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First checklist of centric and araphid diatoms from the benthic environments of the Gulf of Tomini, Sulawesi, Indonesia

SULASTRI ARSAD[1,2,3,♥], MAŁGORZATA BĄK[2], FRANCISCO OMAR LÓPEZ-FUERTE[4], JINSOON PARK[5], MATEUSZ RYBAK[6], ROMAIN GASTINEAU[2]

[1]Doctoral School of the University of Szczecin. Mickiewicza 18, 70-384 Szczecin, Poland. Tel.: +48-914442477, ♥email: sulastri.arsad@phd.usz.edu.pl
[2]Institute of Marine and Environmental Sciences, University of Szczecin. Mickiewicza 16, 70-383 Szczecin, Poland
[3]Faculty of Fisheries and Marine Science, Universitas Brawijaya. Jl. Veteran Malang, Lowokwaru, Malang 65145, East Java, Indonesia. Tel.: +62-341-553512, ♥email: sulastriarsad@ub.ac.id
[4]Departamento Académico de Ciencias Marinas y Costeras, Universidad Autónoma de Baja California Sur. Boulevard Forjadores S/N, La Paz, Baja California Sur, C.P. 230-80, Mexico
[5]Department of Marine Bioscience and Environment, Korea Maritime and Ocean University. Busan 49112, Republic of Korea
[6]Faculty of Biotechnology, Medical College, University of Rzeszów. Ćwiklińskiej 2D, Rzeszów, Poland

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Abstract. *Arsad S, Bąk M, López-Fuerte FO, Park J, Rybak M, Gastineau R. 2026. First checklist of centric and araphid diatoms from the benthic environments of the Gulf of Tomini, Sulawesi, Indonesia. Biodiversitas 27 (5): d270510. https://doi.org/10.13057/biodiv/d270510.* Sulawesi, one of the largest islands in Indonesia, includes the Gulf of Tomini, a region with diverse coastal ecosystems. However, comprehensive taxon-based checklists of benthic diatoms remain limited. The aim of this study is to present the first systematic checklist of centric and araphid marine diatoms from the benthic environment of the Gulf of Tomini, Sulawesi, documenting their occurrence across sampling sites and substrate types, and highlighting taxa with the highest cumulative counts and taxonomically uncertain taxa. Fourteen samples were collected from seven sites across the gulf from various substrates, including sediment, rocks, macroalgae, seagrass, and mangrove roots. Identification was carried out using Light Microscopy (LM) based on standard taxonomic literature. A total of 82 taxa were recorded, comprising 40 genera and 20 families; among these, 13 taxa were identified as sp., seven as cf., and four as var. The species-level uncertainty for taxa identified as sp., including *Cyclophora*, *Thalassiosira*, *Cratericulifera*, *Opephora*, *Ardissonea*, *Dimeregramma*, *Neofragilaria*, *Rhaphoneis*, *Tabularia*, and *Talaroneis* may result from the limited ultrastructural resolution of LM and the absence of comparable data in the literature. *Grammatophora marina* and *Hyalosynedra laevigata* were consistently recorded across all sampling sites and substrates. Together with *Tabularia fasciculata*, *Cyclophora* sp., *Paralia longispina*, and *P. sulcata*, these taxa represented the highest cumulative counts from all sites and substrates. This study provides baseline taxonomic information on centric and araphid diatoms for this region and establishes a foundation for future taxonomic, ecological, and diatom diversity in Indonesian coastal waters.

Keywords: Bacillariophyta, biodiversity, biogeography, Celebes, taxonomy

INTRODUCTION

High biodiversity and endemism in the Indo-Australian Archipelago (IAA), including in Indonesia, are closely linked to its geological complexity and historical biogeographical development (Lohman et al. 2011). Within Indonesia, two global biodiversity hotspots are recognized, Sundaland and Wallacea, with Sulawesi belonging to the Wallacean region (Myers et al. 2000). Formerly known as Celebes, Sulawesi is one of the five largest islands in the country and is recognized as an important centre of endemism within Wallacea (Michaux 2010). The island of Sulawesi has a unique shape formed by four major peninsulas (southern, northern/Minahassa, eastern, and southeastern), which are divided by three major gulfs, namely Tomini in the northeast, Tolo in the southeast, and Bone in the south (JICA 2008). The Gulf of Tomini lies adjacent to the island, opening eastward into the Molucca Sea. The Gulf of Tomini supports diverse coastal ecosystems, including coral reefs (USAID Asia 2012), mangroves (Djamaluddin 2015; Djamaluddin et al. 2019), and seagrass beds (Mohamad et al. 2020), and has been the focus of numerous marine studies (Wallace et al. 2000; Djamaluddin 2015; Kadim et al. 2018; Djamaluddin et al. 2019; Mohamad et al. 2020; Olii et al. 2022) due to its ecological significance. However, comprehensive taxon-based checklists of benthic diatoms from this region remain limited.

Diatoms represent a significant component of the marine ecosystem. These microscopic, single-celled photosynthetic algae are uniquely characterized by their ornate silica-based cell walls called frustules (Round et al. 1990; Ajani and Rissik 2009; John 2012). In aquatic environments, they serve as primary producers, playing a vital role in marine food webs and global oxygen production (Dawes 1998; Hoppenrath et al. 2009; Pierella Karlusich et al. 2025). Moreover, they are widely recognized for their importance as bioindicators and bioremediators, or in palaeoecological reconstruction and

climate-change studies (Round et al. 1990; Barinova et al. 2023).

Diatoms inhabit a wide variety of water bodies in which they can thrive as planktonic, benthic, or periphyton attached to a substrate (Ajani and Rissik 2009; John 2012; Arsad et al. 2022). Diatoms are traditionally divided into two major morphological groups, centric and pennate forms, with pennate diatoms further classified into raphid and araphid types based on the presence or absence of a raphe system (Round et al. 1990; Kociolek et al. 2015). In terms of known species number, pennate diatoms exceed centric diatoms. According to Guiry (2024), the numbers of species recorded for the classes Coscinodiscophyceae and Mediophyceae are 1,629 and 1,898, respectively, whereas Bacillariophyceae includes 14,684 species. Recently, Kociolek et al. (2026a) introduced a new classification system based on molecular and phylogenetic analyses, consisting of ten classes, including seven newly established classes. Most of the newly separated classes include centric and araphid diatoms that were previously grouped together. Several studies have documented marine diatoms from Indonesian waters, including Java, Sumatra, Kalimantan, Flores, Rinca Komodo, and southeastern and southwestern Sulawesi (Stidolph et al. 2012; Risjani et al. 2021; Luthfi et al. 2024). Although centric and araphid taxa were included in these previous Indonesian studies, they were treated as part of the overall marine diatom assemblages rather than as a specific focus on centric and araphid taxa. To date, no study has provided a dedicated taxon-based checklist focusing specifically on centric and araphid marine diatoms from the benthic environments of the Gulf of Tomini.

The present study aimed to provide the first annotated taxonomic checklist of centric and araphid marine diatoms from the benthic environments of the Gulf of Tomini, Sulawesi, Indonesia. Specifically, we present illustrative Light Microscopy (LM) micrographs, report species occurrences across sampling sites and substrate types, and document taxa with the highest cumulative counts and taxonomically uncertain taxa.

MATERIALS AND METHODS

Study area and sampling

Field sampling took place in September-October 2022 and June-July 2023 in the Gulf of Tomini, Sulawesi, Indonesia (Figure 1). Sampling was conducted at seven sites, with two samples collected per site, representing different substrate and/or different sampling occasions. Samples were collected by scraping defined surface areas from hard substrates e.g., rocks or mangrove roots, by collecting small portions of seagrass or seaweed, and by taking small amounts of surface sediment. Samples were then placed into 50 mL Falcon tubes. Each sample was preserved in 70% ethanol or 4% Lugol's solution. Although mainly benthic and periphytic samples were collected, the portion of centric diatoms, mostly associated with plankton in literature, indicates a tychoplanktonic origin - the species flout just above the bottom and belong rather to benthic, not planktonic formation. All material was then delivered to the Laboratory of the Institute of Marine and Environmental Sciences, University of Szczecin, Poland, for further processing. Detailed information on the sites, coordinates, substrate types, sampling dates, depth, and number of samples collected is provided in Table 1.

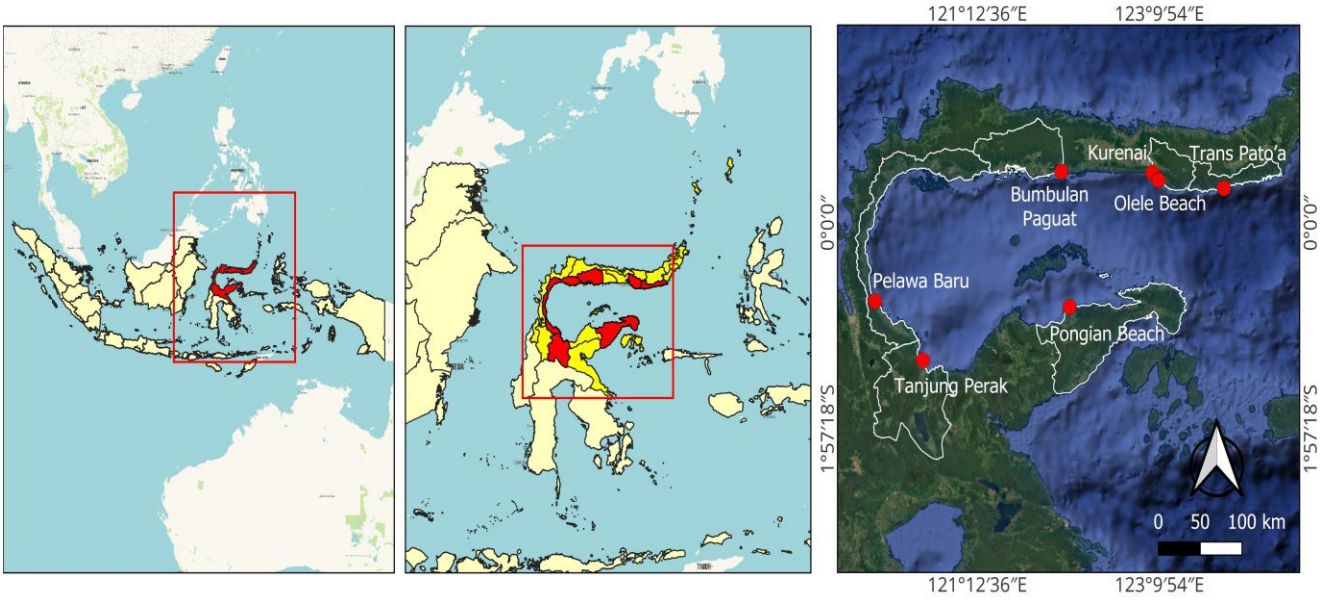

Figure 1. Map of the seven sampling sites in the Gulf of Tomini, Sulawesi, Indonesia

Procedures

Preparation and microscopy

Sample preparation for Light Microscopy (LM) followed the protocol of Kryk et al. (2020). Each sample was placed in a 150 mL glass beaker, and carbonate material was removed by adding approximately 10% hydrochloric acid (HCl) and allowing the reaction to proceed for 24 hours. The supernatant was then discarded, and the remaining material was rinsed repeatedly 4-5 times with distilled water to eliminate acid residues. Furthermore, organic matter was subsequently oxidized using hydrogen peroxide (H_2O_2) with gentle heating, followed by further washing steps to remove any remaining reagents. For slide preparation, a small amount of the cleaned suspension was pipetted onto a coverslip, and a 10% ammonium chloride (NH_4Cl) solution was added to improve frustule dispersion and adhesion. After drying, the material was permanently mounted in Naphrax® for LM observation. Diatoms were observed and documented through systematic scanning of the entire slide for each selected substrate. Diatom images were captured using a ZEISS Axio Scope A1 microscope at 1000× total magnification and a ZEISS AxioCam ERc 5s digital camera. Differential Interference Contrast (DIC) was set, and a drop of immersion oil was applied to the coverslip to ensure optimal resolution. Finally, the micrographs were edited using Adobe Photoshop® exclusively for background cropping, image stacking, and minor adjustments to brightness and contrast.

Morphometric variables recorded included valve length, valve width, and striae density (in 10 µm). Measurements were carried out using ImageJ after setting the image scale based on the 10 µm scale bar embedded in each micrograph. This calibration was applied prior to all measurements to ensure consistency. The voucher slides have been archived in the Szczecin Diatom Collection, University of Szczecin, and are available under accession numbers SZCZ (Acc. No. SZCZ 28768, SZCZ 28773, SZCZ 28806, SZCZ 28807, SZCZ 28814, SZCZ 29007, SZCZ 28818, SZCZ 29016, SZCZ 28820, SZCZ 29017, SZCZ 28993, SZCZ 28995, SZCZ 29004, and SZCZ 29005).

Taxonomic identification framework

Identification was based on morphological diagnostic characters observable under LM, including valve outline, valve dimensions, apical shape, striae density (in 10 µm), striae orientation, axial and central area structure, and overall valve symmetry (Round et al. 1990; John 2012; Spaulding et al. 2021). The nomenclature of species names follows the most recent accepted taxonomy listed in AlgaeBase (https://www.algaebase.org/), which was used to verify the currently accepted names. The list of taxa follows the recent classification of Kociolek et al. (2026b). The classification of the genera that were absent in the work of Kociolek et al. (2026b), such as *Trachysphenia* Petit 1877 followed Cox (2015), and others, namely *Cratericulifera* Chunlian Li, Witkowski & Ashworth, 2016, *Ehrenbergiulva* A.Witkowski, H.Lange-Bertalot & D.Metzeltin, 2004, *Spinodiscus* T.V.Desikachary & K.A.Ranjitha Devi, 1986, *Trilamina* P.A.Sims, J.Witkowski, N.I.Strelnikova & D.M.Williams, 2015, and *Triceratium* Ehrenberg, 1839, follow algaebase.org (Guiry 2024).

Data analysis

Data were analysed using standard marine diatom floras, taxonomic monographs, and journals as identification guides and reference sources for this study. These included book monographs (Schmidt 1874-1959; Peragallo and Peragallo 1897-1908; Hustedt 1930; Foged 1979, 1984, 1986, 1987; Podzorski and Håkansson 1987; Witkowski 2000; Hein et al. 2008), relevant taxonomic journal articles (Meister 1937; Loban et al. 2012; Al-Handal et al. 2016, 2018; Park et al. 2018; López-Fuerte et al. 2020, 2022, 2024; Siqueiros Beltrones et al. 2021, 2023; Guiry 2024; Lobban and Tharngan 2025), as well as online resources, including AlgaeBase (Guiry and Guiry 2026), DiatomBase (Kociolek et al. 2026b), Diatoms of North America (Spaulding et al. 2021; Stidolph et al. 2012) (https://pubs.usgs.gov/of/2012/1163/pages/plates2.html).

Table 1. Characteristics of sampling sites, including coordinates, substrate types, sampling period, depth range, and number of samples collected

Site	Coordinates	Substrate types	Sampling period	Depth (m)	Number of samples
Trans Pato'a, South Bolaang Mongondow District, North Sulawesi	0.330255°N, 123.857768°E	mangrove roots, sediment	22.09.2022	0-7	2
Pelawa Baru, Parigi Moutong District, Central Sulawesi	0.7401°S, 120.112303°E	macroalgae, sediment	29.09.2022	12	2
Tanjung Perak, Poso Pesisir, Poso District, Central Sulawesi	1.300826°S, 120.626947°E	rocks, seagrass	22.09.2022, 01.07.2023	0-1	2
Bumbulan Paguat, Pohuwato District, Gorontalo	0.486274°N, 122.113099°E	*Padina* sp.	05.09.2022, 11.06.2023	0-0.6	2
Kurenai, Kabila Bone, Bone Bolango District, Gorontalo	0.47809°N, 123.089723°E	*Sargassum* sp., *Padina* sp.	03.10.2022, 13.07.2023	0-0.6	2
Olele Beach, Bone Bolango District, Gorontalo	0.411447°N, 123.152990°E; 0.406315° N, 123.155728°E	*Sargassum* sp., rocks	13.07.2023	0-0.6	2
Pongian Beach, Banggai District, Central Sulawesi	0.794793°S, 122.201333°E	mangrove roots, rocks	02.07.2023	0-1	2

The number of valves for each taxon was recorded and summed across all sampling sites and substrates to identify taxa with the highest cumulative counts. In addition, the occurrence of each taxon was determined based on its presence across sampling sites and substrate types.

RESULTS AND DISCUSSION

A total of 82 taxa (including 4 varieties) were identified with 13 taxa enumerated as sp. and seven as cf. These taxa belong to 40 genera and 20 families of diatoms (Figures 2-8). The diatoms belonged to the class Melosirophyceae with the subclass Melosirophycidae, class Coscinodiscophyceae with the subclass Coscinodiscophycidae, class Biddulphiophyceae with the subclass Biddulphiophycidae, class Thalassiosirophyceae with the subclasses Ardissoniophycidae, Thalassiosirophycidae, Eupodiscaphycidae and Thalassiosirophycidae, class Plagiogrammaphyceae, class Fragilariophyceae with the subclasses Staurosirophycidae, Tabellariaphycidae, and Fragilariophycidae, and class Bacillariophyceae incertae sedis.

The following is a systematic list of the diatom taxa found. References for identification are also included.

Classification of diatoms

Division Bacillariophyta Haeckel 1878
Class Melosirophyceae Kociolek, Ashworth & A.J.Alverson 2026
Subclass Melosirophycidae Kociolek, Ashworth & A.J.Alverson 2026
Orde: Melosirales Crawford 1990
Family Melosiraceae Kützing 1844

***Melosira lineata* (Dillwyn) C. Agardh, 1824 (Figure 2.I).** Reference: Kryk et al. (2020) p. 164. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Diameter 27.0-28.0 µm, areolae 18 in 10 µm (n=1).

Order Paraliales R.M.Crawford 1990
Family Paraliaceae R.M.Crawford 1988

***Paralia sulcata* (Ehrenberg) Cleve, 1873 (Figures 2.J-2.L).** References: Witkowski et al. (2000) p. 37 pl. 8; John (2012) p. 71. Samples: Mangrove roots (SZCZ 28768) and sediment Trans Pato'a (SZCZ 28773). Morphometry: Diameter 16.0-22.0 µm, areolation fine (n=3).

***Paralia longispina* S. Konno & R.W. Jordan, 2008 (Figure 2.M).** Reference: Konno and Jordan (2008) p. 56. Samples: Mangrove roots (SZCZ 28768) and sediment (SZCZ 28773) Trans Pato'a, *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Diameter 9.0-11.0 µm, areolation fine (n=2).

Class Coscinodiscophyceae F.E.Round & R.M.Crawford 1990
Order Triceratiales Round & R.M.Crawford
Family Triceratiaceae (Schütt) Lemmermann

***Triceratium balearicum* Cleve, 1881 (Figure 3.H).** Reference: Schmidt (1874-1959) Atlas band I pl. 98. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Diameter 16.0-32.0 µm, areolation fine (n=1).

Subclass Coscinodiscophycidae F.E.Round & R.M.Crawford 1990
Order Coscinodiscales F.E.Round & R.M.Crawford 1990
Family Hemidiscaceae Hendey ex Hasle 1996

***Actinocyclus gallicus* Meister, 1937 (Figure 2.D).** References: Meister (1937) p. 262 pl. 6; Witkowski et al. (2000) p. 20 pl. 4, pl. 5. Sample: *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Diameter 79.0-80.0 µm, areolae 8 in 10 µm (n=1).

***Actinocyclus subtilis* (W.Gregory) Ralfs, 1861 (Figures 2.A-2.C).** References: Witkowski et al. (2000) p. 22 pl. 4, pl. 5; John (2012) p. 69; López-Fuerte et al. (2020) p. 7. Samples: *Sargassum* sp. Kurenai (SZCZ 28820), seagrass Poso Pesisir (SZCZ 29007), *Padina* sp. Kurenai (SZCZ 29017). Morphometry: Diameter 31.0-39.0 µm, areolae 13-16 in 10 µm (n=6).

***Roperia tesselata* (Roper) Grunow ex Pelletan, 1889 (Figures 2.E-2.F).** Reference: Pelletan (1889) p. 158. Samples: *Padina* sp. Paguat (SZCZ 28818), *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Diameter 25.0 µm, areolae 9-10 in 10 µm (n=1). Comment: The specimen in Figures 2.E and 2.F is the same specimen shown at different focal planes.

Class Biddulphiophyceae Kociolek, Ashworth & A.J.Alverson
Subclass Biddulphiophycidae F.E.Round & R.M.Crawford 1990
Order Biddulphiales Krieger 1954
Family Biddulphiaceae Kützing 1844

***Biddulphia biddulphiana* (J.E. Smith) Boyer, 1900 (Figure 3.N).** References: Stidolph et al. (2012) pl. 5; Siqueiros Beltrones et al. (2021) p. 5. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Length 63.7 µm, width 45.1 µm, areolae 6 in 10 µm (n=1).

Class Thalassiosirophyceae Kociolek, Ashworth & A.J.Alverson
Subclass Ardissoniophycidae Kociolek, Ashworth & A.J.Alverson
Order Trigoniumales Kociolek, Ashworth & A.J.Alverson
Family Trigoniumaceae Glezer 2019

***Trigonium formosum* var. *pentagonale* (A.W.F. Schmidt) Desikachary & Prema 1987 (Figure 2.G).** References: Witkowski et al. (2000) p. 456 pl. 7; Al-Handal et al. (2016) p. 6 pl. 3. Sample: Rocks Pongian (SZCZ 29005). Morphometry: Diameter 46.0-54.0 µm, areolae 15-16 in 10 µm (n=1).

***Trigonium graeffeanum* (Witt) Hendey, 1971 (Figure 3.G).** References: Stidolph et al. (2012) pl. 27, pl. 37; Schmidt (1874-1959) Atlas band I pl. 79 as *Amphitetras graeffeiana.* Sample: Rocks Olele (SZCZ 28995). Morphometry: Diameter 94.0-105.0 µm, areolae 8 in 10 µm (n=1). Comment: Our specimen is similar to Stidolph et al. (2012) but different from Schmidt's Atlas where Stidolph refers to.

Order Ardissoneales F.E.Round 1990, emend. Lobban & Ashworth
Family Ardissoceaceae F.E.Round 1990, emend. Lobban & Ashworth

***Ardissonea formosa* (Hantzsch) Grunow (Figures 8.D-8.E).** References: Witkowski et al. (2000) p. 43 pl. 30; Hein et al. (2008) p. 22 pl. 8, 6. Samples: *Padina* sp. Paguat (SZCZ 28818), Rocks Pongian (SZCZ 29005). Morphometry: Length 237.3-402.7 µm, width 15.6-23.2 µm, striae 10 in 10 µm (n=2).

***Ardissonea robusta* (Ralfs ex Pritchard) De Notaris, 1871 (Figure 8.C).** References: Peragallo and Peragallo (1897-1908) p. 309 pl. 78 as *Synedra robusta*; Witkowski et al. (2000) p. 44 pl. 31 as *Ardissonea robusta.* Sample: Rocks Poso Pesisir (SZCZ 28814). Morphometry: Length 301 µm, width 20.8 µm, striae 10 in 10 µm (n=1).

***Ardissonea* sp. (Figures 8.F-8.G).** Samples: *Padina* sp. Paguat (SZCZ 28818), *Padina* sp. Kurenai (SZCZ 29017). Morphometry: Length 202.8-252.6 µm, width 8.9-10.5 µm, striae 10 in 10 µm. Comments: the width of our samples is less than range of *A. formosa*, the apex is different, there is granulation not striation.

***Climacosphenia elongata* J.W.Bailey, 1854 (Figures 7.A-7.B).** References: Peragallo and Peragallo (1897-1908) p. 352 pl. 86; Foged (1984) p. 27 pl. 31; Stidolph et al. (2012) pl. 7; Al-Handal et al. (2016) p. 12 pl. 6; Park et al. (2018) p. 105. Sample: *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Length 333-389.7 µm, width 20-20.1 µm, striae 25 in the upper part and 21 in the bottom part in 10 µm (n=2).

***Climacosphenia* cf. *moniligera* Ehrenberg, 1843 (Figure 7.C).** Reference: Witkowski et al. (2000) p. 44 pl. 18. Sample: *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Length 210.8 µm, striae 33 µm in upper part, µm 30 in the basal part (n=1). Comment: It resembles the specimen in Witkowski et al. (2000), but the number of striae differs from the values reported in the literature by Peragallo and Peragallo (1897-1908) where striae 16-17 at the base and 19-20 at the apex.

***Toxarium hennedyanum* (Gregory) Pelletan, 1889 (Figures 8.A-8.B).** References: Witkowski et al. (2000) p. 83 pl. 30, pl. 31; Stidolph et al. (2012) pl. 16; Al-Handal et al. (2016) p. 10 pl. 6; Siqueiros Beltrones et al. (2021) p. 13, López-Fuerte et al. (2022) p. 8. Samples: Rocks Poso Pesisir (SZCZ 28814), *Padina* sp. Paguat (SZCZ 28818). Morphometry: Length 215.3-644.1 µm, width 7.2-9.3 µm, striae 11 in 10 µm (n=2).

Subclass Thalassiosirophycidae Round et al. 1990
Order Anaulales F.E.Round & R.M.Crawford 1990
Family Anaulaceae (F.Schütt) Lemmermann 1899

***Eunotogramma laeve* Grunow, 1883 (Figure 4.X).** References: Foged (1979) p. 52 pl. 6; Foged (1986) p. 40 pl. 9, 9; Witkowski et al. (2000) p. 32 pl. 10 as *E. laevis*; Cremer et al. (2007) p. 37 pl. 9. Sample: Rocks Poso Pesisir (SZCZ 28814). Morphometry: Length 20.5 µm, width 6.1 µm, pseudosepta 6 per valve (n=1).

***Eunotogramma marinum* (W.Smith) H.Peragallo (Figures 4.V-4.W).** References: Foged (1978) p. 62 pl. 6; Foged (1979) p. 52 pl. 6; Foged (1986) p. 40 pl. 9, 10; Witkowski et al. (2000) p. 32 pl. 10. Sample: Rocks Poso Pesisir (SZCZ 28814). Morphometry: Length 14.9-32.3 µm, width 3.1-3.2 µm, pseudosepta 4-11 per valve (n=2).

Subclass Eupodiscaphycidae Kociolek, Ashworth & A.J.Alverson
Order Eupodiscales Nikolaev & Harwood 2000
Family Odontellaceae P.A.Sims, Williams & Ashworth 2018

***Amphipentas pentacrinus* Ehrenberg, 1841 (Figure 3.M).** References: Witkowski et al. (2000) p. 42 pl. 8 as *Triceratium pentacrinus*; Hein et al. (2008) p. 22 pl. 6 as *T. pentacrinus*; Stidolph et al. (2012) pl. 34 as *T. pentacrinus.* Sample: Rocks Olele (SZCZ 28995). Morphometry: Diameter 45.0-51.0 µm, areolae 10 in 10 µm (n=1).

***Odontella aurita* (Lyngbye) C. Agardh, 1832 (Figures 3.J-3.K).** References: Hustedt (1930) p. 846 as *Biddulphia aurita*; Witkowski et al. (2000) p. 36 pl. 9; Hein et al. (2008) p. 20 pl. 4; Al-Handal et al. (2016) p. 5 pl. 2. Sample: Rocks Poso Pesisir (SZCZ 28814). Morphometry: Length 14.9-22.0 µm, width 19.5-19.7 µm, areolae 12 in 10 µm (n=2).

***Odontella edwardsii* (Febiger ex H.L.Smith) Grunow, 1884 (Figure 4.A).** Reference: Hein et al. (2008) p. 20 pl. 6. Sample: Rocks Olele (SZCZ 28995). Morphometry: Length 62.2 µm, width 33.0 µm, areolae 8 in 10 µm (n=1).

***Odontella obtusa* Kützing, 1844 (Figure 3.L).** References: Lavigne et al. (2015) p. 6; López-Fuerte et al. (2020) p. 6; Siqueiros Beltrones et al. (2023) p. 13. Samples: Rocks Poso Pesisir (SZCZ 28814), Rocks Olele (SZCZ 28995). Morphometry: Length 13.3-20.6 µm, width 32.6-51.1 µm, areolae 12-14 in 10 µm (n=2).

***Pseudictyota dubium* (Brightwell) P.A.Sims & D.M.Williams, 2018 (Figures 4.B-4.F).** References: Schmidt (1874-1959) Atlas band I pl. 78 as *Triceratium dubium*; Witkowski et al. (2000) p. 42 pl. 8 as *T. dubium*; Kryk et al. (2020) p. 166; Park et al. (2018) p. 103 as *T. dubium*; López-Fuerte et al. (2020) p. 6; Siqueiros Beltrones et al. (2021) p. 7 as *Pseudodictyota dubia.* Samples: Sediment Trans Pato'a (SZCZ 28773), macroalgae Pelawa Baru (SZCZ 28806), *Sargassum* sp. Kurenai (SZCZ 28820), Rocks Olele (SZCZ 28995). Morphometry: Length 13.3-30.0 µm, areolae 5 in 10 µm (n=5).

Family Eupodiscaceae Ralfs

***Trilamina rotundata* (R.K.Greville) J.Witkowski, P.A.Sims, N.I.Strelnikova & D.M.Williams, 2015 (Figure 3.I).** References: Schmidt (1874-1959) Atlas band I pl.128 as *Triceratium rotundatum*; Witkowski et al. (2015) p. 34. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Diameter 22.0-27.0 µm (n=1).

Subclass Thalassiosirophycidae Round et al. 1990
Order Thalassiosirales Glezer & Makarova 1986
Family Thalassiosiraceae Lebour 1930

***Cyclotella striata* (Kützing) Grunow, 1880 (Figure 3.F).** References: Foged (1986) p. 31 pl. 1; Al-Handal et al. (2018) p. 114; Siqueiros Beltrones et al. (2023) p. 9.

Sample: *Padina* sp. Paguat (SZCZ 29016). Morphometry: Diameter 15.7-16.3 µm, areolation fine (n=1).

***Cyclotella stylorum* Brightwell, 1860 (Figure 3.A).** References: Foged (1986) p. 31 pl. 1; Al-Handal et al. (2018) p. 114. Sample: *Padina* sp. Paguat (SZCZ 29016). Morphometry: Diameter 44.8-45.7 µm, areolation fine (n=1).

***Shionodiscus oestrupii* var. *venrickae* (G.Fryxell & Hasle) A.J.Alverson, S.H.Kang & E.C.Theriot, 2006 (Figures 3.C-3.D).** References: Fryxell and Hasle (1980) p. 810 as *Thalassiosira oestrupii* var. *venrickae*; Alverson et al. (2006) p. 260. Sample: Mangrove roots Pongian (SZCZ 29004). Morphometry: Diameter 13.8-27.5 µm, areolae 10-12 in 10 µm (n=2).

***Thalassiosira* sp. (Figure 3.E).** Sample: Rocks Poso Pesisir (SZCZ 28814). Morphometry: Diameter 12.0-13.8 µm, areolae 10-12 in 10 µm (n=2).

***Ehrenbergiulva granulosa* Witkowski & Lange-Bertalot, 2004 (Figure 3.B).** Reference: Stidolph et al. (2012) pl. 4. Sample: Sediment Pelawa Baru (SZCZ 29005). Morphometry: Diameter 33.8 µm, areolae 9 in 10 µm (n=1).

Class Plagiogrammaphyceae Kociolek, Ashworth & A.J.Alverson
Order Plagiogrammiales E.J.Cox ex Kociolek, Ashworth & A.J.Alverson
Family Plagiogrammaceae De Toni 1890

***Dimeregramma minor* (Gregory) Ralfs, 1861 (Figures 4.Y-4.Z).** References: Witkowski et al. (2000) p. 29 pl. 11; López-Fuerte et al. (2020) p. 9. Samples: Sediment Pelawa Baru (SZCZ 28807), seagrass Poso Pesisir (SZCZ 29007). Morphometry: Length 8.5-25.6 µm, width 4.5-7.1 µm, striae 13-14 in 10 µm (n=2).

***Dimeregramma* sp. (Figure 4.AA).** Sample: Sediment Pelawa Baru (SZCZ 28807). Morphometry: Length 15.1 µm, width 7.6 µm, striae/areolae 18 in 10 µm. Comment: Our specimen looks like *Dimeregramma maculatum*, but the middle part is rounder in *D. maculatum* (n=1).

***Neofragilaria anomala* (Giffen) Witkowski & Dąbek (Figure 6.L).** Reference: Li et al. (2015) p.10. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Length 16.6 µm, width 7.9 µm, striae 7 in 10 µm (n=1).

***Neofragilaria* cf. *nicobarica* Desikachary, Prasad & Prema, 1987 (Figure 6.K).** References: Witkowski et al. (2000) p. 68 pl. 22; Hein et al. (2008) p. 28 pl. 11. Sample: Macroalgae Pelawa Baru (SZCZ 28806). Morphometry: Length 18.0 µm, width 5.6 µm, striae 8 in 10 µm (n=1).

***Neofragilaria* sp. (Figure 6.M).** Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Length 35.1 µm, width 7.9 µm, striae 8 in 10 µm.

***Plagiogramma atomus* Greville, 1863 (Figure 4.Q).** References: Sato et al. (2008b) p. 262; Hein et al. (2008) p. 21 pl. 4; Lobban (2015) p. 41. Sample: Rocks Pongian (SZCZ 29005). Morphometry: Length 35.7 µm, width 9.9 µm, striae 10 in 10 µm (n=1).

***Plagiogramma costatum* Greville, 1863 (Figures 4.G-4.I).** Reference: Stidolph et al. (2012) pl. 40. Samples: Macroalgae (SZCZ 28806) and sediment Pelawa Baru (SZCZ 28807). Morphometry: Length 28.9-65.3 µm, width 11.5-13.6 µm, striae 18 in 10 µm (n=4).

***Plagiogramma rhombicum* Hustedt, 1955 (Figure 4.P).** Reference: Witkowski et al. (2000) p. 38 pl. 11. Sample: Mangrove roots Trans Pato'a (SZCZ 28768). Morphometry: Length 23.3 µm, width 11.0 µm, striae 8 in 10 µm (n=1).

***Plagiogramma staurophorum* (W. Gregory) Heiberg, 1863 (Figures 4.N-4.O).** References: Al-Handal et al. (2016) p. 5 pl. 4; Lobban et al. (2012) p. 254 pl. 10. Samples: Sediment Trans Pato'a (SZCZ 28773), sediment Pelawa Baru (SZCZ 28807), seagrass Poso Pesisir (SZCZ 29007). Morphometry: Length 16.9-33.4 µm, width 10.0-13.8 µm, areolae 6-8 in 10 µm (n=3).

***Plagiogramma subatomus* Lobban, S. Konno, Y. Arai & R.W. Jordan (Figures 4.R-4.S).** References: Witkowski et al. (2000) p. 37 pl. 3 as *P. atomus*; Lobban (2021) p. 236. Samples: Sediment Trans Pato'a (SZCZ 28773), Rocks Pongian (SZCZ 29005). Morphometry: Length 11.3-19.7 µm, width 5.5-8.2 µm, striae 10 in 10 µm (n=2).

***Plagiogramma tenuistriatum* Cleve, 1883 (Figures 4.J-4.M).** Reference: Frenguelli (1938) p. 309 as *Plagiogramma interruptum* var. *tenuistriatum.* Samples: Macroalgae (SZCZ 28806) and sediment Pelawa Baru (SZCZ 28807). Morphometry: Length 18.1-27.4 µm, width 6.4-7.8 µm, striae 16 in 10 µm (n=4).

***Talaroneis* sp. 1 (Figure 4.T).** Reference: Park et al. (2018) p. 105. Sample: Seagrass Poso Pesisir (SZCZ 29007). Morphometry: Length 26.2 µm, width 7.8 µm, striae 24 in 10 µm (n=1).

***Talaroneis* sp. 2 (Figure 4.U).** Reference: Siqueiros Beltrones et al. (2021) p. 7 as *Talaroneis* sp. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Length 21.3 µm, width 5.2 µm, striae very fine (n=1).

Order Rhaphoneidales Round 1990
Family Rhaphoneidaceae Forti 1912

***Psammodiscus nitidus* (W. Gregory) Round & D.G. Mann, 1980 (Figure 5.T).** References: Witkowski et al. (2000) p. 75 pl. 23; Hein et al. (2008) p. 29 pl. 5, pl. 12; John (2012) p. 72; Lobban et al. (2012) p. 258 pl. 14; Siqueiros Beltrones et al. (2021) p. 7; Siqueiros Beltrones et al. (2023) p. 13. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Diameter 26.8 µm, striae 5 in 10 µm (n=1).

***Perissonoë crucifera* (Kitton) Desikachary, Gowthaman, Hema, Prasad & Prema, 1987 (Figure 5.U).** References: Hein et al. (2008) p. 28 pl. 11 as *P. cruciata*; Lobban et al. (2012) p. 258 pl. 14 as *P. cruciate*. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Width 30.2 µm, striae 6 in 10 µm (n=1).

***Rhaphoneis amphiceros* (Ehrenberg) Ehrenberg, 1844 (Figures 5.W-5.Y).** References: Peragallo and Peragallo (1897-1908) p. 329 pl. 83; Witkowski et al. (2000) p. 77 pl. 22; Hein et al. (2008) p. 30 pl. 11; Stidolph et al. (2012) pl. 1; Lobban et al. (2012) p. 258 pl. 14; Siqueiros Beltrones et al. (2021) p. 7; López-Fuerte et al. (2022) p. 6 as *R. amphiceros* var. *amphiceros.* Samples: Sediment Trans Pato'a (SZCZ 28773), macroalgae Pelawa

Baru (SZCZ 28806), *Sargassum* sp. Kurenai (SZCZ 28820), seagrass Poso Pesisir (SZCZ 29007). Morphometry: Length 23.8-29.3 µm, width 17.6-21.4 µm, striae 6-7 in 10 µm (n=6).

***Rhaphoneis castracanii* Grunow (Figure 5.V).** References: Podzorski and Håkansson (1987) p. 34 pl. 6 as *R. castracanii*; Lobban et al. (2012) p. 258 pl. 14 as *R. castracanii*; López-Fuerte et al. (2024) p. 8; Lobban and Tharngan (2025) p. 31. Sample: Rocks Poso Pesisir (SZCZ 28814). Morphometry: Length 21.9 µm, width 15.7 µm, striae 8 in 10 µm (n=1).

***Rhaphoneis* sp. 1 (Figures 5.Z-5.AC).** Samples: Macroalgae (SZCZ 28806) and sediment Pelawa Baru (SZCZ 28807). Morphometry: Length 18.1-33.1 µm, width 8.7-9.7 µm, striae 7-8 in 10 µm (n=5).

Cf. *Rhaphoneis* (?) sp. 2 (Figure 5.AD). Sample: Rocks Pongian (SZCZ 29005). Morphometry: Length 32.9 µm, width 7.6 µm, striae 11 in 10 µm (n=1).

Class Fragilariophyceae Round 1990
Subclass Staurosirophycidae Kociolek, Ashworth & A.J.Alverson
Order Staurosirales Kociolek, Ashworth & A.J.Alverson
Family Staurosiraceae Medlin 2016

***Hendeyella dimeregrammopsis* Ashworth, 2016 (Figures 5.AE-5.AG).** Reference: Li et al. (2016) p. 1025. Samples: Sediment Trans Pato'a (SZCZ 28773), sediment Pelawa Baru (SZCZ 28807), Mangrove roots Pongian (SZCZ 29004). Morphometry: Length 15.3-17.0 µm, width 6.9-7.5 µm, striae 11 in 10 µm (n=4). Comment: The size of our specimens is larger than that reported in the literature, the striae density is also out of range.

***Hendeyella* cf. *dimeregrammopsis* (?) Ashworth, 2016 (Figures 5.AI-5.AJ).** Reference: Li et al. (2016) p. 1025. Samples: Sediment Trans Pato'a (SZCZ 28773), sediment Pelawa Baru (SZCZ 28807). Morphometry: Length 24.1-27.0 µm, width 6.2-6.3 µm, striae 10-12 in 10 µm (n=2). Comment:

***Hendeyella rhombica* Ashworth, 2016 (Figure 5.AH).** Reference: Li et al. (2016) p. 1024. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Length 16.2 µm, width 6.7 µm, striae 13 in 10 µm (n=1).

***Opephora mutabilis* (Grunow) Sabbe & Vyverman, 1995 (Figure 6.N).** References: Witkowski et al. (2000) p. 72 pl. 25; Al-Handal et al. (2016) p. 7 pl. 4 (different from our sample); López-Fuerte et al. (2022) p. 6 (different from our sample); López-Fuerte et al. (2024) p. 8. Sample: Mangrove roots Trans Pato'a (SZCZ 28768). Morphometry: Length 15.7 µm, width 3.1 µm, striae 10 in 10 µm (n=1).

***Opephora* sp. (Figure 6.O).** Sample: *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Length 15.4 µm, width 3.9 µm, striae 12-13 in 10 µm (n=1).

***Staurosira* cf. *subsalina* (Hustedt) Lange-Bertalot, 2004 (Figures 4.AD-4.AE).** Reference: Lange-Bertalot et al. (2017) p. 572 pl. 11. Sample: Sediment Pelawa Baru (SZCZ 28807). Morphometry: Length 15.6-20.1 µm, width 4.9-5.2 µm, striae 13-14 in 10 µm (n=2).

Subclass Tabellariaphycidae Kociolek, Ashworth & A.J.Alverson
Order Rhabdonematales F.E.Round & R.M.Crawford 1990
Family Grammatophoraceae Lobban & Ashworth 2014

***Grammatophora hamulifera* Kützing, 1844 (Figures 5.J-5.K).** References: Witkowski et al. (2000) p. 57 pl. 14; Stidolph et al. (2012) pl. 24; López-Fuerte et al. (2020) p. 13; Siqueiros Beltrones et al. (2021) p. 6; Siqueiros Beltrones et al. (2023) p. 10. Samples: Macroalgae (SZCZ 28806) and sediment (SZCZ 28807) Pelawa Baru. Morphometry: Length 20.6-22.5 µm, width 4.6-10.3 µm, striae 20 in 10 µm (n=2).

***Grammatophora marina* (Lyngbye) Kützing, 1844 (Figures 5.F-5.H).** References: Witkowski et al. (2000) p. 58 pl. 15; Stidolph et al. (2012) pl. 34; Park et al. (2018) p. 108; López-Fuerte et al. (2020) p. 13; Siqueiros Beltrones et al. (2021) p. 17. Samples: *Padina* sp. Paguat (SZCZ 28818), *Padina* sp. Kurenai (SZCZ 29017). Morphometry: Length 19.3-34.5 µm, width 5.0-12.0 µm, striae 24-26 in 10 µm (n=3).

***Grammatophora* cf. *marina* (Lyngbye) Kützing, 1844 (Figure 5.I).** References: Witkowski et al. (2000) p. 58 pl. 15; Stidolph et al. (2012) pl. 34; López-Fuerte et al. (2020) p. 13; Siqueiros Beltrones et al. (2021) p. 17. Sample: Rocks Poso Pesisir (SZCZ 28814). Morphometry: Length 10.5-11.5 µm, width 10.6-12.5 µm, striae very fine (n=1).

***Grammatophora oceanica* Ehrenberg, 1840 (Figures 5.A-5.E).** References: Witkowski et al. (2000) p. 59 pl. 15, pl. 16, pl. 17; Lobban et al. (2012) p. 262 pl. 19; Stidolph et al. (2012) pl. 24, pl. 37; Al-Handal et al. (2016) p. 12 pl. 4; Siqueiros Beltrones et al. (2021) p. 17; Siqueiros Beltrones et al. (2023) p. 10. Samples: Sediment Trans Pato'a (SZCZ 28773), *Padina* sp. Paguat (SZCZ 28818), *Sargassum* sp. Kurenai (SZCZ 28820), seagrass Poso Pesisir (SZCZ 29007), *Padina* sp. Paguat (SZCZ 29016). Morphometry: Length 37.2-67.2 µm, width 4.5-5.6 µm, striae 25 in 10 µm (n=4).

***Grammatophora oceanica* var. (?) (Figures 5.L-5.M).** Sample: *Padina* sp. Paguat (SZCZ 28818). Morphometry: Length 56.6-57.3 µm, width 6.0-7.3 µm, striae 28 in 10 µm (n=1). Comment: The specimen in Figures 5.L and 5.M is the same specimen shown at different focal planes.

***Grammatophora undulata* Ehrenberg (Figures 5.N-5.Q).** References: Lobban et al. (2012) p. 263 pl. 19, pl. 20, pl. 44; Siqueiros Beltrones et al. (2021) p. 16. Samples: Sediment Trans Pato'a (SZCZ 28773), *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Length 47.7-79.2 µm, width 5.4-6.7 µm, striae 18-20 in 10 µm (n=2). Comment: The specimen in Figures 5.N and 5.O is the same specimen shown at different focal planes as well as Figures 5.P and 5.Q.

***Grammatophora undulata* var. *gibba* (Ehrenberg) Grunow, 1881 (Figures 5.R-5.S).** Reference: Van Heurck (1881) p. 118 pl. 53. Sample: *Padina* sp. Kurenai (SZCZ 29017). Morphometry: Length 42.7-42.1 µm, width 7.7-7.0 µm, striae 20 in 10 µm (n=1). Comment: The specimen in Figures 5.R and 5.S is the same specimen shown at different focal planes.

Subclass Fragilariophycidae F.E.Round 1990
Order Fragilariales P.C.Silva 1962
Family Fragilariaceae Kützing

Cf. *Cratericulifera* (?) sp. 1 (Figure 4.AH). Sample: Rocks Pongian (SZCZ 29005). Morphometry: Length 12.3 µm, width 4.2 µm, striae 12 in 10 µm (n=1).

Cf. *Cratericulifera* (?) sp. 2 (Figure 4.AI). Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Length 12.4 µm, width 4.6 µm, striae 16 in 10 µm (n=1).

Family Fragilariaceae Greville 1833

***Synedra* cf. *lata* (Giffen) A.Witkowski, 2000 (Figures 7.G-7.H).** References: Witkowski et al. (2000) p. 81 pl. 30; Hein et al. (2008) p. 31 pl. 13; Lobban et al. (2012) p. 257 pl. 13. Samples: Sediment Trans Pato'a (SZCZ 28773), macroalgae Pelawa Baru (SZCZ 28806). Morphometry: Length 33.1-63.0 µm, width 7.6-7.9 µm, striae 14 in 10 µm (n=2). Comment: Width of our samples is smaller than the literature.

***Tabularia fasciculata* (C. Agardh) D.M. Williams & Round, 1986 (Figures 7.D-7.F).** References: Witkowski et al. (2000) p. 80 pl. 30 as *Synedra fasciculata*; John (2012) p. 84; Al-Handal et al. (2016) p. 8 pl. 6; Siqueiros Beltrones et al. (2021) p. 15. Samples: Mangrove roots (SZCZ 28768) and sediment (SZCZ 28773) Trans Pato'a, rocks Poso Pesisir (SZCZ 28814). Morphometry: Length 54.1-106.0 µm, width 4.0-4.9 µm, striae 11-12 in 10 µm (n=3).

Tabularia [Planothidium raphe-less valve]? sp. (Figures 4.AB-4.AC). Sample: Mangrove roots Pongian (SZCZ 29004). Morphometry: Length 27.3-27.7 µm, width 7.7-8.3 µm, striae 13-15 in 10 µm (n=2). Comment: We doubt whether these specimens belong to *Tabularia* or to a monoraphid *Planothidium* with a rapheless valve.

Family Thalassionemataceae F.E.Round 1990

***Hyalosynedra laevigata* (Grunow) Williams & Round, 1986 (Figure 7.I).** References: Foged (1984) p. 97 pl. 28 as *Synedra laevigata*; Witkowski et al. (2000) p. 62 pl. 17, pl. 29, pl. 30; Navarro and Lobban (2009) p. 136; Al-Handal et al. (2016) p. 7 pl. 6; Park et al. (2018) p. 106; López-Fuerte et al. (2020) p. 11; Siqueiros Beltrones et al. (2021) p. 15; López-Fuerte et al. (2022) p. 7. Samples: Sediment Trans Pato'a (SZCZ 28773), *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Length 49.9-76.8 µm, width 4.3-5.4 µm, striae very fine (n=2).

***Thalassionema nitzschioides* (Grunow) Mereschkowsky, 1902 (Figure 6.P).** References: Podzorski and Håkansson (1987) p. 35 pl. 7; Siqueiros Beltrones et al. (2023) p. 14. Sample: *Padina* sp. Paguat (SZCZ 28818). Morphometry: Length 29.7 µm, width 3.5µm, striae 11 in 10 µm (n=1).

Order Cyclophorales Round & Crawford 1990
Family Cyclophoraceae Round & Crawford 1990

***Cyclophora tenuis* Castracane, 1878 (Figure 7.L).** References: Foged (1987) p. 33 pl. 7; Navarro and Lobban (2009) p. 136; Ashworth et al. (2012) p. 686; Park et al. (2018) p. 106; Siqueiros Beltrones et al. (2021) p. 13; Lobban and Tharngan (2025) p. 39. Samples: Macroalgae Pelawa Baru (SZCZ 28806), *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Length 53.7 µm, width µm, striae in 10 µm (n=1).

***Cyclophora* sp. (Figures 7.J-7.K).** Sample: Macroalgae Pelawa Baru (SZCZ 28806). Morphometry: Length 83.1-83.6 µm, width 6.8-7.0 µm (n=2).

Order Licmophorales Round 1990
Family Licmophoraceae Kützing 1844

***Licmophora abbreviata* C. Agardh, 1831 (Figure 6.H).** References: Witkowski et al. (2000) p. 63 pl. 20; Al-Handal et al. (2016) p. 9 pl. 4; Siqueiros Beltrones et al. (2023) p. 11. Sample: *Sargassum* sp. Kurenai (SZCZ 28820). Morphometry: Length 43.2 µm, width 6.2 µm, striae 12 in 10 µm (n=1).

***Licmophora curvata* Lobban, Tharngan & Ashworth, 2018 (Figure 6.C).** Reference: Lobban et al. (2018) p. 195. Sample: Rocks Olele (SZCZ 28995). Morphometry: Length 140.5 µm, width 21.4 µm, striae 20 in 10 µm (n=1).

***Licmophora gracilis* (Ehrenberg) Grunow, 1867 (Figure 6.G).** References: Witkowski et al. (2000) p. 65 pl. 19; Siqueiros Beltrones et al. (2021) p. 15; Siqueiros Beltrones et al. (2023) p. 11. Sample: Seagrass Poso Pesisir (SZCZ 29007). Morphometry: Length 31.6 µm, width 6.7 µm, striae 28 in 10 µm (n=1).

***Licmophora paradoxa* (Lyngbye) C. Agardh, 1828 (Figures 6.E-6.F).** References: Foged (1978) p. 77 pl. 7; Foged (1986) p. 48 pl. 10; Witkowski et al. (2000) p. 67 pl. 18; Álvarez-Blanco and Blanco (2014) p. 117 pl. 14; Al-Handal et al. (2016) p. 9 pl. 4; López-Fuerte et al. (2020) p. 12; Siqueiros Beltrones et al. (2023) p. 11. Samples: Rocks Poso Pesisir (SZCZ 28814), *Padina* sp. Paguat (SZCZ 28818), *Sargassum* sp. Olele (SZCZ 28993). Morphometry: Length 41.1-46.6 µm, width 7.2-10.5 µm, striae 20-21 in 10 µm (n=2).

***Licmophora pfannkucheae* Giffen, 1970 (Figure 6.B).** References: Witkowski et al. (2000) p. 67 pl. 18; López-Fuerte et al. (2020) p. 12. Sample: *Sargassum* sp. Olele (SZCZ 28993). Morphometry: Length 151.6 µm, width 7.9 µm, striae 27 in 10 µm (n=1). Comment: AlgaeBase lists it as *L. pfannkuckae.*

***Licmophora remulus* Grunow, 1867 (Figure 6.A).** References: Witkowski et al. (2000) p. 68 pl. 19; Hein et al. (2008) p. 27 pl. 11; López-Fuerte et al. (2022) p. 7. Sample: *Padina* sp. Paguat (SZCZ 28818). Morphometry: Length 191.8 µm, width 12.6 µm, striae 23 in 10 µm (n=1)

***Licmophora* cf. *tincta* (C. Agardh) Grunow, 1868 (Figure 6.D).** Reference: Witkowski et al. (2000) p. 67 pl. 19 as *Licmophora paradoxa* var. (?) *tincta.* Sample: Seagrass Poso Pesisir (SZCZ 29007). Morphometry: Length 71.8 µm, width 18.3 µm, striae 28 in 10 µm (n=1).

***Podocystis spathulata* (Shadbolt) Van Heurck, 1896 (Figures 6.I-6.J).** References: Lobban et al. (2012) p. 256 pl. 12; Stidolph et al. (2012) pl. 50; Al-Handal et al. (2016) p. 8 pl. 6; Park et al. (2018) p. 106; Siqueiros Beltrones et al. (2021) p. 7; Siqueiros Beltrones et al. (2023) p. 13. Sample: Rocks Olele (SZCZ 28995). Morphometry: Length 44.4-87.4 µm, width 33.1-54.6 µm, striae 5-8 in 10 µm (n=3).

Family Ulnariaceae E.J.Cox 2015

***Trachysphenia noweirii* A.A.Zalat, 2001 (Figure 4.AG).** Reference: Zalat (2001) p. 424. Sample: Rocks Olele (SZCZ 28995). Morphometry: Length 9.4 µm, width 5.2 µm, striae 114 in 10 µm (n=1).

***Trachysphenia rhombica* A.A.Zalat, 2001 (Figure 4.AF).** Reference: Zalat (2001) p. 422. Samples: Sediment Trans Pato'a (SZCZ 28773), sediment Pelawa Baru (SZCZ 28807). Morphometry: 16.3 µm, width 5.4 µm, striae 13 in 10 µm (n=1).

Cf. *Trachysphenia* sp. (?) (Figure 4.AJ). Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Length 15.0 µm, width 7.1 µm, striae 10 in 10 µm (n=1).

Class Bacillariophyceae Haeckel incertae sedis
Order Bacillariophyceae ordo incertae sedis
Family Bacillariophyceae familia incertae sedis

***Spinodiscus punctatus* (Hendey) Desikachary & Ranjitha (Figure 2.H).** Reference: Desikachary (1986) p.8 pl. 41. Sample: Sediment Trans Pato'a (SZCZ 28773). Morphometry: Diameter 119.0 µm, areolae 8-9 in 10 µm (n=1).

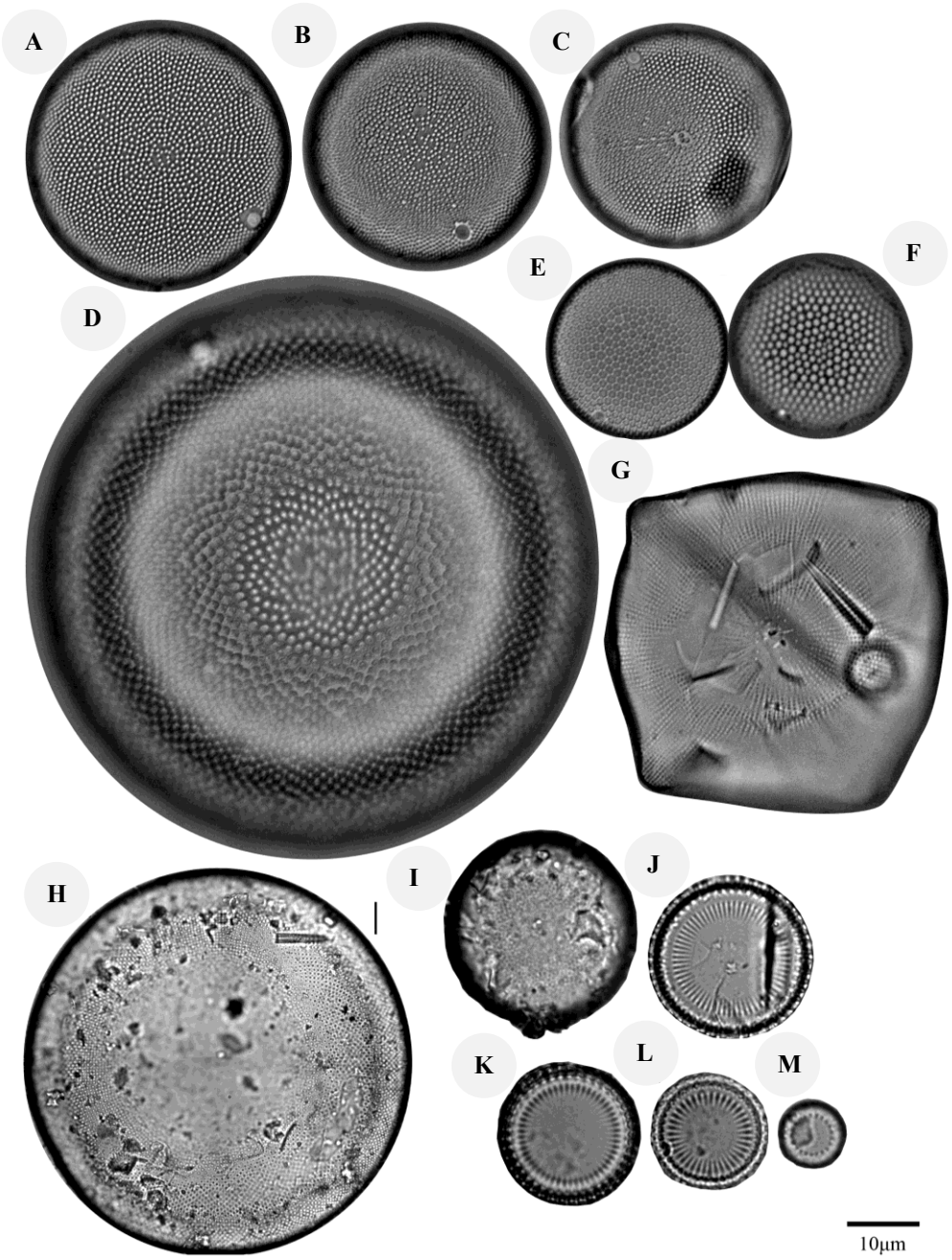

Figure 2. Light microscopy images of marine diatoms from the Gulf of Tomini, Indonesia. A-C. *Actinocyclus subtilis*, D. *Actinocyclus gallicus*, E-F. *Roperia tesselata*, G. *Trigonium formosum* var. *pentagonale*, H. *Spinodiscus punctatus*, I. *Melosira lineata*, J-L. *Paralia sulcata*, M. *Paralia longispina*. Scale bar =10 µm applies to all pictures except for very large specimen, which has been reduced in size and has its own 10 µm scale

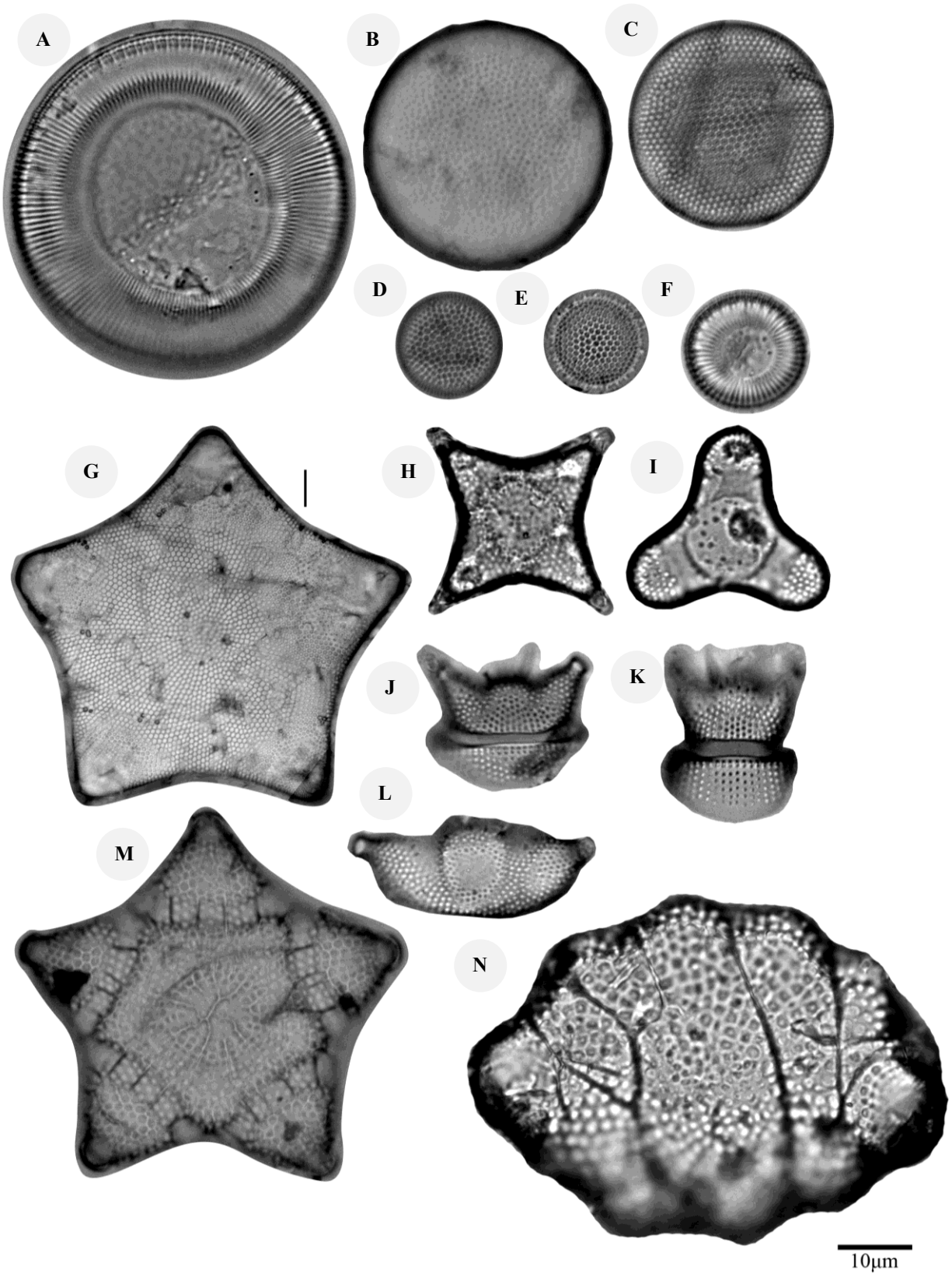

Figure 3. Light microscopy images of marine diatoms from the Gulf of Tomini, Indonesia. A. *Cyclotella stylorum*, B. *Ehrenbergiulva granulosa*, C-D. *Shionodiscus oestrupii* var. *venrickae*, E. *Thalassiosira* sp., F. *Cyclotella striata*, G. *Trigonium graeffeanum*, H. *Triceratium balearicum*, I. *Trilamina rotundata*, J-K. *Odontella aurita*, L. *Odontella obtuse*, M. *Amphipentas pentacrinus*, N. *Biddulphia biddulphiana.* Scale bar =10 µm applies to all pictures except for very large specimen, which has been reduced in size and has its own 10 µm scale

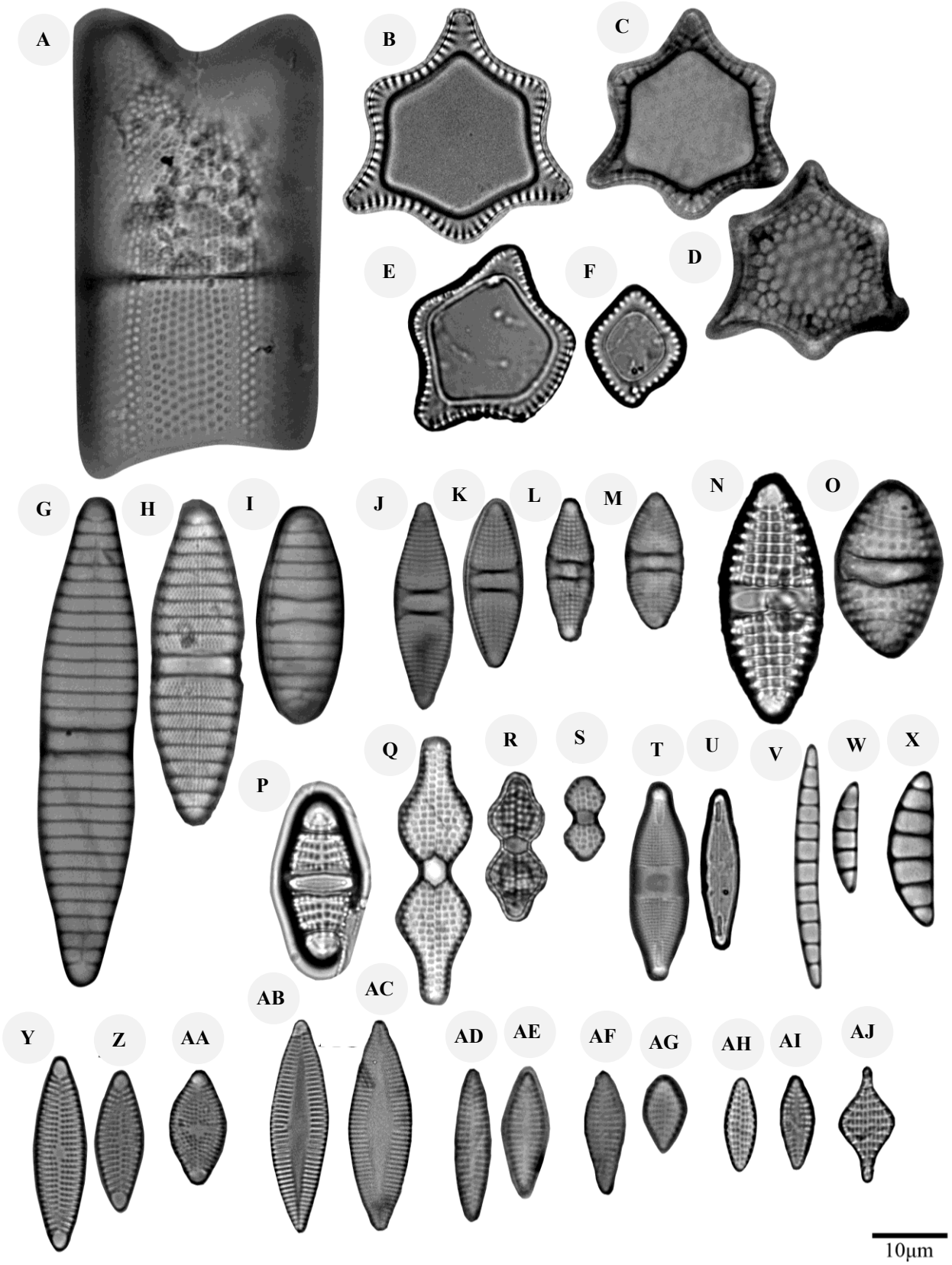

Figure 4. Light microscopy images of marine diatoms from the Gulf of Tomini, Indonesia. A. *Odontella edwardsii*, B-F. *Pseudictyota dubium*, G-I. *Plagiogramma costatum*, J-M. *Plagiogramma tenuistriatum*, N-O. *Plagiogramma staurophorum*, P. *Plagiogramma rhombicum*, Q. *Plagiogramma atomus*, R-S. *Plagiogramma subatomus*, T. *Talaroneis* sp. 1, U. *Talaroneis* sp. 2, V-W. *Eunotogramma marinum*, X. *Eunotogramma leave*, Y-Z. *Dimeregramma minor*, AA. *Dimeregramma* sp., AB-AC. *Tabularia* [*Planothidium* RLV]? sp., AD-AE. *Staurosira* cf. *subsaline*, AF. *Trachysphenia rhombica*, AG. *Trachysphenia noweirii*, AH. Cf. *Cratericulifera* (?) sp. 1., AI. Cf. *Cratericulifera* (?) sp. 2., AJ. Cf. *Trachysphenia* sp. (?). Scale bar =10 µm

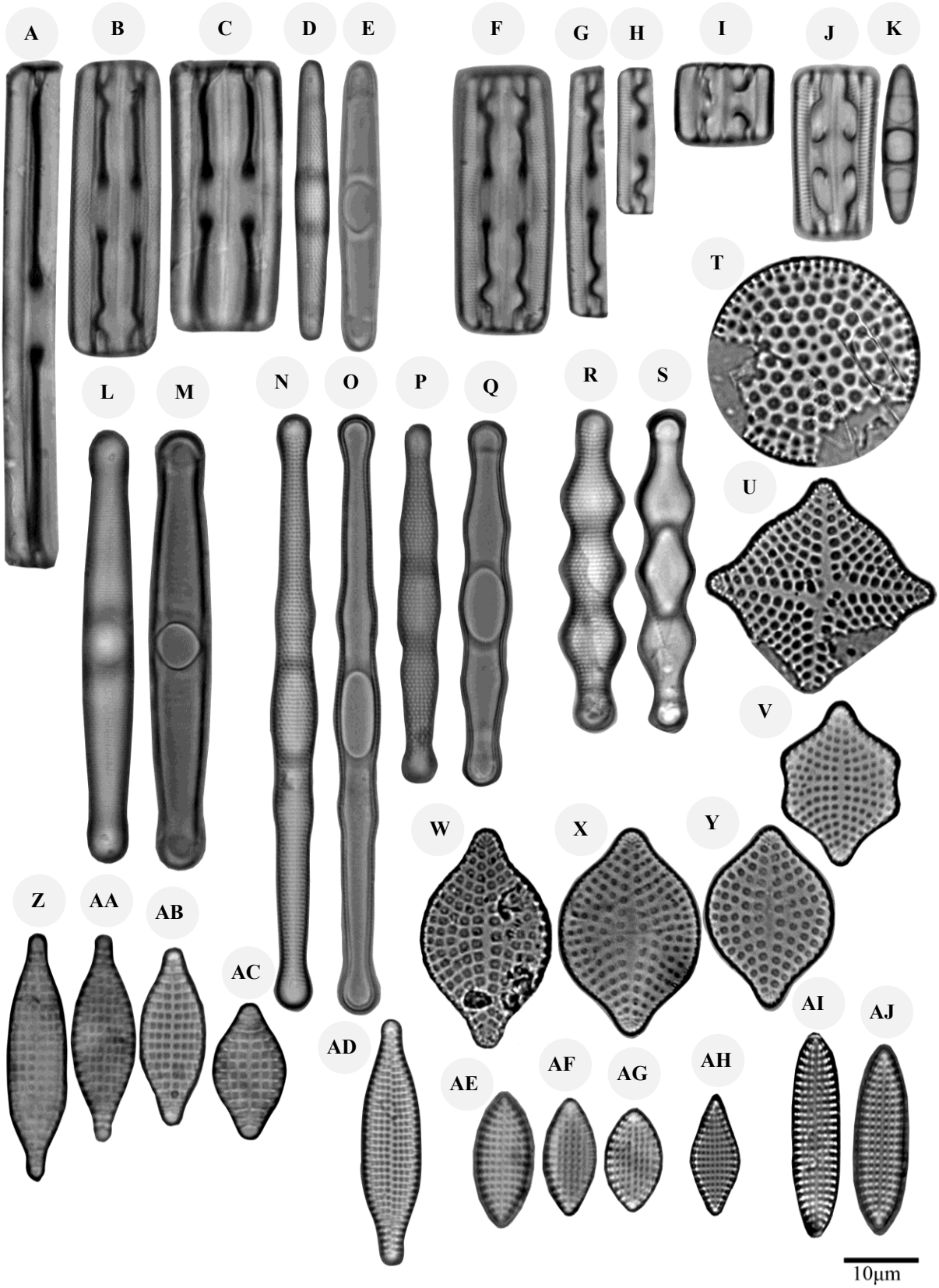

Figure 5. Light microscopy images of marine diatoms from the Gulf of Tomini, Indonesia. A-E. *Grammatophora oceanica* (A-C in girdle view), F-H. *Grammatophora marina* in girdle view, I. *Grammatophora* cf. *marina* in girdle view, J-K. *Grammatophora hamulifera* (J. in girdle view), L-M. *Grammatophora oceanica* var. (?), N-Q. *Grammatophora undulata*, R-S. *Grammatophora undulata* var. *gibba*, T. *Psammodiscus nitidus*, U. *Perissonoë crucifera*, V. *Rhaphoneis castracanii*, W-Y. *Rhaphoneis amphiceros*, Z-AC. *Rhaphoneis* sp. 1, AD. Cf. *Rhaphoneis* (?) sp. 2, AE-AG. *Hendeyella dimeregrammopsis*, AH. *Hendeyella rhombica*, AI-AJ. *Hendeyella* cf. *dimeregrammopsis* (?). Scale bar =10 µm

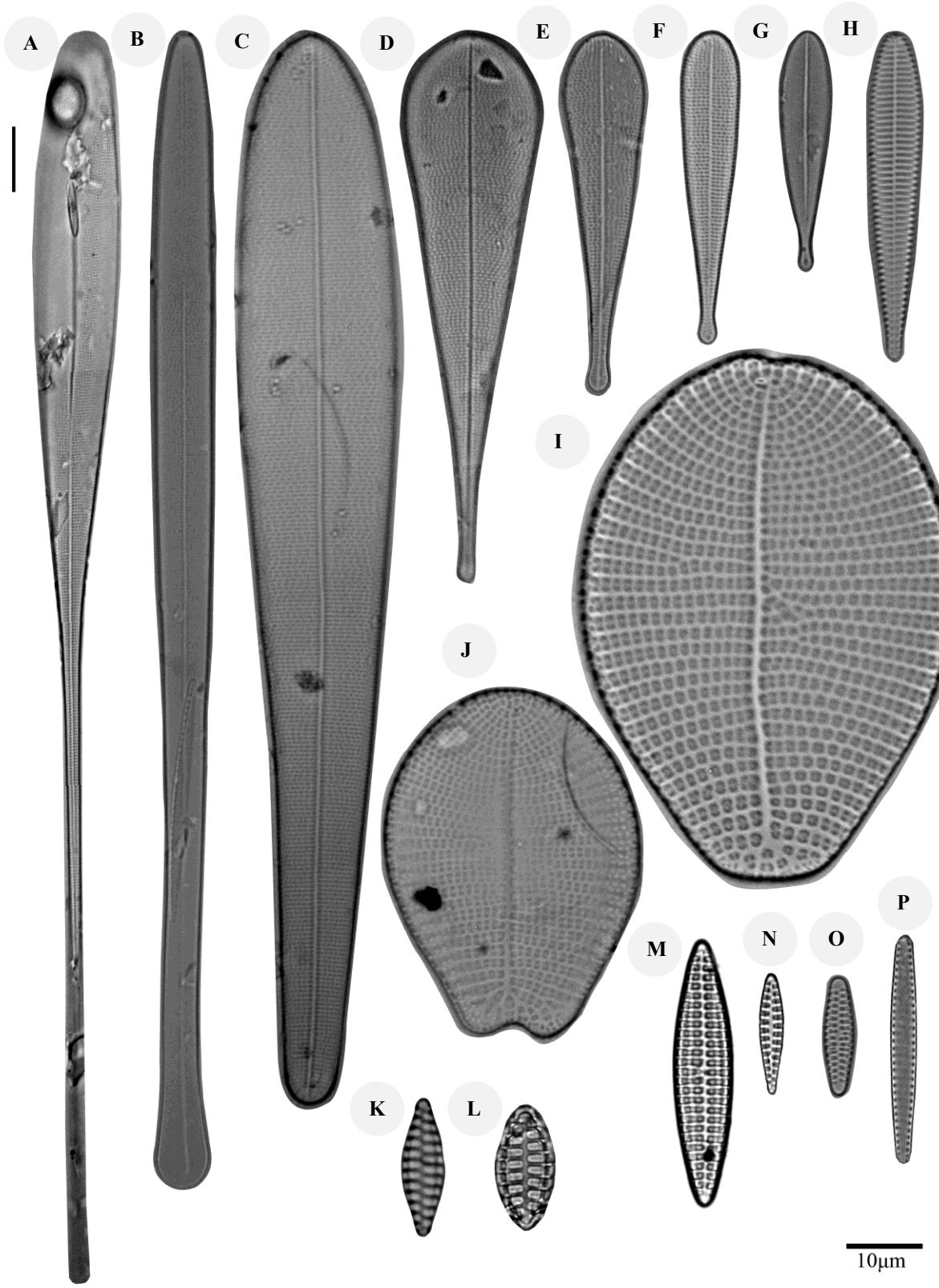

Figure 6. Light microscopy images of marine diatoms from the Gulf of Tomini, Indonesia. A. *Licmophora remulus*, B. *Licmophora pfannkucheae*, C. *Licmophora curvata*, D. *Licmophora* cf. *tincta*, E-F. *Licmophora paradoxa*, G. *Licmophora gracilis*, H. *Licmophora abbreviata*, I-J. *Podocystis spathulate*, K. *Neofragilaria* cf. *nicobarica*, L. *Neofragilaria anomala*, M. *Neofragilaria* sp., N. *Opephora mutabilis*, O. *Opephora* sp., P. *Thalassionema nitzschioides.* Scale bar =10 µm applies to all pictures except for very large specimen, which has been reduced in size and has its own 10 µm scale

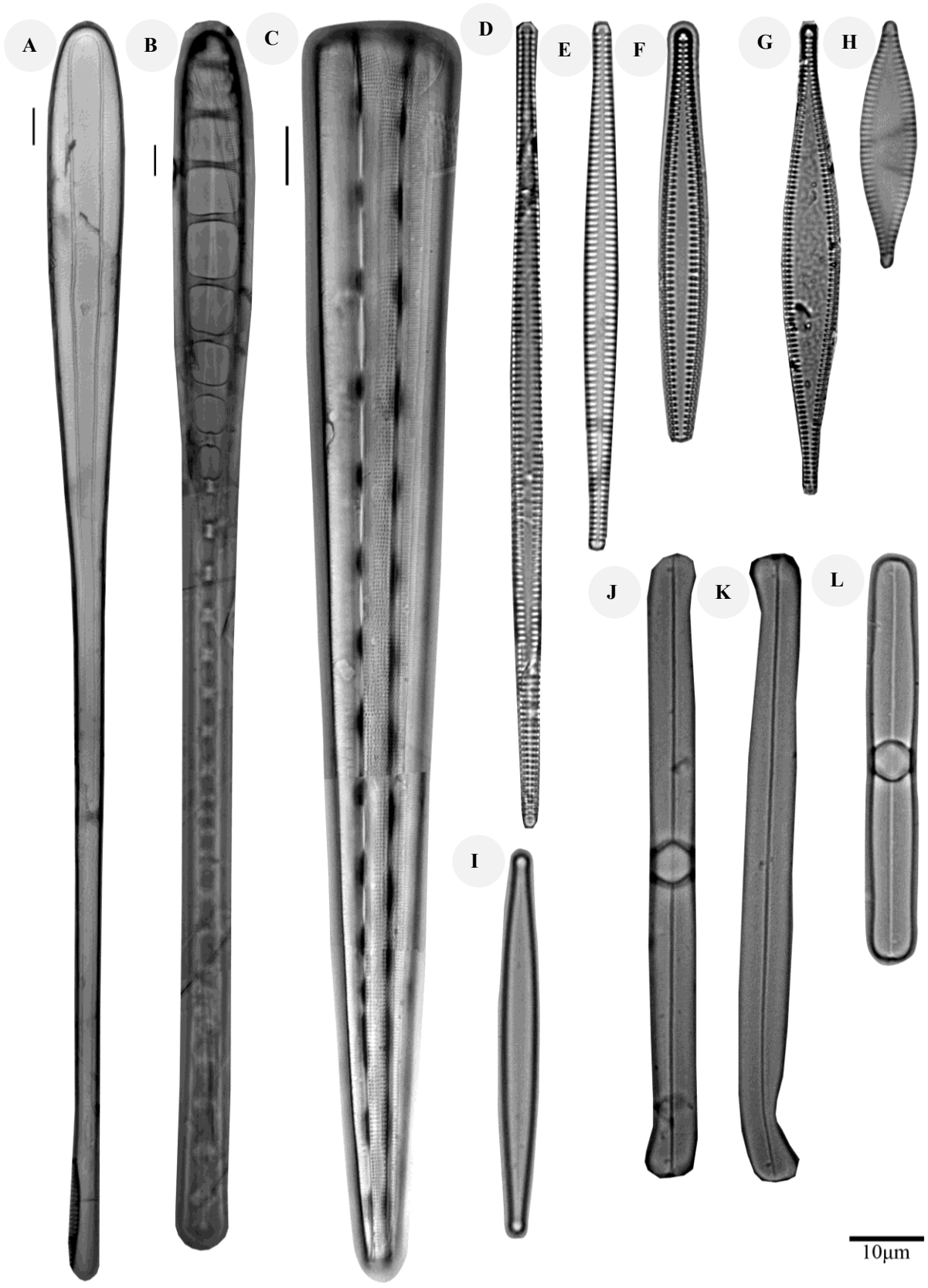

Figure 7. Light microscopy images of marine diatoms from the Gulf of Tomini, Indonesia. A-B. *Climacosphenia elongata*, C. *Climacosphenia* cf. *moniligera* in girdle view, D-F. *Tabularia fasciculata*, G-H. *Synedra* cf. *lata*, I. *Hyalosynedra laevigata*, J-K. *Cyclophora* sp., L. *Cyclophora tenuis.* Scale bar =10 µm applies to all pictures except for very large specimen, which have been reduced in size and has its own 10 µm scale

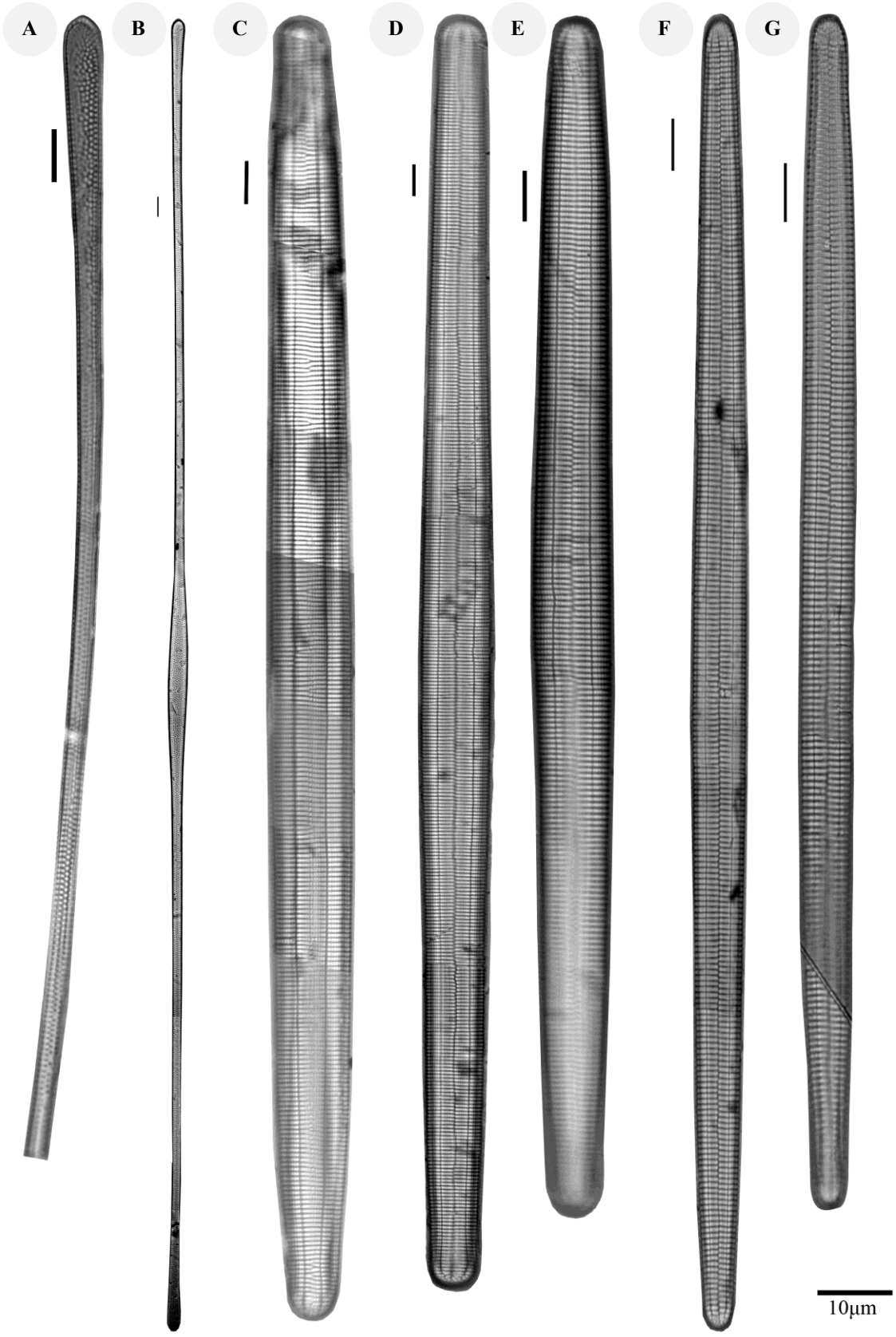

Figure 8. Light microscopy images of marine diatoms from the Gulf of Tomini, Indonesia. A-B. *Toxarium hennedyanum*, C. *Ardissonea robusta*, D-E. *Ardissonea Formosa*, F-G. *Ardissonea* sp.. Each specimen has been reduced in size and has its own 10 µm scale

Previous records of centric and araphid taxa in Indonesia have been reported from areas such as Java (Semarang) and Sumatra, including several species of *Coscinodiscus*, *Triceratium*, *Synedra*, and *Rhabdonema,* based on material sourced from the Morris Watt Collection, Otago Museum, New Zealand (Stidolph et al. 2012). Additional records have been reported by Risjani et al. (2021) from various regions in Indonesia, including Java, Kalimantan, southeastern and southwestern Sulawesi, Flores, and Rinca Komodo. Furthermore, 14 centric and araphid diatom taxa were reported from Bawean Island, Java (Luthfi et al. 2024). Several taxa reported in these studies are also present in the Gulf of Tomini, including *G. marina*, *Thalassiosira*, *P. sulcata*, *A. robusta*, and *Plagiogramma* spp. In the Gulf of Tomini itself, investigations focused on plankton abundance and distribution patterns, including taxa belonging to the classes Coscinodiscophyceae and Mediophyceae (Kadim et al. 2018; Olii et al. 2022), rather than specifically on marine diatoms in the benthic environment. To the best of our knowledge, the present study provides the first taxon-based checklist of centric and araphid marine diatoms from the benthic environments of the Gulf of Tomini, Sulawesi, reporting species occurrences across sampling sites and substrate types and documenting taxa with the highest cumulative counts and taxonomically uncertain taxa with illustrative micrographs. These findings enhance our understanding of benthic centric and araphid diatom diversity in Indonesian coastal waters, which are recognized for their high marine biodiversity.

Certain diatom taxa were consistently observed across all sites and substrates, including *G. marina* and *H. laevigata*, indicating their widespread occurrence within the study area. Therefore, no clear substrate-specific assemblage pattern was observed, as many taxa occurred across multiple substrate types. *Grammatophora marina* is cosmopolitan, commonly found in coastal habitats, and frequently reported in high abundance (Witkowski 2000; Sato et al. 2008a). Also, Risjani et al. (2021) reported that *G. marina* is one of the most dominant taxa found in their study. According to Global Biodiversity Information Facility (GBIF 2023), it has been recorded 5,501 times worldwide, with 17 recognized infraspecific taxa. Similar to *G. marina*, *Hyalosynedra* is widely found in marine benthic habitats, occurring as an epiphyte or attaching to hard substrates. It has a broad global distribution (Belando et al. 2018), with 105 recorded occurrences and eight recognized infraspecific taxa (GBIF 2023). In addition, this species has been reported to exhibit a growth advantage under deeper water conditions (Mao et al. 2025). Together with *T. fasciculata*, *P. longispina*, *Cyclophora* sp., and *P. sulcata*, these taxa constituted the highest cumulative counts of the assemblages across all sites and substrates. The genus *Paralia* Heiberg is considered cosmopolitan, with most records historically attributed to *P. sulcata*. Subsequent studies have documented additional species within the genus, including *P. longispina*, which was first reported from Palau and Haha-jima in the western North Pacific (Konno and Jordan 2008). In the present study, both *P. sulcata* and *P. longispina* were frequently encountered. Centric diatoms are most common in marine waters and most genera lack freshwater representatives (Kociolek et al. 2015). Centric diatoms are generally regarded as predominantly planktonic. Their occurrence on benthic substrates may reflect benthic-pelagic coupling, whereby planktonic cells settle onto substrates or benthic-associated cells become temporarily entrained in the water column, a process that can be influenced by temperature-driven temporal dynamics (Tekwani et al. 2013; Wang et al. 2019). Furthermore, the frequent occurrence of *Cyclophora* spp., particularly *Cyclophora* sp. and *C. tenuis* Castracane as epiphyte on macroalgae at Pelawa Baru (Parigi Moutong District, Central Sulawesi) highlights their close association with such substrate. The genus *Cyclophora* Castracane is characterized by the presence of an elliptical to circular pseudoseptum at the centre of one valve. To date, this genus comprises four described species, some of which were originally described from Guam in the western Pacific (Ashworth et al. 2012).

Thirteen taxa were identified only to the genus level and are therefore treated as sp., reflecting some remaining taxonomic uncertainty. These taxa include representatives from genera such as *Cyclophora*, *Thalassiosira*, *Cratericulifera*, *Opephora*, *Ardissonea*, *Dimeregramma*, *Neofragilaria*, *Rhaphoneis*, *Tabularia*, and *Talaroneis*. In several cases, the diagnostic characters observable under LM were insufficient to allow confident species-level identification. A more detailed examination using SEM would be required to resolve fine valve features such as areola structure, rimoportulae, apical pore, and striae patterns. In addition, molecular data could help clarify species boundaries and phylogenetic relationships. Further integrative work combining morphological and molecular approaches will be important for improving the taxonomic resolution of these taxa and strengthening the regional diatom inventory of the Gulf of Tomini. In addition, future sampling campaigns are expected to further increase the recorded diversity and enhance our understanding of the diatom assemblages.

In conclusion, this first LM-based checklist of centric and araphid diatoms from the Gulf of Tomini documents 82 taxa and provides baseline taxonomic information for the region. While SEM analysis is required to resolve 13 uncertain identifications, this study contributes to the documentation of Indonesian marine diatom diversity and provides a foundation for future ecological monitoring and biodiversity research.

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