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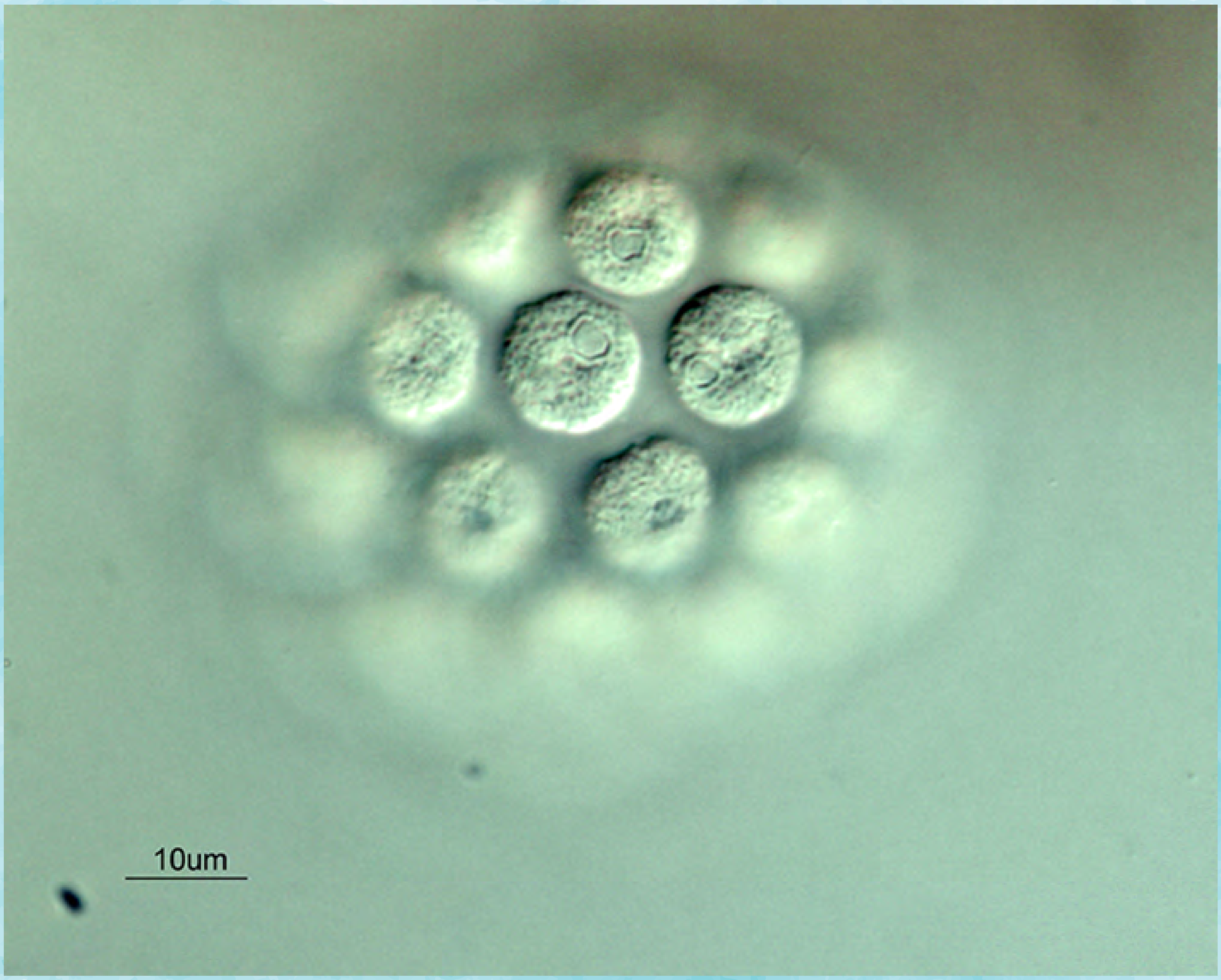
Floristics of epiphytic diatoms on *Thalassia testudinum* from the southern Gulf of Mexico



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El primer número del volumen 7 de *Cymbella* ofrece dos textos florísticos que muestran, nuevamente, la necesidad de seguir estudiando las algas de nuestro país, ambos señalan novedades florísticas, 29 primeros registros de Coscinodiscophyceae en la Isla Guadalupe y el otro anota 238 taxones de los cuales 25 son registros nuevos para el Golfo de México y 27 para las otras costas mexicanas. Lo que hace un total de 267 registros de taxones en las costas de México. Estos registros son resultado de la insistencia de los colegas en conocer y difundir la flora mexicana. *Cymbella* es el medio de difusión para la florística y ese tipo de trabajos siempre serán bienvenidos.

No podemos exigir que se conserven los ecosistemas si no somos capaces de mostrar lo que contienen. Si una de nuestras responsabilidades como ficólogos es la conservación de la diversidad algal, esa tarea empieza con el registro y documentación de la riqueza biológica nacional y regional. Y ese conocimiento y registro, a pesar de ser fundamentales son difícilmente aceptados en otras publicaciones. Y parte causal de la reticencia a publicar este tipo de trabajos es la confusión entre lo moderno y lo antiguo, o eufemísticamente lo tradicional. Esta falsa dicotomía es producto de una visión dividida de las necesidades: las personales o las nacionales. No se trata de criticar, ambas son necesarias, pero lo que es falso es que una sea mejor que la otra. Así como los colegas necesitan publicar en revistas con un factor de impacto alto, también es necesario conocer lo que no aceptan las revistas de ese tipo. Esta falsa dicotomía tiene muchas expresiones, desde la que opone la "taxonomía tradicional" contra la taxonomía moderna o contemporánea (es decir, con biología molecular), hasta las consideraciones de las etapas consecutivas del conocimiento taxonómico (taxonomías alfa, beta y gama) y finalmente las que consideran que existe una crisis en la taxonomía por el cambio de "paradigmas" en la forma como conocemos la biodiversidad. En los enfoques polifásicos, polifacéticos o de taxonomía integral existe la intención de recuperar parte de lo que es la taxonomía como disciplina integrativa, pero los estándares impuestos por las revistas implican siempre la utilización, como fase final e indiscutible, el análisis de secuencias y las relaciones filogenéticas moleculares como criterio de modernidad.

Para tratar de explicar a un grupo de estudiantes la importancia de conocer la estructura, la biología reproductiva, la ultraestructura y las filogenias moleculares como una unidad necesaria en la descripción de las especies, usé como método didáctico una analogía relacionada con la historia de la música. Reconocemos y disfrutamos de la música antigua, la barroca, la clásica, etc., así en el trabajo taxonómico, requerimos y reconocemos de los conocimientos de los autores de los siglos XVIII al actual. Y curiosamente, hay cierta correspondencia con el avance entre los patrones en la composición usados por los grandes músicos y las fases por las que ha pasado el conocimiento de las algas. Como un mero ejercicio para el gozo en reconocer los aportes históricos podríamos hacer la siguiente comparación, en la columna izquierda los periodos musicales, en el centro las fechas aproximadas y en la derecha los principales grupos de caracteres de los sistemas taxonómicos usados en la ficología:

Periodo barroco	≈ 1750	Morfología del talo adulto
Periodo clásico	≈ 1800	Tipos de reproducción
Periodo romántico	≈ 1860	Ciclos de vida
Periodo postromántico	≈ 1900	Bioquímica estructural
Periodo impresionista	≈ 1950	Distribución y extensión de caracteres
Periodo moderno	≈ 1980	Ultraestructura y bioquímica metabólica
Periodo contemporáneo	≈ actual	Biología molecular

Disfrutamos de las grandes obras musicales, sin necesidad de un orden cronológico estricto, pues podemos pasar de Bach, a Ravel, a Stravinsky y a Pärt, así podemos hacer la taxonomía, de lo morfológico macro, a los ciclos de vida y a la biología molecular. Y así como ya no podemos llamar “música clásica” a toda la gama de músicas no “populares” que existen, tampoco podemos llamar taxonomía tradicional a todo lo que no es biología molecular; todo elemento es valioso y necesario. Como podemos reconocer las grandes diferencias y los aportes de cada autor musical, así podremos reconocer y valorar cada elemento que constituye esas obras de arte que llamamos algas.
Incluimos el mapa de visitas a la revista según Google Analytics de los últimos 12 meses. ¡La siguiente meta es aumentar el tono del azul en todo el mundo!

Floristics of epiphytic diatoms on *Thalassia testudinum* from the southern Gulf of Mexico

Florística de diatomeas epífitas de *Thalassia testudinum* del sur del golfo de México

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ABSTRACT

Benthic diatoms are fast colonizers of live substrata, covering large surfaces of their hosts. Few studies exist on floristics of the epiphytic diatoms for the coasts of Mexico, and most of them deal with epiphytic diatoms that live on macroalgae or mangrove roots, while seagrasses which also provide an excellent substrate for diatoms are even scarcer. Our aim was to describe the species composition of epiphytic diatoms growing on blades of *Thalassia testudinum* from the southern Gulf of Mexico. To do this, three bundles of blades of *T. testudinum* were collected in each of 23 sampling sites off the coast of Campeche, Mexico. Epiphytic diatoms were scrapped off from the blades and then were oxidized to clean the diatom frustules, which were then mounted on permanent slides with Pleurax for taxonomic identification using light microscopy with plan-apochromatic optics. Overall, 238 taxa from 66 genera were identified, out of which 25 are new records for the Gulf of Mexico and 52 are new records for the Mexican coasts. The genus *Mastogloia* was the best represented with 51 taxa. This taxocoenosis surpasses the species richness recorded for other seagrass systems and is among the richest for Mexican littorals.

Key words: Campeche, epiphytic diatoms, seagrasses, taxocoenosis

RESUMEN

Las diatomeas bentónicas colonizan rápidamente sustratos vivos, llegando a cubrir gran parte de la superficie disponible de su hospedero. Los pocos estudios sobre florística de diatomeas epifitas para las costas de México tratan principalmente sobre diatomeas epifitas de macroalgas y raíces de mangles, mientras que, sobre pastos marinos, los cuales ofrecen un excelente sustrato para diatomeas, son aún más escasos. Nuestro objetivo fue describir la composición de especies de diatomeas epifitas que proliferan sobre hojas de *Thalassia testudinum* del sur del golfo de México. Para ello, se hicieron muestreos en 23 estaciones en la costa de Campeche, México,

recolectando tres haces de *T. testudinum* en cada una. Las hojas de cada haz se rasparon para la obtención de las diatomeas y el material obtenido se oxidó para limpiar las frústulas y facilitar su identificación. Se montaron en preparaciones permanentes con Pleurax y se revisaron bajo un microscopio compuesto con óptica planapocromática. Se identificaron 238 taxones pertenecientes a 66 géneros de los cuales *Mastogloia* (51 taxones) presentó la mayor riqueza. De los taxones identificados, 25 son nuevos registros para el golfo de México, y 52 son nuevos registros para las costas de México. La taxocenosis descrita supera a las registradas para otros ambientes de pastos marinos y representa una de las más ricas para litorales mexicanos.
Palabras clave: Campeche, diatomeas epifitas, pastos marinos, taxocenosis

INTRODUCTION

Benthic diatoms play an important role within the microbial communities that characterize certain habitats (Siqueiros-Beltrones 2002). They are fast colonizers of both non-living surfaces (MacLulich 1986) and live substrata (Sieburth & Thomas 1973) where they may cover a great part of the available surfaces of their hosts, such as macroalgae (Siqueiros-Beltrones *et al.* 2004; Siqueiros Beltrones *et al.* 2016) or seagrasses (Siqueiros-Beltrones & Ibarra-Obando 1985).

Although studies on epiphytic diatoms may be considered lacking worldwide, mainly because of the enormous scientific research potential around them, sufficient theoretical basis exists to address and investigate diverse roles of epiphytic diatoms, weather on their taxonomy including floristics, their ecology, biogeography, or eco-physiological interactions with their hosts. However, there is still much to do concerning floristics alone (Siqueiros-Beltrones & Martínez-Hernández 2017).

For the Mexican coasts little research exist and has been done on diatom floristics, m ost r elated to epiphytic diatoms from macroalgal hosts. Evidence from these studies suggests that macroalgae provide more than just attaching surfaces for diatoms (Hernández-Almeida & Siqueiros-Beltrones 2008, 2012; Siqueiros-Beltrones & Hernández-Almeida 2006). On the other hand, pioneer research that can be traced to the first floristic study on diatoms found living on blades of sea grass (*Zostera marina* L.) in NW Mexico shows that seagrasses also provide vast surfaces for colonization by as many as 215 species of diatoms, either free living or colonial forms (Siqueiros-Beltrones & Ibarra-Obando 1985). Elsewhere, in Caribbean waters (Grand Cayman) Corlett and Jones (2007) recorded 61 diatom species on *T. testudinum* blades, while López-Fuerte *et al.* (2013) identified 107 taxa and infra-species from Laguna de Yalahau for the Mexican Caribbean. Likewise, along the Atlantic coasts (Florida Bay) Reyes-Vazquez (1970) described 42 species of epiphytic diatoms on *T. testudinum*, while Sullivan (1979) recorded 32 species. More recently, Frankovich *et al.* (2006) listed up to 255 diatom taxa (species and infra-species), the highest species richness of epiphytic diatoms ever observed on *T. testudinum* blades exposing the floristic potential of epiphytic diatoms on this substrate. In contrast, besides the *Mastogloia* species list published by Siqueiros-Beltrones *et al.* (2020) no other formal studies on epiphytic diatoms of seagrasses have been carried out hitherto for the Mexican Atlantic, where turtle-grass *Thalassia testudinum* K. D. Koenig is widely distributed at low depths (Spalding *et al.* 2003).

The extension and resilience of *T. testudinum* beds in the southern Gulf of Mexico (GM) offers an excellent opportunity to study the epiphytic diatoms that use them as hosts, also providing a floristic frame for the *Mastogloia* species that characterize this particular ecosystem (Siqueiros-Beltrones *et al.* 2020). Thus, our objective was to describe the species composition of epiphytic diatom living on *T. testudinum* blades from the southern GM off the coast of Campeche, Mexico. Because our approach was mainly floristics, we proposed the hypothesis that the species richness would be higher than in the above studies and would include taxa that are new additions to the current floristic list for Mexican littorals (López-Fuerte & Siqueiros-Beltrones 2016). We must consider that references such as presence/absence of taxa are used to determine biogeographical distributions based on their relations with various environmental factors. In this way the effort dedicated to floristics may help to trim such interpretations down to a more precise dimension. Albeit relative abundances were estimated also to gain a preview of the more or less conspicuous taxa for later ecological and distribution analyses. And as it turned out, a previous report of this study widened the expectations on any unusual characteristic of the epiphytic diatom taxocoenosis, exemplified by the many recorded species of *Mastogloia* (Siqueiros-Beltrones *et al.* 2020).

STUDY AREA

The study area is, located within the southern GM and comprises the north coast of the State of Campeche, between the municipalities of Champotón and Calkiní (19° 19' 43.90" and 20° 20' 23.30" N, 90° 47'48. 90" and 90° 129' 43.30" W). There, three sites were surveyed: 1) Champotón, located in front of the Champotón river, considered the most important estuary in the state (Villalobos-Zapata & Mendoza-Vega 2010); 2) Petenes, located in the northernmost coast of the state within the Biosphere Reserve Los Petenes (DOF, 24, May 1999) that covers an extension of 282,857 ha; and 3) Costa, located on the coast of the city of San Francisco de Campeche (Fig. 1).

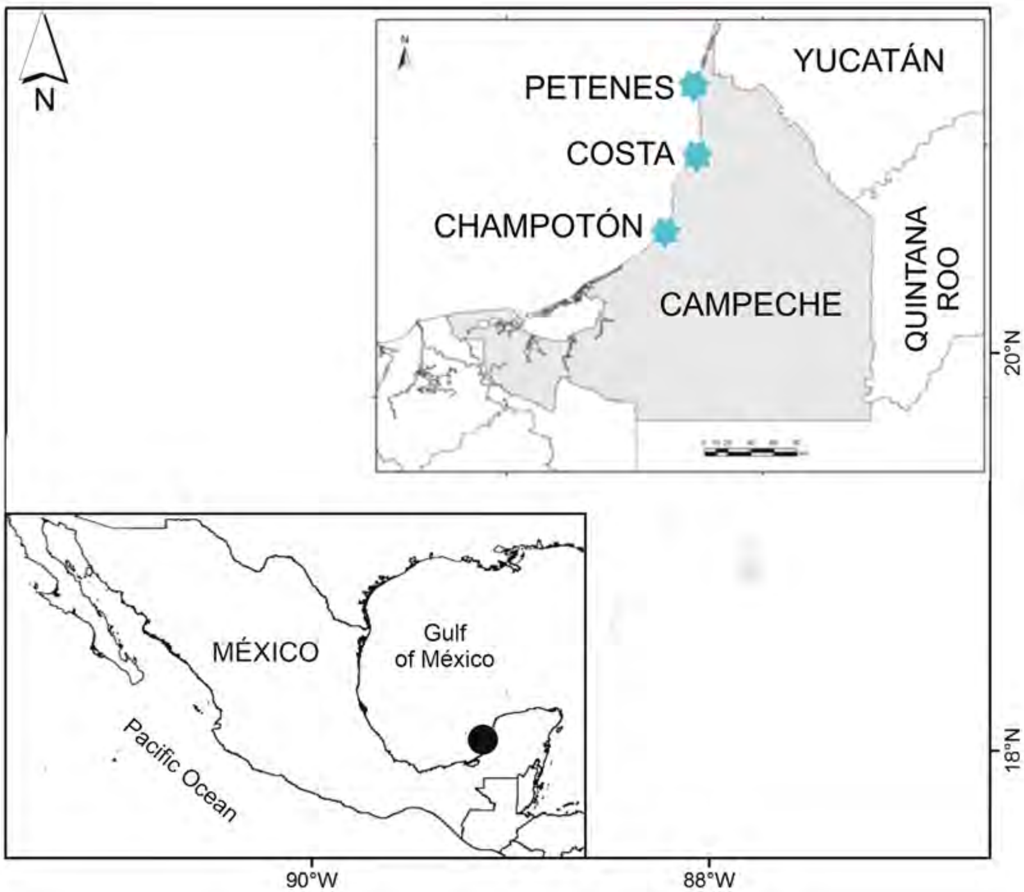

Figure 1.- Study area, and location of sampling sites on the coast of the State of Campeche.

METHODS

Sampling was carried out in 2013 on April 8 -11 in Petenes, from April 29 - May 2 in Champotón, and from August 17 - 20 in Costa, in a total of 23 sampling sites: six in Champotón, seven in Costa, and 10 in Petenes. Sites were chosen according to the occurrence and extension of *T. testudinum* beds. In each site three bundles of the seagrass were collected and stored in 1 L plastic jars. At the laboratory all the blades from the bundles were scraped with a spatula to separate the epiphytic diatoms. The gathered material was oxidized in flasks to eliminate all organic matter using nitric acid and commercial alcohol (Siqueiros-Beltrones 2002). The cleaned diatom frustules were mounted on permanent slides using synthetic resin Pleurax (R.I. = 1.7).

The permanent mounts were observed under an Axioscope 40 Zeiss compound microscope with plan-apochromatic optics. Diatoms were identified on the basis of frustule morphology using classic references: Cleve-Euler (1952, 1953a, 1953b, 1955), Hustedt (1930,1959, 1966), Peragallo & Peragallo (1908), Schmidt (1874-1959); as well as more recent literature: Foged (1975,1978,1984), Krammer & Lange-Bertalot (1991), Lange-Bertalot & Krammer (1987), Lange-Bertalot *et al.* (1996), Lobban *et al.* (2012), Loir & Novarino (2013), López-Fuerte *et al.* (2010), López-Fuerte *et al.* (2013), Metzeltin and

García-Rodrígez (2003), Moreno *et al.* (1996), Novelo *et al.* (2007), Siqueiros-Beltrones (2002), Siqueiros-Beltrones *et al.* (2004), Stidolph *et al.* (2012), Tomas (1997), Witkowski *et al.* (2000). Taxonomic nomenclature was updated using Guiry & Guiry (2020) and Round *et al.* (1990).

Quantitatively, taxa were classified according to their relative abundances (N=500) into rare (15<X≤1), frequent (100<X≤15), abundant (300<X≤100), and very abundant (>300). Similarity between the surveyed localities was measured using Jaccard presence/absence index. The resulting floristic list was contrasted with the recent available floristic lists both for the GM and the Mexican coasts overall (Krayesky *et al.* 2009; Licea *et al.* 2016; López-Fuerte & Siqueiros-Beltrones 2016; López-Fuerte *et al.* 2013; Siqueiros-Beltrones & Martínez-Hernández 2017). Images of representative taxa including several new records were captured using a CMOS Konus digital ocular lens microscope at 1000×.

RESULTS

A total of 238 epiphytic diatom taxa from 66 genera were identified living on the blades of *T. testudinum* from the northern coast of the State of Campeche (Table 1). The most diverse genus was *Mastogloia* with 51 species and varieties, with 11 taxa found in a single locality; following were *Nitzschia* (22 taxa), *Navicula* (17), *Amphora* (13), *Cocconeis* (13) and *Halamphora* (12). Only two taxa on the list were not assigned to a taxon at species level, while 63 other potential species not included in the list remained unidentified, including 25 *Mastogloia*.

Overall, 19 taxa were not accounted for during the quantitative phase. Diatom species distribution was as follows: 100 taxa (42 %) were present in all three localities. In Champotón, 38 exclusive taxa were recorded. Whilst, in Costa and Petenes, 21 and 14 exclusive taxa were recorded, respectively. The diatom assemblages from Champotón yielded the highest species richness with 176 taxa and 54 genera; there, the most diverse genera were *Mastogloia* (43), *Nitzschia* (18) and *Navicula* (15). In Costa 141 taxa and 41 genera were found: 39 *Mastogloia*, 15 *Nitzschia*, 9 *Navicula*, *Cocconeis* and *Halamphora* taxa. In Petenes 136 species were recorded; there, *Mastogloia* comprised 34 species, *Nitzschia* 10, *Cocconeis* 10, and *Amphora* 4. On the basis of their quantitative classification diatom taxa were distributed in a similar way among the three localities, depicting a typical benthic diatom assemblage with few abundant and very abundant taxa, and many rare and frequent taxa (Table 2).

According to the Jaccard similarity index (presence/absence of taxa), two groups were formed separating the Costa from the Petenes and Champotón assemblages (Figure 2).

Table 1.- Distribution of taxa classified according to their relative abundances among the three surveyed localities. VA: very abundant A: abundant; F: frequent; R: rare; T: total.

	Champotón	Costa	Petenes
VA	5	7	9
A	16	14	8
F	67	51	50
R	88	69	69
T	176	141	136

New records. Out of the above taxonomic list, 52 taxa are new records for the Mexican coasts and 25 are new records for the GM (Table 2); several are shown in figures 3-6. Three of these taxa were very abundant, particularly *Cocconeis lineata*, with the higher overall abundance (10.78 %) and *Seminavis obtosiuscula* (2.19 %); these two are new for the GM, and *Mastogloia urveae* (1.64 %), recently recorded for the Mexican coasts overall. For any of the three localities, two of the new records were abundant, three for Mexican coasts and three for the GM; 30 taxa were frequent, 21 for Mexican coasts and nine for the GM; and, 41 new records were rare taxa, 28 for Mexican waters and 13 for the GM. Thus, by locality, Champotón showed the higher number of

Table 2.- List of epiphytic diatom taxa found on *Thalassia testudinum* blades from the northern coast of the State of Campeche. f: frequent; r: rare; a: abundant; va: very abundant: -: absent; * new record for the gulf of México; ** new record for the coasts of Mexico.

Taxa	Champotón	Costa	Petenes
Class: Bacillariophyceae			
Achnanthes cf. *petersenii* Hustedt	-	-	r
Achnanthes trachyderma (F. Meister) Riaux-Gobin, Compère, Hinz & Ector ** fig.4-e,f	r	-	r
Achnanthidium robustum (Hustedt) T. Ohtsuka ** fig. 4-m, p	r	r	f
Achnanthes cf. *namaquae* Giffen** fig. 4-q	-	-	r
Achnanthidium cf. *minutissimum* (Kützing) Czarnecki	r	f	r
Achnanthidium cf. *pyrenaicum* (Hustedt) H. Kobayasi	r	r	r
Actinocyclus gallicus Meister**	r	-	-
Actinocyclus octonarius var. *sparsus* (Gregory) Hendey ** fig.3-a, b	r	r	r
Actinoptychus aster J.J. Brun* fig.3-c, d	-	-	-
Actinoptychus octonarius (Ehrenberg) Kützing	-	-	r
Amphora angusta Gregory	f	f	f
Amphora angusta var. *ventricosa* (W. Gregory) Cleve	-	r	-
Amphora arenaria Donkin	-	-	-
Amphora bigibba Grunow	r	-	-
Amphora cf. *arcus* Gregory	-	r	-
Amphora cf. *delicatissima* Krasske	a	f	f
Amphora corpulenta var. *capitata* Tempère & Peragallo	r	-	-
Amphora grevilleana Gregory	-	-	-
Amphora obtusa Gregory	r	-	-
Amphora ostrearia var. *ostrearia* Brébisson	-	r	-
Amphora proteus Gregory fig. 5-j	r	-	r
Amphora richardiana B.J. Cholnoky ** fig. 5-h	-	-	r
Amphora sp.4 fig. 6-r	-	r	-
Ardissonea crystallina (C. Agardh) Grunow	-	-	-
Ardissonea cuneata Mills** fig. 4-w, x	f	-	-
Auricula adriatica H. & M. Peragallo**	-	-	r
Auricula cf. *minuta* Cleve	-	-	r
Auricula complexa (Gregory) Cleve** fig. 6-n	r	-	-
Auricula intermedia (Lewis) Cleve	r	-	r
Brachysira cf. *estonarium* Witkowski, Lange-Bertalot & Metzeltin	a	va	a
Brachysira cf. *procera* Lange-Bertalot & Moser	r	-	r
Caloneis excentrica (Grunow)	r	r	-
Caloneis hustedtii Aleem** fig. 5-r	-	r	-
Caloneis liber (W. Smith) Cleve	r	-	-
Caloneis liber var. *linearis* Cleve	r	r	f

Campylodiscus ralfsii W. Smith	r	-	r
Campylodiscus sp.2 fig. 5-l, m	-	-	r
Campylodiscus subangularis Cleve & Möller** fig. 6-k	r	-	-
Climaconeis lenzii Schmidt**	r	f	f
Cocconeis ahlefeldii Janisch** fig. 4-aa	f	-	f
Cocconeis angularipunctata Riaux-Gobin, Romero, Compère & Al Handal	-	-	-
Cocconeis convexa Giffen	-	-	r
Cocconeis discrepans A. W. F. Schmidt	-	r	r
Cocconeis krammeri Lange-Bertalot & Metzeltin	-	-	-
Cocconeis maxima (Grunow) H. Perragallo & M. Perragallo	f	f	f
Cocconeis placentula var. *euglypta* (Ehrenberg) Grunow	va	va	va
Cocconeis lineata Ehrenberg* fig. 4-c, d.	va	va	va
Cocconeis pseudodiruptoides Foged	-	r	-
Cocconeis pseudomarginata Gregory	a	r	f
Cocconeis scutellum Ehrenberg	a	f	a
Cocconeis thalassiana Romero & López-Fuerte	a	a	a
Cocconeis woodii Reyes	r	r	f
Cymatoneis cf. *margarita* Witkowski	-	r	r
Diploneis apis (Ehrenberg) Ehrenberg**	-	-	r
Diploneis cf. *smithii* (Brébisson) Cleve	-	f	-
Diploneis chersonensis (Grunow) Cleve	r	-	r
Diploneis decipiens var. *paralela* Cleve* fig. 4-h, i	r	r	-
Diploneis littoralis (Donkin) Cleve	r	r	r
Diploneis subcincta (A. Schmidt) Cleve* fig. 34-z	-	-	r
Diploneis suborbicularis (Gregory) Cleve var. *suborbicularis*** fig. 4-g	r	-	-
Diploneis vacillans (A. Schmidt) Cleve	f	a	f
Encyonema cf. *evergladianum* Krammer	f	a	f
Encyonema cf. *gracile* Rabenhorst	r	r	r
Entomoneis paludosa (W. Smith) Reimer* fig. 5-n	-	r	-
Entomoneis paludosa var. *duplex* (Donkin) Makarova & Achmetova	r	f	r
Epithemia pacifica (Krammer) Lobban & J.S. Park	a	a	a
Fallacia cf. *lenzii* (Hustedt) Lange-Bertalot	r	r	r
Fogedia cf. *geisslerae* Witkowski, Metzeltin & Lange-Bertalot			
Fragilariforma cf. *virescens* (Ralfs) D.M. Williams & Round	va	va	va
Grammatophora macilenta W. Smith	r	r	r
Grammatophora marina var. *undulata* Ehrenberg** fig. 3-g	f	f	f
Grammatophora oceanica (Ehrenberg) Grunow	r	-	r
Grammatophora serpentina (Ralfs) Ehrenberg* fig. 3-e, f	r	-	-
Gyrosigma subangustum Hustedt*	-	-	-
Halamphora cf. *acutiuscula* (Kützing) Levkov	-	r	-

Halamphora cf. *interrupta* (Heiden) Levkov	r	-	-
Halamphora cf. *luciae* (Cholnoky) Levkov	f	a	f
Halamphora cf. *perpusilla* (Grunow) Q.M. You & Kociolek	r	f	r
Halamphora cf. *subacutiuscula* (Schoeman) J.G. Stepanek & Kociolek	f	a	f
Halamphora cf. *tenerrima* (Aleem & Hustedt) Levkov	f	a	f
Halamphora coffeiformis (C. Agardh) Mereschkowsky** fig. 5-f	f	f	f
Halamphora costata (W. Smith) Levkov* fig. 5-g	f	r	r
Halamphora cymbifera (Gregory) Levkov	-	f	-
Halamphora eunotia (Cleve) Levkov	-	-	-
Halamphora hybrida (Grunow) Levkov* fig. 5-k	r	r	r
Halamphora terroris (Ehrenberg) Wang**	r	-	r
Hyalosynedra laevigata (Grunow)	va	va	va
Licmophora abbreviata C. Agardh	-	-	-
Licmophora aff. *debilis* (Kützing) Grunow	r	-	-
Licmophora grandis var. *divisa* (Kützing) Grunow**	r	f	-
Licmophora remulus Grunow	f	r	r
Mastogloia angulata Lewis	f	r	r
Mastogloia asperula Grunow	f		r
Mastogloia asperuloides Hustedt*	r	f	f
Mastogloia bahamensis Cleve	f	r	r
Mastogloia barbadensis (Geville) Cleve	r	-	r
Mastogloia belaensis Voigt**	f	r	r
Mastogloia binotata (Grunow) Cleve	r	r	f
Mastogloia biocellata (Grunow) G. Navarino & A.R. Muftah	f	f	f
Mastogloia borneensis Hustedt	-	-	r
Mastogloia cf. *angusta* Hustedt	f	f	f
Mastogloia cf. *braunii* Grunow	-	r	-
Mastogloia cf. *pseudolacrimata* Yohn & Gibson	-	r	-
Mastogloia cf. *staurophora* Hustedt	-	-	f
Mastogloia cf. *tenera* Hustedt	f	r	f
Mastogloia cocconeiformis Grunow	f	r	f
Mastogloia corsicana (Grunow) H. Peragallo & M. Peragallo	a	a	a
Mastogloia cribrosa Grunow	f	f	f
Mastogloia crucicula (Grunow) Cleve	va	va	va
Mastogloia cuneata (Meister) R. Simonsen	r	r	-
Mastogloia cyclops Voigt**	f	r	-
Mastogloia decipiens Hustedt*	f	f	f
Mastogloia decussata Grunow**	r	-	-
Mastogloia depressa Hustedt**	r	r	r
Mastogloia emarginata Hustedt	r	r	-

Mastogloia erythraea Grunow	-	r	-
Mastogloia erythraea var. *biocellata* Grunow**	r	r	-
Mastogloia erythraea var. *grunowii* Foged ** fig. 4-ab, ac, ad	r	f	-
Mastogloia foliolum (Brun) A. Shmidt**	-	r	-
Mastogloia frickei Hustedt**	r	r	r
Mastogloia frimbriata (Brightwell) Grunow	f	f	f
Mastogloia horvathiana Grunow	r	r	f
Mastogloia ignorata Hustedt	a	r	f
Mastogloia lanceolata Thwaites	f	f	r
Mastogloia mauritiana Brun**	r	-	-
Mastogloia ovalis A. Schmidt**	f	f	a
Mastogloia ovata Grunow	f	r	f
Mastogloia ovulum Hustedt	r	r	r
Mastogloia ovum-paschale (A. Schmidt) A. Mann*	f	f	f
Mastogloia parva Hustedt**	f	r	f
Mastogloia pulchella Cleve	r	-	-
Mastogloia punctifera Burn	f	f	f
Mastogloia pusilla var. *linearis* Ostrup**	-	f	-
Mastogloia pusilla var. *pusilla* Grunow**	f	f	-
Mastogloia pusilla var. *subcapitata* Hustedt	f	r	a
Mastogloia regula Hustedt**	-	-	-
Mastogloia rimosa Cleve**	f	f	-
Mastogloia robusta Hustedt	f	-	r
Mastogloia similis Hustedt**	r	-	-
Mastogloia subaffirmata Hustedt	f	f	f
Mastogloia urveae Witkowski**	a	f	a
Mastogloia varians Hustedt	f	f	f
Navicula archibaldiana Foged	r	-	r
Navicula cf. *apta* Hustedt	f	f	r
Navicula cf. *commutabilis* Hustedt	-	-	-
Navicula cf. *debilissima* Grunow	f	r	-
Navicula cf. *microcari* Lange-Bertalot	f	r	-
Navicula cincta (Ehrenberg) Ralfs*	-	f	-
Navicula circumtexta F. Meister** fig. 5-s	r	-	-
Navicula digito-radiata (Gregory) Ralfs	r	-	-
Navicula duerrenbergiana Hustedt* fig. 5-u	f	a	r
Navicula formenterea Cleve	f	f	r
Navicula hamulifera Grunow* fig. 5-b	r	-	-
Navicula johannrossi Giffen	f	-	f
Navicula longa (Gregory) Ralfs	r	r	r

Navicula mutica var. *producta* Grunow	r	-	-
Navicula normaloides Cholnoky	a	a	va
Navicula phyllepta Kützing** fig. 5-t	f	-	-
Navicula platyventris Meister	r	-	-
Navicula ramosissima var. *ampilus* (C. Agardh) Cleve** fig. 5-p	f	f	f
Neodelphineis silenda (Hohn & Hellerman) Desianti & Potapova	r	-	-
Neosynedra tortuosa (Grunow) D.M. Williams & Round	f	f	f
Nitzschia angularis W. Smith fig. 3-q	f	r	f
Nitzschia capitellata Hustedt, nom. inval. *	f	-	r
Nitzschia carnicobarica Desikachary & Prema** fig. 5-v	-	r	-
Nitzschia cf. *fluminensis* Grunow	r	f	-
Nitzschia cf. *fusiformis* Grunow	-	r	-
Nitzschia cf. *liebethruthii* Rabenhorst	f	a	-
Nitzschia cf. *linearis* var. *subtilis* Hustedt	f	f	-
Nitzschia cf. *palea* (Kützing) W.Smith	r	r	-
Nitzschia dissipata (Kützing) Rabenhorts fig. 6-e	f	f	f
Nitzschia distans W. Gregory	f	f	f
Nitzschia epithemoides Grunow	r	r	r
Nitzschia frustulum (Kützing) Grunow	a	a	va
Nitzschia grossestriata Hustedt* fig. 6-c, d	f	r	r
Nitzschia incognita Lengler & Krasske**	r	-	-
Nitzschia laevissima Grunow** fig. 6-b	-	r	r
Nitzschia longissima (Brebisson) Ralfs	r	-	-
Nitzschia longissima f. *costata* Hustedt	r	-	r
Nitzschia macilenta f. *abbreviata* Grunow**	-	-	-
Nitzschia marginulata var. *didyma* Grunow nom. inval. * fig. 6-f	r	-	-
Nitzschia perminuta (Grunow) M. Peragallo	a	a	f
Nitzschia prolongata Hustedt** fig. 6-a	f	r	-
Nitzschia sigma (Kützing) W. Smith	r	r	-
Oestrupia vidovichii Grunow** fig. 5-d	r	-	-
Opephora marina (Gregory) Petit* fig. 4-k, l	r	-	-
Opephora mutabilis Sabbe & Wyverman nom. inval.	r	r	r
Petroneis plagiostoma (Grunow) D. G. Mann* fig. 5-l	-	-	-
Pinnunavis yarrensis (Grunow) H. Okuno*	-	-	-
Plagiogramma cf. *adriaticum* Grunow	-	-	-
Planothidium campechianum (Hustedt) Witkowski, Lange-Bertalot & Metzeltin	r	r	r
Planothidium cf. *pericavum* (J. R. Carter) Lange-Bertalot	f	f	f
Pleurosigma salinarum (Grunow) Grunow	r	f	r
Podocystis adriatica (Kützing) Ralfs**	r	-	r
Psammothidium cf. *grischunum* (Wuthrich) Bukhtiyarova & Round	r	f	f

Pseudo-nitzschia cf. *fraudulenta* (Cleve) Hasle	-	-	-
Pteroncola cf. *inane* (Giffen) F.E. Round	f	r	-
Rhabdonema adriaticum Kützing	a	f	f
Rhabdonema arcuatum (Lyngbey) Kützing* fig. 3-j	r	-	-
Rhopalodia constricta (W. Smith) Krammer* fig. 6-i	f	r	-
Rhopalodia musculus (Kützing) O. Müller fig. 6-p, g	f	-	r
Rhopalodia succincta Brébison** fig. 6-j	r	-	f
Seminavis gracilenta (Grunow) D.G. Mann* fig. 5-o	-	r	-
Seminavis obtusiuscula (Grunow) Danieledis & D.G. Mann*	a	f	va
Seminavis strigosa (Hustedt) Danieledis & Economou-Amilli	f	f	f
Seminavis ventricosa (Gregory) M. Garcia-Baptista	r	f	f
Staurophora gregoryi Mereschkowsky** fig. 5-i	r	-	-
Staurosira leptostauron (Ehrenberg) Kulikovskiy & Genkal* fig. 4-u, v	r	-	-
Staurosira venter (Ehrenberg) Cleve & J.D. Möller** fig. 4-r, s, t	r	-	-
Staurosirella guenter-grassii (Witkowski & Lange-Bertalot) Morales, Wetzel & Ector** fig. 4-j	f	-	r
Staurosirella pinnata (Ehrenberg) D.M. Williams & Round	-	-	-
Surirella fastuosa (Ehrenberg) Ehrenberg fig. 6-g, h	r	-	-
Synedra bacillaris (Grunow) Hustedt	f	-	r
Tabularia affinis var. *acuminata* (Grunow) Aboal**	r	-	-
Tabularia fasciculata (C. Agardh) D.M. Williams & Round	f	f	f
Tabularia laevis Kützing**	f	r	-
Tetramphora securicula (Peragallo & Peragallo) Stepanek & Kociolek	-	r	-
Thalassiophysa hyalina (Greville) Paddock & P.A. Sims** fig. 4-m	-	f	-
Trachysphenia acuminata Peragallo	a	f	f
Tryblionella apiculata W. Gregory	f	a	f
Tryblionella marginulata f. *parva* (Grunow) Louvrou & Economou-Amilli**	r	-	-
Class: Coscinodiscophyceae			
Amphipentas pentacrinus Ehrenberg	r	-	r
Melosira cf. *moniliformis* var. *octogona* (Grunow) Hustedt	r	f	r
Paralia sulcata (Ehrenberg) Cleve	f	-	r
Paralia sulcata f. *radiata* Grunow* fig. 4-b	r	-	-
Podosira stelligera (Bailey) A. Mann	r	-	-
Triceratium cf. *broeckii* Leuduger-Fortmorel	r	-	-
Triceratium reticulum Ehrenberg* fig. 4-a	-	-	-
Class: Mediophyceae			
Ardissonea formosa (Hantzsch) Grunow*	f	r	r
Biddulphia biddulphiana (J.E. Smith) Boyer** fig. 3-i	-	-	r
Biddulphia regina W. Smith** fig. 3-h	-	-	-
Cyclotella striata (Kützing) Grunow	f	f	r
Cyclotella stylorum Brightwell	-	f	r

Cymatosira lorenziana Grunow	a	r	f
Lampriscus cf. *shadboltianum* (Greville) Peragallo & Peragallo	-	-	r
Toxarium hennedyanum (Gregory) Pelletan* fig. 4-y	a	va	va
Toxarium undulatum Bailey	f	r	r
Tropidoneis pusilla (Gregory) Cleve	r	r	r

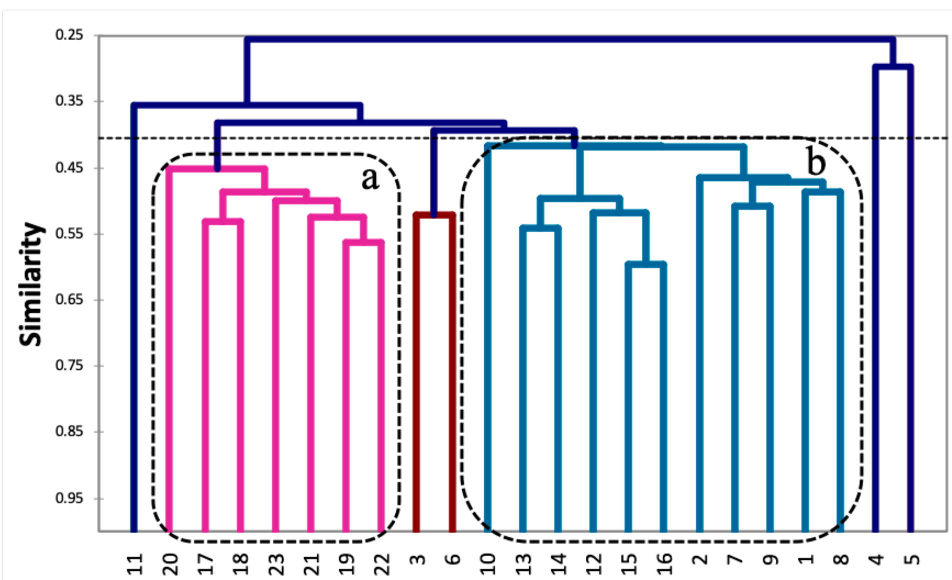

Figure 2.- Jaccard Similarity Index. Numbers indicates stations: Petenes 1-10, Champotón 11-16, and Costa 17-23. group A: stations from Costa; group B: stations from Petenes and Champotón.

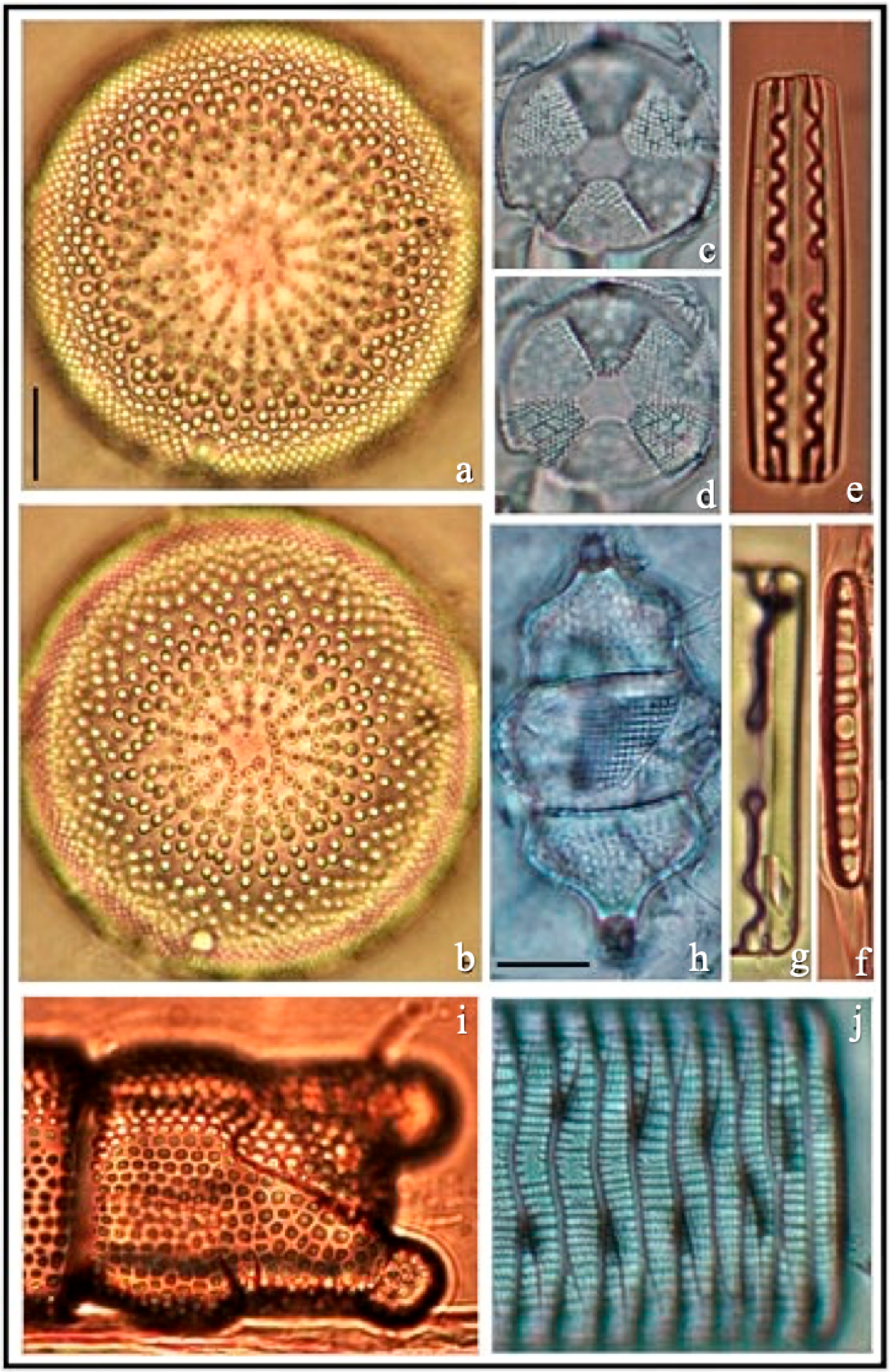

Figure 3.- (a, b) *Actinocyclus ehrenbergii* var. *sparsa*; **(c, d)** *Actinoptychus aster*; **(e, f)** *Grammatophora serpentina*; **(g)** *Grammatophora marina* var. *undulata*; **(h)** *Biddulphia regina*; **(i)** *Biddulphia pulchella*; **(j)** *Rhabdonema arcuatum*.

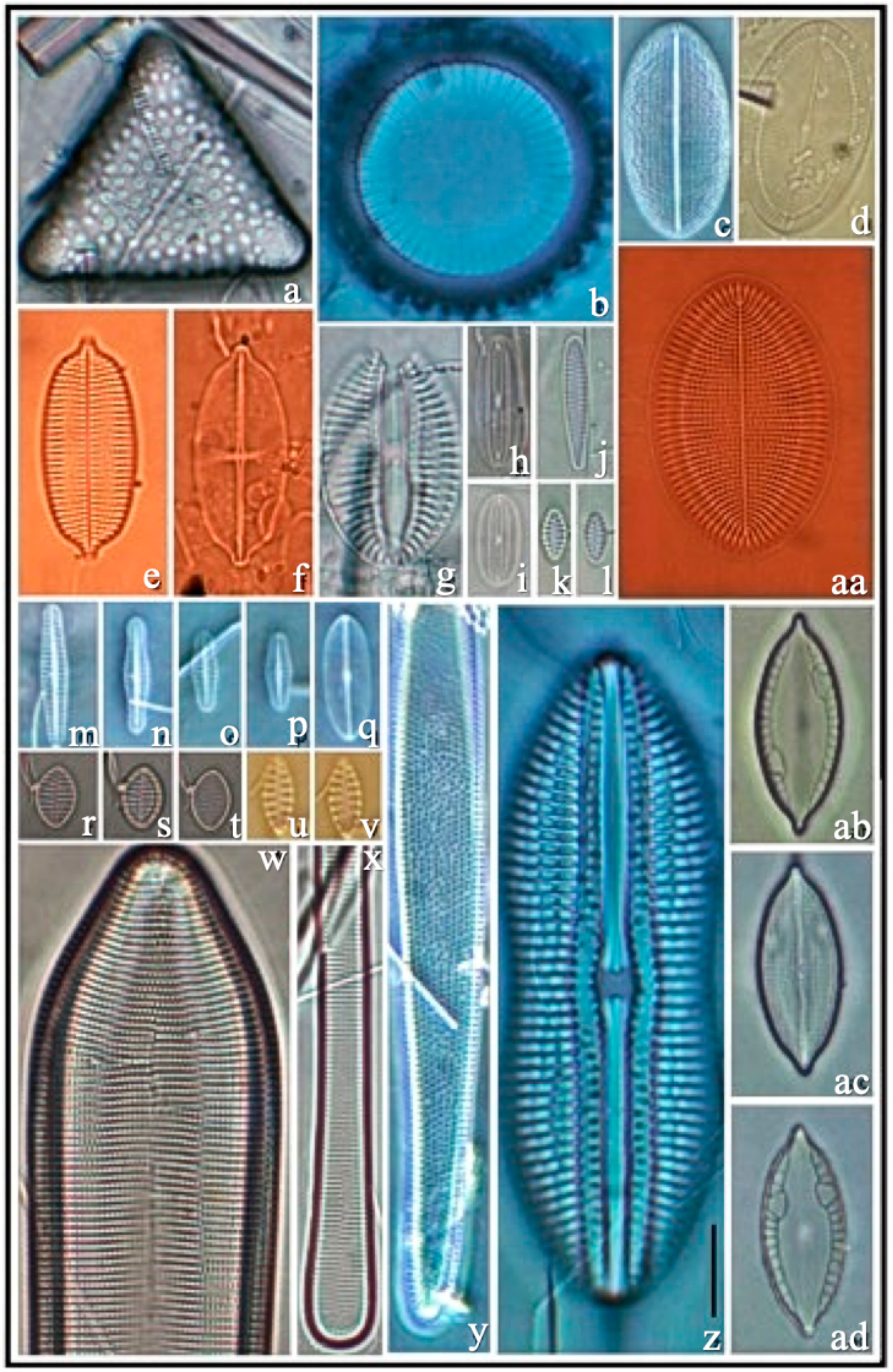

Figure 4.- (a) *Triceratium reticulum*; **(b)** *Paralia sulcata* f. *radiata*; **(c, d)** *Cocconeis placentula* var. *lineata*; **(e, f)** *Achnanthes trachyderma*; **(g)** *Diploneis suborbicularis* var. *suborbicularis*; **(h, i)** *Diploneis decipiens* var. *paralela*; **(j)** *Opephora gunter-grassi*; **(k, l)** *Opephora marina*; **(m-p)** *Achnanthidium minutissima* var. *robusta*; **(q)** *Achnanthes* cf. *namaquae*; **(r-t)** *Staurosira construens* var. *venter*; **(u, v)** *Staurosirella leptostauron*; **(w, x)** *Synedra cuneata*; **(y)** *Toxarium hennedyanum*; **(z)** *Diploneis subcincta*; **(aa)** *Cocconeis ahlefeldii*; **(ab, ac, ad)** *Mastogloia erythraea* var. *grunowii*.

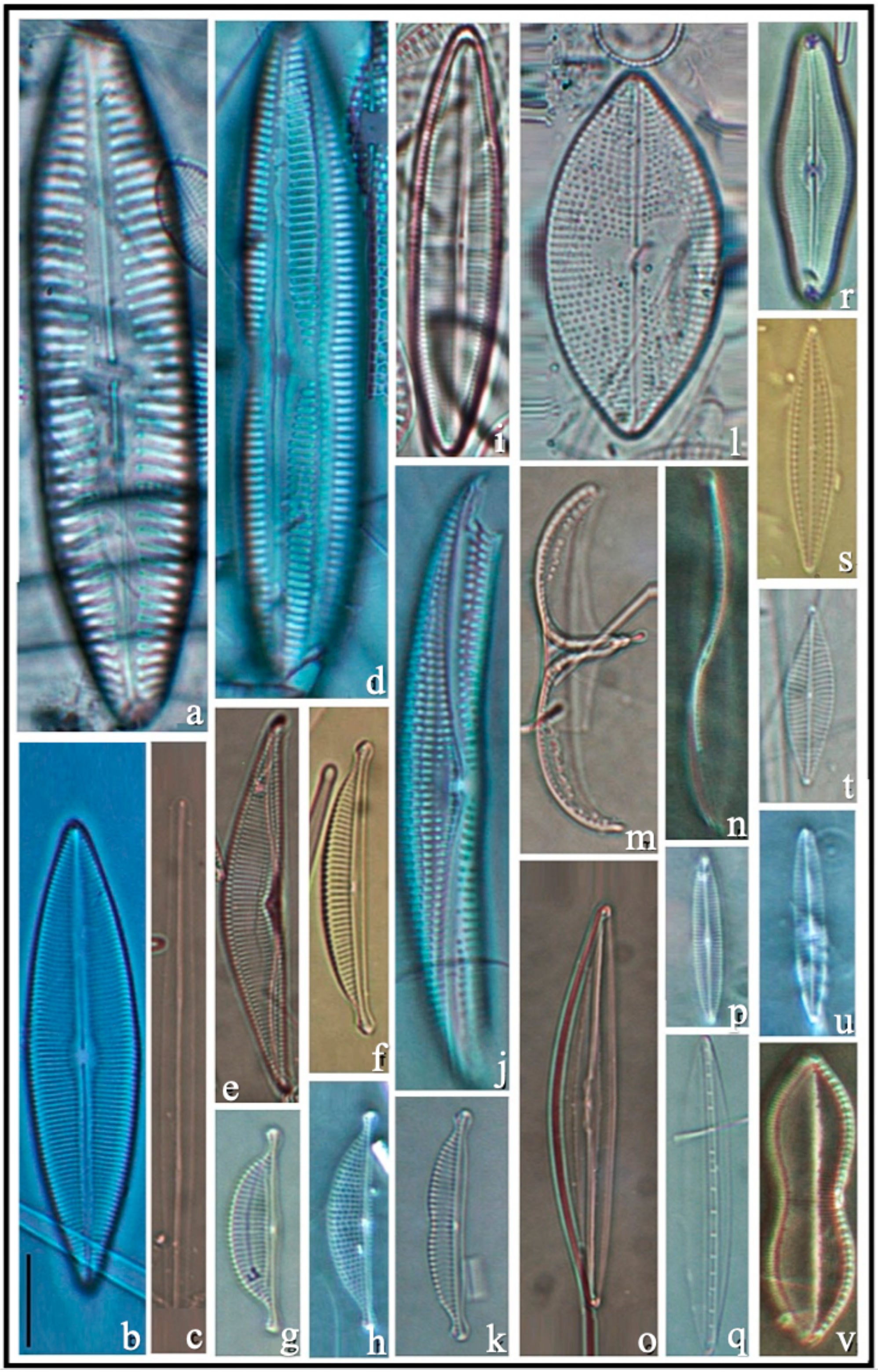

Figure 5.- (a) *Pinnunavis yarrensis*; **(b)** *Navicula hamulifera*; **(c)** *Berkeleya fragilis*; **(d)** *Oestrupia vidovichii*; **(e)** *Amphora ostrearia* var. *ostrearia*; **(f)** *Amphora coffeaeformis*; **(g)** *Halamphora costata*; **(h)** *Amphora richardiana*; **(i)** *Staurophora gregory*; **(j)** *Amphora proteus*; **(k)** *Halamphora hybrida*; **(l)** *Petroneis plagiostoma;* **(m)** *Thalassiophysa hialina*; **(n)** *Entomeneis paludosa*; **(o)** *Seminavis gracilenta*; **(p)** *Navicula ramosissima* var. *ampilus*; **(q)** *Nitzschia angularis*; **(r)** *Caloneis hustedtii*; **(s)** *Biremis circumtexta*; **(t)** *Navicula phyllepta*; **(u)** *Navicula durrenbergiana*; **(v)** *Nizschia carnicobarica*

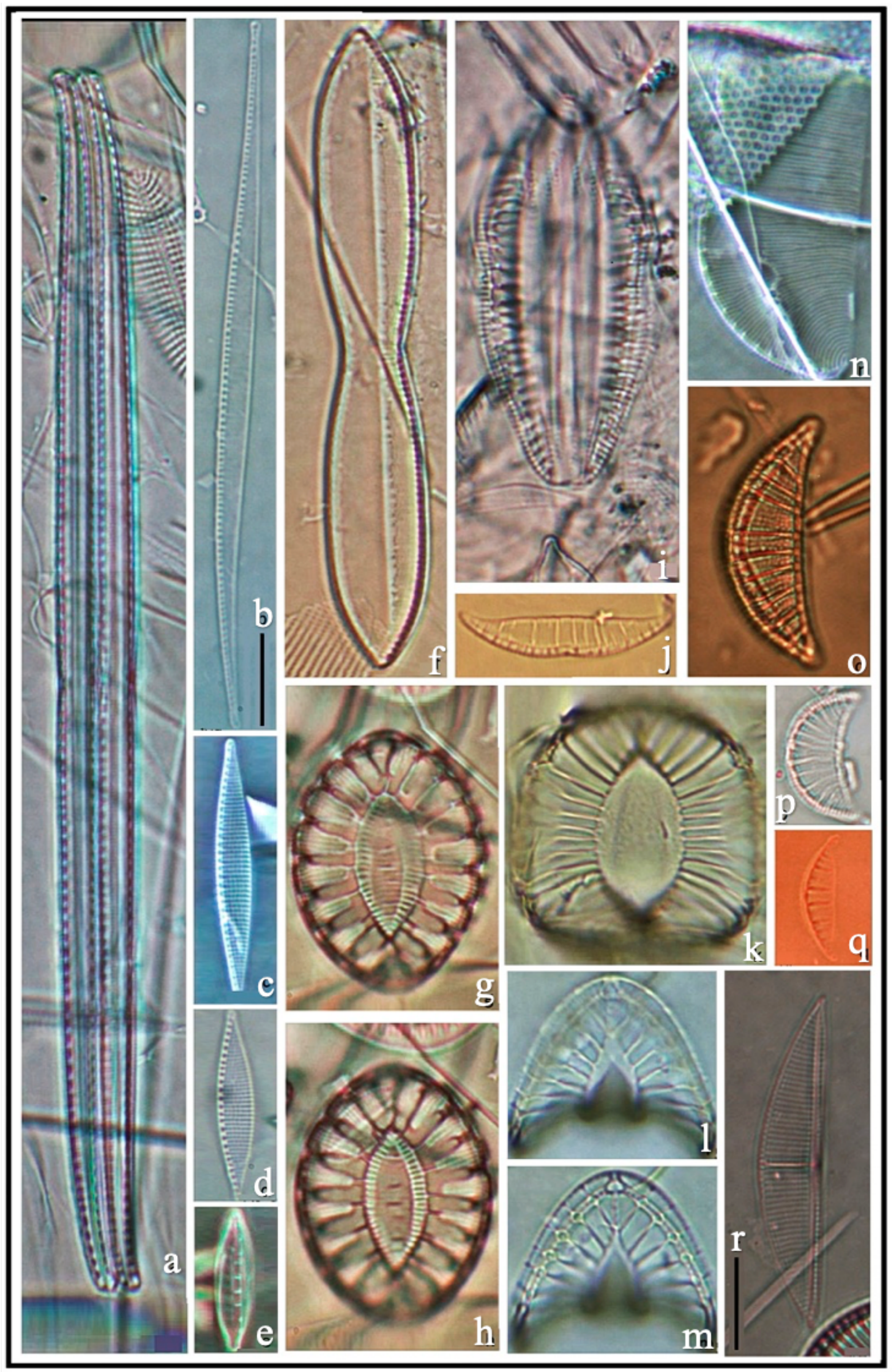

Figure 6.- (a) *Nitzschia prolongata*; **(b)** *Nitzschia laevissima*; **(c, d)** *Nitzschia grossestriata*; **(e)** *Nitzschia dissipata*; **(f)** *Nitzschia marginulata* var. *didyma*; **(g, h)** *Surirella fastuosa*; **(i)** *Rhopalodia constricta*; **(j)** *Rhopalodia* succincta; **(k)** *Campylodiscus subangularis*; **(l,m)** *Campylodiscus* sp. 2; **(n)** *Auricula complexa*; **(o)** *Rhopalodia* cf. *musculus*; **(p, q)** *Rhopalodia musculus*; **(r)** *Amphora* sp. 4

new records (38 taxa), 16 for Mexico and 7 for GM. In Costa nine new records, six overall for Mexico and three for the GM. The Petenes locality had the lower number of new records (seven taxa), six for Mexico and one for GM.

DISCUSSION

Although the Champotón locality yielded the highest species richness and Petenes the lowest, these were grouped together, segregated from the Costa locality in the similarity analysis. The former two were surveyed during the dry season and the latter in the rainy season, suggesting that species composition of the diatom assemblages varied according to the corresponding seasonal environmental conditions. Besides the import of fresh-water taxa or seasonal exclusion of strict marine forms, the seasonal distribution of other coastal marine taxa requires investigation, along with further taxonomic issues.

It is but surprising that this report on the epiphytic diatoms of *Thalassia testudinum* is only the fourth formal floristic study on seagrasses (the third was derived from the same project, Siqueiros-Beltrones *et al.* 2020) that serve as hosts for diatoms in Mexican waters after Siqueiros-Beltrones and Ibarra-Obando (1985) for *Zostera marina*, a second one for *T. testudinum* (López-Fuerte *et al.* 2013). Although the floristic account in this study (238 taxa) is one of the richest for Mexican littorals, it is surpassed by the epipelic assemblages (325 taxa) observed in Bahía Magdalena, BCS, Mexico (López-Fuerte & Siqueiros-Beltrones 2006), and by the epiphytic diatom assemblages from multi-specific macroalgae hosts (271 taxa) surveyed by Hernández-Almeida & Siqueiros-Beltrones (2012).

Albeit, compared to similar studies, the species richness in this study surpasses the 215 taxa recorded for *Zostera marina* in NW Mexico (Siqueiros-Beltrones & Ibarra-Obando 1985), being very similar to the 232 epipelic diatom taxa recorded at Guerrero Negro lagoon, also in the NW region (Siqueiros-Beltrones *et al.* 2017). And, although it falls short from the 255 taxa recorded by Frankovich *et al.* (2006) in the Florida (USA) *T. testudinum* beds, more than 60 taxa remain unidentified for the Campeche samples. As it is, it more than doubles the 107 taxa recorded recently by López-Fuerte *et al.* (2013) for the same species host in the Caribbean.

Our *ex professo* qualitative outlook for diatom species living on *T. testudinum* blades was influential in supporting part of our hypothesis; the high species richness may well be a combination of this and the tropical habitat, which could be reflected on the numerous species observed of *Mastogloia* (Siqueiros-Beltrones *et al.* 2020), although only 51 identified to species level. This agrees with the taxonomic diversity of this genus (>80 taxa) recorded for the Caribbean by Loir and Novarino (2013) albeit in sediments. It would thus seem more related to a biogeographical factor than to substrate affinity, both for this genus and rest of the recorded taxa.

Similar comparisons to the above are now possible based on this floristic account of epiphytic diatoms of *T. testudinum* for the southern Gulf of Mexico. Besides the biogeographic implications, this taxonomic reference may aid in ecological studies, e.g., trophic relations with various species of grazers such as snails, sea-turtles, and manatees that forage on these seagrass beds. However, much formal taxonomic work is needed on the benthic diatoms of Mexican littorals in order to adequately complement the much-needed floristic studies. This is supported also by the high abundance of six new records.

Notwithstanding, both the species richness and the observed species composition of these epiphytic diatom assemblages may serve as reference in assessing environmental impact as to how undisturbed habitat conditions may reflect on the structure of these diatom assemblages.

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