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Taxonomy and systematics

High species richness of epiphytic *Mastogloia* (Mastogloiales: Bacillariophyceae) on *Thalassia testudinum* along the coast of Campeche, southern Gulf of Mexico

Alta riqueza de especies de Mastogloia *(Mastogloiales: Bacillariophyceae) epifitas de* Thalassia testudinum *en la costa de Campeche, sur del golfo de México*

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Abstract

Diatoms of the genus *Mastogloia* are naviculoid forms that are generally easy to discriminate due to the presence of marginal chambers known as partecta. They exhibit a wide marine distribution, and are basically benthic forms usually conspicuous in epiphytic and epipelic diatom assemblages. Our objective was to identify species of *Mastogloia* epiphytic on *Thalassia testudinum* blades from the southern Gulf of Mexico region. Blades of *T. testudinum* were collected off the coast of Campeche State, Mexico; the epiphytic diatoms were scrapped off, cleaned and mounted on permanent slides for identification under light microscopy. A total of 76 *Mastogloia* taxa were recorded. This is the highest number of *Mastogloia* taxa recorded for Mexican coasts. Seven taxa had not been observed for the region: *Mastogloia angusta*, *M. belaensis*, *M. depressa*, *M. ovalis*, *M. pseudolacrimata*, *M. regula*, and *M. urveae*. Likewise, 20 *Mastogloia* species are new records for the Gulf of Mexico, while 15 are new records for Mexican coasts overall. This study confirms that *Mastogloia* species are mostly distributed in tropical and subtropical habitats, and shows that much floristics and formal taxonomy are required on benthic diatoms from different types of substrata for Mexican littorals.

Keywords: Benthic diatoms; Distribution; Diversity; Floristics; Taxonomy

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Resumen

Las especies de *Mastogloia* son formas naviculoides generalmente fáciles de distinguir por sus cámaras marginales denominadas partecta; presentan amplia distribución, principalmente marina. El género comprende formas bentónicas, conspicuas en asociaciones epipélicas y epifitas. El objetivo fue identificar las formas epifitas de *Mastogloia* en hojas de *Thalassia tetsudinum* del sur del golfo de México. Se recolectaron hojas de *T. testudinum* frente a las costas del estado de Campeche, México. Las diatomeas se desprendieron mediante cepillado, se montaron en laminillas permanentes y se identificaron bajo microscopía óptica. Se registraron 76 taxones de *Mastogloia*; éste constituye el mayor número de especies de *Mastogloia* para las costas de México. Siete especies identificadas no habían sido registradas para la región sur del golfo de México: *M. angusta*, *Mastogloia belaensis*, *M. depressa*, *M. ovalis*, *M. pseudolacrimata*, *M. regula*, y *M. urveae*. Asimismo, 20 taxones son registros nuevos para el golfo de México, mientras que 15 son nuevos para costas mexicanas. Se confirma que las especies de *Mastogloia* se distribuyen principalmente en ambientes tropicales y subtropicales y se muestra que aun se requieren estudios sobre florística y taxonomía formal de diatomeas bentónicas en distintos tipos de sustrato para litorales mexicanos.

Palabras clave: Diatomeas bentónicas; Distribución; Diversidad; Florística; Taxonomía

Introduction

Identification of diatom species and construction of floristic lists are still much needed activities for the Mexican coasts which are actually improving on the basis of comprehensive taxonomic works that incorporate the latest advances in diatom systematics. It is evident that the lack of floristic studies on benthic diatoms in much of the Mexican littoral precludes insight of their ecology and distribution (Siqueiros-Beltrones et al., 2017a), inasmuch floristics relates taxonomy with ecology. Besides carrying out continuous floristic surveys that will allow establishing ecological relations and biogeographic affinities of benthic diatom flora in the coasts of Mexico, more specific surveys dealing with particular groups, mainly the conspicuous ones may prove to be useful while addressing the above topics. This approach has been recently realized focusing on the genus *Lyrella* for the northwestern Mexican Pacific coasts, responding to controversial statements on the geographical distribution and indicative properties of *Lyrella* spp., and taking advantage of their observed diversity and abundance in a coastal lagoon in northwestern Mexico (Siqueiros-Beltrones et al., 2017b). In the present case a similar pattern was noted while describing the assemblage structure of epiphytic diatoms of *Thalassia testudinum* along the coast of Campeche, Mexico (southern Gulf of Mexico), where many *Mastogloia* species were observed in the mounted samples (López-Mejía, 2016).

Mastogloia species are classified in the order Mastogloiales (Bacillariophyceae). Their naviculoid isopolar frustules are readily recognized and discriminated by the presence of partecta, *i.e*., loculate marginal septa that bear 1 or many chambers in the valvocopulae.

Live cells exhibit 2 plastids, 1 towards each pole (Round et al., 1990). Most species of *Mastogloia* are ubiquitous marine forms although some are common in brackish water and freshwater habitats. Most species are benthic and are abundant in epipelic and epiphytic assemblages (Round et al., 1990), particularly in subtropical and tropical latitudes where they appear in great numbers and showing high species richness (Frankovich et al., 2006).

Regionally, Meave-del Castillo et al. (2003) compiled 25 *Mastogloia* taxa records in the tychoplankton of the Mexican Pacific, while Moreno et al. (1996) accounted for 38 *Mastogloia* taxa in phytoplankton samples of the Gulf of California. Also, Bahía Magdalena in the Mexican northwestern Pacific on the other side of the Baja California Peninsula, was proposed as a "hot spot" for diatom species diversity, in which the high number (S = 20) of *Mastogloia* taxa (and of *Lyrella* spp.) marked the difference with other ecosystems in the region (López-Fuerte et al., 2010), while further north, off the west coast of Baja California a taxocoenosis from Isla Guadalupe for which a biogeographical affinity could not be established yielded many tropical species including 13 *Mastogloia* spp. (López-Fuerte et al., 2015).

In contrast, for the Mexican Atlantic region and the highly diverse Caribbean Sea, Navarro and Hernández-Becerril (1997) compiled 89 *Mastogloia* taxa records in a survey of 47 studies. Also, Loir and Novarino (2013) recorded a similar number of species (> 80) for several islands in the Caribbean Sea, which they described and illustrated, while Hein et al. (2008) recorded 75 *Mastogloia* taxa from the Bahamas Archipelago. Moreover, in a previous study on epiphytic diatoms of *T. testudinum* off the coast of Quintana Roo (Caribbean Sea) López-Fuerte et al. (2013) recorded 30 *Mastogloia* species. These accounts set a reference as to the expected species variety in any given area for the genus *Mastogloia*, particularly within tropical regions. Our objective, thus, was to determine the species richness of *Mastogloia* thriving on *T. testudinum* blades in a tropical environment exhibiting also their hitherto unattended taxonomic potential.

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Materials and methods

The study area is located in the northern coast of the state of Campeche (19º19'43.90" - 20º20'23.30" N, 90º47'48.90" - 90º29'43.30" W). It includes 3 localities: Champotón, City of Campeche, and the Biosphere Reserve Los Petenes (Fig. 1), which show extensive *T. testudinum* beds. Campeche is divided by the Champotón River into the southern part where rivers are a characteristic trait, and the northern part where surficial rivers are scarce due to the permeability of the lime rock (Villalobos-Zapata & Mendoza-Vega, 2010).

The dry season in the coastal zone of Campeche extends from November to April, while the warm, rainy season (September-April) is seasonally influenced by cold northwesterly winds which cause mixing of the water column (Zavala-Hidalgo et al., 2014). Temperature varies from 29.7 ºC in Summer to 24 ºC in Winter (Callejas-Jiménez et al., 2012). Mean salinity values are higher than 36 for these periods (Limoges et al., 2013).

Sampling was carried out in 2013 during the dry season in April (Petenes), April-May (Champotón), and in the rainy season during August (Costa, Campeche). Sites were selected on the basis of the distribution of *Thalassia testudinum* (Fig. 2). In each site, 3 bundles of seagrass were collected randomly and stored in 1 L plastic jars. Overall, 23 sites were sampled: 6 at Champotón, 7 at Costa, and 10 at Petenes (López-Mejía, 2016). Overall, more than 300 blades of *T. testudinum* were processed; these ranged in size from 36 to 70 cm^2; no statistical differences between blade size from the 3 sampled sites were found (López-Mejía, 2016). Thus, considering that between 3,000 and 4,000 diatoms cells may be found on 1 mm^2 of a host surface (Siqueiros-Beltrones et al., 2002), and that the random sampling of the blades compensated for the patchy distribution of diatom assemblages (Siqueiros-Beltrones, 2002), confidence exists on the representativeness for the upcoming estimation of proportionality or relative abundances of the distinct taxa in the diatom assemblages occupying this substrate, specifically of the identified *Mastogloia* infrataxa.

In the laboratory, the epiphytic diatoms were scraped off the *T. testudinum* blades with a spatula, cleaned by oxidizing the organic matter with nitric acid, and rinsed with distilled water until reaching a pH > 6 (Siqueiros-Beltrones, 2002). Afterwards, the diatom frustules were mounted on permanent slides using synthetic resin Pleurax (RI = 1.7), i.e., 3 slides per site (69 slides).

Mastogloia species and infra-specific taxa were identified on the basis of frustule morphology following the classic works by Peragallo and Peragallo (1908), Hustedt (1966), Cleve-Euler (1953), Schmidt et al. (1959), and recent literature: Foged (1975, 1978, 1984), Moreno et al. (1996), Witkowski et al. (2000), Siqueiros-Beltrones (2002), Metzeltin and García-Rodríguez (2003), Siqueiros-Beltrones et al. (2004), Hein et al. (2008), Novelo et al. (2007), López-Fuerte et al. (2010, 2013), Stidolph et al. (2012), Loir and Novarino (2013), Lobban et al. (2012). All species names were checked in the Guiry and Guiry (2016) online Algaebase.

Considering the entire epiphytic diatom taxocoenosis, i.e., > 300 diatom species (López-Mejía, 2016), the different *Mastogloia* taxa were classified according to their estimated proportions or relative abundances among all the observed diatom taxa. This was computed on the basis of a sample size of n = 500 valve count in a slide (Siqueiros-Beltrones, 2002; Siqueiros-Beltrones et al., 1985), i.e., 1,500 valves per site, and > 34,500 valves for the 3 localities; taxa were classified as: rare ($1< x \leq 15$), frequent ($15 < x \leq 100$, abundant ($100 < x \leq 300$), and very abundant (> 300).

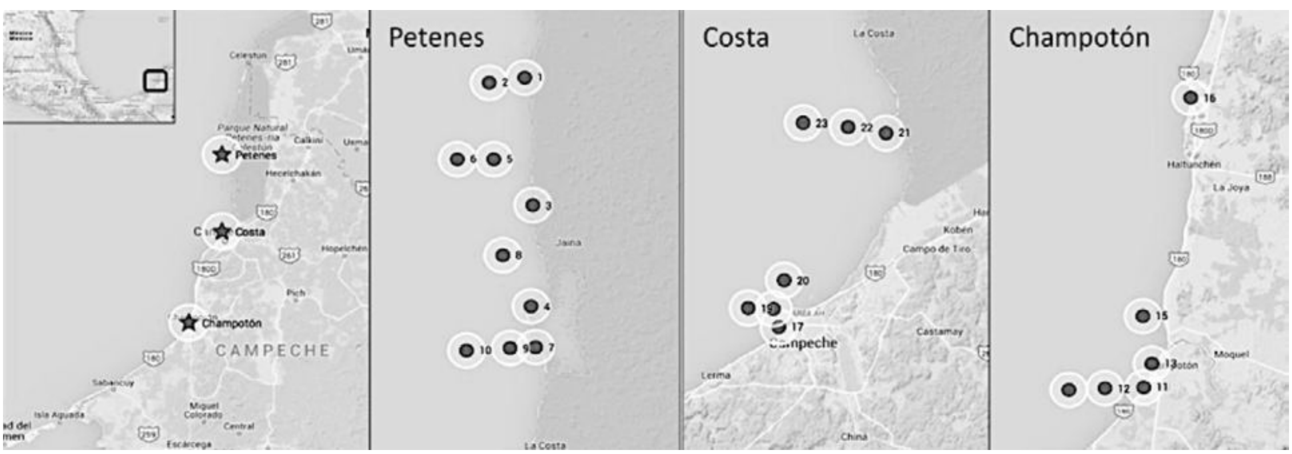

Figure 1. Study area comprising the 3 sampled localities: Champotón, City of Campeche, and the Biosphere Reserve Los Petenes.

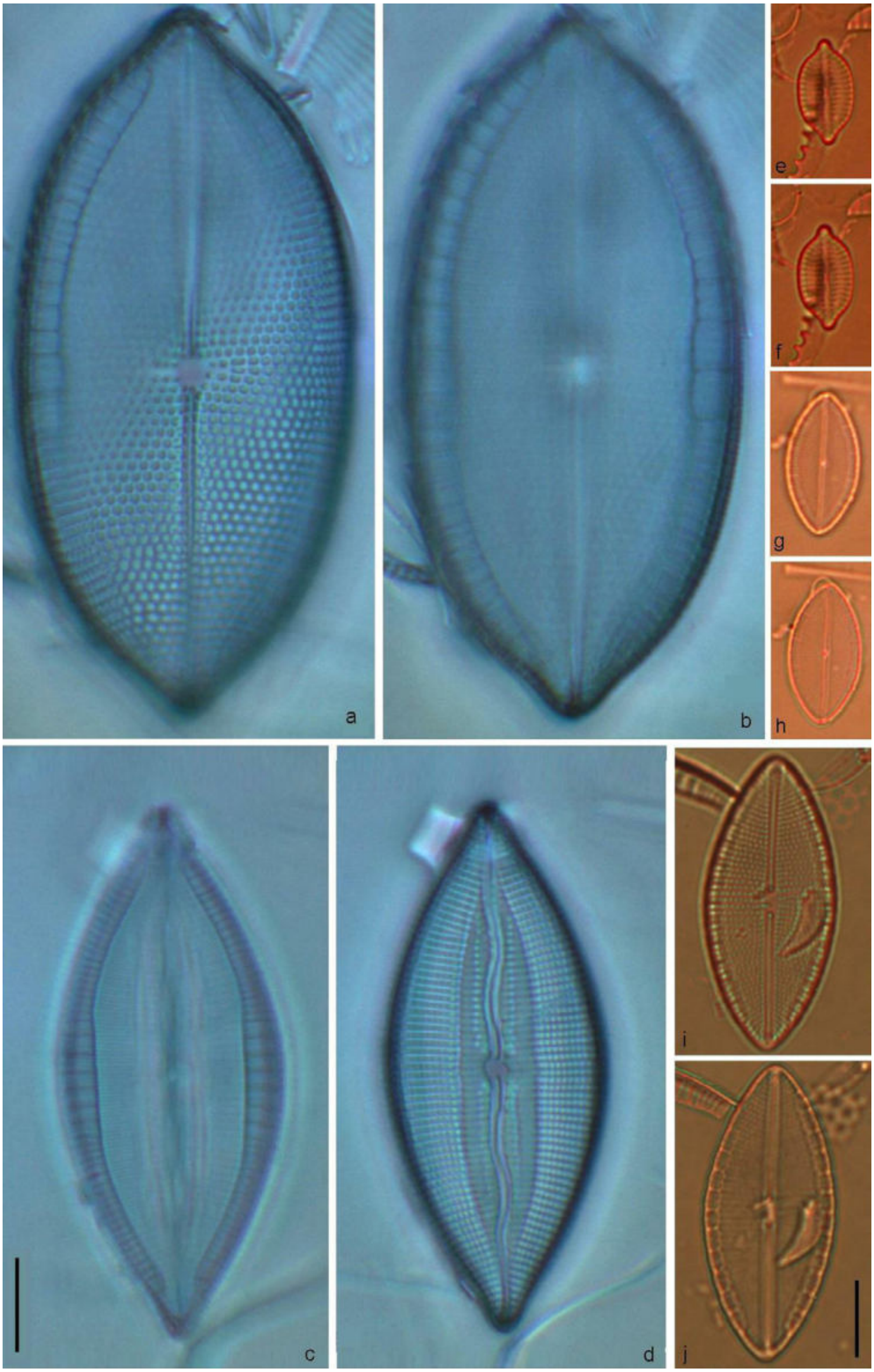

Figure 2. *Mastogloia angulata* (a, b), *M. belaensis* (c, d), *M. Corsicana* (e, f), *Mastolgoia* cf. *Ovulum* (i, j), *M. ovata* (g, h). Scale bars = 10 µm; i, j have a different scale.

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Results

The genus *Mastogloia* exhibited the highest number of taxa with 75 out of 301 identified diatom taxa found as epiphytes on *Thalassia testudinum* blades from the sampling area (López-Mejía, 2016), which were distributed among 70 diatom genera. In fact, *Mastogloia* taxa represented > 25 % of the total taxa found within the epiphytic taxocoenosis. Only 51 *Mastogloia* species or infra-specific taxa could be formally identified. In contrast 25 were left as cf. or sp. status (Table 1, Appendix). Petenes and Champotón, sampled during the dry season, yielded 38 and 52 *Mastogloia* taxa, respectively, while in Costa, which was sampled during the rainy season, 55 taxa were recorded. *Mastogloia crucicula* was the most abundant taxon (very abundant) in the 3 locations. Seven *Mastogloia* taxa had not been hitherto observed for the southern Gulf of Mexico region comprising the study area: *Mastogloia angusta*, *M. belaensis*, *M. depressa*, *M. ovalis*, *M. pseudolacrimata*, *M. regula*, and *M. urveae*. While 20 of the 76 identified constitute new records for de Gulf of Mexico, and 15 are new records overall for the Mexican coasts. Several of these taxa stand out, such as *M. urveae* (very abundant) and *M. ovalis* (abundant).

Table 1

List of species of *Mastogloia* recorded for the north coast of Campeche State. Figure number and their occurrences are included. f: Frequent; r: rare; a: abundant; va: very abundant; -: absent; *: new record for the Gulf of Mexico; **: new record for the Mexican coasts; NI: no image.

Class: Bacillariophyceae			
Order: Mastogloiales			
Family: Mastogloiaceae			
Genus *Mastogloia*: Thwaites ex W.Smith, 1856	Petenes	Champotón	Costa
M. angulata Lewis (Fig. 2a, b)	r	f	r
M. asperula Grunow ex Cleve (Fig. 10a)	r	f	
M. asperuloides Hustedt * (Figs. 9 c-e, 10 d, e)	f	r	f
M. bahamensis Cleve (Fig. 9a, b)	r	f	r
M. barbadensis (Geville) Cleve (Fig. 10j)	r	r	-
M. belaensis Voigt ** (Figs. 2c, d; 10b, c)	r	f	r
M. binotata (Grunow) Cleve (Fig. 9f, g)	f	r	r
M. biocellata (Grunow) G.Novarino & A.R.Muftah (Figs. 8c; 12c-f)	f	f	f
M. borneensis Hustedt (Fig. 8m)	r	-	-
M. cf. *angusta* Hustedt (NI)	f	f	f
M. cf. *asperula* Voigt (NI)	-	f	f
M. cf. *asperuloides* Hustedt (NI)	-	-	-
M. cf. *braunii* Grunow (Fig. 10f-i)	-	-	r
M. cf. *borneensis* Hustedt (Fig. 9h)	-	-	-
M. cf. *corsicana* (Grunow) Peragallo & Peragallo (NI)	-	r	-
M. cf. *crucicula* (Grunow) Cleve (Fig. 4p)	-	f	r
M. cf. *delicatissima* Hustedt (Figs. 10m, q; 13f, g)	-	-	-
M. cf. *erythraea* Grunow (Fig. 11f)	-	-	-
M. cf. *foliolum* Brun (NI)	r	-	-
M. cf. *mauritiana* Brun (NI)	r	-	-
M. cf. *ovulum* Hustedt (Fig. 2i, j)	-	-	-
M. cf. *ovum-paschale* (A.Schmidt) A.Mann (Fig. 3a, b, i, j)	-	-	r
M. cf. *pulchella* Cleve (NI)	-	-	r
M. cf. *rimosa* Cleve (Fig. 11a-c)	-	r	-
M. cf. *staurophora* Hustedt (Figs. 6a-c; 7h, i)	f	-	-
M. cf. *tenera* Hustedt (Fig. 8a, b)	f	f	r
M. cocconeiformis Grunow (Fig. 4a, b)	f	f	r
M. corsicana (Grunow) Peragallo & Peragallo (Figs. 2e, f; 4c, e)	a	a	a
M. corsicana (Grunow) Peragallo & Peragallo var. 1 (Fig. 11j, k)	-	r	r

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Table 1

Class: Bacillariophyceae			
M. corsicana (Grunow) Peragallo & Peragallo var. 2 (Fig. 11l, m)	-	-	r
M. corsicana (Grunow) Peragallo & Peragallo var. 3 (Fig. 11o-s)	-	-	r
M. cribrosa Grunow (Figs. 5g, h; 12m)	f	f	f
M. crucicula (Grunow) Cleve (Fig. 4j-o)	va	va	va
M. cuneata (Meister) R.Simonsen (Fig. 5r-t)	-	r	r
M. cyclops Voigt ** (Fig. 4f, g)	-	f	r
M. decipiens Hustedt * (Fig. 11g)	f	f	f
M. decussata Grunow ** (Fig. 11n)	-	r	-
M. depressa Hustedt ** (Figs. 4 h-i; 13 c-e)	r	r	r
M. emarginata Hustedt (Fig. 5e, f)	-	r	r
M. erythraea Grunow (Figs. 5i-k; 12a, b, k, l)	-	-	r
M. erythraea Grunow for. 1 (Fig. 12g, h)	f	f	f
M. erythraea Grunow for. 2 (Fig. 12i, j)	-	-	-
M. erythraea var. *grunowii* Foged ** (Fig. 5a-d)	-	r	f
M. foliolum (Brun) A.Schmidt ** (Figs. 10r-t; 12n-q)	-	-	r
M. frickei Hustedt ** (Fig. 13a, b)	r	r	r
M. frimbriata (Brightwell) Grunow (Fig. 7a, b, d)	f	f	f
M. horvathiana Grunow (Fig. 6k, l)	f	r	r
M. ignorata Hustedt (Fig. 3c, d; 9k)	f	a	r
M. lanceolata Thwaites ex W.Smith (Figs. 3g, h; 8o, p)	r	f	f
M. mauritiana Brun ** (Fig. 13 j-l)	-	r	-
M. ovalis A.Schmidt ** (Figs. 5l-q; 13h, i)	a	f	f
M. ovata Grunow (Fig. 2g, h)	f	f	r
M. ovulum Hustedt (Fig. 10k, l, n-p)	r	r	r
M. ovum-paschale (A.Schmidt) A.Mann * (Fig. 8r, s)	f	f	f
M. parva Hustedt ** (Fig. 8n)	f	f	r
M. pseudolacrimata Yohn & Gibson** (Fig. 3e, f)	-	-	r
M. pulchella Cleve (NI)	-	r	-
M. punctifera Burn (Fig. 9l-o)	f	f	f
M. pusilla var. *linearis* Ostrup * (Fig. 11h, i)	-	-	f
M. pusilla (Grunow) Cleve var. *pusilla* Moreno *(Fig. 7q-t)	-	f	f
M. pusilla var. *subcapitata* Hustedt (Fig. 7m-p)	a	f	r
M. regula Hustedt ** (Fig. 6d, e)	-	-	-
M. rimosa Cleve** (Fig. 11d, e)	-	f	f
M. robusta Hustedt (Fig. 13m-p)	r	f	-
M. similis Hustedt ** (Fig. 7l)	-	r	-
M. sp.1 (Fig. 8q)	f	r	f
M. sp.2 (NI)	-	-	-
M. sp.3 (NI)	-	-	r
M. sp.4 (NI)	-	-	r
M. sp.5 (NI)	-	r	-
M. sp.6 (NI)	-	-	f
M. sp.7 (NI)	-	-	-
M. sp.8 (NI)	-	f	f
M. subaffirmata Hustedt (Fig. 8k, l)	f	f	f
M. urveae Witkowski ** (Fig. 6o-r)	a	a	f
M. varians Hustedt (Fig. 6f-j, m, n)	f	f	f

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New records for the Gulf of Mexico and Mexican coasts***

The following descriptions and distributions of *Mastogloia* taxa were complemented following Witkowski et al. (2000), Hein et al. (2008), Loir and Novarino (2013), whose descriptions coincide with our observations in each taxon. Also, Guiry and Guiry (2016) AlgaeBase was consulted for distribution data.

**Mastogloia asperuloides* Hustedt (Figs. 9c-e, 10d, e): valves lanceolate with cuneate to cuneate sub-rostrate apices, 14.1-31 µm long, 8.5-16 µm broad. Striae, 18/10 µm; partecta, 4/10 µm. Raphe slightly wavy, external central endings slightly bent in one side. Axial area very narrow, central area small, circular or transapically elongated. Distribution: reported in the Caribbean Sea, Canary Islands, Biscayne Bay, Puerto Rico, Samoa, and Baja California.

***Mastogloia belaensis* Voigt (Figs. 2c, d, 10b, c): valves lanceolate with obtusely rounded apices, 55-92 µm long, 14-19 µm broad. Raphe undulating, axial area moderately broadly linear, at apices narrowed, central area rectangular connected to hyaline lateral areas. Transapical striae coarsely punctate radiate, at apices parallel, 13-14 in 10 µm, puncta 12-13 in 10 µm. Partectal ring displaced towards the raphe sternum, variable in size, 1.5 to 3 µm broad; 5 to 10 in 10 µm. Distribution: reported for brackish-water near Karachi in Pakistan and Moroccan coasts.

***Mastogloia cyclops* Voigt (Fig. 4f-g): valves elliptic-lanceolate with slightly protracted apices, 25 -46 µm long, 11-13 µm broad. Raphe strongly wavy, axial area very narrow, central area small, asymmetrically semi-circular. Transapical striae parallel throughout, 20-22 in 10 µm, crossed by longitudinal, slightly wavy ribs. Partectal ring 1.5-2.0 µm broad, terminating just below apices, partecta transapically rectangular with inner margin slightly convex, 10 in 10 µm. Distribution: described from Japan

**Mastogloia decipiens* Hustedt (Fig. 11g): valves elliptical with rostrate to rostrate-capitate apices, 20-33 µm long, 9.5-12 µm broad. Raphe straight to slightly undulating, external central endings approximate, axial area narrow, central area small, narrow, transapically elongated. Transapical striae parallel to slightly radiate towards the apices, 26-28 in 10 µm crossed by some equidistant longitudinal wavy lines, 14-17 in 10 µm. Partecta inseparable, equal, square to transapically rectangular, 7.5-9 in 10 µm, 1.3-1.8 µm broad, extending to a short distance from the apices. Inner margins flat to slightly convex. Distribution: France, China, Caribbean Sea, Mediterranean, Tanzania, Guadalupe, Seychelles Islands, Tahiti, and Baja California.

***Mastogloia decussata* Grunow (Fig. 11n): valves lanceolate with slightly protracted broadly rounded apices, 70-130 µm long, 22-27 µm broad. Raphe slightly undulating, axial area very narrow, central area small ovoid or slightly transapically, widened. Transapical striae parallel, 26-30 in 10 µm, composed of 3 areolae row crossing each other. The number of decussate rows equals that of the transapical one. Partecta ring ca. 4 µm broad, terminates at some distance below apices; partecta uniform in shape, transapically elongated, rectangular with inner margin straight, 9-10 in 10 µm. Distribution: commonly found on the tropical coasts of the Indian and Pacific Oceans, Caribbean, Kuwait, Tanzania, Seychelles Islands, and Tahiti.

***Mastogloia depressa* Hustedt (Figs. 4h-i, 13c-e): valves elliptical with subrostrate apices, 14-25 µm long and 6.1-10.3 µm broad. Raphe branches are very gently sinuous. Trasapical striae monoseriate, 20-28 in 10 µm, slightly radiate at center and strongly radiate at poles. Partecta are apically rectangular, gently convex on the free margin, more or less similar in shape and size (0.8-1.0 µm in width). Distribution: Mediterranean coasts, Philippines, and South China Sea.

***Mastogloia erythraea* var. *grunowii* Foged (Fig. 5a-d): valves lanceolate to rhombic-lanceolate with cuneate to protracted apices, 23-89 µm long, 6-18 µm broad. Raphe strongly undulating, axial area very narrow, central area small asymmetric. Transapical striae in the middle parallel, but slightly radiate towards the apices, slightly convergent at the apex, 21-25 in 10 µm, crossed by slightly wavy longitudinal ribs, 16-20 in 10 µm. Partecta large, one at each margin of the valve, at opposite sides of the central area. Distribution: the littoral of Cuba (Although Witkowski mentions it as common in the Gulf of Mexico, we did not find any records).

***Mastogloia foliolum* Brun in A. Schmidt (Figs. 10r-t, 12n-q): valves elliptical with more or less rostrate apices, 26.36 µm long, 12-14 µm broad. Raphe straight, axial area narrow. Central area transversely expanded into a widened fascia to about one half of the valve width. At both sides of the raphe, semi-lanceolate lateral areas cover about half of the valve surface Transapical striae within marginal areas, 25-27 in 10 µm. Partecta inseparable, sub-equal, square to rectangular, extending shortly below the apices. Groups of 3 to 5 central larger partecta, 4-5 in 10 µm. Distribution: reported for Biscayne Bay.

***Mastogloia frickei* Hustedt (Fig. 13a-b): valves lanceolate with cuneate slightly protracted apices; 52-65 µm long, 12-16 µm in width. Raphe wavy, central area asymmetric; middle slightly large at only one side. Transapical striae 16-21 in 10 µm, radiate in the middle and convergent toward the apices, crossed by longitudinal wavy ribs. Partectal ring 1.5 µm broad continuing up to the apices; partecta rectangular to square, 8 in 10 µm.

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Distribution: common in the Caribbean and allegedly recorded from Campeche bay, although, we did not find any records.

**Mastogloia mauritiana* Brun (Fig. 13j-l): valves lanceolate with rounded apices, 20-75 µm long, 11.5-22 µm broad. Raphe very undulated, external central endings slightly expanded. Axial area narrow, central area small. Transapical striae radiate, 21-24 in 10 µm, crossed by longitudinal lines, 17-20 in 10 µm. Partecta inseparable, sub-equal, extending up to a short distance from the apices. Distribution: Adriatic Sea, Australia, Colombia, Caribbean, France, Guadalupe, Mediterranean, Philippines, China, Tanzania.

**Mastogloia ovalis* A. Schmidt (Figs. 5l-q, 13h-i): valves elliptical 9.5-22.5 µm long, 6.5-11 µm broad. Raphe straight or slightly sinuous, external central endings expanded, distant. Axial area narrow, central area narrow, apically elongated. Transapical striae radiate to strongly radiate at apices, 20-22 in 10 µm, composed of rounded areolae, 21-23 in 10 µm. A central group of 2 to 7 partecta inseparable, equal, apically elongated, 4.3-55.5 in 10 µm. Distribution: Albania, France, China, Guam, Caribbean Sea, Biscayne Bay, and Philippines.

**Mastogloia ovum-paschale* (A. Schmidt) A. Mann (Fig. 8r-s): valves elliptical, 32-52 µm long, 21-30 µm broad. Raphe sinuous, external central endings expanded, moderately distant. Axial area very narrow, lined by 2 series of transapically elongated areolae. Central area transapically widened. Transapical striae radiate, 12-16 in 10 µm, composed of transapically elongated areolae, 8-10 in 10 µm. Partecta inseparable, equal, rectangular, transapically slightly elongated, 5-6 in 10 µm continuing up to the apices. Distribution: reported from Bahia de la Ventana Baja California, Caribbean Sea, Adriatic Sea.

**Mastogloia parva* Hustedt (Fig. 8n): valves linear-elliptic with protracted apices, 20-23 µm long, 9-10 µm broad. Raphe straight, axial area very narrow, central area very small. Transapical striae in the middle parallel, towards apices becoming slightly radiate, 21-23 in 10 µm, crossed bay slightly sinuous longitudinal ribs. Partectal rings 0.75-1.0 µm broad, terminating close to the apices, 4-6 in 10 µm. Distribution: Australia.

**Mastogloia pseudolacrimata* Yohn & Gibson (Fig. 3e-f): valves elliptical with acute apices, 53 µm long, 15 µm wide. Transapical striae coarsely punctate, middle parallel in the, becoming slightly radiate towards apices 15/10 µm, partecta 9/10 µm, with partectal ring ending close to the apices. Distribution: Bahamas.

**Mastogloia pusilla* var. *linearis* Östrup (Fig. 11h-i): valves linear with parallel margins and rostrate ends, 40 µm long, 5-6 µm broad. Transapical striae 20-24 in 10 µm. Partectal ring terminates close to the apices, partecta variable in size, the largest partecta located in the middle, 4 in 10 µm, the other partecta smaller 6-8 in 10 µm. Distribution: wide, Australia, Gulf of California, Colombia, Danish coast, Tasmania.

**Mastogloia pusilla* (Grunow) Cleve var. *pusilla* Moreno (Fig. 7q-t): valves linear-elliptic to lanceolate with broadly rounded apices, 15-35 µm long, 5-7 µm broad. Raphe straight, axial area very narrow, central area very small, lanceolate. Transapical striae in the middle parallel towards apices becoming radiate, 18-20 in 10 µm, crossed by longitudinal ribs, 24 in 10 µm. Partectal ring terminates close to the apices, partecta variable in size, the largest partecta located in the middle (usually 1-2), 4 in 10 µm, the other partecta smaller 6-8 in 10 µm. Gulf of California.

**Mastogloia regula* Hustedt (Fig. 6d-e): valves linear with almost parallel margins and broadly rounded, 18-23 µm long, 4-7 µm broad. Raphe straight to slightly wavy, axial area very narrow, central area very small. Transapical striae parallel in the middle becoming slightly radiate at the apices, 20-22 in 10 µm. Partecta ring 0.5-1 µm wide terminating close to the apices, 8 in 10 µm. Distribution: Bosnia-Hertzegovina, Mediterranean coasts.

**Mastogloia rimosa* Cleve (Fig. 11d, e): lanceolate valves, very acute, 37 µm long and 13 µm broad. Transapical striae parallel 11 in 10 µm. Axial area very narrow. Raphe straight. Partecta ring 2 µm broad, partecta small, rectangular transapically, 10 in 10 µm. Distribution: Bahamas, China, and Guam.

**Mastogloia similis* Hustedt (Fig. 7l): valves linear-lanceolate with rostrate to rostrate-capitate apices, 29-39 µm long, 9-10.5 µm broad. Raphe straight to barely sinuous, external central endings. Axial area narrow, central area small. Transapical striae 30-32 in 10 µm. Partecta inseparable, rectangular apically elongated. Large central partecta 4.5-6.3 in 10 µm. Smaller partecta towards the apices, 8-9.5 in 10 µm, extending to some distance below the apices. Inner margins flat, external margins slightly convex. Distribution: Caribbean Sea, Borneo, Philippines, Kuwait, Seychelles, France, and China.

**Mastogloia urveae* Witkowski (Fig. 6o-r): valves linear-lanceolate with rounded apices, 9.2-17.8 µm long, 3.6-4.8 µm broad. Raphe straight to barely sinuous, external central endings distant. Axial area and central area very narrow. Transapical striae parallel to barely radiate towards the apices, 25-29 in 10 µm. Partecta inseparable, a single large median partecta, 4-6 in 10 µm. Distribution: Gulf of Mexico (USA).

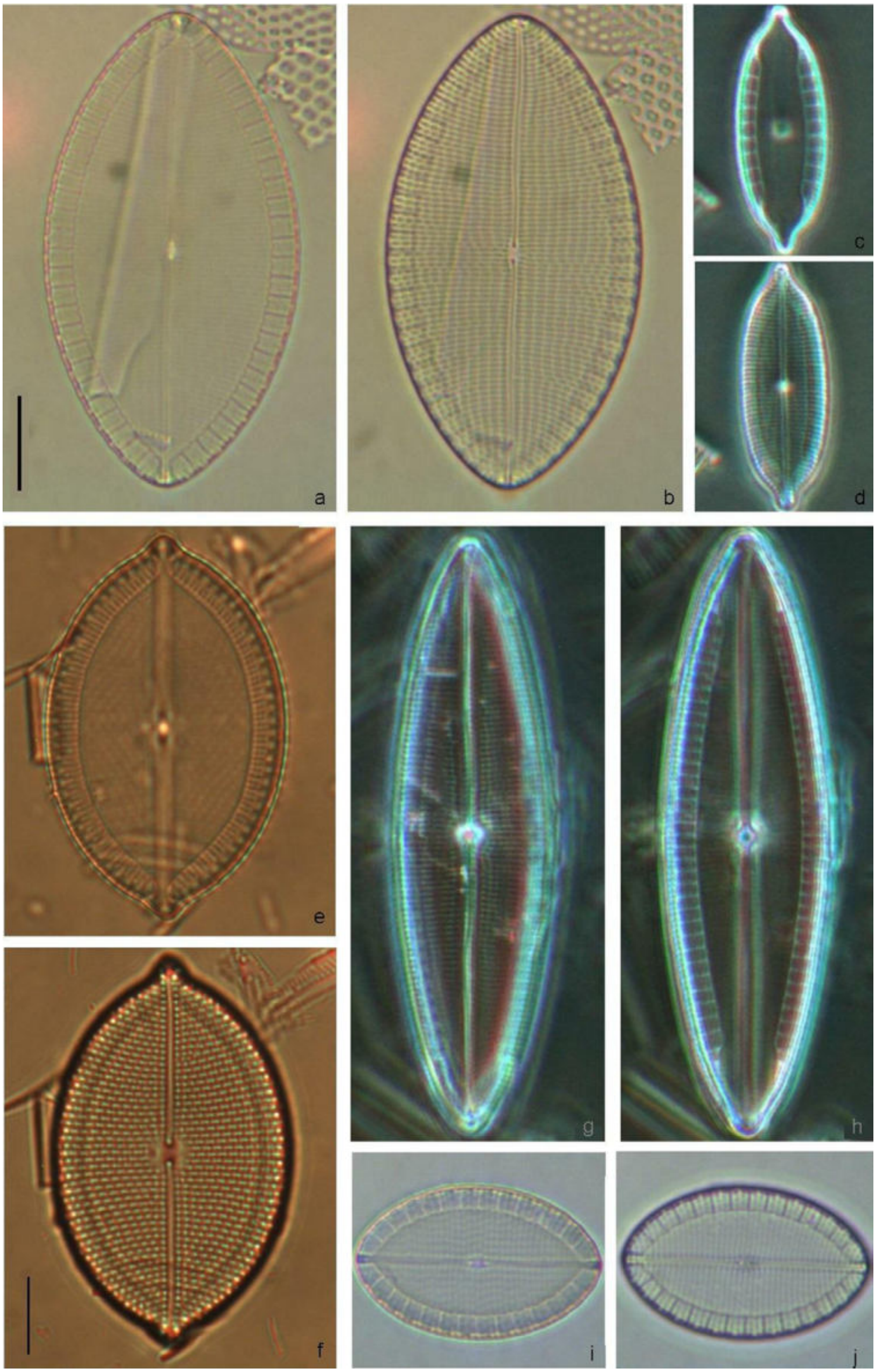

Figure 3. *Mastogloia* cf. *ovum paschale* (a, b, i, j), *M. ignorata* (c, d), *Mastogloia pseudolacrimata* (e, f), *M. lanceolata* (g, h). Scale bars = 10 µm; e, f, have a different scale.

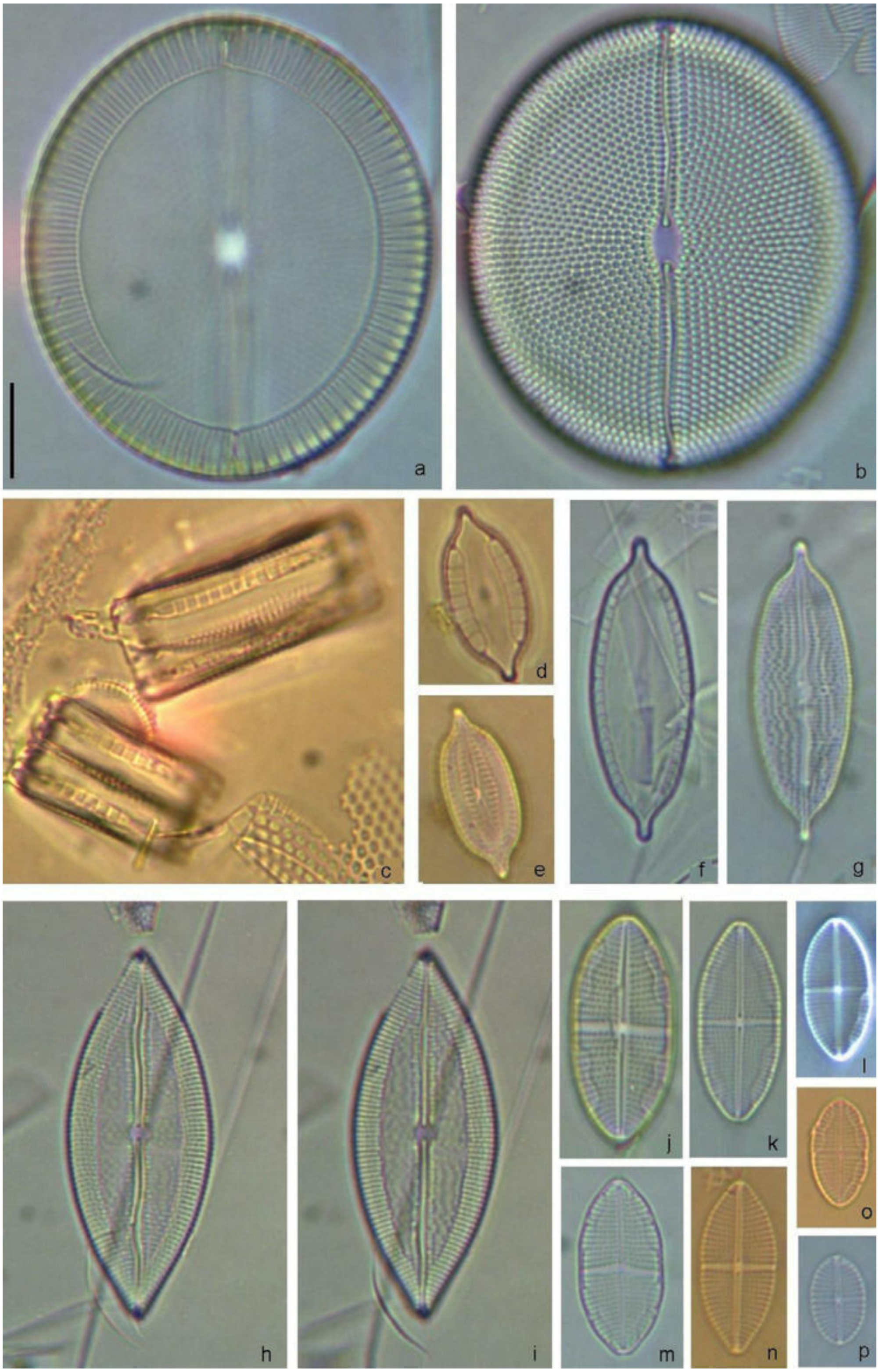

Figure 4. *Mastogloia cocconeiformis* (a, b), *M. corsicana* (c-e), *M. cyclops* (f, g), *M. depressa* (h, i), *M. crucicula* (j-o), *Mastogloia* cf. *crucicula* (p). Scale bar = 10 µm for all specimens.

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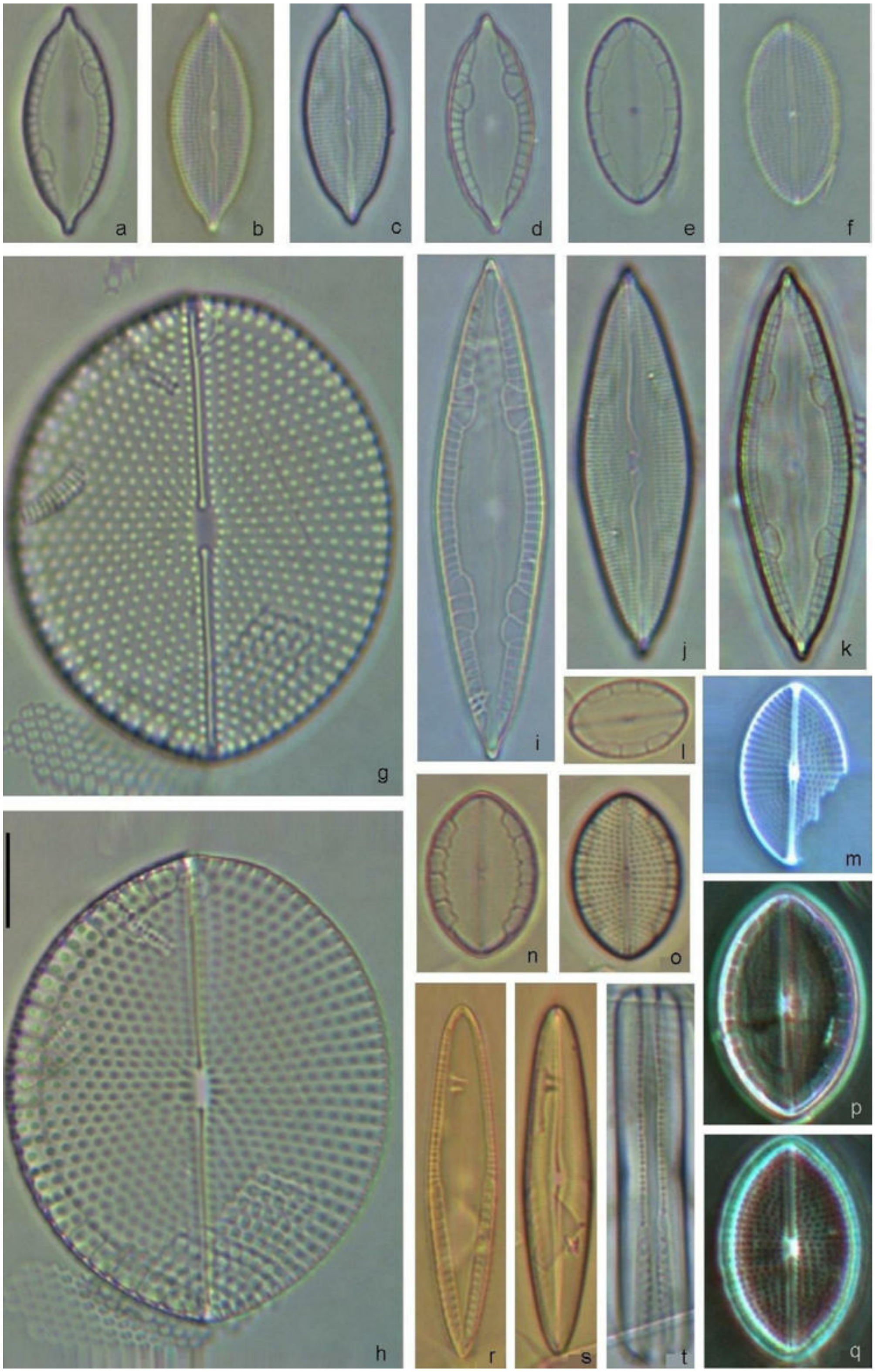

Figure 5. *Mastogloia erythraea* var. *grunowii* (a-d), *M. emarginata* (e, f), *M. cribrosa* (g, h), *M. erythraea* (i-k), *M. ovalis* (l-q), *M. cuneata* (r-t). Scale bar = 10 µm for all specimens.

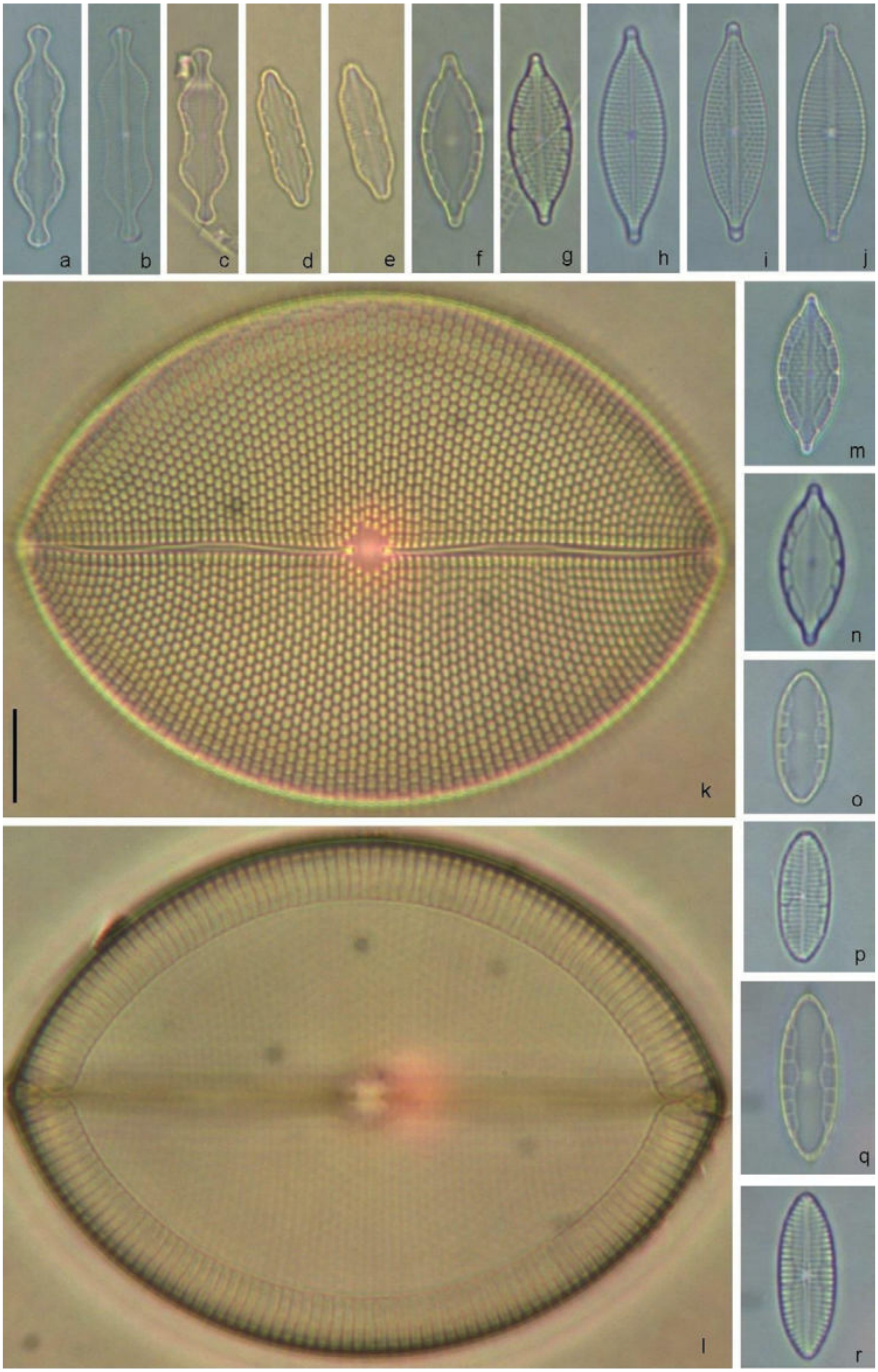

Figure 6. *Mastogloia* cf. *staurophora* (a-c), *M. regula* (d, e), *M. varians* (f-j, m, n), *M. horvathiana* (k, l), *M. urveae* (o-r). Scale bar = 10 µm for all specimens.

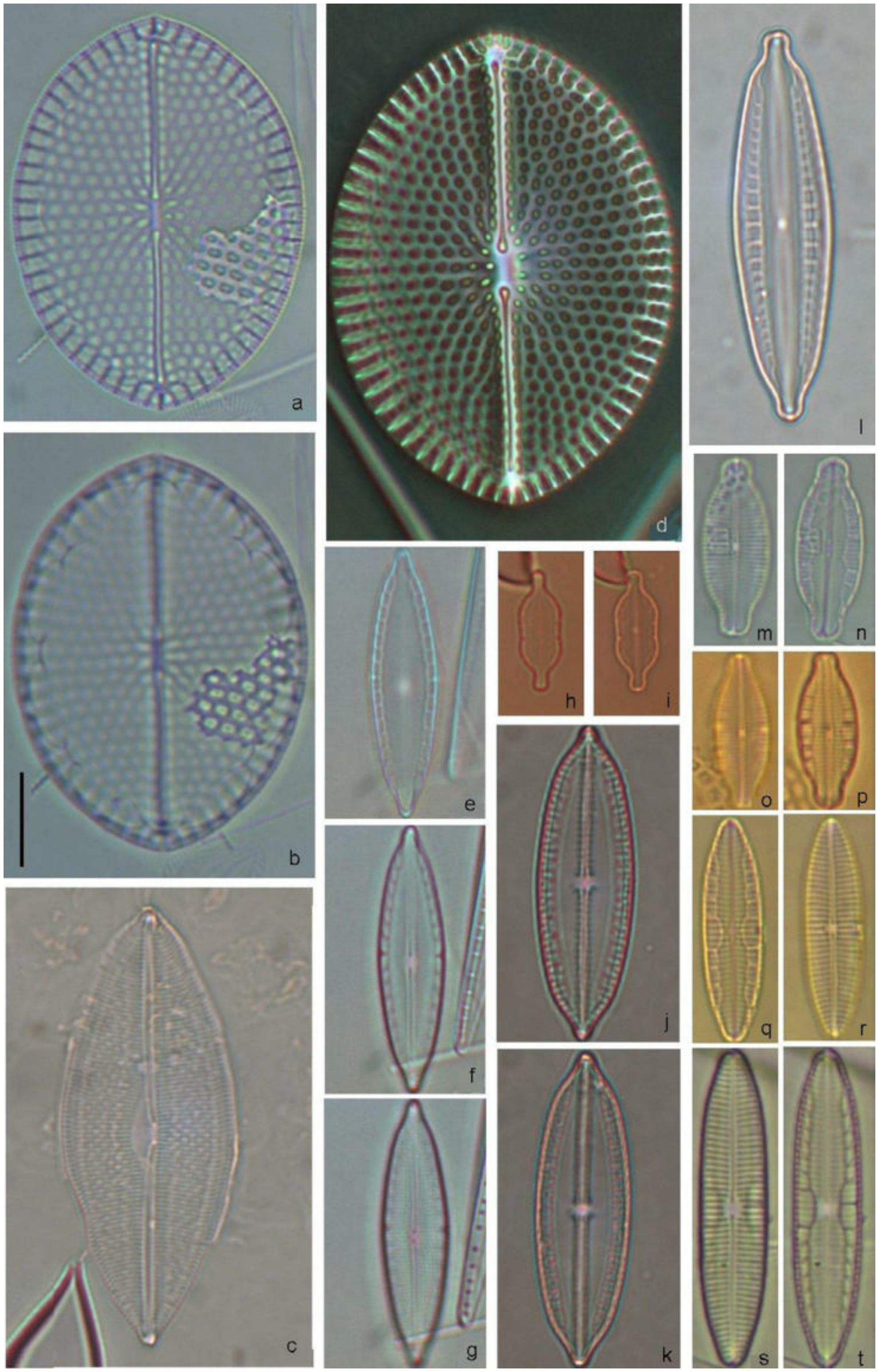

Figure 7. *Mastogloia frimbriata* (a, b, d), *Mastogloia* sp. 5 (c), *Mastogloia* sp. 3 (e-g), *Mastogloia* cf. *staurophora* (h, i), *Mastogloia* sp. 4 (j, k), *M. similis* (l), *M. pusilla* var. *subcapitata* (m-p), *Mastogloia pusilla* var. *pusilla* (q-t). Scale bar = 10 µm for all specimens.

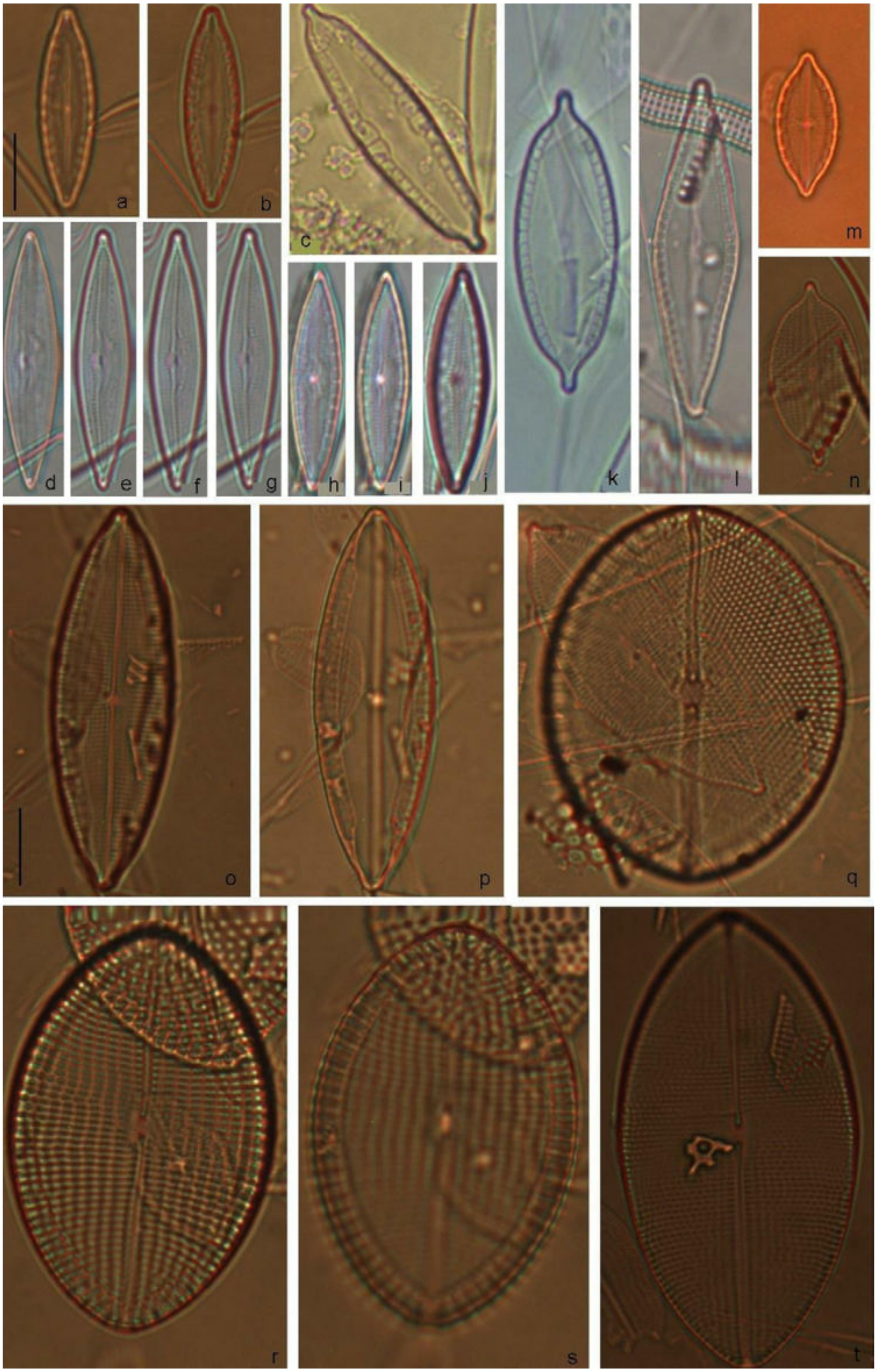

Figure 8. *Mastolgoia* cf. *tenera* (a, b), M. *biocellata* (c), *Mastogloia* sp. 6 (d-j), *M. subaffirmata* (k, l), *M. borneensis* (m), *M. parva* (n), *M. lanceolata* (o, p), *Mastogloia* sp. 1 (q), *M. ovum-paschale* (r, s), *Mastogloia* sp. 2 (t). Scale bar = 10 µm for all specimens.

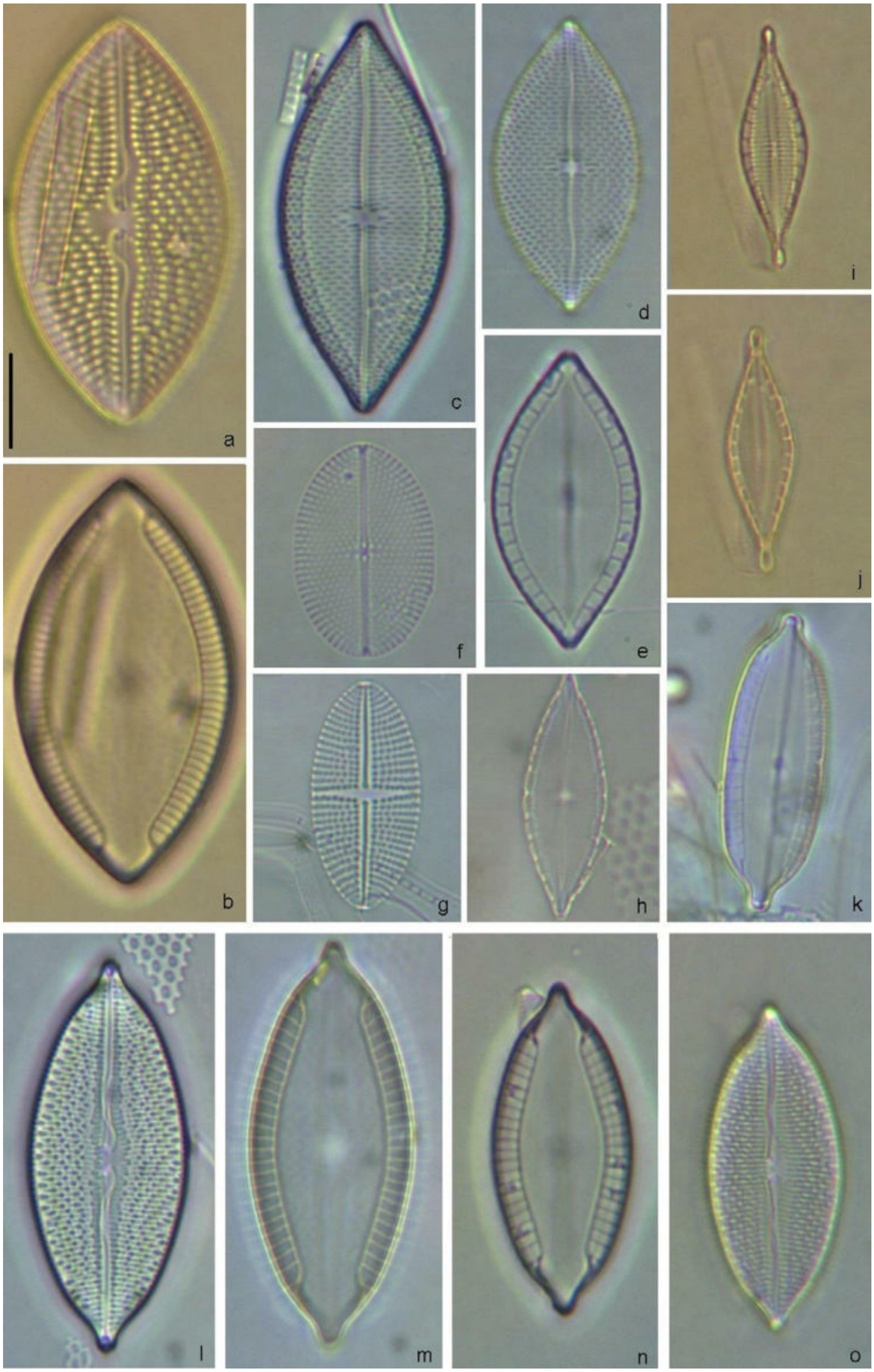

Figure 9. *Mastogloia bahamensis* (a, b), *M. asperuloides* (c-e), *M. binotata* (f, g), *Mastogloia* cf. *borneensis* (h), *Mastogloia angusta* (i, j), *M. ignorata* (k), *M. punctifera* (l-o). Scale bar = 10 µm for all specimens.

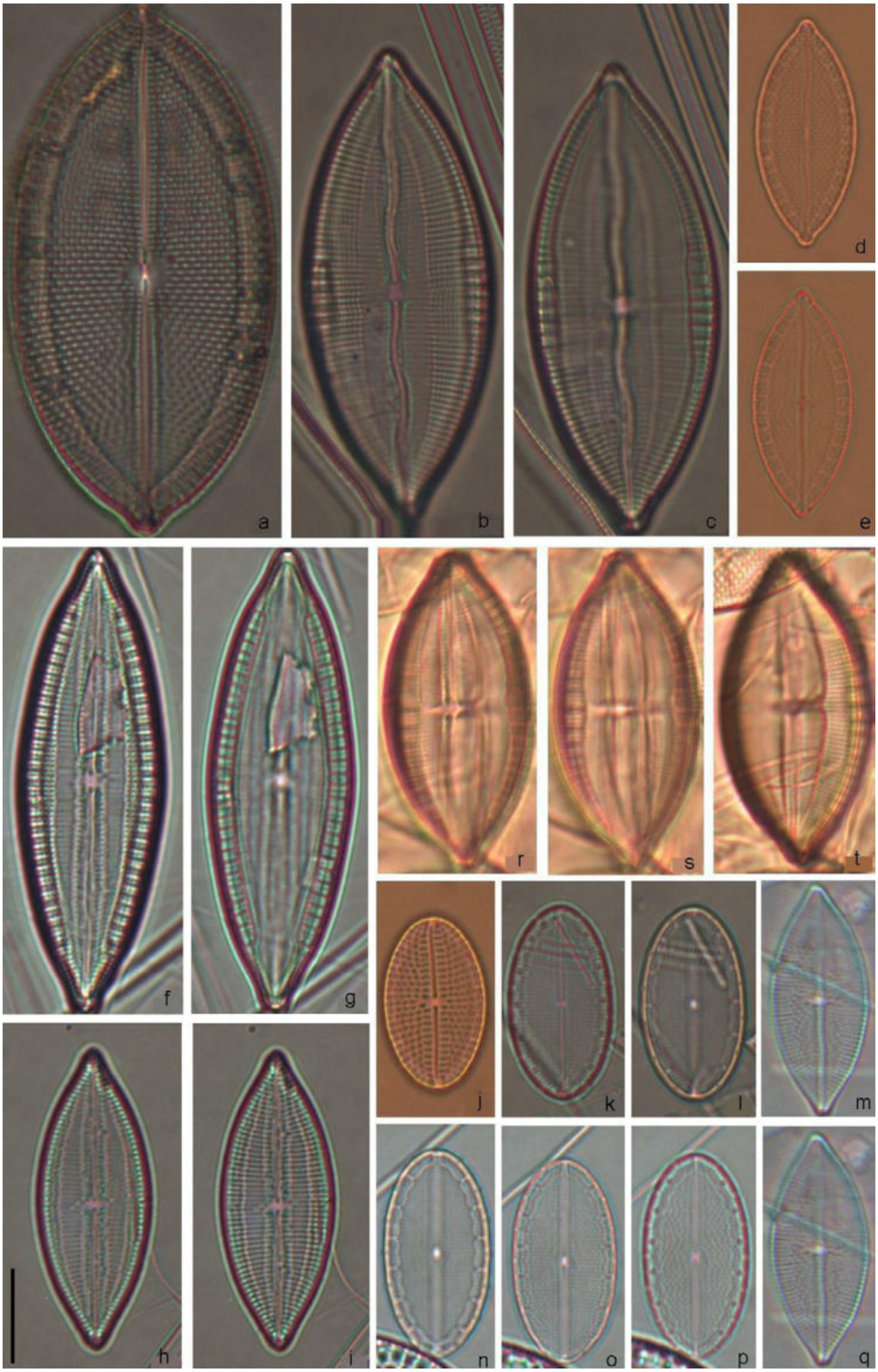

Figure 10. *Mastogloia asperula* (a), *M. asperuloides* (d, e), *M. belaensis* (b, c), *Mastogloia* cf. *braunii* (f-i), *M. barbadensis* (j), *Mastogloia ovulum* (k, l, n-p), *Mastogloia* cf. *delicatissima* (m, q), *M. foliolum* (r, s, t). Scale bar = 10 µm for all specimens.

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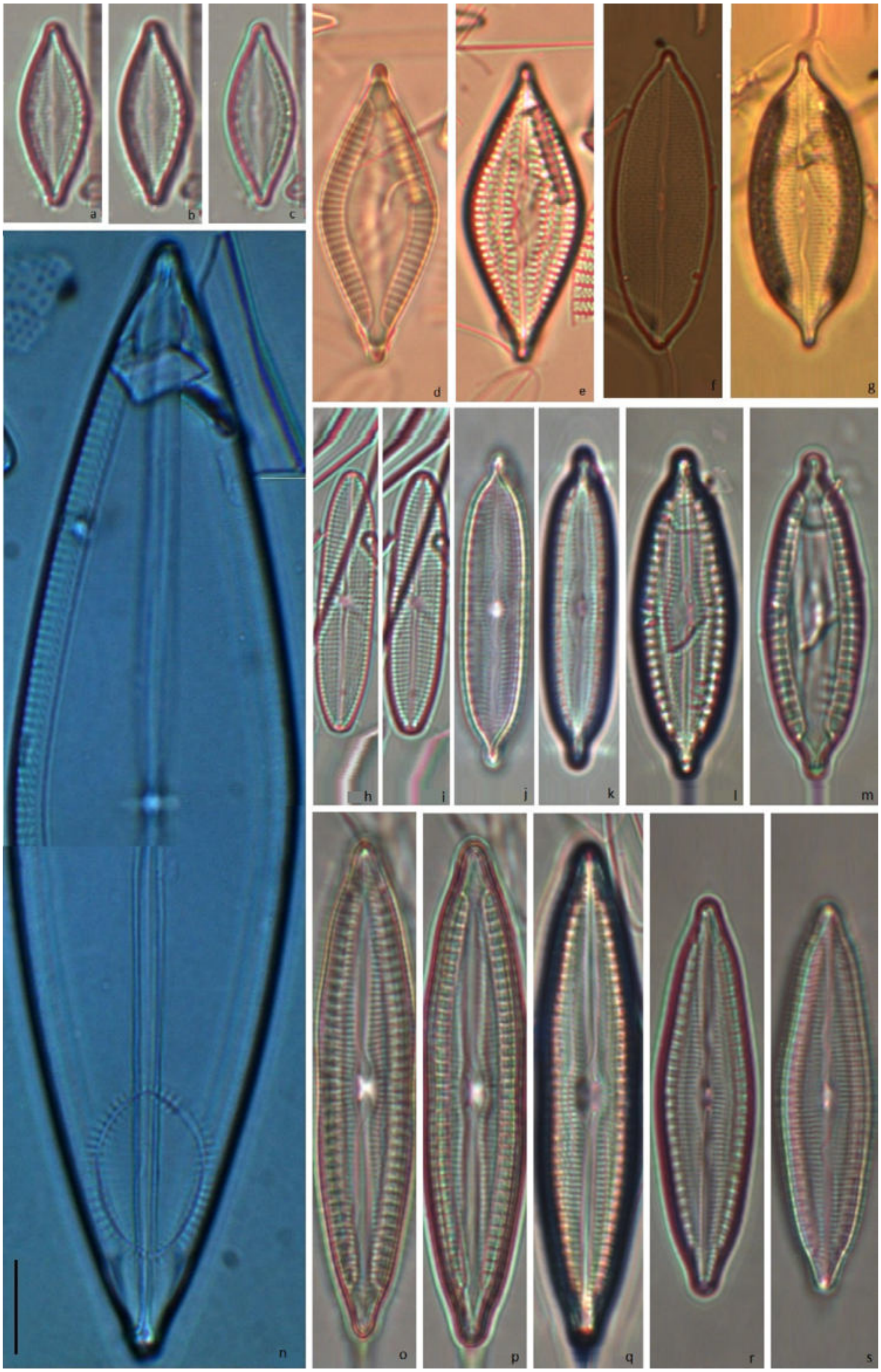

Figure 11. *Mastogloia* cf. *rimosa* (a-c), *M. rimosa* (d, e), *Mastogloia* cf. *erythraea*; (f) *M. decipiens* (g), *M. pusilla* var. *linearis* (h, i), *M. corsicana* var. 1 (j, k), *M. corsicana* var. 2 (l, m), *M. decussata* (n), *M. corsicana* var. 3 (o-s). Scale bar = 10 µm for all specimens.

https://doi.org/10.22201/ib.20078706e.2020.91.2976

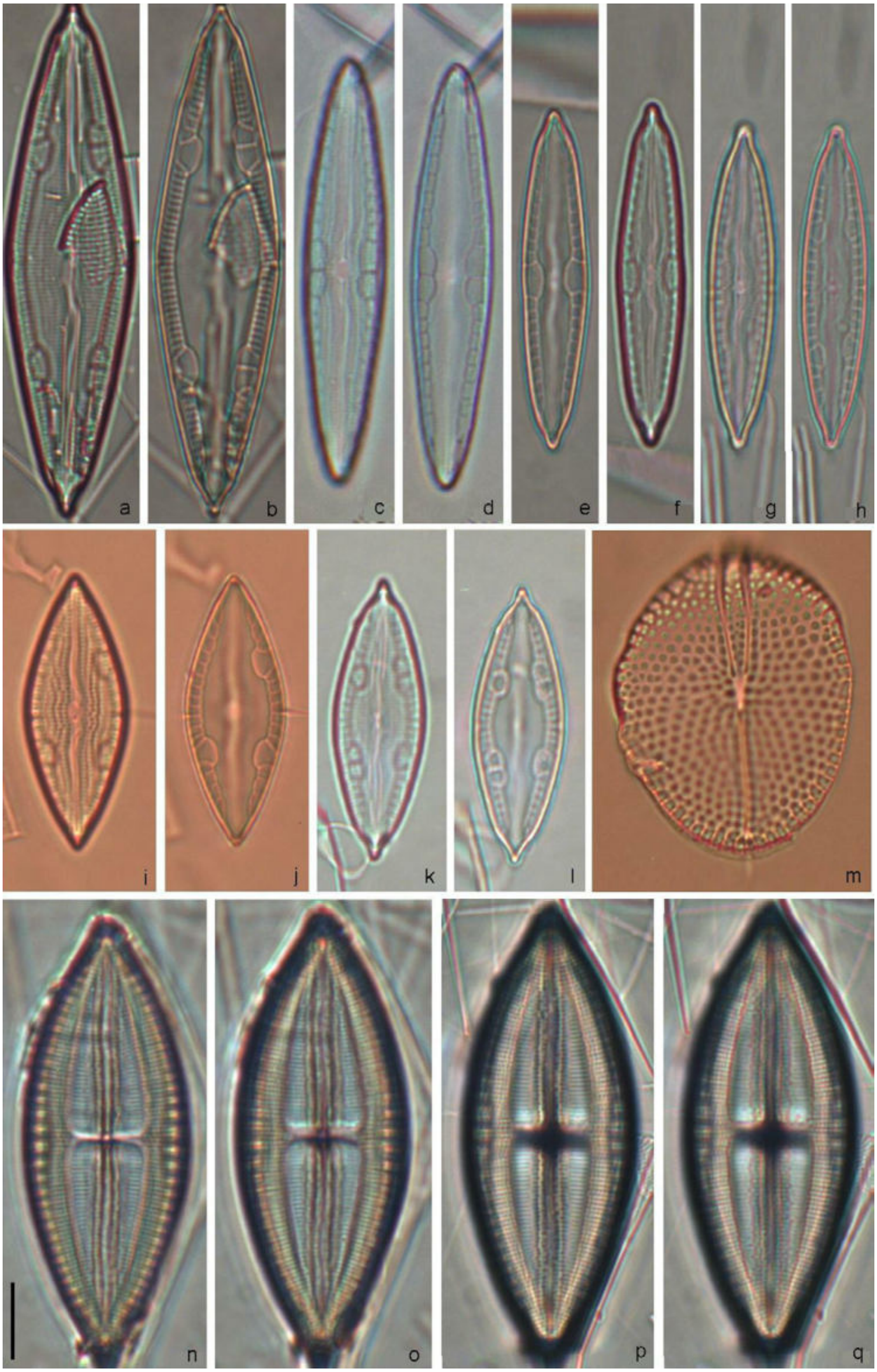

Figure 12. *Mastogloia erythraea* (a, b, k, l), *M. biocellata* (c-f), *M. erythraea* f. 1 (g, h), *M. erythraea* f. 2 (i, j), *M. cribrosa* (m), *M. foliolum* (n-q). Scale bar = 10 µm for all specimens.

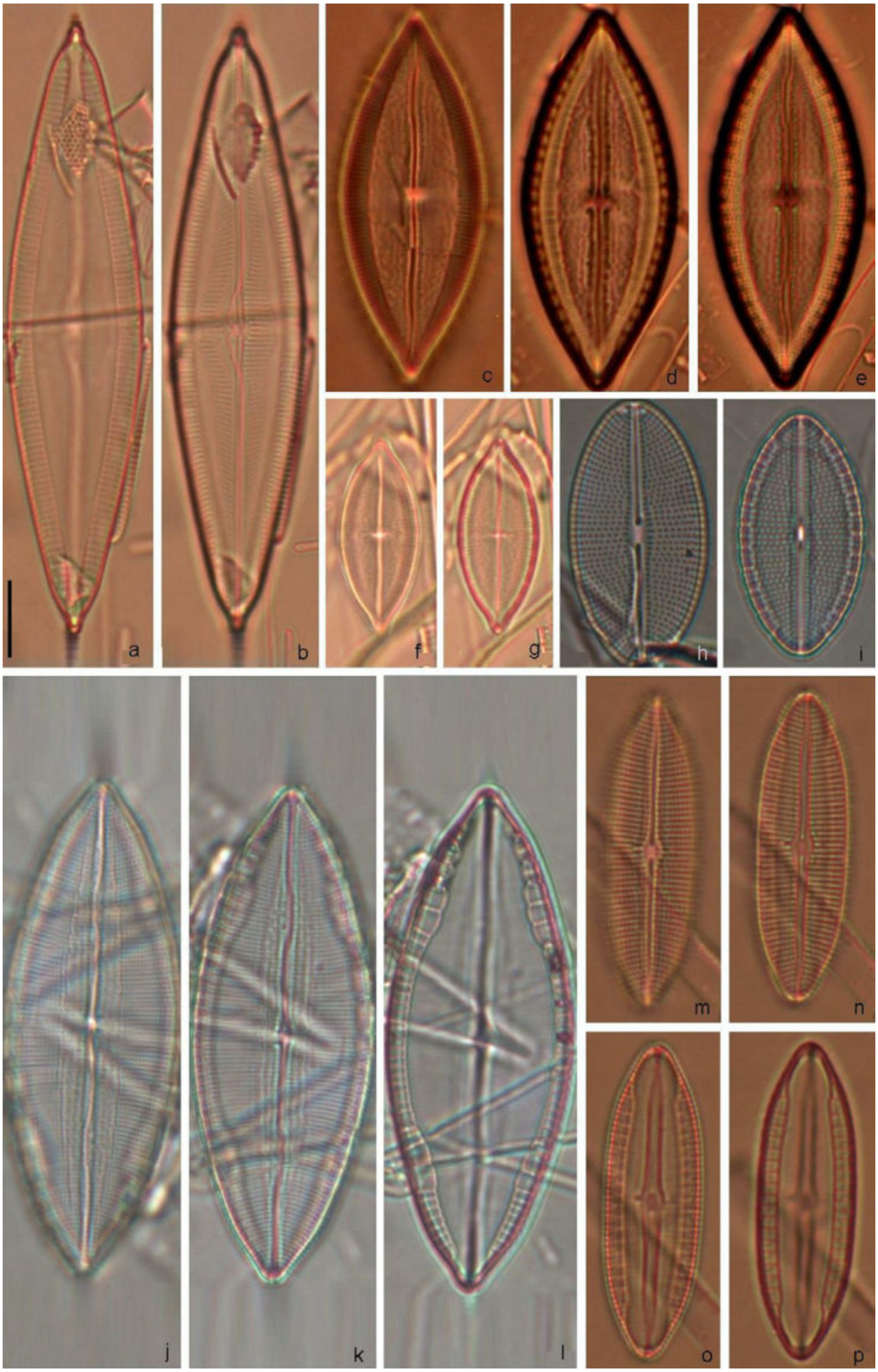

Figure 13. *Mastogloia frickei* (a, b), *M. depressa* (c-e), *Mastogloia* cf. *delicatissima* (f, g), *M. ovalis* (h-i), *M. mauritiana* (j-l), *M. robusta* (m-p). Scale bar = 10 µm for all specimens.

Discussion

Although differences occurred in the number of *Mastogloia* taxa from the 3 localities from the coast of Campeche, in each one they represented less than 30% of the recorded diatom taxa (López-Mejía, 2016), which may be serendipitous, rather than related to differences in the environment. This and the common substrate (*T. testudinum*) allows for considering the 3 localities as a homogeneous study area.

Overall, the *Mastogloia* species in this report comprised > 25% of the total taxa found within the epiphytic taxocoenosis living on *Thalassia testudinum*, collected in 3 dates solely in the Campeche area, and represents the highest species richness for this genus hitherto recorded in Mexican waters on the basis of >30 studies by the first author (López-Fuerte & Siqueiros-Beltrones, 2016; López-Fuerte et al., 2017; Siqueiros-Beltrones, 2002; Siqueiros-Beltrones et al., 2017a), and a previous checklist by Navarro and Hernández-Becerril (1997). This percentage is similar to those recorded elsewhere by Frankovich et al. (2006), and López-Fuerte et al. (2013), i.e., 24.6% and 27%, respectively. By comparison, Navarro and Hernández-Becerril (1997) compiled 89 *Mastogloia* taxa records from the highly diverse Caribbean Sea in a survey of 47 studies. However, only 30 species from said survey correspond to the Gulf of Mexico (Loir & Novarino, 2013). Another study carried out by the latter authors at the French Lesser Antilles yielded a similar number of species (> 80) but comprised a 7-year sampling effort. While, Hein et al. (2008) recorded 75 *Mastogloia* taxa from the Bahamas archipelago. Finally, the closest survey to the present one, carried out in the coast of Quintana Roo, around the continental division between the Gulf of Mexico and the Caribbean Sea, Mexico, yielded 30 *Mastogloia* species epiphytic on *T. testudinum* (López-Fuerte et al., 2013), out of which, 19 were not observed in our Campeche samples; whereas 23 taxa from our study were not observed in the Quintana Roo samples. These add to around 106 *Mastogloia* species and varieties between both localities, sharing approximately 40% of the taxa. However, neither sampling efforts may be considered exhaustive so as to suggest a definitive distribution.

The recent survey by López-Fuerte and Siqueiros-Beltrones (2016) showed that, out of the > 1,100 benthic diatom taxa ever recorded for Mexican waters, 73 *Mastogloia* species are included. Thus, considering that 30 of these taxa correspond to the Mexican Caribbean (López-Fuerte et al., 2013), only a little over 40 *Mastogloia* taxa from Mexican non tropical waters are left, mainly from the Mexican northwestern coasts. In summary, according to the present account, plus the latest observations (Hein et al., 2008; Loir & Novarino, 2013; López-Fuerte et al., 2013), it is more likely that *Mastogloia* species are more diverse and abundantly distributed in tropical and subtropical marine regions as proposed by Frankovich et al. (2006) than on a global perspective as suggested by Round et al. (1990).

Finally, the many (25) unidentified *Mastogloia* forms in this survey suggests the need for a formal taxonomic treatment of this taxon, inasmuch the available literature proved to be an insufficient reference for identifying all the specific and infra-specific taxa, including the 3 undetermined (informal) varieties of *Mastogloia corsicana* (Grunow) Peragallo and Peragallo and the 2 (informal) forms of *Mastogloia erythraea* Grunow recorded (Table 1, Appendix). In comparison, Loir and Novarino (2013) experienced the same difficulty in their more comprehensive survey, inasmuch they left 21 forms as unidentified species of *Mastogloia*, out of over 80 taxa. Likewise, Hein et al. (2008) left 22 forms unidentified out of 75 taxa.

This study corroborates that *Mastogloia* species are mostly distributed in tropical and subtropical habitats, and shows that much floristic and formal taxonomic studies are still required on this genus and overall for benthic diatoms from all types of substrata in general for the Mexican littorals.

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