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# Additional floristic study of planktonic and seaweed-associated diatoms in Chuuk, Micronesia

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Benthic diatoms; coral reefs; Micronesia; species diversity; tychoplankton

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**Abstract**

The present study enhances knowledge of the biodiversity of diatoms in Chuuk, Micronesia following our 2018 study on the seaweed-associated diatoms. We collected planktonic samples of diatoms from five sites of reef flats using a 20 µm mesh net, and two samples of seaweeds with epiphytes by hand from an islet on the barrier reef. In addition, the seaweed-associated diatoms from our 2018 study were analysed using scanning electron microscopy. A total of 109 diatom taxa are documented in the present study. Of these, 70 species were from net samples, and 39 species from the seaweed-associated diatoms. Thirty-one species are newly recorded from Micronesian waters. Most taxa are benthic or tychoplanktonic; euplanktonic diatoms were rare. The occurrence of benthic diatoms from the water column might be related to the Chuuk environmental conditions which include shallow water, strong light intensity and high grazing pressure, to which benthic diatoms seem to be able to better adapt than planktonic diatoms.

## Introduction

Diatoms are a significant but still largely unknown component of the photosynthetic microbiota of tropical coral reefs. Much of the early taxonomic work on tropical diatoms was based on dredge samples (e.g. Mann, 1925) or hand collections with little or no habitat information, as noted by Lobban *et al.* (2012). More recently, coral reef diatoms have been studied in diverse regions of tropical oceans: Tahiti, Polynesia (Ricard, 1974, 1975, 1977); Mahé, Seychelles (Giffen, 1980); Puerto Rico (Navarro, 1981*a*, 1981*b*, 1982*b*, 1982*c*, 1982*a*, 1983*a*, 1983*b*; Navarro *et al.*, 1989); Fiji (Foged, 1987); Palawan, Philippines (Podzorski & Håkansson, 1987); Nassau, The Bahamas (Hein *et al.*, 2008); Rodrigues, Réunion (Al-Handal *et al.*, 2016); off Basrah coast of Iraq (Al-Handal *et al.*, 2018). Several of these studies (especially Ricard's and Navarro's) were based on net sampling, which included phytoplankton and tychoplankton, the latter supposedly passively swept up from the benthos (but see Sabir *et al.*, 2018*b*).

The coral reef diatoms of the Micronesian Islands in the Western Pacific Ocean have been intensely studied in Guam (Lobban *et al.*, 2012; Lobban, 2015*a*, inter alia). The number of new species reported from Guam (Lobban *et al.*, 2009–2019) is an indication of the biodiversity still to be discovered in the region, an area larger than the contiguous USA; it stretches 3700 km from Palau in the west to the Marshall Islands in the east and encompasses high islands and many atolls. Chuuk State is located at about 7°N within the Federated States of Micronesia in the western Pacific (Figure 1A). Chuuk lagoon consists of 12 major volcanic islands and 24 coral-reef islands, within a barrier reef (Figure 1B). Of 12 major volcanic islands, Weno (formerly Moen) is located in the eastern part of the lagoon. Park *et al.* (2018) recently began diatom floristic studies there, based on diatoms associated with seaweeds; 143 species were observed. The present collection of new records is based on net sampling of plankton samples at five sites at the same locations, to which we have added two samples from another island in Chuuk Lagoon from the GUAM diatom collection. The new analyses included scanning electron microscopy (SEM), which enabled us to identify to species some taxa previously included at the genus level.

## Materials and methods

Net samples were collected from surface water (2–5 m water depth) at five sites near the coast of Weno Island on 22 May 2017 (Figure 1C, Park *et al.*, 2018) by horizontally towing a 20 µm mesh net. The collected samples were put in 250 ml polyethylene bottles and fixed immediately with Lugol's solution to a final concentration of about 2%. Preparation of samples followed Park *et al.* (2018). In addition, we analysed two samples from Moch Island (Figure 1C, 7°30′50.7″N 151°57′59.8″E) at the Eastern Passage of the barrier reef, collected

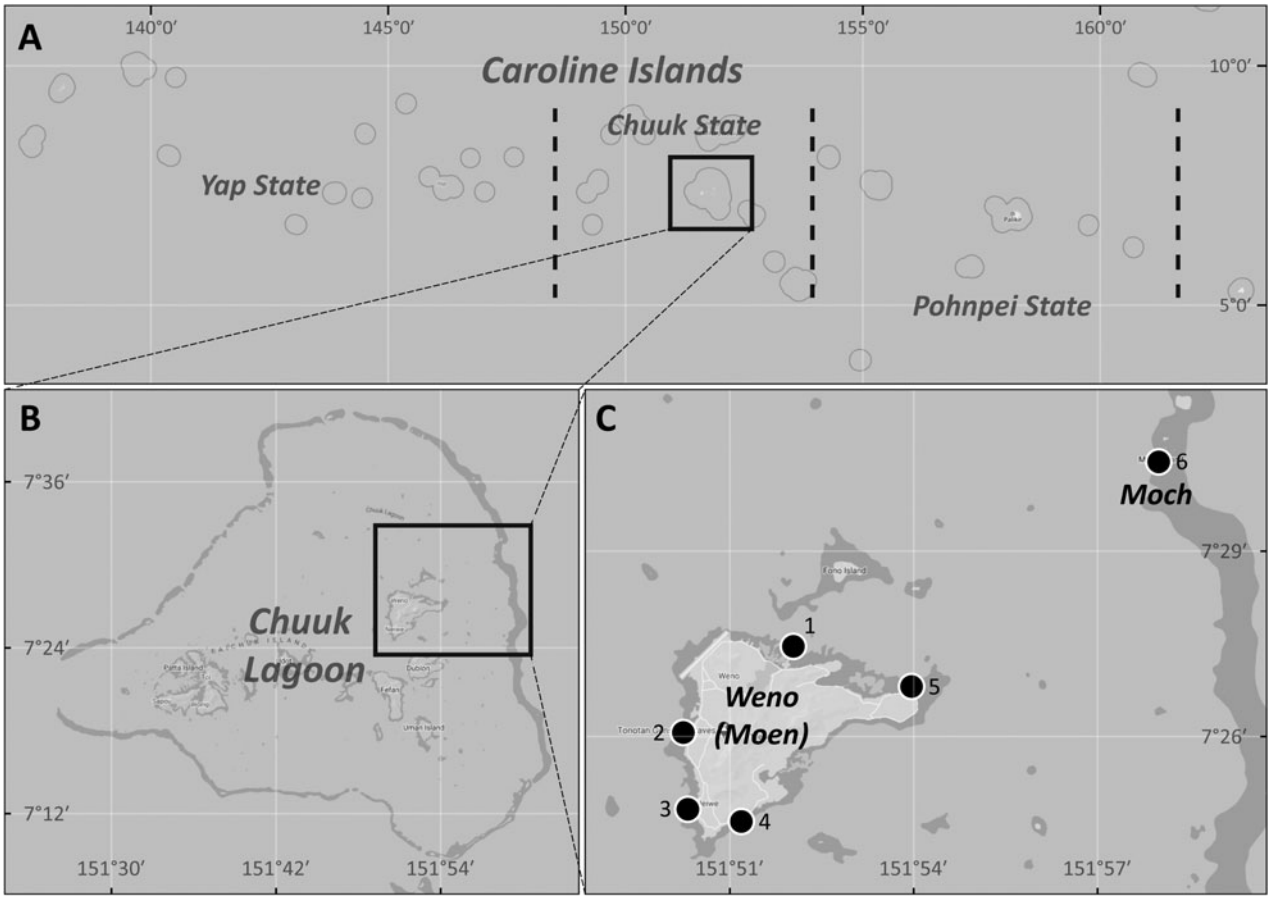


**Fig. 1.** Sampling sites in Weno (Moen) Island in Chuuk Lagoon. (A) Location of Chuuk State (box) in Caroline Islands. (B) Sampling location (box) in Chuuk Lagoon. (C) Six sampling sites in Weno and Moch Islands.

by CSL on 30 May 1991 by hand. These had been preserved in 4% formalin and are curated in the GUAM diatom collection.

Organic matter was removed with HCl-$KMnO_4$, the remaining material was mounted in Pleurax and observed with a light microscope (LM; BX51, Olympus, Tokyo) (Park *et al.*, 2018) or cleaned with $HNO_3$ and mounted in Hyrax, and observed with a Nikon i80 microscope (Lobban, 2015*b*). Scanning electron microscope (SEM) observations were made with a Phenom G2 Pro desktop instrument (Lobban, 2015*b*).

## Results

A total of 109 diatom taxa were observed (Figures 2–168). Of these, 70 taxa were observed from net samples and 39 taxa were added from seaweed-associated habitats from SEM observations. Of 39 taxa, four uncertainly identified species in Park *et al.* (2018) were also further identified with SEM and re-listed in this study: *Thalassiosira cedarkeyensis* (as *Thalassiosira* cf. *cedarkeyensis*), *Pleurosigma* cf. *elongatum* (as *Pleurosigma* sp. 2), *Amphora lunulata* (as *Amphora* sp. 2), *Nitzschia* cf. *amabilis* (as *Nitzschia* sp. 11). Brief diagnostics are included only for 31 species that were unrecorded from Micronesian waters (Table 1), and the figures and dimensions for all diatoms are presented because the evidence of species occurrences may be re-evaluated with further identifications in future. Taxa are listed systematically according to Cox (2015).

### Class COSCINODISCOPHYCEAE Round & R.M. Crawford, 1990
### Subclass MELOSIROPHYCIDAE Cox, 2015
### Order MELOSIRALES R.M. Crawford, 1990
### Family HYALODISCACEAE R.M. Crawford, 1990

***Podosira hormoides* (Montagne) Kützing Figures 2a–b, 72**

References: Kützing (1844): 52, pl. 28, figure 5, pl. 29, figure 84; Giffen (1970): 95; Lobban *et al.* (2012): 248, pl. 4, figures 1 & 2.

Sample: Moen_03 #003.

Dimensions: 35.3 µm in diameter; 30 areolae in 10 µm.

### Family PARALIACEAE R.M. Crawford, 1988

***Paralia* cf. *longispina* Konno & Jordan Figure 3**

References: Konno & Jordan (2008): 56, figures 2–53; Lobban *et al.* (2012): 249, pl. 4, figures 6–8.

Sample: TK28.

Dimensions: 14 µm in diameter.

Comments: It is difficult to distinguish Konno & Jordan's (2008) species from three very similar taxa in the *P. longispina* complex (MacGillivary & Kaczmarska, 2012), even with SEM, and impossible from LM. None of these other species has yet been identified in samples from Micronesia, making it likely that this specimen is *P. longispina*, but we will need additional specimens in SEM to confirm this.

### Subclass COSCINODISCOPHYCIDAE Round & R.M. Crawford, 1990
### Order CHRYSANTHEMODISCALES Round, 1990
### Family CHRYSANTHEMODISCACEAE Round, 1990

***Chrysanthemodiscus floriatus* A. Mann Figure 4**

References: Takano (1965): 7, pl. I, figures 12–14; Round (1978): 157, figures 1–15; Gibson & Navarro (1981): 338, figures 1–9; Navarro & Lobban (2009): 127, figures 2–4.

Samples: TK4, TK28.

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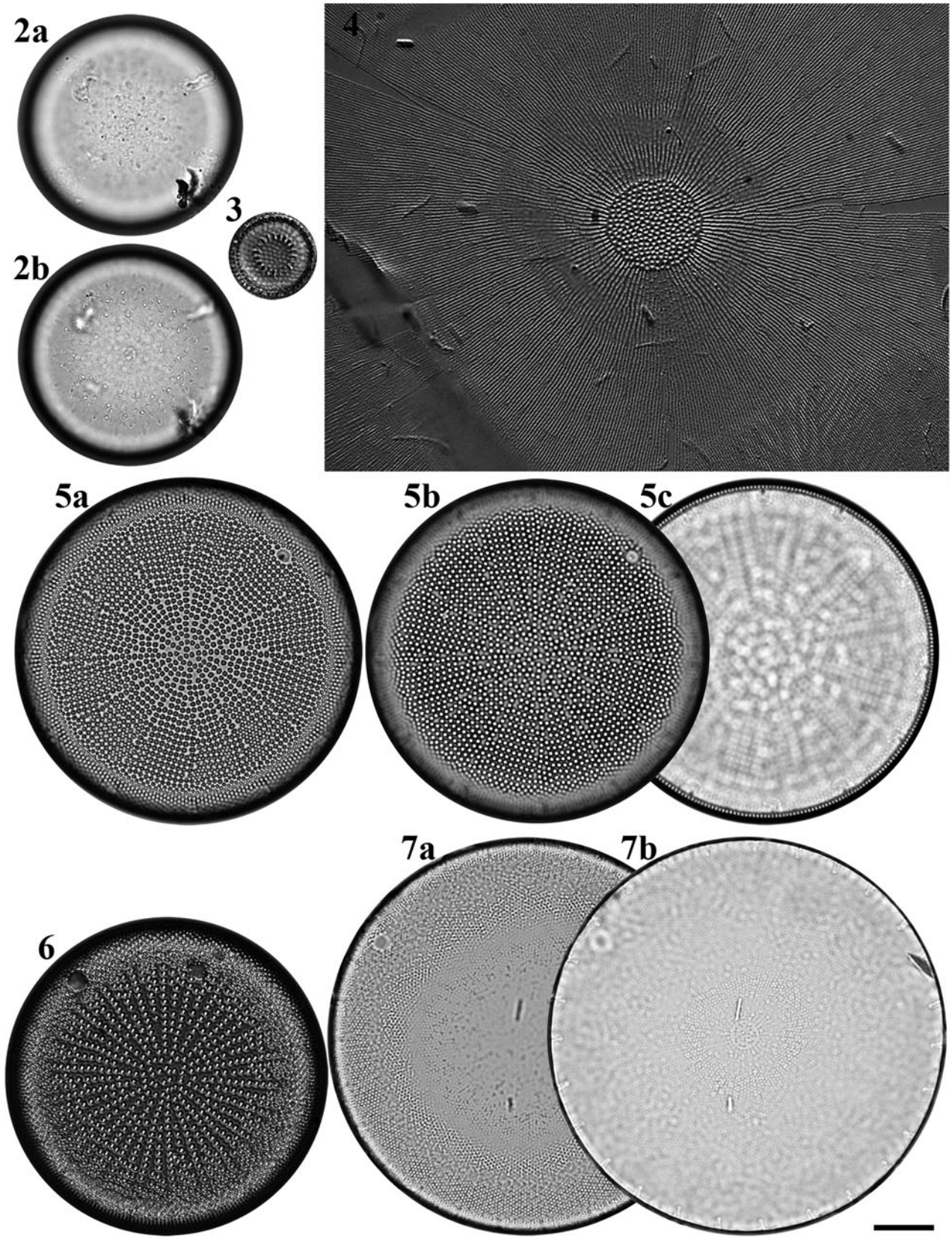


**Figs 2–7.** Light microscopy images of six taxa in Chuuk, Micronesia. **Fig. 2a, b.** *Podosira hormoides* from Weno. **Fig. 3.** *Paralia* cf. *longispina* from Moch. **Fig. 4.** *Chrysanthemodiscus floriatus* from Moch. **Fig. 5a–c.** *Actinocyclus octonarius* var. *tenellus* from Moch. **Fig. 6.** *Actinocyclus ocotonarius* var. *octonarius* from Weno. **Fig. 7a, b.** *Actinocyclus subtilis* from Weno. Scale bar = 10 μm.

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**Table 1.** List of 31 newly recorded diatoms in Micronesia and their distribution and habitats

| Systematics and species | Biogeography/distribution | Habitats |
|---|---|---|
| Class Coscinodiscophyceae | | |
| Subclass Coscinodiscophycidae | | |
| Order Coscinodiscales | | |
| Family Hemidiscaceae | | |
| Genus *Actinocyclus* | | |
| ***A. octonarius* var. *octonarius*** | • **Cosmopolitan** (Hasle & Syvertsen, 1996)<br>• **North-western Pacific:** Moch Island, Chuuk, Micronesia (This study) | Marine, planktonic |
| ***A. octonarius* var. *tenellus*** | • **Indian:** Réunion and Rodrigues Islands (Al-Handal *et al.*, 2016)<br>• **North-western Pacific:** South Kora (Lee *et al.*, 1992); Weno Island, Chuuk, Micronesia (This study) | Marine, tychoplanktonic |
| ***A. subtilis*** | • **Mediterranean Sea:** Alexandria, Egypt (Andersen *et al.*, 1986)<br>• **Indian:** South Iraq, Persian Gulf (Al-Handal *et al.*, 2014); Réunion and Rodrigues Islands (Al-Handal *et al.*, 2016)<br>• **South-western Pacific:** New Caledonia, Carribean, Bear Island (Witkowski *et al.*, 2000)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Marine, tychoplanktonic |
| Class Mediophyceae | | |
| Subclass Biddulphiophycidae | | |
| Order Toxariales | | |
| Family Climacospheniaceae | | |
| Genus *Synedrosphenia* | | |
| ***S. gomphonema*** | • **North-western Atlantic:** Honduras (Janisch & Rabenhorst, 1863)<br>• **Mediterranean:** Banyuls, France (Peragallo & Peragallo, 1897–1908)<br>• **Indo-Pacific:** Boreno Island (Hustedt in Schmidt *et al.*, 1874–1959)<br>• **North-western Pacific:** Moch Island, Chuuk, Micronesia (This study) | Marine, benthic |
| Subclass Chaetocerotophycidae | | |
| Order Chaetocerotales | | |
| Family Chaetocerotaceae | | |
| Genus *Bacteriastrum* | | |
| ***B. furcatum*** | • **North-western Atlantic:** Puerto Rico (Navarro, 1982*a*)<br>• **Mediterranean:** Naples, Italy (Sarno *et al.*, 1997)<br>• **North-western Pacific:** Moch Island, Chuuk, Micronesia (This study) | Marine planktonic |
| Subclass Thalassiosirophycidae | | |
| Order Eupodiscales | | |
| Family Eupodiscaceae | | |
| Genus *Lampriscus* | | |
| ***L. shadboltianus*** | • **North-western Atlantic:** Puerto Rico (Navarro, 1981*a*)<br>• **North-western Pacific:** Moch Island, Chuuk, Micronesia (This study) | Marine, benthic |
| Class Fragilariophyceae | | |
| — | | |
| Order Licmophorales | | |
| Family Ulnariaceae | | |
| Genus *Hyalosynedra* | | |
| ***H. al-shareefii*** | • **Indian:** Saudi Arabia, Red Sea (Sabir *et al.*, 2018*a*)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| Class Bacillariophyceae | | |
| Subclass Bacillariophycidae | | |
| Order Mastogloiales | | |

(*Continued*)

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**Table 1.** (*Continued.*)

| Systematics and species | Biogeography/distribution | Habitats |
|---|---|---|
| Family Mastogloiaceae | | |
| Genus *Mastogloia* | | |
| ***M. constricta*** | • **Cosmopolitan** (Witkowski *et al.*, 2000)<br>• **Indo-Pacific:** Java Sea (Hustedt, 1931–1959)<br>• **North-western Pacific:** Celebes Sea (Voigt, 1942); Moch Island, Chuuk, Micronesia (This study) | Marine, benthic |
| ***M. exigua*** | • **Indian:** South African (Giffen, 1963); Tanzania (Foged, 1975)<br>• **South-eastern Pacific:** Eastern Australia (Foged, 1978); Kemp & Paddock (1990)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| Order Cymbellales | | |
| Family Gomphonemataceae | | |
| Genus *Gomphonema* | | |
| ***G. lagenula*** | • **North-western Atlantic:** Trinidad, Tobago (Kützing, 1844)<br>• **North-eastern Pacific:** Mexico (Abarca *et al.*, 2014)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study)<br>• **South-western Pacific:** Eastern Australia Foged (1978)<br>• **Local streams:** Colombian stream (Sala & Ramírez, 2008); São Francisco Falso River, Paraná, Brazil (Medeiros *et al.*, 2018) | Brackish to freshwater, benthic |
| Order Cocconeidales | | |
| Family Cocconeidaceae | | |
| Genus *Cocconeiopsis* | | |
| ***C. wrightii*** | • **North-eastern Atlantic:** Ireland (Witkowski *et al.*, 2000)<br>• **South-eastern Atlantic:** South Africa (Witkowski *et al.*, 2000)<br>• **Indian:** Kerguelen, Riaux-Gobin & Compère (2004)<br>• **North-western Pacific:** South Korea (Park *et al.*, 2014); Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| Genus *Arnothoneis* | | |
| ***A. eurystoma*** | • **Cosmopolitan** (Witkowski *et al.*, 2000)<br>• **South-western Atlantic:** Garcia & Talgatti (2006)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| Order Naviculales | | |
| Family Cocconeidaceae | | |
| Genus *Luticola* | | |
| ***L. inserata*** | • **Indian:** Mouth of Belawan, Sumatra, Simonsen (1987*c*)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study)<br>• **South-western Pacific:** Eastern Australia (Foged, 1978) | Brackish to freshwater, benthic |
| Family Diploneidaceae | | |
| Genus *Diploneis* | | |
| ***D. cerebrum*** | • **North-western Pacific:** Palau (Pennesi *et al.*, 2017); Weno Island, Chuuk, Micronesia (This study) | Marine, epiphytic |
| ***D. gravelleana*** | • **Atlantic:** Puerto Rico (Hagelstein, 1939)<br>• **North-eastern Pacific:** Baja California, Mexico (Siqueiros Beltrones & López Fuerte, 2006) | Marine, epiphytic |
| Family Naviculaceae | | |
| Genus *Navicula* | | |
| ***N. directa*** | • **Cosmopolitan** (Hasle & Syvertsen, 1996; Witkowski *et al*., 2000)<br>• **Indian:** off Basra coast, Southern Iraq, Persian Gulf (Al-Handal *et al.*, 2018)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| ***N. gregaria*** | • **Cosmopolitan** (Witkowski *et al.*, 2000) | |

(*Continued*)

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**Table 1.** (*Continued.*)

| Systematics and species | Biogeography/distribution | Habitats |
|---|---|---|
| | • **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Brackish to freshwater, benthic |
| Family Pleurosigmataceae | | |
| Genus *Pleurosigma* | | |
| ***P. marinum*** | • **Indian:** Tanzania, Indian Ocean (Foged, 1975)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study)<br>• **South-western Pacific:** Eastern Australia (Foged, 1978) | Marine, benthic |
| Family Pinnulariaceae | | |
| Genus *Caloneis* | | |
| ***C. macquariensis*** | • **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study)<br>• **South-western Pacific:** Eastern Australia (Foged, 1978) | Brackish to freshwater, benthic |
| Order Bacillariales | | |
| Family Bacillariaceae | | |
| Genus *Bacillaria* | | |
| ***B.* gpB var. *tumidula*** | • **Indian:** Bangladesh (type locality, Witkowski *et al.*, 2000)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| Genus *Giffenia* | | |
| ***G. cocconeiformis*** | • **Indian:** South Africa (Giffen, 1963); Tanzania (Foged, 1975); widespread in the Indian Ocean (Witkowski *et al.*, 2000)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study)<br>• **South-western Pacific:** Eastern Australia (Foged, 1978) | Marine, benthic |
| Genus *Nitzschia* | | |
| ***N. lorenziana*** | • **North Atlantic: Indian River of Florida (Navarro, 1982*a*, 1982*b*), Quebec of Canada (*Poulin et al.*, 1990)** | Brackish water, benthic |
| ***N. rectilonga*** | • **Mediterranean:** Karadag natural reserve, Republic of Crimea, Black Sea (Shorenko *et al.*, 2016), Sea of Marmara (Deniz *et al.*, 2006)<br>• **North-western Pacific:** Japanese water (Takano, 1983), Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| Genus *Tryblionella* | | |
| ***T. apiculata*** | • **Mediterranean:** Bosporus, Black Sea (Schmidt *et al.*, 1874–1959)<br>• **Indian:** South Africa (Giffen, 1963)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study)<br>• **South-western Pacific:** Eastern Australia (Foged, 1978) | Marine, benthic |
| ***T. graeffi*** | • **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study)<br>• **South Pacific:** Samoa Archipelago (type locality, Cleve, 1878) | Marine, benthic |
| ***T. jelineckii*** | • **Indian:** Nicobar Islands (type locality, Grunow, 1863)<br>• **Indo-Pacific:** Java Island (Peragallo & Peragallo, 1897–1908)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| ***T. scalaris*** | • **Cosmopolitan** (Witkowski *et al.*, 2000)<br>• **North-western Atlantic:** Surinam, Atlantic (type locality); Cape Cod (Siver & Hamilton, 2005)<br>• **North-eastern Pacific:** California (Ruck & Kociolek (2004), Weno Island, Chuuk, Micronesia (This study)<br>• **Indian:** Huwaiza marsh, South Iraq, Persian Gulf (Al-Handal *et al.*, 2014) | Marine, benthic |
| Order Rhopalodiales | | |
| Family Rhopalodiaceae | | |
| Genus *Epithemia* | | |
| ***E. gibberula* var. *baltica*** | • **Baltic Sea:** Germany (Müller, 1899–1900; Regine, 2002)<br>• **North-eastern Pacific:** Sebastopol (Schmidt *et al.*, 1874–1959) | Marine, benthic |

(*Continued*)

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**Table 1.** (*Continued.*)

| Systematics and species | Biogeography/distribution | Habitats |
|---|---|---|
| | • **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | |
| ***E. gibberula* var. *tumida*** | • **Mediterranean:** Italy (Zanon, 1941)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| ***E. globosa*** | • **Indo-Pacific:** Java Sea (Simonsen, 1987*b*)<br>• **South-western Pacific:** New Caledonia (Moser *et al.*, 1998)<br>• **South-eastern Pacific:** East Australian (Foged, 1978), Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |
| Order Surirellales | | |
| Family Surirellaceae | | |
| Genus *Surirella* | | |
| ***S. oblongoelliptica*** | • **North-eastern Atlantic:** Puerto Rico (Navarro, 1983*a*)<br>• **Indian:** South Africa (Schmidt et al., 1874–1959)<br>• **Indo-Pacific:** Boreno Island (Simonsen, 1987*a*)<br>• **North-western Pacific:** Weno Island, Chuuk, Micronesia (This study) | Marine, benthic |

Dimensions: 65–100 µm in diameter (flattened valve).

Diagnostics: Large cells often forming large nebulous colonies and easily crumpled when mounted. Central area with coarser pore and radiating fine rows of pores from central area. Numerous copulae and the domed valves give the cells a bacillus profile in girdle view.

### Order COSCINODISCALES Round & R.M. Crawford
### Family HEMIDISCACEAE Hendey ex Hasle

***Actinocyclus octonarius* var. *octonarius* Ehrenberg Figure 6**

Reference: Hasle & Syvertsen (1996): 117.

Samples: TK4, TK28.

Dimensions: 53.2 µm in diameter, 9 areolae in 10 µm, 3–5 striae in fascicle.

Diagnostics: Areolae arranged in fascicles separated by compete radial rows of areolae extending from the valve centre to the mantle. Fascicles denser than *A. octonarius* var. *tenellus*.

Comments: This species is new to Micronesian waters including Guam.

***Actinocyclus octonarius* var. *tenellus* (Brébisson) Hendey Figure 5a–c**

References: Villareal & Fryxell (1983): 453, figures 1–14; Lee *et al.* (1992): 194, figures 38–41.

Sample: Moen_05 #002.

Dimensions: 57.3 µm in diameter, 9–11 areolae in 10 µm, 10–11 striae in fascicle.

Diagnostics: Areolae arranged in fascicles separated by compete radial rows of areolae extending from the valve centre to the mantle. Segments distinct. Striae arranged in crisscrossing pattern.

Comments: This species is new to Micronesian waters including Guam.

***Actinocyclus subtilis* (W. Gregory) Ralfs Figures 7a, b, 73**

References: Hustedt (1927–1930); Andersen *et al.* (1986): 467, figures 1–35; Witkowski *et al.* (2000): 22, pl. 4, figure 1; Al-Handal *et al.* (2016): 5, pl. 1, figure 4 (as *Actinocyclus* cf. *subtilis*).

Sample: Moen_04 #001.

Dimensions: 65.9–71.6 µm in diameter; 17–18 areolae in 10 µm in the valve centre.

Diagnostics: Areolae fine, and arranged bifurcately. Central annulus circular and filled with irregular areolae. Pseudonodule distinct.

Comments: The distinction between *Actinocyclus subtilis* and *A. tenuissimus* is subtle. Hustedt's (1927–1930) key distinction between *A. subtilis* and *A. tenuissimus* is the areola density, but his drawings (figs 304, 305 respectively), show *A. subtilis* with dense areolae in the centre, separated by a distinct hyaline ring, and the segments not clearly separated, whereas *A. tenuissimus* has more scattered central areolae and distinct segments with lines of areolae stretching from the rimoportulae to the centre filled in by straight lines of areolae that end at different levels as they meet the segmental lines. The central area of *A. tenuissimus* is not more than 4 µm (Hustedt, 1927–1930). Al-Handal *et al.* (2016) mentioned Hustedt's (1927–1930) criterion to distinguish both species, namely, the areolae size in the valve: *A. subtilis* (18–20 in 10 µm) *vs A. tenuissimus* (12–15 in 10 µm). However, the areolae density of *A. subtilis* is more variable (12–18 in 10 µm) in Andersen *et al.* (1986) and Witkowski *et al.* (2000). We assigned the Chuuk species to *A. subtilis* based on the areola density and the appearance of the segments and the central area. The taxonomy of both species should be re-considered with the taxonomic history and distribution. This species is a first record from Micronesian waters including Guam.

### Class MEDIOPHYCEAE (Jousé & Proshkina-Lavrenko) Medlin & Kaczmarska, 2004
### Subclass BIDDULPHIOPHYCIDAE Round & R.M. Crawford, 1990
### Order BIDDULPHIALES Krieger, 1954
### Family BIDDULPHIACEAE Kützing, 1844

***Biddulphia biddulphiana* (J.E. Smith) Boyer Figure 8**

Synonym: *Biddulphia pulchella* S.F. Gray 1821

References: Hoban (1983): 273, figures 1–27; Navarro & Lobban (2009): 133, figures 28–31; Witkowski *et al.* (2000), pl. 8, figures 8 & 9 (as *B. pulchella*); Al-Handal *et al.* (2016): 7, pl. 2, figure 4, pl. 3, figure 4 (as *B. pulchella*).

Sample: Moen_05 #002.

Dimensions: 41.8 µm long.

***Biddulphopsis membranacea* (Cleve) von Stosch & Simonsen Figures 74 & 75**

References: von Stosch & Simonsen (1984): 15, figures 36–84; Navarro & Lobban (2009): 133, figures 6 & 7.

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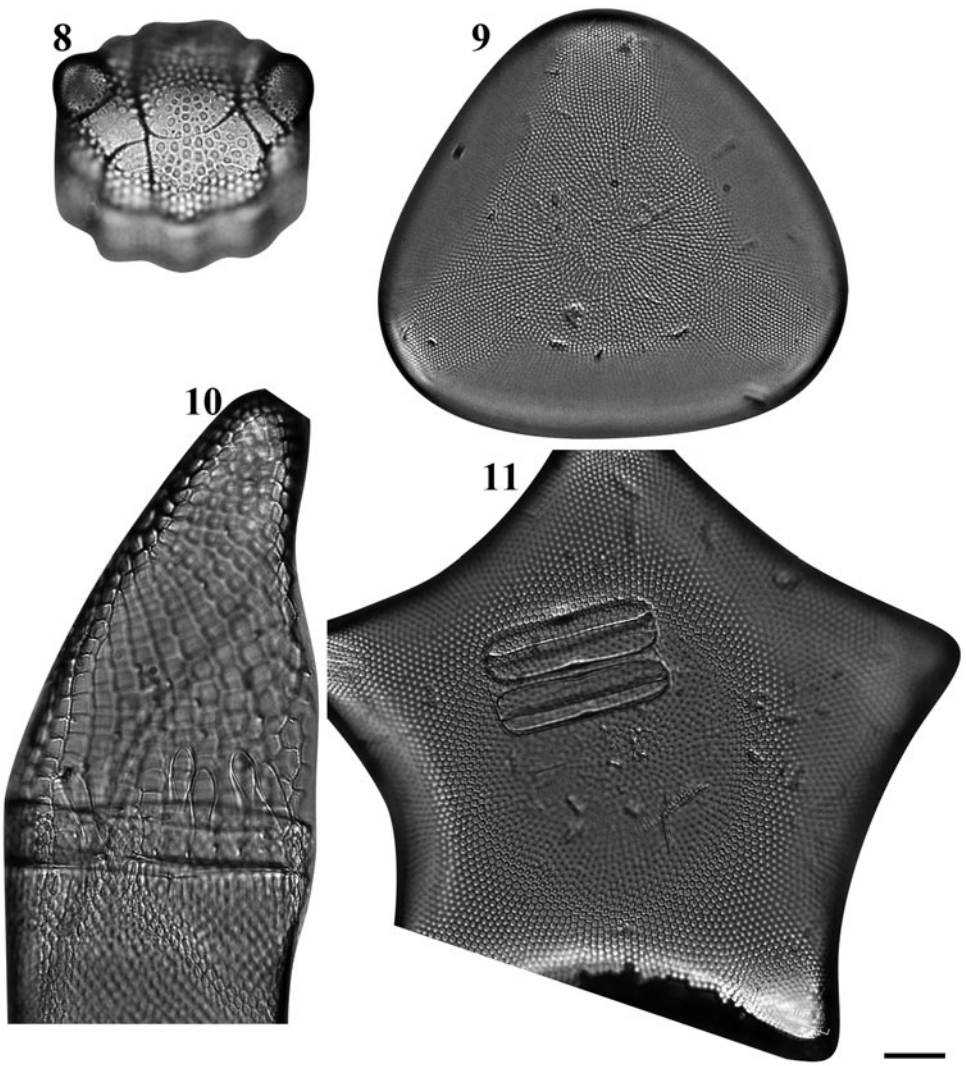


**Figs 8–11.** Light microscopy images of four taxa in Chuuk, Micronesia. **Fig. 8.** *Biddulphia biddulphiana* from Weno. **Fig. 9.** *Biddulphiopsis titiana* from Moch. **Fig. 10.** *Isthmia minima* from Moch. **Fig. 11.** *Trigonium formosum* f. *pentagonale* from Moch. Scale bar = 10 µm.

Sample: TK28.

Dimensions: Valve 217 µm long, 140 µm wide in flattened isolated valves; 11 areolae in 10 µm.

Diagnostics: Huge frustules elliptical in valve view, rectangular in girdle view with many copulae, numerous rimoportulae around each broad apex of the valve. Large oval central patch of randomly arranged areolae differentiated from the striae radiating from it.

***Biddulphopsis titiana* (Grunow) von Stosch & Simonsen**
**Figures 9 & 76**

References: von Stosch & Simonsen (1984): 12, figures 1–35; Lobban *et al.* (2012): 251, pl. 7, figure 3.

Sample: TK28.

Dimensions: 67 µm diameter, 11–12 areolae in 10 µm.

Diagnostics: Circular to triangular valve with small central area slightly differentiated from the striae radiating from it, numerous small rimoportulae around the margin of the valve.

***Isthmia minima* Harvey & Bailey Figures 10, 77, 78**

Reference: Lobban *et al.* (2012): 251, pl. 7, figures 4–6.

Samples: TK4, TK28.

Dimensions: Depth of valve 58–77 µm; width of flattened cell in girdle view 50 µm, length of frustule 200 µm.

Diagnostics: This species is distinguished from congeners by the invaginated cribra on the valve.

***Trigonium formosum* f. *pentagonale* Hustedt Figure 11**

Reference: Navarro & Lobban (2009): 133, figures 32–35.

Samples: TK28.

Dimensions: 109 µm in diameter, 7 areolae in 10 µm.

***Trigonium formosum* f. *quadrangularis* (Greville) Desikachary & Sreelatha Figure 79**

References: Navarro (1981*b*): 617, figure 25; Lobban *et al.* (2012): 252, pl. 8, figure 3.

Sample: TK28.

Dimensions: 71–76 µm wide, 8 areolae in 10 µm.

**Order TOXARIALES Round, 1990**
**Family ARDISSONEACEAE Round, 1990**
***Ardissonea fulgens* (Greville) Grunow Figure 12**

Synonym: *Synedra fulgens* (Greville) W. Smith 1853, p. 74, pl. 12, figure 103.

References: Witkowski *et al.* (2000): 44, pl. 31, figures 9–11; Lobban *et al.* (2012): 259, pl. 16, figures 3–5; Poulin *et al.* (1986), figures 31 & 32 (as *S. fulgens*).

Samples: TK4, TK28.

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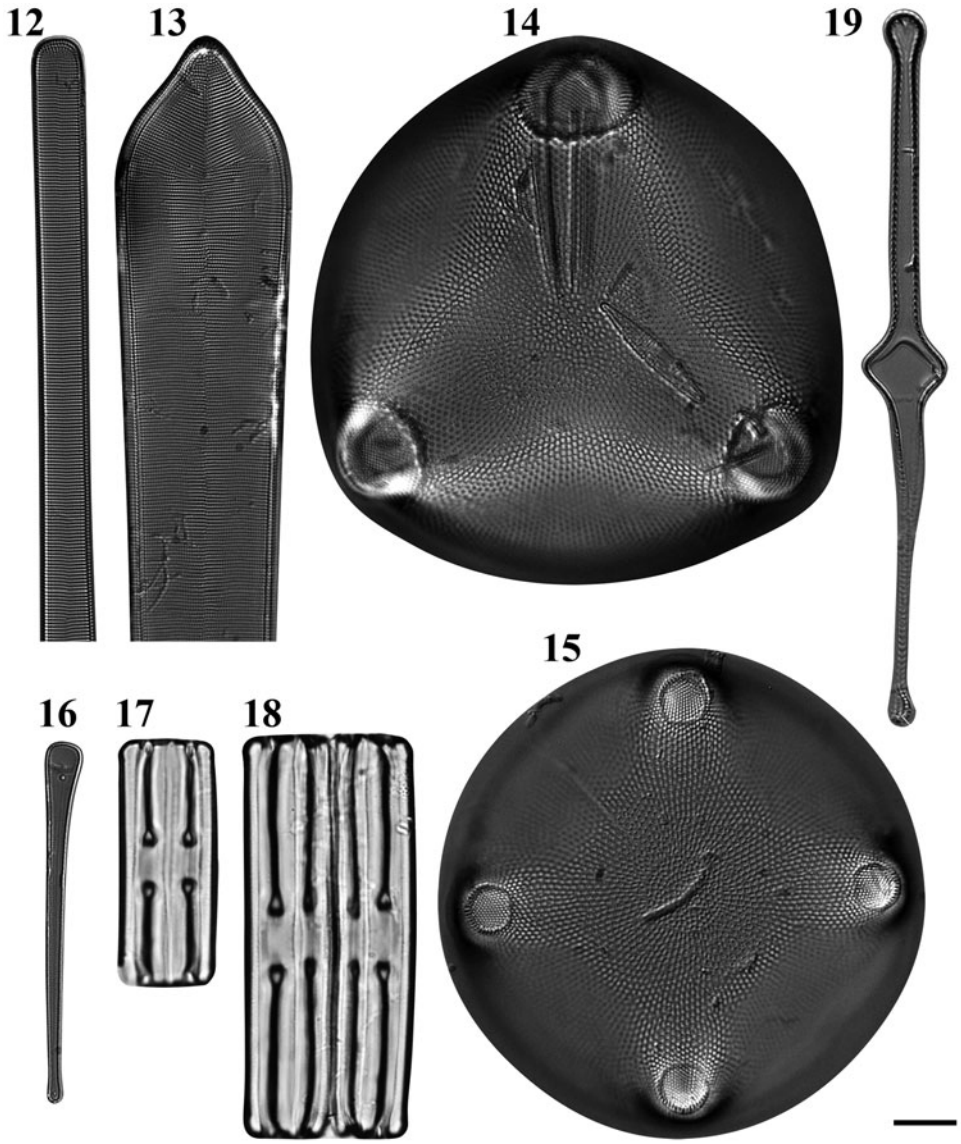


**Figs 12–19.** Light microscopy images of six taxa in Chuuk, Micronesia. **Fig. 12.** *Ardissonea fulgens* from Moch, portion of valve. **Fig. 13.** *Synedrosphenia gomphonema* from Moch, apical portion of valve. **Figs 14, 15.** *Lampriscus shadboltianus* from Moch, specimens with three and four ocelli. **Fig. 16.** *Koernerella recticostata* from Moch. **Figs 17, 18.** *Grammatophora macilenta* from Weno. **Fig. 19.** *Hanicella moenia* from Weno, copula. Scale bar = 10 µm.

Dimensions: 324–427 µm long, 13.2 µm wide, 15 transapical striae in 10 µm, 22 areolae in 10 µm.

**Family CLIMACOSPHENIACEAE Round, 1990**

***Climacosphenia moniligera* Ehrenberg Figure 80**

References: Round (1982), figures 1–3, 7, 8, 9; Witkowski *et al.* (2000): 44, pl. 18, figure 1.

Samples: TK4, TK28.

Dimensions: 338–367 µm long, 36 µm wide at the apex, 9 µm at the base.

Comments: Valve margins gradually sloping (in contrast to *C. elongata*, which is strongly spathulate), often curved.

***Synedrosphenia gomphonema* (Janisch & Rabenhorst) Hustedt Figure 13**

References: Janisch & Rabenhorst (1863): 13, pl. 2, figure 6; Hustedt 1914 in Schmidt *et al.* (1874–1959), pl. 305, figures 32–34; Hustedt (1931–1959): 231, figure 723.

Samples: TK4, TK28.

Dimensions: 250 µm long, 27.8 µm wide near apex, 19 transapical striae in 10 µm, 24 areolae in 10 µm.

Diagnostics: Valves long, broadly clavate with subrostrate head pole.

Comments: This species is new to Micronesian waters including Guam.

**Subclass CHAETOCEROPHYCIDAE Round & R.M. Crawford, 1990**

**Order CHAETOCEROTALES Round & R.M. Crawford, 1990**

**Family CHAETOCEROTACEAE Ralfs in Pritchard, 1861**

***Bacteriastrum furcatum* Shadbolt Figure 81**

References: Hustedt (1927–1930): 612, figure 353 (as *B. delicatulum* Cleve); Sarno *et al.* (1997): 262, figures 19–34; Bosak *et al.* (2015): 132, figures 1–17.

Samples: TK4, TK28.

Dimensions: 12 µm in diameter, length of setae 50 µm. 6–10 inner setae per valve.

Diagnostics: Inner setae bifurcated in valve plane, and its fused part long.

Comments: Hustedt (1927–1930: 612, figure 353) shows the very similar *B. delicatulum* Cleve, implying synonymy, but these species are still both considered valid. There appear to be no

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SEM data for *B. delicatulum*, and it was described from temperate waters, whereas *B. furcatum* is a warm-water species (Bosak *et al.*, 2015). This species is new to Micronesian waters including Guam.

***Chaetoceros* cf. *atlanticus* var. *skeleton* (F. Schütt) Hustedt**
**Figure 82**

References: Cupp (1943): 104, figures 59–B; Lobban *et al.* (2012): 253, pl. 9, figure 3.

Sample: TK28.

Dimensions: 13.5 µm in diameter.

Comments: Although the nominate variety of this species is cold/temperate Atlantic, var. *skeleton*, with extremely shallow valves and slender chaetae, 'reaches its peak in warmer seas' (Hustedt 1927–1930: 645).

**Subclass THALASSIOSIROPHYCIDAE Round & R.M. Crawford, 1990**
**Order EUPODISCALES V.A. Nikolaev & D.M. Harwood, 2000**
**Family EUPODISCACEAE Ralfs, 1861**
***Lampriscus shadboltianus* (Greville) Peragallo & Peragallo**
**Figures 14 & 15**

References: Hustedt (1927–1930): 807–810, figures 470, 471; Navarro (1981*b*): 618, figures 33a–36.

Samples: TK4, TK28.

Dimensions: 50–83 µm in diameter.

Comments: We did not observe crenulate copulae (var. *crenulatus* Navarro), as are most specimens collected in Guam (Navarro & Lobban, 2009), and have thus left the name at the species level. This is a first record from Micronesian waters.

***Odontella aurita* (Lyngbye) C. Agardh Figure 83**

Reference: Lobban *et al.* (2012) 250, pl. 6, figures 1 & 2.

Sample: CHP3-2 st1265.

Dimensions: 16.4–42.3 µm long; 5.2–22.3 µm wide; 11–20 areolae in 10 µm.

**Order THALASSIOSIRALES Glezer & I.V. Makarova, 1986**
**Family THALASSIOSIRACEAE Lebour, 1930**
***Thalassiosira cedarkeyensis* Prasad Figures 84 & 85**

Reference: Park *et al.* (2018): 105, figure 4 (as *Thalasssiosira* cf. *cedarkeyensis*).

Samples: Moen_01 #001, Moen_02 #001, Moen_03 #001, CHP-2 st1285, CHP-3 st1286.

Diagnosis: Valves tangentially undulate; single fultoportula in the depressed part of valve; external tube of marginal rimoportula prominent.

Comments: With SEM examination, the morphological details of this small taxon confirm its identity as *T. cedarkeyensis*. This species was abundant with over $5.4 \times 10^5$ cells $l^{-1}$ in the seaweed-associated sample at sites 1 and 2. *Thalassiosira cedarkeyensis* was first described from Florida benthos (Prasad *et al.*, 1993, 2011), and also reported from the Guangdong coast (Li *et al.*, 2013). In addition, Risjani *et al.* (2021) also identified this species from Indonesian coral reef habitats. Despite the few reports of *T. cedarkeyensis*, the occurrences of tropical benthic diatoms in different ocean basins (Atlantic and Pacific) might be widespread along the coral reefs in the western Pacific Ocean based on its occurrence from coral reef regions.

***Thalassiosira* cf. *catharinensis* M. Garcia Figure 86**

Reference: García & Dutra (2016): 62, figures 1–14.

Samples: CHB1-1 st1263, CHP-2 st1285.

Dimensions: 6.9 µm in diameter; 45 areolae in 10 µm, arranged fasciculate.

Diagnostics: Valve very small. Areolation fasciculate. Rimoportula adjacent to a marginal fultoportula.

Comments: Although the small valve size, areolae density and areolation of the Chuuk specimen match the *T. catharinensis* from Brazilian waters (García & Dutra, 2016), the internal structures such as number of satellite pores and slit direction of the rimoportula are needed to identify positively.

**Class FRAGILARIOPHYCEAE Round, 1990**
**Subclass FRAGILARIOPHYCIDAE Round, 1990**
**Order FRAGILARIALES P.C. Silva, 1962**
**Family FRAGILARIACEAE Kützing, 1844**
***Koernerella recticostata* (Körner) Ashworth, Lobban & Theriot**
**Figures 16 & 87**

Reference: Lobban *et al.* (2011*a*): 181, figures 1, 3, 8, 9, 21–25.

Samples: TK28.

Dimensions: 58 µm long, 5 µm wide at base.

**Order RHABDONEMATALES Round & Crawford, 1990**
**Family GRAMMATOPHORACEAE Lobban & Ashworth, 2014**
***Grammatophora macilenta* W. Smith Figures 17 & 18**

References: Witkowski *et al.* (2000): 58, pl. 15, figures 16–18; Lobban *et al.* (2012): 262, pl. 19, figures 3–5.

Sample: Moen_04 #001.

Dimensions: 39.2–65.0 µm long; 15.6–27.6 µm in pervalvar axis.

Diagnostics: Septa almost straight in girdle view.

Comments: Lobban *et al.* (2012) showed *G. macilenta* from Guam with the valve view under SEM observation. The valve in Guam specimens were heteropolar and two spines were present in the narrow pole (cf. Lobban *et al.*, 2012, figures 3–5). In the Chuuk specimens, the valve outline was not observed, the marginal spine seems to absent from the pole, and we did not observe the apical pseudosepta. Al-Handal *et al.* (2016) described *Grammatophora* cf. *macilenta* from the coral reefs of Réunion and Rodrigues Islands and it differed from *G. macilenta* by the slightly bent frustule and wavy septa in the upper part of the frustule.

***Grammatophora marina* (Lyngbye) Kützing Figure 88**

Reference: Witkowski *et al.* (2000): 58, pl. 16, figures 4, 6, 7; Sato *et al.* (2003): 186, figures 5a, b, 15, 16, 25, 26.

Sample: TK28.

Dimensions: 39 µm long, striae 18 in 10 µm.

Diagnostics: Valve undulate, septum with a distinct wave at the apices.

Comments: We reported *G. marina* in our previous work (Park *et al.*, 2018), which actually matches *G. oceanica* in both the septum shape and the stria density according to Sato *et al.* (2003). Therefore, we correctly report *G. marina* again.

***Hanicella moenia* Lobban & Ashworth Figure 19**

Reference: Lobban & Ashworth (2014): 881, figures 1a, b, 4–11.

Sample: TK28.

Dimensions: 119 µm long, 3.4 µm wide except 6.6 µm at apical inflations and 13.7 µm at central inflation.

Diagnosis: Valves with capitate apices and a diamond-shaped central inflation; silica flaps attached to the valve margin that resemble ramparts on a castle wall. Distinctive open copulae with half septa (illustrated).

Comments: This species has been only observed from Guam (Lobban & Ashworth, 2014) and Chuuk in the North-western Pacific.

***Microtabella interrupta* (Ehrenberg) F.E. Round Figure 89**

References: Round *et al.* (1990): 673; Lobban & Ashworth (2014): 873, figures 3E–J, 12, 13.

Sample: CHB1-1 st1293.

Dimensions: 20.2 µm long; 2.1 µm wide; 28 transapical striae in 10 µm; 34 areolae in 10 µm.

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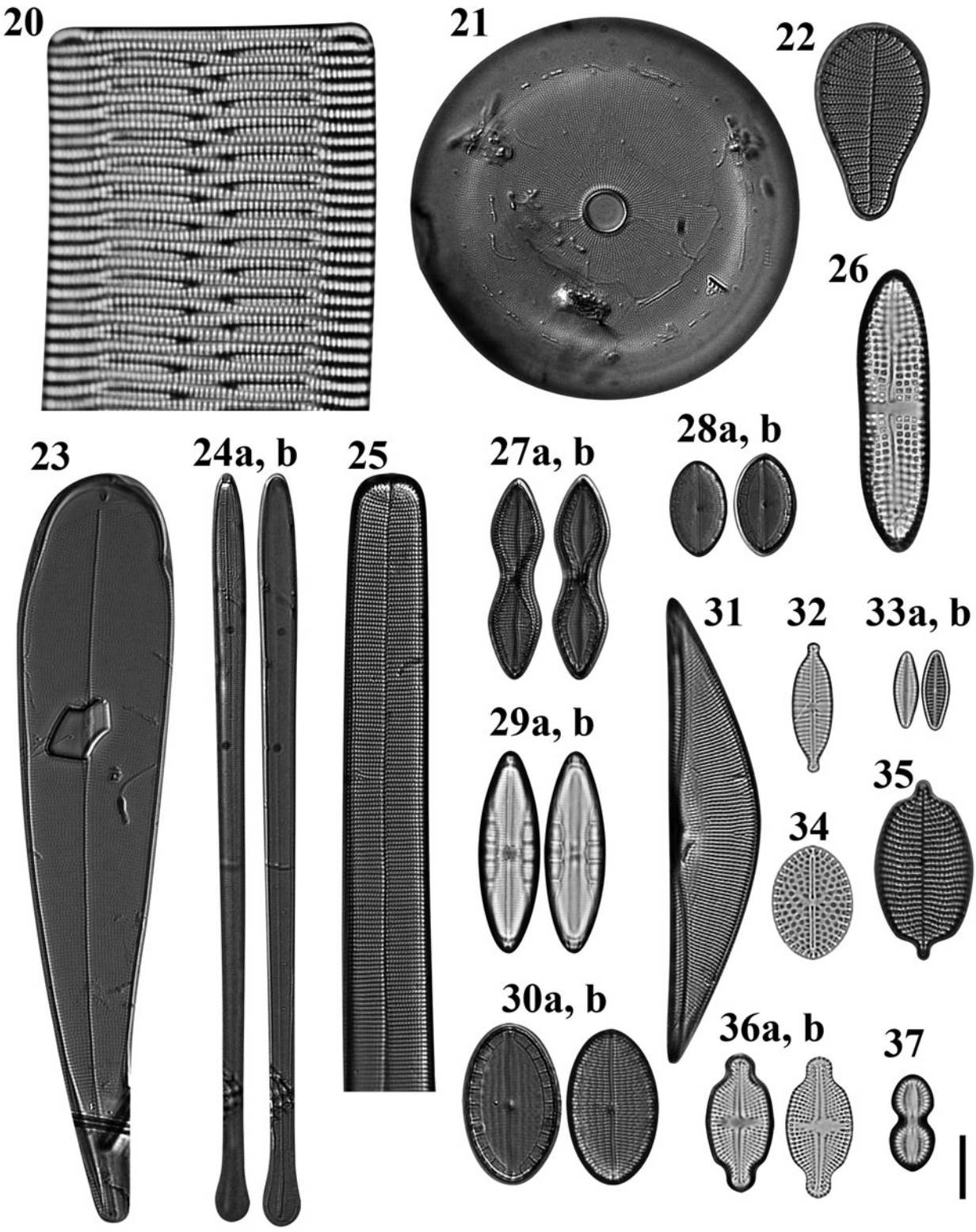


**Figs 20–37.** Light microscopy images of 18 taxa in Chuuk, Micronesia. **Fig. 20.** *Rhabdonema* cf. *adriaticum* from Weno. **Fig. 21.** *Astrosyne radiata* from Moch. **Fig. 22.** *Podocystis adriatica* from Moch. **Fig. 23.** *Licmophora curvata* from Moch. **Fig. 24a, b.** *Licmophora flabellata* from Moch. **Fig. 25.** *Synedra bacillaris* from Moch, portion of valve. **Fig. 26.** *Achnanthes brevipes* from Weno. **Fig. 27a, b.** *Mastogloia constricta* from Moch. **Fig. 28.** (A, B) *Mastogloia emarginata* from Moch. **Fig. 29.** (A, B) *Mastogloia exigua* from Weno. **Fig. 30a, b.** *Mastogloia ovata* from Moch. **Fig. 31.** *Tetramphora intermedia* from Moch. **Fig. 32.** *Gomphonema lagenula* from Weno. **Fig. 33a, b.** *Planothidium campechianum* from Weno. **Fig. 34.** *Cocconeiopsis wrightii* from Weno. **Fig. 35.** *Schizostauron* cf. *trachyderma* from Moch. **Fig. 36.** (A, B) *Luticola inserata* from Weno. **Fig. 37.** *Diploneis gravelleana* from Weno. Scale bar = 10 μm.

***Rhabdonema* cf. *adriaticum* Kützing Figure 20**

Reference: Lobban & Ashworth (2014): 873, figures 3D, 15–17.

Sample: Moen_05 #001.

Dimensions: 51.0 μm long; 13 striae in 10 μm.

Comments: Lobban & Ashworth (2014: 882) referred Guam specimens to '*Rhabdonema* cf. *adriaticum*' because of a large divergence in the molecular tree between samples from Mexico and Guam, raising the possibility that the Guam flora (and by

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implication Micronesian flora) might have a different species not yet distinguished morphologically, instead of or in addition to authentic *R. adriaticum*.

**Order CYCLOPHORALES Round & R.M. Crawford, 1990**
**Family CYCLOPHORACEAE Round & R.M. Crawford, 1990**
***Astrosyne radiata* Ashworth & Lobban Figure 21**

Reference: Ashworth *et al.* (2012): 688, figures 10–13, 37–41.
Samples: TK4, TK28.
Dimensions: 33–61 µm in diameter.
Diagnosis: The distinctive circular valve with a cuplike pseudoseptum in the centre is actually a pennate diatom, related to *Cyclophora*.
Comment: This species has been only reported from Guam, Chuuk and Marshall along the tropical coral reefs in the North-western Pacific (Ashworth *et al.*, 2012).

**Order LICMOPHORALES Round, 1990**
**Family LICMOPHORACEAE Kützing, 1844**
***Podocystis adriatica* Kützing Figure 22**

Reference: Lobban *et al.* (2012): 256, pl. 12, figures 2 & 3.
Sample: TK4.
Dimensions: 30–35 µm long, 17–18 µm wide; striae 17 in 10 µm.

***Licmophora curvata* Lobban, Tharngan & Ashworth Figures 23 & 90**

Reference: Lobban *et al.* (2018): 95, figures 76–117.
Samples: TK4, TK28.
Dimensions: 120–153 µm long, 19–28 µm wide; striae 19 in 10 µm.
Diagnostics: Broad, slightly curved, clavate *Licmophora*; its curved congener *L. normaniana* (Greville) Wahrer is narrow and arcuate.
Comment: The occurrence of *L. curvata* from Chuuk is the second record after Guam by Lobban *et al.* (2018). Beside these studies, there was no report from outside of Micronesia until now.

***Licmophora flabellata* (Carmichael ex Greville) C.A. Agardh Figures 24a, b**

References: Sar & Ferrario (1990): 404, figures 1–13; Honeywill (1998): 230, figures 1a–i; Lobban *et al.* (2011*b*): 20, figures 29–33.
Samples: CHB1-1 st1262, CHB1-1 st1263, TK4.
Dimensions: 94.4–149.4 µm long; 6.2–6.8 µm; 36 transapical striae in 10 µm.
Diagnostics: Valves with numerous intercalary rimoportulae along the sternum; differing from *L. comnavmaria* Lobban & Schefter in being areolate throughout.

***Licmophora remulus* (Grunow) Grunow Figures 91–93**

References: Navarro & Lobban (2009): 136, figures 54–57; Lobban *et al.* (2011*b*): 19, figures 26–28.
Samples: TK28.
Dimensions: 144 µm long, 12 µm wide; striae 29 in 10 µm.
Diagnostics: Slender, strongly spathulate valves, the apical portion areolate throughout; striae on the 'stems' comprising a single areola on each side of the sternum.
Comments: This species has been found in Guam and Yap but is also present in the Honduras material that Grunow used to describe *L. remulus*, and probably is also pantropical epiphyte on coral reef seaweeds (Lobban, 2021*a*), sometimes abundant, but the shape is not unique. There is a similar species, *L. romuli* Lobban, that may have been mistaken for *L. romulus*. It has decreasing vimines toward the apex.

**Family ULNARIACEAE Cox, 2015**
***Hyalosynedra al-shareefii* Sabir & Theriot Figure 95**

Reference: Sabir *et al.* (2018*a*): 16, figures 33–36.
Sample: CHP3-2 st1265.
Dimensions: 15.3 µm long; 4.1 µm wide; 61 transapical striae in 10 µm.
Diagnostics: Small, wide cells with narrow linear sternum, apex rounded.
Comments: This is a first record from Micronesian waters.

***Hyalosynedra* cf. *sublaevigata* Álvarez-Blanco & S. Blanco Figures 96 & 97**

References: Álvarez-Blanco & Blanco (2014): 105, pl. 54, figures 1–6; Sabir *et al.* (2018*a*): 16, figures 20–26.
Sample: CHB1-1 st1263.
Dimensions: 28.5–38.3 µm long; 3.3–3.7 µm wide; 58–66 transapical striae in 10 µm.
Diagnostics: Medium cells with lanceolate sternum, apex subcapitate.
Comments: Although Sabir *et al.* (2018*a*) described the sternum as lanceolate, and these specimens key out to this species in their key, Álvarez-Blanco & Blanco (2014) describe the sternum as 'narrow', implying it is linear rather than lanceolate. Moreover, the sterna in our specimens are perhaps more broadly lanceolate than specimens shown by Sabir *et al.* (2018*a*).

***Synedra bacillaris* (Grunow) Hustedt Figures 25 & 94**

References: Sullivan & Wear (1995): 182, figures 9–12; Lobban *et al.* (2012): 256, pl. 13, figures 1 & 2.
Samples: TK4, TK28.
Dimensions: 410–432 µm long, 16–19 µm wide; striae 13–14 in 10 µm.
Comments: Dimensions given by Lobban *et al.* (2012) may confound two different species, the smaller one undescribed and also present in Chuuk samples. The size range given by Hustedt (1931–1959) matches the specimens shown here, but his stria density does not.

## *Incertae Sedis*

***Gato hyalinus* Lobban & Navarro Figure 98**

Reference: Lobban & Navarro (2013): 23, figures 1–21.
Samples: TK4, TK28.
Dimensions: 33 µm long, 12 µm wide.
Diagnostics: Asymmetrical, hyaline, oval cells in mucilage tubes, striae extremely fine, visible only in SEM.
Comments: This is a first record from Micronesian waters.

**Subclass BACILLARIOPHYCIDAE D.G. Mann, 1990**
**Order MASTOGLOIALES D.G. Mann, 1990**
**Family ACHNANTHACEAE Kützing, 1844**
***Achnanthes brevipes* C. Agardh Figure 26**

Reference: Lobban *et al.* (2012): 284, pl. 38, figures 1–4.
Sample: Moen_03 #002.
Dimensions: 44.0 µm long, 11.2 µm wide; 9 transapical striae in 10 µm; 10 areolae in 10 µm.
Diagnosis: Valve linear with somewhat acute apices. Transapical fascia distinct in valve centre and reaching valve margin.
Comments: Toyoda & Williams (2004) clearly summarized three differences between *A. brevipes* var. *brevipes* and *A. brevipes* var. *intermedia*. According to criteria to distinguish between both varieties by Toyoda & Williams (2004), the linear valve and almost flat valve surface of Chuuk specimen match *A. brevipes* var. *brevipes*. Although Park *et al.* (2018) reported *A. brevipes* from seaweed-associated diatoms, its quadrangular areolae and narrow fascia reaching the valve margin are closer to *A. cuneata* than *A. brevipes*. Therefore, we correctly report *A. brevipes* again.

**Family MASTOGLOIACEAE Mereschkowsky, 1903**
***Craspedostauros* cf. *neoconstrictus* E.J. Cox Figures 99–101**

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Reference: Cox (1999): 140, figures 1–5, 11–14, 24, 31, 35, 40, 46, 50.

Sample: CHB1-2 st1263.

Dimensions: 45 µm long, 4 µm wide, striae 23 in 10 µm.

Diagnostics: The length, number of striae and form of the internal central nodule serve to distinguish *C. neoconstrictus*, but it has hyaline extensions of the mantle beyond the stauros, which are not visible in this perpendicular image.

Comments: The stria density distinguishes the Chuck specimen from *C. paradoxa* Ashworth & Lobban, recently described from Guam, which has much finer striae and a very reduced stauros (Ashworth *et al.*, 2017).

***Mastogloia constricta* Cleve Figures 27a, b**

Reference: Hustedt (1931–1959): 506, figure 931B.

Sample: TK28.

Dimensions: 32 µm long, 8.5 µm wide, constricted to 5.5 µm; striae 22 in 10 µm.

Comments: This species, characterized by Hustedt (1931–1959) as rare, has been reported from Java and Borneo. This is a first record from Micronesian waters.

***Mastogloia corsicana* Grunow Figure 102**

References: Yohn & Gibson (1981): 643, figures 17a, b, c, 18–21; Lobban *et al.* (2012): 269, pl. 26, figures 1–3.

Sample: CHP3-2 st1265.

Dimensions: 24.3–26.3 µm long, 11.1 µm wide; 19–20 striae in 10 µm.

Diagnostics: Valves elliptical with protracted apices. Raphe sinuous. Two longitudinal ribs interrupting the transapical striae.

Comments: This is a first record for Micronesian waters.

***Mastogloia emarginata* Hustedt Figures 28a, b**

References: Witkowski *et al.* (2000): 245, pl. 77, figures 9–12; Lobban (2015*a*): 7, figures 51–55; Pennesi *et al.*, 2013, figures 65, 66.

Sample: TK28.

Dimensions: 16 µm long, 9 µm wide; striae 27 in 10 µm.

Diagnostics: Characterized by the prominent pores on the outer side of the elongate chambers. The stria density is higher than the range in Hustedt (1931–1959) or Lobban (2015*a*).

***Mastogloia exigua* F.W. Lewis Figures 29a, b**

References: Schmidt *et al.* (1874–1959), pl. 185, figures 33, 35; Kemp & Paddock (1990), figures 43–45.

Sample: Moen_02 #001.

Dimensions: 31.7 µm long, 9.6 µm wide; 23 striae in 10 µm.

Diagnostics: Valves elliptic-lanceolate with rounded apices. Transapical striae slightly radial in valve centre and convergence near the valve ends. Five partecta positioned in the middle, their size decreasing towards the apices.

Comments: This is a first record from Micronesian waters.

***Mastogloia exilis* Hustedt Figure 103**

Reference: Lobban *et al.* (2012): 273, pl. 28, figures 6 & 7.

Sample: CHB1-2 st1295.

Dimensions: 21.3 µm long, 8.6 µm wide; 31 striae in 10 µm.

Diagnostics: Small slightly rostrate valves with half-lanceolate hyaline areas extending from the central area in the form of an H, chambered only in the middle.

***Mastogloia hustedtii* Meister Figure 104**

Reference: Lobban *et al.* (2012): 274, pl. 29, figures 3–5.

Sample: CHB1-2 st1263.

Dimensions: 20.5 µm long, 10.5 µm wide; 32 striae in 10 µm.

Diagnostics: Recognized in external SEM by the sinuous raphe (whereas *M. mediterranea* has a straight raphe) and the conopea.

***Mastogloia mauritiana* Brun Figure 105**

Reference: Lobban *et al.* (2012): 278, pl. 32, figures 4–10.

Sample: CHP3-2 st1265.

Dimensions: 57.5 µm long, 22.8 µm wide; 14 striae in 10 µm.

Diagnostics: Valves lanceolate with broadly rounded apices. Raphe slightly sinuous. Partectal ring with inflated cells in each quadrant.

***Mastogloia ovata* Grunow Figure 30a, b**

References: Lobban *et al.* (2012): 279, pl. 33, figures 7, 8; Pennesi *et al.* (2016): 153, figures 4A–H.

Sample: TK28.

Dimensions: 24.3 µm long, 14 µm wide; striae 19 in 10 µm.

Diagnostics: Distinguished from *M. emarginata* by the shorter, wider partecta without prominent pore.

***Tetramphora decussata* (Grunow) Stepanek & Kociolek Figures 106 & 107**

Basionym: *Amphora decussata* Grunow 1877: 178, pl. 195, figure 9.

References: Stepanek & Kociolek (2016): 139; Lobban *et al.* (2012): 298, pl. 1, figures 7–9, pl. 54, figure 5, pl. 55 figures 1–3 (as *A. decussata*).

Sample: TK28.

Dimensions: 61 µm long, 14 µm wide; striae 19 in 10 µm.

Comments: The taxonomy was revised by Stepanek & Kociolek (2016).

***Tetramphora intermedia* (Cleve) Stepanek & Kociolek Figure 31**

Basionym: *Amphora rhombica* var. *intermedia* Cleve 1895: 127.

References: Stepanek & Kociolek (2016): 131, figures 35–44; Lobban (2015*a*): 2, figures 7–9 (as *A. rhombica* var. *intermedia*).

Sample: TK28.

Dimensions: 60 µm long, 13 µm wide; striae 18 in 10 µm.

## Order CYMBELLALES D.G. Mann, 1990

### Family GOMPHONEMATACEAE Kützing, 1844

***Gomphonema lagenula* Kützing Figure 32**

Synonym: *Gomphonema parvulum* var. *lagenulum* (Kützing) O.Müller 1905

References: Sala & Ramírez (2008): 1171, figures 25–27; Abarca *et al.* (2014): figures 2.26–28, 3.4, 5.6; Medeiros *et al.* (2018): 15, figures 44–46, 116–119; Foged (1978): 71, pl. XL, figures 10, 11 (as *G. parvulum* var. *lagenulum*).

Sample: Moen_01 #001.

Dimensions: 20.2 µm long, 6.2 µm wide; 16 striae in 10 µm.

Diagnostics: Valves heteropolar, elliptical with protruded ends. Striae slightly radial in the centre and parallel near the ends. Central area delimited by the shortening of one median stria. A stigma near one shortening stria.

Comments: *Gomphonema lagenula* is distinguished from *G. parvulum* by strongly protruding valve ends (Abarca *et al.*, 2014). This is a freshwater species (M.D. Guiry in Guiry & Guiry, 2020), and a first report from Micronesian waters.

## Order COCCONEIDALES Cox

### Family ACHNANTHIDIACEAE D.G. Mann, 1990

***Planothidium campechianum* (Hustedt) Witkowski & Lange-Bertalot Figure 33a, b**

Reference: Lobban *et al.* (2012): 285, pl. 39, figure 4.

Samples: Moen_03 #001, CHP-3 st1286.

Dimensions: 8.4–12.2 µm long, 4.1–4.8 µm wide; 16–18 striae in 10 µm in both valves.

Diagnostics: Valves lanceolate with slightly obtuse apices.

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**Family COCCONEIDACEAE Kützing, 1844**

***Anorthoneis eurystoma* Cleve Figure 108**

References: Witkowski *et al.* (2000): 97, pl. 54, figures 4–8; Garcia & Talgatti (2006): 8, figures 1, 2, 5–8; Pennesi *et al.* (2018): 214, figures 35–48.

Sample: CHP3-2 st1265.

Dimensions: 16.5 µm long, 12.0 µm wide; 19 striae in 10 µm in rapheless valve.

Diagnostics: Valves broadly elliptical. In rapheless valve, sternum elliptical in the middle and abruptly narrowing towards apices. Transapical striae radial.

Comments: Only two species of *Anorthneis* have a broad hyaline area on the sternum valve (SV), the other being *A. hyalina* Hustedt. The SV of *A. hyalina* can be distinguished from *A. eurystoma* by the transapically elongated areolae, and the latter has a round areolae (Pennesi *et al.*, 2018). This is a first record from Micronesian waters.

***Cocconeiopsis wrightii* (O'Meara) Witkowski, Lange-Bertalot & Metzeltin Figure 34**

References: Witkowski *et al.* (2000): 176, pl. 67, figure 24; Riaux-Gobin & Compère (2004): 62, Pl. III, figures 16–22, Pl. IV, text figs d, e; Park *et al.* (2014): 233, figures 1b–d.

Sample: Moen_01 #001.

Dimensions: 17.7 µm long, 12.7 µm wide; 12 striae in 10 µm.

Diagnostics: Valve elliptical. Striae radiate in a single row of areolae and two rows near valve margin. Raphe straight. Axial area linear, central area transapically expanded and connected with an H-shaped area.

Comments: This is a first record from Micronesian waters.

***Cocconeis coronatoides* Riaux-Gobin & Romero Figure 109**

Synonym: *Cocconeis coronata* Riaux-Gobin & Romero in Riaux-Gobin *et al.*, 2010: 279, figures 1–17, 30.

References: Lobban *et al.* (2012): 286, pl. 39, fig. 6; Al-Handal *et al.* (2016): 21, pl. 7, figure 10, pl. 12, figure 8; Riaux-Gobin *et al.* (2010): 279, figures 1–17, 30 (as *C. coronata*).

Sample: Moen_03 #002.

Dimensions: 14.2 µm long, 8.1 µm wide; 13 striae in 10 µm in sternum valve; 16 areolae in 10 µm in a stria.

Diagnostics: Valve elliptical. Striae parallel to slightly radiate. Crista marginalis distinct. Numerous round spine-like expansions around the areolae.

**Order NAVICULAES Bessey, 1907**

**Suborder NEIDIINEAE D.G. Mann, 1990**

**Family BERKELEYACEAE D.G. Mann, 1990**

***Climaconeis* cf. *petersonii* Lobban, Ashworth & Theriot Figures 110–112**

Reference: Lobban *et al.* (2010): 300, figures 9, 10, 26–32.

Sample: CHB1-2 st1263.

Dimensions: 254 µm long, 7 µm wide except 9 µm at apex and centre; striae 21 in 10 µm.

Diagnostics: Long straight valve with square to apically elongate areolae.

Comments: This specimen is considerably shorter than the range given in Lobban *et al.* (2010), 350–380 µm, but the stria density and the shapes of the areolae are similar, so there is little reason to think this is a new species.

***Climaconeis riddleae* A.K.S.K. Prasad Figures 113–115**

References: Prasad (2003): 14, figures 26–41; Lobban *et al.* (2010): 302, figures 16, 17, 39–43.

Sample: CHB1-1 st1262.

Dimensions: 107 µm long, 4 µm wide; striae 25 in 10 µm.

Diagnostics: Curved valves with ± square areolae, the stria density distinguishing it from *C. inflexa* (Brébisson) Cox and *C. tarangensis* (Lobban ms submitted).

***Climaconeis scalaris* (Brébisson) Cox Figures 116–118**

Reference: Lobban (2018): 358, figures 4, 34–38.

Sample: CHB1-1 st1292.

Dimensions: 110 µm long, 5.7 µm wide; striae 21 in 10 µm.

Diagnostics: Straight valves with apically elongate areolae, the stria density and width distinguishing it from *C. undulata* (Meister) Lobban, Ashworth & Theriot.

Comments: This is a first record from Micronesian waters.

***Parlibellus biblos* (Cleve) Cox Figures 119–121**

Synonym: *Stauroneis biblos* (Cleve) Hustedt, p. 145.

References: Cox (1988): 23; Lobban *et al.* (2012): 296, pl. 52, figures 4 & 5; Hustedt (1931–1959): 703, figure 1178 (as *S. biblos*).

Sample: Moen_05#001.

Dimensions: 70.1 µm long, 16.0 µm wide; 17 striae in 10 µm; 20 areolae in 10 µm.

Comments: Lobban *et al.* (2012) identified this species as *Stauroneis retrostauron* (Mann) Meister, noting its similarity to *Stauroneis biblos*. On re-examining Mann (1925) and Meister (1937), in comparison with Hustedt (1931–1959) and Cox (1988), we conclude that we have *P. biblos*, not *S. retrostauron* both here and in the Guam flora. The dimensions given by Mann (1925: 118, pl. 25, figure 5, pl. 26, figures 1 & 2) are: length 90–141 µm, width 29–35 µm, rather large and the stria density (11 in 10 µm) much too coarse. Most tellingly, Mann's girdle view (pl. 26, figure 1) seems to show only one wide girdle band, not a large number of narrow ones. It is also different from the planktonic species *Meunieria membranacea* (Cleve) P.C. Silva, especially in the plastids (see Al-Yamani & Subarova, 2009).

**Family DIADESMIDACEAE D.G. Mann, 1990**

***Diadesmis confervacea* Kützing Figure 122**

Synonym: *Navicula confervacea* (Kützing) Grunow 1880, pl. 14, figure 36.

References: Navarro & Lobban (2009), Novelo *et al.* (2007): 143, figures 80, 81; Schmidt (1874–1959), pl. 297, figures 77, 78 (as *N. confervacea*).

Sample: CHP-2 st1285.

Dimensions: 20.8–2.7 µm long, 8.2–8.5 µm wide; 21 striae in 10 µm; 34–40 areolae in 10 µm.

Diagnostics: Frustule rectangular in girdle view, formed band-like colonies. Valve elliptical with slightly protracted apices. Marginal spines present along the junction of valve margin and mantle.

Comments: This is a terrestrial species (M.D. Guiry in Guiry & Guiry, 2020). Lobban (unpubl.) has observed blooms of this species in nutrient-enriched water in a terraced secondary water treatment plant in Guam and it is also common in natural streams.

***Luticola inserata* (Hustedt) D.G. Mann Figures 36a, b**

Basionym: *Navicula inserata* Hustedt 1955, p. 125, figure 18.

References: Hustedt (1961–1966): 627, figure 1624a (as *N. inserata*); Foged (1978): 91, pl. 28, figure 8; Simonsen (1987*c*), pl. 638, figures 7 & 8 (as *N. inserata*).

Samples: Moen_01 #002, Moen_03 #001.

Dimensions: 21.7–21.0 µm long, 10.5 µm wide; 19–20 striae in 10 µm; 16–17 areolae in 10 µm in a stria.

Diagnostics: Valve elliptical with capitate ends. Striae radiate. Sternum tapered towards apices, central area transapical expanded.

Comments: This is a brackish-water species, common in the western Pacific (Rybak *et al.*, 2021). However, it is distinguished only by some ultrastructural details from *L. seposita* (Hustedt) D.G. Mann, a freshwater species that Rybak *et al.* (2021) also reported from a marine habitat. Although we lack the details of this species by SEM, we identified this species as *L. inserta* on

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the basis of the habitat. This is the first record of the nominate variety from Micronesia, although *L. inserata* var. *undulata* (Hustedt) Navarro & Lobban was reported from Guam (Navarro & Lobban, 2009).

### Suborder SELLAPHORINEAE D.G. Mann, 1990
### Family PINNULARIACEAE D.G. Mann, 1990

***Caloneis egena* (A. Schmidt) Cleve Figures 38 & 123**

References: Schmidt *et al.* (1874–1959), pl. 160, figures 42 & 43, pl. 212, figure 1; Lobban *et al.* (2012): 294, pl. 49, figures 3 & 4.

Samples: TK4, TK28.

Dimensions: 13 µm long, 2.5–3.0 µm wide; striae 37 in 10 µm.

***Caloneis macquariensis* Foged Figures 39a, b, 40, 124, 125**

Reference: Foged (1978): 38, pl. 24, figure 1.

Samples: Moen_03 #002, CHP3-2 st1265.

Dimensions: 60.2–80.1 µm long, 14.1–14.2 µm wide; 15–16 striae in 10 µm.

Diagnostics: Valve linear-lanceolate with broadly rounded apices. Transapical striae regularly parallel throughout. Axial area almost linear, narrow near ends. Central fascia present.

Comment: This is a freshwater species described from eastern Australia; new record for Micronesian waters.

***Oestrupia* sp. 4 *sensu* Hein *et al.* Figures 126 & 127**

References: Hein *et al.* (2008): 101, pl. 67, figure 15; Lobban *et al.* (2012): 294, pl. 50, figure 4.

Sample: CHP3-2 st1265.

Dimensions: 48.2 µm long, 15.5 µm wide; 30 transapical striae in 10 µm.

Diagnostics: Valve linear-lanceolate with broadly rounded apices. Raphe linear-sigmoid.

***Pinnularia* cf. *borealis* Ehrenberg Figure 41**

Synonym: *Navicula borealis* (Ehrenberg) Kützing 1844: 96. pl. 28, figures 68, 72c.

References: Foged (1978): 113, pl. 33, figure 15, pl. 34, figure 9 (as *N. borealis*); Novelo *et al.* (2007): 49, pl. 9, figure 4 (as *N. borealis*).

Samples: Moen_03 #002, CHP3-2 st1265

Dimensions: 45.2 µm long, 8.4 µm wide; 5 striae in 10 µm.

Diagnostics: Valve linear with broadly rounded apices. Raphe curved in axial area. Central fascia present. Striae coarse.

### Suborder DIPLONEIDINEAE D.G. Mann, 1990
### Family DIPLONEIDACEAE D.G. Mann, 1990

***Diploneis cerebrum* Pennesi, Caputo & Lobban Figures 128 & 129**

Reference: Pennesi *et al.* (2017): 213, figures 66–75.

Sample: CHP3-2 st1265.

Dimensions: 55.8 µm long, 19.8 µm wide; 10 striae in 10 µm.

Diagnostics: Valve panduriform with broadly rounded apices. Striae consisted of transapically elongated slit-like areolae. Longitudinal canals straight, the areolae having a characteristic brain-like pattern in the volae.

Comments: This is a first record for Micronesian waters.

***Diploneis gravelleana* R. Hagelstein Fig. 37**

References: Hagelstein (1939): 352, pl. 5, figure 2; Foged (1978): 52, pl. 24, figure 11.

Sample: Moen_03 #001; Siqueiros Beltrones & López Fuerte (2006), figure 3.11.

Dimensions: 14.7 µm long, 7.1 µm wide; 20 striae in 10 µm.

Diagnostics: Valve small, strongly constricted. Striae radiate.

Comments: This species has been observed with SEM in samples from Yap (http://www.protistcentral.org/Taxa/get/taxa_id/586012) and Palau, but there is no comparable SEM of the Puerto Rico species, which in LM resembles *D. caffra* (Giffen) Witkowski, Lange Bertalot & Metzeltin. The longitudinal canals follow a biarcuate path close to the alveolate striae rather than paralleling the raphe sternum. This is a first record from Micronesian waters.

### Suborder NAVICULINEAE Hendey, 1937
### Family NAVICULACEAE Kützing, 1844

***Gyrosigma* cf. *balticum* (Ehrenberg) Rabenhorst Figure 42a, b**

References: Navarro (1982*a*): 324, figures 66–68; Cardinal *et al.* (1989), figures 3 & 46; Sterrenburg (1995): 402, figures 1–4, 13–15.

Samples: Moen_02 # 001, CHP-2 st1285.

Dimensions: 261.7 µm long, 22.9 µm wide; 13 striae in 10 µm transapically, 12 areolae in 10 µm apically.

Diagnostics: Valves sigmoid with rather obtusely rounded ends. Raphe sternum with double curvature, gradually curved throughout.

Comments: *Gyrosigma sterrenburgii* Stidolph (Stidolph, 1992; Sterrenburg, 1995) is a simulacrum species, differing only in some ultrastructural details and we cannot distinguish them on the basis of LM.

***Navicula directa* (W. Smith) Ralfs Figure 43a, b**

References: Witkowski *et al.* (2000): 275, pl. 129, figure 1, pl. 133, figures 10–12; Al-Handal *et al.* (2018): 127, figure 50.

Samples: Moen_03 #001, Moen_04 #001.

Dimensions: 63.2–73.7 µm long, 6.7–8.0 µm wide; 10–11 striae in 10 µm.

Diagnostics: Valves narrowly long lanceolate with acute apices. Transapical striae parallel throughout but convergent near apices.

Comments: Hendey (1964) mentioned 'A wide range of variation exists in this species and several subspecific taxa have been described. In all of them the striae are strongly lineate.' This is a first report from Micronesian waters.

***Navicula gregaria* Donkin Figures 44 & 130**

References: Cox (1995): 109, figures 37–42, 68–72; Witkowski *et al.* (2000): 280, pl. 124, figures 8–25, pl. 129, figure 9, pl. 142, figures 4 & 5; Bruder & Medlin (2008), figures 5a–d; Van de Vijver *et al.* (2011): 293, figures 97–106.

Samples: Moen_01 #001, Moen_02 #002, Moen_03 #001, CHP-3 st1286.

Dimensions: 20.0–35.5 µm long, 5.7–7.1 µm wide; 14–18 transapical striae in 10 µm.

Diagnostics: Valves lanceolate with protracted apices. Transapical striae radiate in the middle and convergent at apices. Areolae visible in LM. Central area variable in size, markedly asymmetric.

Comments: The small size of Chuuk specimen is considered as a freshwater form. This is a first record from Micronesian waters.

***Navicula mannii* Hagelstein Figure 131**

Reference: Lobban *et al.* (2012): 293, pl. 47, figure 9.

Sample: CHB1-1 st1262, CHB1-2 st1295

Dimensions: 29 µm long, 9.4 µm wide; 9 striae in 10 µm.

Comments: The shape and low stria density distinguish this from other small, ± rhomboidal *Navicula* spp. This species has been reported from Guam but elsewhere known only from Puerto Rico (Lobban *et al.*, 2012).

***Navicula plicatula* Grunow Figure 45**

Reference: Lobban *et al.* (2012): 293, pl. 48, figures 1–3.

Sample: Moen_05 #001.

Dimensions: 66.9 µm long, 20.2 µm wide; 15 striae in 10 µm; 19 areolae in 10 µm in a stria.

***Navicula tsukamotoi* (Sterrenburg & Hinz) Yuhang Li & Kuidong Xu Figures 132 & 133**

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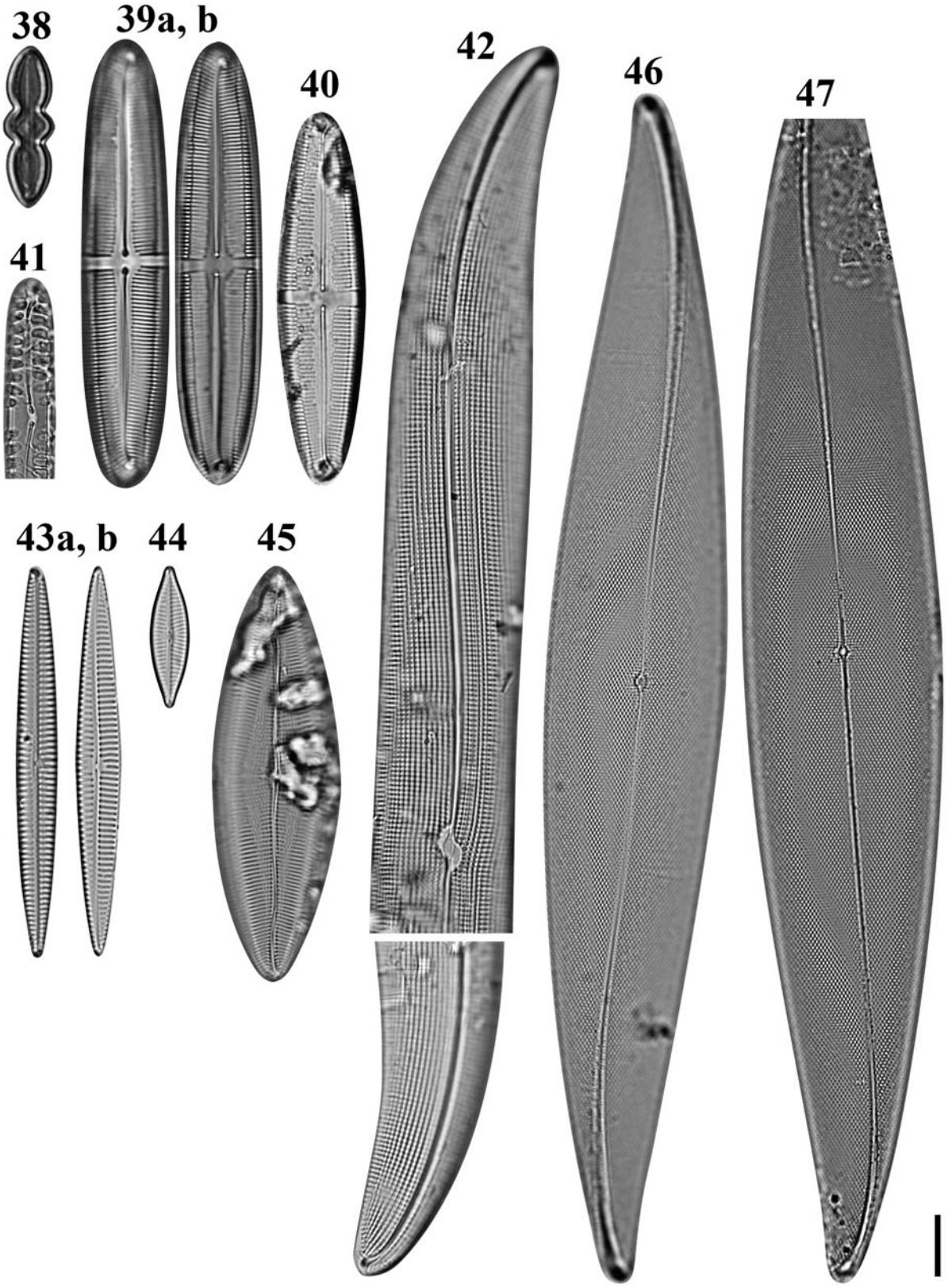


**Figs 38–47.** Light microscopy images of eight taxa in Chuuk, Micronesia. **Fig. 38.** *Caloneis egena* from Moch. **Figs 39a, b**, **40.** *Caloneis macquariensis* from Weno. **Fig. 41.** *Pinnularia* cf. *borealis* from Weno. **Fig. 42a, b**. *Gyrosigma* cf. *balticum* from Weno. **Fig. 43a, b.** *Navicula directa* from Weno. **Fig. 44.** *Navicula gregaria* from Weno. **Fig. 45.** *Navicula plicatula* from Weno. **Figs 46, 47.** *Pleurosigma marinum* from Weno. Scale bar = 10 μm.

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Synonym: *Haslea tsukamotoi* Sterrenburg & Hinz 2015, p 151, figures 14, 15, 33–38.

References: Sterrenburg *et al.* (2015): 151, figures 14, 15, 33–38 (as *H. tsukamotoi*); Li *et al.* (2017): 454, figures 5–21 (as *H. tsukamotoi*).

Sample: CHP3-2 st1265.

Dimensions: 26.1 µm long, 5.3 µm wide; 16 transapical striae in 10 µm.

Diagnostics: Valve linear-lanceolate with acute apices. Transapical striae slightly radial.

Comments: Lobban *et al.* (2020) concluded that Guam specimens identified as *H. howeana* are correctly identified with the new species *N. tsukamotoi* on the basis of genetic and structural evidence in Li *et al.* (2017) and Sterrenburg *et al.* (2015), but could not say whether *H. howeana*, originally described from the Caribbean, is conspecific with *N. tsukamotoi*.

### Family PLEUROSIGMATACEAE Mereschkowsky, 1903

#### *Pleurosigma marinum* Donkin Figures 46 & 47

Reference: Foged (1978): 120, pl. XXIII, figure 2.

Samples: Moen_04 #001, CHP3-2 st1286.

Dimensions: 89.0–204.2 µm long, 10.1–32.0 µm wide; 20–23 transverse striae in 10 µm; 17–20 diagonal striae in 10 µm.

Diagnostics: Valve lanceolate with slightly sigmoid ends. Raphe straight from axial area to middle of valve and curved near valve ends.

Comments: This is a first record from Micronesian waters.

#### *Pleurosigma* cf. *elongatum* W. Smith Figures 134 & 135

References: Sar *et al.* (2014): 160, figures 48–55; Al-Handal *et al.* (2014), figure 55.

Samples: Moen_04 #003, CHP3-2 st1265.

Dimensions: 153.0–162.9 µm long, 16.2–16.6 µm wide; 23 transverse striae in 10 µm; 20 diagonal striae in 10 µm.

Diagnostics: Valves long, slender. Central area small and symmetric. Transverse and oblique striae angle 61°.

Comments: Park *et al.* (2018) reported this taxon in an unidentified status as *Pleurosigma* sp. 2. Valve shape and internal bisected areolae by bar are similar to *P. elongatum* (Sar *et al.* 2014), but the absence of calcar at the terminal ends in the Chuuk specimen is different from *P. elongatum*. We did not observe the external details such as central raphe fissure and areolae slits in the Chuuk sample. Further details are needed to identify this taxon positively. Nevertheless, there was no record on this *P. elongatum*-like species from Micronesian waters until now.

#### *Rhoicosigma compactum* (Greville) Grunow Figures 136 & 137

Reference: Lobban (2015*a*): 14, figures 139–143.

Sample: CHB2-1.

Dimensions: 106 µm long; striae 25 in 10 µm.

Comments: The stria density is at the high end of the several different ranges given in the literature, but appears to match specimens from Guam identified as this species by Lobban (2015*a*).

### Family STAURONEIDACEAE D.G.Mann, 1990

#### *Schizostauron* cf. *trachyderma* (F.Meister) Górecka, Riaux-Gobin & Witkowski Figure 35

Synonyms: *Cocconeis citronella* A. Mann; *Achnanthes citronella* (A. Mann) Hustedt

Reference: Davidovich *et al.* (2017): 80, figures 1–24 (as *Schizostauron* sp. 1); Górecka *et al.* (2021): 1475, figure 2.

Sample: TK4.

Dimensions: 28 µm long, 15 µm wide; striae 10 in 10 µm (sternum valve).

Comments: This species, which has been reported as *A. citronella* from Guam (Lobban *et al.*, 2012) and Tahiti (Ricard, 1977), now falls into *Schizostauron* (Davidovich *et al.*, 2017; Górecka *et al.*, 2021), but we cannot tell from the LM if the Chuuk specimen belongs to *S. trachyderma* as proposed or to *S. kajotkei* Dabek, Górecka & Witkowski. The distinction is hard to pin down because while Davidovich *et al.* (2017) state that their *Schizostauron* sp.1 is very similar to *S. trachyderma* except for the latter having only 9.8–12.1 striae in 10 µm on the SV, in transferring *trachyderma* from *Achnanthes* to *Schizostauron*, Górecka *et al.* (2021) give the stria density as 10–17 (*vs* 10–14). Even without that confusion, our cell, with 10 striae in 10 µm fits both. *Schizostauron trachyderma* has been reported from several Western Pacific sites as well as the Indian Ocean, *S. kajotkei* so far only from Madagascar. It is possible that our material fits neither but we will need good SEM to tell. *Schizostauron* is not related to *Achnanthes*, but in gene trees is sister to *Astartiella* and was transferred to Naviculales: Stauroneidaceae (Górecka *et al.*, 2021).

### Order THALASSIOPHYSALES D.G. Mann, 1990

### Family CATENULACEAE Mereschkowsky, 1902

#### *Amphora biggiba* Grunow Figure 138

Reference: Navarro & Lobban (2009): 150, figures 135 & 136.

Sample: CHP3-2 st1265.

Dimensions: 11.1 µm long, 2.5 µm wide; 34 striae in 10 µm in dorsal part, 37 striae in 10 µm in ventral part.

#### *Amphora lunulata* Wachnicka & Gaiser Figure 139

Reference: Wachnicka & Gaiser (2007): 426, figures 141–143.

Sample: CHB1-1 st1262 0018.

Dimensions: 30.0–31.9 µm long, 5.3–6.2 µm wide; 23 striae in 10 µm in dorsal part, 23 striae in 10 µm in ventral part.

Diagnosis: Valves semi-elliptical with slightly acute apices. Raphe dorsally arched. Hyaline longitudinal line crossing dorsal striae.

Comments: Park *et al.* (2018) described this taxon in an unidentified status as *Amphora* sp. 2. The striae in the Chuuk specimen are denser than original description (17–20 in 10 µm). The most striking feature of this specimen is the internal rib alongside the raphe. As Wachnicka & Gaiser (2007) did not show SEM for this species, the identification is not strongly supported by our single SEM image.

#### *Amphora ostrearia* var. *vitrea* Cleve Figure 140

References: Wachnicka & Gaiser (2007): 411, figures 82 & 83; Lobban *et al.* (2012): 299, pl. 56, figures 5 & 6.

Sample: Moen_03 #002.

Dimensions: 55.1 µm long, 13.3 µm wide; 11 striae in 10 µm in dorsal part, 11 striae in 10 µm in ventral part.

#### *Amphora* cf. *abuldens* Simonsen Figure 141

References: Simonsen (1960): 129, pl. 2, figures 10–12; Witkowski *et al.* (2000): 128, pl. 163, figures 18 & 19.

Sample: CHB1-1 st1262.

Dimensions: 17.5 µm long, 3.5 µm wide; 50 striae in 10 µm in dorsal part.

Diagnostics: Valve semi-lanceolate, almost straight ventral margin with acute apices. Transapical striae only distinct in the valve margin of dorsal part. Raphe slightly arched. Axial area on the dorsal part broad. Transverse fascia distinct.

Comments: Simonsen (1960) and Witkowski *et al.* (2000) described the stria density of *A. abludens* as above 38 in 10 µm, but the Chuuk specimen density is even denser.

#### *Amphora* cf. *egregia* Ehrenberg Figure 142

References: Schmidt *et al.* (1874–1959), pl. 28, figures 13–15, 18, pl. 39, figures 26, 27, 31; Levkov (2009): 271, pl. 113, figure 2, pl. 269, figures 1–6, pl. 283, figures 4 & 5.

Sample: CHB1-1 st1263.

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Dimensions: 56.5 µm long, 8.3 µm wide; 9 striae in 10 µm in dorsal part, 9 striae in 10 µm in ventral part.

Diagnostics: Valve linear semi-elliptic with broadly round apices. Dorsal and ventral part parallel in the middle part and smoothly curved toward ventral part. Areolae coarse and loculate. Striae slightly radiate in middle part and convergent in ends. Raphe sternum flap toward dorsal part covering adjacent areolae.

Comments: Although this species has the general characters of *A. egregia*, our specimen has striae all along the ventral side rather than just at the apices and along the margin, and appears to lack a longitudinal rib across the dorsal striae near the dorsal margin (Levkov, 2009).

### *Amphora* cf. *helenesis* Giffen Figure 143

References: Giffen (1973): 5, figures 7–9; Witkowski *et al.* (2000): 139, pl. 163, figures 31–33; Al-Handal *et al.* (2016): 32, pl. 13, figures 5 & 6; Kim *et al.* (2017): 607, figures 2A–L.

Sample: CHP3-2 st1265.

Dimensions: 5.0–10.3 µm long; 1.8–2.6 µm wide; 40–46 striae in 10 µm in dorsal part, 31–37 striae in 10 µm in ventral part.

Diagnosis: Valve lunate with rounded apices. Raphe slightly bi-arcuate.

Comments: Chuuk specimen is similar to *A. helenensis*, but the stria density is substantially higher than in the original description (17–20 in 10 µm).

## Order BACILLARIALES Hendey, 1937
## Family BACILLARIACEAE Ehrenberg, 1831

### *Bacillaria* Group B sensu Schmid var. *tumidula* Figures 144 & 145

Synonym: *Bacillaria paxillifer* var. *tumidula* (Grunow) Witkowski *et al.*, 2000: 357, pl. 196, figure 8.

References: Witkowski *et al.* (2000): 357, pl. 196, figures 5–7, pl. 207, figure 9; Schmid (2007): 304, figure 9.

Sample: CHB1-1 st1263.

Dimensions: 110 µm long, 8 µm wide; striae 21 in 10 µm, 10 fibulae in 10 µm.

Diagnostics: The variety *tumidula* is distinguished by an inflated centre with silica flaps at the edge of the valve face.

Comments: This group has still not been given a species name, which it lacks since Schmid (2007) restricted *B. paxillifer* to estuarine forms. This form is also abundant in mangrove samples from Vietnamese coasts (A. Witkowski, personal communication). This is a first record from Micronesian waters.

### *Giffenia cocconeiformis* (Grunow) Round & Basson Figures 48 & 49

References: Giffen (1963): 244; Foged (1975): 45, pl. 29, figure 6; Witkowski *et al.* (2000): 374, figures pl. 188, figures 8 & 9.

Sample: Moen_03 #001.

Dimensions: 33.1–42.1 µm long, 16.5–21.5 µm wide; 7 striae in 10 µm; 21–22 areolae in a stria.

Diagnostics: Valves elliptical with cuneate apices. Transapical striae biseriate, composed of rows of circular areolae, parallel, at apices radiate and interrupted by hyaline fold.

Comments: This is a first record from Micronesian waters.

### *Nitzschia lorenziana* Grunow Figures 51a, b, 154

Reference: Navarro (1982*a*, 1982*b*): 54, pl. 35, figure 4; Poulin *et al.* (1990): 87, figures 63, 64, 67, 68, 71, 72; Witkowski *et al.* (2000): 392, pl. 211, figure 3.

Sample: Moen_04 #001, CHB1-1 st1263.

Dimensions: 55.4–133.0 µm long; 4.4–5.7 µm wide; 15 striae in 10 µm.

Diagnostics: Valves linear, abruptly tapered into long rostrate apices. Raphe eccentric. Striae coarse and separated by externally solid equidistant costae.

Comments: This is a brackish-water species and has been observed from the Atlantic Ocean for example the Indian River (Florida, Navarro, 1982*a*, 1982*b*), Quebec (Canada, Poulin *et al.*, 1990). This is a first report from Micronesian waters, North-western Pacific.

### *Nitzschia maiae* Lobban, Ashworth, Calaor & E.C. Theriot Figure 148

References: Park *et al.* (2018): 133, figure 155 (as *Nitzschia* sp. 5); Lobban *et al.* (2019): 208, figures 13, 26–34.

Samples: CHB1-1 st1263; CHP3-2 st1265.

Dimensions: 24.7–38.72 µm long, 3.8–5.0 µm wide; 41–42 transapical striae in 10 µm.

Diagnosis: Valves lanceolate with rostrate apices. Transapical striae parallel. Raphe slightly eccentric. Conopea present only at apices.

Comments: Park *et al.* (2018) reported this species with an unidentified status as *Nitzschia* sp. 5.

### *Nitzschia rectilonga* Takano Figures 149–151

References: Takano (1983): 18, figures 4, 24–30, 31; Shorenko *et al.* (2016): 23, figures 2a–c, 3a–c, 5, 6.

Samples: Moen_02 #001, CHP-2 st1285, CHP-3 st1286.

Dimensions: 264.4 µm long, 8.3 µm wide; 37 striae in 10 µm, 8 fibulae in 10 µm.

Diagnostics: Valves linear-lanceolate usually straight, abruptly narrowed into very long rostrate ends. Raphe strongly eccentric, central nodule present, transapical striae in LM not resolvable.

Comments: This species is similar to *N. longissima*, but *N. rectilonga* differs in the presence of the hyaline field, a labiate cylinder on the margin of fibulae and with respect to the size of the projection of the raphe central nodule on the inside (Shorenko *et al.*, 2016). This is a first record from Micronesian waters.

### *Nitzschia* cf. *amabilis* Suzuki Figures 152 & 153

Synonym: *Nitzschia laevis* Hustedt 1939: 662, figures 116–118.

References: Suzuki *et al.* (2009): 274, figures 1–23; Rivera & Cruces (2011): 96, figure 1A–K; Simonsen (1987*b*), pl. 385, figures 10–18 (as *N. laevis*); Witkowski *et al.* (2000): 387, pl. 188, figures 13–15, pl. 190, figures 1–6 (as *N. laevis*).

Samples: CHP3-2 st1265.

Dimensions: 12.6–13.5 µm long; 4.8 µm wide; 51–53 striae in 10 µm.

Diagnostics: Cells small, delicate. Valves broadly linear-elliptical with blunt, rounded and slightly protruding ends. Sometimes middle part constricted.

Comments: Park *et al.* (2018) reported this taxon with an unidentified status as *Nitzschia* sp. 11. The valve outline of our material is close to *N. amabilis*, but a special structure on the central nodule of *N. amabilis* and stria density is finer than previous reports: ~40 by Witkowski *et al.* (2000); 32–34 in 10 µm by Rivera & Cruces (2011).

### *Nitzschia* cf. *clausii* Hantzsch Figures 50, 146, 147

Reference: Witkowski *et al.* (2000): 373, pl. 199, figures 8–10, pl. 200, figures 1 & 2.

Sample: Moen_01 #001.

Dimensions: 47.1 µm long, 4.3 µm wide; striae 38 in 10 µm, 8 fibulae in 10 µm.

Diagnostics: Valves linear, slightly concave in the middle with sigmoid short rostrate apices. Striae fine, invisible in LM.

### *Nitzschia* cf. *electrae* Lobban, Ashworth, Calaor & E.C.Theriot Figure 52

Reference: Lobban *et al.* (2019): 228, **figures 22, 130–140**.

Sample: Moen_04 #001.

Dimensions: 187.4 µm long, 6.4 µm wide; 8 fibulae in 10 µm.

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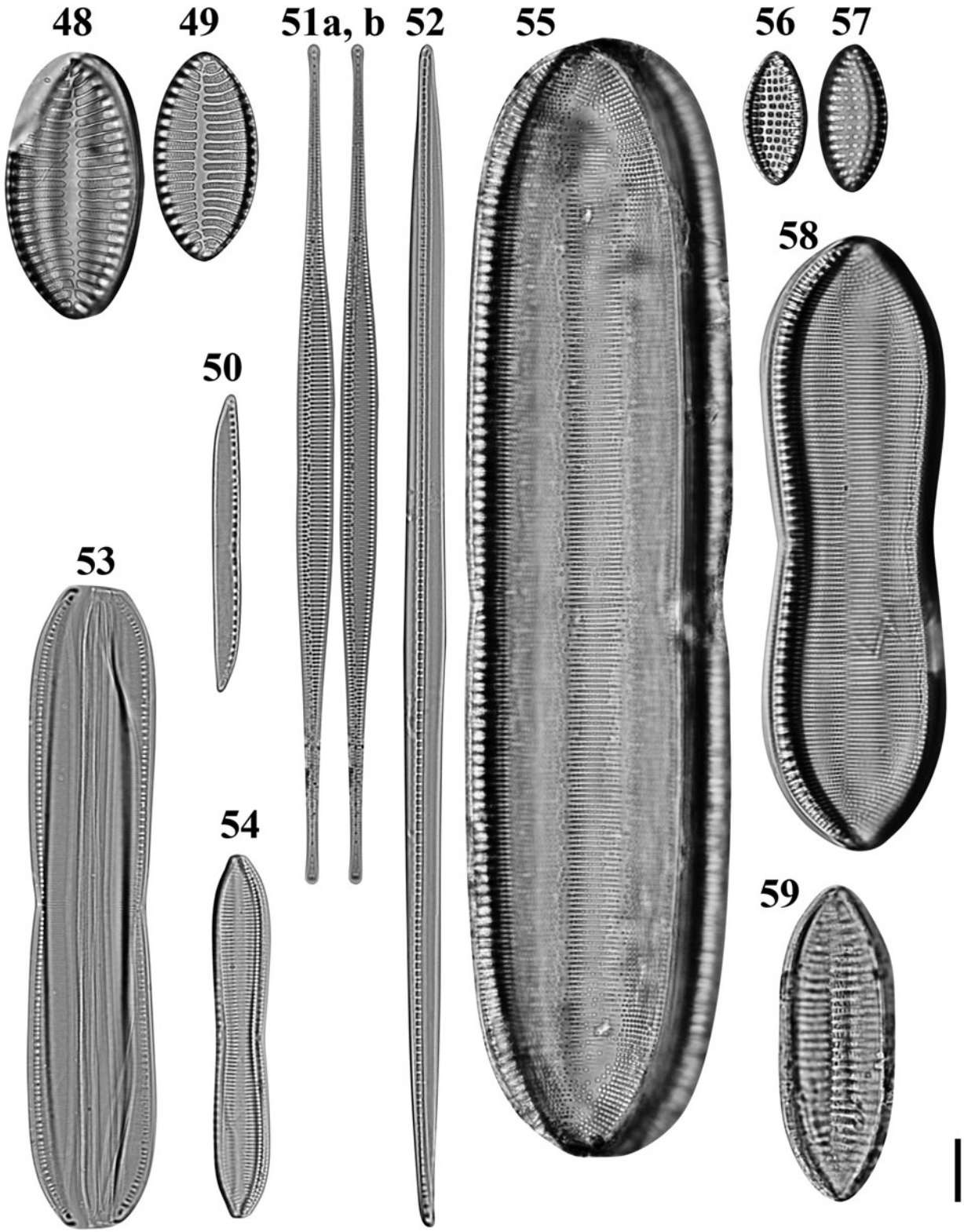


**Figs 48–59.** Light microscopy images of 10 taxa in Chuuk, Micronesia. **Figs 48, 49.** *Giffenia cocconeiformis* from Weno. **Fig. 50.** *Nitzschia* cf. *clausii* from Weno. **Fig. 51a, b**. *Nitzschia lorenziana* from Weno. **Fig. 52.** *Nitzschia* cf. *electrae* from Weno. **Fig. 53.** *Nitzschia* cf. *hybrida* from Weno. **Fig. 54.** *Tryblionella apiculata* from Weno. **Fig. 55.** *Tryblionella graeffii* from Weno. **Figs 56, 57.** *Tryblionella granulata* from Weno. **Fig. 58.** *Tryblionella* cf. *jelineckii* from Weno. **Fig. 59.** *Tryblionella* cf. *levidensis* from Weno. Scale bar = 10 μm.

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Diagnostics: Valve narrowly lanceolate with acute apices. Transapical striae invisible. Identity uncertain without SEM.

***Nitzschia* cf. *hybrida* Grunow Figure 53**

References: Poulin & Cardinal (1983): 113, figure 12; Witkowski *et al.* (2000): 385, pl. 191, figures 12–14; Al-Handal *et al.* (2014), figure 92; Al-Handal *et al.* (2016): 35, pl. 10, figure 10.

Sample: Moen_01 #001.

Dimensions: 101.4 µm long, 19.8 µm wide; 27 striae in 10 µm; 13 fibulae in 10 µm.

Diagnostics: Frustule rectangular, slightly constricted in the middle with acutely rounded apices.

***Tryblionella apiculata* W. Gregory Figure 54**

References: Schmidt *et al.* (1874–1959), pl. 331, figures 14 & 15, Giffen (1963): 243; Hendey (1964): 279; Lange-Bertalot & Krammer (1987): 8, 13.

Sample: Moen_01 #001.

Dimensions: 57.4 µm long, 9.1 µm wide; 16 striae in 10 µm; 10 fibulae in 10 µm.

Diagnostics: Valve constricted in the middle part with subcapitate apices. Striae parallel.

Comments: The apparent hyaline area present is a focus artefact of the longitudinal undulation, in contrast to *T. acuminata* W. Smith, which has a longitudinal hyaline stripe (Witkowski *et al.*, 2000: 366, pl. 188, figures 1–3). This is a first record from Micronesian waters.

***Tryblionella graeffii* (Grunow ex Cleve) D.G. Mann Figure 55**

Reference: Witkowski *et al.* (2000): 383, pl. 192, figure 1.

Sample: Moen_03 #001.

Dimensions: 176.6 µm long, 37.6 µm wide; 12 striae in 10 µm.

Diagnostics: Valve linear, robust. Striae packed throughout the valve and loose in the valve ends.

Comments: This is a first record from Micronesian waters.

***Tryblionella granulata* (Grunow) D.G. Mann Figures 56 & 57**

Reference: Navarro & Lobban (2009): 145.

Sample: Moen_01 #001, Moen_02 #001.

Dimensions: 21.1–23.3 µm long, 10.0–10.8 µm wide; 7 striae in 10 µm; 9 areolae in 10 µm; 8 fibulae in 10 µm.

***Tryblionella jelineckii* (Grunow) D.G. Mann Figure 58**

Reference: Peragallo & Peragallo (1897–1908): 268, pl. 69, figure 19.

Sample: Moen_04 #001.

Dimensions: 97.5 µm long, 28.5 µm wide; 13 striae in 10 µm; 8–9 fibulae in 10 µm.

Diagnostics: Valve elliptical in the constricted middle with obtusely rounded apices.

Comments: The fibula density here is slightly higher than given by Peragallo and Peragallo (1897–1908).

Comments: This is a first record from Micronesian waters.

***Tryblionella scalaris* (Ehrenberg) Siver & P.B. Hamilton Figures 155–157**

References: Witkowski *et al.* (2000): 404, pl. 205, figures 1–4; Ruck & Kociolek (2004): 55, pl. 62, figure 1–5, pl. 63–65, figures 6–24; Siver & Hamilton (2005): 374, figures 67–80; Al-Handal *et al.* (2014), figure 94.

Samples: CHB1-1 st1292, CHB1-1 st1262, CHP-2 st1285.

Dimensions: 581.2 µm long; 21.6 µm wide; 10 transapical striae in 10 µm.

Diagnostics: Very long, robust valve, linear with obtusely rounded apices.

Comments: This is a first record from Micronesian waters.

***Tryblionella* cf. *levidensis* W. Smith Figure 59**

References: Giffen (1963): 246; Hendey (1964): 277; Lange-Bertalot & Krammer (1987): 32; Krammer & Lange-Bertalot (1997): 37; Al-Handal *et al.* (2014), figure 106.

Sample: Moen_03 #001.

Dimensions: 49.7 µm long, 18.1 µm wide; 8 transapical ribs in 10 µm.

Diagnostics: Valve linear-elliptic with cuneate, obtusely rounded apices. Transapical striae in LM barely discernible and obscured by coarse transapical ribs in the middle interrupted by a longitudinal fold.

**Order RHOPALOIDALES D.G. Mann, 1990**

***Entomoneis corrugata* (Giffen) Witkowski *et al.*, 2000 Figures 60a, b, 158**

Reference: Navarro & Lobban (2009): 147, figures 108–111.

Samples: Moen_01 #001, CHP-3 st1286.

Dimensions: 50.7–53.5 µm long, 31.1–33.0 µm wide; 16–17 striae in 10 µm.

Diagnostics: Valve with crenulated margin.

Comments: The Chuuk specimen has a smaller valve and finer striae than other observations (Giffen, 1963, 1967; Navarro & Lobban, 2009).

***Epithemia gibberula* var. *baltica* (O. Müller) J.S. Park & Lobban, comb. nov. Figures 61 & 62**

Reference: Schmidt *et al.* (1874–1959), pl. 253, figures 33–37.

Samples: Moen_01 #001, Moen_02 #001, Moen_03 #001.

Dimensions: 30.6–50.8 µm long, 8.7–9.7 µm wide.

Diagnostics: Valve lunate, strongly convex dorsal margin and moderately concave ventral margin with acutely rounded apices.

Comments: We propose a new combination name for *Rhopalodia gibberula* var. *baltica* following Ruck *et al.* (2016). The formal nomenclatural changes are made below. This is a first record from Micronesian waters.

***Epithemia gibberula* var. *tumida* (Zanon) J.S. Park & Lobban, comb. nov. Figure 63**

Reference: Zanon (1941): 536, pl. 4, figures 10 & 11.

Sample: Moen_03 #001.

Dimensions: 34.5 µm long, 14.1 µm wide.

Diagnostics: Valve strongly convex dorsal margin and straight ventral margin with rounded rostrate apices. Striae multiseriate.

Comments: We propose a new combination name for *Rhopalodia gibberula* var. *tumida* following Ruck *et al.* (2016). This is a first record from Micronesian waters.

***Epithemia globosa* (Hustedt) J.S. Park & Lobban, comb. nov. Figure 64**

References: Simonsen (1987*b*): 240, pl. 350, figures 6 & 7; Moser *et al.* (1998): 215, pl. 67, figures 1, 2, 6.

Sample: Moen_03 #001.

Dimensions: 46.0 µm long, 21.3 µm wide; 17 striae in 10 µm; 19 areolae in 10 µm in a stria.

Diagnostics: Valve dorsiventral, orange-segment shaped. Striae multiseriate, flabellate with transapical costae. Raphe eccentric, running along the dorsal margin.

Comments: We propose a new combination name for *Rhopalodia globosa* following Ruck *et al.* (2016). This is a first record from Micronesian waters.

***Protokeelia cholnokyi* (M.H. Giffen) Round & Basson Figure 159**

Basionym: *Auricula cholnokyi* M.H. Giffen

References: Round & Basson (1995): 213, figures 2–9; Lobban (2015*a*): 12, figures 114–117; Giffen (1963): 220, pl. II, figures 27–29 (as *A. cholnokyi*).

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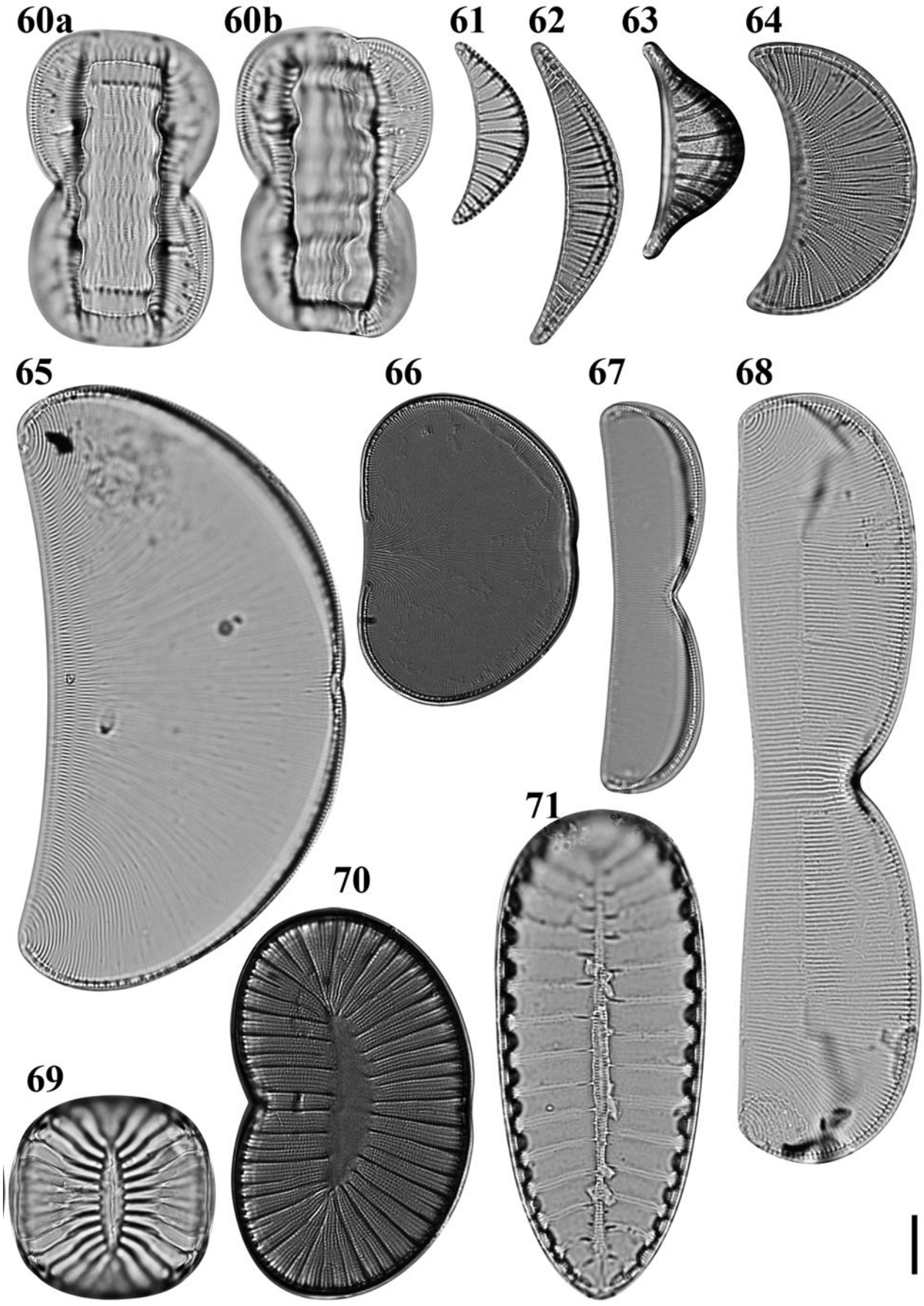


**Figs 60–71.** Light microscopy images of six taxa in Chuuk, Micronesia. **Fig. 60a, b.** *Entomoneis corrugata* from Weno. **Figs 61, 62.** *Epithemia gibberula* var. *baltica* from Weno. **Fig. 63.** *Epithemia gibberula* var. *tumida* from Weno. **Fig. 64.** *Epithemia globosa* from Weno. **Fig 65.** *Auricula complexa* from Weno. **Fig. 66.** *Auricula flabelliformis* from Weno. **Fig. 67.** *Auricula intermedia* from Weno. **Fig. 68.** *Auricula* sp. from Weno. **Fig. 69.** *Campylodiscus* cf. *biangulatus* from Weno. **Fig. 70.** *Plagiodiscus martensianus* from Moch. **Fig. 71.** *Surirella oblongoelliptica* from Weno. Scale bar = 10 μm.

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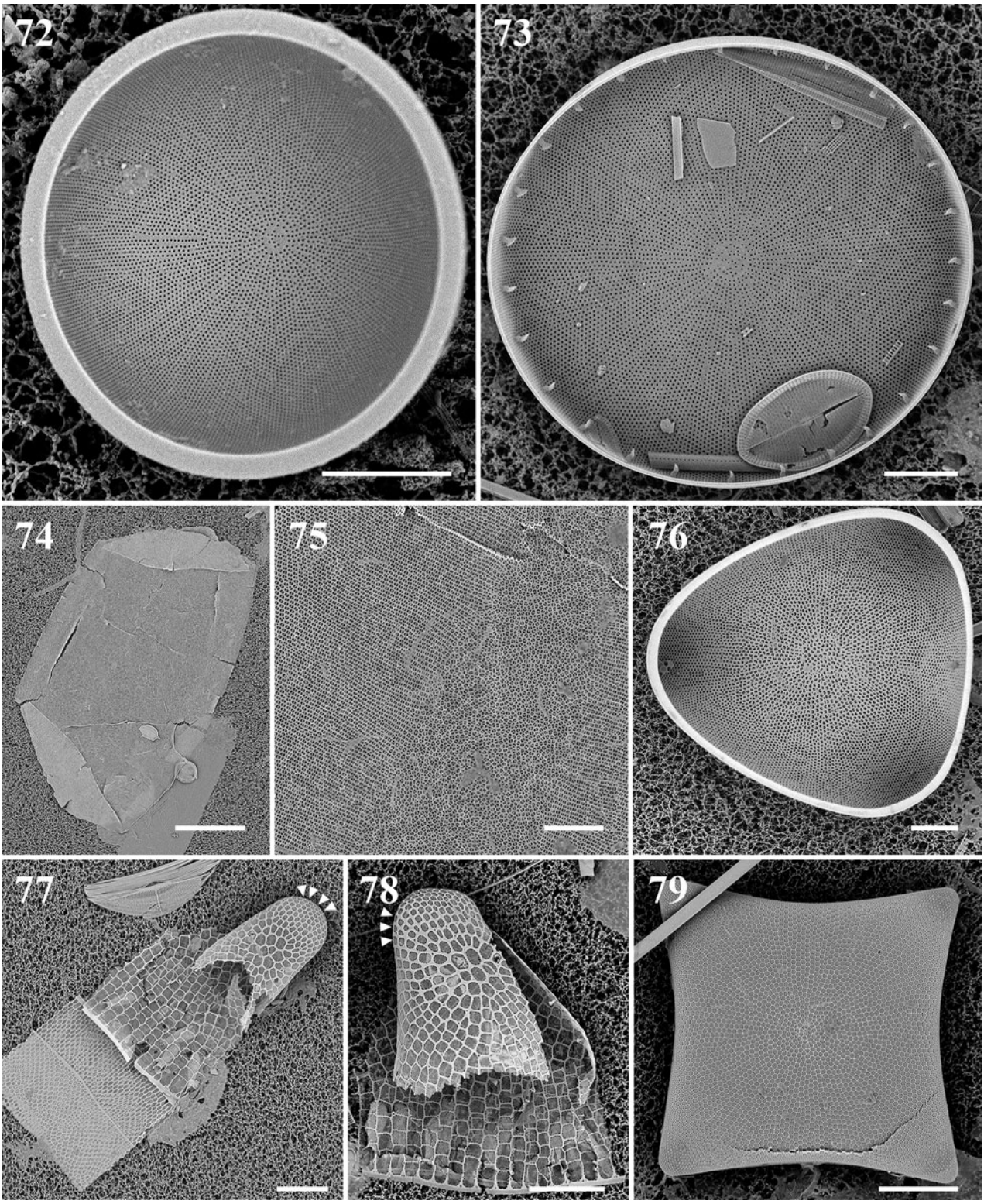


**Figs 72–79.** Scanning electron microscopy images of six taxa in Chuuk, Micronesia. **Fig. 72.** *Podosira hormoides* from Weno. **Fig. 73.** *Actinocyclus subtilis* from Weno. **Figs 74, 75.** *Biddulphopsis membranacea* from Moch, whole valve and detail showing broad central area and radiating striae. **Fig. 76.** *Biddulphopsis titiana* from Moch, interior. **Figs 77, 78**. *Isthmia minima* from Moch, valve with copulae and detail of valve, both showing the mesh invaginations (arrowheads). **Fig. 79.** *Trigonium formosum* f. *quadrangularis* from Moch, exterior. Scale bars: 50 µm (Fig. 74), 20 µm (77–79), 10 µm (Figs 72, 73, 75, 76).

Sample: CHB1-1 st1263.

Dimensions: 11.8 µm long, 7.0 µm wide; 23 striae in 10 µm.

**Order SURIRELLALES D.G. Mann, 1990**

***Auricula complexa* (Gregory) Cleve Figures 65 & 160**

References: Navarro & Lobban (2009): 147, figures 112–114; Park *et al.* (2014): 238, figure 3a.

Sample: Moen_03 #001.

Dimensions: 68.9–101.7 µm long, 38.6–49.8 µm wide; 15–16 striae in 10 µm.

Diagnostics: Frustule semi-elliptical with a slightly concave ventral and a fairly convex dorsal margin in girdle view. Striae flabellate, radiating from ventral margin to dorsal raphe canal. Costae frequently bifurcated.

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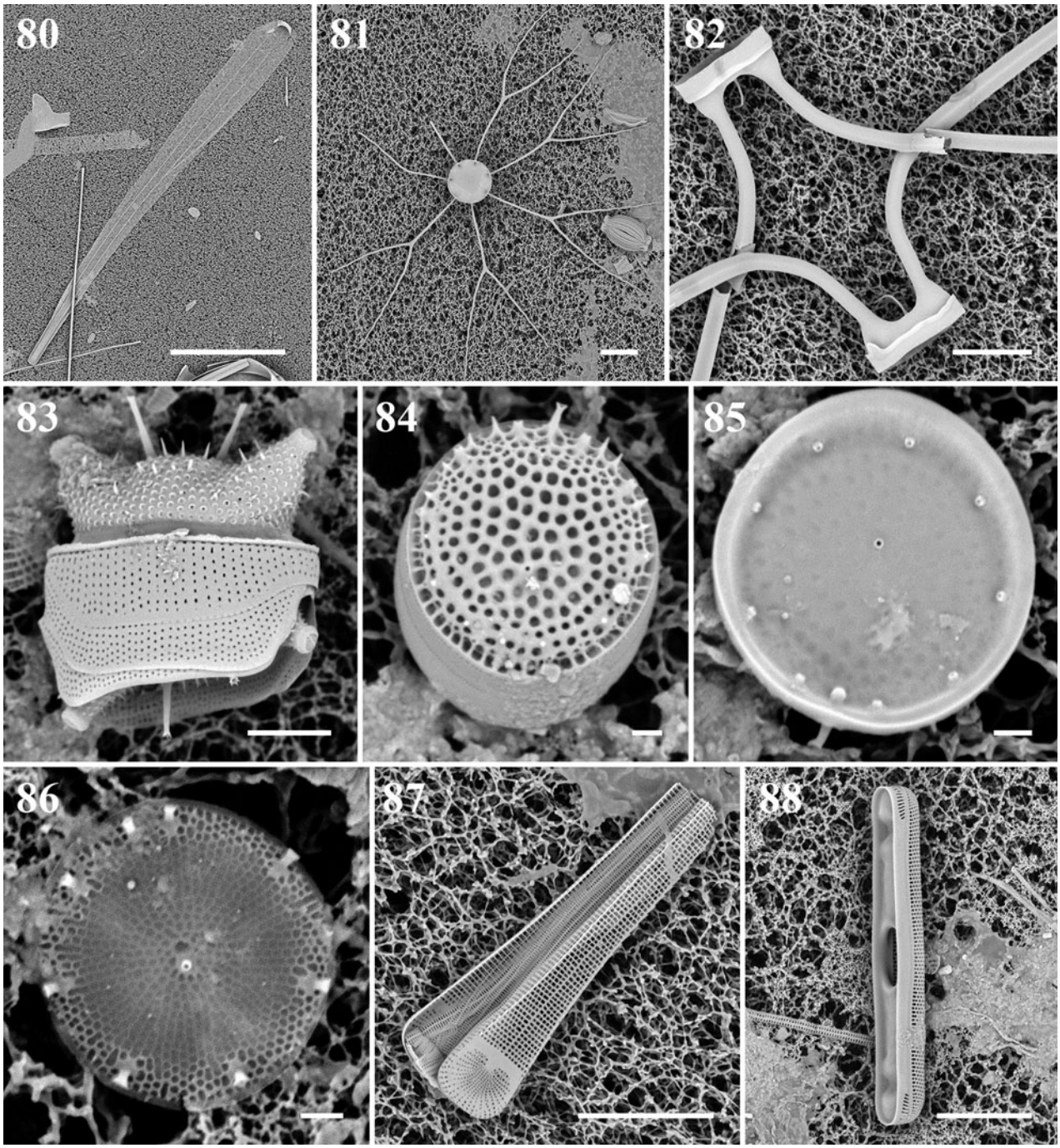


**Figs 80–88.** Scanning electron microscopy images of eight taxa in Chuuk, Micronesia. **Fig. 80.** *Climacosphenia moniligera* from Moch. **Fig. 81.** *Bacteriastrum furcatum* from Moch. **Fig. 82.** *Chaetoceros* cf. *atlanticus* var. *skeleton* from Moch. **Fig. 83.** *Odontella aurita* from Weno. **Figs 84, 85.** *Thalassiosira cedarkeyensis* from Weno. **Fig. 86.** *Thalassiosira* cf. *catharinensis* from Weno. **Fig. 87.** *Koernerella recticostata* from Moch (apex missing). **Fig. 88.** *Grammatophora marina* from Weno, oblique advalvar view of valvocopula with septum and valve. Scale bars: 100 µm (Figure 80), 10 µm (Figs 81, 82, 87, 88), 5 µm (Fig. 83), 1 µm (Figs 84–86).

Comments: Lobban *et al.* (2012) reported *A. complexa* from Guam, but the valve size and striae density match *Auricula densestriata* K. Osada (Osada, 1997).

### *Auricula flabelliformis* Voigt Figure 66

Reference: Lobban (2015*a*): 3, figures 10–12.

Sample: Moen_03 #001.

Dimensions: 58.2 µm long; 18 striae in 10 µm.

Diagnostics: Frustule reniform. Striae flabellate, radiating from centre of the ventral margin to dorsal raphe canal. Costae frequently bifurcated.

### *Auricula intermedia* (F.W. Lewis) Cleve Figure 67

Reference: Lobban *et al.* (2012): 304, pl. 63, figures 3 & 4.

Samples: Moen_05 #001.

Dimensions: 65.7 µm long, 16.3 µm wide; 21 striae in 10 µm.

Diagnostics: Frustule semi-elliptical with a slightly concave ventral and a round dorsal margin that constricted in the middle part in girdle view. Striae very fine and parallel in the middle part and radiating from ventral margin to dorsal raphe canal in the valve ends.

Comments: The Chuuk specimen of *A. intermedia* has finer striae than the other specimens from Guam (16–18 in 10 µm (Lobban *et al.*, 2012) and off Basra, Iraq (16–17 in 10 µm (Al-Handal *et al.*, 2018)).

### *Auricula* sp. Figure 68

Sample: Moen_03 #001.

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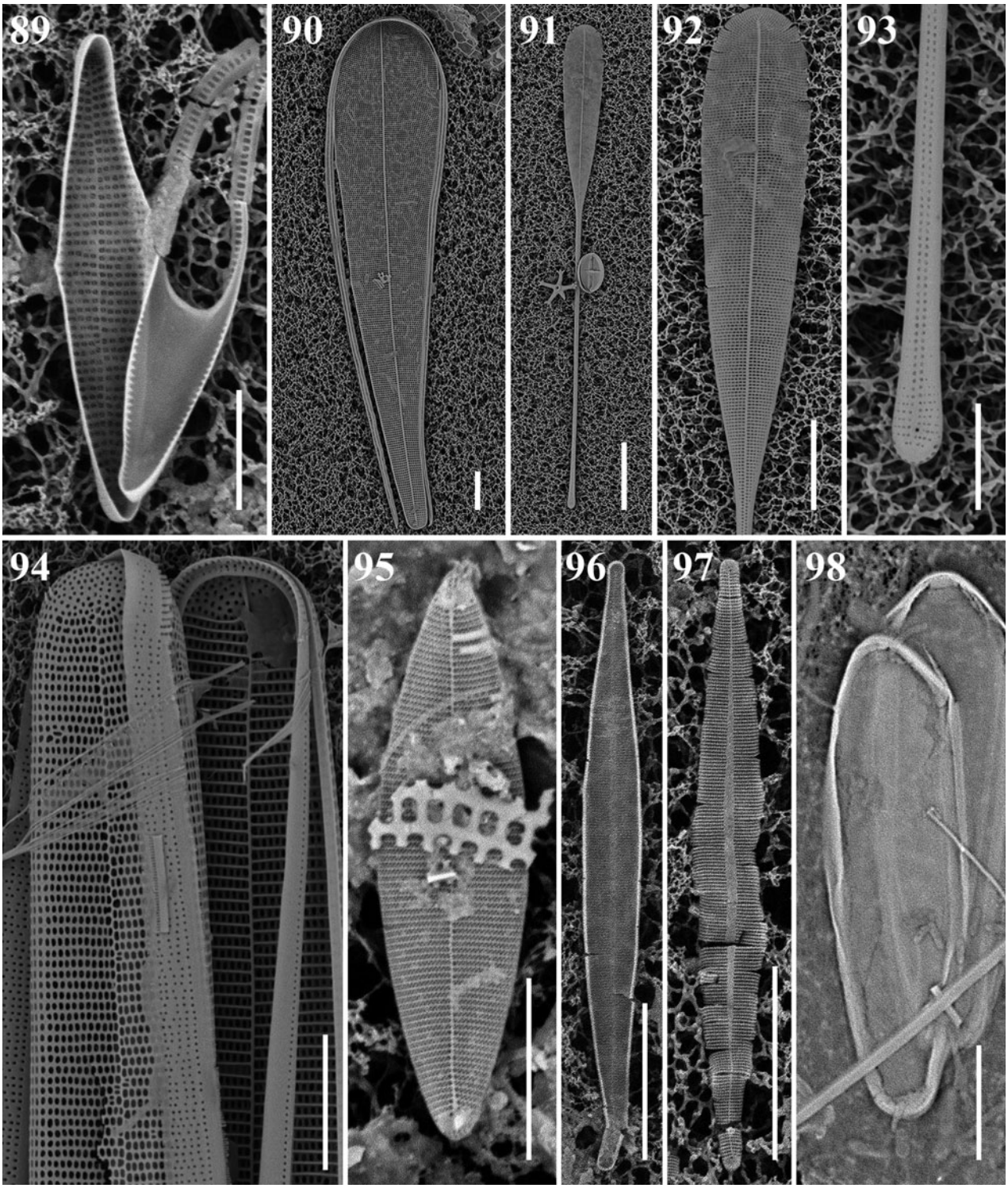


**Figs 89–98.** Scanning electron microscopy images of seven taxa in Chuuk, Micronesia. **Fig. 89.** *Microtabella interrupta* from Weno, interior valve and copula with septum. **Fig. 90.** *Licmophora curvata* from Moch, interior valve and valvocopula. **Figs 91–93.** *Licmophora remulus* from Moch, showing valve, details of spathulate apex and basal region with rimoportula and multiscissura. **Fig. 94.** *Synedra bacillaris* from Moch. **Fig. 95.** *Hyalosynedra al-shareefii* from Weno. **Figs 96, 97.** *Hyalosynedra* cf. *sublaevigata* from Weno. **Fig. 98.** *Gato hyalinus* from Moch, two frustules in mucilage tube. Scale bars: 20 µm (Figs 91, 99), 10 µm (Figs 90, 92, 94, 96–98), 5 µm (Figs 89, 93, 95).

Dimensions: 130.5 µm long, 30.3 µm wide; 13 striae in 10 µm.

Diagnostics: Frustule semi-elliptical with a slightly undulate ventral and a round dorsal margin that constricted in the middle part in girdle view. Striae coarse and parallel in the middle part and radiating from ventral margin to dorsal raphe canal in the valve ends. Costae bifurcated in the radiating striae area.

Comments: This species resembles *A. intermedia* at a first glance, but the valve size is larger and striae density sparser than *A. intermedia*.

### *Campylodiscus* cf. *biangulatus* Greville Figure 69

References: Greville (1862): 20, pl. III, figure 2; Schmidt *et al.* (1874–1959), pl. 14, figures 18–22, pl. 208, figures 8?, 9, 15; Williams (1988): 21, pl. 26, figures 3 & 4.

Sample: Moen_03 #002.

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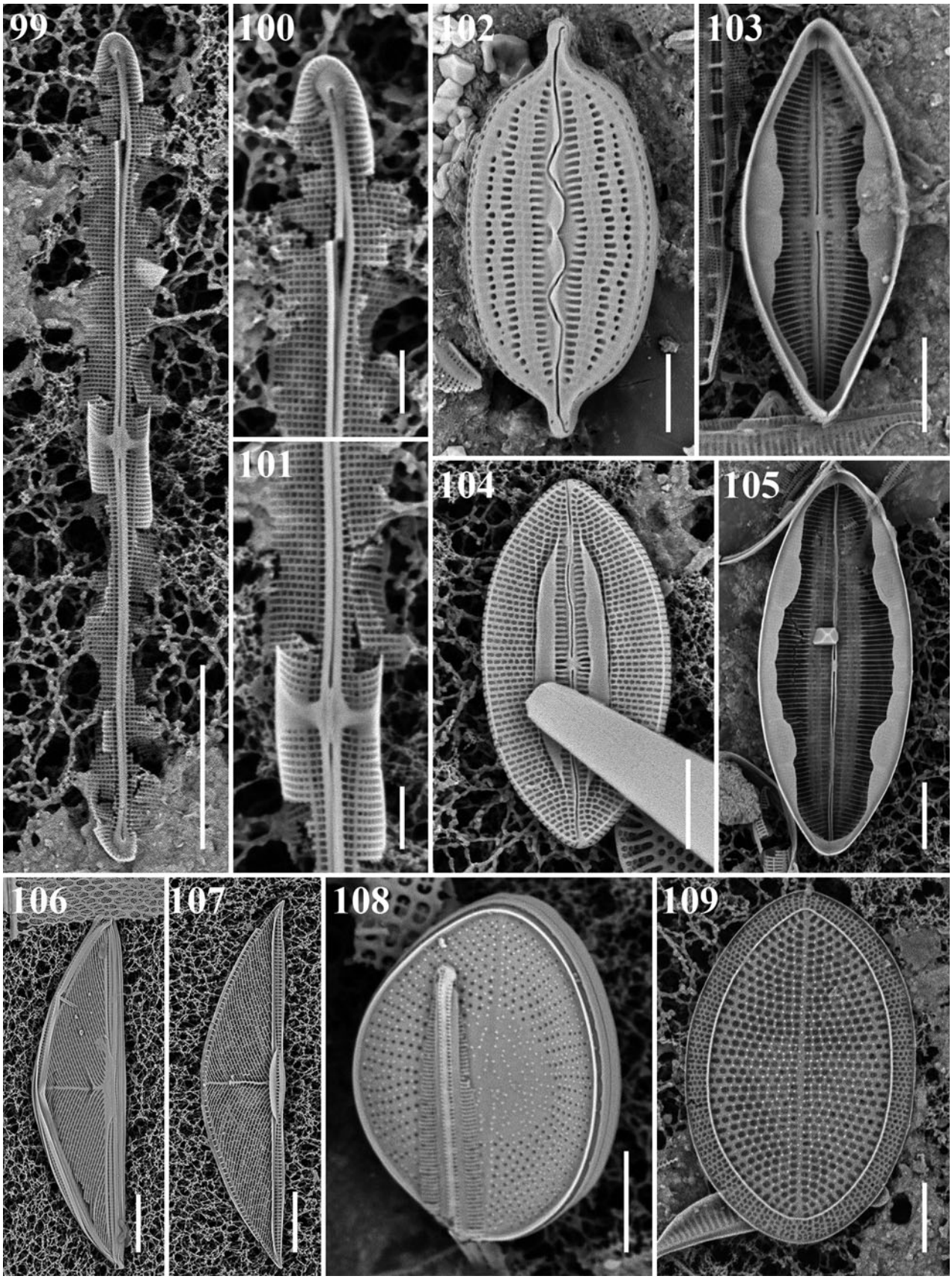


**Figs 99–109.** Scanning electron microscopy images of eight taxa in Chuuk, Micronesia. **Figs 99–101.** *Craspedostauros* cf. *neoconstrictus* from Weno, whole valve interior and details of apical and central portions. **Fig. 102.** *Mastogloia corsicana* from Moch. **Fig. 103.** *Mastogloia exilis* from Weno. **Fig. 104.** *Mastogloia hustedtii* from Weno. **Fig. 105.** *Mastogloia mauritiana* from Weno. **Figs 106, 107.** *Tetramphora decussata* from Moch, exterior and interior views, respectively. **Fig. 108.** *Anorthoneis eurystoma* from Weno, sternum valve. **Fig. 109.** *Cocconeis coronatoides* from Weno, sternum valve. Scale bars: 10 μm (Figs 99, 105–107), 5 μm (Figs 102–104, 108, 109), 2 μm (Figures 100, 101).

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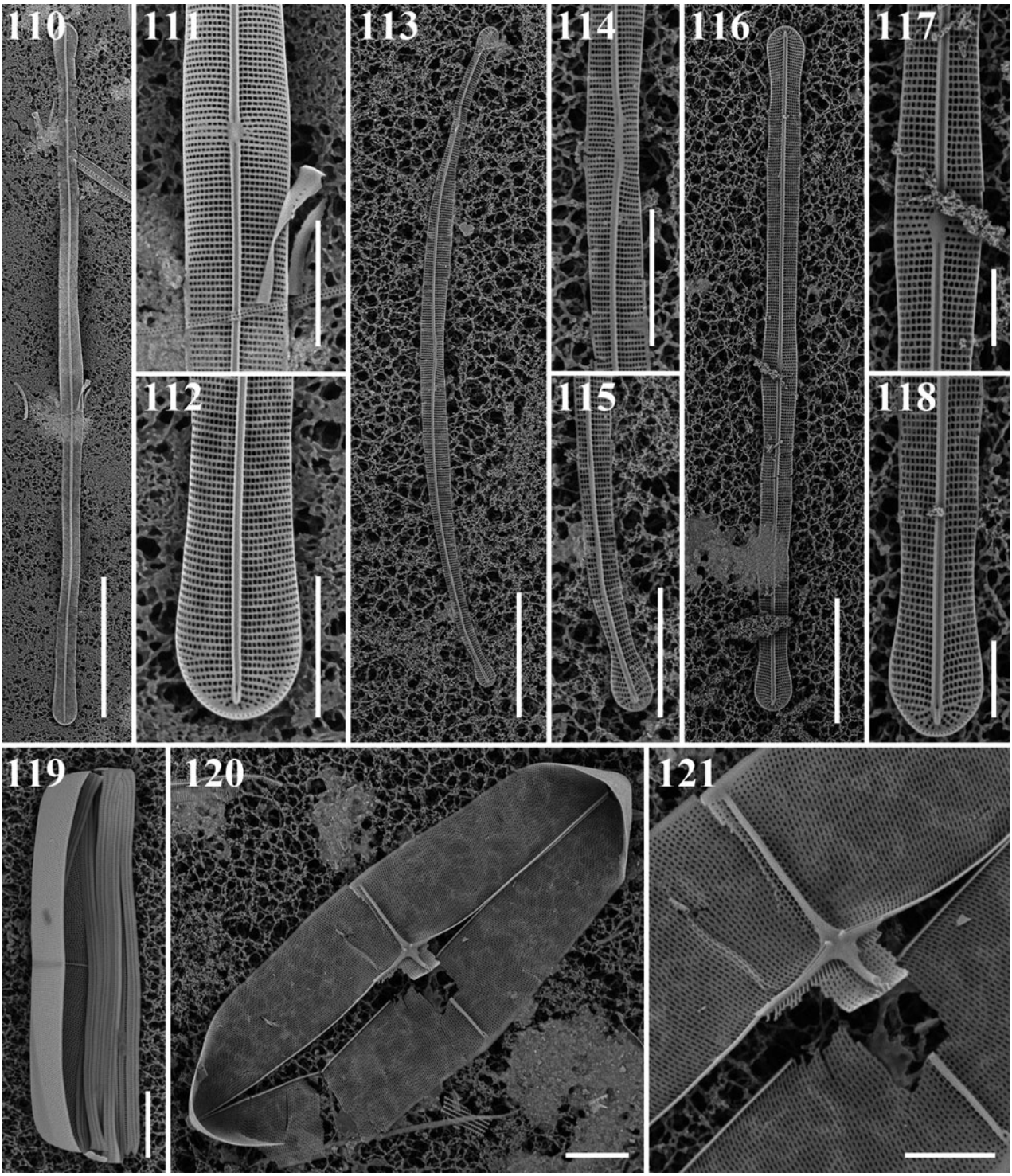


**Figs 110–121.** Scanning electron microscopy images of four taxa in Chuuk, Micronesia. **Figs 110–112.** *Climaconeis* cf. *petersonii* from Weno. **Figs 113–115.** *Climaconeis riddleae* from Weno. **Figs 116–118.** *Climaconeis scalaris* from Weno. **Figs 119–121.** *Parlibellus biblos* from Weno. Scale bars: 50 µm (Fig. 110), 20 µm (Figs 113 & 116), 10 µm (Figs 111, 112, 114, 115, 119, 120), 5 µm (Figs 117, 118, 121).

Dimensions: 264.4 µm long, 8.3 µm wide; 8 fibulae in 10 µm.
Diagnostics: Costae curved in the half of valve.

***Petrodictyon patrimonii* (F.A.S. Sterrenburg) F.A.S. Sterrenburg Figure 161**

Reference: Lobban *et al.* (2012): 306, pl. 66, figures 2 & 3.
Sample: CHB1-1 st1262.
Dimensions: 71.9 µm long, 26.1 µm wide.
Diagnostics: Valve oval with longitudinally straight/zigzag and lateral, slightly radiating costae.

***Plagiodiscus martensianus* Grunow & Eulensetin Figures 70, 162–164**

References: Ruck & Kociolek (2004): 44, pl. 51, figures 1–4; Lobban *et al.* (2012): 307, pl. 61, figure 1.
Sample: TK28.
Dimensions: 70 µm long, 40 µm wide; striae 14 in 10 µm. Costae every 3–5 striae.
Diagnostics: Striae appearing continuously triseriate externally, but internally with a reticulate pattern of both virgae and vimines.

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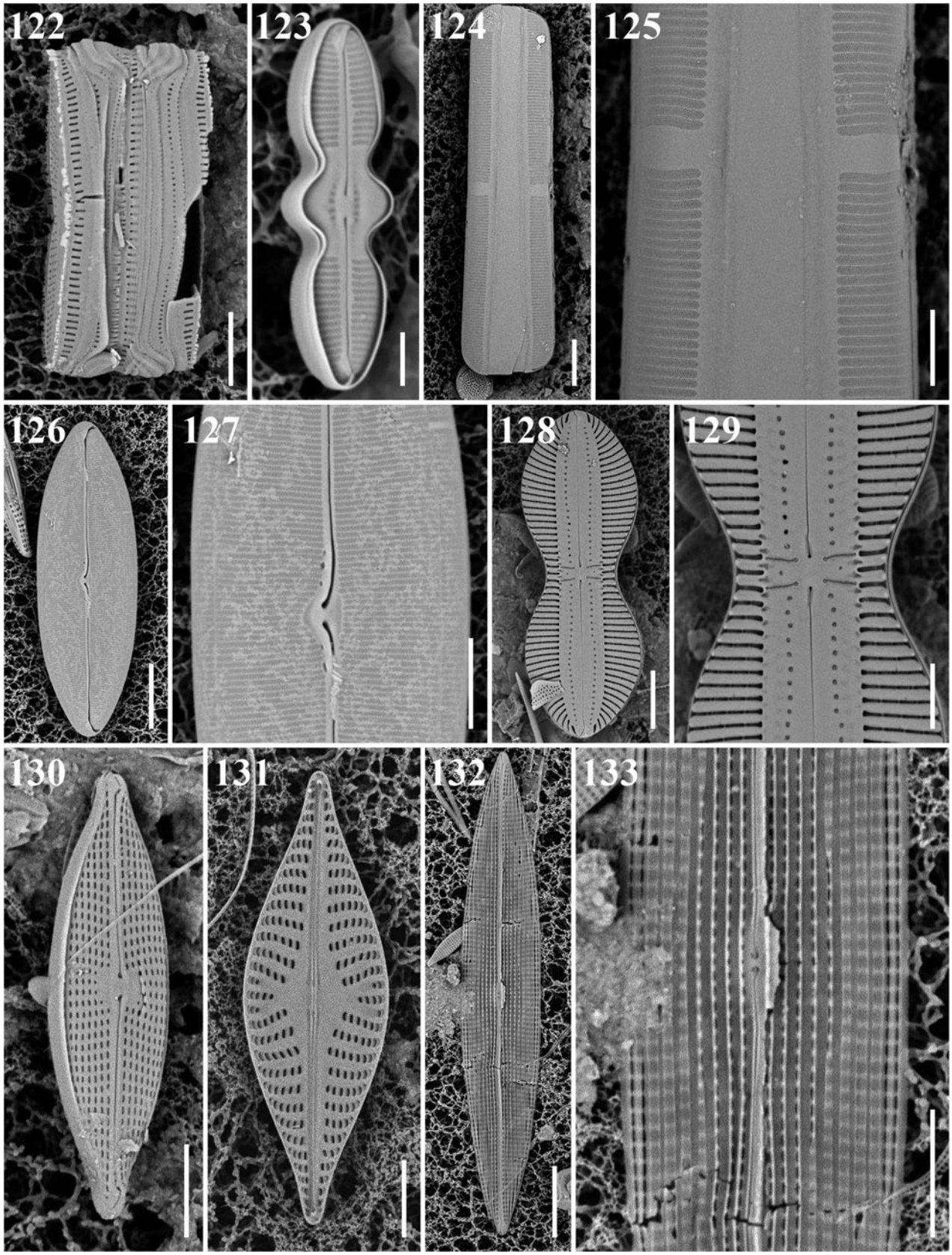


**Figs 122–133.** Scanning electron microscopy images of eight taxa in Chuuk, Micronesia. **Fig. 122.** *Diadesmis confervacea* from Weno. **Fig. 123.** *Caloneis egena* from Moch. **Figs 124, 125.** *Caloneis macquariensis* from Weno, frustule in girdle view. **Figs 126, 127.** *Oestrupia* sp. 4 *sensu* Hein *et al.*, from Weno. **Figs 128, 129.** *Diploneis cerebrum* from Weno. **Fig. 130.** *Navicula gregaria* from Weno. **Fig. 131.** *Navicula mannii* from Weno. **Figs 132, 133.** *Navicula tsukamotoi* from Weno. Scale bars: 10 μm (Figs 124, 126, 128, 132), 5 μm (Figs 122, 125, 127, 129–131, 133), 2 μm (Figure 123).

Comments: Our images of the flat sacs (palmulae) show the poration more clearly than in Paddock's images (Paddock, 1978). He describes the palmula thus: 'The stem is hollow … and the blade is composed of two laminar layers, though so far it is not known whether the envelope formed by the lamina[e] is sealed.' In the captions to his figures 5B and 5D (reproduced

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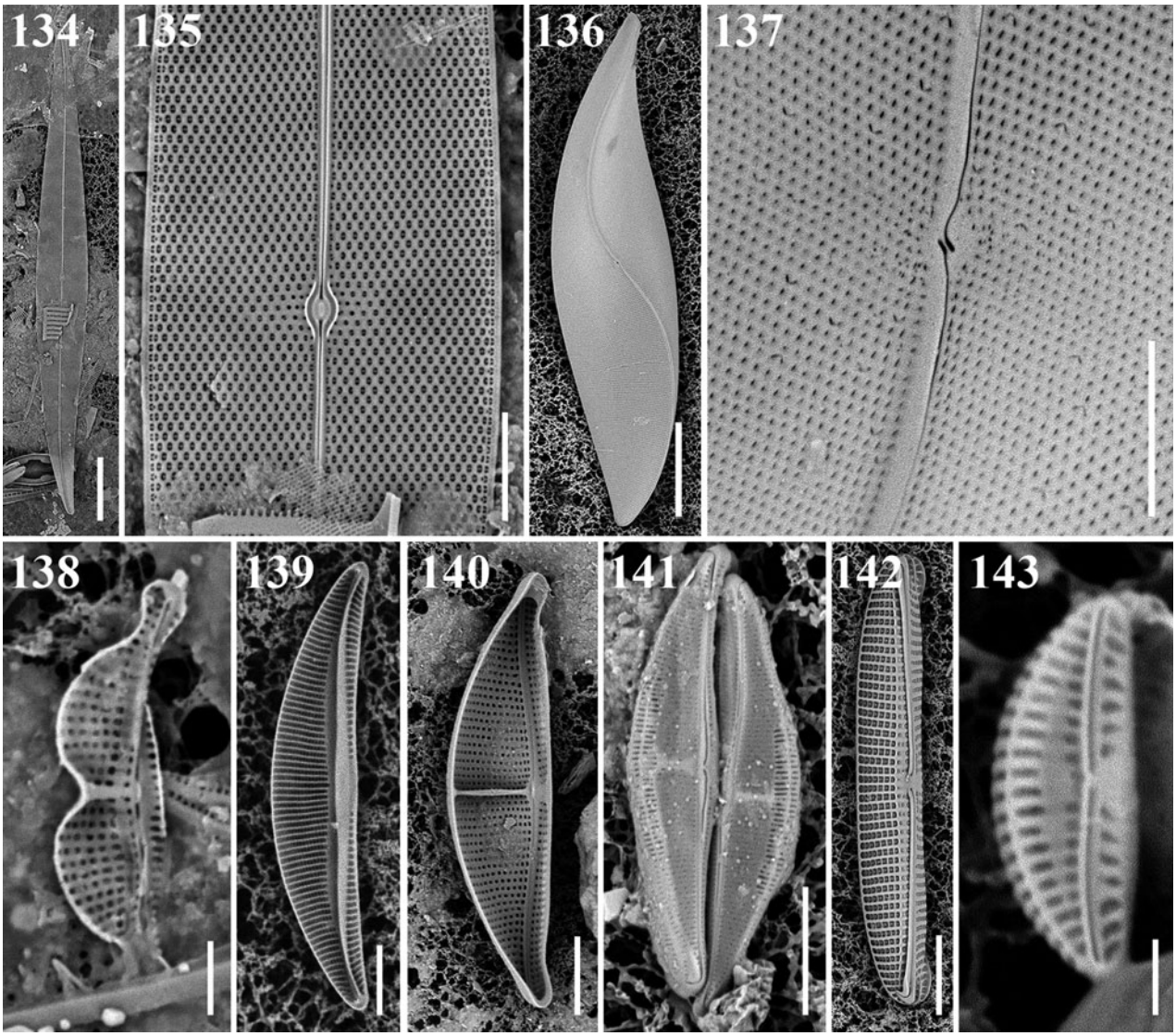


**Figs 134–143.** Scanning electron microscopy images of seven taxa in Chuuk, Micronesia. **Fig. 135.** *Pleurosigma* cf. *elongatum* from Weno. **Figs 136, 137.** *Rhoicosigma compactum* from Weno. **Fig. 138.** *Amphora biggiba* from Weno. **Fig. 139.** *Amphora lunulata* from Weno. **Fig. 140.** *Amphora ostrearia* var. *vitrea* from Weno. **Fig. 141.** *Amphora* cf. *abuldens* from Weno. **Fig. 142.** *Amphora* cf. *egregia* from Weno. **Fig. 143.** *Amphora* cf. *helenesis* from Weno. Scale bars: 20 µm (Figs 134, 136, 140, 142), 10 µm (Fig. 141), 5 µm (Figs 135, 137, 139), 2 µm (Fig. 138), 1 µm (Fig. 143).

in (Round *et al.*, 1990: 641, figure h, i), he describes the stem and blade as 'finely marked', but here we can see more pattern in the poration and we can conclude that the palmula is a sac, not two separate laminae.

### *Surirella oblongoelliptica* Hustedt ex Simonsen Figures 71, 165–168

References: Schmidt *et al.* (1874–1959), pl. 309, figure 6; Simonsen (1987*a*): 51, pl. 59, figures 1–3; Navarro (1983*b*): 396, figures 75 & 76 (misidentified as *Surirella gemma*).

Samples: Moen_02 #001, CHP-2 st1285, CHP-3 st1286.

Dimensions: 80.5–82.6 µm long, 34.0–35.4 µm wide.

Diagnostics: Valves linear-oval, slightly heteropolar, circlet flattened to a single longitudinal line.

Comments: Hustedt found this species from Miang Besar, Borneo but did not describe it validly (Schmidt *et al.*, 1874–1959). Simonsen (1987*a*) validly published this species and briefly described it as having a valve, linear-oval, slightly heteropolar tip broadly rounded, about 135 µm long and 47 µm wide. Navarro (1983*b*) found this taxon from Puerto Rico, but he identified as *S. gemma*. This is a first record from Micronesian waters.

## *Nomenclatural changes*

***Epithemia gibberula* var. *baltica* (O. Müller) J.S. Park & Lobban, comb. nov.**

Basionym: *Rhopalodia gibberula* var. *baltica* O.Müller, *Hedwigia* 38: p. 287, pl. 11, figures 3 & 4, 1899.

***Epithemia gibberula* var. *tumida* (Zanon) J.S. Park & Lobban, comb. nov.**

Basionym: *Rhopalodia gibberula* var. *tumida* Zanon, *Atti della Reale Accademia d'Italia, Memoria della Classe di Scienze Fisiche, Matematische e Naturali* 536: pl. 4, figures 10 & 11, 1941.

***Epithemia globosa* (Hustedt) J.S. Park & Lobban, comb. nov.**

Basionym: *Rhopalodia gibberula* var. *globosa* Hustedt, *Archiv für Hydrobiologie Supplement* 15: 58, pl. XIV, figure 15, 1938.

Synonym: *Rhopalodia globosa* (Hustedt) Moser *et al.*, 1998: 215, pl. 67, figures 1, 2, 6.

***Campylodiscus giffenii* (M.H. Giffen) Lobban & J.S. Park, nom. nov.**

Basionym: *Surirella scalaris* M.H. Giffen, *Nova Hedwigia*,13: 284, figures 121–123, 1967.

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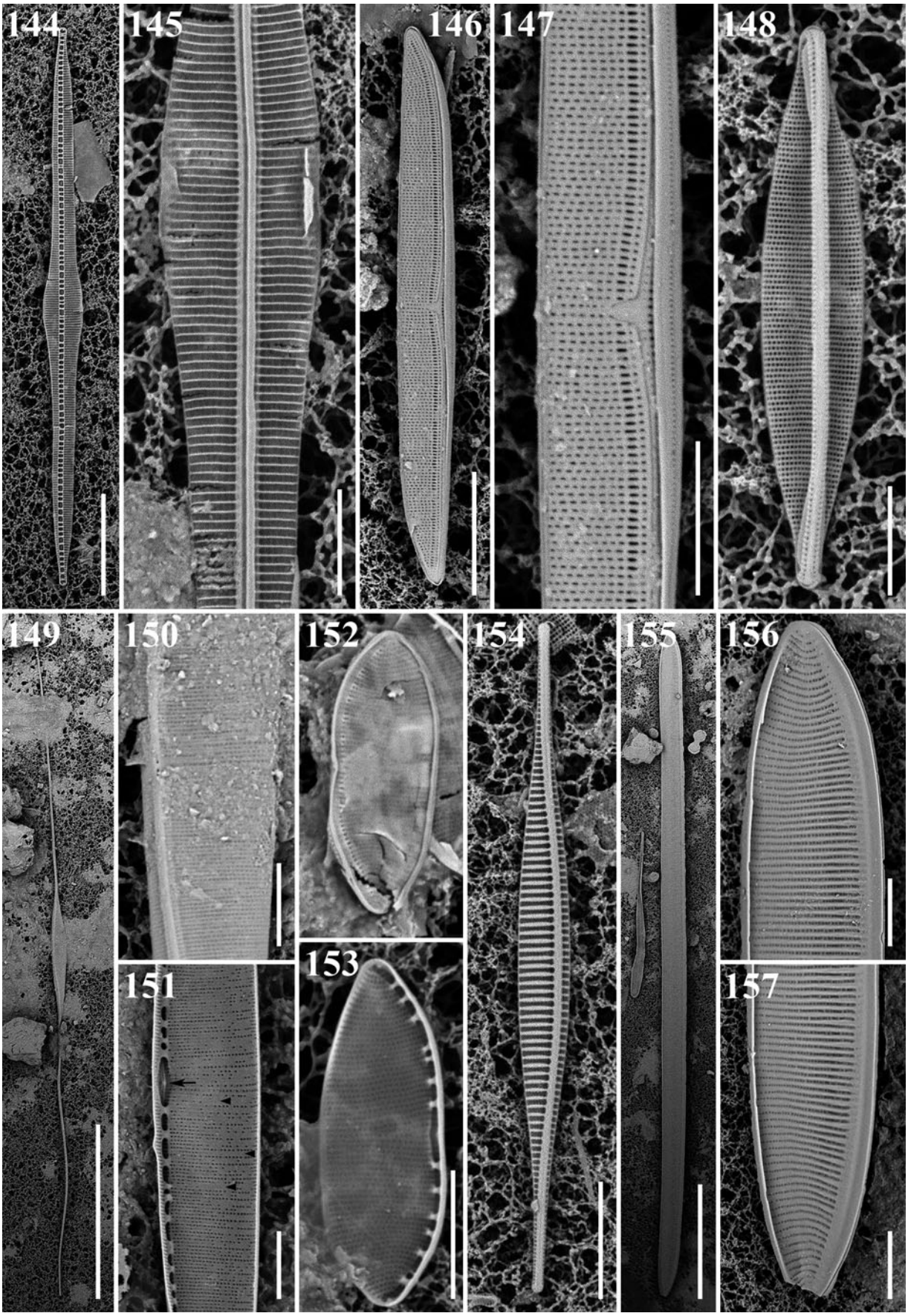


**Figs 144–157.** Scanning electron microscopy images of seven taxa in Chuuk, Micronesia. **Figs 144, 145.** *Bacillaria* Group B sensu Schmid var. *tumidula* from Weno, valve internal view and detail of central portion exterior showing silica flap. **Figs 146, 147.** *Nitzschia* cf. *clausii* from Weno. **Fig. 148.** *Nitzschia maiae* from Weno. **Figs 149–151.** *Nitzschia rectilonga* from Weno, entire valve, external central area, and internal central area showing the raphe central nodule (arrow), and hyaline field in the internal valve (arrowheads). **Figs 152, 153.** *Nitzschia* cf. *amabilis* from Weno. **Fig. 154.** *Nitzschia lorenziana* from Weno. **Figs 155–157.** *Tryblionella scalaris* from Weno. Scale bars: 100 μm (Figs 149, 155), 20 μm (Fig. 144), 10 μm (Figs 146, 152, 154, 156, 157), 5 μm (Figs 145, 147, 148, 150, 151, 153).

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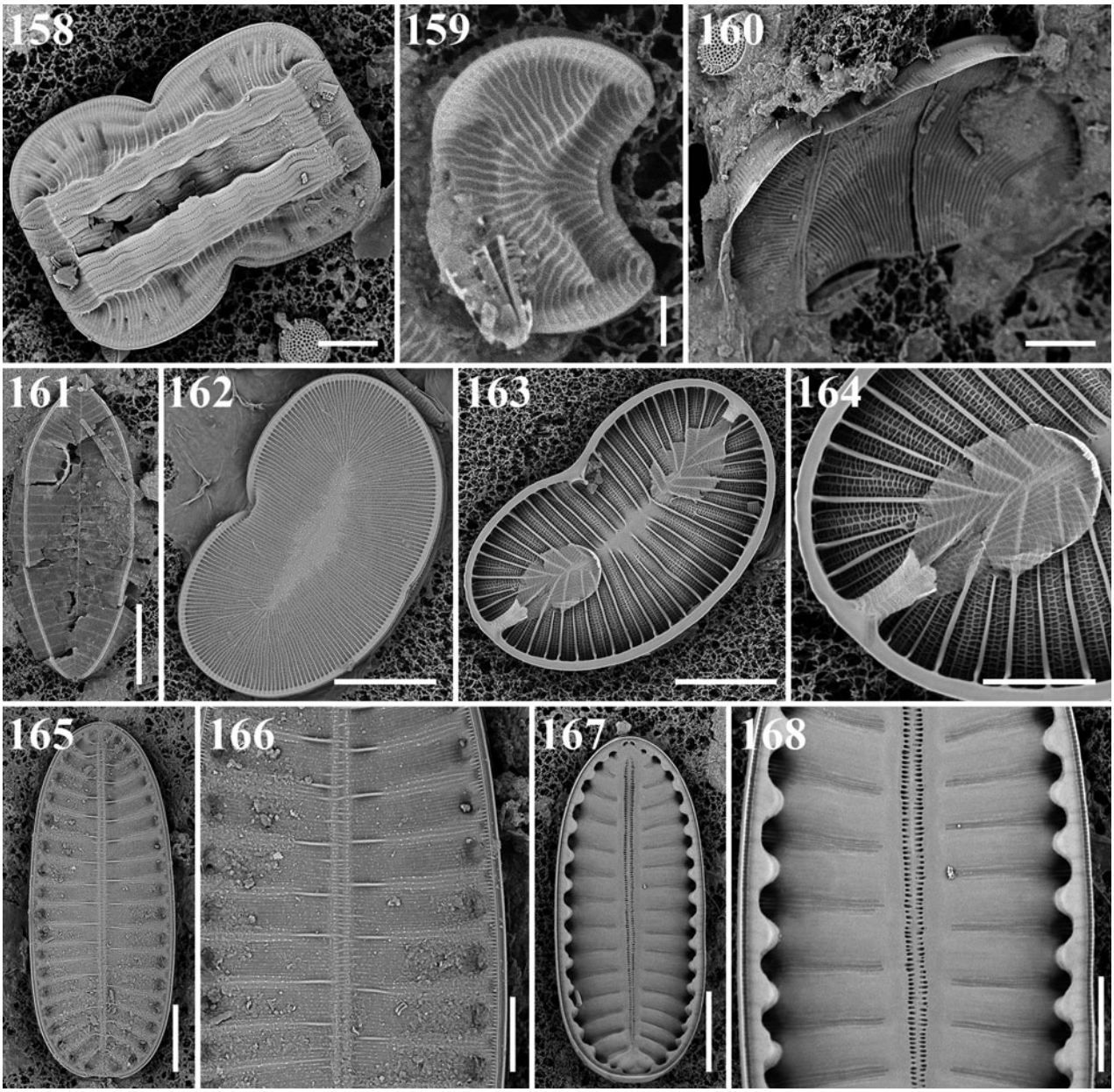


**Figs 158–168.** Scanning electron microscopy images of six taxa in Chuuk, Micronesia. **Fig. 158**. *Entomoneis corrugata* from Weno. **Fig. 159.** *Protokeelia cholnokyi* from Weno. **Fig. 160.** *Auricula complexa* from Weno. **Fig. 161.** *Petrodictyon patrimonii* from Weno. **Figs 162–164.** *Plagiodiscus martensianus* from Moch, external valve, internal valve, and detail of the palmulae. **Figs 165–168.** *Surirella oblongoelliptica* from Weno. Scale bars: 20 µm (Figs 161–163, 165, 167), 10 µm (Figs 158, 160, 164, 166, 168), 5 µm (Fig. 162), 2 µm (Fig. 159).

Synonym: *Campylodiscus scalaris* (M.H. Giffen) Lobban & J.S. Park, *Phytotaxa* 351: 134, 2018. Illegit.

M. Guiry (personal communication, Sep. 2019) pointed out that our 2018 new combination was a homonym for *C. scalaris* Tempère & J.-J. Brun 1889, and we take this opportunity to correct that oversight.

## Discussion

With addition of 105 diatom taxa in this study (excluding four species re-identified and as reported in Park *et al.*, 2018), 248 diatoms are known from Chuuk, although many taxa still remain unidentified or uncertainly identified. In comparison, Lobban (2015*a*, 2015*b*) reported an accumulation of 271 new records in Guam. Of the 105 species in this study, 31 species are newly recorded for the Micronesian waters (Table 1). Most diatom species were benthic around Weno Island, despite the collection of the planktonic samples using a phytoplankton net. The presence of benthic diatoms from plankton samples might be related to the wind-driven shear current in shallow water. The water depth of sampling sites did not exceed 10 m. The water column in shallow water can be vertically mixed by Langmuir circulation caused by wind in shear. Langmuir supercells can suspend sediments and transport the resuspended particles offshore by inducing turbulence along the highly sheared oscillatory wave that serves to lift sediment grains from the seafloor into the water column (Gargett *et al.*, 2004). Langmuir circulations generally occur only for wind speeds greater than 3 m $s^{-1}$ and appear within a few tens of minutes of wind onset (Talley *et al.*, 2011). Annual mean wind speed in Chuuk was 5.14 m $s^{-1}$ (Ko *et al.*, 2015), this is sufficient to produce Langmuir circulations and caused resuspension of benthic diatoms.

There were no euplanktonic diatoms except for *Bacteriastrum furcatum* and *Chaetoceros* cf. *atlanticus* var. *skeleton*, and both

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were observed from the passage of the barrier reef near open water. Coral reef environments are characterized by relatively stable temperature, low nutrients and high irradiance (Lobban & Jordan, 2010). These environmental characteristics seem to have no advantages for planktonic diatoms compared with benthic ones. Strong light level can be a factor that inhibits the growth of phytoplankton (Moore & Villareal 1996), and nutrient acquisition is more favourable at the bottom than the water layer. In addition, the planktivorous zooplankton is highly abundant in coral reef systems (Nakajima *et al.*, 2017), thus will act as a high grazing pressure for phytoplankton.

Although we collected the samples inshore, some freshwater taxa such as *Gomphonema* cf. *lagenula*, *Diadesmis confervacea*, *Navicula gregaria*, *Caloneis macquariensis*, *Pinnularia* cf. *borealis* and *Surirella oblongoelliptica* were observed. There are small streams near the sampling sites in Weno Island, and the freshwater species, observed from acid-cleaned specimens, were most likely dead. The freshwater diatoms of Micronesian islands have scarcely been studied (Zolan, 1981; Navarro & Lobban, 2009 and unpublished observations by Lobban), but we do not expect great diversity because on these small islands the streams are short, shaded and ephemeral (Lobban *et al.*, 1991).

Many new species and some new genera have been reported from Guam in the last decade and it is not surprising that some of them are turning up elsewhere in Micronesia as exploration gets underway in Chuuk, Yap, Palau and the Marshall Islands (e.g. here reported *Hanicella moenia*, *Astrosyne radiata*, *Licmophora curvata* and *Gato hyalinus*). At the same time, those islands are also revealing new species, even from the relatively small sampling effort, some not yet found in Guam despite much more extensive sampling (e.g. *Divergita macinnisii* Lobban and *Licmophora complanata* Lobban from the Marshall Islands (Lobban, 2021*a*, 2021*b*); several species from Yap (Lobban, 2021*a*)). While we have tended to assume a priori that all species are ubiquitous, an essentially untestable hypothesis, we are coming around to an assumption of regional endemicity as a starting point, recognizing that while there are many ubiquitous species, there are also different levels of endemicity both geographically and within genera (Lobban, in review).

It is tempting, in floristic studies such as this to compare species richness or species diversity of the list to date with the findings from other places but, apart from the question of the amount of effort put into different regions, the more important reason to avoid such comparisons is that the method in our floristic studies is to present micrographic documentation of each species as evidence for each hypothesis of identity. We have included some taxa here identified only to genus because of limited sampling, whereas Lobban's records papers (Lobban *et al.*, 2012; Lobban, 2015*a*) report only taxa identified to species during the progress of a long-term study. The state of knowledge of tropical marine diatoms is still very preliminary, even in a few relatively well-studied places, and taxonomy is still in a state of flux as new studies uncover previously hidden diversity. Our studies in Guam have shown repeatedly that there are lookalike species that either cannot be distinguished in LM or that have a striking feature, thought to be unique, that leads to the similar species being overlooked. The documentation and arguments we provide for species records claims are essential for the continued utility of the work, so that findings can be reinterpreted as needed when new information is available. Lists with little or no documentation, even by very experienced authors (e.g. Giffen's (1980) list for Mahé, Seychelles), become outdated. The question of regional endemicity in benthic marine diatoms has scarcely been addressed but it is becoming clear, from our work in progress based on the approach used by Williams & Kociolek (2017), that at least some genera have strongly regional floras. Large-scale ecological studies such as those by Kryk *et al.* (2020) and Risjani *et al.* (2021) are able to make comprehensive comparisons of species diversity by including many incompletely identified species (essentially 'operational taxonomic units'). Kryk *et al.* (2020: 161), said of their results for Madagascar, 'Amongst all 332 taxa, only 35% have been identified to the species level. Many of the taxa identified to the generic level may turn out to represent taxa new to science after further SEM examination and DNA sequencing.' The ratio is probably still lower for the studies in Micronesia but we have not yet tried to distinguish and tally the unidentified species.

There remains much work to be done on the Chuuk flora, both with the relatively few samples collected already and the need for more systematic collections. The marine flora to date continues to show strong similarities to the much better-known flora of Guam while also revealing species not yet reported from there, and for all Micronesian islands there are still few mangrove and sediment biofilm samples.

## Data

The diatom samples were deposited in the Library of Marine Samples, Korea Institute of Ocean Science & Technology, Republic of Korea and Guam Diatom Herbarium, USA.

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**Authors' contributions.** JSP, KWL and CSL collected the samples. JSP and CSL analysed and observed the samples. JSP and CSL wrote the manuscript. KWL and SWJ arranged the figures and gave constructive comments for the manuscript. All authors read and approved the final manuscript.

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