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Four new records for the benthic diatoms (genera *Cocconeis, Seminavis, Synedra*, and *Trachysphenia*) from the Aegean Sea

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Abstract: *Cocconeis pseudomarginata* W.Greg., *Seminavis robusta* Danielidis & D.G.Mann, *Synedra gaillonii* (Bory) Ehrenb. var. *macilenta* (Grunow) H.Perag., and *Trachysphenia australis* Petit var. *rostellata* Hust. from Bacillariophyceae were reported for the first time from Turkish coastal waters. Additionally, *Synedra gaillonii* var. *macilenta* and *Trachysphenia australis* var. *rostellata* were the first records at variety level for Mediterranean coasts. Morphological characteristics of these species were given in detail, and information on their distribution was provided.

Key words: Bacillariophyceae, benthic diatom, morphometric data, Mediterranean

Ege Denizinden bentik diyatomlara (cinsler *Cocconeis, Seminavis, Synedra* ve *Trachysphenia*) ait dört yeni kayıt

Özet: Bacillariophyceae sınıfı üyelerinden *Cocconeis pseudomarginata* W.Greg., *Seminavis robusta* Danielidis & D.G.Mann, *Synedra gaillonii* (Bory) Ehrenb. var. *macilenta* (Grunow) H.Perag. ve *Trachysphenia australis* Petit var. *rostellata* Hust. Türkiye kıyısal sularında ilk kez rapor edilmiştir. Aynı zamanda *Synedra gaillonii* var. *macilenta* ve *Trachysphenia australis* var. *rostellata* varyete düzeyinde Akdeniz kıyıları için ilk kayıttır. Bu türlerin morfolojik özellikleri ayrıntılı olarak açıklanmış ve dağılımları ile ilgili bilgiler verilmiştir.

Anahtar sözcükler: Bacillariophyceae, bentik diyatom, morfometrik bilgi, Akdeniz

Introduction

Many studies are available on microplanktonic and macroscopic marine plants. However, a few studies were conducted concerning benthic diatoms in lagoons (Sıvacı et al., 2008; Gönülol et al., 2009). This community, also known as microphytobenthos, is responsible for the high primary productivity in estuarine and coastal ecosystems that allows the benthic and planktonic food webs to mix with each other.

Diatoms generally are the primary colonies in the whole littoral zone (Munda, 2005). The importance

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of diatoms as primary colonies in natural and artificial substrata was first suggested by Scheer (1945) and followed by Hendey (1951), Santelices et al. (1981), and Falciatore et al. (2002). Therefore, samples collected from varying substrata of a single area aid in the evaluation of all of the diatom species (Reavie & Smol, 1997; Lim et al., 2001).

There are 72 lagoons in Turkey and these occupy an area of 36,000 ha. Few algological studies have been performed in these lagoon systems. The seasonal variations of phytoplankton in Akyatan and Tuzla lagoons, which are located in southern Anatolia, were investigated by Çevik et al. (2008). The algal flora of important dammed lakes and running waters of the lower Euphrates basin was examined by Baykal et al. (2009) in the south-east Anatolian region. Gökpınar et al. (1996) studied the phytoplankton communities of Karine Lagoon, and Egemen et al. (1999) studied Güllük Lagoon in western Anatolia. The Kızılırmak and Yeşilırmak lagoon series are located around the mouths of the Kızılırmak and Yeşilırmak rivers in northern Anatolia. Among these series, the phytoplankton of Balık Lagoon and Uzun Lagoon (Gönülol & Çomak, 1992, 1993), Gici Lagoon (Soylu & Gönülol, 2006), Cernek Lagoon (Tas & Gönülol, 2007), and Karaboğaz Lagoon (Baytut et al., 2006) was investigated within the Kızılırmak lagoon series. In the delta of the Yeşilırmak River, Simenit Lagoon (Ersanlı & Gönülol, 2006) and Akgöl Lagoon (Ersanlı et al., 2006) were investigated in respects to algal flora. In addition to these studies, the seasonal variations of benthic algae in Karagöl Lake were examined by Kolaylı and Şahin (2009) in north-east Anatolia.

In the present study, *Cocconeis pseudomarginata* W.Greg., *Seminavis robusta* Danielidis & D.G.Mann, *Synedra gaillonii* var. *macilenta* (Grunow) H.Perag., and *Trachysphenia australis* Petit var. *rostellata* Hust., from Bacillariophyceae, were recorded for the first time from the Turkish coasts. *Synedra gaillonii* var. *macilenta* and *Trachysphenia australis* var. *rostellata* were reported for the first time at variety level from the Mediterranean coasts of Turkey. Elsewhere, 12 species of the genus *Cocconeis*, 18 species of the genus *Synedra*, and a single species of the genus *Trachysphenia* were reported from the eastern part of the Adriatic Sea (Viličić et al., 2002).

Materials and methods

Homa Lagoon (38°33′10″N, 26°49′50″E) is located 25 km to the north-west of the Gulf of İzmir and within the borders of the town of Menemen (Figure 1). Located adjacent to the Çamaltı Salt Pan and İzmir Bird Paradise, the lagoon has a surface area of 1800 ha and its management was transferred to the Faculty of Fisheries at Ege University in 1986 (Alpbaz & Kınacıgil, 1988). The depth of the fish trap was at maximum 1.5 m, and the depth varied between 0.5 and 1 m. Environmental conditions of the study area caused fluctuations in physicochemical parameters. During the study period, the temperature ranged from 4 to 27 °C, and salinity between 35 and 50 psu. The coastal region of Homa Lagoon was investigated at 4 different stations between June 2006 and September 2007 in order to determine the epipelic, epiphytic, and epilithic diatom communities. Station 1 was deeper than the other stations, open to the waves, with the bottom covered with gravel, sand, and especially broken seashells. This bottom structure made it difficult to take the sediment samples. Station 2 was located in the region where the sea water and lagoon water mix. This station was a little more sheltered than station 1 and had soft sediment substrata. Compared to station 2, station 3 was less affected by seawater, but had the same bottom structure as station 2. Station 4 was located in a completely sheltered area. The bottom structure was covered with muddy sediment, in which, during the tide, drying and fracturing could be seen.

Microphytobenthos sampling was carried out for epipelic algae on sediment, for epiphytic algae on macroalgae, and for epilithic algae on rocks. Sediment samples were taken using cylindrical Plexiglas corers (13 cm long, 6.1 cm in diameter) in order to determine the epipelic diatom flora living in the coastal sediments. The sediment corers were left undisturbed for 24 h. During the exposure period, the corers were artificially illuminated for 2 h. After the waiting period, the sample from the upper 0-2 cm part was taken and transferred to 250 mL polythene bottles containing distilled water (Ribeiro et al., 2003).

For defining the species composition of epilithic diatoms in the benthic regions, stones of 15-20 cm in diameter in the lagoon were used. Stones were chosen

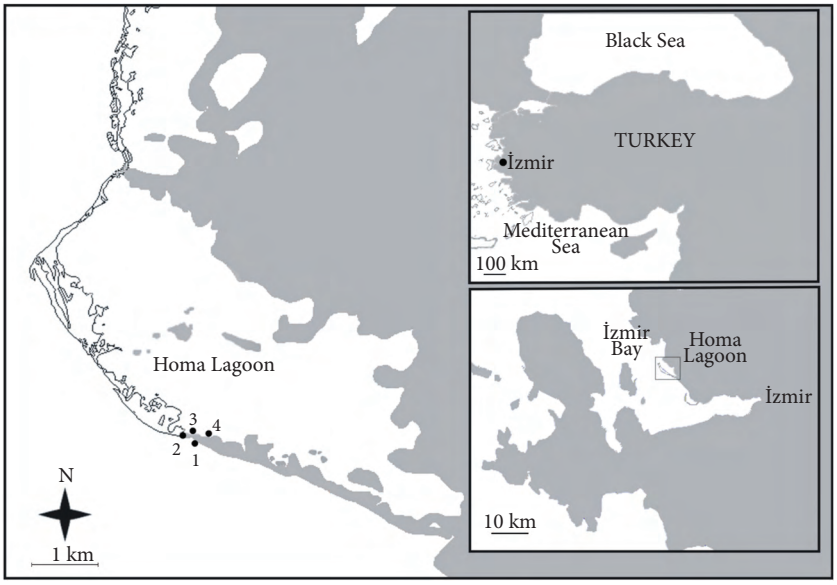

Figure 1. The study area and the location of sampling points.

as randomly as possible from among those that were not smothered with filamentous algae, and those that had an obvious diatom film were taken into consideration. Selected stones were put in a 1 L plastic bath, into which 200 mL of distilled water was added. The upper parts of the stones were rubbed with a hard toothbrush, and, finally, the mixture was decanted into 250 mL polythene bottles (Winter & Duthie, 2000).

In order to define the species composition of epiphytic diatoms, *Ulva lactuca* L. was chosen in the research region. The main purpose for choosing this macroalgae was to have a large area of thallus structure. The collected *Ulva lactuca* was placed in a large, wide-mouthed 1 L sample container. The macroalgae were collected until the container was about half full, and 100-200 mL of distilled water was added. The lid was closed and the container was shaken strongly for about 60 s. The substrata were rubbed gently to remove the remaining benthic algae. Finally, the suspension was decanted in a 250 mL sample bottle (Aligizaki & Nikolaidis, 2006).

Sample bottles were fixed with formaldehyde until the concentration was 4%. Materials obtained were subjected to chemical processing with 10% HCl, 30% H_2SO_4, $KMnO_4$, and oxalic acid (Lauriol et al., 2006). Samples entirely cleaned of organic material were made ready as permanent preparations. Clean diatom valves were identified via phase contrast apochromat objectives on an OLYMPUS BX-50 research microscope. The taxa were identified following the descriptions by Foged (1985a, 1985b), Hartley (1996), Hendey (1964), Peragallo and Peragallo (1897-1908), and Witkowski et al. (2000).

Results and discussion

The species identified in this study were generally uncommon species. *Cocconeis* Ehrenb. species are often found on seaweeds (Takano, 1962; McIntire & Moore, 1977; Suzuki et al., 1999; Suzuki et al., 2000) and seagrasses (Tanaka, 1984). Recently, Romero (1996) and Romero and Navarro (1999) reported their studies, in which light (LM) and electron microscopy (EM) were used for the morphological examinations of several species, such as *Cocconeis scutellum* Ehrenb. var. *scutellum* and *Cocconeis pseudomarginata* W.Greg. var. *pseudomarginata* (*Cocconeis pseudomarginata* in the original), and they described new species from the south-east Pacific Ocean. In a study by Romero and Navarro (1999), *Cocconeis pseudomarginata* was noted to be obtained by scanning the filamentous algae of the coastal zone. *Cocconeis pseudomarginata* has been recorded from the Atlantic Ocean (Gil-Rodríguez et al., 2003;

Procopiak et al., 2006) and the Adriatic Sea (Viličić et al., 2002). The genus *Cocconeis* has been reported in many previous studies by various authors (Aktan & Aykulu, 2005; Çelekli, 2006; Sıvacı et al., 2008); however, this species had not been found in Turkish seas.

In a study by Danielidis and Mann (2002), the recently established genus *Seminavis* was described for the first time in detail. For the previous 140 years, *Amphora angusta* W.Greg., *Amphora ventricosa* W.Greg., and *Amphora macilenta* W.Greg. were interpreted wrongly. These species were described by Gregory (1857), from sublittoral sediments on the western coast of Scotland. Despite the fact that the illustrations were excellent for their time, it was not convenient to rely on identifications in the aforementioned paper. In following studies, several authors argued that records of those taxa were not trustworthy without any photographic support. *Amphora angusta* reported in that paper was, in fact, a species of *Amphora* Ehrenb., whereas *A. ventricosa sensu* W.Greg. represents 2 individual species of the genus *Seminavis* D.G.Mann (in Round et al., 1990), namely *Seminavis ventricosa* (W.Greg.) Garcia-Baptista (non *S. ventricosa sensu* Garcia-Baptista 1993) and *Seminavis arranensis* Danielidis & D.G.Mann. The generally recognized form of *A. ventricosa* represents neither of these and a name is necessary. This form has been reported commonly for many years as *A. ventricosa* or *A. angusta* var. *ventricosa,* and it has also been confused with *A. cymbelloides* (Grunow in Schmidt, 1874-1959, pl. 25, figs. 10, 14). However, Cleve (1895) reported that Grunow's species was more fragile.

There are many reports of species resembling *Seminavis robusta* (as *A. angusta* var. *ventricosa* or *A. ventricosa*), e.g. those by Foged (1984, 1986, 1987), Hendey (1951, 1964), John (1983, 1990), and Navarro (1982a, 1982b). Although detailed examination of specimens is of extreme necessity, some of them may be representative of *Seminavis robusta*. *Seminavis robusta* (Danielidis & Mann, 2002) has been reported from the United Kingdom, Greece, and south-east Asia. This genus has not been recorded before in Turkish seas.

The genus *Ardissonea* De Not. (1871) was based on *Synedra robusta* Ralfs (in Pritchard, 1861) and has commonly been known as a subgenus of *Synedra* Ehrenb. (e.g. Peragallo & Peragallo, 1897; Hustedt, 1933; Patrick & Reimer, 1966). Poulin et al. (1986) supported the suggestion of Round (1979) that it should be included in the generic rank. In order to differentiate these 2 genera, Round et al. (1990) created a new order, the Ardissoneales. As previously noted by various authors (e.g. Poulin et al., 1987; Round et al., 1990), the internal surface of the valve in *Ardissonea* is more elaborate and chambered than that of *Synedra*. *Synedra gaillonii* (Bory) Ehrenb. has been reported from Romania (Caraus, 2002), Spain (Varela, 1982; Álvarez Cobelas & Estévez García, 1982), and the Canary Islands (Gil-Rodríguez et al., 2003). In a study by Viličić et al. (2002) covering the whole Adriatic Sea, the species *Synedra gaillonii* (Bory) Ehrenb. was reported from the northern and middle Adriatic. The genus *Synedra* was listed many times by various authors in previous studies (Çetin & Şen, 1998; Şahin, 2001; Kalyoncu et al., 2009). *Synedra gaillonii* var. *macilenta* (Grunow) H.Perag. is a new record at variety level for Mediterranean coasts.

Viličić et al. (2002) found *Trachysphenia australis* Petit on northern Adriatic coasts where fresh water input was observed. This genus has not been reported before from Turkish seas.

All of the species were also checked at the AlgaeBase website (Guiry & Guiry, 2009). The taxonomies of these species are as follows.

Phylum: Bacillariophyta

Class: Bacillariophyceae

Subclass: Bacillariophycidae

Order: Achnanthales

Family: Cocconeidaceae

Genus: *Cocconeis*

Cocconeis pseudomarginata W.Greg.

Class: Bacillariophyceae

Order: Naviculales

Family: Naviculaceae

Genus: *Seminavis*

Seminavis robusta Danielidis & D.G.Mann

Class: Fragilariophyceae

Subclass: Fragilariophycidae

Order: Fragilariales

Family: Fragilariaceae

Genus: *Synedra*

Synedra gaillonii var. *macilenta* (Grunow) H.Perag.

Class: Fragilariophyceae

Subclass: Fragilariophycidae

Order: Fragilariales

Family: Fragilariaceae

Genus: *Trachysphenia*

Trachysphenia australis Petit var. *rostellata* Hust.

Cocconeis pseudomarginata W.Greg.

Lit. Foged (1985a), p. 21, pl. 13, fig. 6; Hartley (1996), p. 124, pl. 54, 1,2; Hendey (1964), p. 179, pl. 28, fig. 20; Peragallo & Peragallo (1897-1908), p. 12, pl. 2, fig. 21-24; Witkowski et al. (2000), p. 113, pl. 34, 8,9, pl. 35, 1-4.

Cocconeis pseudomarginata frustule has very dissimilar valves, varying in outline from narrow to broadly elliptical. Central area small, usually dilated to one side. Polar nodules small and surrounded by small hyaline areas. Valves 40.7 µm in length and 30.55 µm in width. Valve surface striate, striate 16-17 in 10 µm (Figure 2).

Seminavis robusta Danielidis & D.G.Mann

Lit. Danielidis & Mann (2002).

Valves lanceolate to rhombic-lanceolate, 39-51 µm long, with more or less obtusely rounded ends. Valves semi-lanceolate, 7.6-9.6 µm wide, with convex dorsal and very slightly convex ventral margins. The dorsal striae are radiate in the middle, 18-19 in 10 µm, but at the apices they close together and become denser, 21-22 in 10 µm. The ventral striae 17-18 in 10 µm, distinctly radiate in the middle but much denser and parallel at the apices (Figure 3).

Synedra gaillonii var. ***macilenta*** (Grunow) H.Perag.

Lit. Peragallo & Peragallo (1897-1908), pl. 80, fig. 8.

Valves 131.7 µm in length and 8.90 µm in width. Cells supported on short pedicels occur often in small clusters, narrow linear-lanceolate valves gently taper to obtuse apices. Valve surface striate, striate marginal, transverse. 12 in 10 µm (Figure 4).

Trachysphenia australis Petit var. ***rostellata*** Hust.

Lit. Witkowski et al. (2000), p. 84, pl. 24, fig. 13.

Heteropolar valves clavate with obtusely rounded head-pole and rostrate, acute foot-pole. Valve surface striate, transapical striae coarsely punctate. Valves 19.70 µm in length and 7.50 µm in width, striate 9 in 10 µm (Figure 5).

In this study, *Cocconeis pseudomarginata* was detected in the autumn of 2006 from the epilithic flora of station 2, *Seminavis robusta* in the autumns of 2006 and 2007 from the epiphytic and epilithic flora of stations 2 and 3, *Synedra gaillonii* var. *macilenta* in the

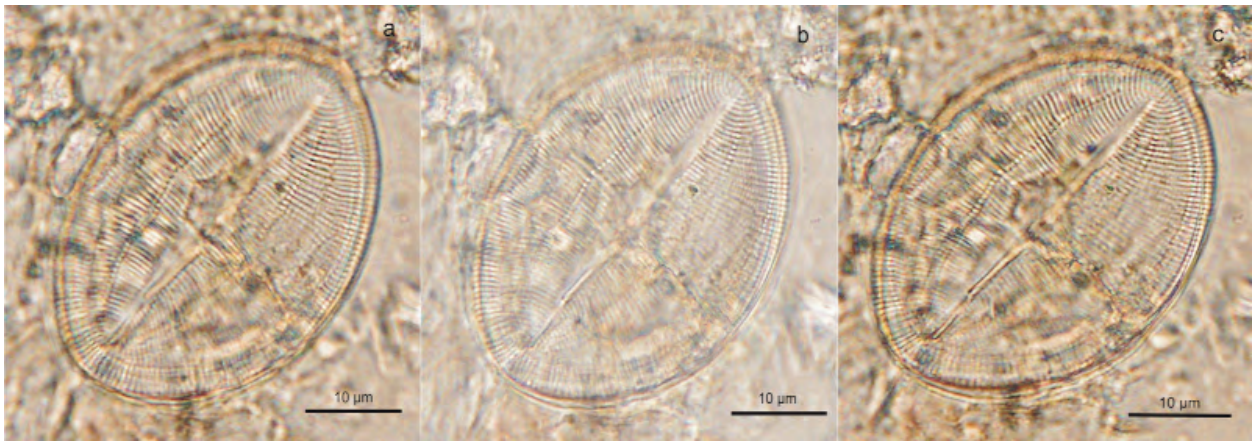

Figure 2. Phase contrast photographs of *Cocconeis pseudomarginata*.

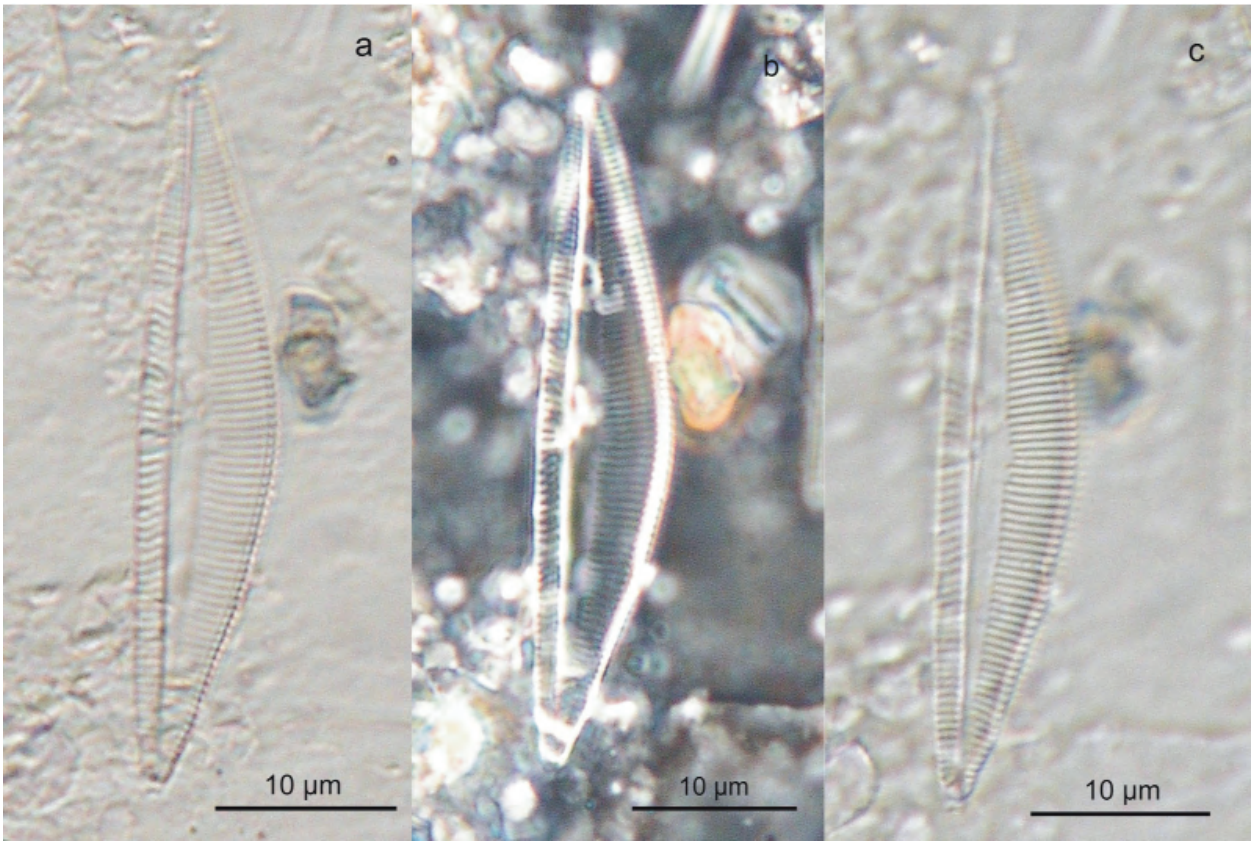

Figure 3. Phase contrast photographs of *Seminavis robusta*.

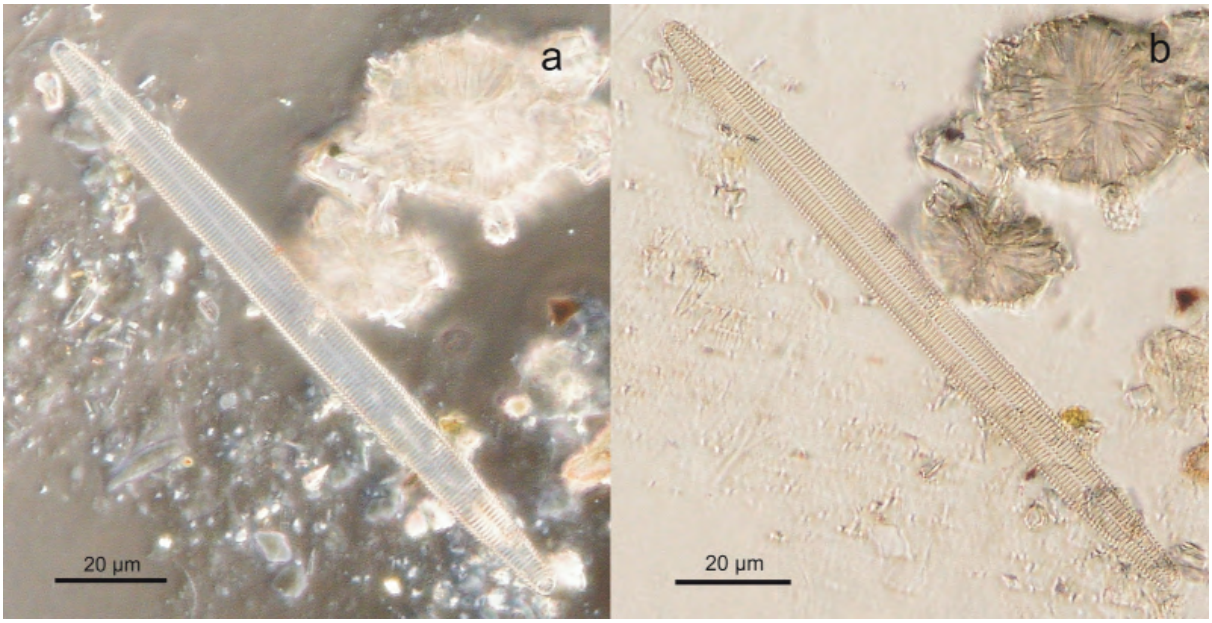

Figure 4. Phase contrast photographs of *Synedra gaillonii* var. *macilenta*.

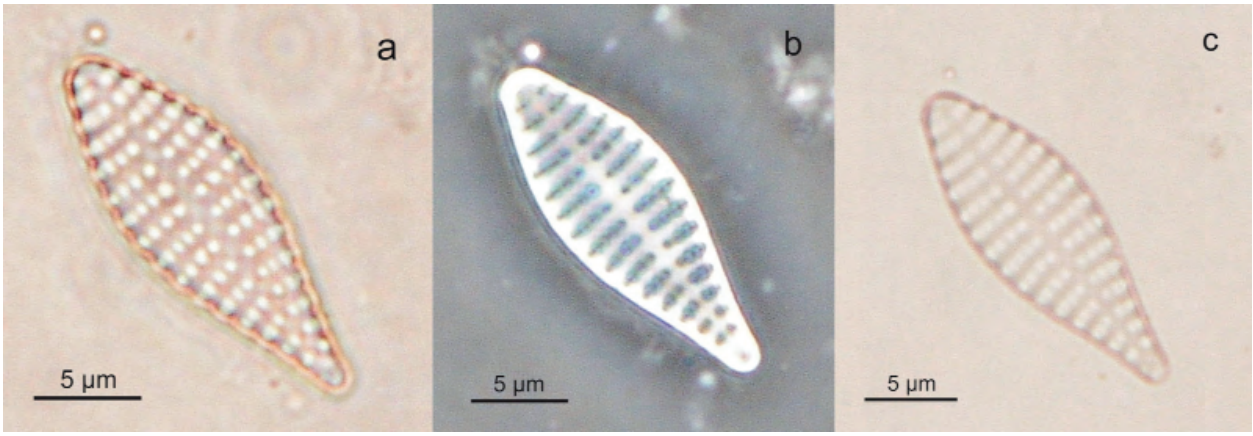

Figure 5. Phase contrast photographs of *Trachysphenia australis* var. *rostellata*.

autumn of 2006 from the epipelic flora of station 2, and *Trachysphenia australis* var. *rostellata* in the summer of 2007 from the epipelic flora of station 1 (Table). While *Cocconeis* Ehrenb. and *Trachysphenia* species Petit in Folin and Périer are often abundant on epiphytic flora (Hartley, 1996; Suzuki et al., 1999; Suzuki et al., 2000), *Seminavis* D.G.Mann (in Round et al., 1990) is generally present on epipelic flora (Danielidis & Mann, 2002). On the other hand, *Synedra* Ehrenb. species have been reported from both epiphytic and epipelic flora (Pickett-Heaps et al., 1991). Munda (2005) first observed the epilithic species on an artificial substratum. The author reported that sand particles accumulated on these plaques over time, depending on water movements, and, consequently, epipelic and epipsammic species were seen in addition to the epilithic ones.

When benthic and pelagic studies are compared, those on microphytobenthos are very limited (Cahoon & Laws, 1993; Schreiber & Pennock, 1995). The taxonomic literature on brackish water diatoms is particularly unclear and scattered. Microphytobenthic studies are important in order for the general ecology of communities to be understood. In this context, beside the reports on pelagic microalgae, studies on the taxonomy of benthic microalgae will contribute to the algae flora.

Acknowledgements

We are grateful to Dr. Oscar E. Romero (Department of Geosciences, University of Bremen, Germany) for the personal communication during *Cocconeis pseudomarginata* identification.

Table 1. The date, station name, and habitat information of the identified species.

Species name	Date	Station no.	Habitat
Cocconeis pseudomarginata	September 2006	2	Epilithic
Seminavis robusta	September 2006	3	Epiphytic
	September 2007	2	Epilithic
Synedra gaillonii var. *macilenta*	September 2006	2	Epipelic
Trachysphenia australis var. *rostellata*	June 2007	1	Epipelic

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