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New Records for Microalgae Species of the Turkish Seas Under the Effect of Intense Mucilage in the Sea of Marmara

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ABSTRACT

Objective: New records of microalgae species for Turkish seas taking into account the species lists published to date have been reported in this study conducted in the Sea of Marmara and the Aegean Sea. Furthermore, new records of microalgae species for the Sea of Marmara and the Aegean Sea were listed.

Materials and Methods: New record species for Turkish seas were described by their morphological and ecological features and also their images were taken under a light microscope with epifluorescence attachment, and also some of them were photographed on a scanning electron microscope.

Results: A total of 66 new record species were identified in this study. A total of 25 microalgae taxa belonging to 11 taxonomic classes were recorded for the first time for Turkish seas. Two taxa were freshwater or brackish water form, which is known from the lakes. The class Prymnesiophyceae had seven taxa that were recorded for the first time, followed by Bacillariophyceae and Dinophyceae with four taxa and the other classes. Furthermore, a total of 65 taxa belonging to 16 taxonomic classes were recorded for the first time for the Sea of Marmara. Twelve taxa were freshwater or brackish water form, which is known from the lakes. Among these, Dinophyceae had 24 taxa, followed by Prymnesiophyceae with 11 taxa, and Bacillariophyceae with 9 taxa and the other classes. In addition, one new record taxon was detected for the Aegean Sea.

Conclusion: New records of microalgae detected in the Sea of Marmara during this study period will provide an important contribution to both the microalgae checklist of Turkish seas, the Sea of Marmara and the Aegean Sea.

Keywords: Mucilage, new records, phytoplankton, biodiversity, Turkish coastal waters

INTRODUCTION

The phytoplankton studies in Turkish seas began in 1950's, and its number increased, especially since 1980's and 1990's. The first detailed checklist of phytoplankton species of Turkish seas was prepared by Koray (1). Furthermore, the first detailed checklist of phytoplankton species of the Sea of Marmara was prepared by Balkis (2). New records of species have been added to this checklist in the studies in the following years (3-9).

Turkish seas contain the southern Black Sea, Sea of Marmara, eastern Aegean Sea and northeastern Mediterranean Sea, each of which has different ecological features. The Sea of Marmara (SoM), where this study was conducted, is a semi-enclosed inland sea and transition

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zone between Mediterranean Sea and Black Sea, with a surface area of 11,500 km^2 and a maximum depth of 1390 m. It connects to the Black Sea by the İstanbul Strait and to the Aegean Sea by the Çanakkale Strait. The SoM has a two-layer water system; the upper layer water with low salinity (~18) coming from the Black Sea with nutrient-rich water and lower layer water with high salinity (~38) coming from the Mediterranean Sea, and it has a strong intermediate layer at a depth of ~25m. The vertical mixing in the SoM is limited as a result of two-layered system. The oceanographic conditions in the SoM are controlled by the two straits (10-13). Oxygen consumption increases in the lower layer due to the decomposition of organic particles coming from the upper layer, the oxygen level is regulated by the Mediterranean water content which has a rich oxygen level (13). However, the organic material on the surface has been carried to the benthic region with time. This case led to a decrease in dissolved oxygen in the bottom layer. It is determined that the mucilage material is rich in terms of carbohydrate and protein in the intense mucilage period (14), and the dominant microalgae responsible for the formation were reported (7, 15).

This study presents a list of the microalgae species recorded for the first time for Turkish seas with their descriptions during the studies conducted in the Sea of Marmara in 2021, when intense mucilage was observed, and also 2022, when mucilage formation disappeared. In addition, new records of microalgae species also for the Sea of Marmara and the Aegean Sea were listed in this study. It is considered that new records in microalgae during this study period will provide an important contribution for both the microalgae checklists of Turkish seas and the Sea of Marmara.

MATERIALS AND METHODS

In this study, which was carried out at 16 sampling stations (Sts. 1-16) in the Sea of Marmara and one station in the Aegean Sea (St. 17), samples were collected from different depths (especially 0.5 m) during and after an intense mucilage period from March 2021 to June 2022 (Figure 1). For identifications and enumerations of microalgae species, samples were taken from mucilage aggregates at stations that have dense mucilage and also were collected with plankton nets with 20 and 40 µm mesh sizes, and Niskin bottles at stations that have less mucilage.

The net samples collected for qualitative analysis of microalgae species were fixed with a neutral formaldehyde solution (2-4%) and examined under the Olympus BX51 bright-field microscope at magnifications of 100, 200, 400 and 1000× (with immersion oil). The water samples collected for quantitative analysis of microalgae species were fixed with an acidic Lugol-iodine solution (2%) (16) and the samples were sedimented in accordance with the Utermohl sedimentation technique (17). After the sedimentation, upper water was removed and the sample was concentrated up to 10 mL (18). The homogenized subsample of one ml was taken and counted under the "Olympus CK2" model phase-contrast inverted microscope using the Sedgewick-Rafter counting chamber (19).

Furthermore, microalgae species were also examined with an FEI Versa 3D model scanning electron microscope (SEM). Samples

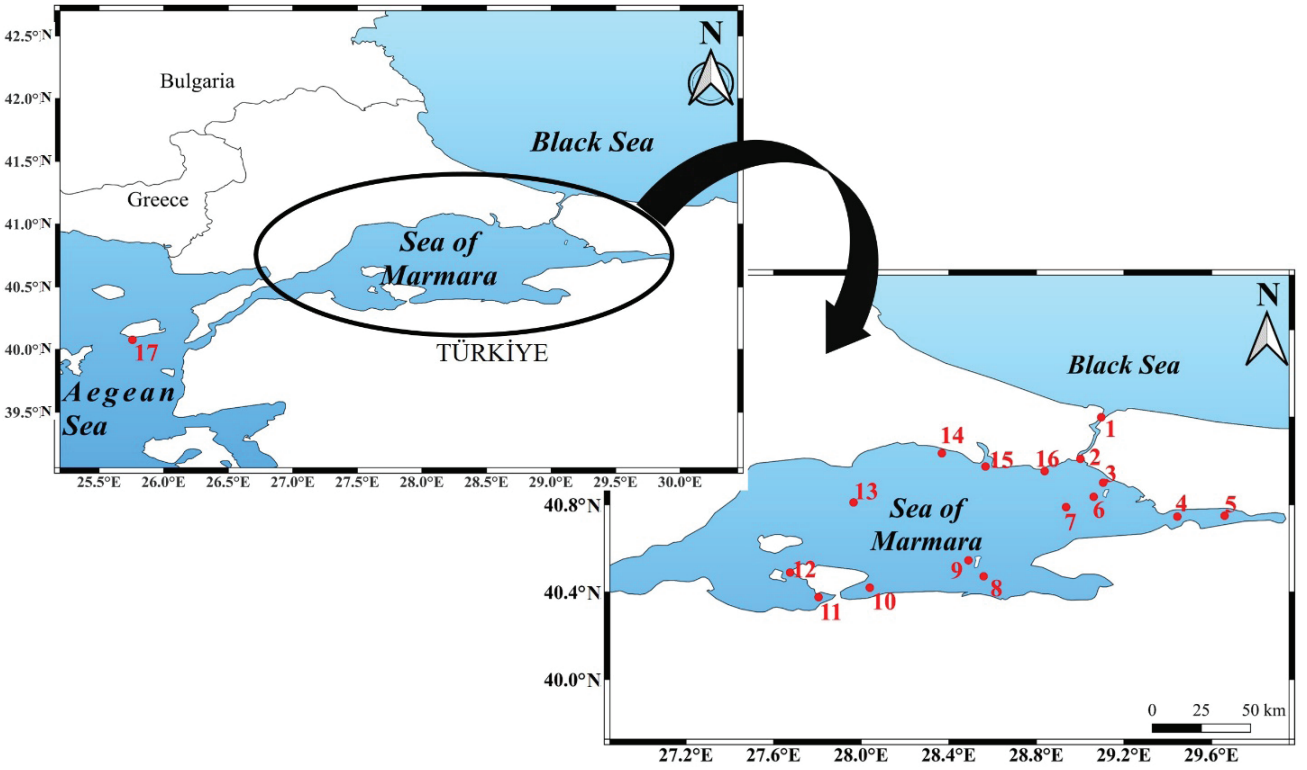

Figure 1. Sampling stations in the Sea of Marmara and Aegean Sea.

were digested with acids (HCl and H_2O_2) for Bacillariophyceae members (20, 21). In the classes, except for Bacillariophyceae, SEM imaging was performed after the fixation of samples with osmium tetroxide (OsO_4). For this, the samples were fixed with OsO_4 at a final volume of 2% during the field and kept at +4°C in the dark until analysis. Afterwards, the samples, which were desalted by washing several times with distilled water, were passed through various volumes of ethanol series (20, 40, 60, 80, and 95%) for dehydration (22) and transferred to stubs which had carbon bands on them. They were left to dry for half an hour in an oven at 50°C. The stubs were kept in desiccators for 30 minutes to remove moisture, then coated with platinum for 90 seconds.

Taxonomic classifications were made as Heimdal (23), Throndsen (24), Hasle & Syvertsen (25) Steidinger & Tangen (26) and World Register of Marine Species (27) and Algaebase (28) were used for the current nomenclatures of species. For the identifications of species, the sources used were as follows: Cleve (29), Schmidle (30), Hustedt (31), Gantt & Conti (32), Bukry (33), Fukuyo (34), Vørs (35), Heimdal (23), Throndsen (24), Hasle & Syvertsen (25), Steidinger & Tangen (26) 1997, Young et al. (36), Haywood et al. (37), Fresnel & Probert (38), Hoppenrath et al. (39), Takano & Matsuoka (40), Idei et al. (41), Hardardóttir et al. (42), Han et al. (43), Young et al. (44).

RESULTS

Group Composition

Phytoplankton biodiversity obtained from the water and net samples examined during this study showed that a total of 25 taxa belonging to 13 taxonomic classes were recorded for the first time for Turkish seas. Seven taxa among them were at the genus level. Two taxa among them were freshwater or brackish water form. The distribution of the new record taxa by classes is as follows: Bacillariophyceae and Dinophyceae with four taxa, Prymnesiophyceae with seven taxa and each of other classes (Chrysophyceae, Xanthophyceae, Pelagophyceae, Raphidophyceae, Euglenophyceae, Pyramimonadophyceae, Ulvophyceae, Zygnematophyceae, Florideophyceae and Porphyridiophyceae) included one taxon (Table 1; Figures 2-9).

Table 1. The list of new record taxon in the Turkish coastal waters, the Sea of Marmara and Aegean Sea. (*indicates the potentially toxic species, ** indicates harmful species, and *indicates freshwater species)

No	TAXON	New Record for Turkish Coastal Waters	New Record for Sea of Marmara	New Record for Aegean Sea
	CYANOPHYTA			
	Cyanophyceae			
1	**Aphanocapsa delicatissima* West & G.S.West, 1912		✓	
2	**Glaucospira* sp.		✓	
3	*Richelia intracellularis* Schmidt, 1901		✓	
4	*Stigonema* sp.		✓	
	Total Number of Cyanophyceae	0	4	0
	CHROMOPHYTA			
	Bacillariophyceae			
1	*Auricula* sp.	✓	✓	
2	**Craticula cuspidata* (Kutzing) D.G.Mann, 1990		✓	
3	*Cyclophora* sp.		✓	
4	*Diploneis* cf. *papula* (A.W.F.Schmidt) Cleve, 1894			✓
5	*Donkinia* sp.	✓	✓	
6	*Eucampia* cf. *groenlandica* Cleve, 1896	✓	✓	
7	**Fragilaria crotonensis* Kitton, 1869		✓	
8	*Licmophora* cf. *inflata* Mereschkowsky, 1901	✓	✓	
9	**Synedra famelica* Kützing, 1844= *Fragilaria famelica*		✓	

Table 1. The list of new record taxon in the Turkish coastal waters, the Sea of Marmara and Aegean Sea. **(continued)**
(*indicates the potentially toxic species, ** indicates harmful species, and *indicates freshwater species)

No	TAXON	New Record for Turkish Coastal Waters	New Record for Sea of Marmara	New Record for Aegean Sea
10	*Triceratium antediluvianum* (Ehrenberg) Grunow, 1868= *Biddulphia antediluviana*		✓	
	Total Number of Bacillariophyceae	4	9	1
	Dinophyceae			
1	*Amoebophrya ceratii* (Koeppen) J.Cachon, 1964	✓	✓	
2	**Amphidinium carterae* Hulburt, 1957		✓	
3	*Amphidinium crassum* Lohmann, 1908		✓	
4	**Amphidinium operculatum* Claparède & Lachmann, 1859		✓	
5	**Coolia monotis* Meunier, 1919		✓	
6	*Diplopelta asymmetrica* (Mangin) M.Lebour ex Balech 1988= *Dissodium asymmetricum*		✓	
7	*Heterocapsa minima* A.J.Pomroy, 1989		✓	
8	*Heterocapsa niei* (Loeblich III) Morrill & Loeblich III, 1981		✓	
9	*Heterocapsa pygmaea* Lobelich III, R.J.Schmidt & Sherley, 1981		✓	
10	**Karenia* cf. *brevis* (Davis) Hansen & Moestrup, 2000		✓	
11	**Karenia* cf. *mikimotoi* (Oda) Hansen & Moestrup, 2000		✓	
12	**Karenia* cf. *selliformis* Haywood, Steidinger & MacKenzie, 2004	✓	✓	
13	**Ostreopsis* sp.		✓	
14	*Oxytoxum caudatum* Schiller, 1937		✓	
15	*Oxytoxum* cf. *longum* Schiller, 1937		✓	
16	*Oxytoxum mediterraneum* Schiller, 1937		✓	
17	*Prorocentrum* cf. *emarginatum* Fukuyo, 1981	✓	✓	
18	*Prorocentrum shikokuense* Hada, 1975	✓	✓	
19	*Pyrocystis* cf. *fusiformis* Thomson, 1876		✓	
20	*Pyrocystis pseudonoctiluca* Wyville-Thompson, 1876		✓	
21	*Spatulodinium pseudonoctiluca* (Pouchet) J.Cachon & M.Cachon, 1968		✓	
22	*Tripos azoricus* (Cleve) F.Gómez, 2013		✓	
23	*Tripos hexacanthus* (Gourret) F.Gómez, 2013		✓	
24	*Tripos vultur* (Cleve) Hallegraeff & Huisman, 2020		✓	
	Total Number of Dinophyceae	4	24	0
	Raphidophyceae			
1	*Olisthodiscus* sp.	✓	✓	

Table 1. The list of new record taxon in the Turkish coastal waters, the Sea of Marmara and Aegean Sea. **(continued)**
(*indicates the potentially toxic species, ** indicates harmful species, and *indicates freshwater species)

No	TAXON	New Record for Turkish Coastal Waters	New Record for Sea of Marmara	New Record for Aegean Sea
	Total Number of Raphidophyceae	1	1	0
	Chrysophyceae			
1	***Chrysophaeum taylorii* Lewis & Bryan, 1941**		✓	
2	*Kephyrion* sp.		✓	
3	*Ollicola* cf. *vangoorii* (W.Conrad) Vørs, 1992= *Calycomonas wulfii*	✓	✓	
	Total Number of Chrysophyceae	1	3	0
	Xanthophyceae			
1	*Meringosphaera mediterranea* Lohmann, 1903	✓	✓	
	Total Number of Xanthophyceae	1	1	0
	Pelagophyceae			
1	*Sarcinochrysis marina* Geitler, 1930	✓	✓	
	Total Number of Pelagophyceae	1	1	0
	Prymnesiophyceae			
1	**Chrysochromulina* sp.		✓	
2	*Corisphaera* sp.	✓	✓	
3	*Dicrateria* sp.	✓	✓	
4	*Discosphaera tubifer* (G.Murray & V.H.Blackman) Ostenfeld, 1900		✓	
5	*Gephyrocapsa oceanica* Kamptner, 1943	✓	✓	
6	*Hayaster perplexus* (Bramlette & Riedel) Bukry, 1973	✓	✓	
7	*Helladosphaera cornifera* (J.Schiller) Kamptner, 1937= *Syrachosphaera cornifera*	✓	✓	
8	**Ochrosphaera neapolitana* Schussnig, 1930	✓	✓	
9	**Phaeocystis globosa* Scherffel, 1899		✓	
10	*Scyphosphaera apsteinii* Lohmann, 1902		✓	
11	*Umbilicosphaera sibogae* (Weber Bosse) Gaarder, 1970	✓	✓	
	Total Number of Prymnesiophyceae	7	11	0
	CHLOROPHYTA			
	Euglenophyceae			
1	*Astasia* sp.	✓	✓	
2	**Lepocinclis acus* (O.F.Müller) B.Marin & Melkonian, 2003= *Euglena acusformis*		✓	
3	**Trachelomonas* sp.		✓	

Table 1. The list of new record taxon in the Turkish coastal waters, the Sea of Marmara and Aegean Sea. **(continued)**
(*indicates the potentially toxic species, ** indicates harmful species, and *indicates freshwater species)

No	TAXON	New Record for Turkish Coastal Waters	New Record for Sea of Marmara	New Record for Aegean Sea
	Total Number of Euglenophyceae	1	3	0
	Pyramimonadophyceae			
1	*Pyramimonas* cf. *diskoicola* Hardardóttir, N.Lundholm, Moestrup & T.G.Nielsen, 2014	✓	✓	
	Total Number of Pyramimonadophyceae	1	1	0
	Trebouxiophyceae			
1	**Crucigenia* sp.		✓	
	Total Number of Trebouxiophyceae	0	1	0
	Chlorophyceae			
1	**Scenedesmus acuminatus* (Lagerheim) Chodat, 1902= *Tetradesmus lagerheimii*		✓	
	Total Number of Chlorophyceae	0	1	0
	Ulvophyceae			
1	*Binuclearia lauterbornii =Planctonema lauterbornii* (Schmidle) Proshkina-Lavrenko, 1966	✓	✓	
	Total Number of Ulvophyceae	1	1	0
	CHAROPHYTA			
	Zygnematophyceae			
1	**Cosmarium* sp.		✓	
2	**Staurastrum tetracerum* Ralfs ex Ralfs, 1848	✓	✓	
	Total Number of Zygnematophyceae	1	2	0
	RHODOPHYTA			
	Florideophyceae			
1	**Batrachospermum* sp.	✓	✓	
	Total Number of Florideophyceae	1	1	0
	Porphyridiophyceae			
1	*Porphyridium purpureum* (Bory) K.M.Drew & R.Ross, 1965	✓	✓	
	Total Number of Porphyridiophyceae	1	1	0
	Total Number of Phytoplankton Species	**25**	**65**	**1**

Furthermore, a total of 65 taxa belonging to 14 taxonomic classes were recorded for the first time for the Sea of Marmara. In addition, one new record taxon (*Diploneis* cf. *papula*) was detected for the Aegean Sea. Sixteen taxa were at the genus level. Twelve taxa among these were freshwater or brackish water form.

The distribution of the new record taxa by classes is as follows: Cyanophyceae with four taxa (Figure 5), Bacillariophyceae with nine taxa (Figures 2, 8), Dinophyceae with 24 taxa (Figures 3, 4), Chrysophyceae with three taxa (Figure 5), Prymnesiophyceae with 11 taxa (Figures 6, 9), Euglenophyceae with three taxa (Figure

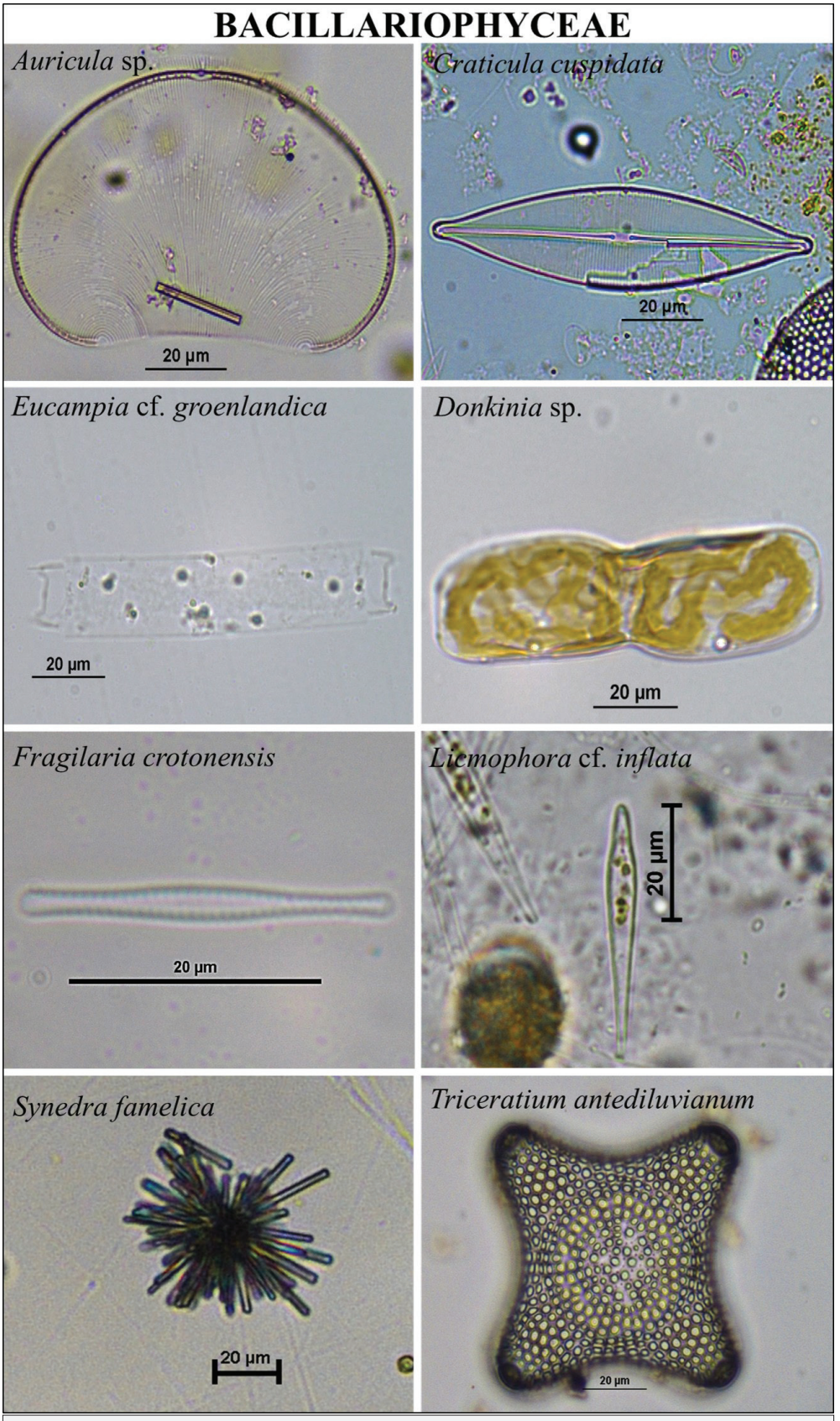

Figure 2. The images of new record Bacillariophyceae species were taken with a bright-field microscope.

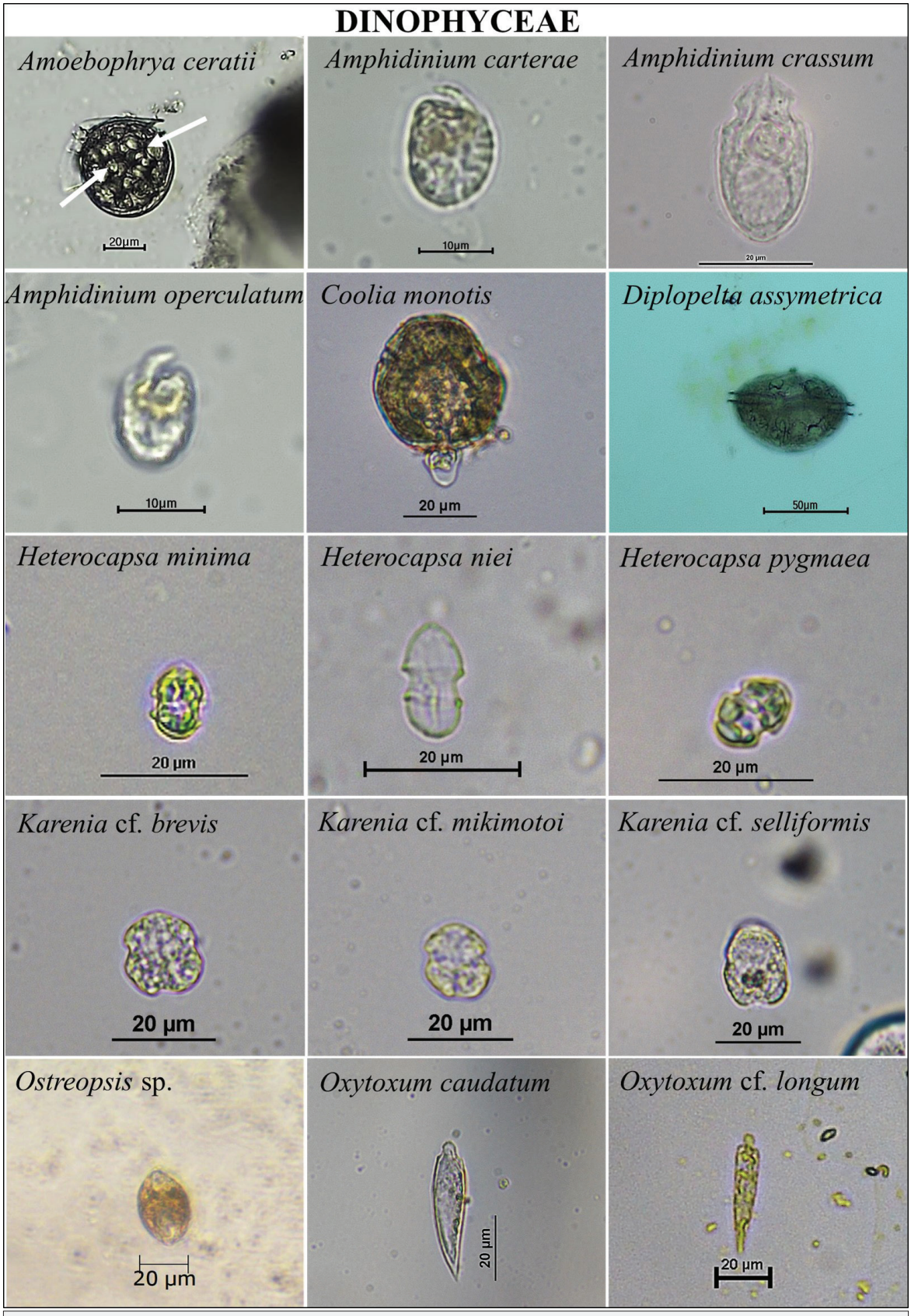

Figure 3. The images of new record some Dinophyceae species were taken with a bright-field microscope (arrows indicate the cells of the species).

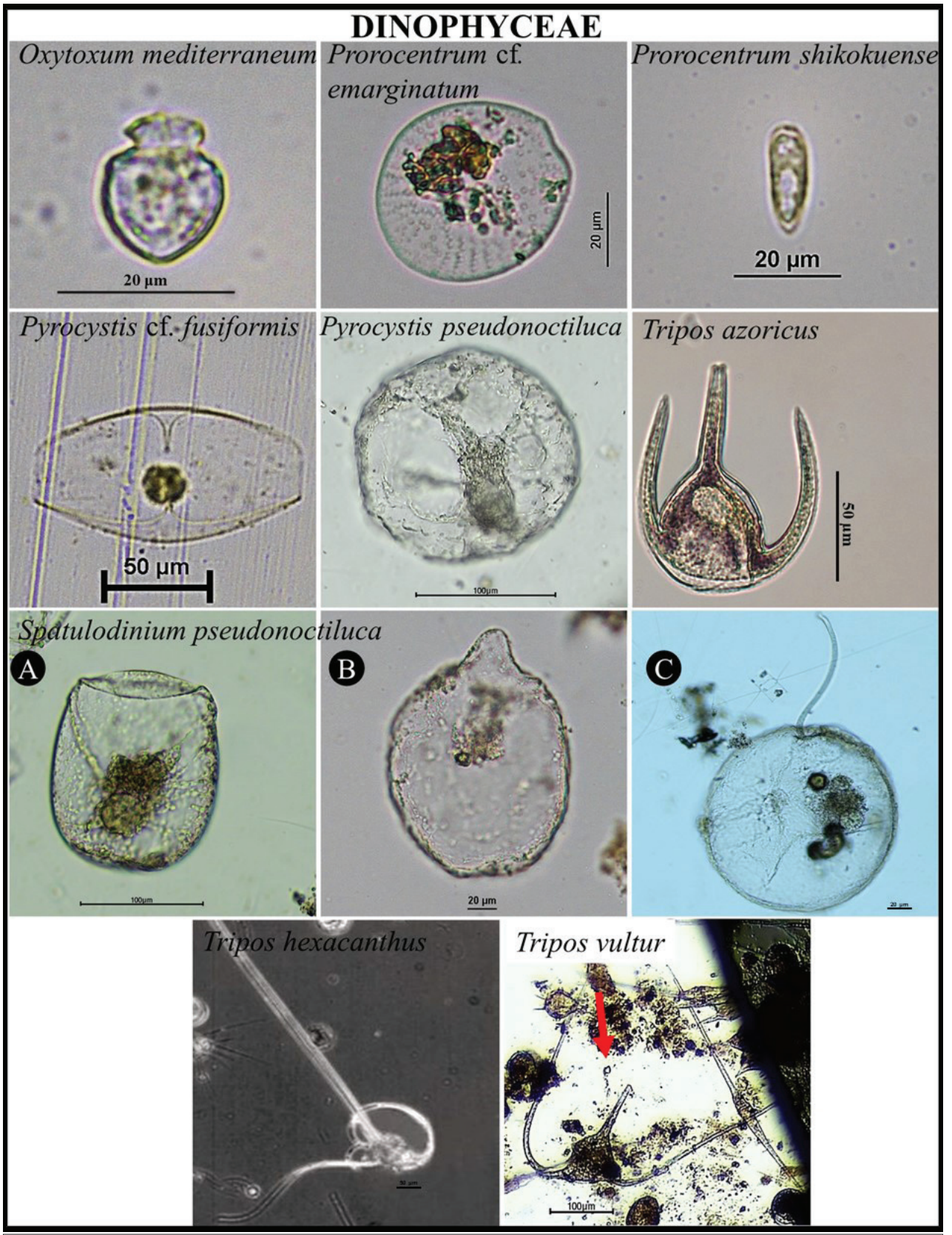

Figure 4. The images of new record other Dinophyceae species were taken with a bright-field microscope (arrow indicates the species; A-C show the different morphological stages of *S. pseudonoctiluca*).

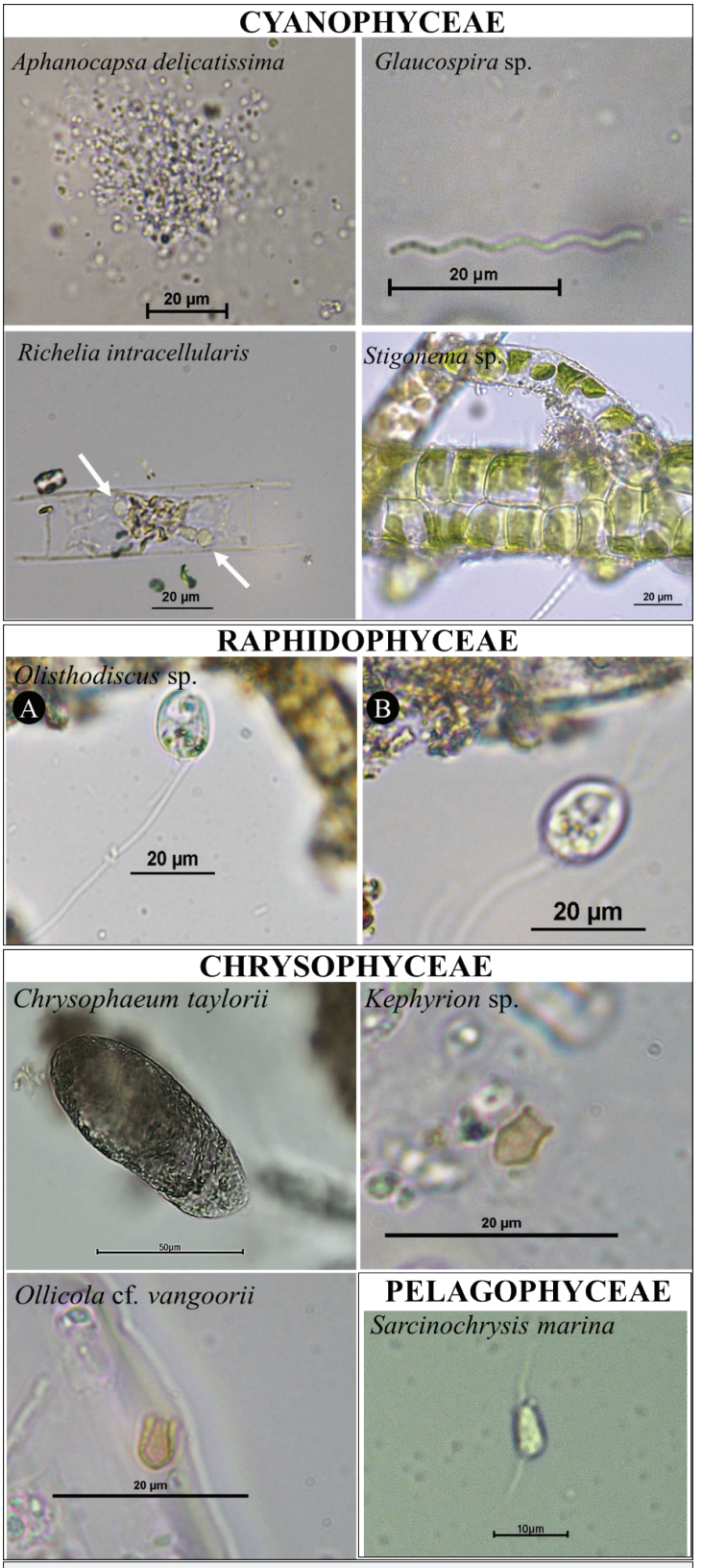

Figure 5. The images of new record Cyanophyceae, Raphidophyceae, Chrysophyceae and Pelagophyceae species were taken with a bright-field microscope (arrows indicate the heterocysts of *R. intracellularis*; A-B show the different images of *Olisthodiscus* sp.).

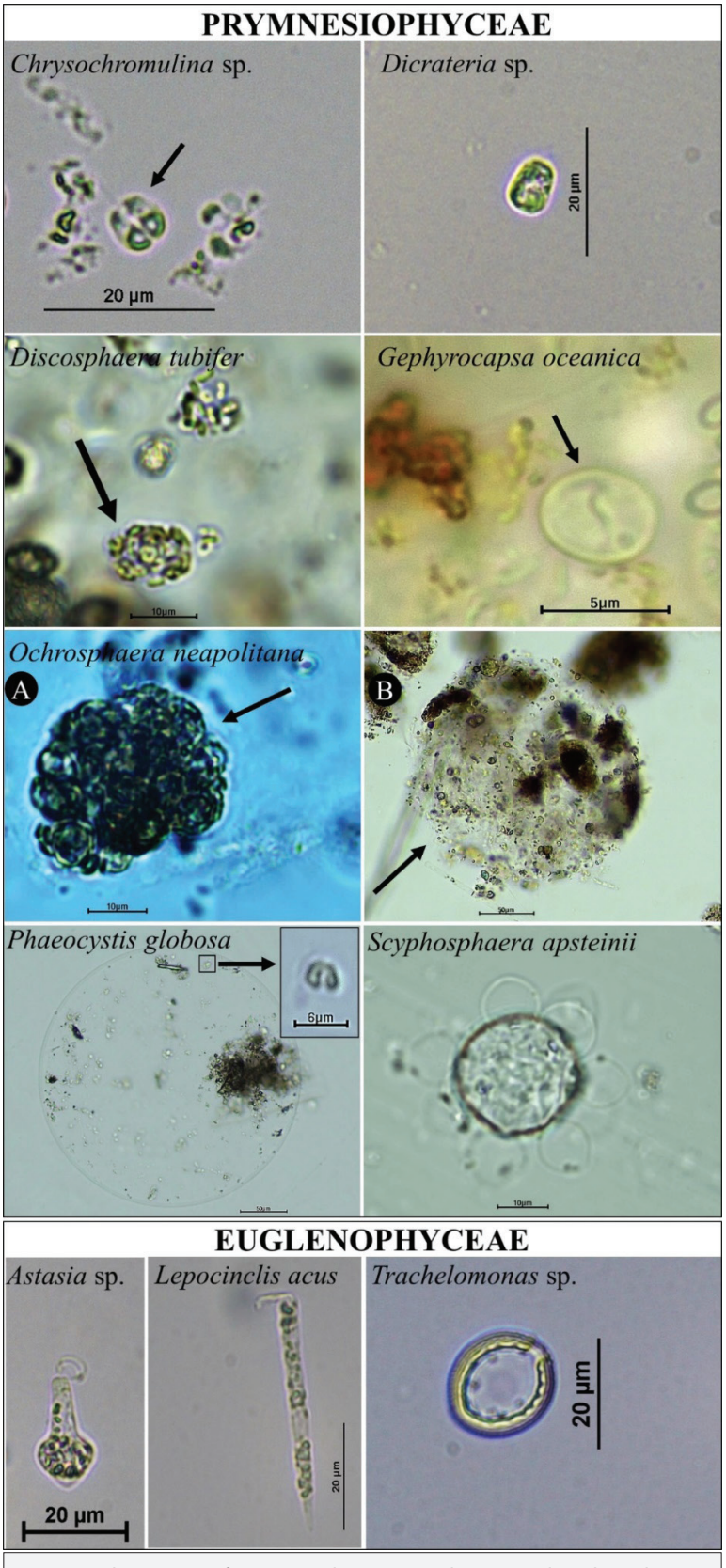

Figure 6. The images of new record Prymnesiophyceae and Euglenophyceae species were taken with a bright-field microscope (arrows indicate the cells/colony of species; A-B show the different colonial view of *O. neapolitana*).

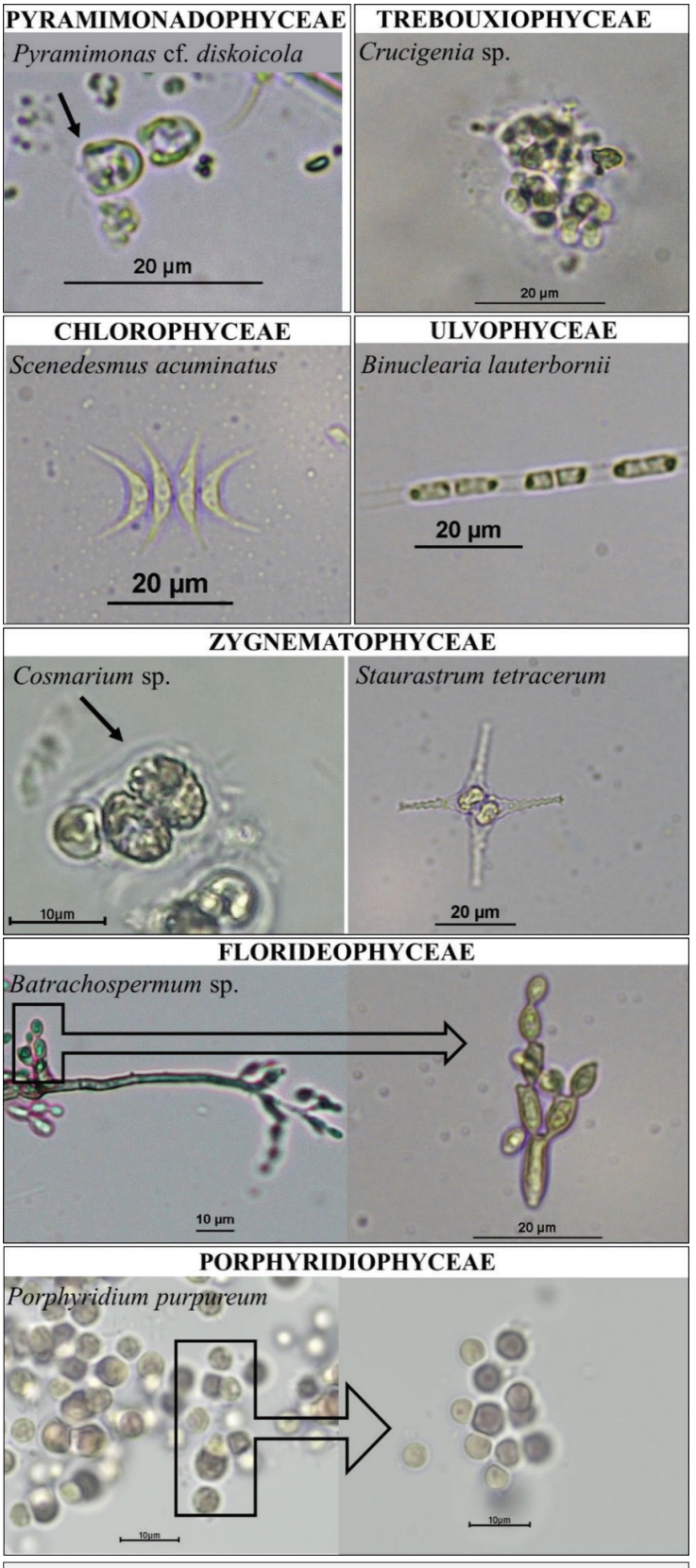

Figure 7. The images of new record other microalgae species were taken with a bright-field microscope (arrows indicate the cells/colony of species).

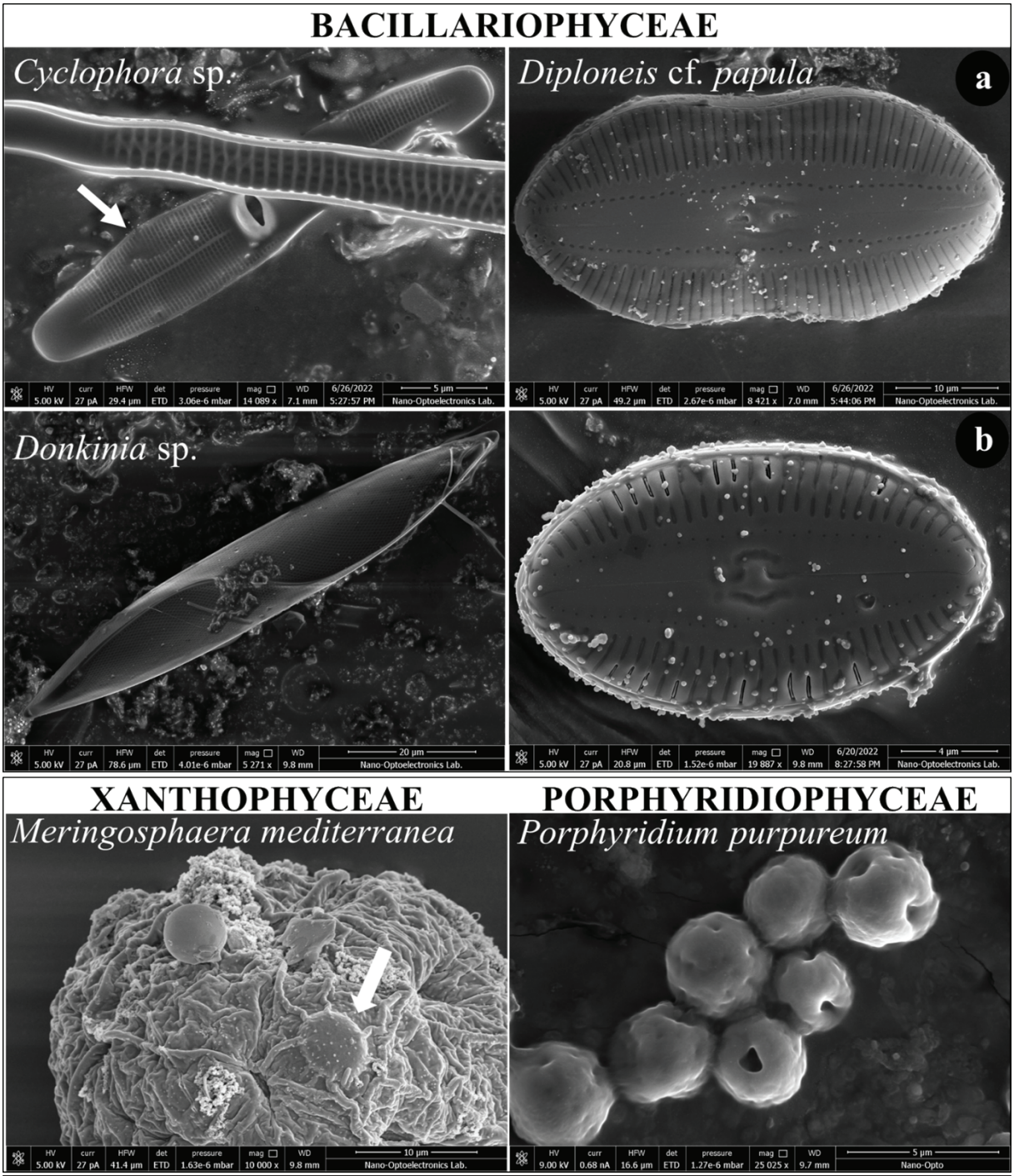

Figure 8. The images of new record Bacillariophyceae, Xanthophyceae and Porphyridiophyceae species were taken with the scanning electron microscope (arrows indicate the cells of species; a-b shows the different images of *Diploneis* cf. *papula*).

6), Zygnematophyceae with two taxa (Figure 7) and each of other classes (Xanthophyceae, Pelagophyceae, Raphidophyceae, Pyramimonadophyceae, Trebouxiophyceae, Chlorophyceae, Ulvophyceae, Florideophyceae and Porphyridiophyceae; Figures 5-8) included one taxon (Table 1).

Eleven species among these 66 new record taxa were potentially toxic and/or harmful microalgae (45-49). These toxic species (*Amphidinium carterae, A. operculatum, Coolia monotis, Karenia* cf. *brevis, K.* cf. *mikimotoi, K.* cf. *selliformis, Ostreopsis* sp., *Chrysophaeum taylorii, Chrysochromulina* sp., *Ochrosphaera neapolitana* and *Phaeocystis globosa*) should be monitored carefully. Among these, *Karenia* cf. *selliformis* and *Ochrosphaera neapolitana* were recorded for the first time from Turkish coastal waters.

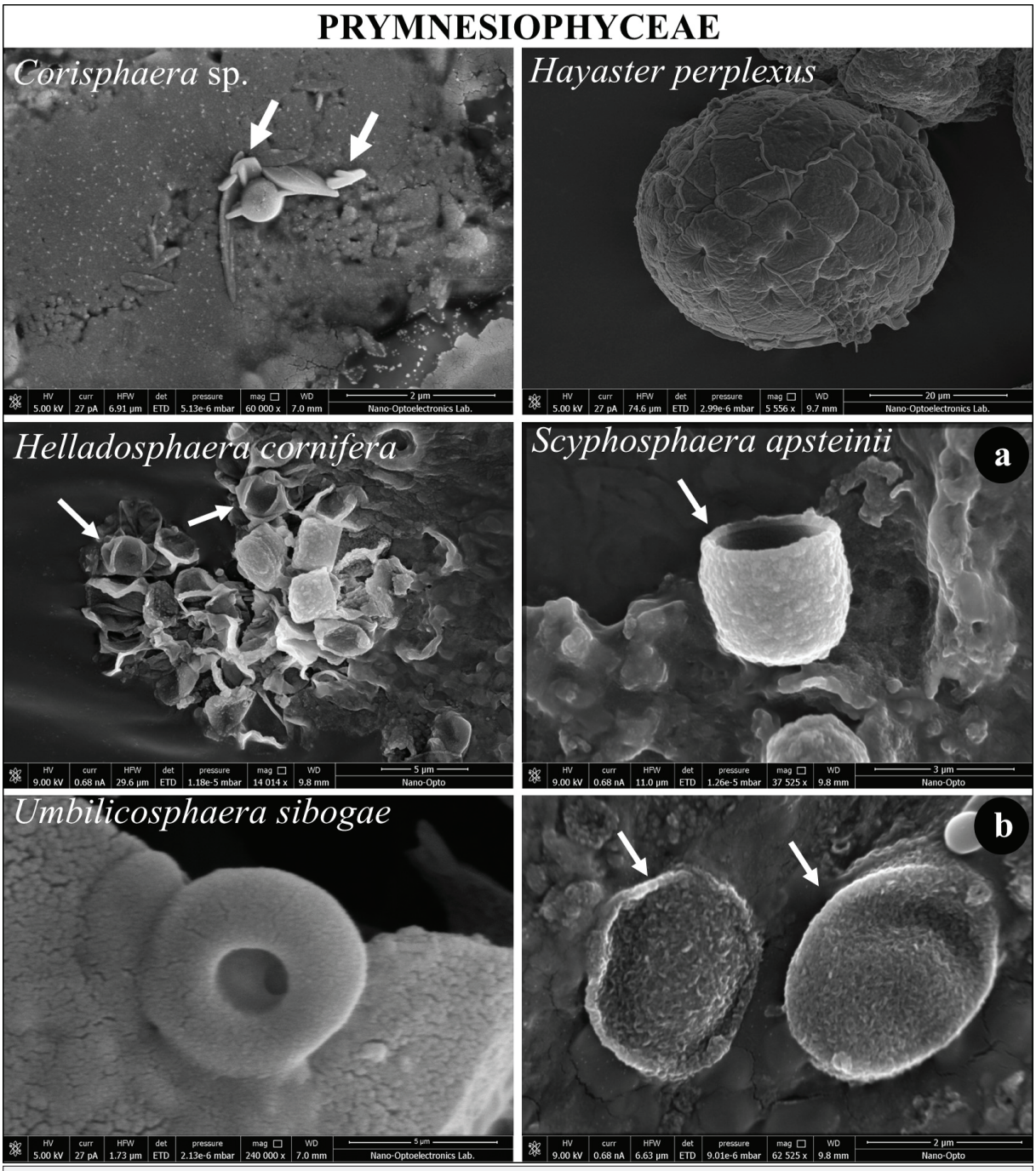

Figure 9. The images of new record Prymnesiophyceae species were taken with the scanning electron microscope (arrows indicate the cells of species; a-b shows the different images of *Scyphosphaera apsteinii*).

Species Descriptions

The descriptive features of the species reported as new records for Turkish coastal waters are given below (species at genus level were not described).

CHROMOPHYTA Christensen (1962); Bourrelly (1968); Hibberd (1972)
Class: BACILLARIOPHYCEAE Haeckel, 1878
Order: Hemiaulales Round & Crawford, 1990
Family: Hemiaulaceae Heiberg, 1863
Genus: *Eucampia* Ehrenberg, 1839

Eucampia* cf. *groenlandica Cleve, 1896

Cells are silicified, curved or straight, spiral chains occasional. Apical length of cells varied between 16.5-18.7 µm and pervalvar axis were 95.6-100.0 µm, as in the literature (25).
Locality: This species was found only in the St.9 (August 2021) and its abundance was 1500 cells L^{-1}.

Order: Licmophorales Round, 1990
Family: Licmophoraceae Kützing, 1844
Genus: *Licmophora* Agardh, 1827

Licmophora* cf. *inflata Mereschkowsky, 1901
Cells are narrow in girdle view, linear-wedge shaped with slightly rounded upper corners as mentioned in Hustedt (31). The cell size was 42.9 µm in length and 6.1 µm in width.
Locality: The cells of this species were found only in plankton net samples in the St.5 (May 2021, the Sea of Marmara).
Class: DINOPHYCEAE Fritsch, 1927
Order: Syndiniales Loeblich III, 1982
Family: Amoebophryaceae Cachon ex Loeblich III
Genus: *Amoebophrya* Koeppen, 1894

Amoebophrya ceratii (Koeppen) Cachon, 1964
Synonym**:** *Hyalosaccus ceratii* Koeppen, 1899
Endocytoplasmic parasitic dinoflagellates which they do not have chloroplasts (39). Their cells were found into the dinoflagellate *Phalacroma rotundatum*. The diameters of these specimens varied between 4.5-8.5 µm.
Locality: The cells of this species were found only in plankton net samples in the Sts.2, 4, and 15 (June 2022, Sea of Marmara).
Order: Gymnodiniales Lemmermann, 1910
Family: Kareniacea Bergholtz, Daugbjerg, Moestrup & Fernández-Tejedor 2005
Genus: *Karenia* Hansen & Moestrup, 2000

Karenia* cf. *selliformis Haywood, Steidinger & MacKenzie, 2004
Epitheca hemispherical flattened or slightly conical and generally smaller than hypotheca; thin oval outline in longitudinal section. The size of cells was 20-32 µm long, and 16-32 µm wide as mentioned in Haywood et al. (37).
Locality: The cells of this species were found only in plankton net samples in the St.5 (May 2021).
Order: Prorocentrales Lemmermann, 1910
Family: Prorocentraceae Stein, 1883
Genus: *Prorocentrum* Ehrenberg, 1834

Prorocentrum* cf. *emarginatum Fukuyo, 1981
An anterior margin is broadly excavated in the valve view of the small and oval cells. There are tiny pores, which are postmedian arranged radially similar to the literature (26). The size of cells was 46-50 µm in length and 43-46 µm in width.
Locality: The cells of this species were found only in plankton net samples in the St.7 (June 2022) and St.9 (August 2021).

Prorocentrum shikokuense Hada, 1975
Synonym**:** *Prorocentrum donghaiense* Lu, 2001
Cells are asymmetric, vary in shape, and are elongated, narrowing toward the posterior ends. Cells were 20.4-22.9 µm long and 7.6-8.1 µm wide, as mentioned in Takano & Matsuoka (40).
Locality: This species was observed in the St.7 (August 2021), and St.16 (June 2021). Its maximum abundance was determined as 2400 cells L^{-1} in the St.16.
Class: CHRYSOPHYCEAE Pascher, 1914
Order: Chromulinales Pascher, 1910
Family: Dinobryaceae Ehrenberg 1834
Genus: *Ollicola* Vørs, 1992

Ollicola* cf. *vangoorii (Conrad) Vørs, 1992
Synonyms: *Calycomonas wulfii* Conrad, 1938; *Calycomonas vangoorii* (Conrad) Lund, 1960; *Codonomonas vangoorii* W.Conrad, 1938
Description: Cells are tiny and have one chloroplast and a lorica. The size of lorica was 6 µm in length and 3 µm in width as mentioned in Vørs (35).
Locality: This species was just recorded in the St.8 (April 2021), and its abundance was 200 cells L^{-1}.
Class: XANTHOPHYCEAE Allorge ex Fritsch, 1935
Order: Mischococcales Fritsch, 1927
Family: Pleurochloridaceae Pascher, 1937
Genus: *Meringosphaera* Lohmann, 1903

Meringosphaera mediterranea Lohmann, 1903
Synonym: *Meringosphaera baltica* Lohmann
Cells spherical, there are long spines and radiating in all directions. The size of cell was 6.2 µm in diameter, and it has six long spines similar to the literaure (24).
Locality: The cells of this species were found only in plankton net samples in the St.6 (May 2022).
Class: PELAGOPHYCEAE Andersen & Saunders in Andersen, Saunders & Paskind, 1993
Order: Sarcinochrysidales Gayral & Billard, 1977
Family: Sarcinochrysidaceae Gayral & Billard, 1977
Genus: *Sarcinochrysis* Geitler, 1930

Sarcinochrysis marina Geitler, 1930
There are two flagella which are two different directions and they are longer than cell length similar to the literaure (24). The cells were 7.2-7.9 µm long and 4.7-5.8 µm wide as mentioned in Han et al. (43).
Locality: The cells of this species were observed in the St.7 (August 2021), and St.13 (August 2021), and its maximum abundance was recorded as 400 cells L^{-1} in the St.13.
Class: PRYMNESIOPHYCEAE Hibbert, 1976
Order: Isochrysidales Pascher, 1910
Family: Noelaerhabdaceae Jerkovic, 1970
Genus: *Gephyrocapsa* Kamptner, 1943

Gephyrocapsa oceanica Kamptner, 1943
Synonym: *Crenalithus doronicoides* P.H.Roth, 1973
Cells are spherical, and the size of the central area and the development of a collar around the distal opening of the central canal may vary (23). The cell was 4.7 µm in length and 3.8 µm in width
Locality: There was just a specimen in the St.14.
Order: Coccolithales Schwarz, 1932
Family: Calcidiscaceae Young & Bown, 1997
Genus: *Hayaster* Bukry, 1973

Hayaster perplexus (Bramlette & Riedel) Bukry, 1973
Synonym: *Discoaster perplexus* Bramlette & Riedel 1954

The coccoliths are polygonal and thin. The distal shield is straight and larger than the proximal one. Crystallites radiate from a simple centre point and are essentially equant (33). The size of coccoliths was between 8.1 and 11.8 µm in diameter as mentioned in Young et al. (44).
Locality: There was just a specimen in the St.6 (May 2022).
Genus: *Umbilicosphaera* Lohmann, 1902

Umbilicosphaera sibogae (Weber Bosse) Gaarder, 1970
Synonyms**:** *Coccolithus sibogae* (Weber Bosse) Schiller; *Coccosphaera sibogae* Weber Bosse, 1901; *Cyclococcolithus sibogae* (Weber Bosse) Gaarder, 1959; *Umbilicosphaera mirabilis* (Lohmann) Lohmann, 1902
The coccoliths are circular, and the centre is open and broad. The size of the cell was 6.4 µm in diameter and central aperture was 2.3 µm similar to the literature (36).
Locality: There was just one coccolith in the St.1
Family: Calyptrosphaeraceae Boudreaux & Hay, 1969
Genus: *Helladosphaera* Kamptner, 1937

Helladosphaera cornifera (Schiller) Kamptner, 1937
Synonym: *Syracosphaera cornifera* Schiller, 1913
The coccoliths are helladoliths consisting of an oval tube, about 1.5 µm long and 1.0 µm wide, with a thin bridge on each coccolith as mentioned in Heimdal (23). The size of cells was between 2.5-2.7 µm in length and 2.0-2.1 µm in width.
Locality: There was just a specimen in the St.4 (May 2022).
Family: Hymenomonadaceae Senn, 1900
Genus: *Ochrosphaera* Schussnig, 1930

Ochrosphaera neapolitana Schussnig, 1930
Synonym: *Ochrosphaera verrucosa* Schussnig, 1940
Cells are surrounded by a single layer of tremaliths and are circular in the distal view. Cells are 5-12 µm in diameter (38). The size of our samples were between 6.8-7.2 µm in diameter.
Locality: The coccoliths of this species were observed in the St.2 and St.15 (May 2022).
CHLOROPHYTA Reichenbach, 1834
Class: PYRAMIMONADOPHYCEAE Moestrup & Daugbjerg, 2019
Order: Pyramimonadales Chadefaud, 1950
Family: Pyramimonadaceae Korshikov, 1938
Genus: *Pyramimonas* Schmarda, 1849

Pyramimonas* cf. *diskoicola Hardardóttir, Lundholm, Moestrup & Nielsen, 2014
The cells elongate with parallel sides and are distinctly longer than wide. The four flagella are equal, slightly longer than the body, and located in the apical area. The cells were 6.2-7.3 µm in length and 4.9-5.2 µm in width similar to the literature (42).
Locality: This species was observed only in the St.9 (April 2021), and its abundance was 500 cells L^{-1}.
Class: ULVOPHYCEAE Mattox & Stewart, 1978
Order: Ulotrichales Borzi, 1895
Family: Gloeotilaceae Ettl & Gärtner, 1995
Genus: *Binuclearia* Wittrock, 1886

Binuclearia lauterbornii (Schmidle) Proshkina-Lavrenko, 1966
Synonym: *Planctonema lauterbornii* Schmidle, 1903
This species has a multicellular unbranched filament. Cells are cylindrical, and the chloroplasts are usually band-shaped and parietal positioned. The size of cells was 11.2-12.7 µm in length, and 3.1 µm in width similar to the literature (30).
Locality: This species was observed in the St.8 (April 2021), 10 (April 2021), 12 (May 2021), and 15 (June 2022). The maximum abundance was detected in the St.12 as 5000 cells L^{-1}.
CHAROPHYTA Migula, 1889
Class: ZYGNEMATOPHYCEAE Round ex Guiry, 2013
Order: Desmidiales Bessey, 1907
Family: Desmidiaceae Ralfs, 1848
Genus: *Staurastrum* Meyen ex Ralfs, 1848

Staurastrum tetracerum Ralfs ex Ralfs, 1848
Cell was deeply constricted and sinus V- or U-shaped. The semi-cell body was usually bowl-shaped to rectangular. The cell body had some spines on it as mentioned in Coesel & Meesters (50). The length of cell was 20 µm in length and 5 µm in width
Locality: This species was only observed in the plankton net sample of St.10 (April 2021).
RHODOPHYTA, Wettstein, 1901
Class: PORPHYRIDIOPHYCEAE Shameel, 2001
Order: Porphyridiales Kylin, 1937
Family: Porphyridiaceae Kylin, 1937
Genus: *Porphyridium* Nägeli, 1849

Porphyridium purpureum (Bory) K.M.Drew & R.Ross, 1965
Synonym**:** *Aphanocapsa cruenta* (Smith) Hansgirg, 1885; *Byssus purpurea* Lamarck, 1778; *Chaos sanguinarius* Bory ex Desmazières, 1823; *Coccochloris cruenta* (Smith) Sprengel, 1827; *Merrettia purpurea* (Bory) Trevisan, 1848; *Olivia cruenta* Gray, 1821; *Palmella cruenta* (Smith) Agardh, 1824; *Phytoconis cruenta* (Smith) Trevisan, 1842; *Phytoconis purpurea* Bory de Saint-Vincent, 1797; *Porphyridium cruentum* (Gray) Nägeli, 1849; *Porphyridium marinum* Kylin, 1937; *Sarcoderma sanguineum* Ehrenberg; *Tremella cruenta* Smith, 1807
The cells could be single or irregular colonies and circular-shaped. The cells include a single chloroplast. The size of cells was 3.4-5.0 µm in diameter, as showed in Gantt & Conti (32).
Locality: This species was only observed in the plankton net samples of St.11 (December 2021).

DISCUSSION

Phytoplankton are primary producers in the food chain and their biodiversity is important for a healthy functioning of marine ecosystem. The number of microalgae species of a certain region can give us some important information about its ecological status. So, it may be said that an increase in biodiversity in the microalgae community in the marine environment will have a positive effect on its water quality. Therefore, the revealing of phytoplanktonic biodiversity has a very importance meaning in the marine ecosystem.

The most comprehensive check-list of microalgae of Turkish seas was created in 2001 (1). Koray (1) listed 7 prokaryotic and 485 eukaryotic microalgae taxa in his study. It is considered that this number of microalgae taxa has increased significantly in the studies carried out in the Sea of Marmara in the last two decades. In the present study conducted in the Sea of Marmara and the Aegean Sea, 25 microalgae taxa were recorded for the first time for Turkish seas. The addition of these new record taxa will provide an important contribution to the check-list of microalgae of Turkish seas.

The most detailed check-list study covered the Sea of Marmara with the Turkish Straits System and was achieved by Balkis & Tas (3), and at total of 333 microalgae taxa were reported. The new record taxa continued to be reported also after 2016 (4-6, 8). With the contribution of these studies, the number of microalgae known to exist in the Sea of Marmara increased to 348. Four more taxa were recorded for the first time during the mucilage event in the Sea of Marmara in 2021 (7, 9). With the addition of 65 more taxa identified in the present study, the recorded number of taxa in the Sea of Marmara increased to 417. In addition, a total of 452 benthic diatom species was reported in a study conducted in the Sea of Marmara (51). However, the researchers (51) have not been provided any descriptive information and images on the new recorded species for the Turkish seas and the Sea of Marmara.

The increase of the number of taxa for Turkish seas including the Sea of Marmara will provide an important contribution. In addition, it should be taken into account that there were some potentially toxic and/or harmful species among the new recorded species. Among the new recorded taxa during this study period, 2 of 25 taxa for Turkish seas and 9 taxa within 65 taxa for the Sea of Marmara were detected as potentially toxic and/or harmful. Among these, *Phaeocystis globosa, Chrysophaeum taylorii, Ochrosphaera neopolitana, Coolia monotis* and *Ostreopsis* spp. are species that are able to produce mucilage, and it was suggested that other species belonging the genus *Phaeocystis* (*P. pouchettii*) were responsible from mucilage on the surface (7). It has been reported that *Chrysophaeum taylorii*, observed for the first time in the Aegean Sea in 2011, was a new record for Turkish coastal waters (47). This species is known to cause the mucilage phenomenon in benthic regions, especially in the Atlantic and Western Pacific coasts. *Ochrosphaera neopolitana* is observed frequently in the littoral zones of seas, and it is a known species from especially the North Atlantic, Indian Ocean and Mediterranean Sea (38). Along with this species, some coccolithophores are able to produce TEP (Transparent Exopolymer Particulate) and DMSP (Dimethylsulfoniopropionate). These species are able to produce TEP at the growth phase stage in haploid and diploid life stages and in a viral infection (48, 52). *Ostreopsis* sp., one of the toxic species among them, is an epiphytic/epibenthic species and displays a distribution in a coastal area (53). One of the toxic species of this genus is *Ostreopsis ovata* and it was reported for the first time in Turkish coastal areas from the Aegean Sea (54). *Coolia monotis*, a benthic species, can form bloom and excretes mucilage in different amounts in certain environmental conditions (55). This species produces a polyether toxin (a mono-sulphated polyether compounds; Cooliatoxin) from a monosulfate polyether from bioactive compounds (56). Moreover, it has been detected that *Coolia monotis* with *Amphidinium carterae*, are other harmful algal bloom species recorded in a previous study (57). Considering their possible negative effects on the marine ecosystem, these harmful microalgae should be monitored carefully with the main environmental factors.

CONCLUSION

The observation of the new microalgae species in the present study carried out in the Sea of Marmara indicates that microalgae species may be used as indicator organisms depending on the various environmental conditions. The remarkable changes in the phytoplankton composition indicate the probable effect of climate change. The increase of freshwater inflows, carried by streams after terrestrial runoffs following the precipitation, causes an increase in the freshwater microalgae species in marine ecosystems. It is considered that the changes in the phytoplankton composition in the study area were a result of the effect of the environmental conditions. Furthermore, potentially toxic and/or harmful species detected among the new recorded taxa during this study should be monitored carefully accompanied by the environmental factors affecting their abundance.

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