, cruciately divided when mature, 14-15 µm wide x 29-30 µm long. Carposporangial ampullae not found; gonimoblasts 60-80 µm immersed inside the medulla and surrounded by branched ampullar filaments and a network of secondary medullary filaments.

Comments: Regarding the dimensions of the thallus, tetrasporangia and gonimoblasts show a smaller size than those recorded in specimens from Japan (Faye et al., 2004). Mexican specimens of *Grateloupia subpectinata* are morphologically similar to *G. filicina* (J.V. Lamouroux) J. Agardh. Nevertheless, both species have a considerable morphological plasticity (Faye et al., 2004, Verlaque et al., 2005). Compressed and branching *Grateloupia* species are notoriously difficult to identify due to their morphological similarity and lack of clear-cut diagnostic characters. The characteristics of our specimens are closer to the concept of *Grateloupia subpectinata*, so it is considered a new record for Tabasco and the Mexican Atlantic. This taxon has been also recorded in the Caribbean Islands (Wynne 2017), Britain, France, Spain and Australia (Guiry & Guiry 2017).

Discussion

1. Floristic composition

Here we report the presence of 115 previously unreported benthic marine and estuarine algae and 26 Cyanobacteria for the continental coasts of Tabasco, two of them, new records for the Atlantic coast of Mexico. Including the recently published reports of species from Tabasco (Senties & Dreckmann 2013, Quiroz-González et al., 2017), the total number of species increases to 194. This represents an increase of 150% (67) updated from the number published in the recent articles of Senties & Dreckmann (2013) and Quiroz-González et al. (2017), who based their analyses on reports in the literature and recent collections obtained by these authors. When analyzing the different taxonomic groups (Table 2), our survey resulted in a considerable increase in the number of Rhodophyta taxa (53.9%), followed by Chlorophyta (29.5%), and Phaeophyceae (16.6%).

Among the new records we can highlight: *Acrochaetium sagreanum, A. microscopicum*, *Antithamnionella boergesenii, An. elegans, Heterosiphonia crispella, Gayliella mazoyerae, G. fimbriata, Peyssonnelia armorica*, *Asterocladon rhodochortonoides*, *Hecatonema floridanum*, *Herponema tortugense, Phaeophila dendroides, Ulvella lens, Ul. scutata,* and *Ul. viridis*. Epiphytes are a very important group in the algal flora, especially in Tabasco, whose coast has many floodplains, extensive sandy beaches, coastal lagoons, breakwaters, and very exposed rocky coasts, lacking of algae.

In this study, a total of 26 taxa of Cyanobacteria were found at six localities of Tabasco and constituted 17.67% of the new records. A list of identified species is given in Table 2. There was a dominance of members of the orders Oscillatoriales and Pleurocapsales (27%), and Nostocales (15%), and all 26 taxa were reported for the first time in studies of the Tabasco coast. Species with wide distribution in the study area are *Lyngbya confervoides*, *Calothrix parietina and Scytonematopsis crustacea*, all of which have been reported in Campeche and Quintana Roo. With regard to the species of Chroococcales and Pleurocapsales, such as *Pseudocapsa maritima*, *Chroococcus ercegovicii*, *Aphanocapsa littoralis*, all were recorded from one locality, while *Entophysalis conferta* was present in five of the six study sites, being the most frequent and abundant of all the cyanobacteria recorded in our study.

In the last 50 years, the presence of cyanobacteria in brackish-water systems has been increasingly reported worldwide. Then, a wide diversity of cyanobacteria species can be found in brackish water systems (Lopes & Vasconcelos 2011). In this study, ten species of Cyanobacteria were observed in San Pedro Centla, locality with estuarine environment, while in the Sanchez Magallanes breakwater 16 species were recorded. Finding such a number of species confirms the ability of cyanobacteria to colonize the substrate available, ability for epiphytism, and to form mats in brackish (estuarine) and marine waters.

Most of these organisms requires culture studies and, when possible also the application of molecular-genetic techniques (Bernecker & Wehrtmann 2009). A detailed taxonomic analysis of these taxa will result in higher species numbers for Tabasco.

2. Type of environment and substrate

According to our study, of the 173 species, 109 develop exclusively in marine environment, 20 in estuarine environment, while 43 were located in both estuarine and marine environments. Most of the Rhodophyta develop in marine rocky areas, whereas members of Chlorophyta are established and developed in both marine and estuarine environments. In the case of brown algae, most of them (14) occur in the marine environment. These results agree with those described by McGlathery et al. (2013), who indicated that brown and red algae are almost exclusively marine species and the Chlorophyta can occasionally be abundant in the lower salt marsh zone in estuaries.

In our study, the localities with rocky substrate with marine water influence present high species richness compared with estuarine localities. A total of 89 species was registered in this type of substrate. The rocky substrate is favorable for the development of a great number of marine tropical seaweeds of Ceramiales, Corallinales, Cladophorales and Bryopsidales. On the other hand, the sampling sites with artificial substrate as plastic, net ropes, fishing lines, textiles and concrete debris present lower richness (25); it may be because the artificial substrate limits growth of marine algae and cyanobacteria because they aren't hard and/or stable (Santelices 1977, Garduño-Solórzano et al. 2005, Mateo-Cid et al. 2013). Moreover, our results agree with the statement by Hartog (1967), who indicates that the flora of the brackish water is poor in species in comparison with those of the sea and the fresh water. Most of the marine organisms are stenohaline and are unable to live permanently in water with a higher or lower salt-content than that of the sea.

3. Epiphytic species

Epiphytes are small size, often microscopic, and their adaptive strategy as epiphytes depends on the permanence of their host and is affected by competition between them for the substrate and light, among other factors. The identification of these species is complicated because their characteristics are difficult to observe. On the other hand, previous works were developed with different objectives, so they have not been similarly inventoried.

Seventy-five epiphytic species (Table 2) were found, 25 of which correspond to Cyanobacteria, 35 to Rhodophyta, six to Phaeophyceae and nine to Chlorophyta. The highest number of epiphytes was observed in the dry season with 45, with a greater number of cyanobacterial species, as well as the families Acrochaetiaceae, Rhodomelaceae and Ceramiaceae, which cover other algae up to almost 90% of their surface. This finding agrees with what is observed in some brown algae and marine phanerogams, in which the level of epiphytism is greater when the surface and biomass of these organisms are larger. This condition is also attributed to the decrease of defense substances against the epiphytes as the host becomes senescent (Ortuño-Aguirre and Riosmena-Rodríguez, 2007).

Most of the epiphytes were frequently found growing on perennial red algae such as *Acanthophora, Bryocladia, Gracilaria,* and *Grateloupia.* It has been suggested that host longevity should be long enough to allow these organisms to complete their life cycle and that this might be a likely reason for the absence of epiphytes on annual and ephemeral algae (Santelices, 1977).

4. Seasonality

Temperature and light determine the latitudinal distribution of seaweeds, and therefore their geographical distribution for they also influence the composition, variation and periodicity of populations at the intertidal and subtidal levels (Santelices, 1977). In our study area summer days are 4 to 5 hours longer that in the winter. Hence, the availability of light for seaweed and estuarine organisms is higher, which influences the species richness of these organisms during the summer (rainy season), with 62 Rhodophyta (49.2%), 15 Phaeophyceae (11.9%), 28 Chlorophyta (22.2%) and 21 Cyanobacteria (16.68%). The lowest specific richness occurred in winter rains ("nortes" in which the rain is greater than 10.2% and temperature values between 20 and 22 ° C) with 29 Rhodophyta (46.77%), 1 Phaeophyceae (1.62%), 19 Chlorophyta (30.65%), and 13 Cyanobacteria (20.96%). Finally, during the dry season 41 Rhodophyta (49.4%), 11 Phaeophyceae (13.3%), 24 Chlorophyta (28.9%), and 7 Cyanobacteria (8.4%) occurred (Figure 4) for our results are similar to those reported in previous studies in the Mexican Atlantic where mentioned that the species richness of algae is higher in the rainy season (Ortega et al., 2001, Callejas-Jimenez et al, 2005, Mateo-Cid et al., 2013).

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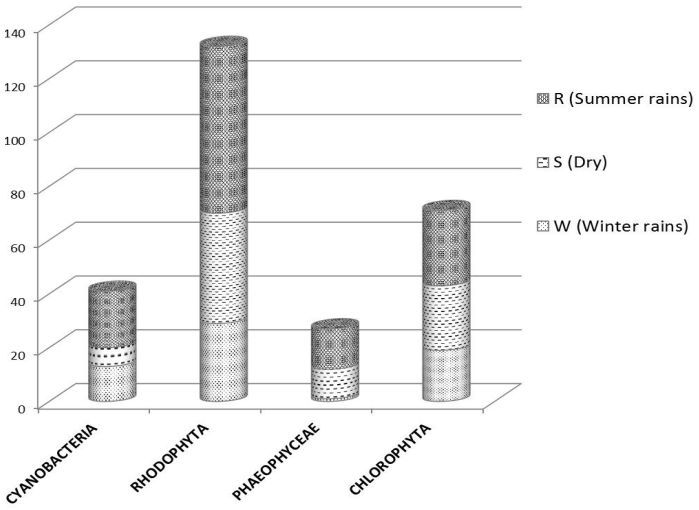

Figure 4. Number of species per division per season

Table 3. Feldmann and Cheney indexes for some marine and estuarine environments of the Gulf of Mexico and Mexican Caribbean coast.

Locality	Feldmann Index (R/P)	Cheney Index (R+C)/P
Isla Mujeres, Quintana Roo	4.50	7.15
Isla Cozumel, Quintana Roo	4.40	7.04
Puerto Morelos, Quintana Roo	3.40	5.60
Coast of Yucatan	6.00	9.00
Coast of Campeche	5.37	9.30
Coast of Tabasco (This study)	4.42	6.73

In the rocky zone of the Sanchez Magallanes breakwater and Playa Paraiso breakwater numerous species of the families Corallinaceae, Rhodomelaceae, Ectocarpaceae, Dictyotaceae and Ulvaceae occurred. Rhodophyta dominates in number, with 60 in Sánchez Magallanes and 36 in Playa Paraíso. In the dry and rainy seasons *Ulva fasciata*, *U. rigida, Cladophora vagabunda* and *Bryopsis pennata* are common; while *Asteronema breviarticulatum* and *Ectocarpus siliculosus* are the most common in the rainy season. It is evident that in the estuarine areas the smallest number of species is presented, the Laguna Mecoacan having the lowest diversity with only 10 Rhodophyta, 7 Chlorophyta and 3 Cyanobacteria.

5. Biogeography

The results of the present study were analyzed applying the Feldmann and the Cheney indexes and compared with findings by Mateo-Cid & Mendoza-González (2007) for Cozumel island; Mendoza-González et al. (2007) of Mujeres Island, Dreckmann et al. (1996) for Puerto Morelos, Huerta-Múzquiz et al. (1987), Ortegón-Aznar et al. (2001, 2009) and Sánchez-Molina et al. (2007) for the coast of Yucatán and Mateo-Cid et al. (2013) for the coast of Campeche. Table 3 shows the data obtained applying the Feldmann and Cheney indexes to the five regions mentioned; the phycoflora of the study area is similar to that of the coast of the state of Quintana Roo, with a value close to that obtained for the Cozumel and Mujeres Islands, both distinctly Caribbean localities.

The indexes used indicate that the marine and estuarine algae of the coast of Tabasco have a predominantly tropical distribution, with tropical elements such as *Melanothamnus ferulaceus*, *Hypnea musciformis, Jania adhaerens, Gracilaria flabelliformis, Gracilariopsis longissima, Dictyopteris delicatula, Dictyota crenulata, Chnoospora minima, Chaetomorpha antennina, Ulva rigida* and *Cladophora flexuosa*, among others. The phycoflora of the coast of Tabasco conforms to the pattern found in all coastlines of the states of the Gulf of Mexico (Ortega et al. 2001, Mateo-Cid et al., 2013).

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Author contributions

A. Catalina Mendoza-González collected and identified specimens, analyzed data and participated in writing the text.

Luz Elena Mateo-Cid collected and identified specimens, participated in writing the text, analyzed data and edited the photographs.

Deisy Yazmín García-López collected and identified the samples and edited map.

All authors contributed to critical revision, adding intellectual content.

Conflicts of interest

The authors declare that they have no conflict of interest related to the publication of this manuscript.

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