John Paul II University of Applied Sciences in Biala Podlaska

Recent and fossil freshwater diatoms from Poland: taxonomy, distribution and their significance in the environmental reconstruction

Part 1
Coscinodiscophyceae, Mediophyceae and Fragilariaceae

Abdelfattah A. Zalat, Jerzy Nitychoruk, Marta Chodyka, Irena A. Pidek, Fabian Welc

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Preface

Detailed diatom investigation from the sediments of some lakes in northern Poland beside the Eemian deposits of central Poland through the period from 2017-2020, led to identifying and imaging a huge amount of diatom taxa. As a result of diatom data, the Faculty of Technical Sciences, John Paul II University of Applied Sciences in Biala Podlaska, Poland and Department of Geomorphology and Paleogeography, Institute of Earth and Environmental Sciences, Maria Curie-Sklodowska University, Lublin, Poland and cooperation with Geology Department, Faculty of Science, Tanta University, Egypt decided to issue the recent and fossil diatom flora of Poland in an attempt to understand the native species, to serve as an introduction to the common species found in Polish ecosystems and offer important data for sustainable biodiversity conservation.

The current project will produce a comprehensive series of monographs that provide information on the taxonomy, ecology, and distribution of more than 1300 diatom taxa distributed in different Polish ecosystems as well as preserved as fossils in the Pleistocene-Holocene deposits. Results of this research work will be represented through four volumes of diatom monographs. This series of monographs consider a significant source of information for geologists, biologists, and botanists interested in bio-geographic diatom distribution, diatom taxonomy, paleoenvironmental and paleoclimate reconstruction, in particular during the Quaternary period. It is also a reference work for the Polish scientists and it will be a useful identification guide of the freshwater diatoms recorded from Poland. In addition, this work will help in the study of hydrological changes, eutrophication, and climate change. Moreover, the reported diatom data are intended to assist future biomonitoring and paleolimnological efforts and may serve as a valuable environmental marker for the diatomists in the world, especially European researchers involved in environmental and paleoclimate reconstruction based on diatom communities.

Authors

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Content

Abstract

High-resolution diatom investigation from the Polish ecosystem is presented as a contribution to our knowledge of diatom floristics, ecology, biogeography, and their significance in environmental and climate reconstruction in Poland. The study is based on the analysis of 821 sediment samples taken from different lakes in northern Poland, besides 8 borehole-originated from the Eemian paleolakes sites in central Poland. The preceding diatom results in published papers included the diatom flora that were recorded from different habitats in Poland are mentioned in the present work to complete the Polish diatoms list. The current work is the first part in a series of monographs dealing with the diatom taxa belonging to classes Coscinodiscophyceae, Mediophyceae and subclass Fragilariophycidae. A total of 269 diatom species and varieties belonging to 38 genera are recognized. The checklist is comprising 86 entries of Coscinodiscophyceae that includes all radial centric diatoms and 183 taxa of Fragilariophyceae that includes araphid pennate diatoms. Of these 97 diatom taxa are represented as a new record for Poland and 12 new combinations and new varieties. A detailed diatom description, distribution in Poland, and autecological information are presented to round up the content of this volume and documented with 120 plates including 2423 excellent light micrographs of diatom taxa, which allows for a better understanding of morphology to aid in the identification. This work is proposed to contribute towards a general view of the high diatom biodiversity that characterizes Polish ecosystems and provides a revised diatom checklist from Poland. Additionally, it offers the first taxonomic and autecological catalog, which will be significant in the assessment of the water quality monitoring, paleoenvironmental interpretation, and construct the paleoclimate changes.

1. Introduction

1.1. General statement of diatoms

Diatoms are a unicellular systematic group of microalgae, which have microscopic dimensions from 3 µm to 200 µm length or diameter and occur mostly as single cells (solitary) with some species that can appear as filaments, chains, or colonies. They live either in the water column (plankton) or attached to any substratum (benthic) or epiphytic that live attached to other macrophytes and microalgae. The benthic diatoms are more diverse than the plankton, both in terms of the number of species and the life forms present. Within the benthos, a division can be made between the diatoms that live attached to the substratum.

Diatoms have a wide geographical distribution in most types of aquatic environments from fresh to marine waters (oceans, sea, rivers, estuaries, lakes, ponds), brackish water, and other wet habitats, such as moist soils, rocks, caves, glaciers, springs, natural and artificial wet substrates and cold, hot and salty environments. They play a major role as primary producers in rivers, lakes, and oceans, and their contribution to the global net primary production amounts to about 25% (Stoermer & Smol, 1999). Although diatoms have universal distribution, many species are greatly restricted in their habitat requirements (Stevenson et al., 2010). They are represented by approximately 200,000 species, making them one of the most diverse algal groups and many of these taxa have only been illustrated with light microscopy (Round et al., 1990; Mann & Droop, 1996).

Diatoms have a global significance, as they may be responsible for one-fifth of the total of the Earth's photosynthesis (Mann, 1999). Their contribution to total global primary production is greater than all of the rainforests put together (Field et al., 1998; Mann, 2010) with the important difference that their organic carbon is rapidly consumed and made available to the food webs. Ecologically, diatoms are very sensitive to many environmental factors. They are significantly impacting the inorganic chemical concentrations of the aquatic environment, especially silica, nitrates, and phosphates, that play a major role in their cycling between the animate and inanimate components of the biosphere (Round et al., 1990). Therefore, diatoms play a vital role in environmental assessment and paleoclimatic reconstruction.

1.2. Diatom morphology

Diatoms have distinct features that make them unique amongst the microalgae. They have a distinguished cell wall composed of hydrated silicon dioxide and known as a frustule, which is generally well preserved in sediments. This frustule consists of two valves of similar or dissimilar sizes, which fit together, like the two parts of a pillbox or a Petri dish. Each is connected by a circular piece of silica known as girdle bands. In its simplest form, the frustule has three main components: two valves, which are called the epivalve and the hypovalve, and a girdle also called the cingulum (Fig. 1). The frustules are highly sculptured by different structural elements, forming a huge variety of distinctive shapes, sizes, and detailed ornamentation unique to each species, with symmetrical or asymmetrical valves, which are taxonomically diagnostic. A few numbers of diatoms are acknowledged in which the valves are seemingly smooth. The morphological characters of the diatom valves have been examined in detail with light and electron microscopy. Guides to the structure of diatom frustules have included Anonymous (1975), Ross et al. (1979), and Theriot & Serieyssol (1994), both of which have been extensively cited in the literature. Besides, the critical examination of diatom valves with light and scanning electron microscopy by several authors (e.g., Morales et al., 2001; Novais et al., 2009; Kociolek et al., 2015) has led to recognizing distinctive terms associated with the minutiae of valve morphology.

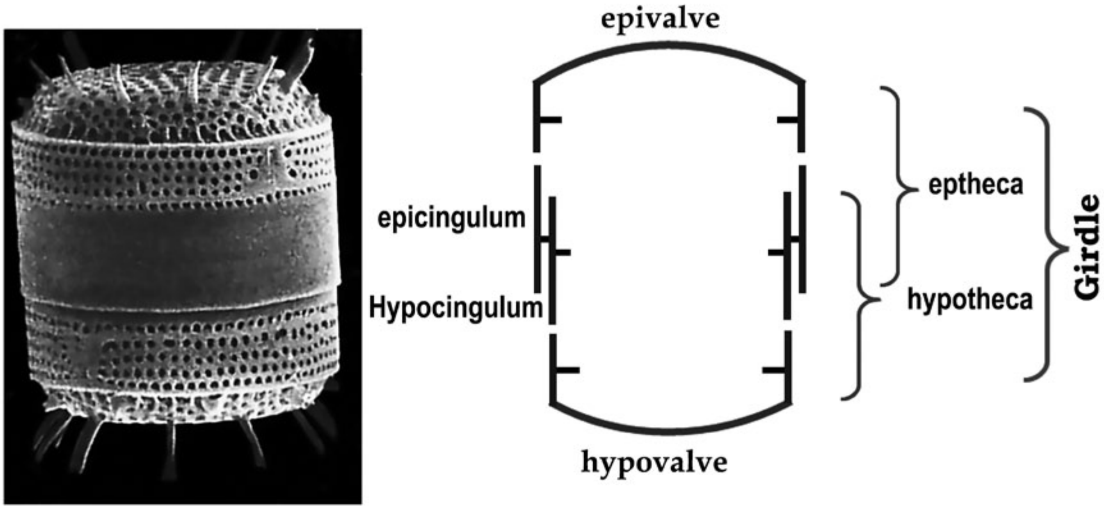

Fig. 1. Diatom frustules morphology

1.3. Diatom taxonomy

Taxonomy of diatoms is essentially based on the shape and structural elements of the siliceous frustules and species are described fundamentally by morphological characters. Diatoms are markedly distinguishable into two major groups, the Centrals and the Pennales, based on the symmetry of the valve and orientation of the structural elements on the valve surface (Round et al., 1990). The centric diatoms display a concentric or radiating sculpture around a point, usually radial symmetry (Figs. 2, 3), and have variable valve shapes, including circular, discoid, cylinder, triangular, quadratic, polygonal, or irregular shape with marked variability in frustule structure. They are most abundant as plankton in the ocean and sea, with few genera are found in fresh and brackish water environments. The pennate diatoms are possessing sculptures arranged to a longitudinal line, often with a raphe or pseudoraphe (Figs. 4, 5). They are mainly elongated, bilaterally symmetrical, linear or club-shaped, or more or less crescentic or arcuate, sigmoid, or undulate, ovate-lanceolate, or wedge-shaped. They are most often found in shallow areas of seas and dominate the freshwater lakes, rivers, soil, and epiphytic environments.

The concept of the genus and species in diatoms has received great consideration from many researchers. Among the significant studies (e.g., Mann, 1984, 1988, 1989, 1994; Williams & Round, 1986, 1987; Round et al., 1990; Håkansson & Meyer, 1994; Round, 1995, 1996; Kociolek, 1997). Round (1996) indicated that the diatom genus has been based on very broad, relatively simple features of the gross construction of the cell and particularly of the valve. However, the classification of diatoms at the species level is somewhat difficult because it is not easy to estimate the range of intraspecific variation of taxonomic characters (Round et al., 1990). In general, the taxonomy of diatoms is mainly based upon frustule characteristics, which including the shape of the valve, symmetry, structure, and density of striae, the structure of the areolae, position, and nature of the raphe, presence or absence of raphe slits, presence or absence of fultoportulae and rimoportulae in centric diatoms (Fig. 3), presence or absence of apical pore fields in pennate diatoms, details of copula and characters in the valve mantle and girdle.

In the last few decades, the diatom taxonomy has undergone significant changes with many new diatom genera being established. Recently with the onset of 21^{th}, several proposals of many new taxonomic names and classification schemes are published (e.g., Nikolaev & Harwood, 1999, 2002; Nikolaev et al., 2001; Medlin & Kaczmarska, 2004; Cox, 2011; Medlin, 2016). This may attribute to the rate of publication of new diatom genera and species increased and large numbers of diatom taxa are currently being described each year (Medlin, 2016).

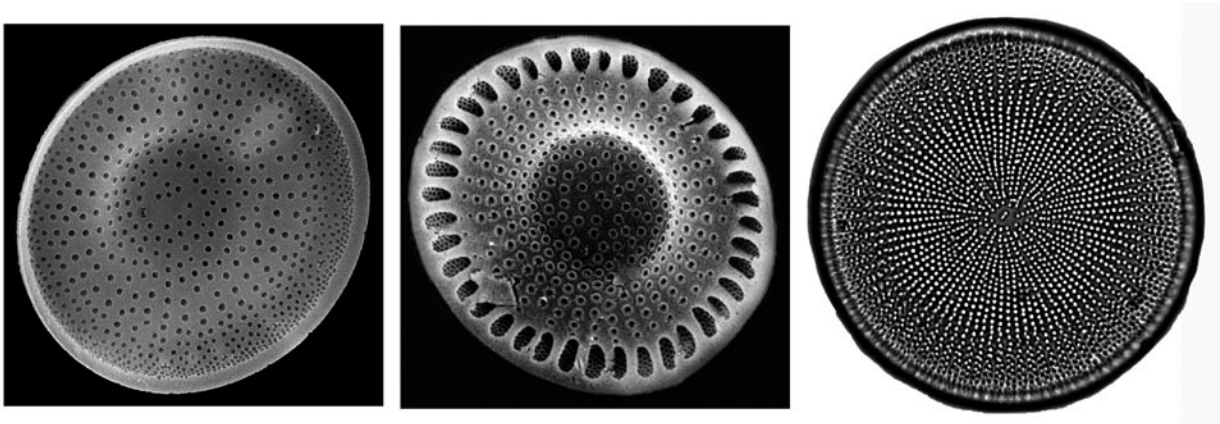

Fig. 2. Centric diatoms showing concentric or radiating sculpture and radial symmetry

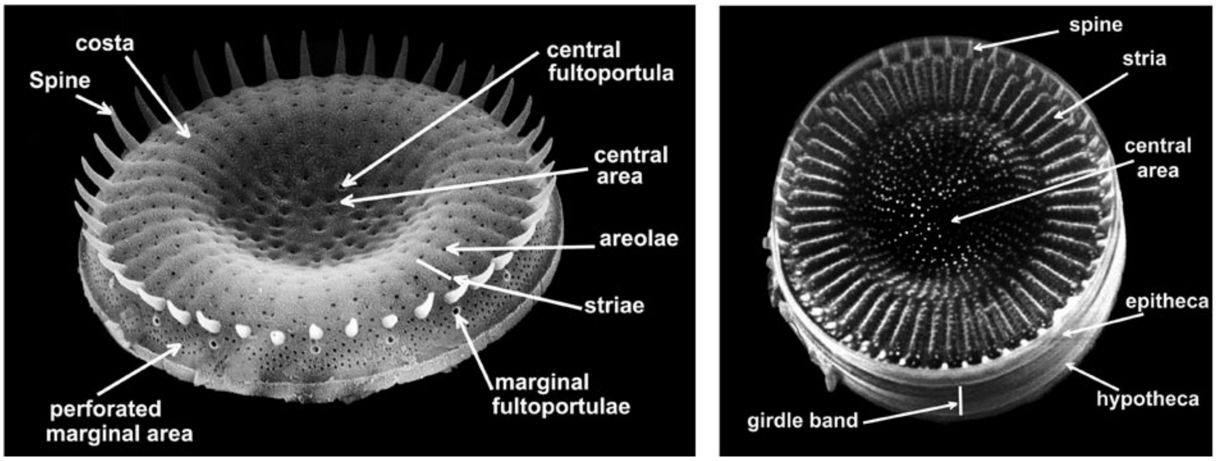

Fig. 3. Centric diatoms showing valve view with the main structural elements and girdle band.

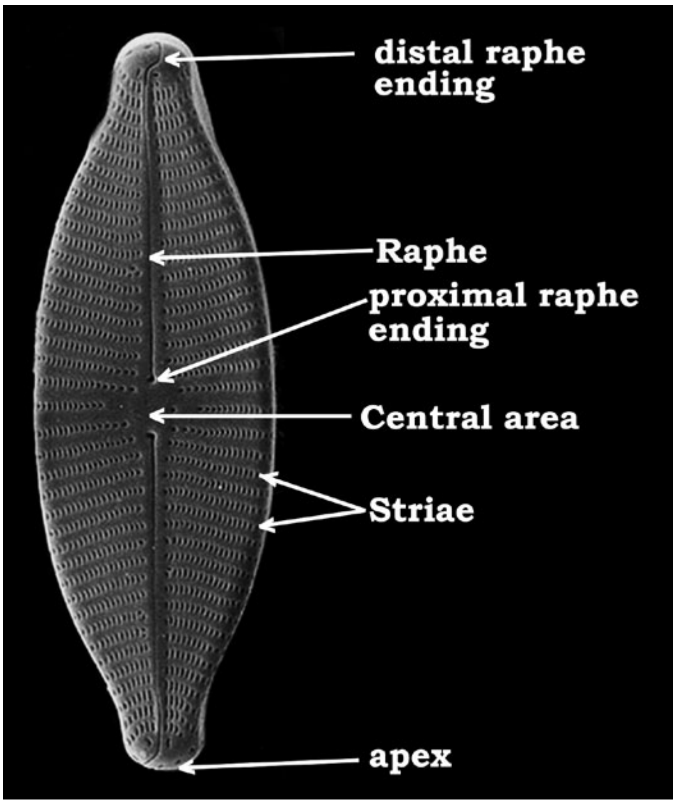

Fig. 4. Pennate diatom showing the different morphological structures on the valve view

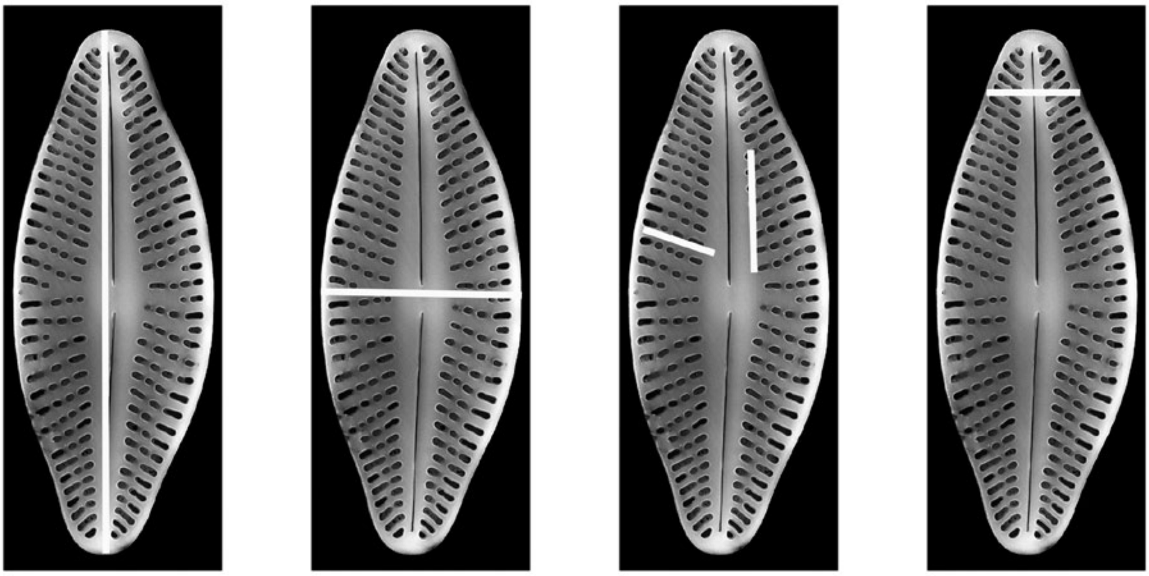

Fig. 5. Pennate diatom measurements, length, width, direction of striae, number of striae per 10 µm, and width at the apex respectively.

1.4. Diatom analysis in environmental and climate studies

A large database occurs within the literature indicating the utility of diatoms deposited in lake sediments as effective bioindicators of past environmental and climate conditions (e.g., Fritz, 1996; Smol & Douglas, 2007; Zalat & Servant-Vildary, 2007; Douglas & Smol, 2010; Zalat et al., 2018). Many reasons make diatoms a proxy indicator group for the environmental conditions in lakes and water quality assessment. They are extremely diverse (Smol & Stoermer, 2010), their siliceous cell walls are robust, preserving well in aquatic sediments, and have taxonomically distinct ornamentations that allow identification to low taxonomic levels, they are very easy to collect and store, their ability to respond rapidly to changes in the environment and different species often have distinct environmental optima (Stoermer & Smol,1999; Keatley et al., 2006; Smol, 2008). They are sensitive indicators of various environmental variables including salinity, pH, water temperature, water quality, water velocity acidification, and organic pollution, ice cover, and water depth (Lange-Bertalot, 1979; Coste et al., 1991; Lobo et al., 1995; Battarbee et al., 2001; Zalat & Servant-Vildary, 2005; Smol & Stoermer, 2010). They have a broad spectrum of tolerances to conditions ranging from oligotrophic to eutrophic (Álvarez-Blanco et al., 2013; Lobo et al., 2016). Furthermore, many studies on lake systems have shown that seasonal changes in the composition and diversity of diatom assemblages are mainly related to variations of limnological variables such as the duration and timing of ice cover, the stability of the water column (thermal stratification), or the turbulence of the water column due to wind action (e.g., Smol, 1988; Lotter & Bigler, 2000; Mackay et al., 2003).

Therefore, diatoms are an effective proxy for climate-induced changes in lake conditions. When sub-fossil assemblages are analyzed down-core, past environmental variables can be inferred, allowing reconstructions of important limnological variables over a range of different time scales from decades to millennia (Smol, 2008). Past climate changes can be inferred from fluctuations in species abundance within a sediment core, as the ecological requirements are well known for many ‘indicators’ species. These species indices are indicative of several variables, including lake level oscillation, acidification, salinity, and nutrient availability. These variables are dependent upon a combination of primary factors including precipitation, solar output, and wind strength and secondary factors comprising the upwelling and erosion.

Consequently, because the response time of diatom communities is very rapid, diatoms are extremely useful and reliable indicators of temperature changes (Smol, 1988). Diatom assemblages can be especially sensitive to warming-induced changes in lake properties that favor, depending on the limnological setting, the growth of small planktonic species (Rühland et al., 2008; Winder & Sommer, 2012), and/or the development of more complex and diverse periphytic diatom assemblages (Smol et al., 2005; Douglas & Smol, 2010). During warm periods, larger areas of open water in the lake remain longer than during cold periods, which causes enhanced thermal stratification and more wind-induced turbulence. These conditions favor planktonic diatoms because they are suitable to take advantage, and remain suspended in this newly available habitat of open water. (Smol et al., 2005; Smol & Douglas, 2007; Rühland et al., 2008). However, during cold periods with extensive ice cover, benthic diatom species will predominate because open water on the lake is short-lived and, when it is present, is most often found around the border of the lake in the shallow littoral zone. Rühland et al. (2008) demonstrated that changes in the trends of the planktonic Aulacoseira spp., Cyclotella spp., and the periphytic Fragilaria sensu lato could be applied throughout the upper latitudes of the northern hemisphere as reliable proxies of recent, rapid warming., The lakes in the northern hemisphere may be impacted by changes in physical factors, such as the amount of ice and snow cover, the length of the growing season, the amount of solar and ultraviolet radiation, and alterations in thermal stratification and mixing regimes (Smol et al., 1991; Moser et al., 1996). All these factors affect directly the diatom composition and their distribution in the lakes. Moreover, the surface wind, temperature, and lake level are the primary controls of thermal stratification and lake circulation while influencing water chemistry, which, in turn, influences diatom compositions (Stoermer & Smol 1999; Anderson et al., 2000).

Moreover, numerous paleolimnological studies on the Arctic and European lakes demonstrated that shifts in the relative abundances between planktonic Coscinodiscophyceae taxa and periphytic diatoms particularly small benthic fragilarioid taxa may have been a response to changes in the duration of ice cover (Smol, 1983, 1988; Smol & Douglas, 2007; Douglas & Smol, 2010). In shallow lakes of northern Poland, a distinct shift in diatom composition is commonly observed from an assemblage dominated for millennia by benthic fragilarioid species to assemblage dominated by small planktonic Cyclotella sensu lato species (Zalat et al., 2018). This shift is consistent with warming-induced habitat expansion resulting from a shorter ice cover period and the associated multitude of interrelated lake property changes resulting from a longer growing season.

1.5. Objectives

The main goal of the present work is twofold. The first to create a Polish diatom database that helps to estimate the diatom biodiversity in Poland and provide accurate and easily available information about the ecology and distribution of these taxa which are essential for the good interpretation of any modern or fossil diatom assemblage in Poland. The second is to encourage and facilitate the study of diatoms as a valuable tool for water quality monitoring, paleoenvironmental interpretation, and construct the paleoclimate changes. On the other hand, the precise identifications with a good illustration of diatom species will form the basis for further diatom taxonomic studies by Polish scientists. This work is supplemented also with a diatom flora checklist of Poland.

2. Diatom research in Poland

Diatom flora from the modern Polish ecosystems and the Quaternary sediments have been studied since the beginning of the twentieth century, but detailed analysis of diatom assemblages on a larger scale started about thirty years ago. The first floristic work on diatoms of Poland was started with Raciborski (1888) who studied the diatoms from the region of Wyżyna Krakowsko-Częstochowska upland. This earlier diatom research was represented by the initial data on the centric diatoms class Thalassiosirophycidae. This was followed by the diatom investigation from the Vistula River in Krakow (Gutwiński, 1895). Subsequently, the floristic aspects of diatoms in Poland have been the subject of research for the botanists, biologists, and geologists for over 100 years especially since the middle of the twentieth century (e.g., Cabejszekówna, 1935; Siemińska, 1947; Kądziołka, 1963; Stępień, 1963; Skalska, 1966a, b; Skalna, 1969; Kubik, 1970; Kadłubowska, 1970; Hojda, 1971; Siemińska, 1977), which included the diatom flora of the region's streams and springs such as springs of Kobylanka stream. Most of those reports were only diatom checklists, with some line drawings of the most common taxa. Besides, the first diatom study in the Gulf of Gdańsk, north Poland dated back to 1920 (Witak, 2013).

The diatom studies are continued due to the vast richness and diversity of diatoms in polish ecosystems including the lakes, rivers, and streams and the list of diatom publications is very long. In southern part of Poland, several diatom studies were carried out such as the diatom records from the mountain watercourses (e.g., Kawecka, 1980; Kwandrans, 1986, 1993; Cantonati et al., 2001; Picińska-Fałtynowicz, 2007), the rivers and streams (e.g., Kwandrans, 1989; Siemińska, 1990; Siemińska & Pająk, 1993), in calcium-rich waters of Kobylanka stream and its springs, the Wyżyna Krakowsko-Częstochowska upland (Wojtal, 2001a, b, 2003a, b, 2004, 2009; Wojtal & Kwandrans, 2006), the transitory zone of Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream (Wojtal et al., 2005), in a hardwater stream, south of Poland (Wojtal & Sobczyk, 2006), the running and standing waters on the territory of Rzeszów and the surrounding area (Noga et al., 2012), spring waters from various geological formations (Wojtal, 2013), the cultivated soils (e.g., Stanek-Tarkowska & Noga, 2012; Stanek-Tarkowska et al., 2015), Duszatyńskie Lakes, Western Bieszczady Mts., south Poland (Noga et al., 2013), and taxonomic diatom studies (e.g., Budzyńska & Wojtal, 2011; Bąk et al., 2012, 2014).

In central Poland, the diatom flora studies were limited and represented by some authors (e.g., Rakowska, 1996 a, b, 1997, 2001), diatoms from the central section of the Pilica River and Sulejów Reservoir (Szczepocka & Szulc, 2006), springs of Łódź Hills – Central Poland and from athalassic habitats, salt marshes near Łęczyca (Zelazna-Wieczorek, 2011; Żelazna-Wieczorek et al., 2015). However, the diatom flora from the northern part of Poland included the reservoir Mylof on the Brda River in the Tuchola Forests (Sekulska-Nalewajko, 1999), diatom assemblages in the littoral zone of the urban Lake Jeziorak Mały (Mazurian Lakeland) (Zębek, 2007), diatoms from the water bodies of Piaski, Kąpielowe, and Żółwia Błoć lakes, Western Pomerania, northwestern Poland (Witkowski et al., 2011), the Vistula River estuary (Majewska et al., 2012), lower Vistula River phytoseston (Dembowska, 2014), diatom flora from Szczecin Lagoon (Bąk, 2004), and epilithic diatoms of high mountain lakes from other regions (e.g., Tolotti, 2001; Tolotti & Cantonati, 2002; Sisko & Kosi, 2002).

Furthermore, over the past few years, numerous studies have been carried out on diatom diversity from different Polish habitats. Amongst these studies, the diversity of diatoms growing in flowing waters in the Subcarpathian Voivodeship, Podkarpacie Province, southern Poland (e.g., Mucha et al., 2009; Tambor & Noga, 2011; Noga, 2012; Bernat & Noga, 2012; Noga et al., 2012; Noga et al., 2015; Peszek et al., 2015), in high mountain lakes under the stress of acidification, Tatra Mts., Poland (Kawecka & Galas, 2003), in the Łubienka stream, the left bank tributary of the San River near the town of Dynów (Noga & Siry, 2010), from soil of Podkarpacie voivodeship in Dąbrowa village, in the Subcarpathian Province, SE Poland (Stanek-Tarkowska & Noga, 2012), in streams of the Tatra National Park (Poland) (Kawecka, 2012), in the Mleczka River, Morwawa River and Różanka Stream (tributaries of the Wisłok River), SE Poland, (Pajączek et al., 2012), the Duszatyńskie Lakes, Western Bieszczady Mts (Noga et al., 2013), in rivers, streams and on cultivated soils of the Podkarpacie Region, including Wisłok River, the Żołynianka and Różanka streams and the Mleczka (Noga et al., 2014a), within boundaries of the City of Rzeszów (Kocielska-Streb et al., 2014), on fallow soil in Pogórska Wola near Tarnów, southern Poland (Stanek-Tarkowska et al., 2015), in the natural, mid-forest Terebowiec stream-Bieszczady National park and suburban stream (Przyrwa stream) of Wisłok River in the Rzeszów city in SE Poland (Noga et al., 2016), diatom diversity under winter wheat and oats in village of Kosina, near the Kosinka stream (Stanek-Tarkowska et al., 2017), in freshwater spring located above the upper limit of forest, at the Goprowska Pass, Bieszczady National Park (Żelazna-Wieczorek & Knysak, 2017). Also, the diatom diversity of water ecosystems of Polish Lowland, Łódź (Rakowska, 2001), in springs of Łodź Hills, central Poland (Żelazna-Wieczorek, 2011), the "Korzeń" National Nature Reserve in central Poland (Szulc & Szulc 2012), some springs in the vicinity of Łódź (Central Poland) (Kwiatkowska et al., 2016), the Gulf of Gdańsk (Zgrundo et al., 2009), the Vistula River estuary, Northern Poland **(**Majewska et al., 2012).

Evaluation of water quality in some Polish lakes, rivers, and streams were done using diatom flora as bioindicators (e.g., Kwandrans et al., 1998, 1999; Kawecka et al., 1996, 1999; Kawecka & Kwandrans, 2000; Żelazowski et al., 2004; Zgrundo & Bogaczewicz-Adamczyk, 2004; Rakowska et al., 2005; Rakowska, 2007; Szczepocka, 2007; Szczepocka & Szulc, 2009; Rakowska & Szczepocka, 2011; Noga et al., 2013d; Noga et al., 2014b; Bielczyńska, 2015; Peszek et al., 2015; Kawecka & Galas, 2016; Noga et al., 2016).

Diatoms were used as environmental indicators for studying the palaeoecological status of various Polish ecosystems, palaeogeography, and environmental monitoring. Schulz (1926) was the first to use fossil diatoms to reconstruct palaeogeography and palaeoecology of the Ancylus Lake. He published the first list of freshwater diatoms that occurred in sediments of Gdańsk vicinity, the Vistula Delta Plain, and Hel Peninsula. Diatom analysis from the Pleistocene-Holocene sediments developed from the second half of the twentieth century and continued. Most of the published studies focused on the historical development of the Polish lakes and environmental changes during the Holocene. Several diatom investigations have been carried out on the lakes and Holocene lacustrine sediments situated in North and north-east Poland (e.g., Marciniak, 1973; Bogaczewicz-Adamczak, 1977; Przybyłowska-Lange, 1976, 1979, 1981;Marciniak & Kowalski, 1978; Marciniak, 1979; Przybyłowska-Lange, 1981; Bogaczewicz- Admaczak & Miotk, 1985; Niewiarowski, 1987; Bogaczewicz-Adamczak, 1990; Kowalczyk et al., 1999; Witak, 2000; 2002, 2005; Witkowski et al., 2004, 2009; Lutyńska, 2008 a, b; Mazurek et al., 2008; Lutyńska & Rotnicki, 2009; Winter et al., 2008; Woszczyk et al., 2008, 2010; Zębek et al., 2012; Sienkiewicz, 2013; Galka et al., 2014; Staszak-Piekarska & Rzodkiewicz, 2015; Pędziszewska et al., 2015; Zalat et al., 2018).

Moreover, some environmental studies by using diatoms were done in southern Poland (e.g., Marciniak, 1981, 1986b, 1998; Wojtal et al., 2009), Middle Pleistocene diatoms from interglacial lake sediments in central and eastern Poland (Marciniak, 1990, 1991), diatom record of mid-to late Eemian at Kozłów – Central Poland (Pidek et al., 2021), Late Saalian–Eemian Interglacial at the Struga site – Central Poland (Zalat et al., 2021), Eemian lacustrine sediments at Zbytki, Leszno Upland, Western Poland (Marciniak, 1994), Lake Biskupinskie, western Poland (Niewiarowski 1995), post-glacial acidification of two alpine lakes Mały Staw and Wielki Staw, Sudetes Mts., South-western Poland (Sienkiewicz, 2016).

Concerning the taxonomic diatom's studies in Poland included (e.g., Kawecka & Kwandrans, 2000; Siemińska & Wołowski, 2003; Wojtal, 2001, 2003a, b, 2004; Wojtal & Sobczyk, 2006; Wojtal & Kwandrans, 2006; Buczkó et al., 2009; Żelazna-Wieczorek et al., 2010; Budzyńska & Wojtal, 2011; Buczkó et al., 2013; Noga et al., 2013a; Bąk et al., 2014; Noga et al., 2014c; Noga et al., 2017a, b.)

3. Study area and site description

3.1. Northern Poland

Northern Poland is a glacially overprinted region with diverse topography, a wide variety of glacial landforms, common glaciofluvial deposits, and more than 7000 lakes distributed with a total surface area of about 281,377.0 ha (Rdzany, 2014; Choiński & Ptak, 2020). These lakes have different morphometric features, hydrological regimes, water chemistries, and trophic states (Kondracki, 2000; Witak et al., 2017), and they undergo the influence of various anthropogenic pressures (Ptak, 2015). Lakes in north-eastern Poland have been poorly recognized owing to vast forest areas. This particularly refers to the Warmian–Masurian Voivodship, where forest covers over 30% of its area. The present work was performed on some lakes situated in northern and northeast Poland and including Jeziorak, Młynek, Radomno, Kamionka, Francuskie, and Zeilone lakes (Figs. 6, 7). These Polish lakes are very sensitive to climate and environmental fluctuation. Their laminated sediments are considered an excellent natural archive of chemical, biological, and physical characteristics of the lakes, which in turn are used to reconstruct long-term climate and environmental changes (Jones et al., 2001; Zalat et al., 2018).

Jeziorak Lake

Jeziorak Lake is the longest lake in Poland with 28 km long, mean width of about 1.2 km, and the sixth largest lake with a surface area of about 3460 ha, and a total volume of 141.6 m^3. It is situated in the Iława Lakeland Landscape Park, at latitude 53° 37' 80" N, and longitude 19° 32' 82" E. It is a part of Iławskie Lake District in northeast Poland and the Vistula-Drweca catchment area. The lake is shallow with a maximum depth of 12.0 m, and the average depth is about 4.5 m (Jańczak, 1997). It is a post-glacial lake of a meridian-like placement containing sixteen islands (Donderski & Swiontek-Brzezinska, 2001). The lake is a part of the Elbląg Canal. There is a rich shoreline around the lake which is surrounded by the forests. It is strongly exposed to human pressure, so it is one of the eutrophic water bodies (Gizinski & Wisniewski, 1971). The Jeziorak Lake was recognized as one of the latest seven wonders of Poland by the readers of the traveling magazine "National Geographic Traveler.

Młynek Lake

Młynek Lake is a small water body that has occupied a glacial tunnel valley. It is located in the Iławskie Lakeland, north-east Poland at latitude 53° 49' 29.99 "N, and longitude 19° 43' 30.10" E and close to the archaeological site Janiki Wielkie (Welc et al., 2021). It is a gutter lake with 720 m long and 165 m wide at its maximum and maintains a NNE-SSW course. The area of the Młynek lake covers 7.5 ha (Choiński, 1991), its water surface rises to about 101 m above sea level, but the maximum depth is just over 2 m. The lake is surrounded by a corrugated moraine plateau, which raised at an altitude of 120-130 m above sea level. On the upland surface, at the turning point from the late to post-glacial era, the dead ice melted creating out-of-flow cavities of the N-S subglacial gutter in which the Młynek lake formed. The gutter slopes are steep, cut to the depth of about 25 m, and up to 250 m wide (Zalat et al., 2018; Welc et al., 2021). In the eastern vicinity of the Młynek Lake, there is a group of kame hills made of fine sands and silts, reaching 200 m, although their height does not exceed a dozen meters or so. They were formed during the smelting of ice sheets of the Vistula Glaciation (Rabek & Narwojsz, 2008).

Radomno Lake

Radomno Lake is located several kilometers to the south of Iława, within Warmia-Masuria district, southwest of Tabory, east of Bagno and northeast of Gryźliny, northern Poland, at the latitude 53° 30' 36.32" N, and longitude 19° 34' 05" E. The lake is shallow, water depth not more than 4 m, eutrophic with a water level is about 90.2 m above sea level. There is a significant archeological island situated in the central part of the lake. The morphology of the island indicates almost flat nearshore fragments separated by steep slopes from the central, rather leveled peak of the island. A well preserved, oval-shaped hillfort is located at the highest point of the southern part of the island, about 110 m a.s.l (Welc et al., 2018). The island is built mainly of fine-grained, horizontally bedded kame sand and sandy silt. The shape of the island and its setting along a subglacial flow direction indicates that the form occurred at the junction of 3 subglacial troughs (Gałązka, 2009).

Kamionka Lake

Kamionka Lake is located in the Iławskie Lakeland, northern Poland, south-west Jeziorak Lake at latitude 53° 36' 22.45" N, and longitude 19° 30' 33.10" E. The lake is relatively small, shallow, highly eutrophic, and relatively polluted. It covers an area of about 16.8 ha with a maximum depth of 18 m and an average depth of 4.5 m.

Francuskie Lake

Francuskie Lake is known as the French Lake a water nature reserve that situated at the latitude 53° 33' 25.15" N, and longitude 19° 57' 21.19" E, in the Warmian-Masurian Voivodeship on Dylewska Góra near Ostróda region and the village of Wysoka Wieś, north-eastern Poland. It is the highest lake, about 285 m above sea level. It is a small, mid-forest dystrophic Lake of a trailing character with an area of about 2.93 ha, and the remaining part of the lake is occupied by the adjacent forest of about 10.71 ha. The lake is a remnant of the excavation after the Baltic glaciation. The south-eastern shore is covered with about 140-year-old beech. The reserve has been founded to protect the relic swamp willow and the well-preserved local beech forest.

Zielone Lake

Zielone Lake is located in the Iława Lake District approximately 5 km southeast of Iława, 6 km south of Świętajno, 18 km east of Szczytno, and at the latitude 53° 33.5′ N; and longitude 19° 36.9′ E. This typical glacial ribbon lake has an elongated shape and extends longitudinally with a maximum length of about 1450 m and a maximum width of 250 m. It is a small, shallow low eutrophic lake with an area of about 20.2 ha and a maximum depth of 2.4 m. The lake was initially dominated by vascular flora and submerged macrophytes disappeared. In contrast, Lake Francuskie was dominated by submerged plants and macrophyte domination. The drainage basin of Zielone Lake is constituted by gently descending shores, covered mostly with mixed forest. Along the southern shore, a marshy meadow stretches. A small watercourse flows into the reservoir from the southern side. In the northern part, there is also a periodic watercourse that connects the lake with the Iławka River. Physico-chemical parameters of water in Zielone Lake indicate the relatively low eutrophic level and low electrolytic conductivity (Dembowska et al., 2018).

3.2. Central Poland

Several cores were drilled in the Garwolin Plain that is located in the southern zone of the paleolake lacustrine sediments of the Eemian interglacial fossil great Lakeland of Central Poland (Fig. 6). The paleolakes of the Eemian age were recognized during cartographic work for the Detailed Geological Map of Poland (1:50 000 Scale, Garwolin sheet) (Żarski, 2017). The Garwolin Plain covers an area of about 900 km^2 and lies on the eastern side of the Middle Vistula Valley, between the Mienia river valley (Świder tributary) in the north and the Okrzejka river valley in the south and borders neatly on the east with the Kałuszyn Upland and the Żelechów Plateau. It is a loamy and sandy denudation plain, which is cut across the tributaries of the Vistula – Świder, and Wilga. The surface of the plain is mainly covered with tills of Saalian Glaciation (MIS 6). The plain is sloping northwest from about 140 m above sea level to 130 m above sea level.

Seven core profiles were studied for diatom analysis, including the sites Struga (ST.19 and G-120), Kozlow 2 (K2-19**),** Żabieniec (Za-19), Parysów (Pa-19), Puznówka (Pu-19), and Jagodne (Ja-19) (Fig. 6).

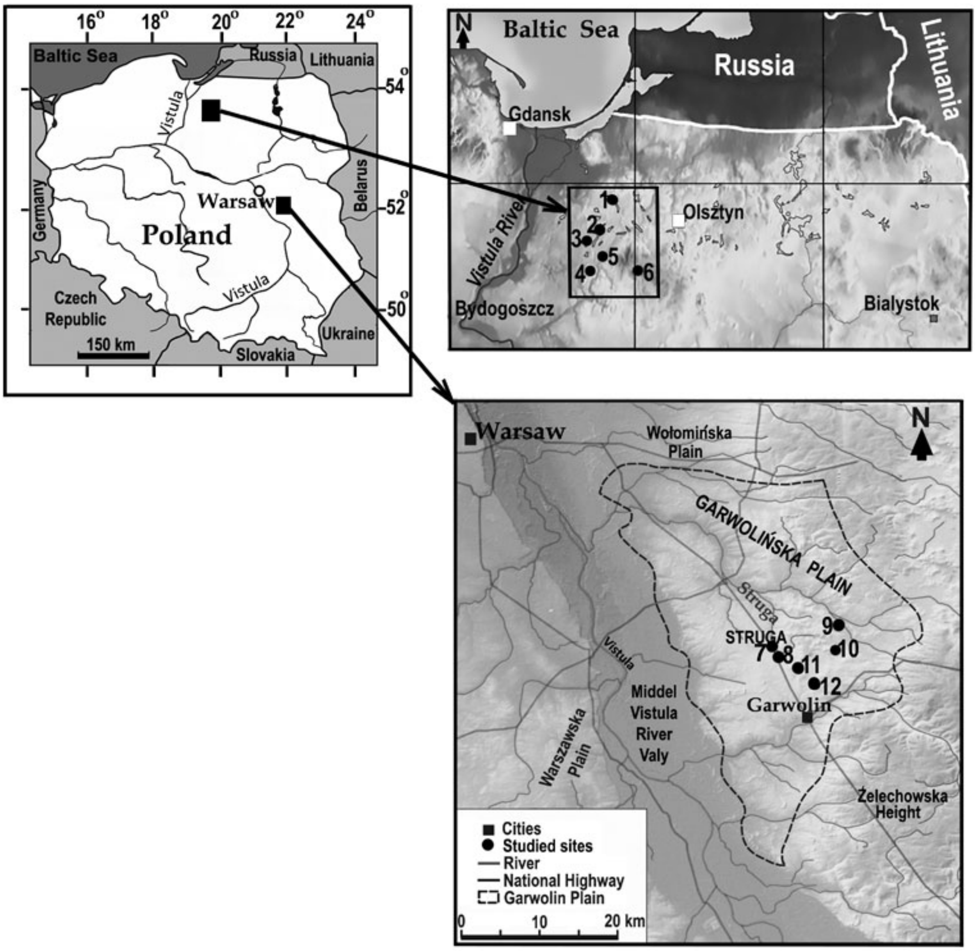

Fig. 6. Location map showing the studied sites in the north and central Poland

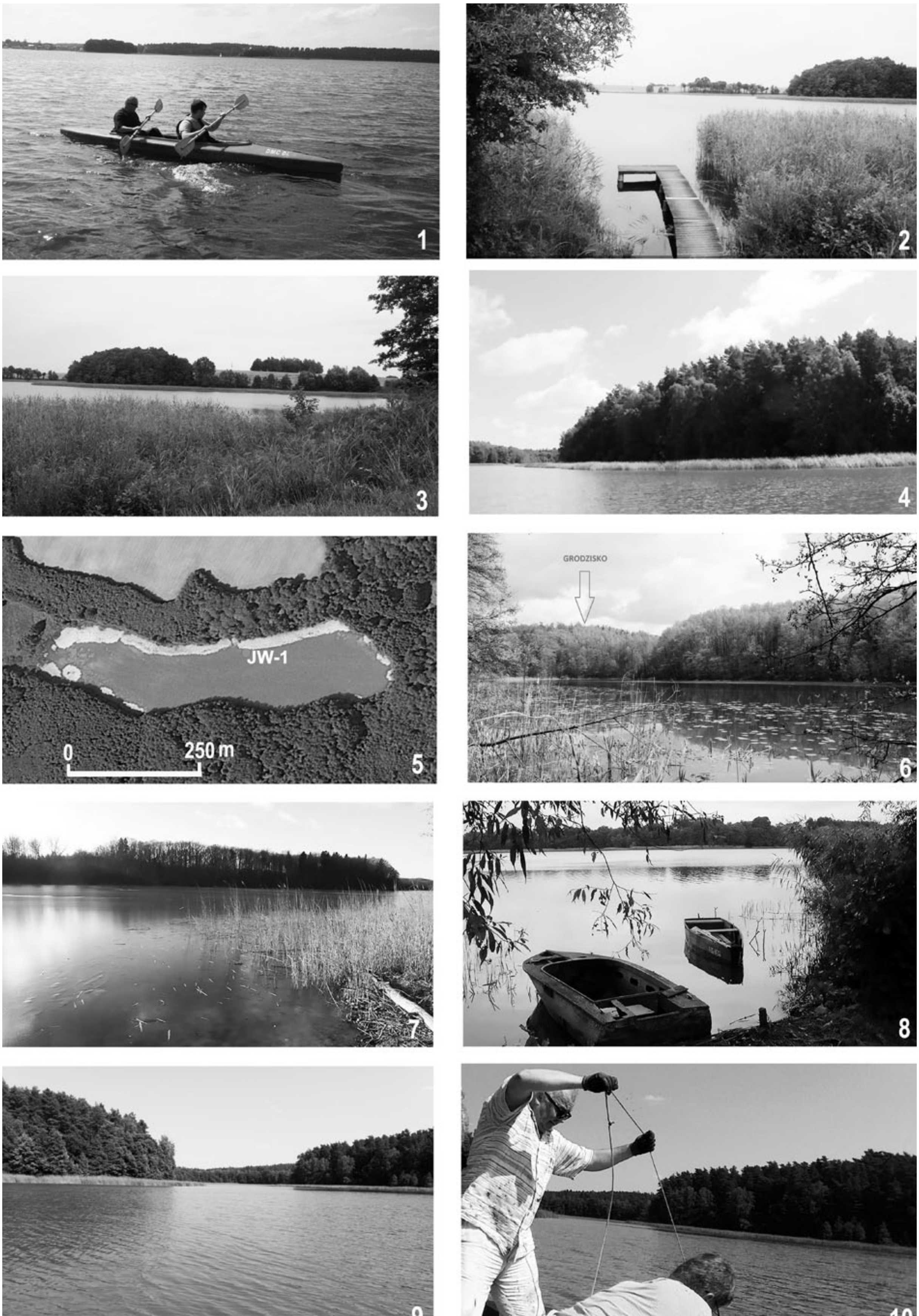

Fig. 7. General photos of the studied lakes in North Poland: 1-3. Jeziorak Lake, 4. Radomno Lake, 5-6. Młynek Lake, 7-8. Kamionka Lake, 9-10. Francuskie Lake

4. Materials and methods

4.1. Materials of study

A total of 821 samples were obtained from the studied sites. 352 samples were collected from the lakes in northern Poland, and 469 sediment samples were taken from the late Saalian-Eemian palaeolake deposits in Garwolin Plain, central Poland (Fig. 6). Each core sediment sequence was cut into 5 cm sections and packed in plastic bags, with some samples are cut into 1-2 cm slices. The sediments of the cores that obtained from the lakes in northern Poland have been stored in the cold container in the Department of Geology, John Paul II University of Applied Sciences in Biala Podlaska, while the sediments of the cores that collected from the palaeolake deposits in Garwolin Plain, central Poland have been stored in the cold storage room of the Institute of Earth and Environmental Sciences of Maria Curie-Sklodowska University in Lublin, Poland. Parts from all investigated samples are packed in plastic bags and carried into the Geology Department, Faculty of Science, Tanta University, Egypt for diatom analysis. The investigated samples are explained as follows:

- Jeziorak Lake: 20 sediment samples were collected from the surface sediments of the lake in October 2018. These samples are composed mainly of greenish to grayish sandy mud and muddy silt.
- Młynek Lake: 34 sediment samples were obtained from the core JW-1, with a total length of 3.45 m that recovered from the central northern bank of Młynek Lake, northern Poland. Lithologically, the sediments from the depth 0.00 to 0.40 m were composed of gray-brown, hydrated gyttja, 0.40 to 1.10 m were gray-brown, gyttja, 1.10 – 1.45 m gray-brown, very plastic gyttja, 1.45 – 1.80 m gray-brown, organogenic gyttja, and 1.80 – 3.45 m gray-brown gyttja with organic matter.
- Radomno Lake: 87 sediment samples were obtained from the core sequence at the depth of 0.40 to 9.00 m. Most of the studied samples are composed of gray-brown, very plastic gyttja, and organogenic gyttja with short intervals of sandy gyttja.
- Kamionka Lake: 70 sediment samples were obtained from the core section with a total depth of 6.90 m. The examined samples were gray-brown gyttja, with some samples consisting of gray- gyttja with organic matter and a few sandy gyttja.
- Francuskie Lake: 71 sediment samples taken from the profile at the depth interval from 1.00 to 4.92 m. The samples consisted mainly of dark gray- gyttja with organic matter and fragments of plant remains at some intervals.
- Zielone Lake: 70 sediment samples from the core section with a total depth of 6.85 m. The samples were composed of gray-brown, gyttja, plastic gyttja, and somewhat sandy gyttja at some intervals.
- Struga core section (G-120) was represented by 117 samples within the depth interval from 1.39 to 6.52 m. The investigated samples were composed of dark grey gyttja with peat, slightly carbonate, olive to grey-brown gyttja with layering of various sand, black and brown gyttja with silty sand.
- Struga core section (St-19) comprised 119 samples within the depth interval from 2.10 to 8.00 m. The samples are mainly constituting peat mud, peat gyttja, black peat poorly decomposed with layers of sand, and dark brown carbonate gyttja with fragments of malacofauna.
- Kozlow 2 core section (K2-19**)** encompassed 107 samples from depth interval 2.50 to 7.80. The samples are composed mainly of the gyttjas traces of peat at the bottom of the core. The biogenic sediments attain ca 7.5 m thick and there is a layer of gyttja-shales between 7.80 and 8.15 m.
- Żabieniec core section (Za-19) included 57 samples from depth interval 9.60 to 12.40m, which are consists of dark grey gyttja with peat.
- Parysów core section (Pa-19) covered 29 samples from depth interval 10.80 to 13.15m, which contains dark grey gyttja and peat gyttja.
- Puznówka core section (Pu-19) embraced by 17 samples obtained from depth interval 2.40-3.20 m. The samples are composed of dark grey-brown gyttja with few layering of fine sand
- Jagodne core section (Ja-19) contained 23 samples taken from depth intervals 5.70-6.80 m, which are comprising dark grey to olive gyttja with peat.

4.2. Diatom preparation

Laboratory treatment of sediments for diatom analysis was carried out according to the technique proposed by Battarbee et al. (2001). One gram of dry sediment of each sample was processed using the disintegration method in HCl and H_2O_2. The sample was treated with 30% H_2O_2 and boiled on a hot plate until the reaction was completed and all organic material was digested. After that, the sample was treated with 10% hydrochloric acid to remove carbonates, then washed with distilled water several times until all peroxide and most of the clay fractions were removed. Permanent slide preparations were obtained from the sample residue of 50 ml. About 0.1 ml was taken from the center of the homogenized suspension, randomly put on coverslips (22x50 mm), left to dry at low temperature, and then mounted onto a glass slide using Naphrax for microscopic observation. Diatom slides were prepared and deposited at the Geology Department, Faculty of Science, Tanta University, Egypt. and part of the prepared slides concerning the Polish lakes were placed at the Faculty of Technical Sciences John Paul II University of Applied Sciences in Biala Podlaska.

For Scanning Electron Microscopy observations**,** one drop of the final cleaned material of diatom suspension was spread over a small coverslip (20 x 20 mm) and left to dry in a desiccator containing silica gel for 24 hrs to make sure that it became completely dry. The dried coverslip was fixed on the aluminum microscope stub with carbon tape then sputter-coated with gold**.** The coated coverslips were examined with Field Emission scanning electron microscope (FE-SEM), Quanta FEG 250, FEI with EDAX, and Jeol scanning microscope 5300, working under a high vacuum 20 and 30 kv, which is usually adequate voltage for examining diatoms to reveal the fine details. Scanning electron microscopy (SEM) studies were carried out in the electronic microscope unit at National Research Center- Dokki- Egypt.

4.3. Diatom identification

The diatom assemblages were examined quantitatively using an Optika light photomicroscope with a digital 10-megapixel camera and equipped with a Brightfield and Differential Interference Contrast (DIC) optics at 1200× magnification with 100x oil immersion. Diatom species were identified to the species level and ecological information of the recognized diatom taxa were based on extensive literature and comparisons with the most up-to-date literature (e.g., Hustedt, 1925-1957; Patrick & Reimer, 1966, 1975; Krammer & Lange-Bertalot, 1986-1991; Denys, 1991-1992; Lange-Bertalot & Metzeltin, 1996; Metzeltin & Witkowski, 1996; Douglas & Smol, 1999; Lange-Bertalot & Genkal, 1999; Witkowski et al., 2000; Krammer, 2002; Zalat & Servant-Vildary, 2005, 2007; Tanaka, 2007; Levkov, 2009; Hofmann et al., 2011; Houk et al., 2010, 2014; Ector et al., 2015; Lange-Bertalot et al., 2017; Bahls et al., 2018; Ribeiro et al., 2019). The arrangement and placement of the different taxa in the 121 plates of this first monograph follow, when possible, the current diatom classification in alphabetical order.

All of the taxonomic data was updated by more recent algae databases (Guiry & Guiry, 2021). Recent taxonomic advances have split many diatom taxa of the former genus *Cyclotella sensu lato* into several new genera, including *Cyclotella, Discostella, Puncticulata, Pantocsekiella,* and *Lindavia*. *Fragilaria sensu lato* including *Fragilaria*, *Pseudostaurosira, Staurosira,* and *Staurosirella* (Williams & Round, 1987). The magnification of the micrographs is x 1200 unless otherwise indicated. This allows a more direct comparison between taxa of different sizes

Numerical analysis of diatom taxa was performed by counting 1000 valves in transverse scans of each slide at 1000 x magnification. For the less populated samples, a minimum of 300 valves was counted. The counting method was achieved to estimate the percentage of the abundance of individual taxa within the community. Relative frequencies of every species were calculated as percentages of total diatom valves (%TDV). The diatom stratigraphic data were divided into diatom assemblage zones based on constrained cluster analysis of the investigated samples performed by Past program v. 4.03 (Hammer et al., 2001). The diatom concentration was calculated by adding a known concentration of synthetic microspheres to the samples and the result was expressed as valves per gram of dry weight (dwg) sediment (Battarbee & Kneen, 1982).

The ecological preferences of the recognized diatom taxa comprised four pH categories according to Ehrlich (1973, 1975): acidophilous (pH <7 to 5.5), circumneutral (pH around 7), alkaliphilous (pH over 7 to 8.5), and alkalibiontic (pH over 8.5). Regarding salinity, most of the recognized taxa were classified as oligohalobous, with a small number being mesohalobous. The oligohalobous species were included in three categories: halophobous, indifferent, and halophilous (Hustedt, 1953, 1957).

5. Results

The diatom assemblages from the sediment of the investigated entire cores of the studied lakes and Eemian deposits in central Poland were rich and very well preserved. However, the broken valves were also recorded in particular the top parts of the studied core sections. More than 1300 species and intraspecific diatom taxa were recognized. Based on the species composition and the associated changes between ecological groups of diatoms, two major groups including the planktonic, centric taxa of class Coscinodiscophyceae and the benthic Fragilaria sensu lato species were dominant and have a good opportunity to use as indicators of the paleoenvironment and climate changes. As well as, the diatom association contains large numbers of the other benthic and epiphytic taxa, which are distributed frequently.

Jeziorak Lake

In Jeziorak Lake, northern Poland, a detailed diatom investigation on 20 surface sediment samples led to identifying 248 diatom species assigned to 59 genera. Preservation of the recognized diatom taxa was well to moderate in the most of investigated samples, associated with many teratological diatom frustules. Benthic and epiphytic forms were predominant and counted about 82% of the total assemblage. The planktonic taxa were distributed infrequently by species of the genera Aulacoseira, Cyclotella radiosa complex, and Ellerbeckia. Most of the reported diatom taxa were oligohalobous and alkaliphilous with a considerable amount of the alkalibiontic forms. The common occurrence of the teratological diatom reflects the human pressure on the lake. The great abundance of the benthic and epiphytic taxa points to a shallow, alkaline, eutrophic freshwater environment with the development of macrophytes.

Młynek Lake

Results of diatom analysis from 345 cm long core recovered from Młynek Lake, northern Poland explained the occurrence of 215 diatom species and varieties represented by 54 genera. Their fossil state fluctuated between rich to frequent and very well to poorly preserved. Of the recorded species, 58 diatom taxa were distributed regularly and 15 species were either common and/or abundant. The remaining taxa are infrequently distributed throughout the core samples. The recognized diatom assemblages displayed marked floristic changes from an assemblage dominated by benthic Fragilaria sensu lato species to a planktonic one in distinct zones. Base on the cluster analysis and the relative abundances of the dominant and subdominant taxa, the Młynek core sequence was divided into eleven diatom zones, which reflected six phases of lake development through the period from 2250 years to the present (Fig. 8, Zalat et al., 2018). Most of the recognized taxa belonging to the oligohalobous salinity group with very limited taxa less than 5% were considered as mesohalobous forms. The planktonic taxa were dominant by Aulacoseira spp., followed by common Puncticulata radiosa, small Cyclotella species, and frequent occurrence of Cyclostephanos dubius and Stephanodiscus spp. The benthic species were represented by small Fragilaria sensu lato species including a great abundance of Staurosira venter, S. construens, together with frequent occurrence of Staurosirella pinnata and Pseudostaurosira brevistriata, besides the common appearance of Gyrosigma acuminatum. Other benthic species of the genera Amphora, Navicula, Sellaphora, Cymbella, Encyonema, Nitzschia, Diploneis, Pinnularia, and Surirella were distributed infrequently. A high percentage of benthic to plankton taxa has been reported as indicative for a lowering of the lake level with long ice cover in a cold dry climate and a shift from benthic to planktonic diatom taxa reflects arising water level with longest growing season and reduced ice cover on the lake during a warm wet climate (Zalat et al., 2018; Welc et al., 2021).

Radomno Lake

Diatom investigation of Radomno Lake core sediments (0.40-9.00 m long) revealed the presence of 265 diatom taxa belonging to 54 genera. The recognized diatom taxa were abundant and well to moderately preserve in the most of investigated samples; except a short interval from 1.8 to 2.95 m are devoid of diatoms. Results of diatom analysis explained that the epiphytic and benthic diatom species are most dominant throughout the core samples than the planktonic forms, especially from the middle to the top of the core, while the lower part is distinguished by the predominance of planktonic rather than the benthic and epiphytic taxa. The great abundance of periphytic taxa to planktonic is indicative of the shallowness of the lake and somewhat existence ice-cover during the cold periods. The increase in planktonic diatoms occurred rather gradually at the lower part of the core between ca. 630 – 720 cm and 770 – 840 cm sediment depth and at short intervals 160-170 cm. This reflects an increase in spring air temperatures, with increasing water levels. The variations in the abundances of planktonic and periphytic taxa can be considered as indicators of lake level changes.

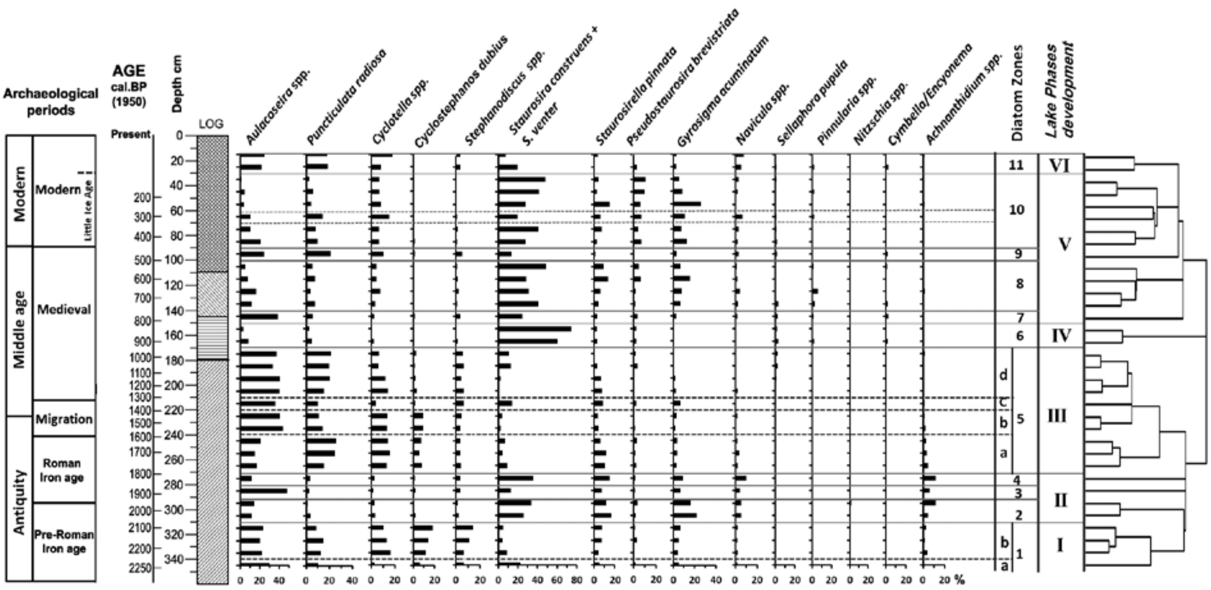

Fig. 8. Diatom stratigraphy of studied core JW-1, Młynek Lake, showing the diatom zones and lake phases development (Zalat et al., 218)

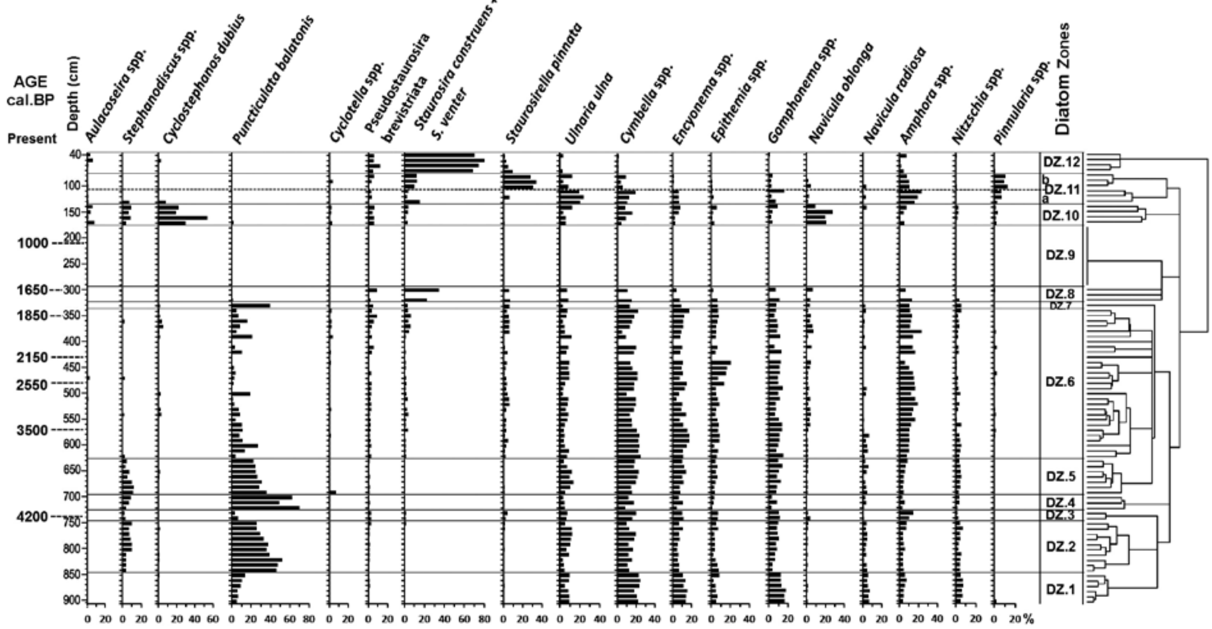

Fig. 9. Diatom stratigraphy of the Radomno Lake core, showing the diatom zones

Results of diatom analysis and the stratigraphic distribution pattern of the identified diatom taxa throughout the studied core explained marked transitions in diatom assemblages in which a shift in genera dominance was recorded in the examined core samples (Fig. 9). This variation in diatom species composition and its relative abundance led to distinguish seven diatom ecological groups, represented by twelve diatom zones, which reflect different phases of lake development with marked environmental and climatic changes through its history during the Holocene. It is worthy to mention that the alkaliphilous taxa are dominant and the alkalibiontic diatoms are restricted in some samples with sparsely of few numbers of the acidophilous diatom taxa.

Kamionka Lake

Diatom analysis of 70 sediment samples obtained from the Kamionka Lake core section with a total depth of 6.90 m has shown the occurrence of 240 diatom taxa belonging to 58 genera. The recognized diatom taxa were abundant and well to moderately preserve throughout the studied core samples. The stratigraphic distribution pattern of the identified diatom taxa throughout the core explained marked transitions in diatom assemblages in which a shift in genera and species dominance was recorded. The diatom species composition in the lake core sediments explained the periphytic taxa, especially the genera Fragilaria sensu lato, Navicula, Cymbella, Encyonema, and Amphora increase on the expense of the planktonic taxa. Small Fragilaria sensu lato, which are represented by Staurosira construens, Staurosira binodis, Staurosira venter, Staurosirella pinnata, Pseudostaurosira brevistriata, and Pseudostaurosira pseudoconstruens were the most important components and dominant throughout the core, with relative abundances of over 40%. The predominance of periphytic taxa to planktonic is indicative of a shallow water lake. Moreover, the great abundance of Fragilaria sensu lato species throughout most of the core samples reflects the generally shallow, weaker stratification, alkaline, cold lake water, and relatively increased conductivity and nutrients content with short growing seasons. It is interesting to note that many of the teratological diatom frustules were observed throughout the studied core samples. The occurrence of these forms may due to heavy metal pollution, which reflects the anthropogenic impacts on the lake ecosystem during the time of deposition.

Francuskie Lake

A detailed diatom study was carried out on 71 samples obtained from a core drilled in Francuskie Lake with a depth interval from 1.00 to 4.92 m. The diatom taxa were moderate to poorly preserved with low richness throughout the core section from the depth interval 177 to 400 cm and absent in the bottom core samples. Towards the top part of the core section, the diatom taxa were abundant and well to moderately preserve through the depth interval 100-172.6 cm. Results of diatom analysis led to identifying 97 diatom species belonging to 25 genera. The diatom composition explained a predominance of oligotrophic, acidophilous benthic taxa including Eunotia, Pinnularia, Sellaphora, Nitzschia, and Tabellaria species with the extremely limited occurrence of alkaliphilous forms that distributed sporadically. It is interesting to note that the total absence of planktonic diatoms throughout the core samples, except the topmost part samples where Aulacoseira taxa appeared in significant numbers. The maximum abundance of oligotrophic, acidophilous benthic taxa has been reported as indicative for shallow, stagnant, ultra-oligotrophic, and oligotrophic acidic waters enriched with humic acids.

Zielone Lake

In Zielone Lake, the recognized diatom taxa from 70 sediment samples were distributed sporadically with poorly preserved over the core section of total depth 6.85 m. A total of 34 diatom species belonging to 12 genera were identified. The most apparent taxa were acidic forms belonging to genera Pinnularia, Eunotia, and Tabellaria, which are characteristic of the oligotrophic, low alkalinity, shallow freshwater lake. The sporadic occurrence of diatoms points to a recent decrease in lake productivity.

Garwolin Plain, central Poland

The paleolake lacustrine sediment from 7 core sections obtained at the Garwolin Plain in Central Poland was subjected to diatom analysis (Fig. 6). The main aim of these studies was to assess the environmental history and climatic change occurring during the late Saalian/ Eemian transition, and the whole Eemian interglacial. Altogether, 65 diatom genera including 415 species and varieties were recognized from 469 samples. The diatom taxa were abundant and generally well to moderately preserved through the lower parts of both Struga cores G-120/St-19, and gradually decreased in their abundance with some admixture of mechanically- broken valves were observed upwards. The upper part of the two profiles was barren of diatoms except some sporadic dissolved frustules were seen. However, the diatom taxa were abundant and well to moderately preserved in the other studied cores.

Struga core (St-19) and Kozlow 2 core (K2-19**)** are considered the best two profiles because they form a complete section starting from the late Saalian to the late Eemian, which is dominant by fossil diatoms (Figs. 10, 11) (Zalat et al., 2021; Pidek et al., 2021). Multivariate statistical analyses, including ascending hierarchical clustering and the relative abundance of the dominant and subdominant diatom taxa were used to identify the diatom assemblage zones for each profile, which reflected environmental and climatic variabilities in central Poland during the investigated period. The diatom composition demonstrated a clear shift from an assemblage dominated by periphytic species including Fragilaria sensu lato taxa to a planktonic one comprising Cyclotella sensu lato species through marked intervals in distinct zones. The obvious changes in diatom assemblages and the relative abundance of the dominant and sub-dominant taxa indicated fluctuations in the paleolake water level and the small-scale climate oscillation throughout the entire studied sections (Zalat et al., 2021; Pidek et al., 2021). It has been reported that a high ratio of periphyton fragilarioid diatom species to plankton small *cyclotelloid* taxa is indicative of shallow, unstable lake phases; while a shift from periphytic/benthic to a great abundance of planktonic diatom taxa can be regarded as indicating increased temperatures, well-developed thermal stratification, with the rising water level in a warm-wet climate.

The diatom record obtained from the palaeolake sediments in Garwolin Plain, central Poland provides additional information about the environmental history of the paleolake and the climate change that took place during the late Saalian -Eemian interglacial. The results explain that the Late Saalian was characterized by a clear change in water level related to climate change. The diatom record of the final stage of the Late Saalian indicates that the paleolake level fell during low wind and cold climate conditions. The transition to the early Eemian was marked by a gradual rise in temperature associated with a slight increase in water lake level and a slightly alkaline, mesotrophic freshwater environment. The climate continued to warm through the early Eemian accompanied by high water levels, an alkaline open freshwater environment, and prolonged thermal stratification in summer. The Middle Eemian (E3 R PAZ) started with a relatively warm climate with the paleolake water level falling. Following this, the combination of increasing temperature with a humid climate and a shallow paleolake fostered a more alkaline mesotrophic to the eutrophic freshwater environment.

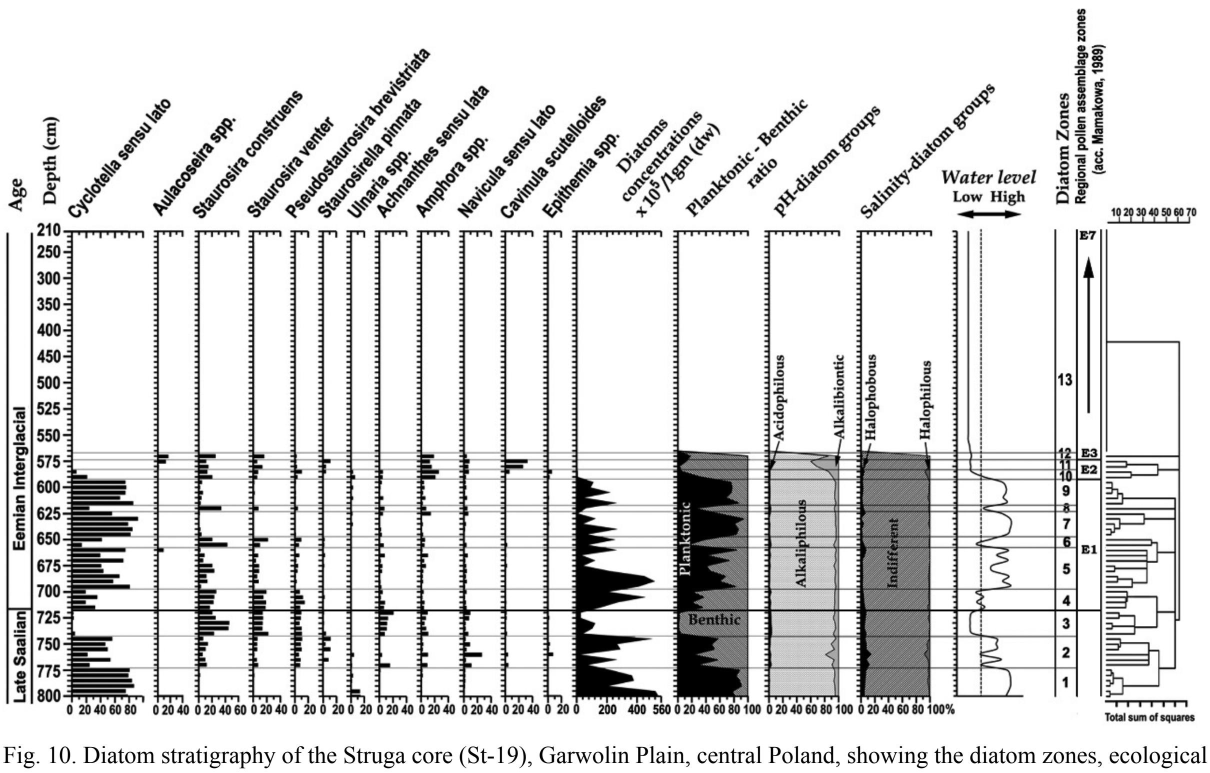

Fig. 10. Diatom stratigraphy of the Struga core (St-19), Garwolin Plain, central Poland, showing the diatom zones, ecological diatom groups, and lake water level (Zalat et al., 2021)

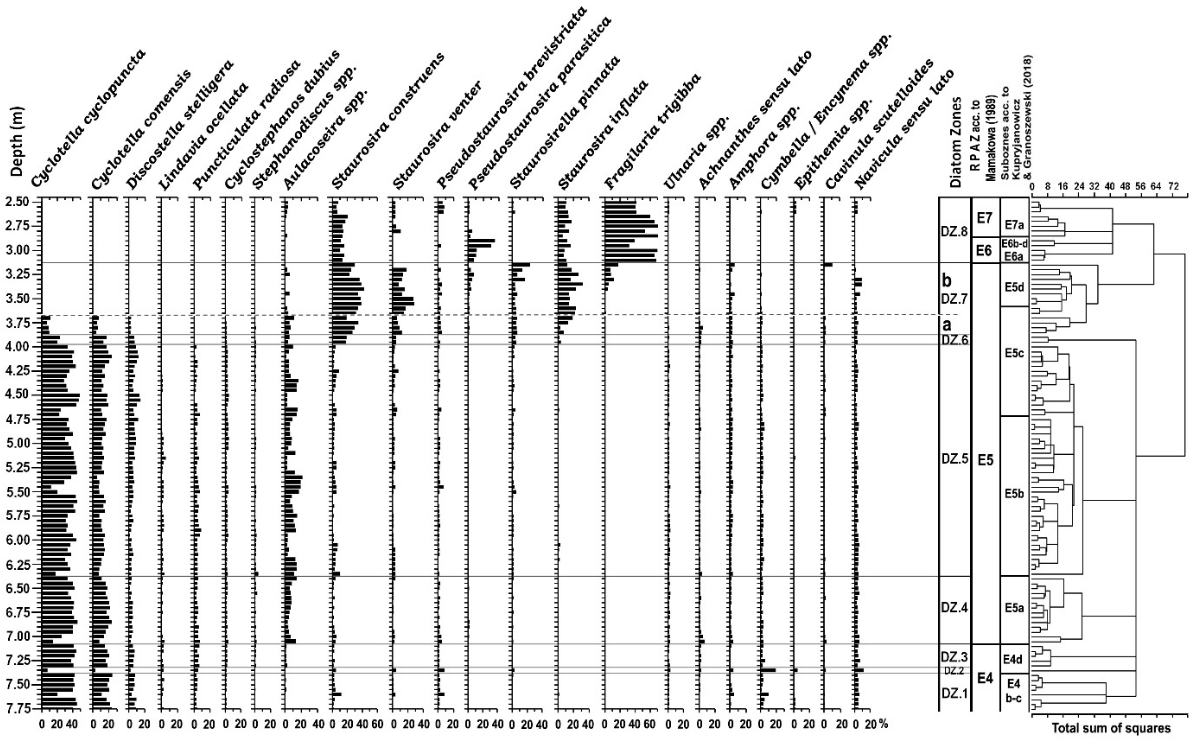

Fig. 11. Diatom stratigraphy of the Kozlow core (K2-19**)** Garwolin Plain, central Poland (Pidek et al., 2021).

6. Diatom taxonomy

The classification system adopted in the present work was proposed by Medlin & Kaczmarska (2004) and recently modified by Medlin (2016). The newer classification is based on the combination of molecular and morphological data in its construction and created two subdivisions: Coscinodiscophytina and Bacillariophytina. The first subdivision is composed of the emended class Coscinodiscophyceae and includes all radial centric diatoms. The second subdivision includes the class Mediophyceae (for the bipolar centric and Thalassiosirales) and an emended class of Bacillariophyceae (comprising all pennate diatoms). This new classification is thought to have a more natural arrangement than the system proposed by Round et al. (1990), for it better reflects the findings of the fossil record (e.g., Sims et al., 2006).

The morphological, ecological characteristics and distributional data of the 41 centric diatom taxa found in Pleistocene-Holocene lacustrine sediments and modern Polish ecosystems are presented. The recognized centric diatoms are mainly characteristic of European lakes and rivers. Data of valve characters (diameter, number of striae/10 mm, etc) for each taxon are integrated from our measurements and literature data. The terminology used in the description of the frustule, raphe structure, follows the definitions gathered in Cox (1996), Krammer & Lange-Bertalot (2000), Ross et al. (1979), and Round et al. (1990).

Kingdom: Chromalveolata Adl et al. 2005
Subkingdom: Chromobiota Cavalier-Smith 1991
Phylum: Ochrophyta (Cavalier-Smith, 1986) T. Cavalier-Smith 1995
Subphylum: Diatomeae (Dumortier, 1821) Cavalier-Smith, 1995 – diatoms
Division: Bacillariophyta *Engler & Gilg 1924*
Subdivision: Coscinodiscophytina Medlin & Kaczmarska 2004

Class: Coscinodiscophyceae Round & Crawford, emend Medlin & Kaczmarska 2004
Subclass: Coscinodiscophycidae Round & Crawford 1990
Order: Aulacoseirales Crawford 1990
Family: Aulacoseiraceae Crawford 1990

Genus *Aulacoseira* Thwaites 1848

Diagnosis: Cells form a long cylindrical chain by uniting adjacent sibling valves with spines around the valve. Valves are circular and their plains with irregularly scattered poroids. Valve mantles deep developed and cells are usually seen in girdles when viewed microscopically. Areolae on the mantle arranging in straight, curved, or spiraling rows in opposite directions between cell junctions. Sulcus is occasionally deep between the collum and areolated mantle. A ring of spines at the junction area of valve and mantle, and two types as separation and interlocking spine.

Holotype species Melosira crenulata (Ehrenberg) Kützing 1844
= Aulacoseira crenulata (Ehrenberg) Thwaites 1848

***Aulacoseira agassizii* (Ostenfeld) Simonsen 1979**

(Pl.1, figs. 1-4)

Ref. Melosira agassizii Östrup; Hustedt in Huber-Pestalozzi 1942, p.383, fig. 458; Gasse 1986, p. 73, pl. 1, figs. 1-3.

Status of name: accepted taxonomically

Synonym: Melosira agassizii Ostenfeld 1909

Diagnosis: Cells are cylindrical, with a well-developed mantle structure. Valve face is nearly flat, punctate, curved slightly at the margin; pseudosulcus small; sulcus is a simple furrow; neck short or moderately long. The surface of the mantle is ornamented by fine to medium-coarse rounded areolae, arranged in longitudinal spiral rows, about 9-11 rows in 10 µm. The valve has a thick ringleiste and long separation spines. The valve diameter is 18-30 µm and the mantle height is 10-15 µm.

Ecological preference: It is a limnobiontic and planktonic species, and the best development was observed in the relatively shallow lakes in east Africa. It seems to prefer waters with low mineral content and low alkalinity with pH 7-8 (Gasse, 1986). The species was observed commonly in eutrophic freshwater environments of low conductivity and moderately alkalinity, with pH values 7.2-7.8 (Zalat & Servant-Vildary, 2005).

Occurrence: The species is recorded infrequently in the Kamionka and Radomno Lakes, and the Eemian deposits of central Poland.

Distribution in Poland: New record in Poland.

Aulacoseira alpigena **(Grunow) Krammer 1990**

(Pl.1, figs. 5-6)

Ref: Krammer & Lange-Bertalot 1991a, p. 34, pl. 2, figs. 3-7; pl. 30, fig. 1; pl. 31, figs. 1-15; pl. 32, figs. 10-16; Valeva & Temniskova-Topalova 1993, p. 69, pl. 1, fig. 15; Lange-Bertalot & Metzeltin 1996, p. 122, pl. 2, figs. 9-14; pl. 4, fig. 1; Siver & Kling 1997, p. 1828, figs. 93, 94, 96, 97.

Status of name: accepted taxonomically

Synonyms: *Melosira distans* subsp. *alpigena* (Grunow in Van Heurck, 1882
Melosira italica var. *alpigena* (Grunow in Van Heurck) Cleve-Euler, 1934
Aulacoseira distans var. *alpigena* (Grunow) Simonsen, 1979
Aulacoseira lirata var. *alpigena* (Grunow) Haworth, 1990

Diagnosis: Frustules are cylindrical and connected with valves to form long filaments. Valves are circular with oblique or curved striae on the mantle, about 15-25 striae in 10 µm. The areolae on the mantle arranging in regular patterns and appearing to be a little larger than the others near the margin. Striae on the mantle are mainly alternate with marginal spines, but their arrangement irregular. The valve diameter is 4-15 µm and the mantle height is 4-7 µm.

Ecological preference: This species is widespread in low alkalinity and oligotrophic freshwaters (Haworth, 1988); it is dominant as acidophilous taxa (Siver & Kling, 1997; Leira, 2005). Freshwater, planktonic, indifferent to halobien and pH, o-saprobic (Medvedeva et al., 2009).

Occurrence: It is recorded infrequently from the Holocene sediments of Radomno and Francuskie Lakes.

Distribution in Poland: It is recorded from the high mountain lakes under the stress of acidification (Tatra Mts, Poland) (Kawecka & Galas, 2003); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Holocene sediments of Mały Staw and Wielki Staw lakes in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2005, 2016); Holocene sediments of Suwalki Landscape Park north-eastern Poland (Gałka, et al., 2014); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015); the high-mountain streams in southern Poland (Tatra Mts) (Wojtal, 2013).

Aulacoseira ambigua **(Grunov) Simonsen 1979**

(Pl. 2, figs. 1-7)

Ref. Simonsen 1979, p. 56; Krammer & Lange-Bertalot 1991 a, p. 25, pl. 1, figs. 4-5; pl. 12, fig. 3; pl. 21, figs. 1-16; Houk 2003, p. 21, pl. 28, figs. 1-15. As Melosira ambigua (Grunow) O. Müller 1903; Husted 1930 a, p. 89, fig. 49; Gasse 1980, p. 32, pl. 7, figs. 3-17; pl. 8, figs. 1-24; pl. 9, figs.1, 5-8; pl. 10, figs. 1-3; Germain 1981, p. 26, pl. 4, figs. 5-7; Gasse 1986, p. 74, pl. 1, figs. 12-17; Zalat 1991, p. 35, pl. 1, fig.1; Siver & Kling 1997, p.1808, figs. 1-12; Siver et al. 2005, p. 33, pl. 1, figs. 22, 25–27; pl. 3, fig. 3; Tremarin et al., 2014, p. 140, figs. 1-47; Bicudo et al., 2016, p. 3, figs. 4-11.

Status of name: accepted taxonomically

Synonyms: *Melosira granulata* var. *ambigua* (Grunow) Thum 1889.
Melosira ambigua (Grunow) O. Müller 1903
Melosira italica f. *ambigua* (Grunow) Bolochonzew 1909
Melosira italica var. *ambigua* (Grunow) Cleve-Euler 1922
Melosira italica subsp. *ambigua* (Grunow) Cleve-Euler 1938

Diagnosis: Cells are cylindrical, linked tightly by interlocking spines to form long tubular filaments. Valves are circular, flat to very slightly convex. The ratio of mantle height and valve diameter is 0.75 to more than 2. Pseudosulcus is marked by a distinct groove. True considerably wide sulcus apparent between the mantle and collum. The surface of the mantle is ornamented by spiraled rows of areolae with about 14-19 striae in 10 µm. Valve diameter 8-16 µm and the mantle height 7-12 µm.

Remarks: Aulacoseira ambigua is distinguished from other species of the genus mainly by the hollow ringleist, a feature that can be observed in the light microscope as a structure in a "U" (sulcus) found in the mantle near the collum.

Ecological preference: Cosmopolitan species. Planktonic, in eutrophic lakes, alkaliphilous, oligosaprobic "meso-oxybiontic" (Hustedt, 1930, 1957); freshwater form, alkaliphilous with pH value 7.5 – 8.0 (Ehrlich, 1973); oligohalobous, meioeuryhaline (Pankow, 1976); it is regarded as being an indicator of low alkalinity (Richardson et al., 1978); limnobiontic, developed optimally in shallow waters, small lakes, or in the marginal areas of big lakes; it is reported from water with a low mineral content and medium–low pH (6.5 – 8.0) and appeared to have a rather narrow temperature range 20 – 28 °C (Gasse, 1986); mesotrophic and eutrophic indicators requiring elevated nutrient levels and is known as alkaliphilous algae (Siver & Kling, 1997); the species was observed commonly in the many freshwater environments such as lakes, ponds and rivers with low conductivity and alkalinity, pH values 7.0 – 8.2, and in unpolluted to slightly polluted waters (Zalat, 2002; Zalat & Servant-Vildary, 2005); it has recorded in oligotrophic water (Stenger-Kovács et al., 2007), and meso-eutrophic environments (Gómez & Licursi, 2001; Ivanov & Kirilova, 2004); it is found in oligotrophic to eutrophic waters (van Dam et al., 1994; Stenger-Kovacs et al., 2007), but prefers nutrient-rich waters, and reported during water mixing and low light conditions (Houk, 2003; Taylor et al., 2007); freshwater, eutraphentic with pH value 7.69 – 8.11 (Witak et al., 2017).

Occurrence: Common in the Młynek Lake sediments, and frequently in Kamionka, Radomno, and the Eemian deposits of central Poland; rare in the Jeziorak, and Francuskie Lakes.

Distribution in Poland: It is recorded from Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Dolgie Wielkie lake on the Gardno-Leba Coastal Plain within the Slowinski National Park, North Poland (Lutyńska, 2008a); Lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); from Duszatyńskie Lakes, south eastern Poland (Noga et al., 2013); the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); Holocene sediments of Suwalki Landscape Park north-eastern Poland (Gałka, et al., 2014); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Aulacoseira canadensis* (Hustedt) Simonsen 1979**

(Pl. 1, figs. 7-8)

Ref. Potapova et al., 2008, pl. 9, figs. 154-161; Bahls et al., 2009, p. 169, figs. 1-20; 33-38.

Status of name: accepted taxonomically

Synonyms: *Melosira canadensis* Hustedt 1952
Melosira youngii f. *canadensis* (Hustedt) Kaczmarska 1985

Diagnosis: Valves are circular with a flat disc. The surface of the mantle is covered by coarse round or oval areolae generally arranged in straight rows, parallel to the pervalvar axis, or somewhat disorganized and more widely spaced in small-diameter cells, about 7-10 coarse rows in 10 µm, and 8-l0 areolae per 10 µm. Valve diameter 4-13 µm and the mantle height 11-20 µm.

Ecological preference: Planktonic, found in fresh water environments, flowing and standing waters, ponds, streams, and rivers (Bahls et al., 2009).

Occurrence: Recorded rare in the sediments of Młynek and Radomno Lakes.

Distribution in Poland: New record.

***Aulacoseira crassipunctata* Kammer 1991**

Ref. Krammer 1991, p. 490, figs 71-79**;** Wojtal et al. 1999, p. 170, figs. 4-5**;** Bahls et al., 2009, p. 170, figs. 21-32; 39-43.

Status of name: accepted taxonomically

Diagnosis: Valves are circular with flat, concave, or convex valve face. The surface of the mantle is covered by coarse round areolae generally arranged in straight rows. The mantle has round areolae with very small external openings. The ringleist is very thick, solid, which occupied almost the whole length of the collum, with the thickest part positioned approximately in the middle of the collum. Linking spines were small and irregular in shape. Valve diameter 8-12 µm and the mantle height 13-20 µm.

Ecological preference: The species was recorded from the shallow freshwater environment of conductivity ranged from 10 to 74 µS/cm, alkalinity 7– 27 µeq/L, pH 5.0–6.1, dissolved organic carbon (DOC) 5–20 mg/L, maximum measured lake depth 1–5 meters (Fallu et al., 2000); acidic, low conductivity ponds and other water bodies, several of which were high in nutrients and stained with humic acids (Siver & Kling, 1997; Siver et al., 2005).

Occurrence: Recorded rare in the sediments of Młynek, Radomno, and Kamionka Lakes.

Distribution in Poland: Recorded from the „Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999).

***Aulacoseira crenulata* (Ehrenberg) Thwaites 1848**

(Pl. 1, fig. 9)

Ref. Krammer & Lange-Bertalot 1991a, p. 30, pl. 26, figs. 1-9; pl. 27, figs.1-12; Siver & Kling 1997, p. 1815, figs. 46-47; Crawford et al., 2003, p. 9, fig. 15.

Status of name: accepted taxonomically

Synonyms: *Aulacoseira italica* f. *crenulata* (Ehrenberg) R. Ross in Hartley 1986
Melosira crenulata (Ehrenberg) Kützing 1844
Melosira italica var. *crenulata* (Ehrenberg) Kützing 1844
Aulacoseira crenulata (Ehrenberg) Thwaites 1848
Orthosira orichalcea var. *crenulata* (Kützing) Rabenhorst 1863
Melosira orichalcea var. *crenulata* (Ehrenberg; Thwaites) Brun 1880

Diagnosis: Cells are cylindrical and united to form long filaments. Valves are circular with a flat disc. The ratio of mantle height to diameter is almost above 1 and below 1 in larger sizes. Valve mantle is covered with relatively fine to moderate elongated or slit-like areolae. Areolar striae are parallel to pervalvar axis, about 12-16 striae in 10 µm. Linking spines are strong and located around the margin of the valve. Valve diameter 7-30 µm and the mantle height 8-20 m.

Ecological preference: The species is cosmopolitan, benthic, or periphytic diatoms, and prefers more and less acidophilic and oligotrophic water bodies, and common in calcium-rich water (Krammer & Lange-Bertalot, 1991a; Sejnohová et al., 2003).

Occurrence: Recorded rare in the sediments of Młynek and Radomno Lakes.

Distribution in Poland: It is recorded from Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); the Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015).

***Aulacoseira distans* (Ehrenberg) Simonsen 1979**

Ref. Krammer & Lange-Bertalot 1991 a, p.32, pl. 1, figs. 2-3; pl. 3, figs. 1-2; pl. 29, figs. 1-23; pl. 30, figs. 1-11. As Melosira distans (Ehrenberg) Kützing; Hustedt 1930 a, p. 92, fig.53; Van Landingham 1967, p. 11, pl. 15, figs. 11-13, 16-49; Andrews 1970, p. 9, pl. 1, fig. 6; Germain 1981, p. 26, pl. 3, figs. 9-13; Gasse 1986, p. 75, pl. 2, fig. 12; Siver & Kling 1997, p. 1823, figs. 72-74.

Status of name: accepted taxonomically

Synonyms: *Gaillonella distans* Ehrenberg 1836
Melosira distans (Ehrenberg) Kützing 1844

Diagnosis: Cells are cylindrical, bound in chains of frustules. The disc surface is flat, coarsely punctate, curved slightly at the margin; disc margin with prominent fine spines; sulcus furrow; pseudosulcus small; neck short, funnel-shaped. The surface of the mantle is slightly convex, perforated; areolae fine, arranged in longitudinal rows parallel to the pervalvar axis or spiral rows, about 12-14 rows in 10 µm, and 13-15 areolae in 10 µm. Valve diameter 5-18 µm and the mantle height about 4-8 µm.

Ecological preference: Freshwater littoral form (Hustedt, 1930); halophobous and acidophilous, a stenothermic cold-water form found in oligotrophic and dystrophic localities in the border areas between temperate and arctic climate (Foged, 1964; Gasse, 1986); the species was recorded from streams characterized by high gradient, strong current and low water temperature, (pH ranging from 3. 5 to 6.0) and low phosphates values (Kwandrans, 1993); freshwater environments of low conductivity, low alkalinity with pH values 6.5-6.8 in Egyptian lakes (Zalat, 2002; Zalat & Servant-Vildary, 2005); fresh water, planktonic and benthic, cold water, indifferent (halobity), acidophilic, χ-osaprobic, boreal (Medvedeva et al., 2009).

Occurrence: Recorded rare in the sediments of Młynek, Radomno, Kamionka and Francuskie Lakes.

Distribution in Poland: It is recorded from the Late Quaternary sediments of Przedni Staw Lake (Polish Tatra Mountains) (Marciniak, 1986a); the Polish acidic mountain streams in the Silesian Beskid (section of the Western Carpathians); the Świętokrzyskie Mts, and in the Karkonosze range (in the Sudetic Mts) (Kwandrans, 1993); the sediments of Mały Staw and Wielki Staw lakes in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2005, 2016); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015).

***Aulacoseira granulata* (Ehrenberg) Simonsen 1979**

(Pl. 3, figs. 1-8; pl. 4, figs. 1-8; pl. 5, figs. 1-8; pl. 6, figs. 1-8)

Ref. Krammer & Lange-Bertalot 1991 a, p. 22, pl. 16, figs. 1-2; pl. 17, figs. 1-10, pl. 18, figs. 11-14; pl. 19, figs. 1-9; as *Melosira granulata* (Ehrenberg) Ralfs in Pritchard; Hustedt 1930, p. 248, fig. 104; Gasse 1980, p. 28, pl. 3, figs. 5-7; pl. 4, figs. 1-2; pl. 5, figs. 1-2; Germain 1981, p. 24, pl.3, figs. 1-6; Gasse 1986, p. 77, pl. 1, figs. 5,8; Ricard 1987, p. 164, figs. 170-173; Ehrlich 1995, p. 31, pl. 1, figs. 8-11; Potapova et al., 2008, p.12, pl. 4, figs. 38-45; Bicudo et al., 2016, p. 4, figs 34–37.

Status of name: accepted taxonomically

Synonyms: *Melosira granulata* (Ehrenberg) Ralfs in Pritchard 1861
Orthosira granulata W. Smith 1865
Melosira granulata var. *granulata* (Ehrenberg) Cleve and Müller 1879
Lysigonium granulatum (Ehrenberg) Kuntze 1891
Orthosira granulata (Ehrenberg) Schonfeldt 1907
Melosira polymorpha subsp. *granulata* (Ehrenberg) Bethge 1925

Diagnosis: Cells are cylindrical, robust, bound in chains of frustules by thin spines. Valves are circular, with the flat disc; neck short or moderately long; pseudosulcus small**.** The surface of the mantle is covered by areolae, coarse, almost square, arranged in longitudinal spiral rows, or curved to the right (dextrorse), about 5-14 in girdle view, and 8-10 coarse spiral rows in 10 µm, areolae various in shape from rounded to sub-rounded and angular, about 7-l0 areolae per 10 µm. Valve diameter 5-20 µm and the mantle height about 7-20 µm.

Remarks: The species is easily recognized by its long, thick, and sharply pointed separation spines of unequal length and the corresponding grooves on the valve mantles.

Ecological preference: This species is commonly widespread in large and turbid freshwaters around the world. It is generally considered as oligohalobous "indifferent", alkaliphilous, and limnophilous. Oligosaprobic, in salinity ranged from 0.0-0.5 g/l (5 g/l), common in alkaline lakes (Hustedt, 1957; Foged, 1964); Hutchinson (1967) and Round (1981) reported high biomass of *Aulacoseira granulata* in lakes with a wide range of environmental conditions, with low, medium or high levels of pollution. Freshwater, planktonic, alkaliphilous, with pH value 7.5 – 8.0 (Ehrlich, 1973); Freshwater, oligohalobous, meioeuryhaline (Pankow, 1976); it flourishes in stronger eutrophic water with higher temperatures (Stoermer et al., l974; Van Dam et al., 1994; Reynolds, 1984); however, Hofmann (1994) classified it as a mesotrophic water species (trophic index 3.99). It exists with optimum development at 19 °C (Stoermer & Ladewski, 1976). According to Nixdorf (1994), the high biomass of *A. granulata* was correlated with high silicon concentrations (6 mg Si l-1) in a shallow eutrophic lake. The species was observed to be abundant and widespread in the most fresh and brackish eutrophic water environments of low to medium mineral content and alkalinity with pH 7-8.2 (Zalat, 2003; Zalat & Servant-Vildary, 2005; Tayloretal, 2007; Kiss et al., 2012); freshwater, Eu-mesotraphentic with pH:7.69-8.11 (Witak et al., 2017).

Occurrence: Recorded common in the sediments of Młynek Lake, infrequently in the Radomno, Kamionka, and Francuskie Lakes, and the Eemian deposits of central Poland.

Distribution in Poland: Recorded from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); from the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Mały Staw lake, located in a post-glacial cirque in the northeastern part of Karkonosze Mts, west Poland (Sienkiewicz, 2005); as dominant taxon in the urban Lake Jeziorak Mały, north eastern Poland (Zębek, 2007); Dolgie Wielkie lake on the Gardno-Leba Coastal Plain within the Slowinski National Park, North Poland (Lutyńska, 2008a); common in mesotrophic Piaseczno Lake, Łęczna-Włodawa Lakeland, east central Poland (Pasztaleniec &

Lenard, 2008); Lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); The palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); dominated in the Pilica River- Central Poland, considered to be tolerant and resistant with respect to organic water pollution (Szczepocka & Szulc, 2009); Low-pH Kąpielowe Lake in Western Pomerania, north-west Poland (Witkowski et al., 2011); abundant at the Swibno- Vistula River estuary in Northern Poland (Majewska et al., 2012); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc 2012); from the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); abundant in the lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015); Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); dominant in the upper part of the Ner River, central Poland (Szczepocka et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Aulacoseira granulata* var. *angustissima* (O. Müller) Simonsen 1979**

(Pl. 6, figs. 9-10**)**

Ref. Krammer & Lange-Bertalot 1991a, p. 23, pl. 18, fig. 13; as *Melosira granulata* var. *angustissima* O. Müller; Hustedt 1930, p. 250, fig. 104 d; Van Landingham 1970, p. 457, pl. 6, figs. 1-4; Gasse 1980, p. 29, pl. 4, figs. 3-7; pl. 5, figs. 5, 8-10; Ehrlich 1995, p. 32, pl. 1, figs. 12-13; Bicudo et al. 2016, p. 6, figs. 38-40.

Status of name: accepted taxonomically

Synonym: *Melosira granulata* subsp. *angustissima* (O. Müller) Cleve-Euler 1938

Diagnosis: Cells are long cylindrical, elongated, and connected to form long tubular filaments. This variety is slender than the type species, so it differs from the type in the length/width ratio. The ratios of mantle height and valve diameter 3-5 (to 10). Areolar striae on mantle relatively weak, obliquely arranged to pervalvar axis, 14-17 striae in 10 µm, and 14-16 areolae in 10µm. The sulcus is slightly pronounced. Valve diameter 3-5 µm and the mantle height 14-20 m.

Ecological preference: It is similar to the type; it is regarded as an eutrophic indicator (Hustedt, 1957); and characterized by optimum development at 17-19.3 °C (Stoermer & Ladewski, 1976). According to Gasse (1986), this variety appears to have its optimal growth in shallow lakes and it tolerates highly turbid waters. It is found mainly in eutrophic rivers and lakes (Krammer & Lange-Bertalot, 1991; Taylor et al., 2007). The optimal conditions seem to be a medium conductivity and a pH around 8-8.5. This variety seems to prefer eutrophic freshwater environments with low to medium conductivity and alkalinity where pH ranges between 7.3-8.2 (Zalat & Servant-Vildary, 2005, 2007); alkaliphilous pH over 7, limnobiontic-slightly euryhaline 0.5-3 psu, mesopolythermic (>18-35 C°) (Moreno-Ruiz et al., 2011).

Occurrence: Recorded common in the sediments of Młynek Lake, infrequently in the Radomno, Kamionka, Francuskie, and Jeziorak Lakes and the Eemian deposits of central Poland.

Distribution in Poland: This taxon was recorded from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); from the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999).

***Aulacoseira humilis* (Cleve) Genkal & Trifonova in Trifonova & Genkal 2001**

Ref. Cleve-Euler 1939, p.6, fig.1; Gasse 1986, p. 76, pl. 3, figs. 1-4, 7-8; Trifonova & Genkal 2001, p. 315

Status of name: accepted taxonomically

Synonyms: *Melosira distans* var. *humilis* A. Cleve 1939

Aulacoseira distans var. *humilis* (A.Cleve) Gasse 1986

Diagnosis: Frustules are cylindrical and form short colonies. The valve face is often strongly convex or concave with straight mantle sides and it is covered by large, round areolae in a marginal ring. These valve face areolae have a density of about 16-18 in 10 µm. The straight pervalvar rows of areolae are positioned in pairs, within grooves, about 10–12 in 10 µm. The spines are located at the end of each pervalvar costa. The spines are long and thin, tapering away from the valve face. The ringleiste is solid, shallow, and broad. The ratio of the mantle height to valve diameter is less than 1. Diameter of the valve 5-10 µm, with a mantle height between 2.5-6 µm.

Distribution in Poland: Late Quaternary sediments of Przedni Staw Lake (Polish Tatra Mountains) (Marciniak, 1986a).

***Aulacoseira islandica* (O. Müller) Simonsen 1979**

(Pl. 1, fig. 10)

Ref. Krammer & Lange-Bertalot 1991 a, p. 26, pl. 22, figs. 1-12; as Melosira islandica O. Müller 1906, Hustedt 1930, p. 252, fig. 106; Cleve-Euler 1951, p. 24, fig. l4 a-c; Schrader 1978, p. 862, pl. 4, figs. L7, 18; pl. 9, figs. 17, 24; pl. l0, figs. 2, 3, 9, 11-18; pl. 11, figs. 23-25; Siver & Kling 997, p. 1815, figs. 29-41; Wojtal et al., 1999, p. 170, figs. 6-8; Potapova et al., 2008, p.14, pl. 3, figs. 35-37.

Status of name: accepted taxonomically

Synonym: *Melosira islandica* O. Müller, 1906

Diagnosis: Frustules are cylindrical, short or long, straight or somewhat curved chain. Valve surface is flat, curved slightly at the margin; pseudosulcus is small; disc margin is denticulate with distinct spines, which taper towards the apex. The long spines of one sibling valve lie within grooves in the other valve and the two valves fix together. Linking spines are spathulate. Neck short; sulcus is a simple furrow; cell wall thick and strong. The surface of the mantle is nearly flat, and perforated by areolae, which are coarse to fine, angular in shape, and arranged in longitudinal straight rows parallel to the pervalvar axis, approximately 12-16 rows in 10 µm. Each row is composed of 7-8 areolae, while the transverse areolae are about 9 per 10 µm. Valve diameter 10-26 µm, and the mantle height 7-8 µm.

Ecological preference: Planktonic, common in freshwater and at lower temperatures (Hustedt, 1930); meso- to eutrophic water, oligo- to mesosaprobic, halophobous (Cleve-Euler, 1951); freshwater with salinity from 0.0 to 0.5 g/l (Simonsen, 1962); alkaliphilous with pH value around 7.0 (Foged, 1970); its maximum abundance at water temperatures of less than 12 °C (Stoermer et al., 1974); oligohalobous, meioeuryhaline (Pankow, 1976). The species is very abundant in the plankton of cold-water lakes and large rivers in Europe (Krammer & Lange-Bertalot, 1991) and North America (Stoermer et al., 1981); it was common in large arctic and temperate Canadian lakes, where it formed substantial populations in late winter under the ice and was often a common element of the spring bloom (Siver & Kling, 1997), it observed commonly in many freshwater environments of low to medium conductivity and alkalinity with pH 7-8.3 (Zalat & Servant-Vildary, 2005, 2007); planktonic, oligohalobous, alkaliphilous, meso- oligotraphenthic, β-mesosaprobous (Witak & Jankowska, 2014); freshwater, meso-oligotraphentic with pH:7.69-8.11(Witak et al., 2017).

Occurrence: Recorded infrequently in the Młynek Lake sediments.

Distribution in Poland: It is recorded from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); from the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); abundant in Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Aulacoseira italica* (Ehrenberg) Simonsen 1979**

(Pl. 1, fig. 11)

Ref. Krammer & Lange-Bertalot 1991 a, p. 29, pl. 2, fig. 2; pl. 24, figs. 1, 3-6; pl. 25, figs. 1-11; Lange-Bertalot & Metzeltin 1996, p. 124, pl. 3, figs. 20-22; as Melosira italica (Ehrenberg) Kützing 1844, Hustedt 1930, p. 257, fig. 109; Foged 1980, p. 647, pl. 1, fig. 7; Gasse 1980, p.34, pl. 8, figs. 28-36; Germain 1981, p. 24, pl. 3, figs. 7-8; Gasse 1986, p. 81, pl. 3, fig. 5; Ehrlich 1995, p. 32, pl. 1, fig. 7; Siver & Kling 1997, p. 1815, figs. 42-45; Crawford et al. 2003, p. 17, figs. 2–14; Potapova et al., 2008, p. 7, pl. 2, figs. 15-29.

Status of name: accepted taxonomically

Synonyms: *Gaillonella italica* Ehrenberg 1838
Melosira italica (Ehrenberg) Kützing 1844
Melosira crenulata var. *italica* Grunow 1881
Aulacoseira italica f. *italica* (Ehrenberg) Davydova 1992

Diagnosis: Cells are cylindrical, bound in chains; disc surface is flat, and curved slightly at the margin to form small pseudosulcus. The sulcus is shallow to nearly flat; the neck is short; the cell wall is moderately thick.

Valve with a developed cylindrical flattened mantle; the surface of the mantle is punctate with fine areolae which are arranged in longitudinal spiraled rows, about 14-16 rows in 10 µm; areolae various in shape from rounded to elongated; disc margin is denticulate with distinct spines. Disc margin with prominent spines, which are of uniform length and simple. Valve diameter 6-9.5 µm and the mantle height 11-13 µm.

Ecological preference: This species lives in temperate fresh-water environments throughout the world as a pelagic form in lakes and as a littoral form in smaller bodies of water (Andrews, 1970); oligosaprobic to mesosaprobic, halophobous (Cleve-Euler, 1951); planktonic, alkaliphilous with pH value 7.5-8.0 (Ehrlich, 1973); oligohalobous "indifferent", alkaliphilous (Foged, 1980). Known from mesotrophic to eutrophic environments, dominant in shallow lakes (Van Dam et al., 1994; Trifonova & Genkal, 2001). The species was observed commonly in most freshwater environments and some brackish water habitats of low to medium conductivity and alkalinity with pH 7.0-8.3 (Zalat & Servant-Vildary, 2005, 2007); planktonic, oligohalobous, alkaliphilous, eu-mesotraphenthic, β-mesosaprobous (Witak & Jankowska, 2014).

Occurrence: Recorded infrequently in the Holocene sediments of Radomno and Młynek Lakes.

Distribution in Poland: It is recorded from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Holocene sediments of Mały Staw and Wielki Staw lakes in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2005, 2016); Holocene sediments of Suwalki Landscape Park north-eastern Poland (Gałka, et al., 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014).

***Aulacoseira lacustris* (Grunow) Krammer 1991**

Ref. Krammer 1991, p. 98; Genkala & Chekryzheva 2011, p. 3, fig. 1e

Status of name: accepted taxonomically

Synonyms: *Melosira lyrata* var. *lacustris* Grunow in Van Heurck 1882
Melosira distans f. *lacustris* (Grunow) Hustedt 1927
Aulacoseira distans var. *lirata* f. *lacustris* (Grunow) Simonsen,
Aulacoseira lirata var. *lacustris* (Grunow).

Diagnosis: The mantle rows of areolae are parallel to the pervalvar axis, about 11–12 rows of areolae in 10 µm. The areolae are rounded or pervalvar-elongated near the valve face and collum. The triangular spines originate from a single pervalvar costa. The valve face has large areolae arranged in tangential rows according to Krammer and Lange-Bertalot 1991) or is plain or with some marginal areolae according to Siver and Kling (1997). The ringleiste is shallow. The species has a valve diameter of 10-28 um and mantle height of 6-11 um (Krammer and Lange-Bertalot 1991).

Occurrence: Recorded infrequently in the sediments of Jeziorak Lake.

Distribution in Poland: Holocene sediments of Mały Staw lake in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2005, 2016).

***Aulacoseira lirata* (Ehrenberg) Ross in Hartley 1986**

Ref. Krammer & Lange-Bertalot 1991 a, p. 37, pl. 34, figs. 1-12; pl. 36, figs. 1-2; Lange-Bertalot & Metzeltin 1996, p. 122, pl. 2, figs. 1-8; Siver & Kling 1997, p. 1828, figs. 95, 98; Potapova et al., 2008, p. 18, pl. 6, figs. 93-97.

Status of name: accepted taxonomically

Synonyms: *Gaillonella lirata* Ehrenberg 1843
Melosira lirata (Ehrenb.) Kützing 1844
Lysigonium liratum (Ehrenberg) Kuntze 1898
Melosira distans f. *lirata* (Ehrenberg) O. Müller 1904
Melosira distans var. *lirata* (Ehrenberg) Van Landingham 1971
Aulacoseira distans var. lirata (Ehrenberg) Simonsen 1979

Diagnosis: Cells are cylindrical, thick, and bound in chains. The valve face is flat with usually a single peripheral ring of areolae. The valve mantle is striated by coarse round or elliptical pervalvar areolae, which are straight, parallel to the pervalvar axis, or slightly curved, about 10-12 striae in 10 µm. The areolae closest to the collum are often the largest. Spines are branching at their apices. The ringleiste is solid and variable in thickness, from moderately shallow to rather deep. Diameter of the valve 8-25 µm, and the mantle height 5-10 µm.

Ecological preference: The species was observed in Canadian Shield localities with a pH between 5 and 6 and low in specific conductivity and nutrients concentrations (Siver & Kling, 1997); Freshwater, planktonic, acidophilic, β-α-mezosaprobic, boreal (Medvedeva et al., 2009).

Occurrence: Recorded infrequently in the sediments of Radomno and Francuskie Lakes.

Distribution in Poland: The sediments of Mały Staw lake in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2005, 2016).

***Aulacoseira muzzanensis* (Meister) Krammer 1991**

(Pl. 7, figs. 1-4)

Ref. Krammer 1991, p. 478, fig. 1; Krammer & Lange-Bertalot 1991 a, p. 24, fig. 20; Cho 1999, p. 151, fig. 32; as Melosira granulata var. muzzanensis (Meister) Hustedt 1930, p. 88, fig. 47; Potapova et al., 2008, p. 18, pl. 4, figs. 46-52.

Status of name: accepted taxonomically

Synonyms: *Melosira polymorpha* var. *muzzanensis* (Meister) Bethge 1925
Melosira granulata var. *muzzanensis* (Meister) Hustedt 1930
Aulacoseira granulata var. *muzzanensis* (Meister) Simonsen 1979

Diagnosis: Cells are drum-shaped or short cylindrical. Valves are circular and flat. The mantle is ornamented with strong areolar striae, straight or nearly parallel to pervalvar axis or lightly curved to the right (dextrorse), about 10-13 striae in 10 µm and areolae 12-19 in 10 µm. The linking spines are short and triangular, while the separation spines are of unequal length, thick, and sharp-pointed. Valve diameter 8-25 µm and the mantle height 4-8 µm.

Ecological preference: This taxon is reported in many more humid regions in the Northern Hemisphere (Krammer & Lange-Bertalot, 1991a).

Occurrence: Recorded infrequently in the Młynek Lake sediments**.**

Distribution in Poland: It is recorded from Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015)

***Aulacoseira pfaffiana* (Reinsch) Krammer 1991**

Ref. Krammer 1991, p. 94, figs 45-54

Status of name: accepted taxonomically

Synonyms: *Melosira pfaffiana* Reinsch 1866
Melosira distans var. *pfaffiana* (Reinsch) Grunow 1878
Melosira polymorpha subsp. *distans* var. *pfaffiana* (Reinsch) Bethge 1925

Diagnosis: The valve is cylindrical. The mantle areolae are in straight rows, which are slightly oblique to the pervalvar axis, about 12-15 rows of areolae in 10 m and 16- 18 areolae in 10 µm. The valve face has large areolae. According to Krammer (1991a), the ratio of mantle height to valve diameter is about 0.25-0.8. Diameter of the valve 4-15 µm with mantle height 4-8 µm**.**

Occurrence: Recorded infrequently in the Jeziorak Lake sediments**.**

Distribution in Poland: from the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999); the sediments of Mały Staw and Wielki Staw lakes in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2016).

***Aulacoseira pseudomuzzanensis* Olszynski & Zelazna-Wieczorek 2018**

(Pl. 7, figs. 5-7)

Ref. Olszynski & Zelazna-Wieczorek 2018, p.157, pl. 160, figs 2-52**.**

Status of name: accepted taxonomically

Diagnosis: Valves are circular with a flat valve face. The mantle is ornamented with strong areolar striae, about 12–15 in 10µm. Areolae are arranged in spiral rows and running dextrorse on the mantle on linking valves or running straight on separation valves. Striae somewhat are parallel to the edge of the mantle. Valve diameter 10–20µm, and the mantle height 5-9 µm.

Occurrence: Recorded infrequently in the Młynek Lake sediments.

Distribution in Poland: New record.

Aulacoseira subarctica **(O. Müller) Haworth 1988**

Ref. Haworth 1988, p. 143, fig. 43; Krammer & Lange-Bertalot 1991 a, p. 28, pl. 2, fig. 2; pl. 3, fig. 3; pl. 23, figs. 1-11; Gleser et al., 1992, p. 82. pl. 61, fig. 19; Siver & Kling 1997, p. 1811, figs. 13-22; Gibson et al., 2003, p. 84, fig. 1; Potapova et al., 2008, p. 14, pl. 5, figs. 53-56.

Status of name: accepted taxonomically

Synonyms: *Melosira italica* subsp. *subarctica* O. Müller 1906
Aulacoseira italica subsp. *subarctica* (O. Müller) Simonsen 1979
Aulacoseira italica var. *subarctica* (O. Müller) Davydova in Gleser, et al. 1992

Diagnosis: Cells are cylindrical, connected to form a long tubular filament. Valve is circular, slightly convex; the ratios of mantles to valve diameter 0.8-2.7. Pseudosulcus is definite around the margin. The mantle is ornamented by round and equidistant areolae. The rows of areolae are curved to the right (dextrorse), about 18-20 striae in 10 µm and 18-21 areolae in 10 µm. Valve diameter 3-15 µm and the mantle height 2.5-18 µm.

Ecological preference: This species is widely distributed in inland waters of Northern Europe, Scandinavia, and North America, it was commonly observed in oligotrophic waterbodies during the spring (Van Dam et al., 1994; Siver & Kling, 1997; Tuji & Houki, 2004); it is considered as a freshwater, planktonic, indifferent (halobity), alkalibiontic, o-β-mezosaprobic (Medvedeva et al., 2009). *A. subarctica* is more competitive in the warmer season than other *Aulacoseira* species, it is considered to be an indicator of mesotrophic water, where it is common at lower total phosphorus concentrations than other common planktonic Aulacoseira species (Gibson et al., 2003). *Aulacoseira subarctica* is common in circumneutral, mesotrophic to eutrophic lakes, and requires water turbulence to keep it in suspension, it blooms in northern temperate and boreal lakes during the cold early spring when low light becomes available for photosynthesis (Sienkiewicz & Gąsiorowski, 2014).

Occurrence: Recorded rare in the sediments of Francuskie Lake and the Eemian deposits of central Poland.

Distribution in Poland: The lakes that located in postglacial cirques in the Tatra Mountains of southern Poland (Sienkiewicz & Gąsiorowski, 2014).

Aulacoseira valida **(Grunow) Krammer 1991**

Ref. Hustedt 1927, p. 260, fig. 109 a; Krammer 1991b, figs. 23–29, 31, 36–39; Siver et al., 2005, p. 40, pl. 3, figs. 1–2; Krammer & Lange-Bertalot 1991a, p. 32, pl. 28, figs. 1–11; pl. 1, figs. 18–20.

Status of name: accepted taxonomically

Synonyms: *Melosira crenulata* var. *valida* Grunow 1882
Melosira valida Meister 1912
Melosira italica var. *valida* (Grunow) Hustedt 1927
Aulacoseira italica var. *valida* (Grunow) Simonsen 1979

Diagnosis: Frustules are cylindrical and form chains. Valves are more robust, with a slightly convex valve face that is covered by small areolae. The mantle has thick walls. The sulcus is a shallow furrow; pseudosulcus small; neck short. Mantle wall thick with well-developed structure, areolate; areolae arranged in longitudinal spiraled rows, about 12-13 rows in 10 µm. Pervalvar rows of rectangular areolae are strongly curved to the right (dextrorse). The mantle areolae are larger near the valve face and gradually become smaller toward the collum. The ratio of the mantle height to valve diameter is about 0.8-1.5. The ringleiste is solid and wide. The spines are large, spatula-shaped, and originate from two pervalvar costae. Valve diameter 10-20 µm and the mantle height 9-15 µm.

Ecological preference: This taxon, reported from neutral to mesotrophic conditions (Siver et al., 2005).

Occurrence: Recorded infrequently in the Holocene sediments of Radomno Lake.

Distribution in Poland: The high-mountain lakes and streams in southern Poland (Tatra Mts) (Wojtal, 2013).

Order: Melosirales Crawford in Round et al. (1990)
Family: Melosiraceae (Kützing 1844) emend. Crawford in Round et al. (1990

Genus *Angusticopula* Houk, Klee & Tanaka 2017

Diagnosis: Frustules are cylindrical to short barrel-shaped, joined forming short chains. Valves are showing thick walls, having a relatively low mantle and rounded flat valve face. Internal valves are occasionally present. Rimoportulae organized in marginal ring close to the valve face margin, visible as a series of tube-like channels. Striae and areolae are faint or indistinct in LM.

Holotype species: Angusticopula dickiei (Thwaites) Houk, Klee & Tanaka 2017

***Angusticopula dickiei* (Thwaites) Houk, Klee & Tanaka 2017**

Ref. Houk et al. 2017, p. 25

Status of name: accepted taxonomically

Synonyms: *Orthoseira dickiei* Thwaites 1848
Melosira dickiei (Thwaites) Kützing 1849
Lysigonium dickiei (Thwaites) Kuntze 1891

Diagnosis: Frustules are loosely joined in short filaments. Valves are cylindrical with a flat face. The valve surface is finely punctate and the areolae are not arranged. In some specimens, the valve face has short spinules, that may aid in filament formation. The mantle is narrow, and most isolated valves lie in valve view. The length of the pervalvar axis of each frustule is 10.2-13.0 µm.

Distribution in Poland: Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004)

Genus *Melosira* Agardh 1824

Diagnosis: Frustules are cylindrical to subspherical with thick walls, united in filaments. The valve face can be flat or convex, covered with small spines or granules, and may be bordered by a corona consisting of larger irregular spines, and it has little ornamentation with granules more or less developed. They lack distinctive features including costae, septae, and spines. Rimoportulae occur usually in a ring near the mantle edge and are sometimes scattered or grouped on the valve; there is a circular external aperture surrounded by an irregular rim.

Holotype species Melosira nummuloides C. Agardh 1824

***Melosira lineata* (Dillwyn) Agardh 1824**

Ref. Krammer & Lange-Bertalot 1991 a, p. 10, pl. 7, figs. 3-9; as Melosira juergensii Agardh, Hustedt 1930, p. 238, fig. 99; Germain 1981, p. 22, pl. 1, figs. 3-7; Witkowski et al., 2000, p. 34, pl. 1, figs. 10, 11.

Status of name: accepted taxonomically

Synonyms: *Gaillonella lineata* (Dillwyn) Bory 1838
Lysigonium lineatum (Dillwyn) Trevisan 1848
Orthosira orichalcea (Mertens ex Jurgens) W. Smith, 1856
Melosira lineata var. *genuina* Cleve-Euler 1951
Melosira juergensii var. *genuina* Cleve-Euler 1951

Diagnosis: Cells are cylindrical with flat to slightly convex valve surface and jointed to form filaments. Valve surface is ornamented with large numbers of fine flat circular granules in-combined with numbers of small conical granules. The mantle of the valve is a more or less uniform thickness**.** Rows of small fine pores lie parallel to the pervalvar axis. No linking spines present. The ratio of mantle height and valve diameter is relatively below 1.0. Valve diameter 7-35 µm and the mantle height 9-20 µm.

Ecological preference: Marine and brackish water, benthic (Medvedeva et al., 2009)

Occurrence: Recorded rare in the sediments of Młynek Lake**.**

Distribution in Poland: found in Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012)

***Melosira moniliformis* (O. Müller) Agardh 1824**

Ref. Hustedt 1930, p. 236, fig. 98; Crawford 1977, p. 299, fig. 1; Ricard 1987, p. 164, figs. 164-169; Krammer & Lange-Bertalot 1991 a, p. 8, pl. 5, figs. 1-7; pl. 6, figs. 1-5; Witkowski et al., 2000, p. 35, pl. 1, figs. 7-9.

Status of name: accepted taxonomically

Synonyms: *Conferva moniliformis* O. Müller 1783
Lysigonium moniliforme (O. Müller) Link 1820
Gaillonella moniliformis Bory 1825
Lysigonium moniliforme (O. Müller) Trevisan 1848
Melosira borreri Greville 1833
Melosira borreri (borrerii) var. *moniliformis* (O. F. Müller) Grunow 1878

Diagnosis: Cells are cylindrical with convex valve surface with round corners, and united into chains. Valves with fine areolae and differentiated into the central and marginal regions. A ring of spines is situated at the boundary of the valve and the connector of adjacent cells. Sulci, pseudosulci in girdle view, and Ringleiste structures inwards of valve absent. Areolae on valve mantle arranged in parallel along pervalvar axis, about 10-12 rows in 10 µm. Rimoportulae near the central area of the valve. Valve diameter 25-70 µm and the mantle height 17-30 µm.

Ecological preference: *M. moniliformis* was observed to be dominant in eutrophic waters of the western Baltic Coast (Hillebrand & Sommer, 1997); it is a tychoplankton species, found in benthic and planktonic, but prefers the benthic habitat in saline environments (Hayward et al., 2004); found in marine and brackish water, planktonic and benthic (Medvedeva et al., 2009).

Occurrence: Recorded rare in the sediments of Młynek, Radomno, and Kamionka Lakes**.**

Distribution in Poland: The species is reported from the Swibno-Vistula River estuary in Northern Poland (Majewska et al., 2012)

***Melosira nummuloides* (Dillwyn) Agardh** 1824

Ref. Hustedt 1930, p. 231, fig. 95; Ricard 1987, p. 164, figs. 158-163; Germain 1981, p. 22, pl. 1, figs. 1-2; Krammer & Lange-Bertalot 1991 a, p. 11, pl. 8, figs. 1-8; Witkowski et al., 2000, p. 35, pl. 1, figs. 3-5, 11, 12.

Status of name: accepted taxonomically

Synonyms: *Fragilaria nummuloides* (Dillwyn) Lyngbye 1819
Gaillonella nummuloides (Dillwyn) Bory 1831
Melosira salina Kützing 1844
Lysigonium nummuloides (Dillwyn) Trevisan 1848

Diagnosis: Cells are elliptical to globose or orbicular in girdle view, and connected to form moniliform filaments. The valve face is circular and convex with a collar-like projection, 'carina', between the valve center and the margin. In the inner parts of the carina, other projections or pieces, collectively called 'corona', surrounding the central area, linking two adjacent valves. The diameter of the valve is 10-40 µm and the mantle height is 10-15 µm.

Ecological preference: This species is cosmopolitan as epibenthic diatoms in brackish and coastal waters and common in organically polluted waters; it is favored by nutrient enrichment, as along the western Baltic Coast, it is most abundant during cold seasons, even in the Arctic Sea, and least abundant during August or summer (Hillebrand & Sommer, 1997).

Occurrence: Recorded rare in the sediments of Młynek and Kamionka Lakes**.**

Distribution in Poland: The species is reported from Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012)

***Melosira undulata* (Ehrenberg) Kützing 1844**

Ref. Nardelli, et al., 2016, p. 4, figs. 19-20

Status of name: accepted taxonomically

Synonyms: *Gaillonella undulata* Ehrenberg 1840
Lysigonium undulatum (Ehrenberg) Trevisan 1848

Diagnosis: Frustules are cylindrical, heavily silicified, usually solitary or linked in chains. The valve faces are flat. In girdle view, the mantles are unevenly thickened internally, creating an undulating appearance. Valves and mantles are conspicuously ornamented with a ring of evenly-spaced rimoportulae and striae, about 10–11 striae in 10 µm on the valve face. The mantle is unevenly thickened internally, giving an undulating appearance. Striae on the valve face are dichotomously branched and radiate from a hyaline central area. The diameter of the valve is 93–94 µm, and the mantle height is 21.5–32.0 µm.

Ecological preference: The species is reported to be a soil diatom, but also found in oligotrophic lakes (Krammer & Lange-Bertalot, 1991 a); an epilithic species occurring in circumneutral, oligohalobous (Foged, 1976), and oligotrophic environments (Carter et al., 2006). It has also been detected in sediments, as well as in the plankton of tropical areas (Germain 1981; Krammer & Lange-Bertalot 1991 a).

Distribution in Poland: Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015)

***Melosira varians* Agardh 1827**

(Pl. 8, figs. 3-5)

Ref. Hustedt 1930, p. 240, fig. 100; Gasse 1980, p. 35, pl. 11, figs. 1-6; Germain 1981, p. 22, pl. 1, figs. 3-7; Gasse 1986, p. 83, pl. 2, fig. 7; Krammer & Lange-Bertalot 1991 a, p. 7, pl. 3, fig. 8; pl. 4, figs. 1-8; Ehrlich 1995, p. 33, pl. 1, figs. 3-4; Metzeltin & Witkowski 1996, p. 34, pl. 1, fig. 15; Wojtal 2009, p. 238, pl. 1, figs. 1–4; pl. 48, figs. 1–6; pl. 49, figs. 1, 2; Hofmann et al. 2011, p. 357, pl. 1, figs. 6–9.

Status of name: accepted taxonomically

Synonym: *Gallionella varians* Ehrenberg 1836
Lysigonium varians (Agardh) De Toni 1892

Diagnosis: Cells are cylindrical, closely united by valves to form long filaments. Disc margin rounded; disc surface flat, and curved slightly at the margin to form a small pseudosulcus; sulcus and neck absent; valve margin denticulate with thin irregular spines. Valve face with many irregular fine granules or nearly hyaline; mantle well developed. Valve diameter 13-32 µm and the mantle height 8-35 µm.

Ecological preference: A cosmopolitan species, benthic and planktic found in fresh and slight brackish waters, littoral, eutrophic lakes, β-mesosaprobic, oligohalobous, alkaliphilous; it seems to prefer benthic or epiphytic habitats (Hustedt, 1930, 1957; Krammer & Lange-Bertalot, 1991a); Giffen (1966) found large populations of this species in neutral to slightly acid waters. Its pH optimum lies about 8.5 (Cholnoky, 1968); oligohalobous, mesoeuryhaline, in water with a salt content of about 10 g/l (Pankow, 1976); it can tolerate small amounts of salt, oligohalobous "indifferent", alkaliphilous (Foged, 1979, 1980). Tychoplanktonic, alkaliphilous, α-mesosaprobous, eutraphentic, and fresh brackish water species (Lange-Bertalot, 1979; Denys, 1991; Van Dam et al., 1994), it is one of the most eutrophilous algae in freshwater, and occurs in dystrophic waters of moor lands and even oligotrophic waters (Karjalainen et al., 1996), a very common species in freshwater, occurring in considerable abundance in streams and lakes, naturally eutrophic to polluted, throughout North America (Stoermer & Julius, 2003), common in fresh and brackish water habitats of low to medium conductivity and low alkalinity with pH 7.0-8.2 (Zalat & Servant-Vildary, 2005); fresh water, planktonic and benthic, halophilic, alkaliphilic, α-β-mezosaprobic (Medvedeva et al., 2009).

Occurrence: Recorded rare in the sediments of Młynek, Radomno, Kamionka, and Jeziorak Lakes, and the Eemian deposits of central Poland.

Distribution in Poland: It is reported from Młynowka stream (Gumiński, 1947); fish ponds in Mydlniki (Siemińska, 1947); Przemsza River (Cabejszek, 1951); Vistula River (Starmach, 1938; Turoboyski, 1956, 1962; Kyselowa & Kysela, 1966; Uherkovich, 1970); Prądnik River (Stępień, 1963); spring of Szklarka stream (Skalska, 1966a, b); Sanka stream (Kądziołka, 1963; Hojda, 1971); spring in Jerzmanowice (Skalna, 1973); Kluczwoda stream (Nawrat, 1993); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Kobylanka stream, south Poland (Wojtal, 2009); dominated in the Pilica River- Central Poland, considered to be tolerant and resistant with respect to organic water pollution (Kadłubowska, 1964a, b; Szulc, 2007; Szczepocka & Szulc, 2009); from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); dominated in the Bzura River- Central Poland, considered to be tolerant and resistant with respect to organic water pollution (Szczepocka & Szulc, 2009); Matysówka stream a right-bank tributary of Strug River, district of Tyczyn (Noga et al., 2013); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, and suburban Przyrwa stream of Wisłok River in the Rzeszów city in south-east Poland (Noga et al., 2016); dominant in the upper part of the Ner River, central Poland (Szczepocka et al., 2016).

Order: Paraliales Crawford 1990

Family: Paraliaceae Crawford 1988

Genus *Ellerbeckia* Crawford 1988

Diagnosis: Drum-shaped frustules, heavily silicified, robust, shortly cylindrical with relatively narrow mantles and joined by valve faces to form curved chains. The interlocking ridges and grooves on linking valves extend to the valve margin. The valve surface is flat and lacks the pores or processes of many centric diatom genera.

Holotype species Ellerbeckia arenaria (Moore) Crawford 1988

***Ellerbeckia arenaria* (Moore) Crawford 1988**

(Pl. 9, figs. 1-7)

Ref. Krammer & Lange-Bertalot 1991a, p. 17, pl. 3, fig. 6; pl. 14, figs. 1–5; pl. 15, figs. 1–3; Wojtal, 2009, p. 198, pl. 1, fig. 5a, b; as Melosira arenaria Moore in Ralfs 1843; Hustedt 1930, p. 269, fig. 114; Germain 1981, p. 28, pl. 5, figs. 1-3; Ehrlich 1995, p. 31, pl. 1, figs. 1-2.

Status of name: accepted taxonomically

Synonyms: *Melosira arenaria* Moore in Ralfs 1843
Paralia arenaria (Moore) Moisseeva 1986

Diagnosis: Frustules are robust, drum-shaped, and joined by valve faces to form long filamentous. Striae on the mantles are perpendicular to the valve face, about 20-22 striae in 10 µm. The interlocking ridges and grooves of linking valves extend from the valve margin to near the central region. Both linking and separation valves have two complementary forms. Unique tubular processes are present on the mantle, which appear as simple pores that are visible in LM. Diameter of the valve 40–75 µm.

Ecological preference: Cosmopolitan, aerophilous and littoral diatom (Krammer & Lange-Bertalot, 1991a); found in a wide trophic spectrum (Lange-Bertalot, 1996); it is considered to be an indicator of oligotrophic conditions (Van Dam et al., 1994); it observed in shallow warm freshwater lakes, pH: 6.9-7.7, low conductivity, alkalinity (meq L^{-1}) from 3.1-4.4 (Jasprica & Hafner, 2005); fresh water, planktonic and benthic, indifferent (halobity), alkaliphilic, o-α- mesosaprobic (Medvedeva et al., 2009), Oligotrophic and oligo-mesotrophic conditions (Dembowska, 2014); alkaliphilous, fresh, nitrogen-autotrophic taxa, oligosaprobous, oligotraphentic (Malinowska–Gniewosz et al., 2018).

Occurrence: Recorded infrequently in the sediments of Młynek and Radomno Lakes.

Distribution in Poland: The species is reported from Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); Wyżyna Krakow skoczęstochowska Upland, Pilica River (Cabejszek, 1951; Kadłubowska, 1964b); spring of Szklarka stream (Skalska, 1966a, b); Kobylanka stream, south Poland, in samples with Vaucheria sp. in Kobylany Village (Wojtal, 2009), Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015); from the industrial water biotopes of Trzuskawica S.A. in the southern Poland (Malinowska-Gniewosz et al., 2018).

Genus *Paralia* Heiberg 1863

Diagnosis: Frustules are cylindrical and strongly silicified, united to form straight chains. Valves are robust, circular. Valve surface with faint radial lines merging into a wide, downward sloping valve margin. The valve mantle is strongly loculated and ornamented with a coarse network of sub-hexagonal cellulation. Valve face and mantles are sharply differentiated. Sibling valves within chains are linked by interlocking ridges and grooves, and also by marginal spines.

The genus is commonly found in marine inshore plankton but probably belonging to sandy sediments.

Holotype species Paralia marina (W. Smith) Heiberg 1863

***Paralia sulcata* (Ehrenberg) Cleve 1873**

(Pl.8, figs. 6-11)

Ref. Hustedt, 1930, p. 276, fig. 119; Hendey, 1964, p. 73, pl. 23, fig. 5; Pankow 1976, p. 320, fig. 108; Andrews 1980, p. 31, pl. 2, fig. 23.

Status of name: accepted taxonomically

Synonyms: *Gaillonella sulcata* Ehrenberg 1838
Melosira sulcata (Ehrenberg) Kützing 1844
Melosira sulcata f. *coronata* Grunow in Van Heurck, 1882
Melosira sulcata f. *radiata* (*Grunow*) Peragallo & Peragallo, 1908
Orthosira marina Smith 1856
Melosira marina (Smith) Janisch 1862
Paralia marina (Smith) Heiberg 1863

Diagnosis: Frustules are robust, short cylindrical. Valves are discoid, often united to form long straight chains. Sibling valve chains are linked with well-developed interlocking. The frustule with a robust margin and strongly formed valve mantle bearing coarse granular markings. Valves are circular, a central area slightly convex, hyaline. Valve surface carrying a ring of short radiating spines, which may be reduced to coarse, irregular punctae. Diameter of the valve 10–60 µm and the mantle height 5–20 µm.

Ecological preference: This species is a brackish to marine diatom, commonly found in eutrophic coastal waters (McQuoid & Hobson, 1998; McQuoid, 2002). It is described as pleioeuryhaline, where it can tolerate salinity from 5 to 35 g/l (Simonsen, 1962) or between 8 and 30 g/l (Roelofs, 1984); polyhalobous, mesoeuryhaline (Pankow, 1976); It is a bottom-dweller, but is often found with marine inshore plankton, and usually associated with sandy habitats (Hendey, 1964; Round et al., 1990). It is found in salinity between 25-35 g/l, and also in estuarine areas (Zong, 1992; Robinson, 1993). Cooper (1995) interprets the decrease of P. sulcata as being due to increased siltation of sandy bottom habitats or an increase of freshwater input into the Bay. It is believed to be a benthic form but is easily carried up into the plankton, it thrives in low light and eutrophicated waters (Zong, 1997). The species was observed to be common in eutrophic brackish water habitats characterized by somewhat high conductivity, medium alkalinity with pH value 7.5- 8.0, and in unpolluted to low polluted water (Zalat

& Servant-Vildary, 2005); alkaliphilous pH over 7, marine euryhaline, mesopolythermic (>18-35 C°) (Moreno-Ruiz et al., 2011).

Occurrence: Recorded rare in the sediments of Młynek and Radomno Lakes.

Distribution in Poland: Holocene sediments from SW Gulf of Gdańsk and the Vistula Lagoon, southern Baltic Sea (Witak, 2013); Late Glacial to Holocene sediments of the southern Baltic Sea coast (Dobosz et al., 2014).

Subdivision: Bacillariophytina Medlin & Kaczmarska 2004
Class: Mediophyceae (Jousé & Proshkina-Lavrenko) Medlin & Kaczmarska 2004
Subclass: Thalassiosirophycidae Round & Crawford 1990
Order: Thalassiosirales Glezer & Makarova 1986
Family: Thalassiosiraceae Lebour 1930, emend. Hasle 1973
Genus *Thalassiosira* Cleve 1873

Cells discoid, drum-shaped, cylindrical, and solitary or forming colony. Valves with fultoportulae and at least one rimoportula. The location of fultoportulae and rimoportulae on the valve is important according to the species. These characteristics are usually distinguishable by careful observation of SEM.

Holotype species Thalassiosira nordenskioeldii Cleve 1873

***Thalassiosira baltica* (Grunow) Ostenfeld 1901**

Ref. Edlund et al., 2000, p.610, figs. 3-7, p. 613, figs.8-11.

Status of name: accepted taxonomically

Synonyms: *Coscinodiscus balticus* (Grunow) Grunow ex Cleve, 1891
Thalassiosira subtilis var. *fluviatilis* Lemmermann, 1904
Thalassiosira baltica var. *fluviatilis* Cleve-Euler 1922

Diagnosis: Valves are disc-shaped, with a flat valve face and broadly curved valve/mantle interface. The areolae are loculate, often hexagonal-shaped, and arranged in radial rows. Areolae number 15-18 in 10 µm. Marginal fultoportulae often appear spine-like. The rimoportulae are present on the valve face, closer to the valve margin. Diameter of the valve 20-40 µm.

Ecological preference: *Thalassiosira baltica* is an euryhaline species (Edlund et al., 2000); brackish, planktonic, neritic, wide-boreal (Medvedeva et al., 2009); it is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009).

Distribution in Poland: It is reported from Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012).

***Thalassiosira duostra* Pienaar 1990**

Ref. Pienaar & Pieterse 1990, p. 106, figs. 1–11; Wojtal 2009, p. 312, pl. 1, fig. 12a–d; Genkal 2019, p. 9, pl.1, figs.1-4.

Status of name: accepted taxonomically

Diagnosis: Valves are disc-shaped, with a flat valve face and broadly curved valve/mantle interface. Areolae arranged radially, about 25–30 in 10 µm on valve face and 20–31 in 10 µm near its junction with the mantle. On valve face, cribra are circular in outline and slightly domed inwards. Marginal fultoportulae are located in a single ring, about 5–10 in 10 µm. Diameter of the valve 10- 26 µm.

Ecological preference: Cosmopolitan species (Wojtal & Kwandrans, 2006). It is characterized as a freshwater, probably mesohalobous species present in the eutrophic Vaal River in South Africa (Pienaar & Pieterse, 1990); it is reported from polluted, eutrophic, or even wastewater (Torgan et al., 2006). In Europe known from the Danube River and Iberian Peninsula (Kiss et al., 2005); it is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009).

Distribution in Poland: It is recorded from springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); Kobylanka stream, south Poland and mud samples from below Kobylany village (Wojtal, 2009); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015).

Thalassiosira guillardii **Hasle 1978**

Ref. Hasle 1978, p. 274, figs. 28-47, 49, 50; Hoppenrath et al. 2007, p. 278, figs. 27, 28; Stachura-Suchoples & Williams 2009, p. 482.

Status of name: alternate representation

Synonym: *Conticribra guillardii* (Hasle) Stachura-Suchoples & Williams 2009

Diagnosis: Valves are disc-shaped with very delicate 'areolation' at the margin. Areolar pattern fasciculate. Marginal fultoportulae in a single ring are spaced regularly, about 7–10 in 10 µm. Diameter of the valve 8- 14 µm.

Ecological preference: Cosmopolitan species and known from European and Asian waters; it is characterized by fairly wide salinity tolerance (Hasle, 1978), and observed in eutrophic, anthropogenically altered aquatic habitats.

Distribution in Poland: The species was reported from the highly organically polluted and saline Zbiornik Puławski reservoir (Bucka & Wilk-Woźniak, 2002; Wilk-Woźniak & Ligęza, 2003); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006).

Order: Stephanodiscales Nikolaev & Harwood 1997

Family: *Stephanodiscaceae* Glezer & Makarova 1986

Genus *Skeletonema* Greville 1865

Diagnosis: Cells are cylindrical to disc-shaped with a relatively high mantle and well-developed girdle. Valves are weakly silicified, circular, slightly undulate with convex to flat faces. A ring of fultoportulae processes is present around the margin of the valve.

Holotype species Skeletonema costatum (Greville) Cleve 1873

Skeletonema potamos **(Weber) Hasle in Hasle & Evensen 1976**

Ref. Weber 1970, p.151, fig. 2 A-C; Hasle & Evensen 1976, p.74, figs. 1-17; Chang & Steinberg 1988, p.199, fig. 5; Krammer & Lange-Bertalot 1991a, p.83, pl. 85, figs. 4-8; Cavalcante et al. 2013, p. 239, figs. 3A-R; as *Stephanodiscus subsalsus* (Cleve) Hustedt 1928; Hustedt 1930, p. 372, fig. 195.

Status of name: accepted taxonomically

Synonyms: *Stephanodiscus subsalsus* (A. Cleve) Hustedt 1928
Skeletonema subsalsum (A. Cleve) Bethge 1928

Diagnosis: Frustules are weakly silicified, short cylindrical forms with a deep mantle. Valves are circular, flat to slightly round with radiate knobby costae. Almost 5-8 short fultoportulae arranged in a marginal ring at valve surface and 5-8 rows of areolae between them. Sub-central rimoportula present. Length of the pervalvar axis 4-10 µm, and diameter 3-6 µm.

Ecological preference: This species prefers water of 2-34‰ salinity (Hasle & Evensen, 1976). It is recorded from the Grand River mouth of Lake Erie, associated with relatively elevated concentrations of phosphorus, nitrogen, and chloride (Nicholls et al., 1983). Cosmopolitan, it is reported from different kinds of inland water bodies, tolerating waters of elevated conductivity, also known from brackish waters, eutraphentic species (Krammer & Lange-Bertalot, 1991). Alkaliphilous, fresh/brackish water taxon, hypereutraphentic, β-mesosaprobous, strictly aquatic (Van Dam et al., 1994). It is restricted to the down streams of river or river mouths and particularly abundant in eutrophic waters. Fresh and brackish water, planktonic, indifferent (pH), boreal (Medvedeva et al., 2009).

Distribution in Poland: Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006)

Genus *Cyclostephanos* Round in Theriot et al. 1987

Diagnosis: Frustule is small disc-shaped with circular valves, which are concentrically or tangentially undulated with a ring of spines on the marginal area. The valve surface is perforated by distinct areolae, which are grouped in radial fascicles. The fascicles are extended uniseriate from the center to 3-4 rows at the valve face/mantle junction. The valve margin is distinctly costate, radiate, and separated the poroidal fascicles. Areolae are continuing down the mantle in separate fascicles. Marginal spines are found on the ridges at the edge of the valve face. Marginal fultoportulae occur below the spines. Scattered fultoportulae with two satellite pores are also occurring on the valve face.

Lectotype species Cyclostephanos novae-zeelandiae (Cleve) Round 1988

***Cyclostephanos delicatus* (Genkal) Casper & Scheffler 1990**

Ref. Genkal 1985, p. 30, figs. 1-5; Casper & Scheffler 1990, pl. 12, figs. 23–31; pl.16, figs. 15–20.

Status of name: accepted taxonomically

Synonyms: *Cyclostephanos tholiformis* Stoermer, Håkansson & Theriot 1987
Stephanodiscus delicatus Genkal 1985

Diagnosis: Valves are small, with a concentrically undulate face and an annulus in the valve center. Areolae are very fine, difficult to observe under LM. In the central area, areolae are weakly organized near the annulus and then become organized into fascicles toward the margin. Fascicles are uniseriate near the valve center and become multiseriate near the margin. Valve diameter 9-15 µm.

Ecological preference: The species can inhabit eutrophic and polluted calcium-rich waters (Casper & Scheffler, 1990; Dreßler & Hübener, 2006); it is reported from waters with elevated salts concentrations (Kharitonov, 2005).

Occurrence: Recorded rare in the sediments of Młynek, Radomno, and Kamionka lakes and the Eemian deposits of central Poland.

Distribution in Poland: The species is reported from Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Zalew Szczeciński lagoon (Bąk et al., 2006); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006). It is recorded as Cyclostephanos tholiformis in Swibno-Vistula River estuary in Northern Poland (Majewska et al., 2012).

***Cyclostephanos dubius* (Fricke) Round in Theriot et al., 1987**

(Pl. 10, figs. 1-19; pl. 11, figs. 1-12; pl. 12, figs. 1-10**)**

Ref. Round 1982, p. 326, figs 7-18; Hickel & Håkansson 1987, p. 36, fig. 9; Ricard 1987, p. 158, fig. 119-123; Theriot et al., 1987, p. 346; Piennar & Pieterse 1990, p. 202, fig. 1; Krammer & Lange-Bertalot 1991a, p. 61, pl. 67, figs. 8a-9b; Håkansson 2002, p. 62, figs. 198-208; Wojtal & Kwandrans 2006, pl. 15, fig. 8; pl.16, figs. 1–11. As *Stephanodiscus dubius* (Fricke) Hustedt 1928, Hustedt 1930, p.367-368, fig. l92; Germain 1981, p. 40, pl. 10, figs. 1-12.

Status of name: accepted taxonomically

Synonyms: *Cyclotella dubia* Fricke 1900
Cyclotella dubia var. *spinulosa* A. Cleve 1915
Stephanodiscus dubius Hustedt 1928
Stephanodiscus dubius var. *radiosus* Cleve-Euler 1951

Diagnosis: Frustules are disc-like, circular in outline, with strong concentric undulating valves. The valve surface is represented by three zones. Areolar fascicules on the valve face are separated by distinct interfascicular costae. Areolae are continuously arranged uniseriate from the center increasing to 2-4 rows towards the margin. The central and marginal zone are distinctly separated due to deep undulation. A ring of fultoportulae and two strut pores are represented on the valve mantle with intervals of 3-4 fascicles and a few fultoportulae are found in the central area. A rimoportula presents on the ring of tubes of the marginal area. Valves with variable numbers of spines at the valve face/mantle junction. Valve diameter ranges 8-35 µm and the central field/diameter cell ratio is about 0.40-0.50.

Ecological preference: A cosmopolitan species, pelagic, common in flowing and stagnant waters in coastal areas, oligosaprobic, alkalibiontic, halophilous "0.0-5 g/l" (Hustedt, 1930, 1957); mesosaprobic (Cleve-Euler, 1951); eutrophic, in fresh and brackish water, pH value 6.9-9.0 (Van Der Werff & Huls, 1957-1974); planktonic, brackish water form (Cholnoky, 1968); halophilous, alkalibiontic, with pH value above 7.0 (Foged, 1973); oligohalobous, meio- mesoeuryhaline (Pankow, 1976). This taxon is halophilic as observed in some brackish inland waters (Hickel & Håkansson, 1987). Euplanktonic, alkalibiontic, brackish/freshwater species, eutraphentic, α- mesosaprobic, strictly aquatic species (Denys, 1991; Van Dam et al., 1994); it is considered as an indicator of poor water quality (Prygiel & Coste, 2000), and highly eutrophic waters (Anderson, 1997; Anderson et al., 1993; Håkansson & Regnell, 1993). The species was recorded from eutrophic freshwater to slightly brackish water environments of medium alkalinity with pH ranges between 7.6 –8.9 (Zalat & Servant-Vildary, 2005); freshwater, eutraphentic with pH value 7.69-8.11 (Witak et al. 2017).

Occurrence: Recorded frequently in the Holocene sediments of Młynek and Radomno Lakes and the Eemian deposits of central Poland; rare in the sediments of Kamionka Lake.

Distribution in Poland: The species is reported from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013d); the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); from the Holocene sediments of Lake Suminko, northern Poland (Pędziszewska et al. 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Fallow soil in Pogórska Wola near Tarnów, southern Poland (Stanek-Tarkowska et al., 2015); Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); dominant in the upper part of the Ner River, central Poland (Szczepocka et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019).

Cyclostephanos invisitatus **(Hohn & Hellermann) Theriot et al. 1987**

(Pl. 12, figs. 11-13)

Ref. Hohn & Hellerman 1963, p. 325. pl. 1, fig. 7; Lowe & Crang 1972, p. 258. fig. 1; Theriot et al., 1987, p. 256, figs. 18-24, Krammer & Lange- Bertalot 1991a, p. 63. pl. 67, fig. 3; Håkansson 2002, p. 67, figs. 221-225; Wojtal & Kwandrans 2006, pl. 15, figs. 9; pl.16, figs. 12–14, 17; Cavalcante et al., 2013, p. 246, figs. 10 A-L; Olszynski et al., 2019, p. 19, figs. 5GG–5JJ

Status of name: accepted taxonomically

Synonyms: *Stephanodiscus invisitatus* Hohn & Hellerman, 1963
Stephanodiscus hantzschii var. *striator* Kalbe 1971

Diagnosis: Valves are discoid, small with a flat valve face and striated marginal area that consists of 15–20 striae in 10 μm. Striae are fine and punctate, radiate, bundled into fascicles, and uniseriate in the center becoming biseriate near the margin. Fascicles are about 14-16 in 10 μm. One central fultoportula is present, but marginal fultoportulae and rimoportula indistinct. Diameter of the valve 7–15 μm.

Ecological preference: The species is common in the eutrophic waters throughout North America (Lowe & Crang, 1972); a cosmopolitan, planktonic species (Krammer & Lange-Bertalot, 1991); it is known from waters of moderate to a higher trophy and moderate alkalinity (Siver et al., 2005); it is regarded as an indicator of eutrophic conditions in rivers (Edlund et al., 2009) and shallow lakes (Yang et al., 2005); freshwater, planktonic, o-β-mezosaprobic (Medvedeva et al., 2009). This species is a typical indicator occurring in the eutrophic freshwaters; it is most frequently reported in aquatic ecosystems subjected to high human impact characterized by an alkaline reaction and increased conductivity (Kiss et al., 2012; Houk et al., 2014; Reavie & Kireta, 2015; Olszyński & Żelazna-Wieczorek, 2018).

Occurrence: Recorded infrequently in the sediments of Młynek, Radomno, and Kamionka Lakes.

Distribution in Poland: The species is reported from the Rawka River (Rakowska, 1984); the heavily polluted Zbiornik Puławski reservoir (Bucka & Wilk-Woźniak, 2002); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, southern Poland (Wojtal et al., 2005); the Zalew Szczeciński lagoon (Bąk et al., 2006); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019).

Genus *Cyclotella* (Kützing) Brebisson 1838

Diagnosis: Valves are circular in valve view, with a tangential or concentric undulated valve face; the undulation more evident in the middle area. The central area is often ornamented with granules or punctae and sometimes smooth. Puncta rows grouping as fascicles from the valve center toward the margin. Disc with marginal radial ribs, short or long, thick or thin. Valve margin without a distinct ring of spines. Fultoportulae are present near the valve margin and found over the valve center.

Holotype species *Cyclotella* tecta Håkansson & Ross 1984

Cyclotella atomus **Hustedt 1937**

(Pl. 13, figs. 1-4**)**

Ref. Hustedt 1937, p. 143, pl.9, figs. 1-4; Lowe 1975, p. 415, fig. 1; Germain 1981, p. 34, pl. 8, figs. 22-23; Simonsen 1987, p. 207, pl. 320, figs 10-13; Krammer & Lange-Bertalot 1991a, p. 53, pl. 51, fig. 19-21; Genkal & Kiss 1993, p. 40, fig. 1; Hakansson 2002, p. 106, figs. 381–388; Wojtal 2009, p. 176, pl. 1, figs. 10-11; pl. 49, figs. 3, 7; Houk et al. 2010, p. 13, pl. 124, figs 1-19; pl. 125, figs 1-17; pl. 126, figs 1-6; pl. 127, figs 1-6; Cavalcante et al., 2013, p. 241, figs. 4 A-P.

Status of name: accepted taxonomically

Diagnosis: Frustules are small with circular valves. The central area is smooth, flat to slightly tangentially undulate. A single fultoportula is present in the central region. Marginal striae are radiate separated by thickened costae, about 14–20 striae in 10 µm. Marginal fultoportulae are dispersed every 3 or 4 striae. One rimoportula is inserted between two marginal fultoportulae. Diameter of the valve 3.5-7 µm.

Remarks: This species differs from Stephanocyclus meneghiniana (Kützing) Skabichevskii by short striae of the marginal area with occurrence of distinct fultoportulae at every third to fifth, appearing as thicker striae and presence of a single subcentral fultoportulae.

Ecological preference: A cosmopolitan, halophilic species, is associated with high conductivity and chloride levels (Makarewicz, 1987; Krammer & Lange-Bertalot, 1991); it is a planktonic, alkaliphilous, α-mesosaprobous, eutraphentic, strictly aquatic and brackish freshwater species (Denys, 1991; Van Dam et al., 1994); it is often associated with polluted, eutrophic, warm harbors and nearshore areas (Yang et al., 2005); Freshwater, planktonic, halophilic, o-saprobic (Medvedeva et al., 2009); alkaliphilous pH over 7, limnobiontic-euryhaline 3-8 psu, mesopolythermic (>18-35 C°) (Moreno-Ruiz et al., 2011).

Occurrence: Recorded common in the Eemian deposits of central Poland, frequent in the sediments of Młynek Lake, and rare in the sediments of Radomno and Jeziorak Lakes.

Distribution in Poland: A common species in Zatoka Gdańska (Witkowski, 1994); Zalew Wiślany (Jankowska et al., 2005); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, southern Poland (Wojtal et al., 2005); Vistula River in Krakow (Kawecka & Kwandrans, 2000; Wojtal & Kwandrans, 2006); Zalew Szczeciński (Bąk et al., 2006); Vistula, Raba, Dunajec and Wisłoka Rivers (Dumnicka et al., 2006); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); Lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); Kobylanka stream, south Poland, in samples with mud and filamentous algae from below Kobylany village (Wojtal, 2009); abundant at the Swibno-Vistula River estuary in northern Poland (Majewska et al., 2012); dominant in the Wisłok River, south Poland (Noga et al., 2013c); from the river and streams in territory of the Podkarpacie Province, south Poland (Noga et al., 2014); found in Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015).

***Cyclotella cryptica* Reimann, Lewin & Guillard 1963**

(Pl. 13, figs. 5-8)

Ref. Reimann et al. 1963, p. 82, figs.4-11; Tesson & Hildebrand 2010, p. 3, figs. 1 A-G; Cavalcante et al., 2013, p. 242, figs. 6 A-K

Status of name: accepted taxonomically

Diagnosis: Frustules are small with circular valves and a smooth central area. Marginal striae radiated, about 7-10 striae in 10 µm. The central portion of the valve is constituting about half or more of the valve diameter, has low relief features, and is relatively flat. The internal valve surface shows opened alveolate striae. Fultoportulae are irregularly arranged along the marginal ring but are always associated with one costa. A single rimoportula is located at the ring of fultoportula. One central fultoportula is distinct. Diameter of the valve 5-9 µm.

Ecological preference: According to Guiry & Guiry (2021), the species is a brackish water form.

Occurrence: Recorded frequently in the Eemian deposits of central Poland, and rare in the sediments of Młynek Lake.

Distribution in Poland: It is reported from the Gulf of Gdansk and surrounding waters, the southern Baltic Sea (Plinski & Witkowski, 2020).

***Cyclotella cyclopuncta* Håkansson & Carter 1990**

(Pl. 13, figs. 9-11)

Ref. Håkansson & Carter 1990, p. 155, figs 6-8**;** Krammer & Lange-Bertalot 1991, pl. 51, figs. 10-14**.**

Status of name: alternate representation

Synonym: *Cyclotella cretica* var. *cyclopuncta* (Håkansson & Carter) Schmidt 1993

Diagnosis: Valves are circular. The central area is distinguished by a single, eccentrically placed fultoportula. The marginal striated zone with striae and interstriae are slightly unequal in length, about 18- 20 in 10 µm. The most important morphological character is the hollows in the marginal area, close to the valve face/ mantle junction. Diameter of the valve 10–32 µm**.**

Ecological preference: A cosmopolitan species, freshwater, alkaliphilous (Krammer & Lange-Bertalot, 1991); freshwater, oligotraphentic with pH value is 7.69-8.11(Witak et al., 2017).

Occurrence: Recorded common in the Eemian deposits of central Poland, frequent in the sediments of Młynek Lake.

Distribution in Poland: It is reported from the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); low-pH Lake Piaski in Western Pomerania north-west Poland (Witkowski et al., 2011); Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013d); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); from the Gulf of Gdansk and surrounding waters, the southern Baltic Sea (Plinski & Witkowski 2020).

Cyclotella distinguenda **Hustedt 1927**

(Pl. 13, figs. 12-35; pl. 14, figs. 1-26)

Ref. Germain, 1981, p. 32, pl. 7, figs. 10-12; Simonsen 1987, p. 101, pl. 159, figs 4-11; Håkansson 1989, p. 259, figs. 8-34; Krammer & Lange-Bertalot 1991a, p. 43, pl. 43, figs. 1-11; pl. 51, figs. 6-8, 16, 18; Metzeltin & Witkowski 1996, p. 34, pl. 1, fig. 7; Håkansson 2002, p. 72, figs. 228, 230–237; Wojtal & Kwandrans 2006, pl. 4, figs. 16–17 & 11: 1–4; Wojtal 2009, p. 176, pl. 1, figs. 13a, b; Houk et al. 2010, p. 20, pl. 164, figs 1-14; pl. 165, figs 1-9; pl. 166, figs 1-6; pl. 167, figs 1-6; pl. 168, figs 1-6.

Status of name: accepted taxonomically

Synonyms: *Frustulia operculata sensu* Kützing 1834
Cyclotella operculata (C. Agardh) Brébisson 1838
Cyclotella kützingiana Thwaites sensu Germain 1981
Cyclotella tecta Håkansson & Ross 1984

Diagnosis: Valves are circular with valve face is differentiated into a distinct central area and a striated marginal zone. The central area is tangentially undulated, and maybe smooth or more frequently ornamented with small pores. There are no central fultoportulae. The marginal striated part is consisting of almost equal radially oriented striae and interstriae, which are about 15–18 in 10 µm. Diameter of the valve 10–30 µm.

Remarks: Hakansson (1989) stated that Cyclotella distinguenda is the correct name to be used for C. operculate (C. Agardh) Brébisson 1838.

Ecological preference: A cosmopolitan species, alkaliphilous, fresh brackish water species, euplanktonic or tychoplanktonic of benthic origin, known from the pelagic zone of lakes, tolerating waters of elevated conductivity (Denys, 1991; Krammer & Lange-Bertalot, 1991; Van Dam et al., 1994); warm alkaline freshwater with temperature 18.7-26.8 °C and pH value 7.5-8.1 (Cantoral-Uriza & Sanjurjo, 2008); freshwater, planktonic, halophilic, alkaliphilic, o-saprobic (Medvedeva et al., 2009).

Occurrence: Recorded common in the Eemian deposits of central Poland, frequent in the sediments of Młynek Lake, rare in the Radomno and Jeziorak Lakes.

Distribution in Poland: The species is reported mainly from northern Poland (Hustedt, 1948; Marciniak, 1973, 1979; Kaczmarska, 1976, 1977; Cieśla & Marciniak, 1982; Bogaczewicz-Adamczak, 1988; Bińka et al.,1988), it is reported as Cyclotella operculata from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); central Poland (Rakowska, 2001) and in rivers of southern Poland. It is reported also from Zalew Szczeciński (Bąk et al., 2006); soft water lakes in Northern Poland (Milecka & Bogaczewicz- Adamczak, 2006); springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); Lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); Kobylanka stream, south Poland (Wojtal, 2009); Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013d); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); the territory of the Podkarpacie Province, Wisłok River (Noga et al., 2014); Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015).

Cyclotella distinguenda **var.** ***unipunctata*** **(Hustedt) Håkansson & Carter 1990**

(Pl. 15, figs. 1-12)

Ref. Krammer & Lange-Bertalot 1991, pl 51, figs. 6, 8, 16, 18.

Status of name: accepted taxonomically

Synonym: *Cyclotella operculata* var. *unipunctata* Hustedt 1922

Remarks: Cyclotella distinguenda var. unipunctata, differs from the nominate species by the features of the marginal zone with the tangential undulate central area and the presence of "hollows" in the central area.

Ecological preference: Freshwater, planktonic, halophilic, alkaliphilic, boreal (Medvedeva et al., 2009)

Occurrence: Recorded common in the Eemian deposits of central Poland.

Distribution in Poland: It is reported from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015).

Cyclotella iris **Brun & Héribaud-Joseph 1893**

(Pl. 15, figs. 13-14**)**

Ref. Serieyssol 1984, p. 201, figs. 1-3, 19, 20,25-36; Ognjanova-Rumenova 1995, p. 302, pl. I, figs. 1-2; 10-13.

Status of name: accepted taxonomically

Diagnosis: Valves are circular with an undulate central area and a striated marginal zone extending inwards one-half to one-third of the valve radius. The striae are undulated and are unequal length, about 10-15 striae in 10 µm. The rimoportula is located on a costa between two alveolar openings. Marginal fultoportulae are found on every first or second costa. Diameter of the valve 25–40 µm.

Ecological preference: Freshwater species (Serieyssol, 1984).

Occurrence: Recorded frequently in the Eemian deposits of central Poland, and rare in the Młynek Lake.

Distribution in Poland: It is reported from the territory of the Podkarpacie Province, Wisłok River (Noga et al., 2014).

Cyclotella lenoblei **Manguin 1949**

(Pl. 15, figs. 15-18; pl. 16, figs. 1-4**)**

Ref. Manguin 1949, p. 95; pl. 2, fig. 26 a-e

Status of name: accepted taxonomically

Diagnosis: Valves are circular with a slight concave central area and slightly convex, a striated marginal zone. The striae are slightly undulated and distinctly unequal in length, about 18-20 striae in 10 µm. Marginal fultoportulae are present. Diameter of the valve 16– 35 µm.

Ecological preference: Freshwater species (Manguin, 1949).

Occurrence: Recorded rare in the Eemian deposits of central Poland.

Distribution in Poland: New record.

Cyclotella meduanae **Germain 1981**

(Pl. 16, figs. 5-8)

Ref. Germain, 1981, p. 36, pl. 8, fig. 28; pl. 154, figs. 4, 4a; Park, et al., 2013, p. 414, fig. 4 A-D; Cavalcante et al., 2013, p. 243, fig. 7 A-Q.

Status of name: accepted taxonomically

Diagnosis: Valves are circular, with flat to slightly tangentially undulate central area, without colliculate ornamentation. The striated part of the valve face is clearly divided from the central hyaline area. The marginal striae are radiate, about 10-13 striae in 10 µm. Valve face fultoportula is absent. Marginal fultoportulae are located on every 2nd to 3rd interstria. A single rimoportula is located on the ring of marginal fultoportulae. Diameter of the valve 5 -8 µm.

Ecological preference: It was found mainly in eutrophic, freshwater (Tanaka, 2007); It is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009); the species has been recorded from different rivers and lakes with different halobity and trophic status (Kiss et al., 2012).

Occurrence: Recorded frequently in the Eemian deposits of central Poland, and rare in the Młynek Lake.

Distribution in Poland: New record.

Cyclotella paradistinguenda **Katrantsiotis & Risberg, in Katrantsiotis et al. 2016**

(Pl. 16, figs. 9-14)

Ref. Katrantsiotis et al. 2016, p. 246, figs 2-42**;**

Status of name: accepted taxonomically

Diagnosis: Valves are circular. The valve face is differentiated into a distinct central area and a striated marginal zone. The central region is large, flat, or slight concentric undulation, smooth, or ornamented with unevenly distributed puncta and depressions, which do not penetrate the valve. There are no central fultoportulae, granules, or spines. The marginal area consists of short, radiate distinct striae and interstriae of almost equal length, about 12–15 striae in 10 µm. The striae are formed of one or two short radial rows of areolae. The interstriae appear hyaline and slightly elevated between the striae. The marginal fultoportulae are found in a ring at the outer ends of the interstriae and a single rimoportula, which is visible externally as a larger rounded pore. Diameter of the valve 18–29 µm.

Ecological preference: This species indicates an open, deep freshwater environment (Katrantsiotis et al., 2016).

Occurrence: Recorded frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

Cyclotella planctonica **Brunnthaler in Brunnthaler, Prowazek & Wettstein 1901**

(Pl. 16, figs. 15-17)

Ref. Brunnthaler et al. 1901, p. 7, figs 1, 2; Cleve 1951, p. 48, fig. 60 a-e; Krammer & Lange-Bertalot 1991a, pl. 59, fig. 9-11.

Status of name: accepted taxonomically

Synonym: *Cyclotella socialis* var. *planctonica* (Brunnthaler) A.Cleve 1951

Diagnosis: Valves are circular with a concentrically undulate valve face. The central area is more or less convex or concave, areolated by radial rows of areolae. The margin area is striated by fine straight striae of about 15-18 in 10 µm. The alveolate striae are often bifurcate at the valve margin with irregular branching of the costae. These striae generally terminate evenly to form a distinct boundary to the central area. Marginal fultoportulae are located on each costa, 4 to 6 in 10 µm. Diameter of the valve 18-35 µm.

Ecological preference: Cyclotella planctonica was determined to be characteristic of oligotrophic lakes, and also found in eutrophic lakes (Hutchinson, 1967; Gönülol & Obali, 1998).

Occurrence: Recorded frequently in the Eemian deposits of central Poland, and rare in the Młynek Lake.

Distribution in Poland: The species is reported from the territory of the Podkarpacie Province, Żołynianka stream, south Poland (Noga et al., 2014); the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al. 2015).

Genus *Discostella* Houk & Klee 2004

Diagnosis: Frustules are small disc-shaped with extremely small valves. Ornamentation in the central valve may be absent, or with stellate ornamentation. The main characters distinguishing Discostella from the other Cyclotella taxa are the position of their marginal fultoportulae between the marginal costae astride the alveoli (Houk, 1992) and the frequent presence of the stellate pattern in the central part of their valves (Haworth & Hurley, 1986). The taxa of this group are often heterovalve and small.

Holotype species Discostella stelligera (Cleve & Grunow) Houk & Klee 2004

Discostella nana **(Hustedt) Chang in Chang & Chang Schneider 2008**

Ref. Hasle & Heimdal 1970, p. 565, pl. 5, figs. 27-33; pl. 6, figs. 34-38; Krammer & Lange-Bertalot 1991a, p. 80, pl. 60, figs. 6a, b; Wojtal 2009, p. 312, pl. 1, figs. 6–9; as Cyclotella nana Hustedt 1957, Wojtal & Kwandrans 2006, pl 4, fig. 8; pl. 7, figs. 20–25.

Status of name: alternate representation

Synonyms: *Cyclotella nana* Hustedt 1957
Thalassiosira pseudonana Hasle et Heimdal 1970

Diagnosis: Valves are small, circular, flat, very weakly silicified. The valve face is striated radially with hexagonal to polygonal areolae, which are often apparent in the central region. Marginal fultoportulae in a single ring, spaced regularly, around the edge of the valve face. Diameter of the valve 3.5–6.0 µm.

Ecological preference: The species is cosmopolitan, planktonic, typically found in freshwater and coastal brackish habitats (Krammer & Lange-Bertalot, 1991a); alkaliphilous, brackish /freshwater taxon, hyper-eutraphentic, α-mesosaprobous, strictly aquatic (Van Dam et al., 1994). It is eurythermal, experiencing good growth from 10–30°C, with an optimum around 21°C (Harris et al., 1995). The species grows well at pH of 7 – 8.8, but its growth rates are reduced at higher pH because CO_2 becomes limiting (Chen & Durbin, 1994); it is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH value 7.86 – 8.55, and surface water temperature 9.81-27.26 °C (Pérez et al., 2009); alkaliphilous pH over 7, marine euryhaline, mesopolythermic (>18-35 C°) (Moreno-Ruiz et al., 2011).

Occurrence: Recorded infrequently in the Eemian deposits of central Poland.

Distribution in Poland: It is reported from Zatoka Gdańska (Witkowski, 1994); Zbiornik Puławski reservoir (Bucka & Wilk-Woźniak, 2002; Wilk-Woźniak & Ligęza, 2003); Zalew Szczeciński (Bąk et al., 2006); Vistula River (Bucka, 2000; Kawecka & Kwandrans, 2000); Rudawa River, Prądnik River, springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); Kobylanka stream, south Poland, in samples with mud and filamentous algae from below Kobylany village (Wojtal, 2009); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Fallow soil in Pogórska Wola near Tarnów southern Poland (Stanek-Tarkowska et al., 2015).

Discostella pseudostelligera **(Hustedt) Houk & Klee 2004**

(Pl. 17, fig. 1)

Ref. Hustedt 1939, p.581, figs. 1, 2; Lowe 1975, p. 421, fig. 22; Gasse 1980, p. 36, pl. 12, figs. 9-11; Germain 1981, p. 36, pl. 8, figs. 19-21; Haworth & Hurley 1986, p. 52, figs. 15-17; Krammer & Lange-Bertalot 1991 b, p. 51, pl. 49, figs. 5-7; Houk & Klee 2004, p. 223, figs. 109, 110; Wojtal & Kwandrans 2006, pl. 12, figs. 1–3; pl. 13, figs. 1–9; Wojtal 2009, p. 196, pl. 1, figs. 16, 17; Houk et al. 2010, p. 50, pl. 317, figs. 1-20; pl. 318, figs 1-6; pl. 319, figs 1-6; pl. 320, figs 1-8.

Status of name: accepted taxonomically

Synonyms: *Cyclotella pseudostelligera* Hustedt 1939

Cyclotella stelligera var. *pseudostelligera* (Hustedt) Haworth & Hurley 1986

Diagnosis: Frustules are small disc-shaped with circular valve face, which is slight concentrically undulate, and a convex or concave central area. Central area with short striae in a star-like arrangement surrounding a group of areolae, separated from the marginal area by an unornamented ring. A single large punctum in the center of stellate ornaments. Radial fascicles are uniform or irregularly arranged and the striated marginal area has 18–22 delicate striae in 10 µm, radially oriented. Marginal fultoportulae are equidistant with long tubes per each 3-5 costae. One rimoportula is observed on the valve mantle. Diameter of the valve 4–8 µm.

Ecological preference: A cosmopolitan species (Krammer & Lange-Bertalot, 1991); Neutrophilous, α-mesosaprobous, eutraphentic, strictly aquatic species (Van Dam et al., 1994); euplanktonic or tychoplanktonic of benthic origin, Brackish/freshwater taxon, eutraphentic, α-meso- saprobous, considered an indicator of moderate water quality (Prygiel & Coste, 2000); it is reported from more eutrophic environments (Siver et al., 2005). This species grows quickly, and is typical of shallow, nutrient-enriched, and often turbid aquatic habitats (Reynolds et al., 2002). Its abundance indicates longer ice-free conditions and more stability in thermal stratification in recent years (Karst-Riddoch et al., 2005); Freshwater, planktonic, indifferent (halobity), indifferent (pH), o-β-mezosaprobic (Medvedeva et al., 2009).

Occurrence: Recorded frequently in the sediments of the Młynek and Radomno Lakes, and rare in the Eemian deposits of central Poland.

Distribution in Poland: The species was reported from different habitat in Poland. Vistula River, Poland (Kiss & Pająk, 1994); the Wyżyna Krakowsko-Częstochowska upland: Vistula, Szreniawa, Dłubnia, in several rivers and reservoirs in southern Poland; Vistula River, Szreniawa River and Dłubnia River (Kawecka & Kwandrans, 2000); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, southern Poland (Wojtal et al., 2005); springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); Rudawa River and Prądnik River (Bucka, 2000; Wojtal & Kwandrans, 2006); Kobylanka stream, south Poland, in mud samples from Zielona village, below Kobylany village (Wojtal, 2009); from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); abundant at the Swibno- Vistula River estuary, Górki Zachodnie and Swibno – Vistula River estuary in northern Poland (Majewska et al., 2012); Duszatyńskie Lakes, Matysówka stream a right-bank tributary of Struga River, district of Tyczyn and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013 b, d); the river and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); The Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015).

Discostella stelligera **(Cleve & Grunow) Houk & Klee 2004**

(Pl. 17, fig. 2)

Ref. Hustedt 1930, p. 339, fig. 172; Okuno 1974, p. 2, figs. 827-828; Lowe 1975, p. 421, fig. 26; Germain 1981, p. 34, pl. 8, figs. 8-13; Harworth & Hurley 1984, p. 44, fig. 1; Kling & Håkansson 1988, p.76, pl. 49, figs. 101-104; Krammer & Lange-Bertalot 1991a, p. 50, pl. 49, figs. 1-4; Ehrlich 1995, p. 36, pl. 2, fig. 20; Lange-Bertalot & Metzeltin 1996, p. 124, pl. 2, fig. 226; pl. 103, figs. 1-4; Wojtal 2009, p. 198, pl. 1, fig. 18.

Status of name: accepted taxonomically

Synonyms: *Cyclotella stelligera* Cleve & Grunow in Van Heurck 1882

Cyclotella meneghiniana var. *stelligera* Cleve & Grunow in Cleve 1881

Diagnosis: Frustules are disc-shaped with a circular valve face, which is concentrically undulated. The central area is raised or depressed with stellate areolar fascicles and a large punctum in the center, it is separated from the marginal area by a smooth, unornamented ring, hyaline zone. The marginal area is striated by 9-12 striae in 10 mm, each composed of a double row of areolae. Fultoportulae are represented per 3-4 costae, with external tubular structures. A rimoportula with labiate aperture is found in the valve margin. Diameter of the valve 6-18 µm.

Ecological preference: The species prefers oligotrophic to somewhat mesotrophic water (Whitmore, 1989); a cosmopolitan freshwater species (Krammer & Lange-Bertalot, 1991a); euplanktonic or tychoplanktonic of benthic origin, brackish/freshwater taxon (Van Dam et al., 1994); common in oligo-mesotrophic environments (Yang & Dickman, 1993: Potapova & Charles, 2007), freshwater, planktonic and benthic, indifferent (halobity), indifferent (pH), χ-saprobic (Medvedeva et al., 2009) and in alkaline waters with high conductivity (Bartozek et al., 2018). It was common in slightly acid to circumneutral pH (6-6.85), low conductivity (24-24.5µS cm-1), and oligotrophic conditions (Silva-Lehmkuhl et al., 2019).

Occurrence: Recorded rare in the sediments of the Młynek Lake, and the Eemian deposits of central Poland.

Distribution in Poland: The species is reported from Vistula River (Turoboyski, 1962; Pudo, 1977); Pilica River (Kadłubowska, 1964b); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland; Biała Przemsza River, artificial pond in Modlniczka near Krakow (Wojtal & Kwandrans, 2006); Kobylanka stream, in epipelon below Kobylany village (Wojtal, 2009); Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al. 2013d); from some rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014).

Discostella woltereckii **(Hustedt) Houk & Klee 2004**

(Pl. 17, figs. 3-11)

Ref. Hustedt 1942, p. 16, figs 11-13; Cho 1996, p. 12, fig. 24; Klee & Houk 1996, p. 20, fig. 1; Houk & Klee 2004, p. 223, figs 119-122; Tuji & Williams 2006a, p. 15, fig. 1; Wojtal & Kwandrans 2006, pl. 12, figs. 4–9, 12–16; pl. 15, figs. 1–3; Guerrero & Echenique 2006, p. 89, figs. 27-30.

Status of name: accepted taxonomically

Synonyms: *Cyclotella woltereckii* Hustedt 1942

Cyclotella stelligera var. *pseudostelligera* f. *woltereckii* (Hustedt) Haworth & Hurley 1986

Diagnosis: Frustules are drum-shaped with flat or somewhat undulate circular valve face. The central area is concave, however, not often developed; it has different sizes from very small to larger, formed by striae running towards the valve center. Marginal striae extending to the center of the valve, about 19–21 striae in 10 µm, each consisting of two rows of areolae. Marginal fultoportular tubes variable in forms: simple, horn-shaped, or grotesque. Diameter of the valve 5-13 µm.

Remarks. Discostella pseudostelligera and D. woltereckii are very closely related species that share several morphological features. Haworth & Hurley (1986) consider D. woltereckii to be a form of D. pseudostelligera.

Ecological preference: Cosmopolitan, tychoplanktonic of benthic origin, brackish/freshwater taxon, it prefers lower conductivity preferences (Wunsam et al., 1995); found in an alkaline eutrophic lake of moderate and high conductivity (Hübener, 1999; Wojtal & Kwandrans, 2006); it is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH 7.86 – 8.55, and surface water temperature 9.81 – 27.26 °C (Pérez et al., 2009).

Occurrence: Recorded rare in the Eemian deposits of central Poland.

Distribution in Poland: The species was reported from reservoirs in central Poland (Bucka & Wilk- Woźniak, 2002); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, southern Poland (Wojtal et al., 2005); springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); Żołynianka stream, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al. 2015).

Genus *Lindavia* (Schutt) De Toni and Forti 1900

Diagnosis: Frustules are drum-shaped with circular to oval valve face, which is almost flat, concave, convex, concentrically, or tangentially undulate. Valves are differentiated into marked central and marginal areas. Central area variable, with or without areolae. Fultoportulae are present with domed cribra, about 2 to 4 fultoportulae on the valve face. Rimoportula found on the valve face and always disassociated from the ring of marginal fultoportulae.

Holotype species *Cyclotella socialis* Schütt 1899
= *Lindavia socialis* (Schütt) De Toni & Forti 1900

***Lindavia affinis* (Grunow) Nakov et al., 2015**

(Pl. 17, figs. 12-15)

Ref. Bahls et al., 2018, p. 38, figs. 21–24; p.146, fig.4.

Status of name: accepted taxonomically

Synonyms: *Cyclotella bodanica* var. *affinis* Grunow, 1878
Cyclotella affinis (Grunow) Houk, Klee, and Tanaka 2010
Handmannia affinis (Grunow) Kociolek & Khursevich 2012

Diagnosis: Frustules are disc-shaped, with circular valve face and distinctly raised or depressed central area. The central area is ornamented by areolae in a radiate pattern. Marginal alveolate striae distinct, about 13-15 striae in 10 µm, and the striae are split into two or three anastomosing branches. One to three rimoportulae are present on the valve face. Fultoportulae are present at the valve margin on marginal ribs and aligned with every 4th or 5th stria. Diameter of the valve 15-30 µm.

Ecological preference: *Lindavia affinis* is a planktonic species found primarily in freshwater lakes with a salinity optimum is 1.8 gL-1 (Fritz et al., 1993), and it has been reported to occur at pH around 7 (Soninkhishig et al., 2003).

Occurrence: Recorded infrequently in the Eemian deposits of central Poland.

Distribution in Poland: It is recorded from the territory of the Podkarpacie Province, Wisłok River (Noga et al., 2014).

***Lindavia baicalensis* (Skvortzow & Meyer) Nakov et al., 2015**

(Pl. 17, figs. 16-21)

Ref. Skvortsov & Meyer 1928, p. 5, pl. I (1), fig. 3; Jewson et al., 2015, p.2116, fig. 2 a, d; Nakov et al. 2015, p. 254

Status of name: accepted taxonomically

Synonym: *Cyclotella baicalensis* Skvortsov & Meyer 1928

Diagnosis: Frustules are disc-shaped, with a circular valve face and slightly raised central area. The central area is large, with a convex central portion, ornamented by areolae in random or slight radiate pattern, finely colliculate, and lacks papillae. The marginal zone is striated with relatively short striae of about 17-20 in 10 µm. The marginal fultoportulae are situated on every costa. Diameter of the valve 25-40 µm.

Ecological preference: Lindavia baicalensis is freshwater species dominated in in June or July after ice break up **(**Jewson et al., 2015)**.**

Occurrence: Recorded rare in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Lindavia bodanica* (Eulenstein ex Grunow) Nakov et al. 2015**

(Pl. 18: 1-14)

Ref. Kling & Håkansson 1988, p. 60, figs. 3-6, 8, 56, 59, 61; Krammer & Lange-Bertalot 1991 a, p. 54, pl. 53, figs. 1-6; pl. 54, figs. 1-4 b; pl. 55, figs. 1-7 b; pl. 56, figs. 3 a-5; pl. 57, figs. 1-5; pl. 58, figs. 1-6; pl. 61, figs. 1-5 b; Håkansson 2002, p. 119, figs. 441-454; Houk et al. 2010, p. 34, figs. 244-247; Kociolek & Khursevich 2012, p. 339; Genkal et al. 2013, p. 85, figs.1-5; Nakov et al. 2015, p. 254.

Status of name: accepted taxonomically

Synonyms: *Cyclotella bodanica* Eulenstein in Grunow 1878
Cyclotella comta var. *bodanica* Grunow in Van Heurck 1882
Cyclotella bodanica var. *intermedia* Manguin 1961
Puncticulata bodanica (Eulenstein ex Grunow) Håkansson 2002
Handmannia bodanica (Eulenstein ex Grunow) Kociolek & Khursevich 2012
Cyclotella intermedia (Manguin) Houk, Klee & Tanaka 2010

Diagnosis: Valves are circular with a concentrically undulate valve face and the central area is more or less convex or concave, sometimes nearly flat. The valve face is distinguished into two distinct parts, the areolate striae at the margin and a punctate central area. Valve face areolate with straight striae, about 10-14 in 10 µm. The central areolae cover about 2/3 of the valve face and are arranged in radiate rows. The alveolate striae are often bifurcate at the valve margin with irregular branching of the costae. These striae generally terminate evenly to form a distinct boundary to the central ornamentation. Marginal fultoportulae are located on each costa, 4 to 8 in 10 µm. Numerous central fultoportulae are arranged in rings. The rimoportulae lie in the middle of the marginal zone. Diameter of the valve 10-40 µm.

Remarks*:* Morphological characters of *Lindavia* bodanica largely coincide with those of *Lindavia* intermedia. Therefore, L. intermedia can be considered conspecific to L. bodanica. However, L. intermedia differs by a smaller number of striae in 10 µm and a more pronounced radial undulation of the central area (Genkal et al., 2013).

Ecological preference: The species is common in low conductivity lakes (<60 µS), oligo-mesotrophic, circumneutral lakes of Canada (Kling & Håkansson, 1988); oligotrophic, circumneutral to a slightly acidic lake (Köster et al., 2005); it is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH value 7.86 – 8.55, and surface water temperature 9.81 – 27.26 °C (Pérez et al., 2009); freshwater species typical for alpine and sub-alpine oligotrophic lakes (Genkal et al., 2013); freshwater, meso-oligotraphentic with pH value 7.69-8.11 (Witak et al., 2017).

Occurrence: Recorded common in the Eemian deposits of central Poland and frequent in the Młynek Lake sediments.

Distribution in Poland. It is reported from Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); from the Gulf of Gdansk, the southern Baltic Sea (Plinski & Witkowski, 2020).

***Lindavia fottii* (Hustedt) Nakov et al. 2015**

(Pl. 19, figs. 1-9)

Ref. Huber-Pestalozzi 1942, p. 400, fig. 492; Krammer & Lange-Bertalot 1991a, p. 49, pl. 47, fig. 3a; Nakov et al. 2015, p. 255.

Status of name: accepted taxonomically

Synonym: *Cyclotella fottii* Hustedt in Huber-Pestalozzi 1942

Diagnosis: Frustule is disc-shaped with a flat valve face. The central and marginal areas of the valve are distinguished. The central area is hyaline, small and its boundary more and less regular. The marginal area has distinct and strong costal ribs, regularly arranged, about 8-10 in 10 µm. Diameter of the valve 20-50 µm.

Ecological preference: This species is classified as typically pelagic and oligotrophic species. It shows major growth between 20-50 m water depth and dominant between 40-150 m depth in Lake Ohrid (Matzinger et al., 2006).

Occurrence: Recorded frequently in the Eemian deposits of central Poland and rare in the Młynek, Radomno, and Kamionka Lakes sediments.

Distribution in Poland: The Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016)

***Lindavia glomerata* (Bachmann) Adesalu & Julius 2017**

(Pl. 19, figs. 10-18)

Ref. Bachmann 1911, p. 131, figs106–108; Low 1975, p. 421, figs. 21, 24, 25; Kling & Håkansson 1988, p. 78, figs. 101, 104; Krammer & Lange-Bertalot 1991, fig. 49; Tuji & Williams 2006 b, pl. 1, figs.1–3, 5–17; pl. 2, figs.1-6; Adesalu & Julius 2017, p. 170.

Status of name: accepted taxonomically

Synonyms: *Cyclotella glomerata* Bachmann 1911

Discostella glomerata (Bachmann) Houk & Klee 2004

Diagnosis: Frustules are disc-shaped, small with a circular valve face, which is differentiated into a distinct central area and a striated marginal zone. The central area is small to moderate in size, convex or concave with a distinct one single, eccentrically placed fultoportula. The marginal striae fine, slightly unequal length, about 18- 20 in 10 µm. The marginal fultoportulae occur on every 3-4 ribs. One rimoportula is present on the valve mantle. Diameter of the valve 8–15 µm.

Ecological preference: The species was often observed worldwide as a planktonic eutrophic species (Krammer & Lange-Bertalot, 1991; Tuji & Houki, 2001; Houk & Klee, 2004), it is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009).

Occurrence: Recorded frequently in the Eemian deposits of central Poland and rare in the Młynek and Jeziorak Lakes sediments.

Distribution in Poland: The species was recognized from springs of Lódz Hills, Central Poland (Zelazna-Wieczorek, 2011); the Periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012).

Lindavia khinganensis **Rioual 2017**

(Pl. 20, figs. 5-6)

Ref. Rioula et al. 2017, p. 539, figs. 6-37

Status of name: accepted taxonomically

Diagnosis: Cells are disc-shaped with a circular valve face, which is flat or slightly concave or convex. Central area with distinct areolae, which are arranged in radiate striae, nearly equal length taking about 40-70% of the valve diameter, about 14-23 striae in 10 µm, each stria is composed of two coarse pores with small pores scattered between them. The interstiae are extremely narrow. Valve face with numerous central fultoportulae that are scattered or arranged in radial rows. Marginal ribs are regularly arranged, 10-14 in 10 µm Diameter of the valve 6-25 µm

Remarks: The morphology of Lindavia khinganensis is relatively similar to the morphology of Lindavia comta (Ehrenberg) Nakov et al., L. radiosa (Grunow) De Toni & Forti, L. praetermissa (Lund) Nakov et al., L. tenuistriata (Hustedt) Nakov et al., Handmannia glabriuscula (Grunow) Kociolek & Khursevich and Puncticulata balatonis (Pantocsek) Wojtal & Budzyńska. However, Lindavia comta, L. radiosa, and L. balatonis were considered synonyms (Krammer & Lange-Bertalot, 1991), and Genkal (2013) considered these taxa as one species with very variable valve morphology. Rioula et al. (2017) explained Puncticulata balatonis differs from Lindavia khinganensis by having a more concave/convex valve face, a higher density of marginal fultoportulae

Ecological preference: The species was observed in deep freshwater, oligotrophic, and it appears to be most abundant in autumn when summer thermal stratification breaks (Rioula et al., 2017).

Occurrence: Recorded frequently in the Eemian deposits of central Poland and rare in the Młynek and Radomno Lakes sediments.

Distribution in Poland: New Record.

Lindavia intermedia **(Manguin ex Kociolek & Reviers) Nakov et al. in Daniels et al. 2016** (Pl. 20, figs. 1-4)

Ref. Houk et al. 2010, p. 34, pls 244-247; Daniels et al. 2016, p. 1; Bahls et al. 2018, pl.56, fig. 7; pl. 77, fig. 5.

Status of name: accepted taxonomically

Synonyms: *Cyclotella bodanica* var. *intermedia* Manguin, 1961
Puncticulata bodanica (Grunow in Schneider), Håkansson 2002
Cyclotella intermedia (Manguin) Houk et al. 2010

Diagnosis: Frustules are drum-shaped. Valves are circular, concentrically slight undulate valve face, have a more or less convex or concave central area, sometimes nearly flat. The central area is ornamented or smooth; with radial rows of areolae. The center of the valve has a group of numerous areolae surrounded by a hyaline ring. Central fultoportulae 2-4 are arranged in rings in radial rows of areolae. The marginal area is striated with distinct ribs, striae are straight, about 10- 20 striae in 10 µm. Marginal ribs often branching dichotomously near the valve mantle. The external rimoportulae lying at the free ends of the striae. Marginal fultoportulae 3-8, are located on each interalveolar septum. Diameter of the valve 15-40 µm.

Ecological preference: The species was observed in a shallow oligotrophic lake and it reaches higher summer temperatures that can exceed 21°C; (Novis et al., 2020).

Occurrence: Recorded frequent in the Eemian deposits of central Poland, and Młynek Lake sediments, and rare in the Radomno Lake sediments.

Distribution in Poland: New Record.

Lindavia praetermissa **(Lund) Nakov et al. 2015**

(Pl. 20, figs. 7-18)

Ref. Lund 1951, p. 93, figs 1 A-H, 2 A-L; Håkansson 2002, p. 116, figs 422-426; Kiss et al. 2012, p. 341, Fig. 16. A-B; Bahls et al. 2018, p. 38, pl.1, figs. 12-13.

Status of name: accepted taxonomically
Synonyms: *Cyclotella praetermissa* Lund 1951
Puncticulata praetermissa (Lund) Håkansson 2002
Handmannia praetermissa (Lund) Kulikovskiy & Solak 2013

Diagnosis: Valves are circular, concentrically slight undulate valve face. The central area is ornamented with areolae and small valve face fultoportulae in a circular pattern. The areolae are not strictly radially arranged. The marginal area is striated with 12-20 striae in 10 µm and having two radial rows of areolae with small punctae between them and increase in number towards the valve margin. Interstriae are slightly unequal in length continue onto the valve mantle. The marginal fultoportulae are located on every fourth (3–6) interstria. One rimoportula is situated on the valve face at the end of a shortened stria. Diameter of the valve 10-30 µm.

Ecological preference: *Cyclotella praetermissa* can be characterized as a freshwater, probably mesohalobous species and can be found in several eutrophic or polluted lakes and rivers (Kiss et al., 2012); freshwater, oligotraphentic with pH:7.69-8.11(Witak et al., 2017).

Occurrence: Recorded frequently in the Eemian deposits of central Poland and Młynek Lake sediments.

Distribution in Poland: It is recorded from the sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Lindavia radiosa* (Grunow) De Toni and Forti 1900**

(Pl. 21, figs. 1-37)

Ref. Lowe 1975, p. 416, fig. 7; Håkansson 1986, fig. 42; Lee & Lee 1988, p. 135, fig. 1; Krammer & Lange-Bertalot 1991a, p. 57, pl. 62, figs. 1-6; Lange-Bertalot & Metzeltin 1996, p. 324, pl. 103, fig. 5; Håkansson 2002, p. 114, fig. 415-421; Wojtal & Kwandrans 2006, pl. 12, figs. 17–22; pl. 15, figs. 4–7; Bahls et al. 2018, pl. 56, figs. 1-3; pl. 109, figs. 1-2.

Status of name: accepted taxonomically
Synonyms: *Cyclotella comta* var. *radiosa* Grunow in Van Heurck 1882
Cyclotella radiosa (Grunow) Lemmermann 1892
Cyclotella comta (Ehrenberg) Kützing 1849
Cyclotella operculata var. *radiosa* Grunow 1878
Handmannia radiosa (Grunow) Kociolek & Khursevich 2002
Puncticulata radiosa (Grunow) Håkansson 2002

Diagnosis: Frustules are disc-shaped. Valves are circular with a concentrically undulated valve face. The central area is slightly concave or convex, characterized by radial rows of areolae, with external openings of central fultoportulae. Marginal area with striae of 3-4 punctate rows of areolae, about 13-16 striae in 10 µm, and interstriae continuing onto the mantle. Several interstriae bifurcate. Marginal fultoportulae openings situated internally on valve mantle, above every third to fourth rib or interstria. The rimoportulae are positioned radially or diagonally, situated on the valve face at the end of a shortened stria. Diameter of the valve 8-40 µm.

Ecological preference: Euplanktonic, alkaliphilous, brackish/freshwater species, eutraphentic, β-mesosaprobous, strictly aquatic species (Denys, 1991; Van Dam et al., 1994). Freshwater, planktonic, indifferent (halobity), alkalibiontic, o-β-mezosaprobic (Medvedeva et al., 2009); it is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009); it is considered to be tolerant and resistant to organic water pollution (Szczepocka & Szulc, 2009). Cyclotella radiosa is a pelagic species of lakes and lowland rivers; it prefers eutrophic conditions with higher conductivity and alkalinity but can also be found in mesotrophic waters. It has a medium frequency in Hungarian running waters with a 13% occurrence rate (Kiss et al., 2012); slightly polluted, of beta-mesosaprobic zones (Szczepocka et al., 2014); freshwater, eu-mesotraphentic with pH value 7.69 – 8.11(Witak et al., 2017); alkaliphilous, fresh-brackish water, nitrogen-autotrophic taxon, p-mesosaprobous, eutraphentic (Malinowska–Gniewosz et al., 2018).

Occurrence: Recorded common in the Eemian deposits of central Poland and Młynek Lake sediments, frequent in Radomno Lake, and rare in the Kamionka and Jeziorak Lakes sediments.

Distribution in Poland: It is reported from the Vistula and Rudawa Rivers (Kawecka & Kwandrans, 2000); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); dominated in the Pilica River- Central Poland (Szczepocka & Szulc, 2009); from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); Low-pH Lake Piaski in Western Pomerania, north-west Poland (Witkowski et al., 2011); found in Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); dominant the Hańcza and Szurpiły lakes in the Suwalki Landscape Park, North East Poland (Jekatierynczuk-Rudczyk et al., 2012); Duszatyńskie Lakes, south eastern Poland (Noga et al., 2013); the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); abundant in the lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); the Linda River central Poland (Szczepocka et al., 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); the industrial water biotopes of Trzuskawica S.A. in the southern Poland (Malinowska–Gniewosz et al., 2018); Holocene sediments of Lake Suchar IV in the area of Wigry National Park in the range of the Pomeranian Phase north-east Poland (Zawisza et al., 2019).

Genus *Pantocsekiella* Kiss & Ács 2016

Diagnosis: Frustules are disc-shaped. Valves are circular or slightly quadrangular, the valve face is divided into a polygonal central area and a striated marginal one. The central area is more or less flat or radially undulate or slightly tangentially undulated. The undulated forms with a pattern of three or more small or large alternating lacunae with or without papillae. The central area can be relatively small or large, not depending on the diameter. The marginal area is structured by alveolate striae externally, separated by hyaline strips, striae are straight, unequal in length and a few of them are bifurcated. Costae are usually equal in length but those bearing a fultoportula are often shorter. The valve has one or a few rimoportulae situated in the submarginal zone underneath the costae.

Holotype species Pantocsekiella ocellata (Pantocsek) Kiss & Ács 2016

***Pantocsekiella comensis* (Grunow) Kiss & Ács in Ács et al. 2016**

(Pl. 22, figs. 1-38)

Ref. Hustedt 1930, p. 353, fig. 182; Krammer & Lange-Bertalot 1991 a, p. 53, pl. 52, figs. 11-2, 4-6, 7-9; Lange-Bertalot & Metzeltin 1996, p. 272, pl. 77, figs. 6-9; pl. 103, figs. 6-7; Hausmann & Lotter 2001, p. 1327, fig. 2; Håkansson 2002, p. 97, figs. 349-351; Kistenich et al. 2014, figs.2-11, 92-93; Kociolek et al. 2014, p. 14, pl. 10, figs. 9-16.

Status of name: accepted taxonomically

Synonyms: *Cyclotella comensis* Grunow in Van Heurck 1882
Cyclotella melosiroides Grunow in Van Heurck 1882
Cyclotella indistincta Kociolek et al. 2014
Lindavia comensis (Grunow) Nakov et al. 2015
Pantocsekiella comensis (Grunow) Kiss & E.Ács in Ács *et al.* 2016

Diagnosis: Valves are disc-shaped with a slight tangentially undulate valve face. The valve face is ornamented by an irregular or star-like shape. The striae often of unequal lengths, about 16-22 in 10 µm, are composed of two rows of fine areolae with a row of small pores present between the larger areolae. A single central fultoportula is present on the depressed half of the valve face. The rimoportula is located at the end of a shortened stria. Marginal fultoportulae occur on the mantle between every 3rd to 4th striae. No spines are present. Diameter of the valve 4-15µm.

Ecological preference: Abundant in circumneutral-alkaline (pH > 8.2, Alk >80 mg/l) and oligo-mesotrophic lakes (Werner & Smol, 2006); fresh water, planktonic, indifferent (halobity), indifferent (pH), o-β-mezosaprobic (Medvedeva et al., 2009).

Occurrence: Recorded common in the Eemian deposits of central Poland, frequent in Młynek Lake sediments, and rare in Radomno Lake sediments.

Distribution in Poland: It is reported from the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al. 2009); Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al. 2015); Holocene sediments of Lake Suchar IV in the area of Wigry National Park in the range of the Pomeranian Phase north-east Poland (Zawisza et al. 2019); from the Gulf of Gdansk, the southern Baltic Sea (Plinski & Witkowski, 2020).

Pantocsekiella costei **(Druart & Straub) Kiss & Ács in Ács et al. 2016**

(Pl. 23, figs. 1-5**)**

Ref. Druart & Straub 1988, p. 183, figs 7-13; Ács et al. 2016, p. 66

Status of name: accepted taxonomically

Synonyms: *Cyclotella costei* Druart & Straub 1988
Lindavia costei (Druart & Straub) Nakov et al. 2015
Cyclotella comta var. *unipunctata* Fricke in Schmidt 1990
Cyclotella operculata var. *unipunctata* Hustedt 1922b
Cyclotella cyclopuncta Håkansson et J.R. Carter 1990

Diagnosis: Frustule are disc-shaped with circular valve face, which is differentiated into a distinct central area and a striated marginal zone. The central area is mostly smooth, sometimes with shallow radial furrows or lines, and it has one single, eccentrically fultoportula. The marginal striae are of nearly equal lengths, about 18- 20 in 10 µm. Diameter of the valve 8–15 µm**.**

Remarks: Pantocsekiella costei is closely related and probably conspecific with Pantocsekiella comensis and Pantocsekiella pseudocomensis (Kistenich et al., 2014). However, Håkansson & Carter (1990) described Cyclotella cyclopuncta from Plitvice Lakes, but later taxonomic analyses of Houk et al. (2010) showed that both species share the same morphological features, and thus, Cyclotella cyclopuncta was considered a synonym Pantocsekiella costei.

Ecological preference: Pantocsekiella costei was originally described as Cyclotella costei by Druart & Straub (1988) from a small alkaline, eutrophic lake Paladru (France), it is reported from littoral and pelagic habitats from alkaline, oligo- to mesotrophic lakes (Houk et al., 2010).

Occurrence: Recorded frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

Pantocsekiella delicatula **(Hustedt) Kiss & Ács in Ács et al. 2016**

(Pl. 24, figs. 1-32)

Ref. Hustedt 1952, p. 376, figs 34-36; Wojtal & Kwandrans 2006, pl. 7, figs. 14–19; pl.8, figs. 1–7; Kiss et al. 2007, p. 294, figs. 20-55; Kiss et al. 2012, p. 333, figs. 12 D-F; Nakov et al. 2015, p. 255; Ács et al. 2016, p. 66.

Status of name: accepted taxonomically

Synonyms: *Cyclotella delicatula* Hustedt 1952
Lindavia delicatula (Hustedt) Nakov et al. 2015

Diagnosis: Valves are circular and often colliculate. The central part of the valve face is flat, smooth, and slightly domed towards the mantle and decorated with only the opening of the valve face fultoportula or with a round to irregular small hollows. Striae are the same length except where the rimoportula is inserted, about 16–18 in 10 µm. A single, central fultoportula is located in the central area surrounded by two satellite pores. Marginal fultoportulae are situated at every fifth costa. The rimoportula is located at the central end of a shortened stria. Alveolate striae extend 1/3 of the radius from the valve margin, about 16-20 in 10 µm. Diameter of the valve 4-11 µm.

Ecological preference: Abundant in calcium-rich eutrophic waters may suggest the ecological requirements of this taxon. The species has been recorded from mesotrophic lakes and rivers with connection to lakes (Kiss et al., 2012); it is typically found in conditions of low total phosphorus and low chloride, and its presence is indicative of pristine conditions (Reavie & Kireta, 2015).

Occurrence: Recorded common in the Eemian deposits of central Poland, frequent in the Młynek Lake sediments, and rare in the Radomno and Jeziorak Lakes sediments.

Distribution in Poland: Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009).

Pantocsekiella hinziae **(Houk, König & Klee) Kiss et al. 2016**

(Pl. 23, figs. 6-17)

Ref. Houk et al. 2015, p. 236, figs. 1-6, 19-37

Status of name: accepted taxonomically

Synonym: *Cyclotella hinziae* Houk, König & Klee 2015

Diagnosis: Cells are short cylindrical with circular valves. The central area is smooth, flat to slightly transversally undulate, often with ill-defined stellate pattern consisting of radially arranged ghost striae and one coarser punctum near the valve center. One central fultoportula is present. Valve margin with the radially arranged striae of nearly equal lengths, about 18–23 striae in 10 µm. The marginal fultoportulae are situated on costae and hardly distinguishable in LM. A single rimoportula is located on a costa in the marginal part. Diameter of the valve 6–12 µm.

Ecological preference: Freshwater species (Houk et al., 2015)

Occurrence: Recorded frequently in the Eemian deposits of central Poland**.**

Distribution in Poland: New record.

Pantocsekiella iranica **(Nejadsattari et al.) Kiss et al. 2016**

(Pl. 25, figs. 1-6)

Ref. Kheiri et al., 2013, p. 37, figs. 2-14; Kheiri et al., 2018, p. 359, Figs 2–3

Status of name: accepted taxonomically

Synonyms: *Cyclotella iranica* Nejadsattari et al., in Kheiri et al., 2013

Lindavia iranica (Nejadsattari, Kheiri, Spaulding & Edlund) Nakov et al. 2015

Diagnosis: Frustules are cylindrical with valves disc-shaped. Valve face ornamented with two distinct parts: a hyaline smooth, flat central area, roughly 1/4–1/7 of total valve diameter, and a marginal striated region. Striae vary in length, extending to mantle, about 18–23 in 10 µm. Central fultoportulae 1–3, arranged randomly, mostly at a proximal end of shorter striae. Mantle fultoportulae are located every 3-6 costae. One rimoportula is located on a costa, in larger valves within striae, in smaller valves near valve face-mantle junction. Diameter of the valve 14 – 20 µm

Remarks: *Pantocsekiella iranica* is most similar to *P. delicatula* (Scheffler et al., 2003, Houk et al., 2010) by having an irregular central area with a similar valve diameter size range. However, the central area in *P. delicatula* is more or less transversally undulate and colliculate with pori or hollows. In contrast, *P. iranica* has a flat central area without colliculae,

Ecological preference: Cyclotella iranica is found in epipelic and epilithic collections from alkaline rivers, and that it is tolerant of nutrient and organic enrichment as evidenced from the low dissolved oxygen and high BOD and COD of the type locality **(**Kheiri et al., 2013)**;** epilithic in the freshwater river with low conductivity and pH 6.2-8.5, (Kheiri et al., 2018).

Occurrence: Recorded infrequently in the Eemian deposits of central Poland**.**

Distribution in Poland: New record.

Pantocsekiella kuetzingiana **(Thwaites) Kiss & Ács 2016**

(Pl. 25, figs. 7-12)

Ref. Håkansson 1990, p. 263, figs 3-10, 35-41; Krammer & Lange-Bertalot 1991a, p.44, pl. 65, figs. 4-6.

Status of name: accepted taxonomically

Synonyms: *Cyclotella kuetzingiana* Thwaites 1848

Cyclotella krammeri Håkansson 1990

Diagnosis: Cells are cylindrical with a circular valve face, which is differentiated into two distinct zones; marginal radial striae, short or moderately long, arranged regularly, about 13-16 striae in 10 µm. Striae are crossed by a sub-marginal shadow line. The central area is circular, ornamented by several scattered pores, about 8-13. The relative diameter of the central field, which varies with the size of the specimen, is about half the cell diameter. Diameter of the valve 19-26 µm.

Remarks: C. krammeri, is proposed for the taxon that has long been called C. kuetzingiana (Håkansson, 1990)

Ecological preference: Freshwater species, was considered unambiguous evidence for cultural acidification due to long-term atmospheric deposition of mineral acidity (Battarbee, 1984); it is recorded associated with cultural catchment disturbance in the late Holocene that caused cultural alkalization of surface water (Renberg et al., 1993).

Occurrence: Recorded infrequently in the Eemian deposits of central Poland**;** frequently in the Holocene sediments of Młynek and Kamionka Lakes.

Distribution in Poland: It is recorded as Cyclotella kuetzingiana from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015).

Pantocsekiella ocellata **(Pantocsek) Kiss & Ács 2016**

(Pl. 26, figs. 1-31; pl. 27, figs. 1-33; pl. 28, figs. 1-26)

Ref. as Cyclotella ocellata Pantocsek 1901; Pantocsek 1912, p. 104, pl. l5, fig. 318; Hustedt 1930, p. 340, fig. 173; Schrader 1974, p. 861, pl. 14, fig. 7; Foged 1981, p. 64, pl. 2, fig. 9; Germain 1981, p. 34, pl. 8, figs. 8-13; Gasse 1986, p. 37, pl. 3, fig. 11; Håkansson 1990, p. 266, figs. 11-17, 42-44; Krammer & Lange-Bertalot 1991 a, p. 51, pl. 50, figs. 1–11, 13, 14; pl. 51, figs. 1–5; Ehrlich 1995, p. 35, pl. 2, figs. 11-13; Håkansson 2002, p. 85, figs 309–318; Kheiri et al., 2018, p.365, figs. 4, 5.

Status of name: accepted taxonomically

Synonyms: *Cyclotella ocellata* Pantocsek 1901
Cyclotella crucigera Pantocsek 1901
Cyclotella kuetzingiana var. *planetophora* Fricke 1900
Cyclotella tibetana Hustedt 1922
Lindavia ocellata (Pantocsek) Nakov et al. 2015

Diagnosis: Frustules are discoid, with circular valves of the nearly flat valve face. The central area is covering 1/3-2/3 of the valve face, rounded or pentagonal in shape; it is ornamented by 3-5 distinct papillae and corresponding depressions with other fine punctae scattered between them. The marginal area is striated by fine radial striae, regularly arranged, about 14-17 in 10 µm. Diameter of the valve 6-25 µm.

Ecological preference: Littoral freshwater form, tolerant to salinity 0.0-0.5 g/l (Hustedt, 1930, 1957); eutrophic, alkalibiontic, with pH value over 7, and optimum pH 8.4 – 8.8 (Cholnoky, 1968); it appears to occupy the extreme oligotrophic end of the spectrum in Great Lakes, (Stoermer & Yang, 1970); oligohalobous "indifferent", pH circumneutral (Foged, 1980); it is recorded from concentrated alkaline waters, where its best development occurred in lakes having a pH of 9.5-10.3 (Gasse, 1986); Euplanktonic, oligosaprobous, alkaliphilous and meso-eutraphentic freshwater species (Denys, 1991; Hakansson, 1993; Van Dam et al*.,* 1994); Freshwater, planktonic and benthic, indifferent (halobity), indifferent (pH), o-saprobic (Medvedeva et al., 2009). The species seems to be common in many fresh and brackish water habitats of low to medium conductivity and medium alkalinity with a pH ranges between 7.5-8.5 (Zalat & Servant-Vildary, 2005); freshwater, mesotraphentic and meso-oligotraphentic with pH:7.69-8.11 (Witak et al., 2017).

Occurrence: Recorded common in the Eemian deposits of central Poland**;** the Holocene sediments of Młynek and Radomno Lakes.

Distribution in Poland: This species is reported frequently in Poland (Rakowska, 1996 a, b; Siemińska & Wołowski, 2003); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al. 2009); Low-pH Lake Piaski in Western Pomerania- north-west Poland (Witkowski et al., 2011); Swibno-Vistula River estuary in Northern Poland (Majewska et al., 2012); the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); the sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019); Holocene sediments of Lake Suchar IV in the area of Wigry National Park in the range of the Pomeranian Phase north-east Poland (Zawisza et al., 2019).

Pantocsekiella paraocellata **(Cvetkoska et al.) Kiss & Ács in Ács et al., 2016**

(Pl. 29, figs. 1-28)

Ref. Cvetkoska et al. 2014, p. 317, figs 1-23, 30-45; Ács et al., 2016, p. 68.

Status of name: accepted taxonomically

Synonyms: *Cyclotella paraocellata* Cvetkoska, Hamilton, Ognjanova-Rumenova & Levkov 2014
Lindavia paraocellata (Cvetkoska, Hamilton, Ognjanova-Rumenova & Levkov) Nakov et al. 2015

Diagnosis: Valves are circular or rectangular, with more or less flat valve face. Central area covered with knots (colliculate), with three orbicular depressions and corresponding papillae in a triangular position. The central area is surrounded by marginal striae of unequal length; about 15–18 striae in 10 µm. Valve face fultoportulae about 3–5 near orbicular depressions. Openings of marginal fultoportulae near valve face/mantle junction, on each 3–5 recessed costae. Three rimoportulae on costae at valve margin. Diameter of the valve 9–34 µm.

Remarks: This taxon is distinguished from Pantocsekiella ocellata by the larger valve size range, number and position of fultoportulae and rimoportulae, number of satellite pores surrounding valve face fultoportulae, and the colliculate central area (Cvetkoska et al., 2014).

Ecological preference: Fresh water taxon and may have the same ecological characters as Pantocsekiella ocellata.

Occurrence: Recorded frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Pantocsekiella paleo-ocellata* (Vossel & Van de Vijver) Kiss, Ector & Ács, 2016**

(Pl. 29, figs. 29-31)

Ref. Vossel et al. 2015**,** p. 65, figs. 2–18, 20–34

Status of name: accepted taxonomically

Synonyms: *Cyclotella paleo–ocellata* Vossel & Van de VijVer in Vossel et al., 2015
Lindavia paleo-ocellata (Vossel & Van de Vijver) Nakov et al. 2015

Diagnosis: Valves are circular, with a nearly flat surface. The central area is colliculate and clearly distinguished from the marginal area. Orbicular depressions of about 4-8 arranged concentrically in the central area presenting occasionally a star-shaped pattern. Papillae present in between the depressions, in number always equal to the number of orbicular depressions. Central fultoportulae are present, about 2–8 near the orbicular depressions. Rimoportulae present near the marginal striae. Marginal fultoportulae located on 1–2 costae. Marginal striae of about 12– 20 in 10 µm, almost equal in length. Valve diameter 15–28µm.

Ecological preference: Pantocsekiella paleo-ocellata is often abundant where Pantocsekiella ocellata is dominating the diatom flora. This taxon is developed in an oligotrophic phase of lake development and has a low tolerance of nutrient enrichment (Vossel et al., 2015).

Occurrence: Recorded frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Pantocsekiella polymorpha* (Meyer & Håkansson) Kiss & Ács in Ács et al. 2016**

Ref. Meyer & Håkansson 1996, p. 64, figs 1-7, 9-29; Nakov et al., 2015, p. 257; Ács et al. 2016, p. 68

Status of name: accepted taxonomically

Synonyms: *Cyclotella polymorpha* Meyer & Håkansson 1996
Lindavia polymorpha (Meyer & Håkansson) Nakov et al. 2015

Diagnosis: Frustules are cylindrical with circular valves of a nearly flat surface and several radial rows of puncta. The central area is colliculate and the marginal area is striated. Striae of nearly equal lengths, about 15–20 in 10 µm. Valve face fultoportulae are situated eccentrically near the center. Marginal fultoportulae are located on every, slightly depressed, 4–5 costae, externally with a simple opening. Diameter of the valve 8–30 µm.

Remarks: *C. polymorpha* has good similarity to *C. ocellata*, *C. kuetzingiana* var. *planetophora,* and *C. kuetzingiana* var. *radiosa.* Meyer & Håkansson (1996) established that *C. polymorpha* is heterovalvate, when valves of one frustule could be considered as either *C. kuetzingiana* var. *radiosa* or *C. kuetzingiana* var. *planetophora*.

Ecological preference: Freshwater, planktonic in eutrophic lakes and eutrophic rivers (Meyer & Håkansson, 1996); freshwater, oligotraphentic with pH:7.69-8.11(Witak et al., 2017).

Occurrence: Recorded infrequently in the Holocene sediments of Radomno and Młynek Lakes.

Distribution in Poland: It is reported from the sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Pantocsekiella pseudocomensis* (Scheffler) Kiss & Ács in Ács et al. 2016**

Ref. Scheffler 1994, p. 356, figs 1-31; Nakov et al. 2015, p. 257; Olszynski et al. 2019, p. 23, Figs. 5RRR–5XXX

Status of name: accepted taxonomically

Synonyms: *Cyclotella pseudocomensis* Scheffler 1994
Lindavia pseudocomensis (Scheffler) Nakov et al. 2015

Diagnosis: Frustules are short cylindrical with circular shaped, slight tangentially undulate valve face, which is decorated by scattered punctae. The marginal striae are radiate, often of unequal lengths, about 18-22 in 10 µm. A central fultoportula is present on the depressed half of the valve face. The rimoportula is located at the end of a shortened stria. Marginal fultoportulae occur on the mantle between every 3rd to 5th striae. Diameter of the valve 5-12 µm.

Remarks: Scheffler & Morabito (2003) considered C. pseudocomensis a synonym of C. comensis. Later, Scheffler et al. (2005) concluded that C. comensis was a dimorphic species, comprising the highly variable morph comensis and the morph minima, which shows slight variability in the shape and structure of the central area.

Although Scheffler (1994) established C. pseudocomensis as a new species distinct from C. comensis, later Scheffler & Morabito (2003) and Scheffler et al. (2005) transferred it to C. comensis.

Ecological preference: This species may have the same ecological preference of the *Pantocsekiella comensis*, it occurs in oligotrophic/mesotrophic to moderate eutrophic lakes (Houk et al. 2010, Olszyński et al. 2019).

Occurrence: Recorded infrequently in the Holocene sediments of Radomno Lake.

Distribution in Poland: The species was reported from post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al. 2019)

***Pantocsekiella rossii* (Håkansson) Kiss & Ács 2016**

(Pl. 30, figs. 1-3)

Ref. Håkansson 1990, p. 266-267, figs. 18-27, 46-49; Krammer & Lange-Bertalot 1991 a, p. 60, pl. 64, figs. 1-8; Metzeltin & Witkowski 1996, p. 34, pl. 1, fig. 9; Håkansson 2002, p. 94, figs. 346-348; Genkal & Chekryzheva 2016, p. 409, figs. 1-26, 29, 30; Kheiri et al., 2018; p.365, fig. 6.

Status of name: accepted taxonomically

Synonyms: *Cyclotella comta* var. *oligactis* (Ehrenberg) Grunow in Van Heurck 1882
Cyclotella oligactis (Ehrenberg) Ralfs in Pritchard 1861
Cyclotella rossii Håkansson, 1990
Lindavia rossii (Håkansson) Nakov et al. 2015

Diagnosis: Frustules are cylindrical with circular valve face. The central area is nearly flat, with several radial rows of puncta of unequal size or randomly distributed. Valve face fultoportulae are situated eccentrically near the center or in the shape of a ring, with a small, simple external opening. Striae of nearly equal lengths, about 12–25 striae in 10 µm. Marginal fultoportulae are situated on every 2–8 costae. A single rimoportula is situated in the marginal area close to the valve central part or close to the alveoli. Diameter of the valve 5–31 µm.

Ecological preference: It is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009); fresh water, planktonic, o-β-mezosaprobic (Medvedeva et al., 2009); it is encountered in waterbodies of different types (lakes, water reservoirs, rivers) and across different trophic states, from oligotrophic to eutrophic waterbodies and water streams of Europe, preferring oligotrophic lakes (Genkal & Chekryzheva, 2016); freshwater river with low conductivity and pH 6.2-8.5, (Kheiri et al., 2018).

Occurrence: Recorded frequently in the Eemian deposits of central Poland.

Distribution in Poland: It is reported as Cyclotella rossii from the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009).

Genus *Puncticulata* Håkansson 2002

Diagnosis: Frustules discoid with a circular outline. The central area is clearly distinguished from the marginal zone. The central area is concentrically slightly elevated, with several scattered openings of valve face fultoportulae. Striae are of unequal length forming an irregularly circular central area, about 15–18 in 10 µm. External openings of the rimoportulae are present at the end of the shortened striae, Marginal fultoportula openings, with two satellite pores, are situated internally on the thickened costae, separated by 3–5 thinner costae. Valve face fultoportula openings are internally covered with domed cribra and surrounded by three satellite pores. The diameter of the valve ranges between 9 and 40 µm.

Holotype species *Puncticulata comta* (Kützing) Håkansson 2002

***Puncticulata balatonis* (Pantocsek) Wojtal & Budzyńska 2011**

(Pl. 30, figs. 4-19)

Ref. Budzyńska & Wojtal 2011, figs. 1–12, 15–22; Olszyński & Żelazna-Wieczorek 2018, p. 174, figs. 226-250.

Status of name: alternate representation

Synonyms: *Cyclotella balatonis* Pantocsek 1901
Handmannia balatonis (Pantocsek) Kulikovskiy & Solak 2013
Lindavia balatonis (Pantocsek) Nakov et al., 2015

Diagnosis: Frustules are disc-shaped. Valves are circular with a concentrically undulated valve face. The central area is slightly elevated, with numerous scattered openings of valve face fultoportulae and ornamented by radiate unequal length striae of about 15-20 in 10 µm and forming an irregularly circular central area. The marginal area is striated with thickened ribs, about 3-5 in 10 µm. Interstriae 14–17 in10 µm having two radial rows of areolae with tiny punctae between them and increase in number towards the valve margin. The rimoportulae are present at the end of the shortened striae. Diameter of the valve 12 – 25 µm.

Remarks: This species is confused with Lindavia khinganensis Rioual 2017, L. praetermissa (Lund) Nakov et al., L. tenuistriata (Hustedt) Nakov et al., L. radiosa (Grunow) De Toni & Forti, and Handmannia glabriuscula (Grunow) Kociolek & Khursevich.

Ecological preference: The species is widely distributed in mesotrophic to eutrophic, alkaline European lakes and rivers in small and shallow, urban, eutrophic to hypereutrophic. It occurs mainly in pelagic or littoral zones of mesotrophic to eutrophic lakes, reservoirs, or slow-running water ecosystems (Houk et al., 2010; Solak & Kulikovskiy, 2013). Its abundance in the lake was also higher in the winter-spring period (Budzyńska & Wojtal, 2011).

Occurrence: Recorded common in the Holocene sediments of Jeziorak, Radomno, Kamionka and Młynek Lakes; frequently in the Eemian deposits of central Poland.

Distribution in Poland: Dominant in Rusałka Lake, in the city of Poznań, Western Poland (Budzyńska & Wojtal, 2011); from shallow reservoirs created by flooding an open-pit iron ore mine in Łęczyca (Łódź Province, Central Poland) (Olszyński & Żelazna-Wieczorek, 2018).

Genus *Stephanocyclus* Skabichevskij 1975

Diagnosis: Frustules are cylindrical with circular, more or less tangential undulating valve face. Valves are distinguished by an outer, distinct striated marginal area and slightly tangentially undulate, smooth, or somewhat slight ornamented central area. The valves have structurally different marginal and central areas that are characteristic of *Cyclotella* but lack the two-layered wall that characteristic of *Cyclotella sensu stricto*, and marginal chambers that are characteristic of *Cyclostephanos.*

Holotype species Stephanocyclus planus Skabichevskij 1975

***Stephanocyclus meneghiniana* (Kützing) Skabichevskii 1975**

(Pl. 31, figs. 1-13)

Ref. Hustedt 1930, p. 341, fig. 174; Cleve-Euler 1932, p.12, fig. 10; Lowe 1975, p. 416, fig. 3; Gerloff & Natour 1982, p. 160, pl. 1, figs. 1-4; Gasse 1986, p. 36, pl. 3, fig. 9; Krammer & Lange-Bertalot 1991a, p. 44, pl. 44, figs. 1–10; Ehrlich 1995, p. 34, pl. 2, figs. 1-4; pl. 3, figs. 1-6; Hakansson 2002, p. 79, figs 263–268; Wojtal & Kwandrans 2006, p. 186, pl 4, figs. 18–21; pl. 7, figs. 1–13; pl. 9, figs. 1–8; pl. 10, figs. 1–5; Wojtal 2009, p. 176, pl. 1, figs. 14, 15; pl. 49, figs. 4–6; Houk et al., 2010, p. 16, pl. 143, figs 1-15; pl. 144, figs 1-6; pl. 145, figs 1-6; pl. 146, figs 1-6; pl. 147, figs 1-6.

Status of name: alternate representation

Synonyms: *Surirella melosiroides* Meneghini 1844
Cyclotella kuetzingiana var. *meneghiniana* (Kützing) Brun 1880
Cyclotella meneghiniana var. *binotata* Grunow in Van Heurck 1882
Cyclotella meneghiniana Kützing 1844
Cyclotella meneghiniana var. *rectangulata* Cleve-Euler 1932

Diagnosis: Frustules are cylindrical in girdle view, circular in valve face with more or less tangential undulating valve. The valve face is divided into two distinct zones; an outer, marginal zone which is radially striated, and smooth slightly tangentially undulate central area. The marginal striae density is 7-10 in 10 µm. Fultoportulae are irregularly arranged along the marginal ring but are always associated with one costa. Valve face fultoportula is one to seven, internally surrounded by three satellite pores. Marginal fultoportulae are located on every interstria. A single rimoportula is located on the ring of marginal fultoportulae. Diameter of the valve 12-30 µm.

Ecological preference: A widespread littoral diatom, known from a broad spectrum of trophic states and conductivity (Krammer & Lange-Bertalot, 1991a; Hakansson, 2002); a tychoplanktonic diatom, alkaliphilous, α-meso- to polysaprobous, eutraphentic, strictly aquatic and brackish fresh taxon, indicator of poor water quality, aquatic and subaerophytic (Denys, 1991; Van Dam et al., 1994; Prygiel & Coste, 2000); the species has been found in varied habitats including brackish water, and both eutrophic and oligotrophic freshwater (Håkansson, 2002; Tanaka, 2007); it is reported abundant in shallow, warm alkaline, highly eutrophic and polluted, brackish waters (Zalat & Servant-Vildary, 2005, 2007), in oligotrophic to eutrophic environments, with a higher abundance in eutrophic waters (Silva et al., 2010; Bartozek et al., 2018); a common species in the littoral and pelagic zone of eutrophic stagnant waters or slowly running rivers (Houk et al., 2010); freshwater, eutraphentic with pH value 7.69 – 8.11 (Witak et al., 2017).

Occurrence: Recorded frequently in the Holocene sediments of Radomno, Kamionka, and Młynek Lakes; and infrequently in the Eemian deposits of central Poland.

Distribution in Poland: It is reported from Vistula River (Turoboyski, 1962; Pudo, 1977; Kawecka & Kwandrans, 2000); the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); the Pilica River (Kadłubowska, 1964a); springs of Kobylanka stream (Skalna, 1969), and the Będkowka (Kubik, 1970); Sanka streams (Hojda, 1971); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006); Lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); Kobylanka stream, south Poland (Wojtal, 2009). Dominated in the Bzura River- Central Poland (Szczepocka & Szulc, 2009), the Swibno- Vistula River estuary in Northern Poland (Majewska et al., 2012); Wisłok River, south Poland, Matysówka stream a right-bank tributary of Strug River, district of Tyczyn, Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013 b,d); the lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014). Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015); fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, and suburban Przyrwa stream of Wisłok River in the Rzeszów city in SE Poland (Noga et al., 2016); dominant in the upper part of the Ner River, central Poland (Szczepocka et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019); Holocene sediments of Lake Suchar IV in the area of Wigry National Park in the range of the Pomeranian Phase north-east Poland (Zawisza et al., 2019).

Genus *Stephanodiscus* Ehrenberg 1845

Diagnosis: Frustules are drum-shaped or discoid rarely cylindrical, with circular and almost flat to concentric undulating valves. Areolae on the valve face are radiating from the center to the margin, grouping into fascicles. Fasciculus striae start as uniseriate in the center to multiseriate towards the margin. A ring of spines and fultoportulae are located around the valve margin and one to several rimoportulae near the valve center. The useful characteristics for identification: the number of radial rows in a fascicle, the width of interfascicles costae, the size and number of the areolae on valve and mantle, the position of fultoportulae and rimoportulae, and the distance between spines and fultoportulae.

Holotype species: Stephanodiscus niagarae Ehrenberg 1845

***Stephanodiscus aegyptiacus* Ehrenberg 1854**

(Pl. 32, figs. 1-3)

Ref. Håkansson & Locker 1981, p. 122, figs. 23-29, 63-68; Håkansson & Meyer 1994, p. 68, figs. 38-43; Zalat 1991, p. 49, pl. 5, figs. 9; pl. 6, figs. 3, 4; Zalat 2015, p. 88, fig. 2:8.

Status of name: accepted taxonomically

Diagnosis: Frustules are circular in outline with strongly convex and concave valves. Valve surface areolate; areolae arranged regularly in radial striae forming fascicles. Each fascicle is composed of 3-4 rows of areolae at the margin of the valve face and uniseriate towards the center. Fascicles are separated by quite distinct hyaline interfascicles of about 5-6 per 10 µm. The valve face fultoportulae about 4-5, with two satellite pores. Mantle fultoportulae occur at the end of every, to every second interfascicle. The mantle is relatively high and areolate down to the opening of the fultoportulae. Valve diameter ranges between 12-45 µm.

Ecological preference: The species were observed as common in freshwater environments of low mineral content and low to medium alkalinity with pH ranges between 7.0-8.2 (Zalat & Servant-Vildary, 2005, 2007).

Occurrence: Infrequently distributed in the Eemian deposits of central Poland, and Holocene sediments of Radomno Lake.

Distribution in Poland: New record.

Stephanodiscus agassizensis **Håkansson & Kling 1989**

(Pl. 32, figs. 4-10)

Ref. Stephanodiscus agassizensis Håkansson & Kling 1989, p. 283-285, figs. 56-69; Genkal 1993, p. 46, figs. 1-34; Håkansson & Meyer 1994, p. 69, figs. 50-55; Zalat 2015, p.88, fig. 2:7.

Status of name: accepted taxonomically

Diagnosis: Frustules are discoid, with a strong concentric undulating valve face. The valve surface is distinctly perforated, areolae arranged in radial rows forming fascicles. Each fascicle begins uniseriate in the center increases to become 3-4 rows at the valve face/mantle junction. Valve face fultoportulae varies between 3-5, each with two satellite pores. The mantle fultoportulae, each with three satellite pores, are located at every second to the third interfascicle near or beneath the spines. One or two rimoportulae are represented at the end of each interfascicle in the ring of spines, transverse to the rows of areolae. The marginal spines are strong. The diameter of the valve ranges between 12-19 µm.

Remarks: This species resembles Stephanodiscus astraea var. intermedia Fricke, but the arrangement of the fultoportulae in the center of the convex valve and in the periphery or marginal area of the concave valve, and coarse areolae of the valve face are the characteristic features in this species.

Ecological preference: Planktonic, common in eutrophic waters, and also in slightly brackish water, it is observed commonly in association with Stephanodiscus rotula (Kützing) Hendey; in freshwater habitats of low conductivity and low alkalinity with pH ranges between 7.0-8.2, in unpolluted to slightly polluted waters (Zalat, 1991; Zalat & Servant-Vildary, 2005).

Occurrence: Frequently distributed in the Eemian deposits of central Poland, and Holocene sediments of Radomno and Młynek Lakes.

Distribution in Poland: New record.

Stephanodiscus alpinus **Hustedt in Huber-Pestalozzi 1942**

(Pl. 32, figs. 11-14)

Ref. Huber-Pestalozzi 1942, p. 412, fig. 508; Krammer & Lange-Bertalot, 1991 b, p. 70, pl. 72, figs. 3a-4; Genkal 1993, p. 50, figs. 35-46; Hickel & Håkansson 1993, p. 89-98, figs. 2-28; Metzeltin & Witkowski 1996, p. 34, pl. 1, fig. 6; Håkansson 2002, p.35, figs. 104-111; Wojtal & Kwandrans, 2006, pl. 16, figs. 23–24; pl. 19, figs. 20–24; Zalat 2015, p. 88, fig. 2:9.

Status of name: accepted taxonomically

Diagnosis: Frustules are discoid, with circular valves and strongly concentrically undulate central part. The radiate areolate fascicles begin as uniseriate in the center of the valve and increases gradually to 2-3 rows towards the valve face/valve mantle junction. Interfascicles, vary between 8-10 in 10 µm. The valve face fultoportulae are represented in the central area by one or two small openings. The mantle fultoportulae are located on every one or second interfascicle beneath the spine. Diameter of the valve 14-45 µm.

Ecological preference: The species is bound to low temperatures and found in the hypolinmion of lakes in the eastern Alps (Huber-Pestalozzi, 1942); it appears to tolerate slight nutrient enrichment (Stoermer & Yang, 1970); it is a winter species dominant in Lake Ontario (Stoermer et al., 1975); it prefers temperatures below 2 degrees Celcius (Stoermer & Ladewski, 1976); a cosmopolitan planktonic species (Krammer & Lange-Bertalot, 1991); Eutrophic-dystrophic species planktonic (Witkowski et al., 2004), common in eutrophic, oligosaprobic freshwaters, it observed in freshwater habitats of low conductivity, low temperature and low to medium alkalinity with pH range between 7.2 to 8.0 (Zalat & Servant-Vildary 2005); mesotrophic, cold freshwater with pH value 7.4-8.1 (Pasztaleniec & Lenard, 2008); planktonic, cold fresh water (Medvedeva et al., 2009).

Occurrence: Frequently occurrence in the Eemian deposits of central Poland, and Holocene sediments of Młynek Lake.

Distribution in Poland: The species is reported from the Wyżyna Krakowsko-Częstochowska upland and Kluczwoda stream (Nawrat, 1993); Zbiornik Puławski reservoir (Bucka & Wilk- Woźniak, 2002; Wilk-Woźniak & Ligęza, 2003); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Zalew Szczeciński lagoon (Bąk et al., 2006); springs and streams of the Wyżyna Krakowsko-Częstochowska upland (Wojtal & Kwandrans, 2006), common in mesotrophic Rogóźnó, Lake, Łęczna-Włodawa Lakeland, east central Poland (Pasztaleniec & Lenard, 2008); Gulf of Gdansk and surrounding waters, the southern Baltic Sea (Plinski & Witkowski, 2020).

***Stephanodiscus binatus* Håkansson & Kling 1990**

Ref. Håkansson & Kling 1990, p. 274, figs 1-8; Olszynski et al. 2019, p. 20, Figs. 5OO–5RR

Status of name: accepted taxonomically

Diagnosis: Frustules are discoid, with concentric undulating valve face. Valve surface with distinctive large areolae arranged in radial rows forming fascicles. The interfascicles are about 14-16 in 10 µm. The valve face fultoportulae varies between 4-6, each with two satellite pores. The mantle fultoportulae, each with three satellite pores, are located at every second to the third interfascicle below the spines. The rimoportulae are represented at the end of each interfascicle in the ring of spines. Valve diameter ranges between 7-10 µm.

Ecological preference: The species has been observed in various water ecosystems ranging from oligotrophic to eutrophic; however, all are characterized by elevated pH value (Håkansson & Kling 1990; Houk et al., 2014; Olszyński & Żelazna-Wieczorek, 2018). It is recorded also in the spring months, lowest in autumn, elevated abundance in December, its occurrence with the highest concentrations of Ca2+, Mg2+ and the highest pH >8, oligohalobous (Olszynski et al. 2019).

Distribution in Poland: It is reported from the post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019)

***Stephanodiscus hantzschii* Grunow in Cleve & Grunow 1880**

(Pl. 33, figs. 1-7)

Ref. Hustedt 1930, p. 370, fig. 194; Germain 1981, p. 40, pl. 9, figs. 9-17; pl. 155, fig. 3; Håkansson & Stoermer 1984, figs. 1-3, 8, 9-11; Gasse 1986, p. 169, pl. 4, fig. 16; Casper et al. 1987, p. 18, fig. 1; Krammer & Lange-Bertalot 1991a, p. 73, pl. 75, figs. 4–14; pl. 76, figs. 1-3; Kling 1992, p. 243, fig. 1; Ehrlich 1995, p. 36, pl. 3, fig. 11; Hakansson 2002, p. 39, figs. 112–119; Wojtal & Kwandrans 2006, pl. 18, figs. 3–8; pl. 19, figs. 1–9; Wojtal 2009, p. 308, pl. 2, figs. 1–3; Kiss et al. 2012, p. 346, fig. 19. A-B

Status of name: accepted taxonomically

Synonyms: *Stephanodiscus hantzschianus* Grunow (in van Heurck) 1881
Stephanodiscus pusillus (Grunow) Krieger 1927
Stephanodsicus zachariasii Brun 1894

Diagnosis: Frustules are disc-like, with small circular, nearly flat, or slightly convex valves. The valve surface is ornamented by distinct areolae, which are arranged in radial rows and grouped into fascicles that are separated by distinct interstriae. Each fascicle is uniseriate in the center and becomes bi- to triseriate towards the margin. The interfascicles are about 7-9 in 10 µm and terminated by a distinct marginal spine. No valve face fultoportulae are present and one rimoportula is located between spines. Valve diameter ranges between 9-25 µm.

Ecological preference: Freshwater form, alkaliphilous (Hustedt, 1957); its pH optimum is about 8.2 or above (Cholnoky, 1968); a cosmopolitan species (Krammer & Lange-Bertalot, 1991a); an alkalibiontic, euplanktonic, hypereutraphentic, α-mesosaprobous to polysaprobous and strictly aquatic, fresh brackish water species (Denys, 1991; Hakansson, 1993; Van Dam et al., 1994); freshwater, planktonic, indifferent (halobity), alkaliphilic, α-β-mezosaprobic (Medvedeva et al., 2009); it is considered to be tolerant and resistant to organic water pollution (Szczepocka & Szulc, 2009); planktonic, oligohalobous, alkalibiontic, eutraphenthic, polysaprobous (Witak & Jankowska, 2014); freshwater, eutraphentic with pH value 7.69-8.11 (Witak et al., 2017).

Occurrence: It is reported frequently in the Eemian deposits of central Poland, and Holocene sediments of Radomno, Kamionka, and Młynek Lakes.

Distribution in Poland: The species is reported from Vistula River (Starmach, 1938; Kawecka & Kwandrans, 2000); Sąspowka stream (Kądziołka, 1963); Pilica River (Kadłubowska, 1964b); from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); Springs and streams of the Wyżyna Krakowsko-Częstochowska upland, Będkowka stream (Kłonowska, 1986; Wojtal & Kwandrans, 2006); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); Dominated in the Bzura and Pilica Rivers- Central Poland (Szczepocka & Szulc, 2009); Kobylanka stream, south Poland, in mud samples from Karniowice and Zielona village (Wojtal, 2009); from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); from springs of Lódz Hills, Central Poland (Zelazna-Wieczorek, 2011); Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); stream a right-bank tributary of Strug River, district of Tyczyn, and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013 b, d); the sediments of Lake

Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); Holocene sediments from the SW Gulf of Gdańsk and the Vistula Lagoon, the southern Baltic Sea (Witak, 2013); abundant in the lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); dominant in the upper part of the Ner River, central Poland (Szczepocka et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019).

***Stephanodiscus medius* Håkansson 1986**

(Pl. 34, figs. 13-15)

Ref. Håkansson 1986, p. 32, figs 11-14; Krammer & Lange-Bertalot 1991, pl. 75, fig. 1a-3b.

Status of name: accepted taxonomically

Diagnosis: Frustule is small discoid, with concentric undulating valve face. The valve surface is distinctly perforated, areolae arranged in radial rows forming fascicles. Each fascicle begins with a single row of areolae in the center of the valve which increases gradually to become 3-4 rows at the valve face/mantle junction. Interfascicles are about 10 -12 in 10 µm. Valve face fultoportulae indistinct. Valve diameter ranges between 7-9 µm

Ecological preference: Mesotrophic, in cold freshwater with pH value 7-8.3 (Pasztaleniec & Lenard, 2008); planktonic, oligohalobous, eutraphenthic (Witak & Jankowska, 2014); freshwater, eu-mesotraphentic with pH:7.69-8.11 (Witak et al., 2017).

Occurrence: Frequently distributed in the Eemian deposits of central Poland.

Distribution in Poland: Recorded common in mesotrophic Piaseczno Lake, Łęczna-Włodawa Lakeland, east central Poland (Pasztaleniec & Lenard, 2008); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); abundant at Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); the sediments of Lake Skaliska northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); Holocene sediments from the SW Gulf of Gdańsk and the Vistula Lagoon, the southern Baltic Sea (Witak, 2013); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Stephanodiscus minutulus* (**Kützing**) Cleve & Möller 1882**

(Pl. 34, figs. 1-12)

Ref. Krammer & Lange-Bertalot 1991a, p. 71, pl. 74, figs. 1–7; Håkansson 2002, p. 44, figs 133–144; Wojtal & Kwandrans 2006, pl. 16, figs. 21–22; pl. 18, figs. 1–2; pl. 19, figs. 11–19; pl. 20, figs. 1–7; Wojtal 2009, p. 308, pl. 2 figs. 4–6; pl. 50, figs. 1, 3; Kiss et al. 2012, p. 348, figs. 20 A-C.

Status of name: accepted taxonomically

Synonyms: *Cyclotella minutula* Kutzing 1844
Discoplea minutula (Kützing) Trevisan 1848
Stephanodiscus astraea var. *minutulus* (Kützing) Grunow 1882
Cyclotella rotula var. *minutula* (Kützing) Ivanov 1901
Stephanodiscus niagarae var. *minutula* (Kützing) Okuno 1952
Stephanodiscus rotula var. minutulus (Kützing) Ross & Sims 1978
Stephanodiscus rugosus Siemińska & Chudybowa 1979
Stephanodiscus parvus Stoermer & Hakansson 1984

Diagnosis: Frustule is discoid, with concentric undulating valve face. The valve surface is distinctly perforated with areolae arranged in radial rows forming fascicles. Sometimes the areolae are disorganized in the center, rounded, and relatively coarse. The interfascicles are about 8 -10 in 10 µm. The number of valve face fultoportulae varies between 3-5, each with two satellite pores. They are located in the marginal area of the concave valve or in the center of the convex valve. The mantle fultoportulae, each with three satellite pores, are located at every second to the third interfascicle near or beneath the spines. One or two rimoportulae are represented at the end of each interfascicle in the ring of spines. Short, solid spines are situated on each interstria at the margin. Just below the spines. Valve diameter ranges between 12-19 µm.

Ecological preference: A cosmopolitan species, known from waters with elevated conductivity and eutraphentic (Krammer & Lange-Bertalot, 1991); Tychoplanktonic, mesosaprobic, and hypereutrophentic species (Denys, 1991; Van Dam et al., 1994); it is classified as alkaliphilous and alkalibiontic (Hakansson, 1993). Freshwater, planktonic, indifferent (halobity), alkaliphilic, o-β-mezosaprobic (Medvedeva et al., 2009); it has been recorded as frequent and abundant in rivers and shallow lakes with different trophic grades. It is a characteristic species in the River Danube during the cold period (Kiss et al., 2012); freshwater, eutraphentic with pH value 7.69-8.11 (Witak et al., 2017).

Occurrence: Frequently distributed in the Eemian deposits of central Poland, and Holocene sediments of Radomno and Młynek Lakes.

Distribution in Poland: The species is reported from the Wyżyna Krakowsko- Częstochowska Upland, Vistula River (Kawecka & Kwandrans, 2000); springs and streams of the Wyżyna Krakowsko-Częstochowska upland, spring of the Biała Przemsza River (Wojtal & Kwandrans, 2006); Lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); Kobylanka stream, south Poland, in samples with filamentous algae and mud from Karniowice and Zielona village (Wojtal, 2009); Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013d); the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al. 2017).

***Stephanodiscus neoastraea* Hakansson & Hickel 1986**

(Pl. 33, figs. 8-13)

Ref. Håkansson & Meyer 1994, p. 68, figs. 28-37; p. 81, figs 64-96; Krammer & Lange-Bertalot 1991a, p. 68-70, pl. 69, fig. 3; pl. 70, fig. 3; pl. 71, figs. 3 a- 5 b; Genkal 1993, p. 50, figs. 47-54; Håkansson 2002, p. 27, figs. 71-76; Wolf et al. 2002, p. 447, figs. 1-5; Genkal 2009, figs.1, 4-9; Kiss et al., 2012, p. 348, figs. 20 D-F; Kheiri et al., 2018; p.365, figs. 9–10.

Status of name: accepted taxonomically

Synonym: *Stephanodiscus heterostylus* Håkansson & Meyer 1994

Diagnosis: Frustules are discoid, with concentric undulating circular valves. The areolae on the valve face are distinct and arranged in radial striae forming fascicles. These fascicles are biseriate to triseriate at the edge of the valve face and uniseriate towards the center. Fascicles appear as a slight depression in the "intercostal" valve face. The interfascicles are domed solid areas of hyaline silica, known as costae, about 7-10 interfascicles in 10 µm. Relatively long spines are represented at the outer end of each interfascicle. There is no valve face fultoportulae. The marginal fultoportulae are found at the end of every second to the third interfascicle, near or beneath a spine. Marginal fultoportulae have 3, rarely 4, satellite pores. Diameter of the valve 25-55 µm.

Remarks: The characteristic feature of this species is the absence of valve face fultoportulae. Under LM, the species appears similar to S. rotula. According to Håkansson & Meyer (1994), one to several rimoportulae may be represented on the concave valve lower than the ring of spines between interfascicles, and on the convex valve at the end of an interfascicle in the ring of spines. Casper & Klee (1992) made a clear differentiation of S. rotula and S. neoastraea based on the valve face fultoportula arrangement.

Ecological preference: Planktonic, common in eutrophic freshwaters, it is recorded associated with Stephanodiscus rotula (Kützing) Hendey. The species was observed in freshwater habitats of low conductivity and low alkalinity with pH ranges between 7.3 – 8.0, in unpolluted to slightly polluted waters (Zalat & Servant-Vildary, 2005); freshwater-brackish water, widespread planktonic species, present in spring-autumn at water temperatures of 10–24 °C, salinity up to 7.5‰, and pH 7.6–8.2 (Genkal, 2009). The species can be found in eutrophic lakes and lowland rivers, but it has also been found in the oligotrophic Lake (Kiss et al., 2012); planktonic, oligohalobous, alkalibiontic, eutraphenthic, β-mesosaprobous (Witak & Jankowska, 2014); freshwater, eutraphentic with pH:7.69-8.11 (Witak et al., 2017).

Occurrence: Frequently distributed in the Eemian deposits of central Poland, and Holocene sediments of Radomno and Młynek lakes.

Distribution in Poland: It is reported from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); Holocene sediments from the

SW Gulf of Gdańsk and the Vistula Lagoon, the southern Baltic Sea (Witak, 2013); Holocene sediment of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Stephanodiscus niagarae* Ehrenberg 1845**

(Pl. 35, figs. 1-7)

Ref. Hustedt, 1942, p. 44, fig. 509; Schrader 1978, p. 863, pl. 5, fig. 1; pl. 6, fig. 5; pl. 7, fig. 10; pl. 8, fig. 1; pl. 16, fig. 1; pl. 17, figs. 1, 2; Laws, 1988, p. 174, pl. 4, fig. 5-8; Håkansson & Meyer 1994, p. 68, figs. 8-16.

Status of name: accepted taxonomically

Diagnosis: Frustule is disc-like, circular in outline, with convex and concave valves. The valves are undulate in the girdle view. The valve surface is ornamented by radial striae of cleared areolae, which are arranged in bundled rows forming a fascicle, about 6-7 fascicles in 10 µm. Each fascicle is bi- to triseriate at the margin and gradually becomes uniseriate towards the central area. The fascicles are separated by a hyaline area of interfascicles or costae, which are arranged regularly, about 6 in 10 µm. The central fultoportulae occur at the center of the valve face, singly or in a ring. The marginal fultoportulae are present, arranged in a ring around the mantle, always occurring beneath each spine. A ring of spines is present around the valve face, occurring in a single row at the end of every second or third costa at the junction of the valve face and mantle. One or a few rimoportulae occur on the mantle-face junction. The diameter of the valve is 45-80 µm, and the central field/diameter cell ratio is about 0.42-0.47.

Remarks: According to Håkansson & Meyer (1994), several valve face fultoportulae, each with two satellite pores, are located in a ring in the central area of the convex and concave valves. Mantle fultoportulae, each with three satellite pores, occur at the end of every one to every third, sometimes the fourth interfascicle. One to several rimoportulae are found in the ring of spines, slightly towards the mantle and transverse to the rows of areolae. The diameter of the valve may reach 135 µm.

Ecological preference: Planktonic, neutral pH, freshwater, oligotrophic, moderate temperatures (Schrader, 1978); Planktonic. Oligohalobous (indifferent); alkaliphilous (Foged, 1981).

Occurrence: Recorded frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Stephanodiscus niagarae* var. *insuetus* Khursevich et Loginova 1986**

Ref. Marciniak and Khursevich 2002, p. 64, figs.a-e, k

Status of name: accepted taxonomically

Diagnosis: Frustule is disc-like, with well concentric undulating circular valves. Valve face is striated by distinct radiate rows of areolae, starting from the center towards the periphery of the valve, and arranged in bundled rows of the fascicle, about 6-8 in 10 µm. The fascicles are separated by hyaline interfascicles or costae, which are arranged regularly, about 6-7 in 10 µm. Valve face fultoportulae occur at the center. The marginal fultoportulae are located around the mantle and below the spines. The rimoportulae are well developed on the mantle-face junction. Diameter of the valve 40-80 µm.

Ecological preference: This variety is an indicator to warm eutrophic freshwater and a high-water level (Marciniak & Khursevich, 2002).

Occurrence: Recorded infrequently in the Eemian deposits of central Poland.

Distribution in Poland: It is recorded from the interglacial lake sediments of the Middle Pleistocene in central and eastern Poland (Marciniak, 1990); lacustrine deposits at Brus in the Lublin Polesie, central Poland (Khursevich et al., 2003); Pleistocene lacustrine-boggy-fluvial sediments at Komorniki, NE Poland (Khursevich et al., 2005); Lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008).

***Stephanodiscus parvus* Stoermer & Håkansson 1984**

(Pl. 36, figs. 1-9)

Ref. Stoermer & Håkansson 1984, p. 500, fig. 1; Krammer & Lange-Bertalot 1991a, p. 71, pl. 74, figs. 1-4; Yang & Duthie, 1993, fig. 3: a-h, fig. 4: a-f; Håkansson 2002, p. 47, figs. 145-150; Olszynski et al. 2019, p. 20, Figs. 5SS–5VV.

Status of name: accepted taxonomically

Synonyms: *Stephanodiscus hantzschii* f. *parva* Grunow in Cleve & Möller 1879
Stephanodiscus hantzschii var. *pusilla* Grunow in Cleve & Grunow 1880

Stephanodiscus pusillus (Grunow) Krieger 1927
Stephanodiscus hantzschii sensu Haworth 1981

Diagnosis: Frustules are small discoid or drum-shaped, with flat to slightly undulating valve face and shallow mantle, never a well-defined central area. Areolae are present across the valve face, weakly organized into rows at the valve center and forming more distinct biseriate fascicles toward the valve margin and uniseriate at the center, each separated with an interfascicle. Interfascicular costae especially broad, radially arranged, 15-20 in 10 µm. A single fultoportula is located close to the center and diagonally opposite the rimoportula. The marginal fultoportula with three strut pores. Spines are present at the end of every interfascicle and are quite distinct in coarse valves but barely visible in finer valves. Diameter of the valve 5-9 µm.

Remarks: Stephanodiscus parvus can be easily confused with S. minutulus (Kützing) Grunow in Cleve. The only differentiating characteristics are the shape and position of the valve face fultoportula. Some authors hold that S. minutulus is a synonym of S. parvus (Kobayasi et al., 1985).

Ecological preference: Stephanodiscus parvus is observed mainly in eutrophic to hypertrophic ecosystems with elevated electrolytic conductivity. It is also a good indicator of waters with a strong anthropogenic impact (Reavie & Smol, 1998; Reavie & Kireta, 2015; Olszyński & Żelazna-Wieczorek, 2018; Reavie & Cai, 2019); it is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009); the species recorded in lake sediments progressing towards eutrophication in European localities: a subalpine hard-water lake of Bavaria (Steinberg & Trumpp, 1993); it is most common in eutrophic lakes Erie and Ontario under conditions of high total phosphorus and moderate chloride concentration (Stoermer et al., 1978; Stoermer & Håkansson, 1984; Reavie & Kireta, 2015); freshwater, eutraphentic with pH value 7.69-8.11 (Witak et al., 2017), eutrophic, alkaliphilous to alkalibiontic (Olszyński et al., 2019).

Occurrence: Frequent in the Eemian deposits of central Poland and the Holocene sediments of Młynek and Radomno Lakes.

Distribution in Poland: It is reported from the lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Holocene sediments in the SW Gulf of Gdańsk and the Vistula Lagoon, southern Baltic Sea (Witak, 2013); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński & Zelazna-Wieczorek, 2018; Olszyński et al., 2019); from the Gulf of Gdansk and surrounding waters, the southern Baltic Sea (Plinski, & Witkowski, 2020).

***Stephanodiscus rotula* (Kützing) Hendey 1964**

(Pl. 36, figs. 10-15)

Ref. Stephanodiscus rotula (Kützing) Hendey; Hendey 1964, p. 75; Krammer & Lange-Bertalot 1991 a, p. 68, pl. 68, fig. 4; pl. 69, figs. 4-5; pl. 70, fig. 2; pl. 71, figs. 1-2; Håkansson & Meyer 1994, p. 68, figs. 17-27**;** Håkansson 2002, p. 27, figs. 61-70; as Stephanodiscus astraea (Ehrenberg) Grunow 1880; Hustedt 1930, p. 368, fig. 193 a-c; Håkansson 1976, p. 30, figs. 1 C, F, 3 A-D, 5; Gasse 1980, p. 46, pl. 17, figs. 2-3; Gasse 1986, p. 167, pl. 5, figs. 1-2

Status of name: accepted taxonomically

Synonyms: *Cyclotella rotula* Kützing 1844
Cyclotella astraea (Ehrenberg) Kützing 1849
Stephanodiscus astraea (Ehrenberg) Grunow 1880

Diagnosis: Frustules are discoid, with a strong concentric undulating valve face. The areolate fascicle comprises 2-3 rows of areolae at the margin and gradually becomes uniseriate towards the central area, about 7-8 per 10 µm. The interfascicles are a smooth hyaline area. Valve face fultoportulae are several, about 7-10 found in a ring of the peripheral uplift of the central area, each with two satellite pores. Mantle fultoportulae occur at the end of every to every third interfascicle in the middle of the mantle. Commonly one rimoportula is found in the ring of spines. Valve diameter ranges between 30-50 µm.

Ecological preference: Planktonic, common in eutrophic waters, and also in slightly brackish water, it can not be grouped as a stenothermic species (Hustedt, 1957, 1962); alkalibiontic, with pH optimum of 8.3 (Cholnoky, 1968); freshwater form, planktonic, alkaliphilous with pH value 7.5 - 8.0, (Ehrlich 1973); oligohalobous, meioeuryhaline

(Pankow, 1976); oligohalobous "indifferent", alkaliphilous (Foged, 1980); the species was observed abundant in many freshwater habitats of low conductivity and low alkalinity with pH ranges between 7.0-8.2 (Zalat & Servant-Vildary, 2005); freshwater, planktonic, indifferent (halobity), alkalibiontic, β-α-mezosaprobic (Medvedeva et al., 2009); it is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009); freshwater, meso-oligotraphentic with pH:7.69-8.11(Witak et al., 2017).

Occurrence: Frequent in the Holocene sediments of Radomno and Młynek Lakes and the Eemian deposits of central Poland; rare in the Kamionka Lake sediments.

Distribution in Poland: The species is reported from Mazovian Interglacial deposits, Lublin Upland, eastern Poland (Marciniak & Khursevich, 2002); lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); from Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); from the Gulf of Gdansk and surrounding waters, the southern Baltic Sea (Plinski, & Witkowski, 2020); as *Stephanodiscus astraea* from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995).

***Stephanodiscus tenuis* Hustedt 1939**

Ref. Hustedt 1939, p. 583, fig. 3; Genkal & Kuzmin 1978, p. 1309, pl. 1, figs. 1-6; Håkansson & Stoermer 1984, p. 486

Status of name: alternate representation

Synonyms: *Stephanodiscus hantzschii* f. *tenuis* (Hustedt) Håkansson & Stoermer 1984
Stephanodiscus tenuis var. *tener* Genkal & Kuzmin, 1978

Diagnosis: Frustules are small discoid-shaped, with a circular flat valve face and an annulus is present at the valve center. Valves are often lightly silicified. Fascicles on the valve surface are multiseriate and may be wavy. The fascicles number 6 – 7 in 10 µm are based on circumferential density. Areolae are fine, occurring 26-28 in 10 µm. Interfascicular costae are radiate and are often not straight, rather they form a slight wavy pattern. Central fultoportulae are absent. Numerous marginal fultoportulae are present. A single rimoportula is located on a costa near the valve face/mantle junction, replacing a spine. Prominent spines terminate each interfascicle. Diameter of the valve 5-10 µm.

Ecological preference: This taxon is characteristic of eutrophic lakes, particularly in higher total phosphorus concentrations (Reavie & Kireta, 2015); freshwater, eutraphentic with pH value 7.69-8.11 (Witak et al., 2017).

Occurrence: It is recorded infrequently in the Eemian deposits of central Poland, and the Holocene sediments of Radomno Lake.

Distribution in Poland: It is reported from the sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017)

Subclass: Biddulphiophycidae Round & Crawford 1990
Order: Triceratiales Round & Crawford 1990
Family: Triceratiaceae (Schütt) Lemmermann 1899
Genus *Pleurosira* (Meneghini) Trevisan 1848

Diagnosis: Cells are as solitary or occur as colonies in straight or zigzag chains united by mucilage pads on the horns. Frustules are rectangular in girdle view, and either bi- or tripolar in valve view. Valve shape is thus circular, triangular, quadrangular, or polygonal, with a flat valve face and sometimes with an undulate outline. Poles possess rounded, pseudocellate elevations. Valves may be segmented; the external ribs or ridges possess associated internal costae. Valve surface is usually punctate with simple areolae; the areolae are scattered, or arranged uniseriate, radiating from the center and continuing without a break down the mantle. Two or more small spines occur at the center. The valve mantle is deep and vertical, and frequently constricted where it meets the girdle. The girdle band is simple, sharply differentiated, appearing finely areolate.

Holotype species *Pleurosira thermalis* (Meneghini) Meneghini 1846: 197
(=Melosira thermalis Meneghini 1846)

***Pleurosira laevis* (Ehrenberg) Compère 1982**

(Pl. 37, figs. 1-4)

Ref. Compère 1982, p. 117-178, figs. 1-17, 20-39; Ricard 1987, p. 198, figs. 416-420; Krammer & Lange-Bertalot 1991a, p. 86, pl. 83, figs. 1-4; Johnson & Rosowski 1992, p. 248, fig. 1; as Biddulphia laevis Ehrenberg 1843; Hustedt 1930, p. 852, figs. 506-507; Hendey 1964, p. 105, pl. 25, fig. 7; Foged 1980, p. 635, pl. 1, fig. 1; Gerloff & Natour 1982, p. 171, pl. 9, fig. 1; Ehrlich 1995, p. 38, pl. 4, figs. 1-7; Witkowski et al. 2000, p. 40, pl. 9, figs. 6-8; Cavalcante et al., 2013, p. 247, figs. 12 A-G.

Status of name: accepted taxonomically

Synonyms: *Cerataulus laevis* (Ehrenberg) Ralfs in Pritchard 1861
Biddulphia laevis Ehrenberg 1843

Diagnosis: Cells are rectangular in girdle view with almost straight sides, and only a very small constriction and a narrow hyaline band. The frustule is almost globose, having three to eight intercalary bands, and cylindrical united together in zigzag filaments. Valves are approximately circular to elliptical and with flat valve face, covered with fine punctae, arranged in radiating or slightly curved striae and very deep valve mantle. Valve with two prominent marginal ocelli, extending from opposite sides of the valve face. Ocelli largely oval, 4-5 µm in width and 8-15 µm in length. Two to three rimoportulae are located in central parts, at intermediate positions between the center and the margin. Areolar striae radiating from the center towards the margin, about 11-14 striae in 10 µm. Spines are present on the margin of the valve. The diameter of the valve is 40-100 µm, and the mantle height is 20-40 µm.

Ecological preference: The species is recorded in different aquatic habitats, fresh to brackish waters; a mesohalobous species (Simonsen, 1962); littoral form, found in waters of reduced salinity in modern estuaries (Hendey, 1964; Andrews, 1980); it prefers lotic environments (Kociolek et al., 1983); eutrophic diatoms occurring in the fertilized waters (Sherwood, 2006); the species also survives in inland waters with higher conductivity, it was observed as abundant in eutrophic brackish water habitats, characterized by low to medium alkalinity, pH values 7.6 – 8.5, and slightly to moderately polluted waters, it is considered to be mesohalobous, alkaliphilous, mesosaprobic species (Zalat & Servant-Vildary, 2005).

Occurrence: The species reported infrequently from the Holocene sediments of Kamionka Lake.

Distribution in Poland: Abundant in the lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); from the Gulf of Gdansk and surrounding waters, the southern Baltic Sea (Plinski & Witkowski, 2020).

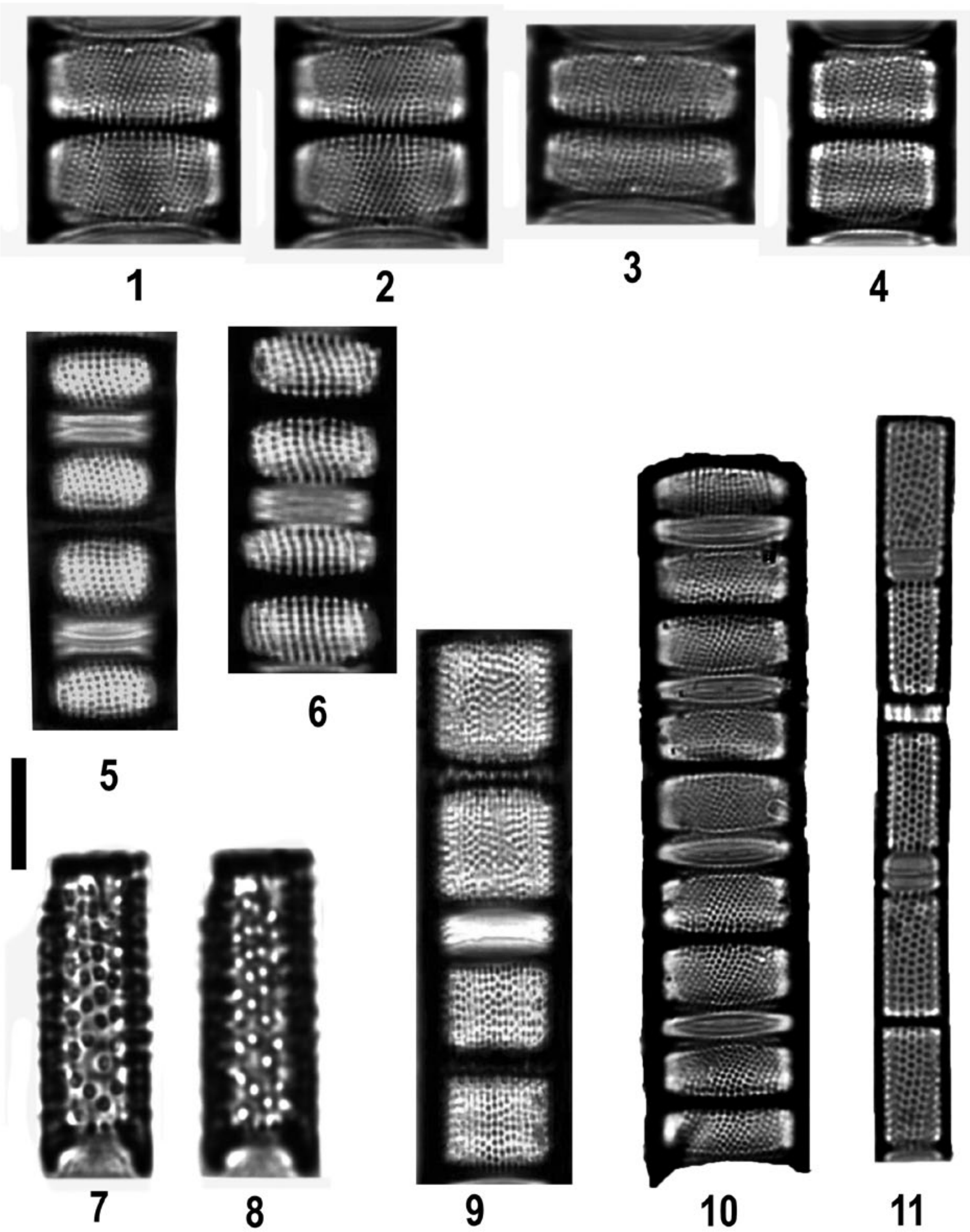

Plate 1: 1-4. *Aulacoseira agassizii* (Ostenfeld) Simonsen 1979; Kamionka Lake; 5-6. *Aulacoseira alpigena* (Grunow) Krammer 1990, Radomno Lake; 7-8. *Aulacoseira canadensis* (Hustedt) Simonsen 1979, Radomno Lake; 9. *Aulacoseira crenulata* (Ehrenberg) Thwaites 1848, Młynek Lake, 10. *Aulacoseira islandica* (O. Müller) Simonsen 1979, Młynek Lake; 11. *Aulacoseira italica* (Ehrenberg) Simonsen 1979, Młynek Lake. Scale bar:10 µm.

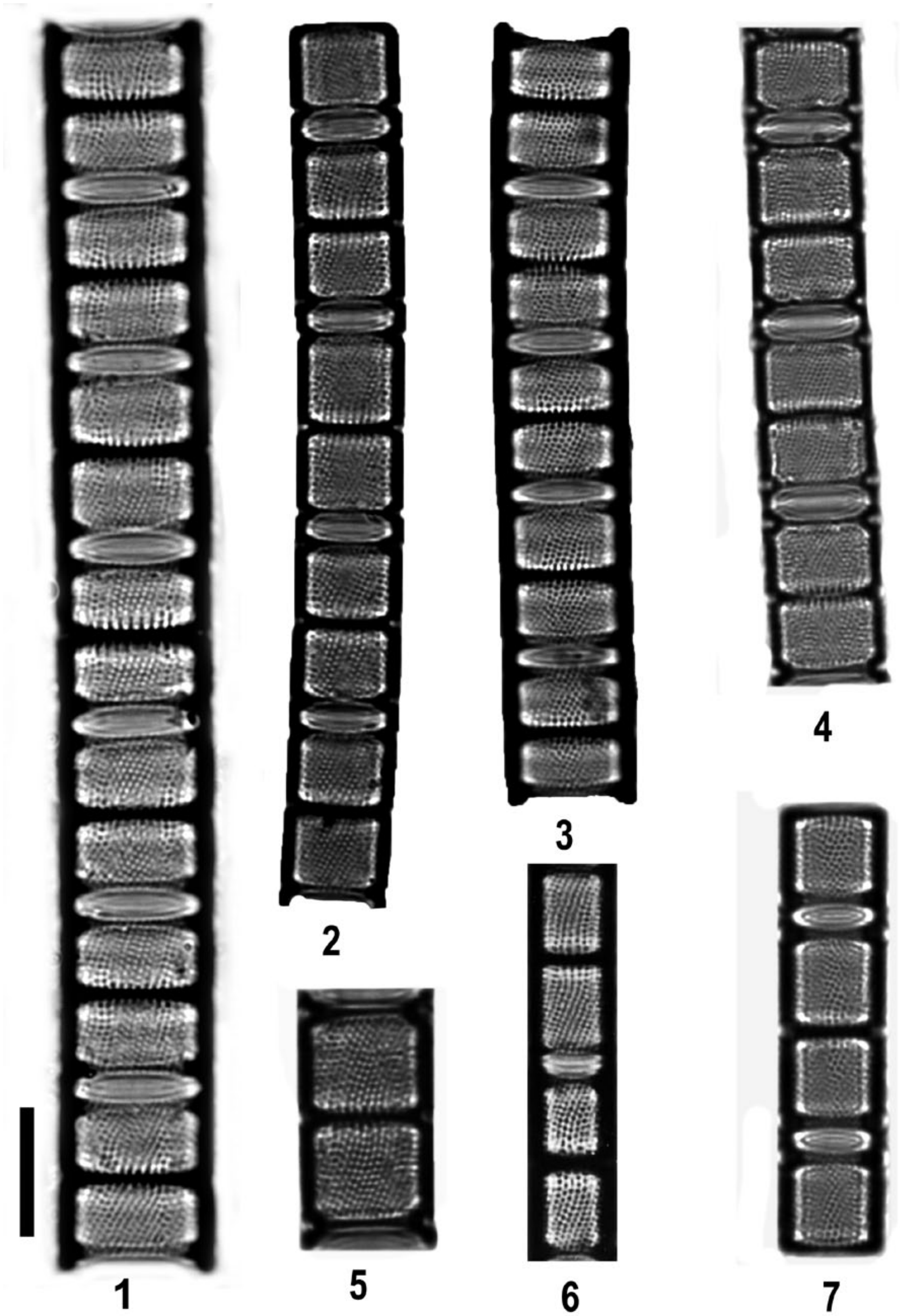

Plate. 2: 1-7. *Aulacoseira ambigua* (Grunow) Simonsen 1979, 1-4. Młynek Lake; 5-7. Kamionka Lake. Scale bar:10 µm.

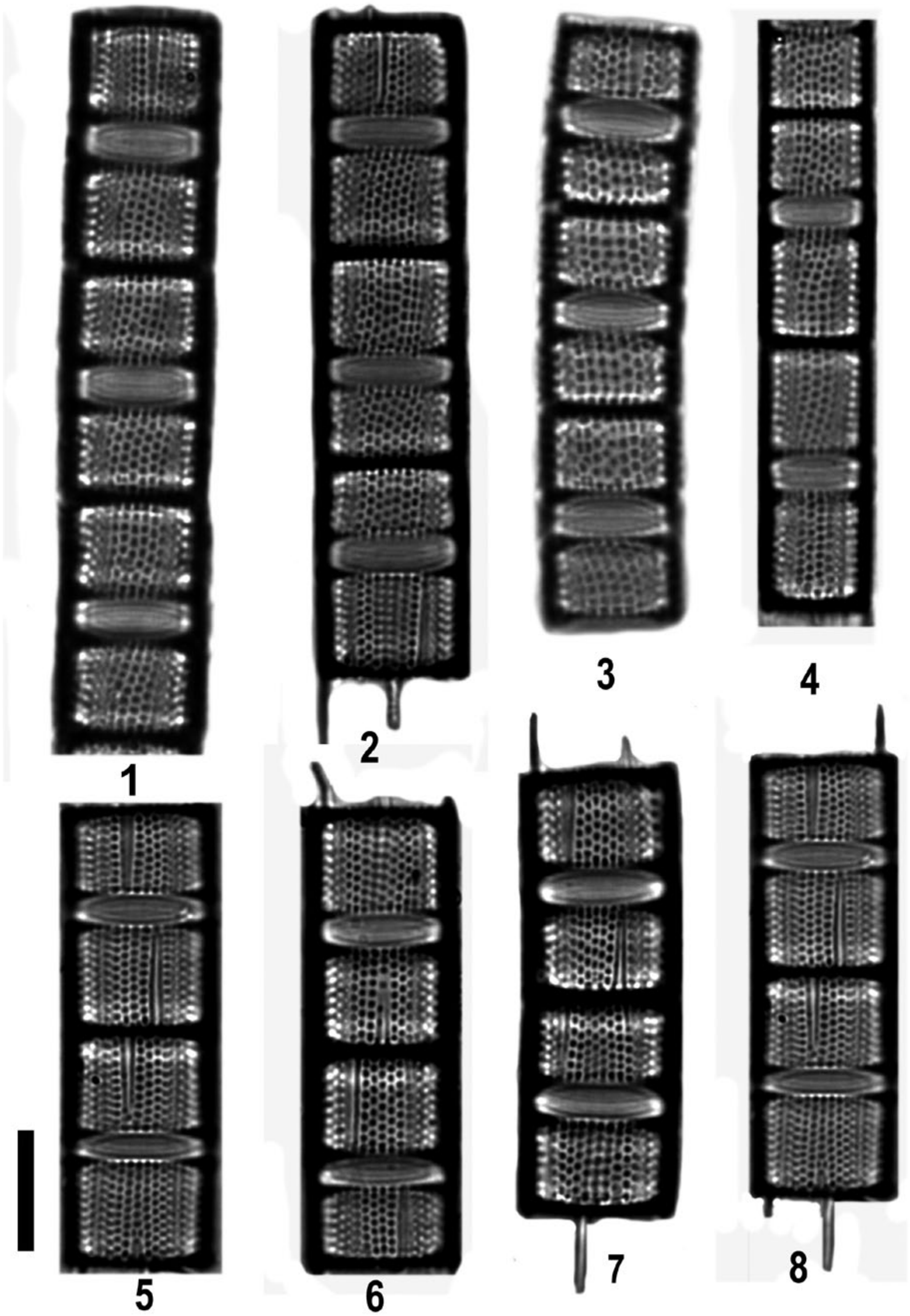

Plate. 3: 1-8. *Aulacoseira granulata* (Ehrenberg) Simonsen 1979, Młynek Lake. Scale bar: 10 µm.

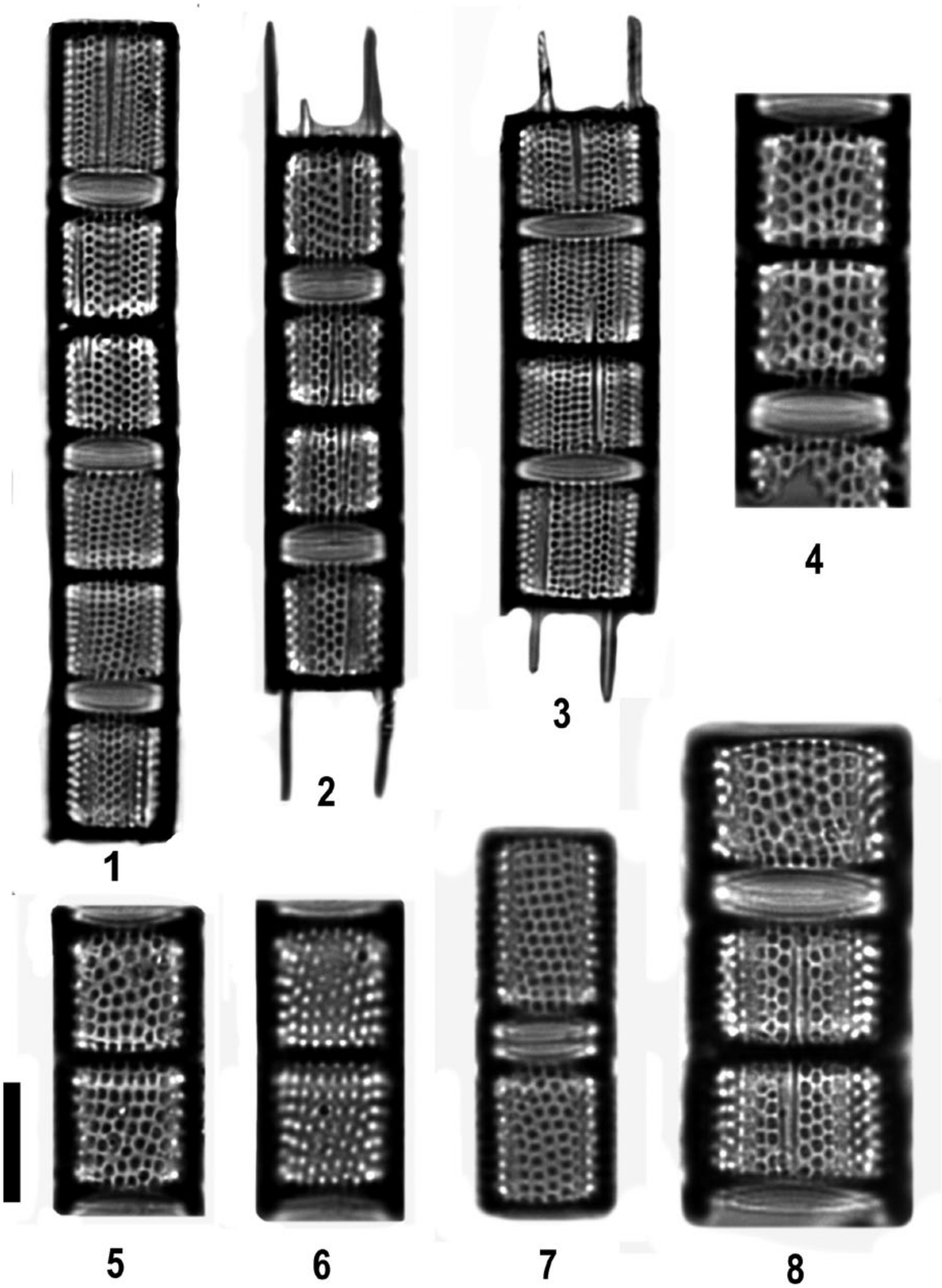

Plate. 4: 1-8. *Aulacoseira granulata* (Ehrenberg) Simonsen 1979, 1-3. Młynek Lake; 4-8. Radomno Lake. Scale bar:10 µm.

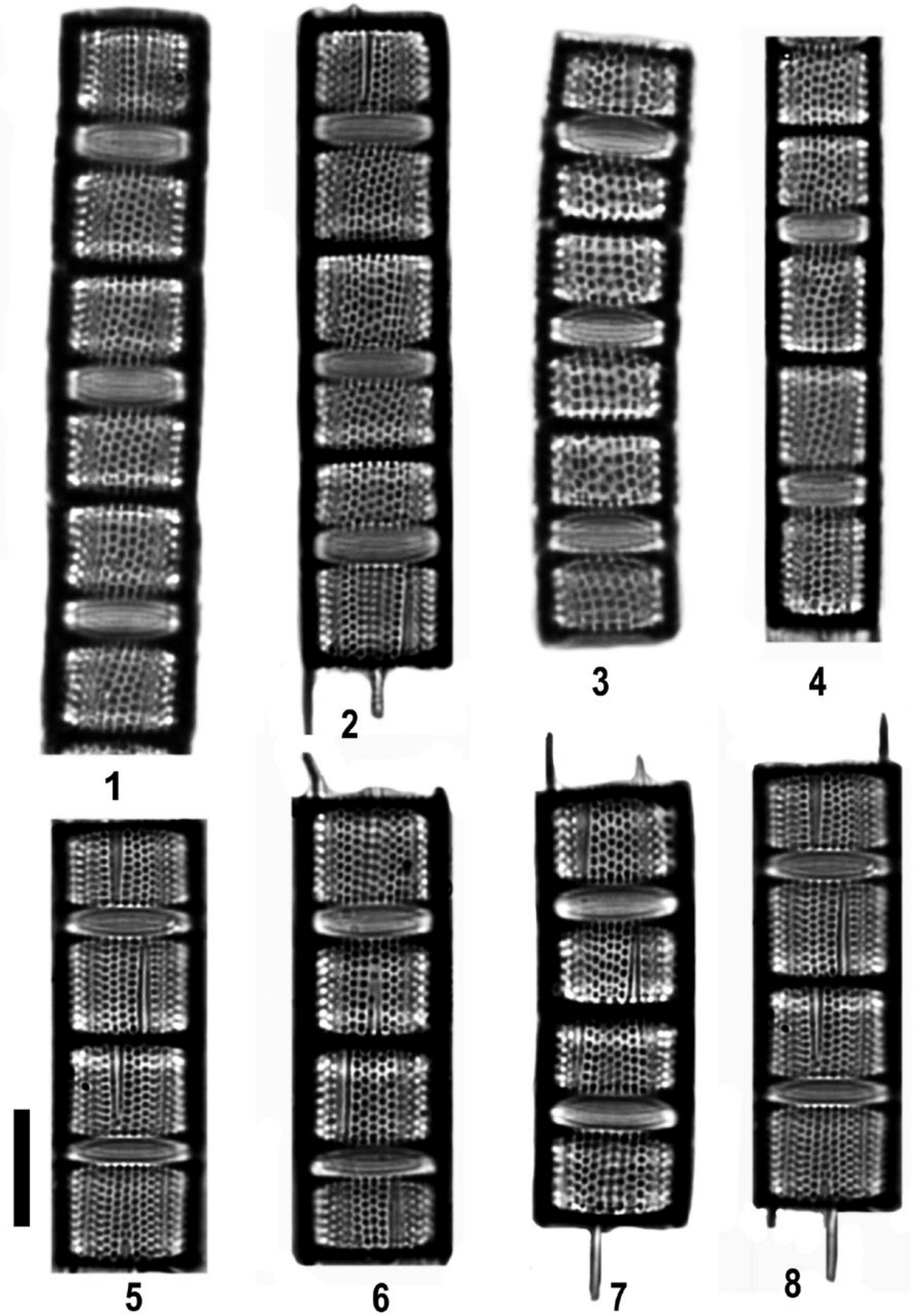

Plate 5: 1-8. *Aulacoseira granulata* (Ehrenberg) Simonsen 1979, 1-4. Kamionka Lake; 5-8. Młynek Lake. Scale bar:10 µm.

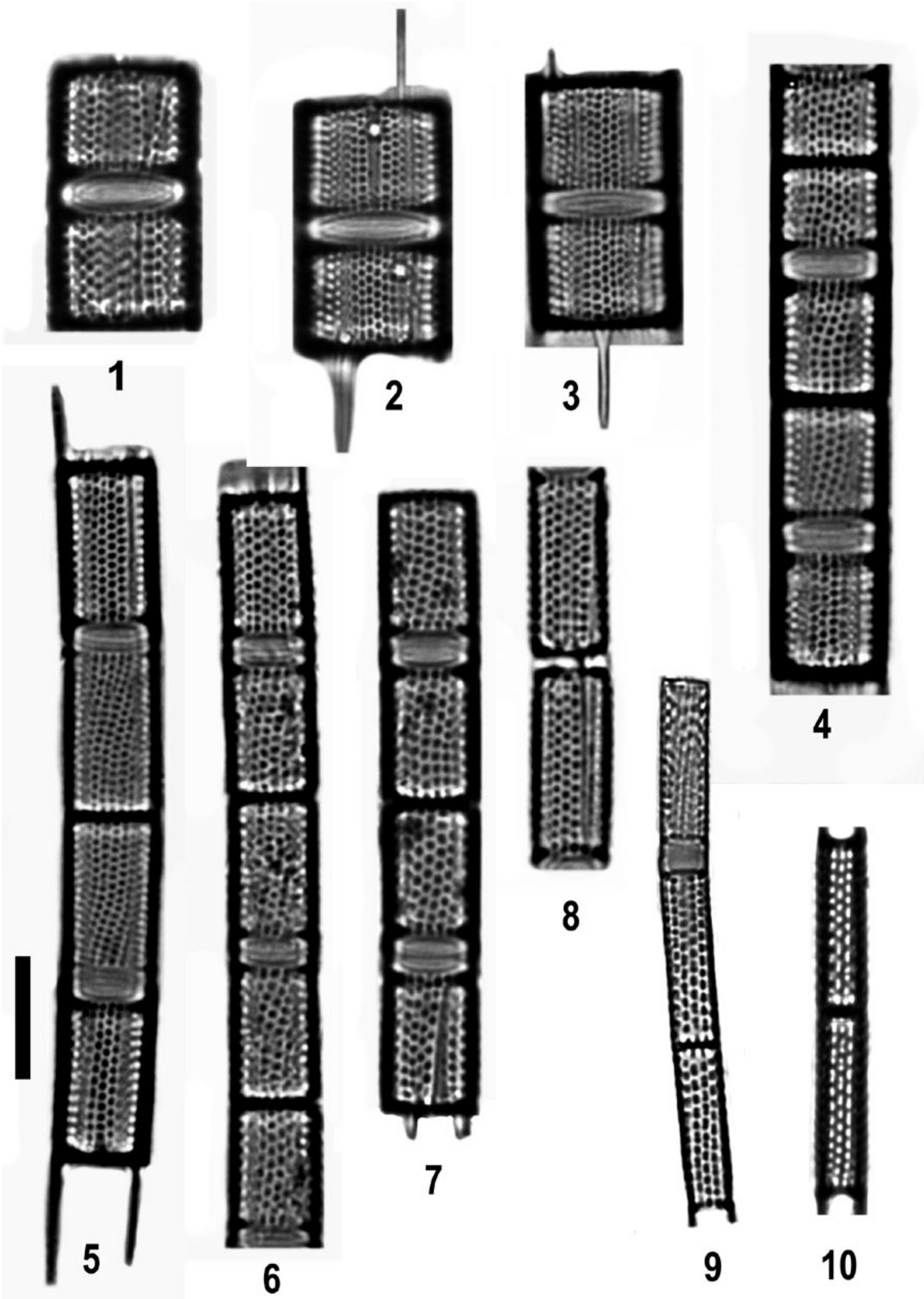

Plate 6: 1-8. *Aulacoseira granulata* (Ehrenberg) Simonsen 1979, 1-4. Eemian deposits; 5-8. Młynek Lake; 9-10. *Aulacoseira granulata* var. *angustissima* (O. Müller) Simonsen 1979, Młynek Lake. Scale bar:10 µm.

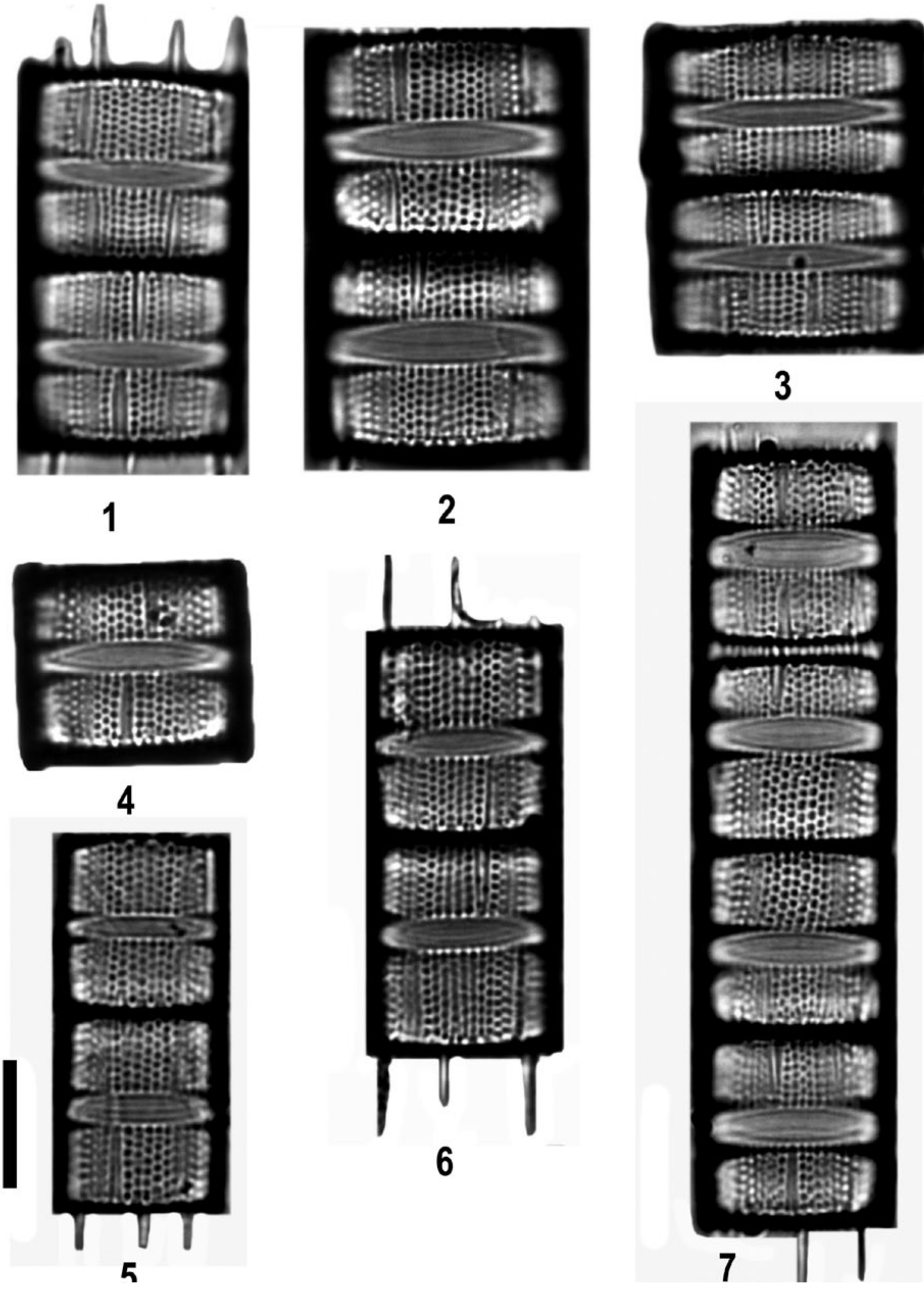

Plate 7: 1-4. *Aulacoseira muzzanensis* (Meister) Krammer 1991, Młynek Lake; 5-7. *Aulacoseira pseudomuzzanensis* Olszynski & Zelazna-Wieczorek 2018, Młynek Lake. Scale bar:10 µm.

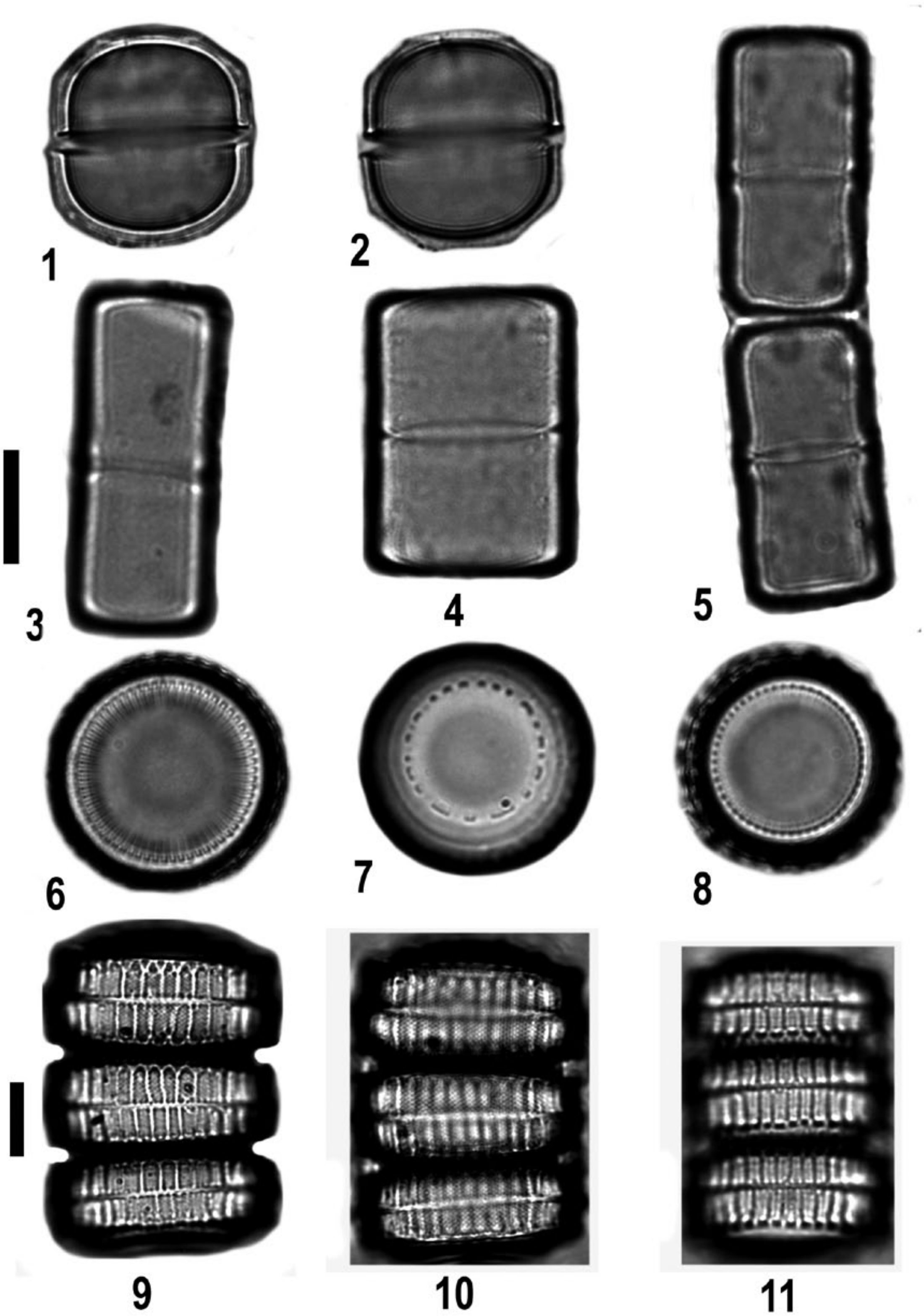

Plate 8: 1-2. *Melosira moniliformis* (O. Müller) Agardh 1824, Młynek Lake; 3-5. *Melosira varians* Agardh 1827, 3. Jeziorak Lake; 4. Młynek Lake, 5. Radomno Lake; 6-11. *Paralia sulcata* (Ehrenberg) Cleve 1873, Radomno Lake. 6-8. Valve face view; 9-11. girdle view. Scale bar:10 µm.

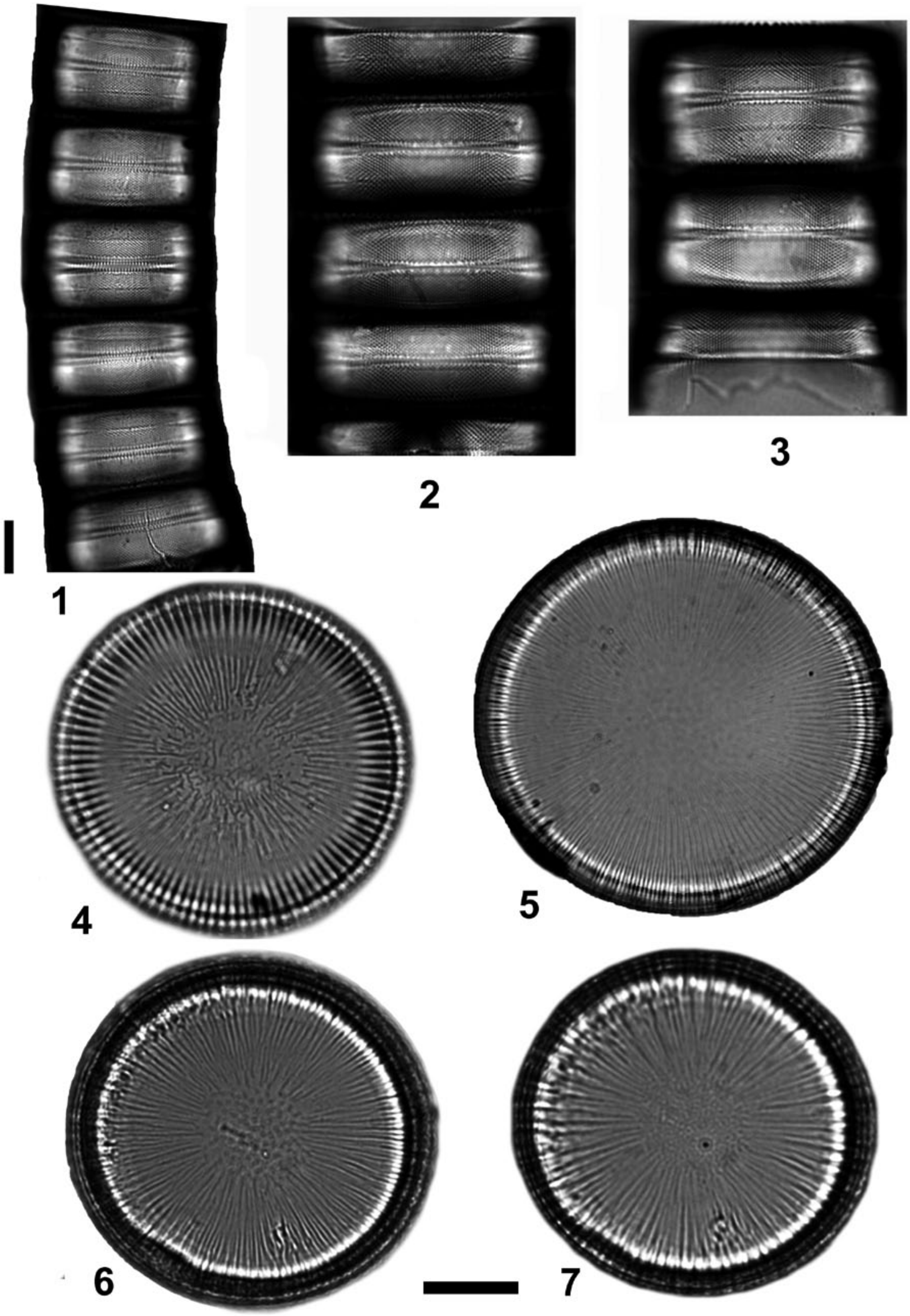

Plate 9: 1-7. *Ellerbeckia arenaria* (Moore) Crawford 1988, 1-3 girdle view, 4-7 valve face view; 1,2,4,5. Jeziorak Lake; 3, 6, 7. Radomno Lake. Scale bar:10 µm.

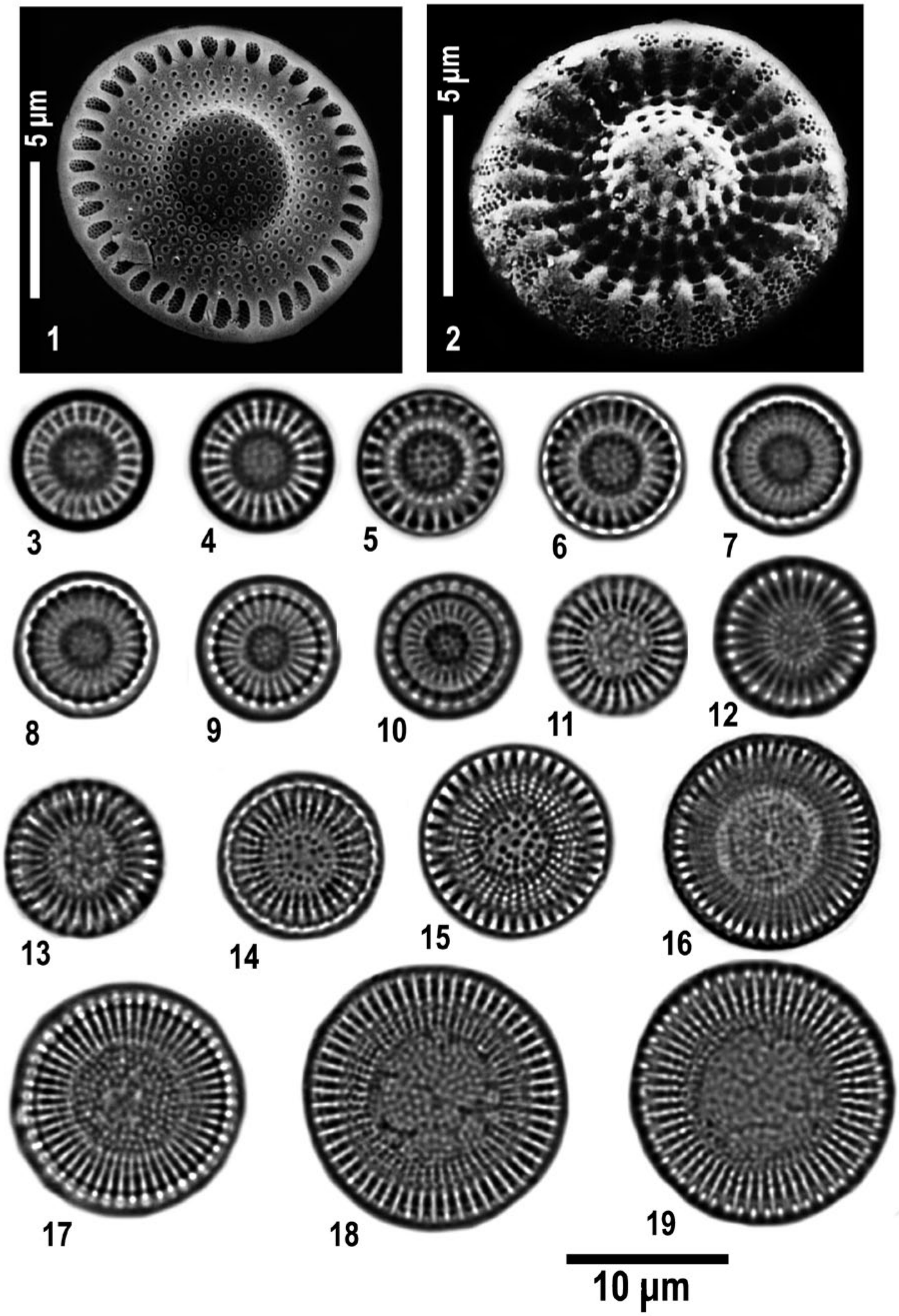

Plate 10: 1-19. *Cyclostephanos dubius* (Fricke) Round in Theriot et al., 1-8, 13-15. Młynek Lake; 9-12, 16-19. Radomno Lake.

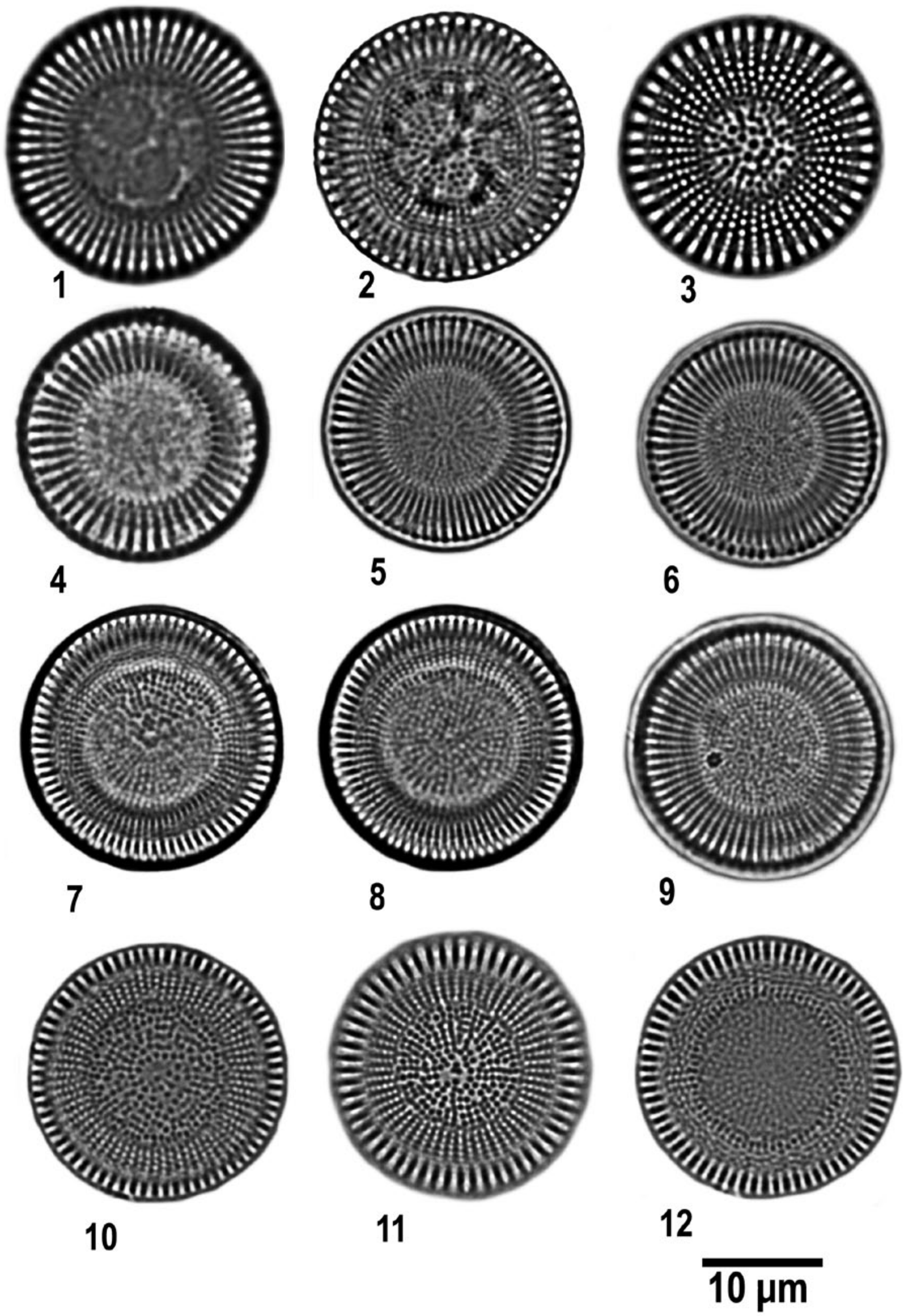

Plate 11: 1-12. *Cyclostephanos dubius* (Fricke) Round in Theriot et al. 1987, 1-9, Młynek Lake; 10-12. Radomno Lake.

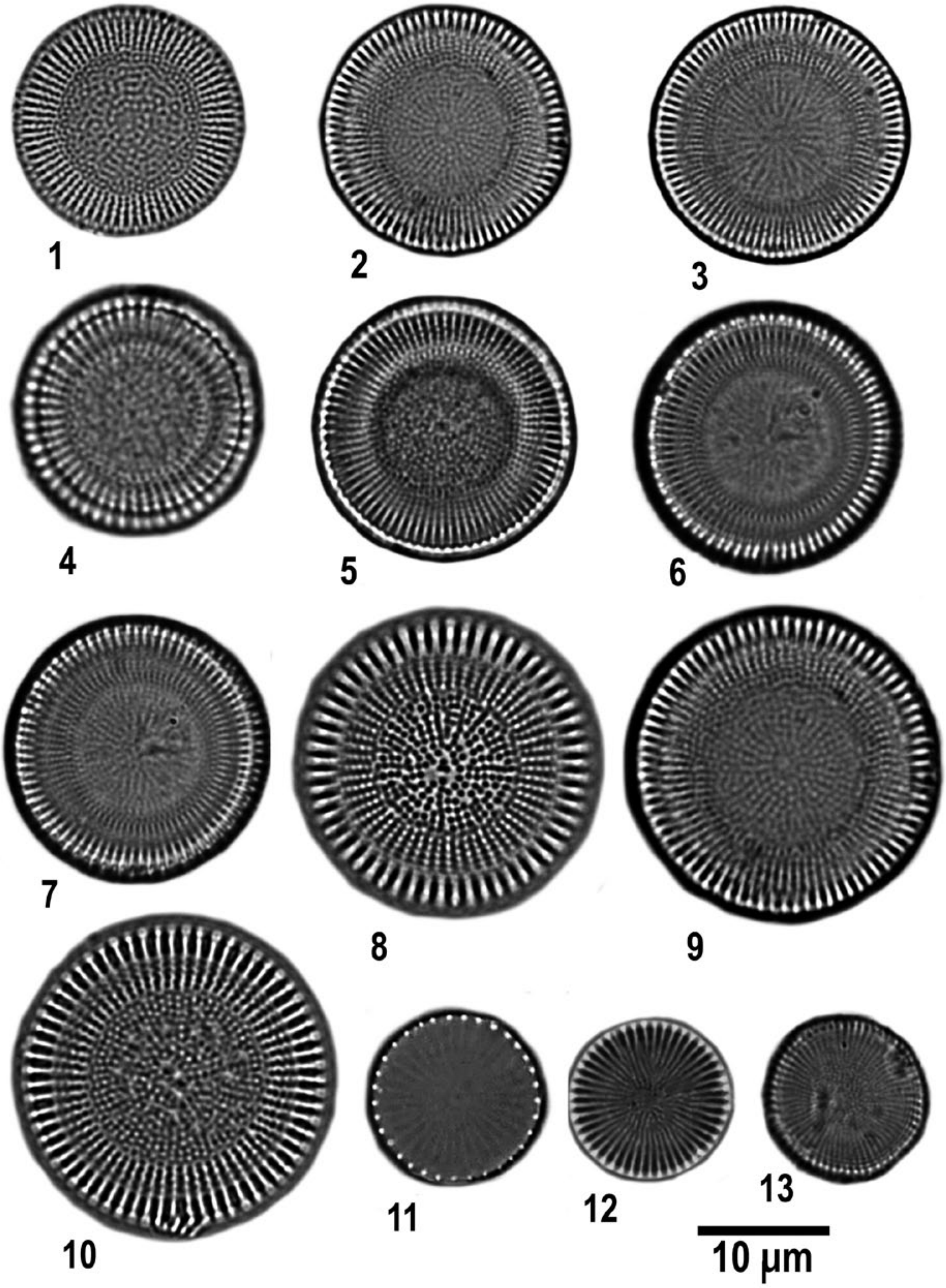

Plate 12: 1-10. *Cyclostephanos dubius* (Fricke) Round in Theriot et al. 1987, 1, 8-10. Radomno Lake, 2-7. Młynek Lake; 11-13. *Cyclostephanos invisitatus* (Hohn & Hellermann) Theriot et al. 1987, Młynek Lake.

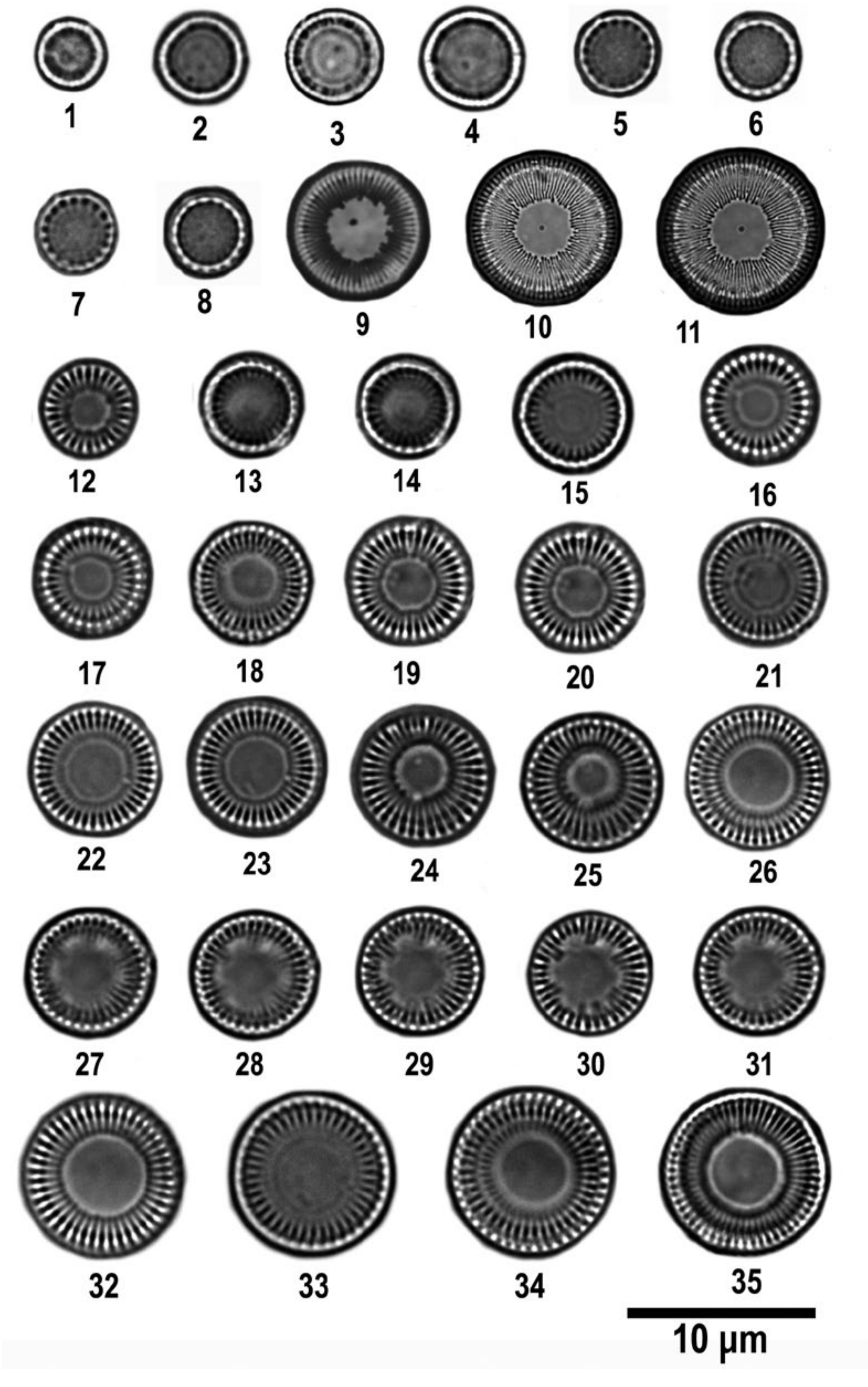

Plate 13. 1-4. *Cyclotella atomus* Hustedt 1937, Eemian deposits; 5-8. *Cyclotella cryptica* Reimann, Lewin & Guillard 1963, Eemian deposits; 9-11. *Cyclotella cyclopuncta* Håkansson & Carter 1990, Eemian deposits; 12-35. *Cyclotella distinguenda* Hustedt 1927, Eemian deposits.

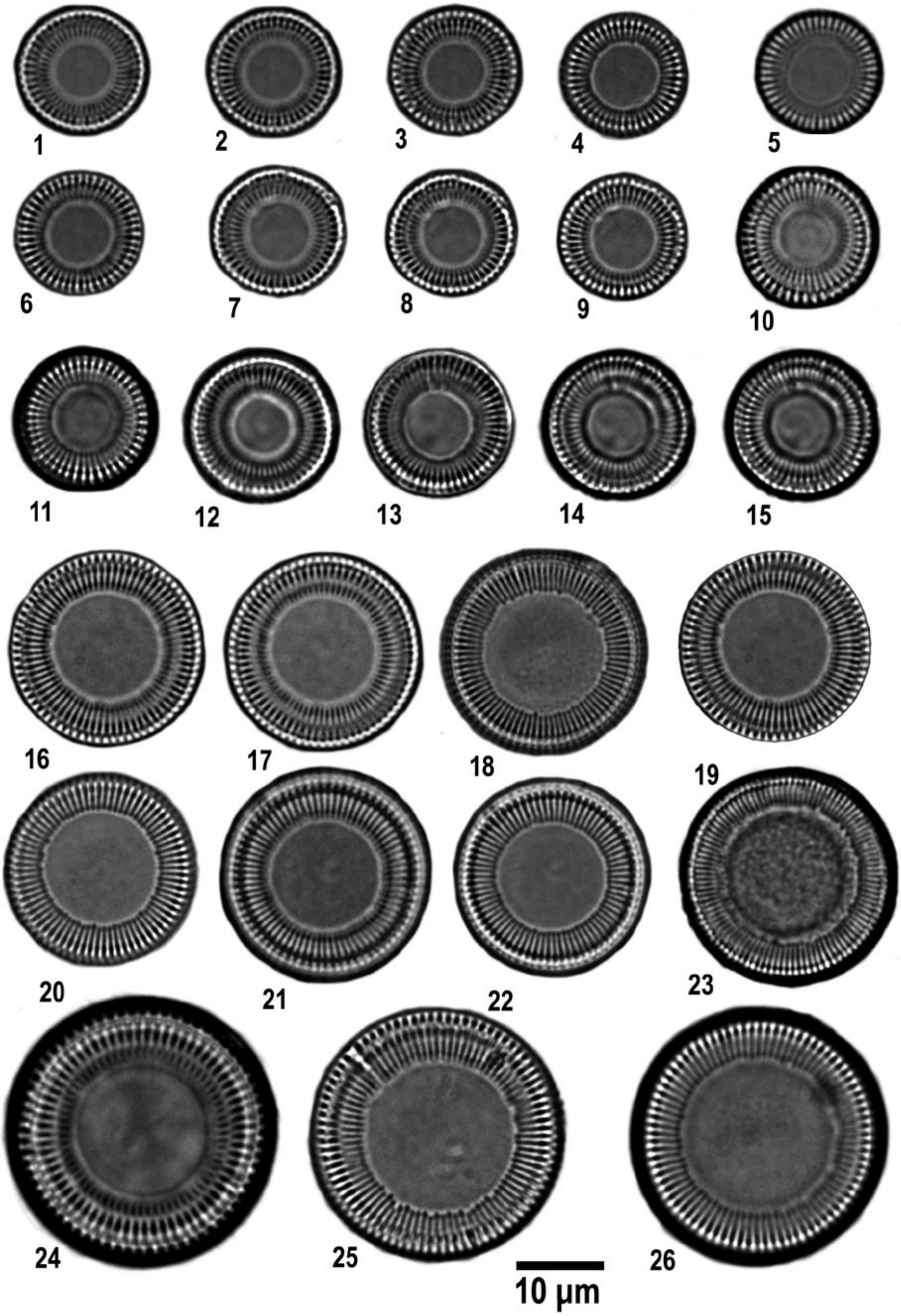

Plate 14. 1-26. *Cyclotella distinguenda* Hustedt 1927, Eemian deposits, central Poland.

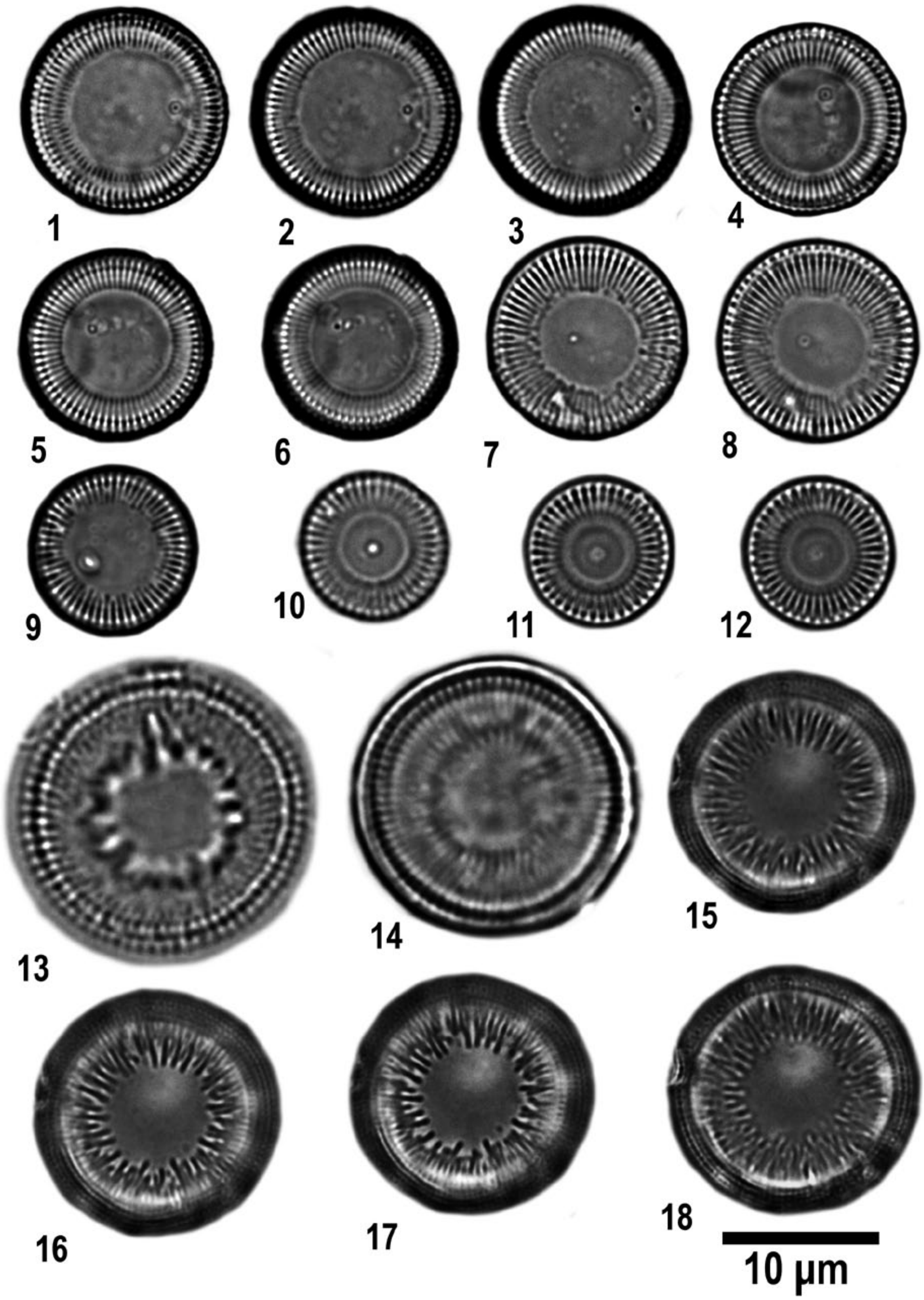

Plate 15: 1-12. *Cyclotella distinguinda unipunctata* (Hustedt) Håkansson & Carter 1990, Eemian deposits; 13-14. *Cyclotella iris* Brun & Héribaud-Joseph 1893, 13. Kamionka Lake; 14. Eemian deposits; 15-18. *Cyclotella lenoblei* Manguin 1949, Eemian deposits.

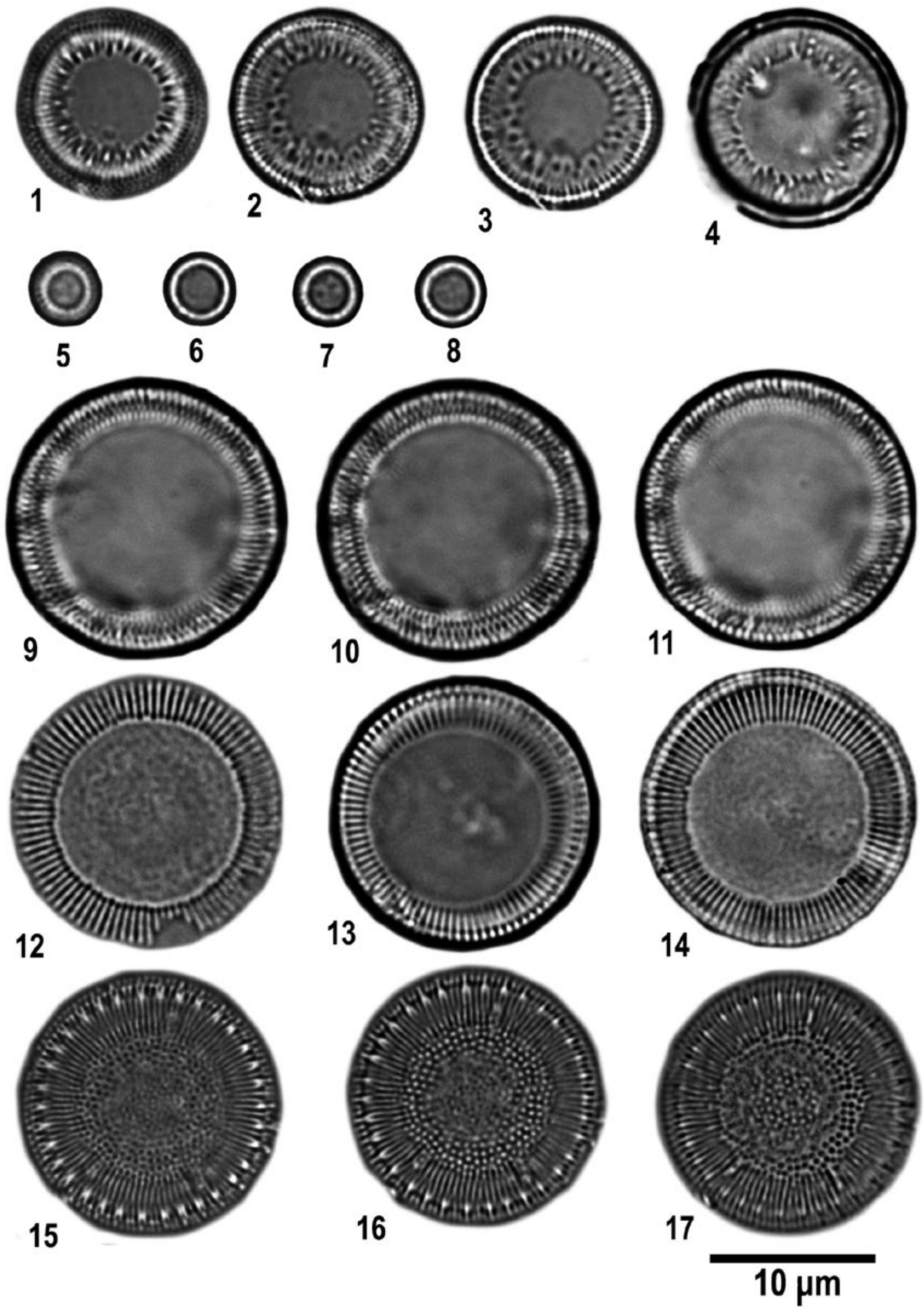

Plate 16: 1-4. *Cyclotella lenoblei* Manguin 1949, Eemian deposits; 5-8. *Cyclotella meduanae* Germain 1981, Eemian deposits; 9-14. *Cyclotella paradistinguenda* Katrantsiotis & Risberg 2016, Eemian deposits; 15-17. *Cyclotella planctonica* Brunnthaler 1901**,** Eemian deposits.

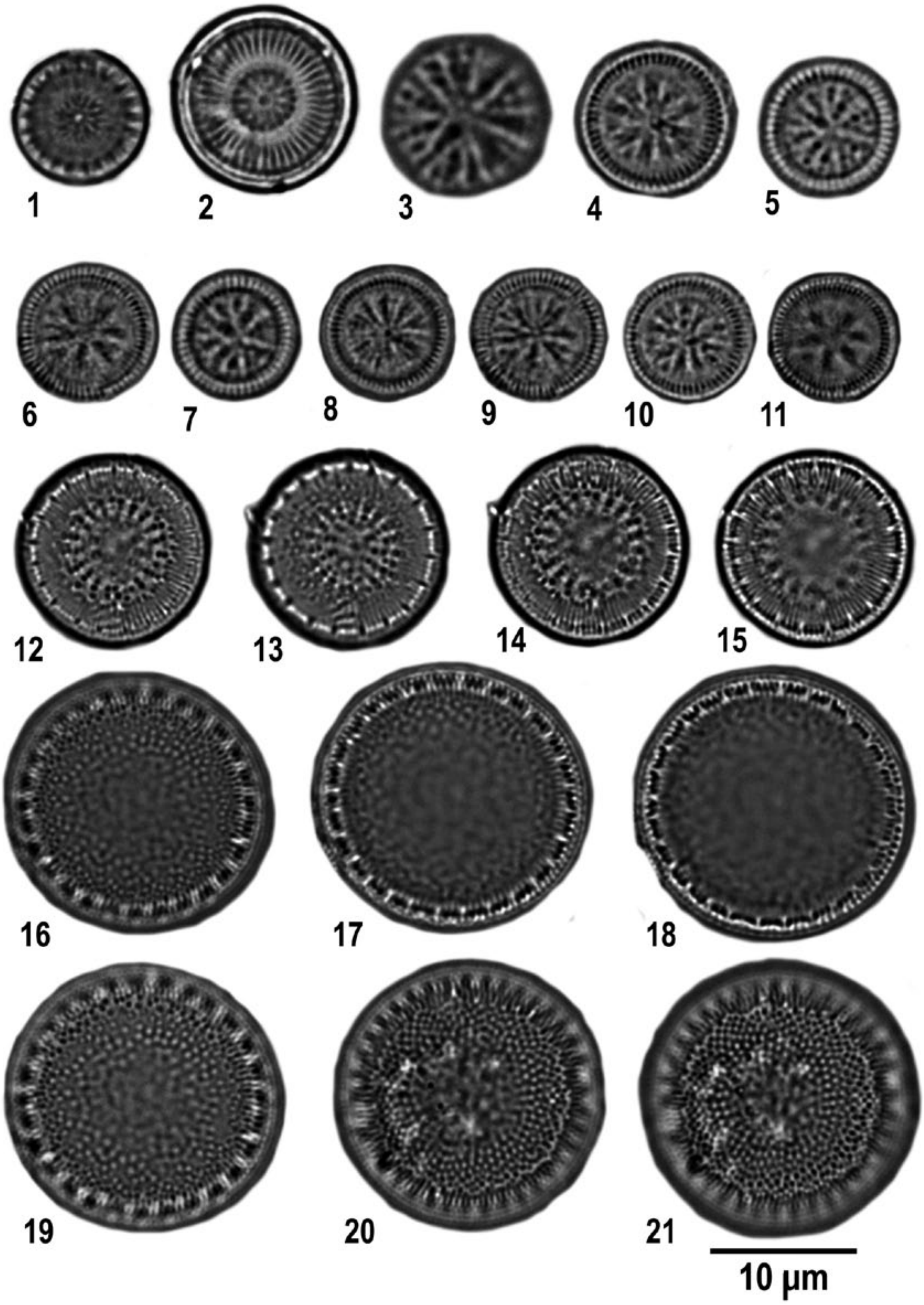

Plate 17. 1. *Discostella pseudostelligera* (Hustedt) Houk & Klee 2004*,* Radomno Lake; 2. *Discostella stelligera* (Cleve & Grunow) Houk & Klee 2004, Młynek Lake; 3-11. *Discostella woltereckii* (Hustedt) Houk & Klee 2004*,* Eemian deposits; 12-15. *Lindavia affinis*; 16-21. *Lindavia baicalensis* Eemian deposits.

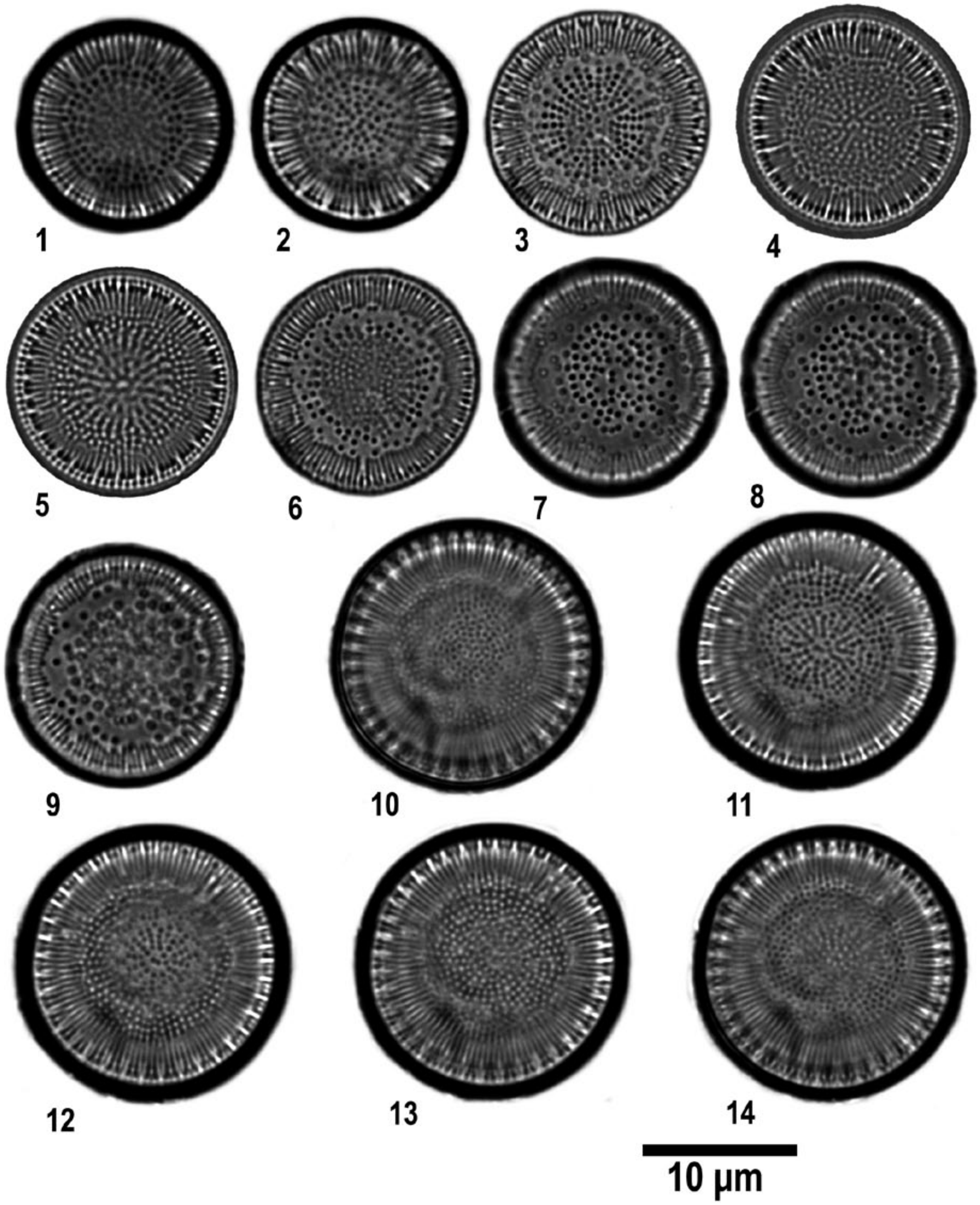

Plate 18: 1-14. *Lindavia bodanica* (Eulenstein ex Grunow) Nakov et al. 2015, Eemian deposits, central Poland.

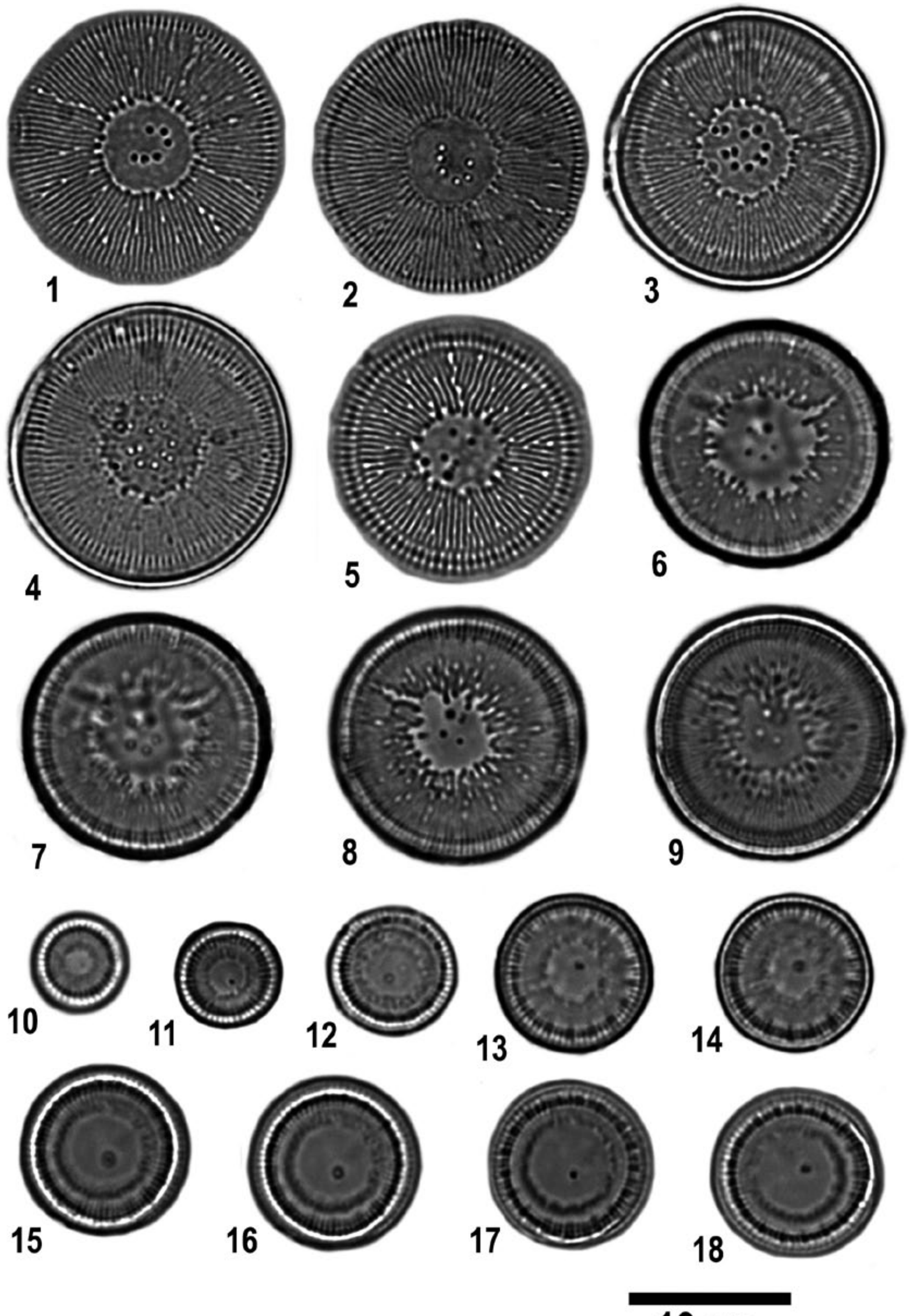

Plate 19: 1-9. *Lindavia fottii* (Hustedt) Nakov et al. 2015, 1-4. Kamionka Lake; 5. Radomno Lake, 6-9, Eemian deposits; 10-18. *Lindavia glomerata* (Bachmann) Adesalu & Julius 2017, Eemian deposits.

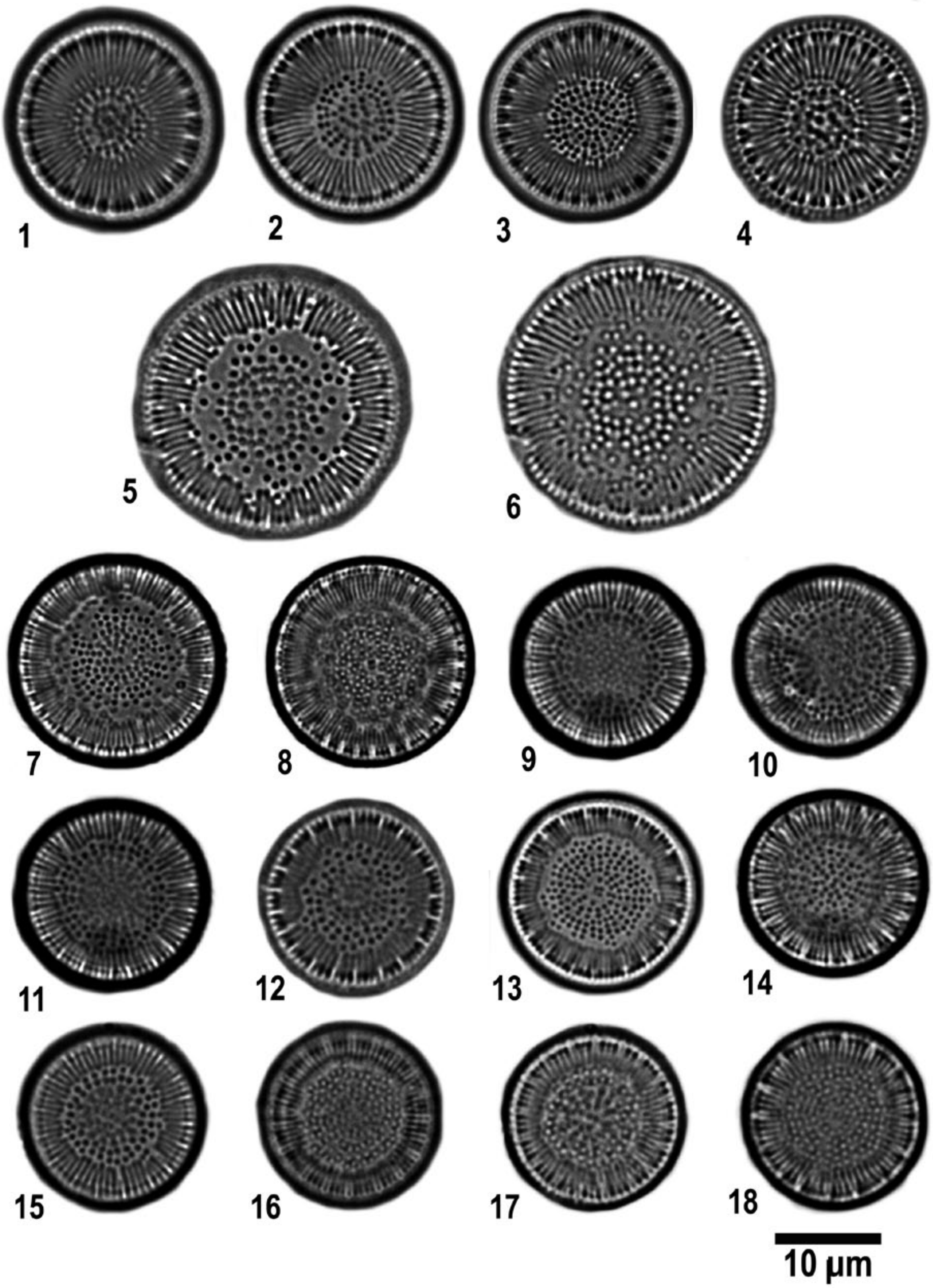

Plate 20: 1-4. *Lindavia intermedia* (Manguin ex Kociolek & Reviers) Nakov et al. 2015, Młynek Lake; 5-6; *Lindavia khinganensis* Rioual 2017, Eemian deposits; 7-18. *Lindavia praetermissa* (Lund) Nakov et al. 2015, Eemian deposits.

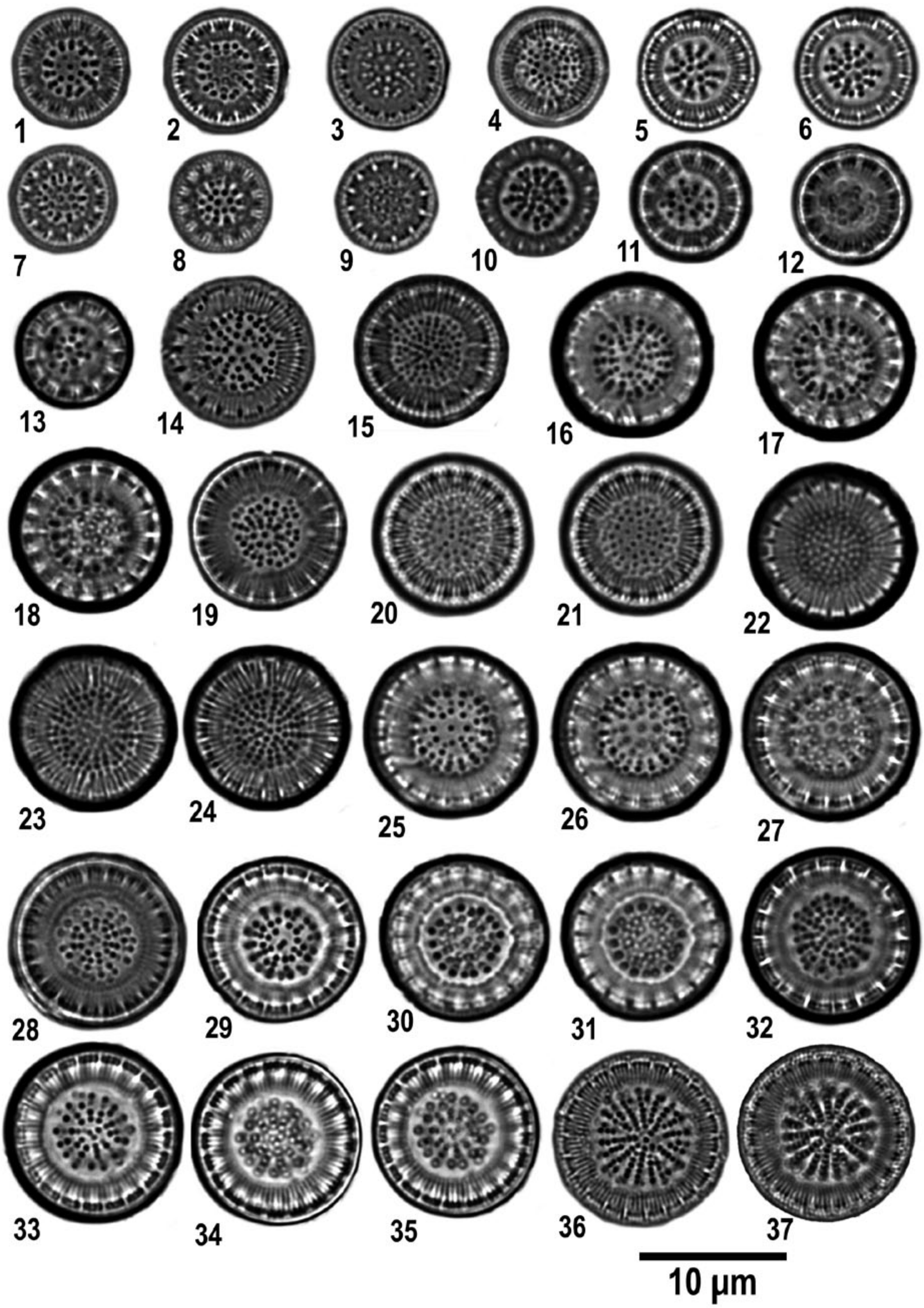

Plate 21: 1-37. *Lindavia radiosa* (Grunow) De Toni & Forti 1900, Eemian deposits.

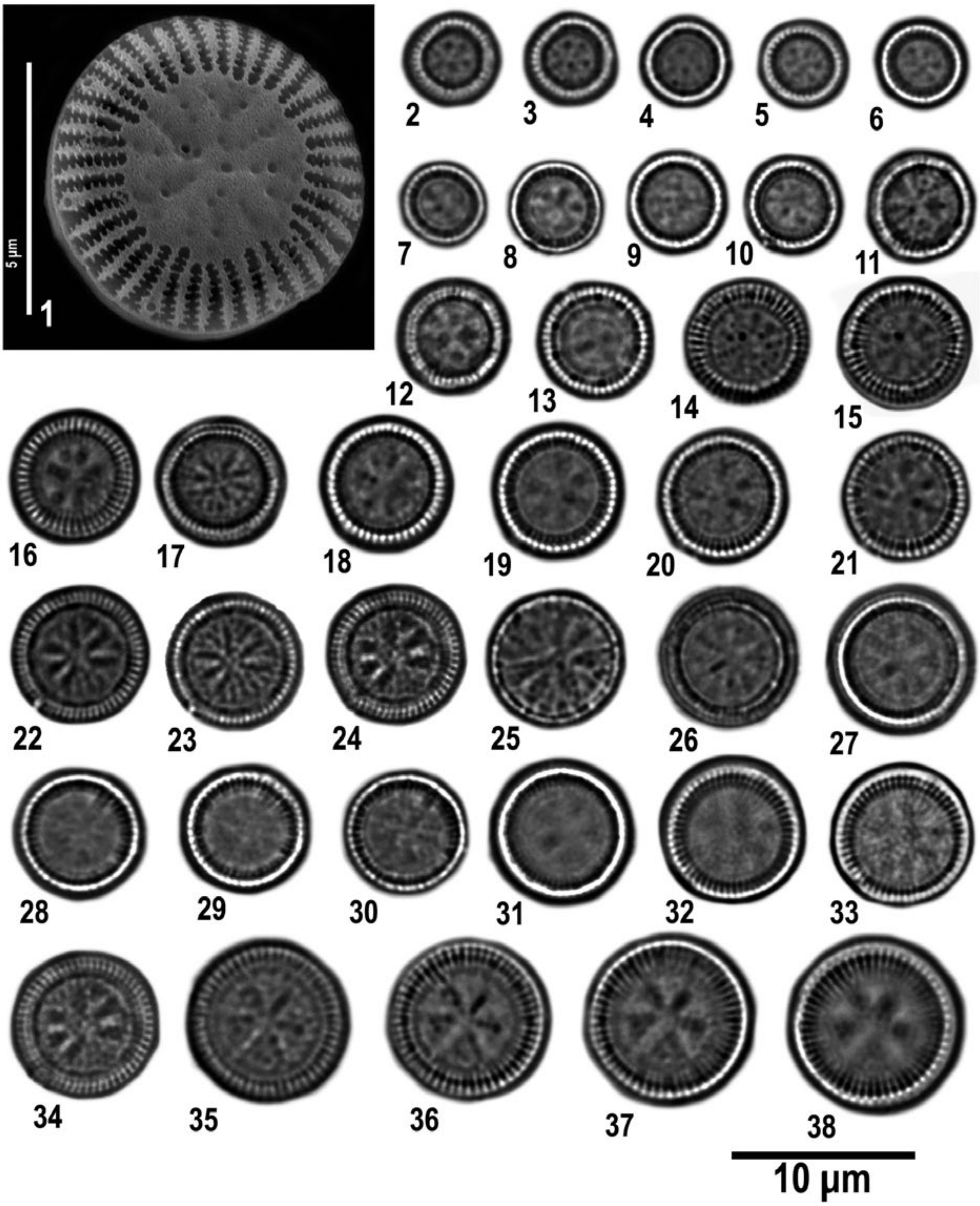

Plate 22: 1-38. *Pantocsekiella comensis* (Grunow) Kiss & E.Ács in Ács et al., 2016, Eemian deposits.

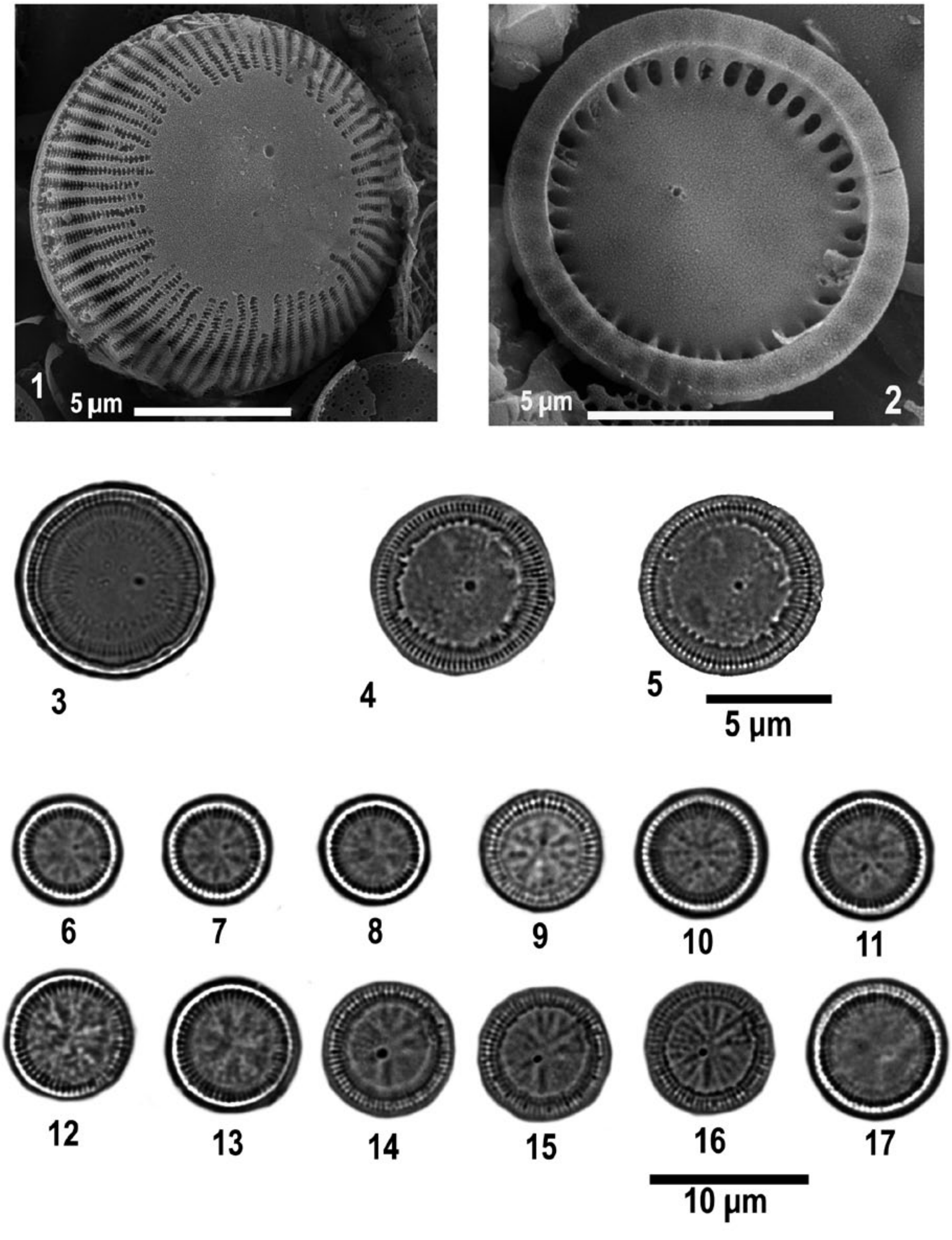

Plate 23: 1-5. *Pantocsekiella costei* (Druart & Straub) Kiss 2016, Eemian deposits; 6-17. *Pantocsekiella hinziae* (Houk, König & Klee) Kiss, Ector & Ács in Ács et al. 2016, Eemian deposits.

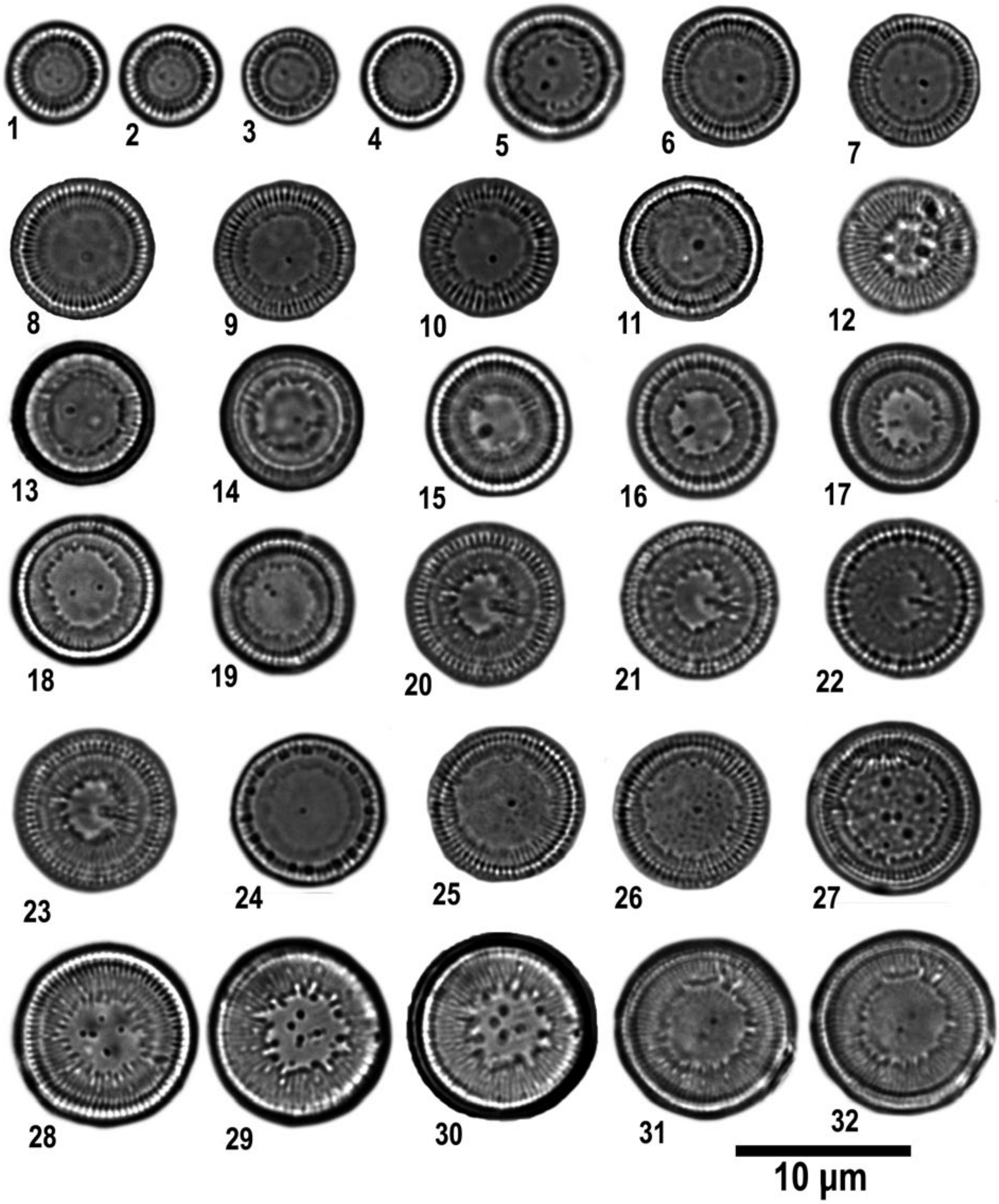

Plate 24: 1-32. *Pantocsekiella delicatula* (Hustedt) Kiss & E.Ács in Ács et al. 2016, Eemian deposits.

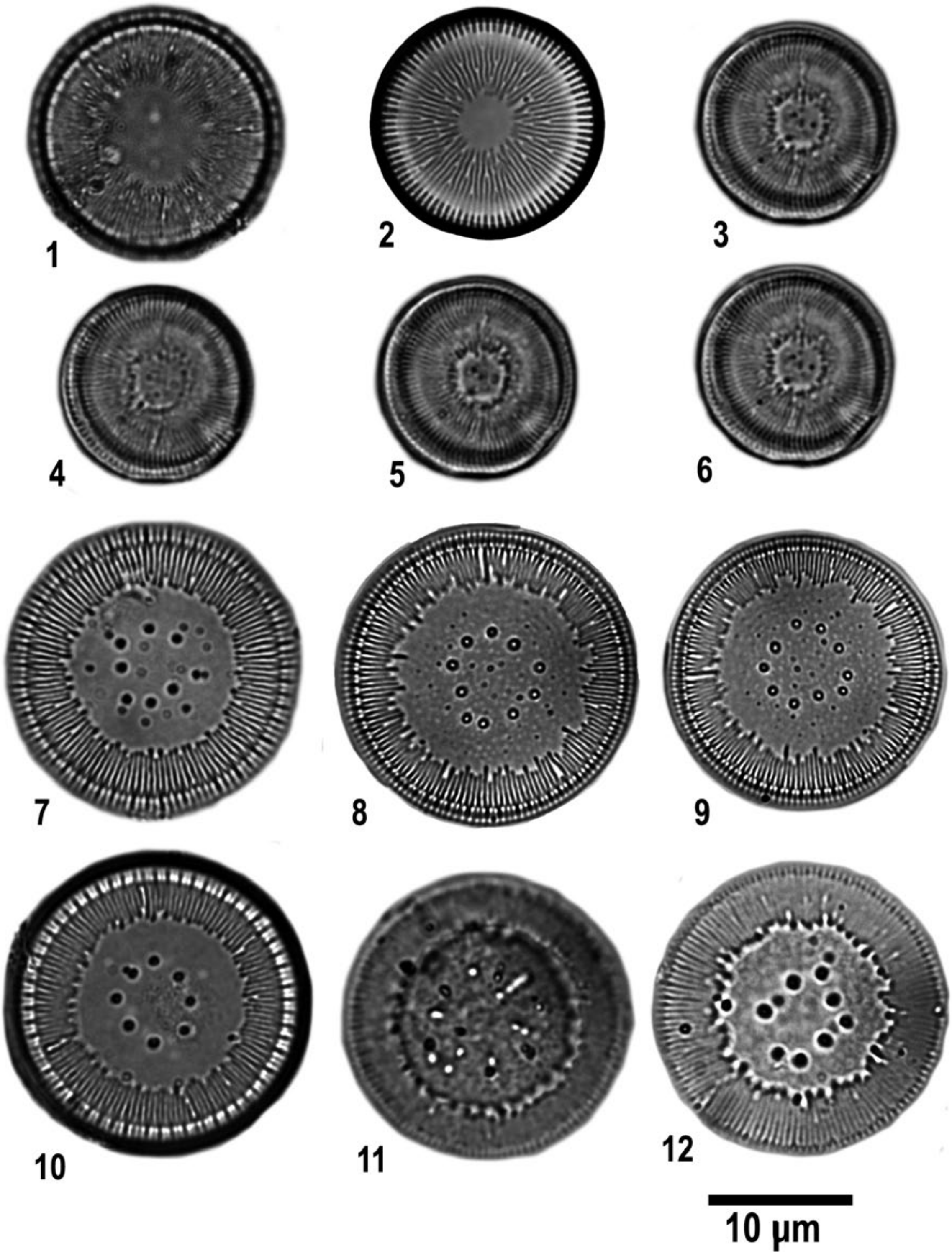

Plate 25: 1-6. *Pantocsekiella iranica* (Nejadsattari, Kheiri, Spaulding & Edlund) Kiss, Ector & Ács in Ács et al., 2016, Eemian deposits; 7-12. *Pantocsekiella kuetzingiana* (Thwaites) Kiss & Ács in Ács et al., 2016; 7-8. Młynek Lake, 9-12. Kamionka Lake.

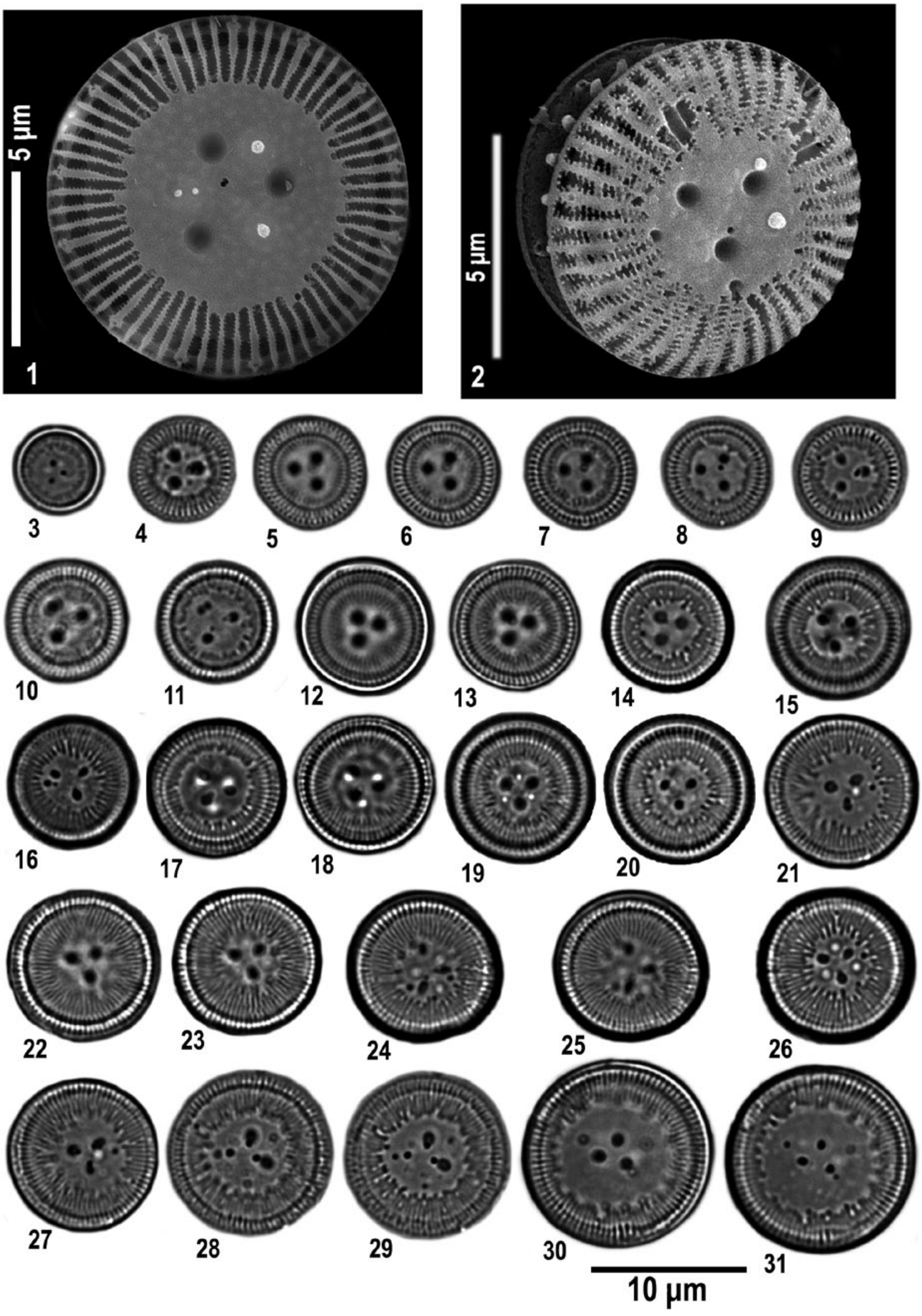

Plate 26: 1-31. *Pantocsekiella ocellata* (Pantocsek) Kiss & Ács in Ács et al., 2016, 1-9, 12-31. Eemian deposits; 10-11, Radomno Lake.

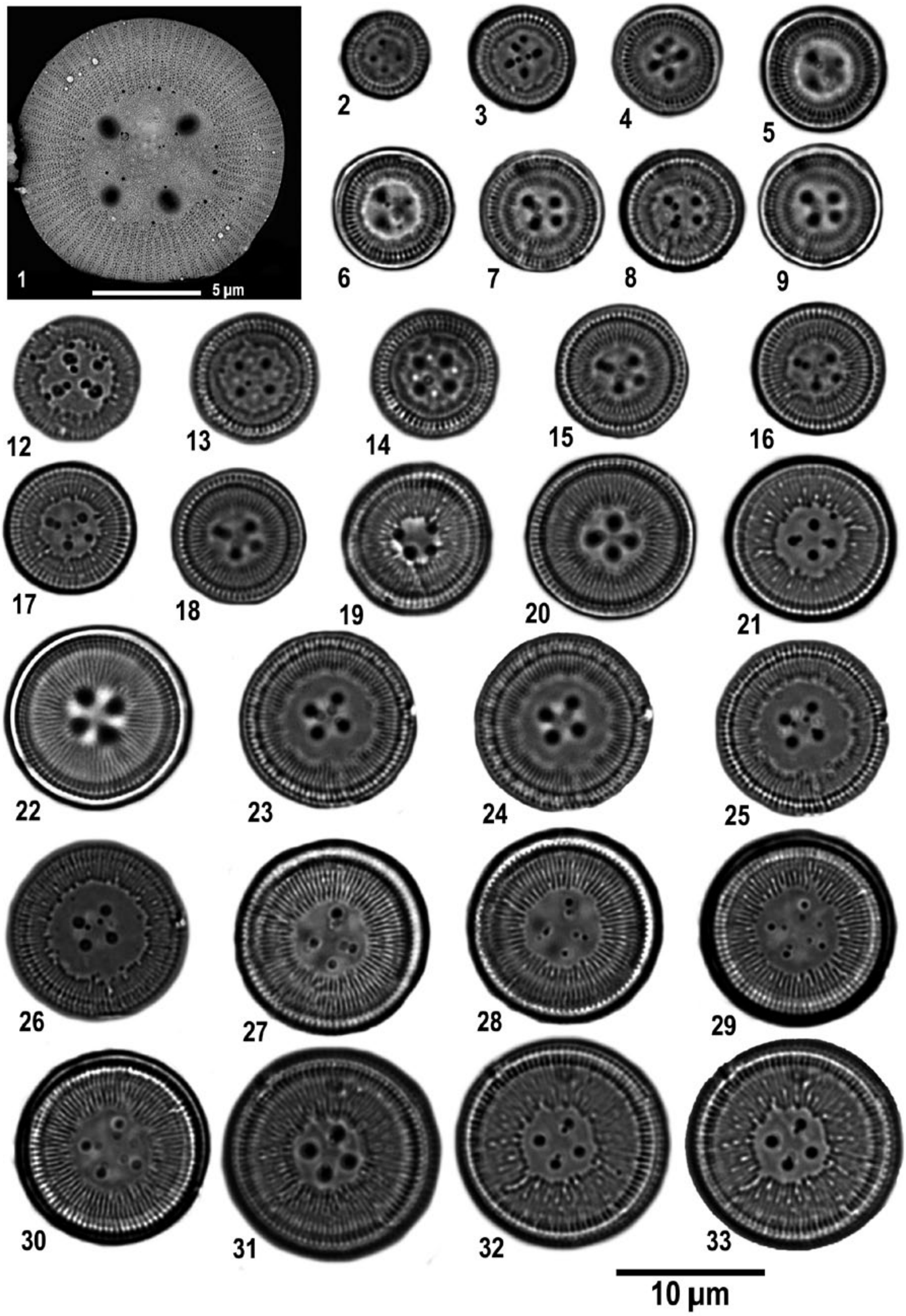

Plate 27: 1-33. *Pantocsekiella ocellata* (Pantocsek) Kiss & Ács in Ács et al., 2016, Eemian deposits.

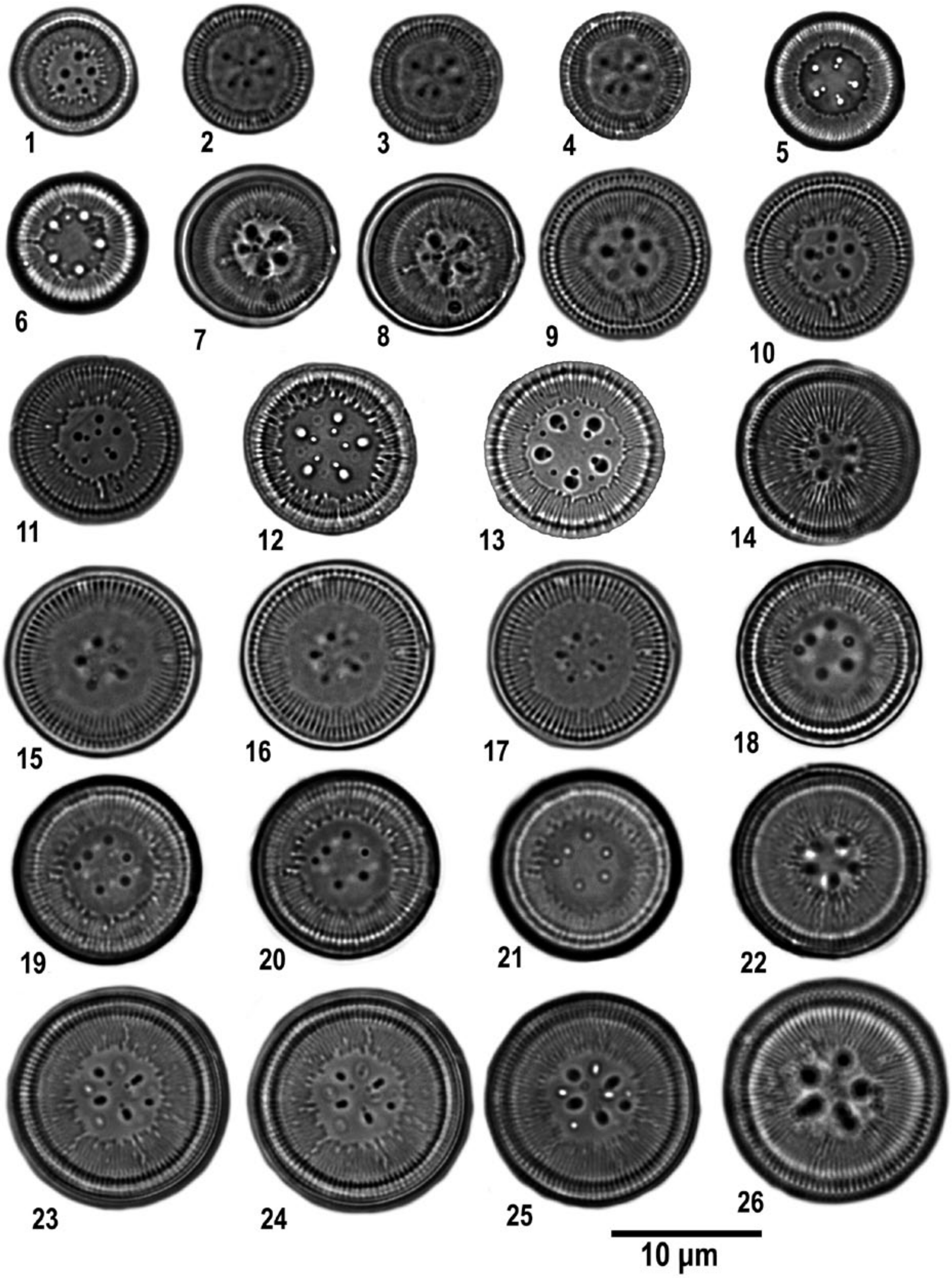

Plate 28: 1-26. *Pantocsekiella ocellata* (Pantocsek) Kiss & Ács in Ács et al., 2016, Eemian deposits.

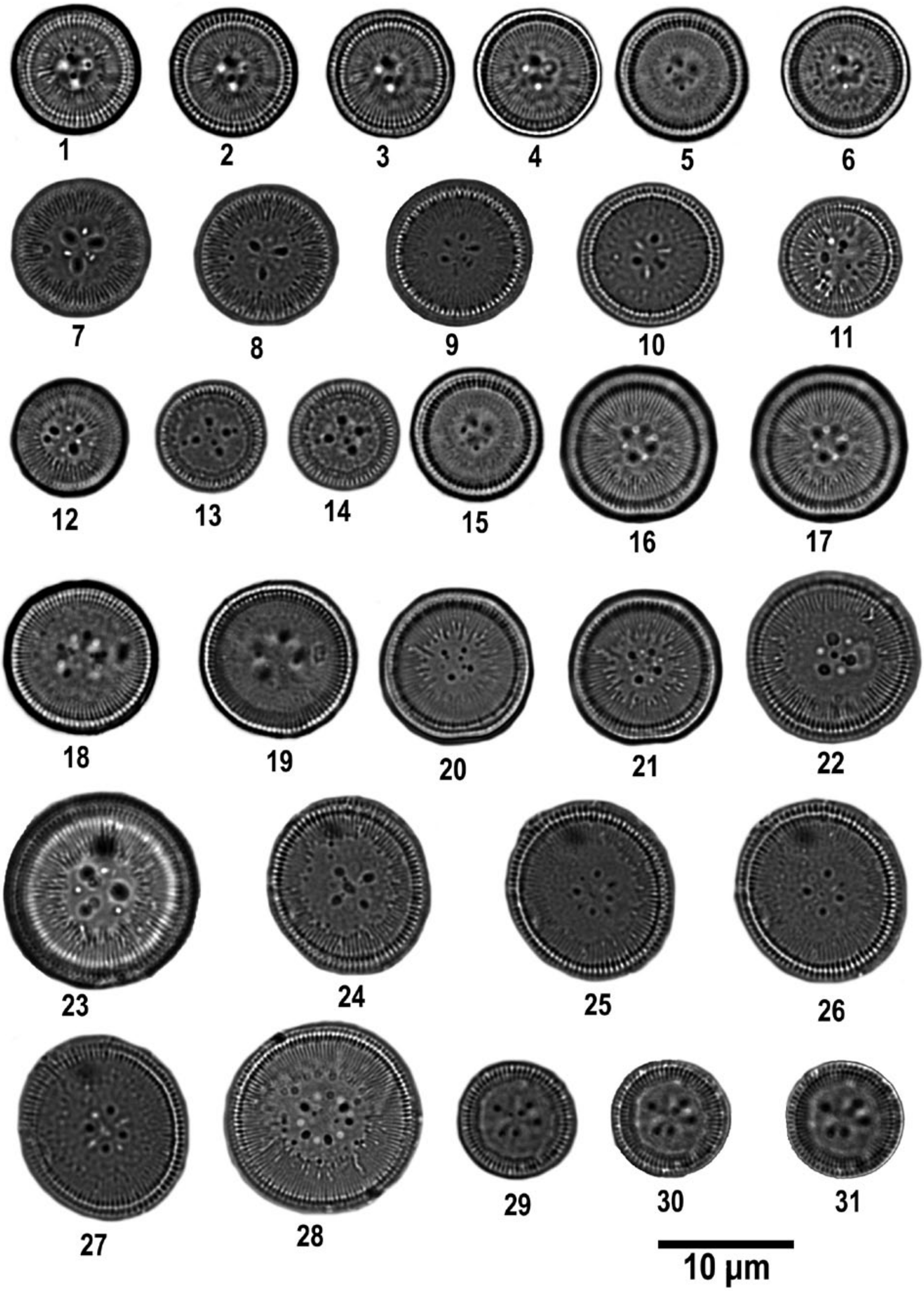

Plate 29: 1-28. *Pantocsekiella paraocellata* (Cvetkoska et al.) Kiss & Ács in Ács et al., 2016, Eemian deposits; 29-31. *Pantocsekiella paleo–ocellata* (Vossel & Van de Vijver) Kiss, Ector & Ács, 2016, Eemian deposits.

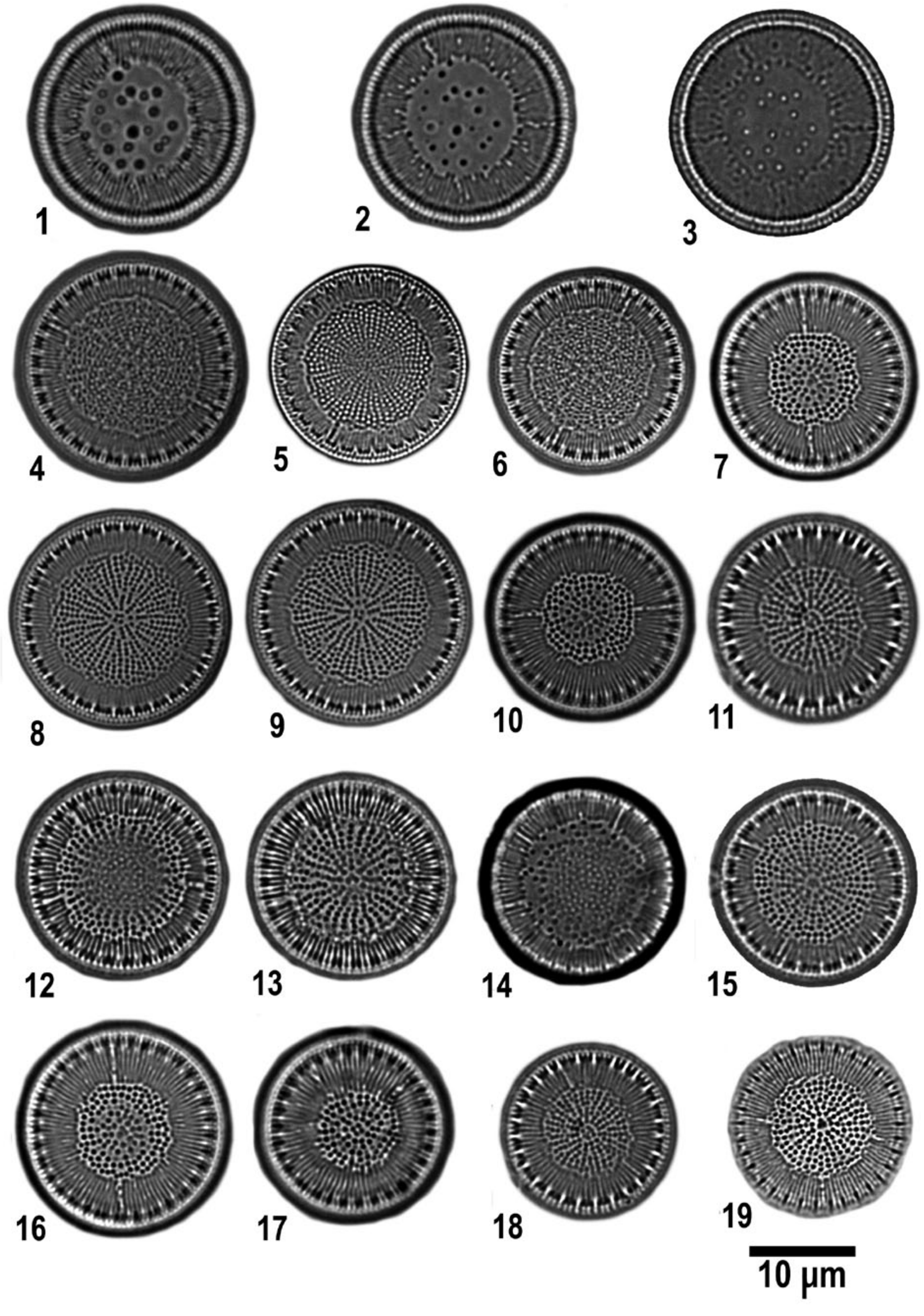

Plate 30: 1-3. *Pantocsekiella rossii* (Håkansson) Kiss & Ács 2016, Eemian deposits; 4-19. *Puncticulata balatonis* (Pantocsek) Wojtal & Budzyńska 2011, 12. Jeziorak Lake; 4-6,8-9. Radomno Lake; 7, 10-11. Młynek Lake; 13-19. Eemian deposits.

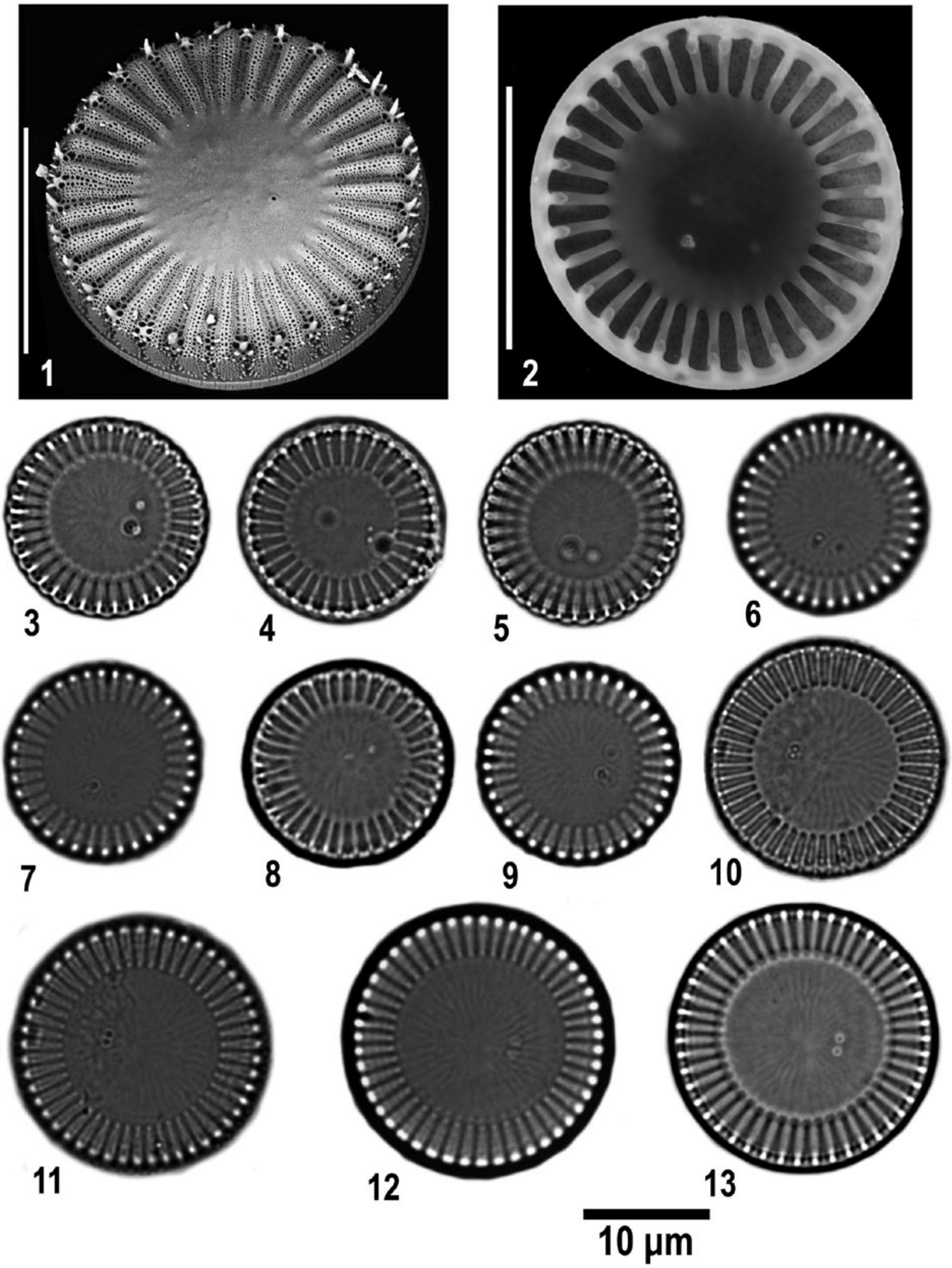

Plate 31: 1-13. *Stephanocyclus meneghiniana* (Kützing) Skabichevskii 1975, Radomno Lake.

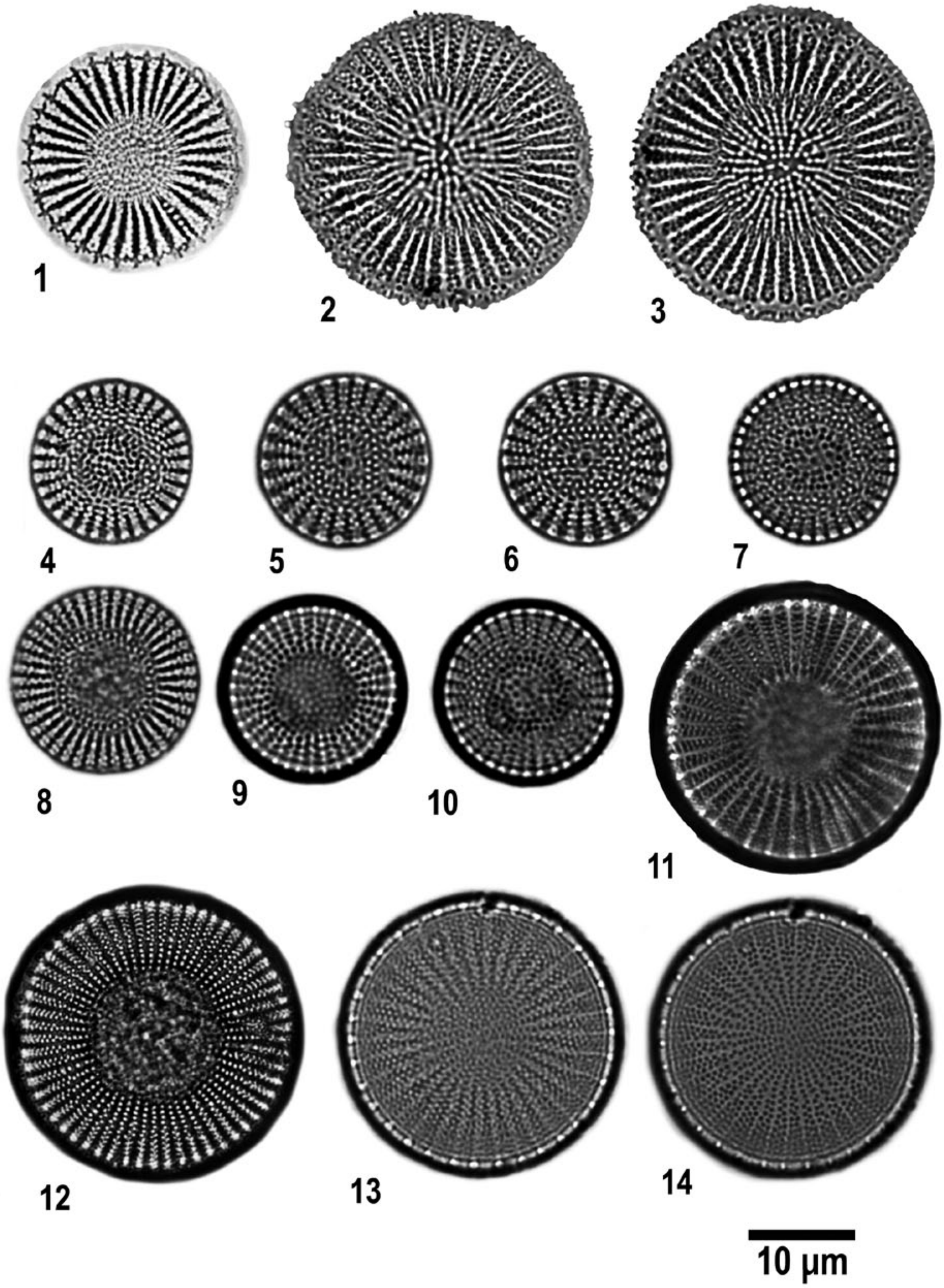

Plate 32. 1-3. *Stephanodiscus aegyptiacus* Ehrenberg 1854, Radomno Lake; 4-10. *Stephanodiscus agassizensis* Håkansson & Kling 1989; 4-6. Kamionka Lake, 7-10 Młynek Lake; 11-14. *Stephanodiscus alpinus* Hustedt in Huber-Pestalozzi 1942, Młynek Lake.

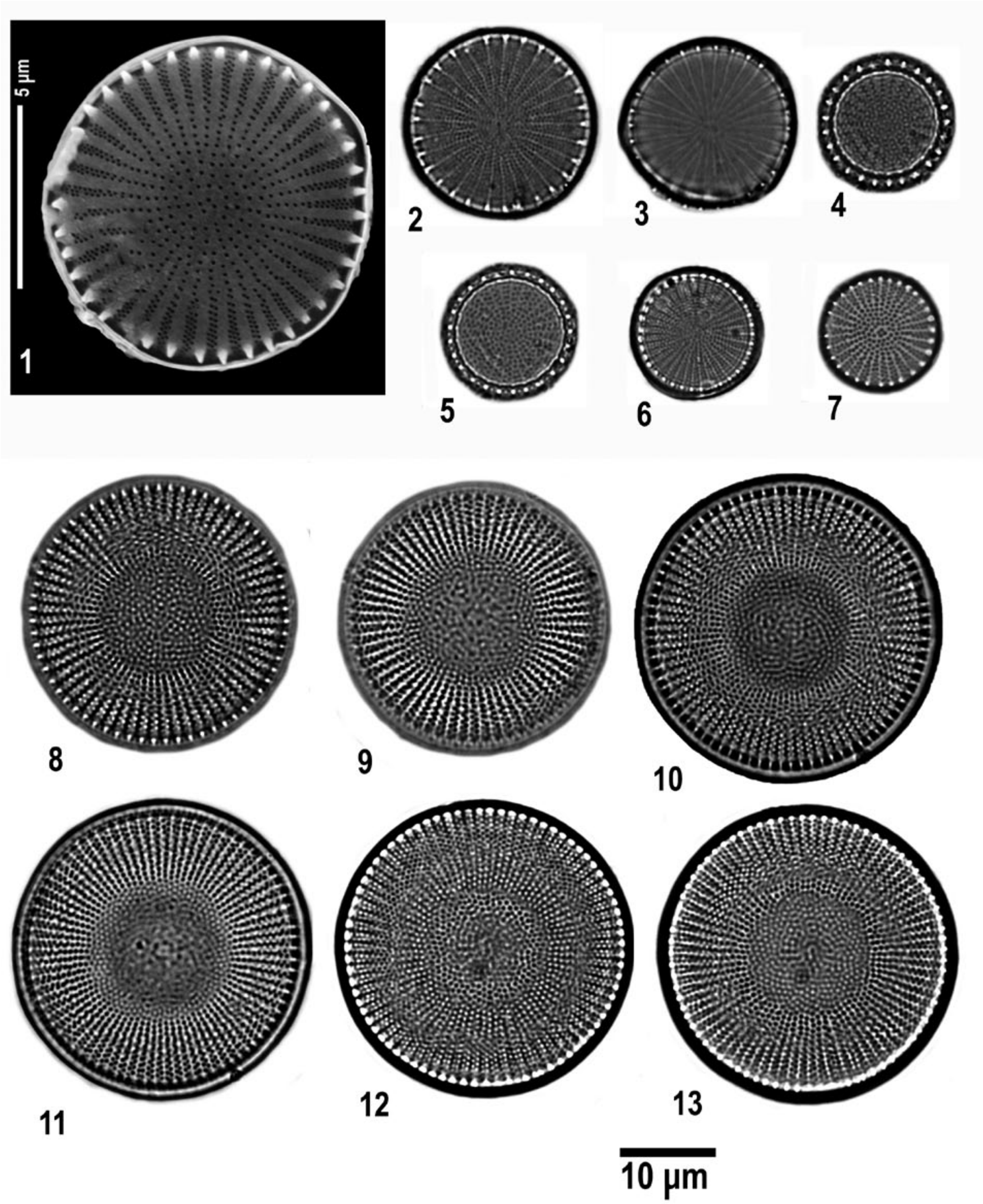

Plate 33. 1-7. *Stephanodiscus hantzschii* Grunow in Cleve & Grunow 1880, Mlynek Lake; 8-13. *Stephanodiscus neoastraea* Håkansson & Hickel 1986, Młynek Lake.

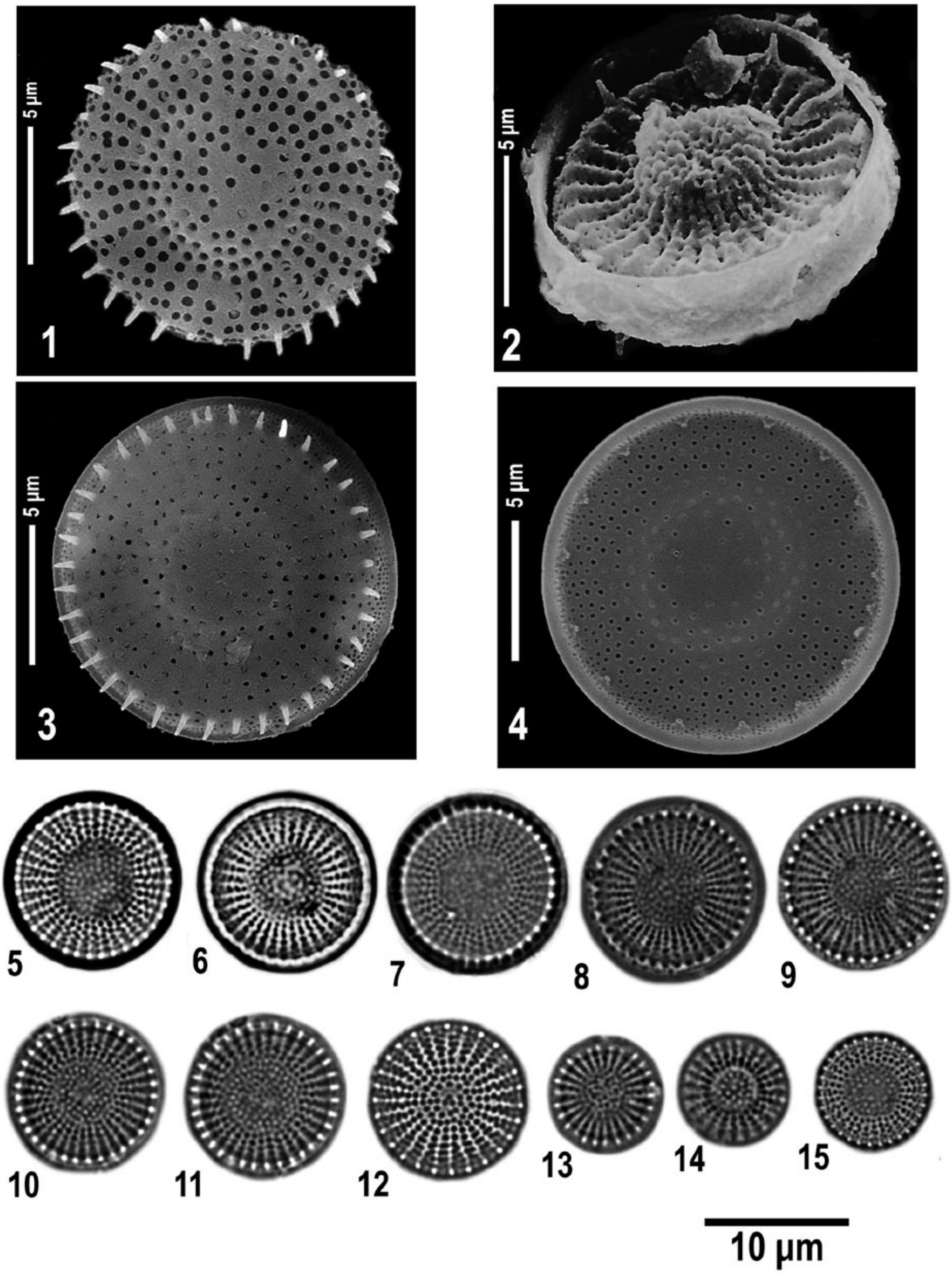

Plate 34: 1-12. *Stephanodiscus minutulus* (Kützing) Cleve & Möller 1882, 1-9. Eemian deposits, 10-12, Radomno Lake; 13-15. *Stephanodiscus medius* Håkansson 1986, Eemian deposits.

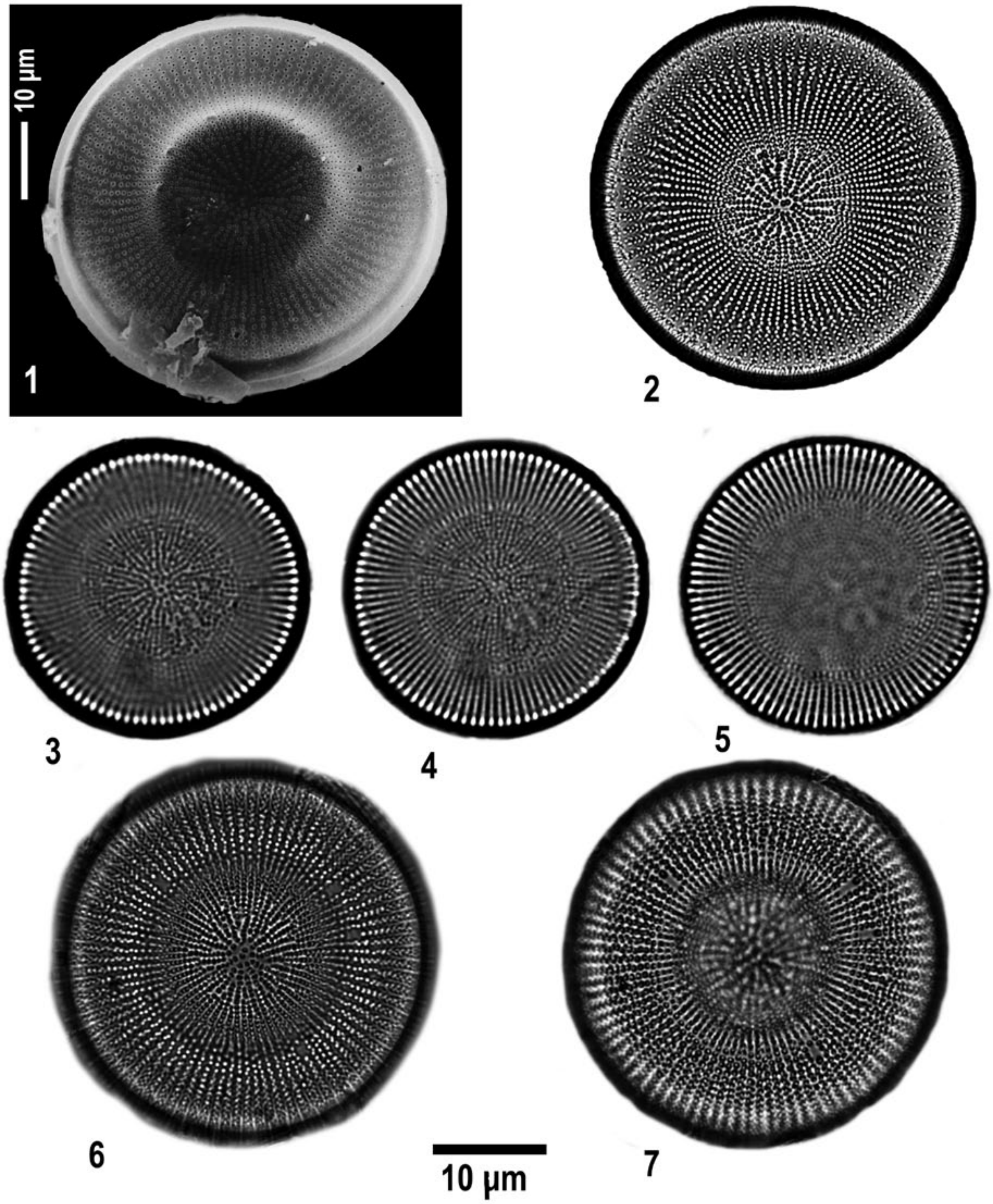

Plate 35: 1-7. *Stephanodiscus niagarae* Ehrenberg 1845, Eemian deposits.

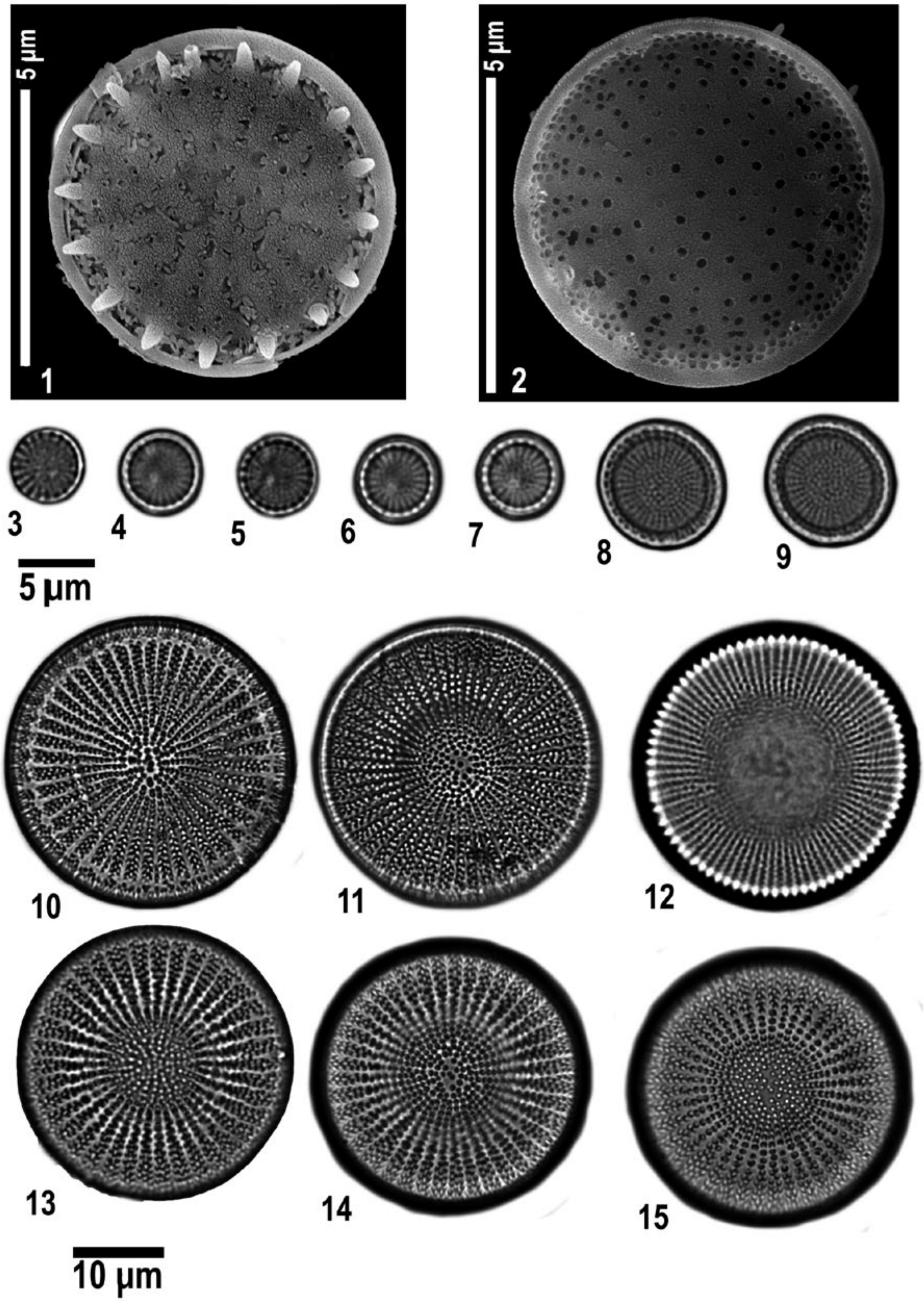

Plate 36: 1-9. *Stephanodiscus parvus* Stoermer & Håkansson 1984, 1-3. Eemian deposits; 4-7. Mlynek Lake; 8-9. Radomno Lake; 10-15. *Stephanodiscus rotula* (Kützing) Hendey 1964, 10-11. Młynek Lake; 12-15. Radomno Lake.

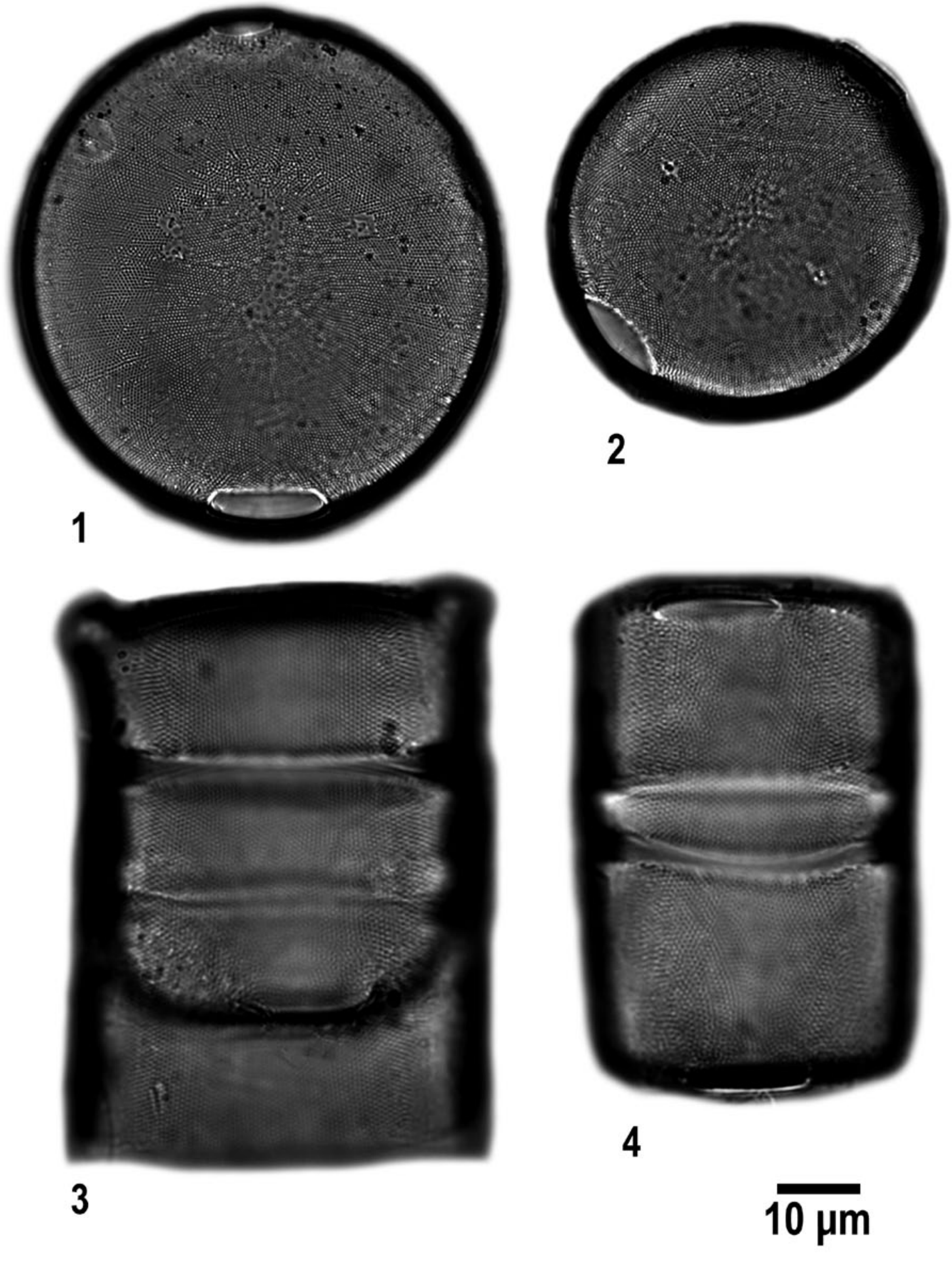

Plate 37: 1-4. *Pleurosira laevis* (Ehrenberg) Compère 1982, Kamionka Lake.

Class: Bacillariophyceae Haeckel, emend. Medlin & Kaczmarska 2004
Subclass: Fragilariophycidae Round 1990
Order: Fragilariales Silva 1962
Family: Fragilariaceae Greville 1833

Genus *Asterionella* Hassall 1850

Diagnosis: Valves are elongate, more or less linear with swollen apices. Striae are very fine, parallel and about 20-30 in 10 µm. Spines are arranged along the margins of the valve. Apical pore fields are present at both ends. The rimoportula is transversely oriented at either end of a valve opening externally via a pore. Several girdle bands, each with one or two rows of pores.

Holotype species *Asterionella formosa* Hassall 1850

***Asterionella formosa* Hassall 1850**

(Pl. 38, figs. 1-3)

Ref. Hustedt 1930, p.147, figs. 156-157; Patrick & Reimer 1966, p. 159, pl. 9, figs. 1-3; Germain 1981, p. 60, pl. 18, figs. 3-5; Ricard 1987, p. 222, fig. 581-582; Round et al. 1990, p. 350, figs. a-i; Krammer & Lange-Bertalot 1991 a, p. 103, pl. 103, figs. 11-9; pl. 104, figs. 9-10.

Status of name: accepted taxonomically

Synonym: *Asterionella gracillima* var. *formosa* (Hassall) Wislouch 1921

Diagnosis: Frustules forming star or rosette-shaped colonies. Valves are narrow-linear, with roundly capitate apices. The axial area is narrow and the central area absent. Transapical striae are very delicate, about 25-27 in 10 µm, often obscure on valves. Length of the valve 48-125 µm, and the breadth 1-3 µm.

Ecological preference: The species was observed in mesotrophic – eutrophic waters, and has generally been described as an indicator of eutrophic conditions (Hutchinson, 1967; Reynolds, 1984); it was dominant in the surface water under ice cover in the fjord regions of Canada (Chassé & Côté, 1991), and can grow even under more extremely alpine oligotrophy (Ilmavirta, 1975; Spaulding et al., 1993); oligotrophic natural freshwaters (Clerk et al., 2000); abundant in nutrient-enriched lakes (Bennion et al., 2000); it dominated the diatom populations with winter maximum in an oligo-mesotrophic lake of Northwest Spain (Negro et al., 2000); freshwater, periphytic on the macrophytes in the river (Bertolli et al., 2010); freshwater, Eu-mesotraphentic with pH:7.69-8.11 (Witak et al., 2017).

Occurrence: Infrequently in the late Holocene sediments of the Młynek Lake.

Distribution in Poland: The species is reported from the Late Quaternary sediments of Przedni Staw Lake (Polish Tatra Mountains) (Marciniak, 1986a); Mazovian Interglacial lake deposits, Krępiec, Lublin Upland, eastern Poland (Marciniak & Khursevich, 2002); the Mały Staw lake, in a post-glacial cirque in the northeastern part of Karkonosze Mts, west Poland (Sienkiewicz, 2005); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); from Górki Zachodnie and Swibno – Vistula River estuary in northern Poland (Majewska et al., 2012); Matysówka stream a right-bank tributary of Strug River, district of Tyczyn (Noga et al., 2013b); abundant in the lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

Genus *Ctenophora* Brebisson ex Kützing 1849

Diagnosis: Frustules are elongate, narrow. Valves are linear to linear-lanceolate with rounded to slightly capitate apices. The valve face is flat with uniseriate parallel striae. The axial area is very narrow. Central area distinct, reaching to margins of the valve.

Holotype species *Ctenophora pulchella* (Ralfs ex Kützing) Williams & Round 1986

***Ctenophora pulchella* (Ralfs ex Kützing) Williams & Round 1986**

(Pl. 38, figs. 4-5)

Ref. Hustedt 1930, p.160, fig. 187; Patrick & Reimer 1966, p. 146, pl. 6, figs. 10, 12; Lange-Bertalot 1980, p. 148, pl. 136, figs. 1-7; Germain 1981, p. 78, pl. 26, figs. 1-4; Williams & Round 1986, p. 330, figs. 53-61; Round et al., 1990, p. 372-73, fig. a-j; Krammer & Lange-Bertalot 1991 a, p. 148, pl. 135, figs. 1-7; Witkowski, Lange-Bertalot & Metzeltin 2000, p. 52, pl. 28, fig. 35; pl. 29, figs. 15-16.

Status of name: accepted taxonomically

Synonyms: *Exilaria pulchella* Ralfs ex Kützing 1844
Synedra pulchella (Ralfs ex Kützing) Kützing 1844
Synedra acicularis W. Smith 1853
Synedra smithii Ralfs in Pritchard 1861
Synedra pulchella var. *smithii* (Ralfs) Grunow in Van Heurck 1881
Synedra pulchella var. *abnormis* Machiati 1889
Fragilaria pulchella (Ralfs ex Kützing) Lange-Bertalot 1980

Diagnosis: Frustule in the girdle view is narrowed toward the ends of the valve. Valves are linear to lanceolate with slightly attenuated rostrate or slightly capitate apices. The axial area is linear, very narrow. The central area is distinct, slightly swollen, reaching to margins of the valve, rectangular to somewhat rounded. Transapical striae are distinctly punctate, parallel to sometimes slightly radiate at ends of the valve, about 12-14 striae in 10 µm. Length of the valve 50-140 µm, with a breadth of about 6-8 µm.

Ecological preference: This species is usually found in the freshwater of high mineral content, or slightly brackish water (Hustedt, 1959; Patrick & Reimer, 1966); It is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009); freshwater, periphytic on the macrophytes in the river (Bertolli et al., 2010).

Occurrence: Infrequently in the late Holocene sediments of Radomno Lake.

Distribution in Poland: The species is reported from Górki Zachodnie – Vistula River estuary in northern Poland (Majewska et al., 2012); Wisłok and Żołynianka rivers in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015)

Genus *Diatoma* Bory 1824

Diagnosis: Frustules are rectangular, broad at the end. Valves are elliptical to linear or lanceolate with rounded to swollen apices. The valve surface is flat, finely striate; striae are parallel at the center, becoming radiate towards the apices. The axial area is very narrow with an indistinct central area. Transapical costae are present, with a single rimoportula as a thickened area at one end of the valve. The outline of the girdle view is rectangular and girdle bands with two rows of pores.

Holotype species *Diatoma vulgaris* Bory 1824

***Diatoma ehrenbergii* Kützing 1844**

(Pl. 38, figs. 6-7)

Ref. Krammer & Lange-Bertalot 1991 a, p. 97, pl. 92, fig. 5; pl. 95, figs. 8- 14; Lange-Bertalot & Metzeltin 1996, p. 270, pl. 76, fig. 30; Wojtal et al., 1999, p. 170, fig.28.

Status of name: accepted taxonomically

Synonym: *Diatoma vulgaris* var. *ehrenbergii* (Kützing) Grunow 1862

Diagnosis: Valves are narrow and elongate becoming lanceolate in smaller valves. Apices are broadly rounded, sub-rostrate to capitate. Transapical striae are uniseriate, finely punctate, hardly visible in LM. Costae are mostly primary, about 10-13 in 10 µm. A single rimoportula is present, oriented perpendicular to the apical axis, near one of the apices. Apical porefields are present at each apex. Length of the valve 20-130 µm, with a breadth of about 5-9 µm.

Ecological preference: *Diatoma ehrenbergii* occurs in fresh to brackish water. It has been recorded in mesotrophic to eutrophic conditions and can occur in the plankton and benthic habitat. It prefers high pH, and occurs among other assemblages living in waters ranging from low to high oxygen concentrations, with moderately high to low levels of organic decomposition (oligosaprobic to beta-mesosaprobic) (Stoermer et al., 1971; Mills et al., 1993; Eulin & Le Cohu, 1998; Dere et al., 2002); low Water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH value 5.46–6.5 (Krizmanić et al., 2015).

Occurrence: Infrequently in the late Holocene sediments of Kamionka Lake**.**

Distribution in Poland: The species is recorded from small water bodies at H. Arctowski Polish Antarctic Station (Kawecka & Olech, 1998), from the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999); in the high mountain lakes under the stress of acidification (Tatra Mts, Poland)

(Kawecka & Galas, 2003); Matysówka stream a right-bank tributary of Strug River, district of Tyczyn (Noga et al., 2013); San (near Jarosław), Wisłoka (near Dębica) and Matysówka rivers in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016).

***Diatoma ehrenbergii* f. *capitulata* (Grunow) Lange-Bertalot 1993**

Ref: Lange-Bertalot 1993, p. 22, pl.3, figs.4-14

Status of name: accepted taxonomically

Synonyms: *Diatoma vulgaris* var. *capitulata* Grunow
Diatoma vulgaris f. *capitulata* (Grunow) Kurz 1922
Odontidium vulgare var. *capitulatum* (Grunow) Patrick 1939
Diatoma vulgaris f. *capitulata* (Grunow) Skabichevskii 1960

Diagnosis: Valves are linear-lanceolate to slight elliptical-lanceolate with capitate apices. The axial area is narrow, indistinct. Transapical striae are uniseriate, hardly visible in LM. Costae are about 8-10 in 10 µm. Apical porefields are present at the apex. Length of the valve 25-40 µm, with a breadth of about 5-8 µm.

Ecological preference: Low Water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH 5.46–6.5 (Krizmanić et al., 2015)

Distribution in Poland: The species is reported from the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al. 2016).

***Diatoma moniliformis* (Kützing) Williams 2012**

(Pl. 38, fig. 8)

Ref. Krammer & Lange-Bertalot 1991a, p. 98, pl. 92, fig. 6; pl. 96, figs. 11–21; Lange-Bertalot 1993, p. 166, figs. 9-16; Wojtal, 2009, p. 193, pl. 3, figs. 11–13; pl. 54, fig. 10; Williams 2012, p. 260, figs 3-5; Kheiri et al., 2018; p. 368**,** figs. 93–94.

Status of name: accepted taxonomically

Synonyms: *Diatoma tenuis* var. *moniliformis* Kützing 1833
Diatoma variabile var. *moniliforme* (Kützing) Rabenhorst 1847

Diagnosis: Frustules are narrow rectangular in girdle view. Valves are elliptical to lanceolate with rounded to subrostrate or slightly protracted apices. The axial area is very narrow. Transapical striae are very fine, may 40-50 in 10 µm. Transapical ribs about 8-11 in 10 µm. Apical pore fields are present at both apices. Length of the valve 10-35 µm, with a breadth of about 3-6 µm.

Ecological preference: The species favors the comparatively high ion contents as halophilous diatom or salt indicating taxon, abundant in spring in the running waters and brackish waters (Ziemann et al., 2001; Potapova & Charles, 2003); it inhabits inland and coastal waters, especially those with higher conductivity (Krammer & Lange-Bertalot, 1991a); it is also found in fresh and salt water, as well as the Baltic and arctic areas with high conductivity (Potapova & Snoeijs, 1997; Rumrich et al., 2000; Levkov et al., 2007; Pniewski & Sylwestrzak, 2018); it is observed in freshwater streams and lakes in arctic areas, in which the temperature of the water is below 10°C (Antoniades et al., 2005); benthic, freshwater, eutrophic, β-meso/oligosaprobic (Zgrundo et al., 2008); low Water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH 5.46–6.5 (Krizmanić et al., 2015); epilithic in the freshwater river with low conductivity and pH 6.2-8.5, (Kheiri et al., 2018).

Occurrence: Infrequently in the late Holocene sediments of Młynek Lake**.**

Distribution in Poland: The species is reported from recorded from the Gulf of Gdańsk (Zgrundo et al., 2008); Kobylanka stream, south Poland (Wojtal, 2009); most abundant in Górki Zachodnie and Swibno-Vistula River estuary in northern Poland (Majewska et al., 2012); Springs and riverhead stream sections in the upper part of the San river, south Poland (Żelazna-Wieczorek, 2012); Wisłok River and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga **et al., 2013d);** the Wisłoka, Ropa, Bielcza and San rivers, south eastern Poland (Noga, et al., 2014); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019).

***Diatoma polonica* Bąk et al. 2014**

Ref: Bąk et al. 2014, p. 115, figs 1a–w, 2a–f, 5a–h.

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view. Valves are elliptical, to elliptical-lanceolate, with obtusely rounded, rarely slightly protracted subcapitate apices. The axial area is very narrow. Primary transapical ribs are unevenly spaced, about 4-8 in 10 µm. Secondary ribs are irregularly intercalated, often not reaching the opposite valve margin. Length of the valve 10-35 µm, and the breadth 5–7 µm.

Distribution in Poland: The species was reported from Puck lagoon, SW Gulf of Gdańsk and the Vistula Lagoon, southern Baltic Sea, Poland (Witak, 2013); from the upland calcium carbonate-rich rivers: Kamienica Zabrzeska, Dunajec, and Ropa, which are belonging to the upper Vistula River system (Bąk et al., 2014).

***Diatoma tenuis* Agardh 1812**

(Pl.38, figs. 9-10)

Ref. Hustedt 1930, p. 127, fig. 111; Patrick & Reimer 1966, p. 109, pl. 2, fig. 6; Germain 1981, p. 52, pl. 14, figs. 1-10; Krammer & Lange-Bertalot 1991a, p. 97, pl. 96, figs. 1–9; Genkal 2004, p. 24, fig. 1.

Status of name: accepted taxonomically

Synonyms: *Diatoma tenue* Agardh 1824
Diatoma elongatum (Lyngbye) Agardh 1824
Candollella tenuis (Agardh) Gaillon 1833
Bacillaria tenuis (Agardh) Tomosvary 1879
Diatoma elongatum var. *tenuis* (*tenue*) (Agardh) Van Heurck 1882
Diatoma elongata var. *tenuis* (Agardh) Van Heurck 1885
Odontidium tenue (Agardh) Kuntze 1898
Odontidium elongatum var. *tenuis* (Agardh) Patrick 1939
Diatoma elongatum subsp. *tenuis* (Agardh) Skabichevskii 1960

Diagnosis: Valves are linear to linear-lanceolate with capitate apices. The axial area is very narrow. Transapical striae are very fine, delicate, about 40-50 in 10 µm. Transapical costae conspicuous, about 8-10 in 10 µm. A row of spines along the edge of valve face, leading to joining sibling cells. Length of the valve 30-100 µm and the breadth 3-5 µm.

Ecological preference: Oligohalobous-halophilous, alkaliphilous, most frequently occurring as a planktonic form (Foged, 1959). The species is observed in the periphyton and plankton of shallow brackish lakes of England (Moss, 1981); in lakes or standing waters with relatively high conductivity and it is classified as halophilic taxon (Ziemann et al., 2001); it was found widespread, euplanktonic, mesosaprobous, alkaliphilous and meso or eutraphentic species (Lange-Bertalot, 1979; Denys, 1991; Krammer & Lange-Bertalot,1991a; Hofmann, 1994; Van Dam et al., 1994); shallow warm freshwater lakes, pH value 6.9-7.7, low conductivity, alkalinity (meq L^{-1}) from 3.1-4.4 (Jasprica & Hafner, 2005); epiphytic taxon on leaf tissues of seagrasses (Chung & Lee, 2008); freshwater, mesotraphentic with pH value 7.69 – 8.11(Witak et al., 2017).

Occurrence: Frequently in the surface sediments of Jeziorak Lake**.**

Distribution in Poland: The species is reported from Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Diatoma vulgaris* Bory 1824**

(Pl. 38, figs. 11-12)

Ref. Hustedt 1930, p. 127, fig. 103; Patrick & Reimer 1966, p. 109, pl. 2, fig. 9; Germain 1981, p. 52, pl. 13, figs. 1-3; Round et al., 1990, p. 364, fig. a-j; Krammer & Lange-Bertalot 1991a, p. 95, pl. 93, figs. 1–12; pl. 94, figs. 1–13; pl. 97, figs. 3–5; Ehrlich 1995, p. 47, pl. 8, figs. 4-5; Hofmann et al., 2011, p. 175, pl. 3, figs. 20–25; Wojtal, 2009, p. 194, pl. 3, figs. 20–24.

Status of name: accepted taxonomically

Synonyms: *Diatoma vulgare* Bory 1831
Bacillaria vulgaris (Bory) Ehrenberg 1836
Diatoma vulgare var. *productum* Grunow 1862
Odontidium vulgare (Bory) Pfitzer 1871

Diatoma vulgaris var. *distorta* Grunow ex van Heurck 1882
Neodiatoma vulgare (vulgaris) (Bory) Kuntze 1891
Diatoma vulgaris f. *producta* (Grunow) A. Kurz 1922

Diagnosis: Frustules are rectangular in girdle view. Valves are elliptical to elliptical-lanceolate with broadly rounded subrostrate apices. The axial area is linear, very narrow. Transapical striae are uniseriate, very fine, about 45-50 in 10 µm, and enclosed between ribs of about 6-10 in 10 µm. One rimoportula is present at one valve apex. Apical pore fields are present at both apices. Length of the valve 25-55 µm, with a breadth of about 8-14 µm.

Ecological preference: Cosmopolitan, littoral form, especially in running water, oligohalobous-indifferent, alkaliphilous (Foged, 1959). The species is recorded from slightly flowing waters and often observed in fairly eutrophic waters, it was classified as differential taxon indicating β-mesosaprobic and oligohalobic (indifferent) taxon (Lange-Bertalot, 1979); cosmopolitan diatom, occurring in waters of moderate conductivity (Krammer & Lange-Bertalot, 1991a); tychoplanktonic, alkalibiontic, β-mesosaprobous, meso-eutraphentic, strictly aquatic and fresh brackish water species, it is characteristic of shallow, eutrophic lakes and often occurs in the littoral zone of lakes (Denys, 1991; Van Dam et al., 1994; Werner & Smol 2005); it is classified as an alkaliphilous species (Håkansson, 1993); it is classified as eutrophic species (trophic index of 4.4) (Hofmann, 1994); abundant in shallow warm freshwater lakes, pH value 6.9-7.7, low conductivity, alkalinity (meq L^{-1}) from 3.1-4.4 (Jasprica & Hafner, 2005). Eutraphents, β -α mesosaprobes (Zębek et al., 2012).

Occurrence: Infrequently in the late Holocene sediments of Kamionka and Francuskie Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species is reported from Vistula River (Starmach, 1938; Turoboyski, 1956, 1962; Kyselowa & Kysela, 1966; Uherkovich, 1970); Młynowka stream (Gumiński, 1947); fish ponds in Mydlniki (Siemińska, 1947); Pilica River (Cabejszek, 1951; Kadłubowska, 1964b); Sanka stream (Kądziołka, 1963); Prądnik River (Stępień, 1963); spring of Szklarka stream (Skalska, 1966a, b); springs of Kobylanka stream (Skalna, 1969); springs of Będkowka stream (Kubik, 1970); Kluczwoda stream (Nawrat, 1993); dominant the urban Lake Jeziorak Mały, within the Iława Lake District, north eastern Poland (Zębek, 2007); Kobylanka stream, south Poland (Wojtal, 2009); abundant on the periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012); Górki Zachodnie and Swibno – Vistula River estuary in northern Poland (Majewska et al., 2012); Matysówka stream a right-bank tributary of Strug River, district of Tyczyn and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b,d); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016).

***Diatoma vulgaris* var. *linearis* Grunow in Van Heurck 1881**
(Pl. 38, fig. 13)
Ref: Hustedt 1957, p. 224; Krammer and Lange-Bertalot 1991 a, p. 95, pl. 93, figs. 1-7.
Status of name: accepted taxonomically
Synonyms: *Odontidium vulgare* var. *linearis* (Grunow) Patrick 1939
Diatoma vulgaris f. *linearis* (Grunow) Hustedt 1957

Diagnosis: Valves are linear with slightly capitate valve apices and nearly parallel margins. The axial area is very narrow. Transapical striae are very fine, delicate, about 40-55 in 10 µm. Transapical costae conspicuous, about 7-10 in 10 µm. Length of the valve 45-110 µm and the breadth 4-5 µm.

Occurrence: Infrequently in the late Holocene sediments of Francuskie Lake and the surface sediments of Jeziorak Lake.

Distribution in Poland. Abundant on the periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012)

Genus *Fragilaria* Lyngbye 1819

Diagnosis: Frustules are rectangular in girdle view, usually forming linear colonies or some as growing singly. Valves are linear to elliptical with rostrate to capitate apices. Transapical striae are more or less evenly spaced.

At the valve center, the striae are often occluded, appearing as ghost structures. The axial area is narrow. An apical pore field is present, situated at the apices of the mantle.

Remarks: Williams and Round (1987) restricted *Fragilaria* to taxa that form colonies and have simple rows of areolae and a single rimoportula.

Lectotype species *Fragilaria pectinalis* (O.F. Müller) Lyngbye 1819

***Fragilaria acidoclinata* Lange-Bertalot & Hofmann in Lange-Bertalot 1993**

(Pl. 39, fig. 1)

Ref. Lange-Bertalot 1993, p. 41, pl. 14, figs 8-13; pl. 82, figs. 11-13; Potapova, 2014, p.77, fig.41

Status of name: accepted taxonomically

Diagnosis: Valves are linear to linear-lanceolate, with narrowly attenuate to rounded capitate apices. The axial area is linear, narrow to narrow-lanceolate. The central area is weakly unilaterally expanded. Transapical striae are parallel, distinctly coarsely dotted, about 11-13 striae in 10 µm. Length of the valve 33-60 µm and the breadth of about 3-4 µm.

Ecological preference: Freshwater environment.

Occurrence: Infrequently in the Holocene sediments of Radomno Lake.

Distribution in Poland. New record.

***Fragilaria amphicephaloides* Lange-Bertalot 2013**

(Pl. 39, figs. 2-5)

Ref. Lange-Bertalot 1991, p. 125, pl. 109, figs. 19-20; pl. 113, figs. 1-2; Lange-Bertalot & Metzeltin 1996, p. 270, pl. 76, fig. 4; Hofmann et al. 2013, p. 256, pl. 7, figs. 7-10; as *Synedra amphicephala* Kützing 1844; Hustedt 1959 a, p. 206, fig. 696 a; Patrick & Reimer 1966, p. 139, pl. 5, fig. 7.

Status of name: accepted taxonomically

Synonyms: *Synedra amphicephala* Kützing 1844
Fragilaria capucina ssp. amphicephala (Kütz.) Lange-Bertalot 1993.
Fragilaria amphicephala (Kützing) Lange-Bertalot 1991
Fragilaria capucina var. *amphicephala* (Kützing) Lange-Bertalot ex Bukhtiyarova 1995

Diagnosis: Valves are linear-lanceolate, with narrowly attenuate to capitate apices. The axial area is narrow. The central area is variable in shape, bilaterally or weakly unilaterally expanded. Transapical striae are parallel, mostly alternate, and may be absent from the central area, or ghost striae may be present, about 10-12 striae in 10 µm. Length of the valve 35-50 µm and the breadth of about 3-4 µm.

Ecological preference: Oligohalobous-indifferent, alkaliphilous, probably cosmopolitan littoral form (Foged, 1959). The species has been reported as *Synedra amphicephala* in warm alkaline freshwater with temperature 10.2-28.7 and pH value 7.22-8.35, low conductivity (Zalm, 2007); oligotrophic to mesotrophic lakes of the Alps and foothills of southern Germany, with few occurrences in rivers and the lowlands of northern Germany (Hofmann et al., 2013).

Occurrence: Infrequently in the Holocene sediments of Radomno Lake and the Eemian deposits of central Poland.

Distribution in Poland. It is recorded as *Fragilaria amphicephala* from Low-pH Lake Piaski in Western Pomerania, north-west Poland (Witkowski et al., 2011).

***Fragilaria austriaca* (Grunow) Lange-Bertalot in Krammer & Lange-Bertalot 2000**

(Pl. 39, figs. 6-7)

Ref. Krammer & Lange-Bertalot 1991a, p. 126, pl. 109, figs. 21–24; pl. 113, figs. 3–5; Wojtal, 2009, p. 208, pl. 2, fig. 7.

Status of name: accepted taxonomically

Synonyms: *Synedra austriaca* Grunow 1881
Synedra amphicephala var. *austriaca* (Grunow) Hustedt 1932
Fragilaria capucina var. *austriaca* (Grunow) Lange-Bertalot 1980

Diagnosis: Valves are narrow lanceolate to linear-lanceolate, with more or less capitate protruded apices. The axial area is very narrow, linear with variable central area. Transapical striae are parallel, alternated, about 11-14 in 10 µm. Length of the valve 25-32 µm and the breadth of about 3-4 µm.

Ecological preference: According to Van Dam et al. (1994), an alkaliphilous and fresh brackish water taxon.

Occurrence: Frequently in the Eemian deposits of central Poland.

Distribution in Poland: The species is recorded from Kobylanka stream, south Poland, in samples with filamentous algae above Kobylany (Wojtal, 2009); Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Matysówka stream a right-bank tributary of Strug River, district of Tyczyn (Noga et al., 2013b); Matysówka river in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016).

***Fragilaria capucina* Desmaziéres 1830**

(Pl. 39, figs. 8-10)

Ref. Hustedt 1930, p. 138, Fig. 126; Hustedt 1959, p. 144, fig. 659: 1-e; Patrick & Reimer 1966, p.118, pl. 3, fig. 5; Germain 1981, p. 64, pl. 19, figs. 1-19; Williams & Round 1987, p. 269, figs. 3-4, 7; Krammer & Lange-Bertalot 1991a, p. 121, pl. 108, figs. 1–8; Lange-Bertalot & Metzeltin 1996, p. 324, pl. 103, fig. 10; Wojtal, 2009, p. 210, pl. 2, figs. 8–13; pl. 52, figs. 5–7; Hofmann et al. 2011, p. 259, pl. 9, figs. 8–12.

Status of name: accepted taxonomically

Synonyms: *Fragilaria capucina* var. *capucina* Desmazieres 1830
Fragilaria capucina var. *lanceolata* Grunow in Van Heruck 1881
Synedra rumpens var. *familiaris* f. *major* Grunow in Van Heruck 1881
Synedra rumpens var. *acuta* (Ehrenberg) Rabenhorst 1864
Staurosira capucina (Desmazières) Comère 1892
Fragilaria capucina f. *lanceolata* (Grunow) Hustedt 1957

Diagnosis: Frustules are linear in girdle view, narrower towards the ends. Valves are linear to linear-lanceolate, attenuated toward swollen to subcapitate apices, and thicker at the central area. The axial area is linear, narrow. The central area is elliptical to rhombic or rectangular forming broad transverse fascia. Transapical striae are parallel, alternated, about 14-16 in 10 μm. Length of the valve 30-50 μm, and the breadth 4-6 μm.

Ecological preference: The species is widely distributed in freshwater lakes, ponds, or slow-flowing streams, it is a saproxenous and alkaliphilous taxon, observed from oligotrophic to slightly mesotrophic waters of low to circumneutral pH and low to moderate conductivity (Krammer & Lange-Bertalot, 1991a); tychoplanktonic, mesosaprobous, mesotrophic to eutrophic and a circumneutral species (Denys, 1991; Hofmann, 1994; Van Dam et al., 1994); an alkaliphilous diatom (Håkansson, 1993); develop in the widest temperature range (Zębek, 2007); Eutraphents, α-mesosaprobes (Zębek et al., 2012); it considered as a planktonic, benthic and terrestrial species in oligo-mesotrophic water (Delgado et al., 2015); low water temperature (6.4–12.5 °C), low Conductivity (213–302 μS cm–1) and pH value 5.46–6.5 (Krizmanić et al., 2015); freshwater, eu-mesotraphentic with pH value 7.69-8.11 (Witak et al., 2017); epiphytic diatom in the freshwater shallow lake, pH 8-9.5, eutrophic (Sanal & Demir, 2018).

Occurrence: Infrequently in the surface sediments of Jeziorak Lake and frequently in the Eemian deposits of central Poland.

Distribution in Poland: The species is recorded from the Wyżyna Krakowskoczęstochowska Upland; Vistula River (Starmach, 1938; Turoboyski, 1962; Kyselowa & Kysela, 1966); Młynowka stream (Gumiński, 1947); fish ponds in Mydlniki (Siemińska, 1947); Sanka stream (Kądziołka, 1963); Prądnik River (Stępień, 1963); Pilica River (Kadłubowska, 1964b); springs of Kobylanka stream (Skalna, 1969); from the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); dominant the urban Lake Jeziorak Mały, within the Iława Lake District, north eastern Poland (Zębek, 2007); Dąbrówka water body in the central part of the Wielkopolska region (Oborniki district), western Poland (Celewicz-Gołdyn & Kuczyńska-Kippen, 2008); lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); Kobylanka stream, south Poland. Fairly common in samples with filamentous algae and mud (Wojtal, 2009); from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); from Low-pH Lake Piaski in Western Pomerania, north-west Poland (Witkowski et al., 2011); Swibno- – Vistula River estuary in Northern Poland (Majewska et al., 2012); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); abundant on the periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012); Matysówka stream a right-bank tributary of Strug River, district of Tyczyn and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); Holocene sediments from SW Gulf of Gdańsk and the Vistula Lagoon, the southern Baltic Sea (Witak, 2013); Springs of the high-mountain habitats in southern Poland (Tatra Mts) West Carpathians, south Poland (Wojtal, 2013); Holocene sediments of

Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Fragilaria cassubica* Witkowski & Lange-Bertalot 1993**

Ref: Witkowski & Lange-Bertalot 1993, p. 65, fig. 4a-m; Witkowski et al. 2000, p. 49, pl. 24, figs. 28-31.

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular to wedge-shaped in girdle view. Valves are linear-elliptical, with an obtusely rounded head and elongated foot pole. The axial area is very narrow and linear. Transapical striae are parallel throughout the valve, about 16-18 in 10 µm. Length of the valve 14-20 µm, and the breadth 3-4 µm.

Ecological preference: Benthic, brackish-freshwater, β-mesosaprobic (Zgrundo et al., 2008)

Distribution in Poland: The species is reported from recorded from the Gulf of Gdańsk (Zgrundo et al., 2008); Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012); Puck Bay, Southern Baltic Sea, Poland (Witak, 2013).

***Fragilaria crotonensis* Kitton 1869**

(Pl. 40, figs. 1-8)

Ref. Hustedt 1930, p. 137, fig. 125; Hustedt 1959, p. 143, fig. 658; Patrick & Reimer 1966, p.121, pl. 3, figs. 11, 12; Germain 1981, p. 64, pl. 18, figs. 1-2; Williams & Round 1987, p. 269, figs. 1-2; Krammer & Lange-Bertalot 1991a, p. 130, pl. 116, figs. 1–5; Wojtal 2009, p. 210, pl 2, fig. 21; Peeters & Ector 2017, p. 184, figs.1-12.

Status of name: accepted taxonomically

Synonyms: *Fragilaria smithiana* Grunow in Van Heruck 1881
Synedra crotonensis (Kitton) Cleve and Möll. 1878
Synedra crotonensis var. *prolongata* f. *belgica* Grunow in Van Heruck 1881
Fragilaria crotonensis var. *prolongata* Grunow in Van Heruck 1885
Nematoplata crotonensis (Kitton) Kuntze 1898

Diagnosis: Frustules are linear in girdle view, swollen at the center, slender toward the ends. Valves are linear to linear-lanceolate with prominent swollen in the middle and somewhat capitate apices. The axial area is very narrow to indistinct. The central area is usually rectangular, extending to the margins of the valve. Transapical striae are parallel, about 16-18 in 10 µm. Rimoportula present at the valve pole. Length of the valve 40-170 µm, and the breadth at swollen portion 2- 4 µm.

Ecological preference: Cosmopolitan, worldwide in temperate freshwater lakes. The species is occurred in a broad ecological spectrum, mostly in slightly alkaline, oligotrophic to weakly mesotrophic waters (Krammer & Lange-Bertalot, 1991a); an alkaliphilous, β-mesosaprobous, mesotraphentic to eutrophic conditions, and fresh brackish water species (van Dam et al., 1994; Hofmann 1994); Huszar et al. (2003) reported high biomass of this species at a low water temperature (15°C) and Zębek (2007) reported the highest mean biomass of this species occurred at 16.5°C. Alkaliphilous, mesotrophic or eutrophic planktonic taxon (Kobayasi et al., 2006), it is considered to be tolerant and resistant to organic water pollution (Szczepocka & Szulc, 2009); freshwater, periphytic on the macrophytes in the river (Bertolli et al., 2010); epiphytic on macrophytes in shallow freshwater, pH 6.8-6.95 (Marra et al., 2016); freshwater, mesotraphentic and meso-oligotraphentic with pH:7.69-8.11 (Witak et al., 2017).

Occurrence: Infrequently in the late Holocene sediments of Młynek Lake, surface sediments of Jeziorak Lake and common in the Eemian deposits of central Poland.

Distribution in Poland: The species is reported from the Wyżyna Krakowsko- Częstochowska Upland, Pond in Mydlniki (Engelhorn, 1939); Vistula River (Turoboy ski, 1956, 1962; Kyselowa & Kysela, 1966; Uherkovich, 1970); Pilica River (Kadłubowska, 1964 b); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); dominant the urban Lake Jeziorak Mały, within the Iława Lake District, north eastern Poland (Zębek, 2007); Kobylanka stream, south Poland, sample from below Kobylany village (Wojtal, 2009); dominated in the Pilica River- Central Poland (Szczepocka & Szulc, 2009); Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Swibno-Vistula River estuary in northern Poland (Majewska et al., 2012); periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012); abundant in the lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska 2014); Wisłok, Zalew Rzeszowski, San (near Jarosław), Żołynianka rivers in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al. 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al. 2017).

***Fragilaria distans* (Grunow) Bukhtiyarova 1995**

(Pl. 39, figs. 11-15)

Ref: Krammer & Lange-Bertalot 1991, p. 109, fig. 16; Bukhtiyarova 1995, p. 417.

Status of name: alternate representation

Synonym: *Fragilaria capucina* f. *distans* Mayer, 1937
Fragilaria capucina var. *distans* (Grunow) Lange-Bertalot 1991
Synedra vaucheriae var. *distans* Grunow in van Heurck 1881

Diagnosis: Valves are linear to linear-lanceolate; attenuate toward rostrate-round apices. The axial area is linear, relatively narrow; with unilateral slight swelling in the central area. Transapical striae are parallel, about 10-12 in 10 μm and slightly shortened on the side opposite the swollen central area. Length of the valve 17-25 μm, and the breath 5-7 μm.

Remarks: This species is relatively similar to *Fragilaria capucina* Desmazières, 1830 and is considered in some literature as a synonym of *Fragilaria vaucheriae* (Kützing) Petersen 1938.

Occurrence: Frequently in the Eemian deposits of central Poland, infrequently in the late Holocene sediments of Radomno Lake and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species is reported from low pH- Piaski Lake, Western Pomerania in northwest Poland (Witkowski et al., 2011); Żołynianka stream, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015).

***Fragilaria gracilis* Østrup 1910**

(Pl. 39, figs. 16-19)

Ref. Østrup 1910, p. 190, pl. 5, fig. 117; Hustedt 1950, p. 456, pl. 36, fig. 3; Krammer & Lange-Bertalot 1991a, p. 123, pl. 111, figs. 1–3; pl. 113, figs. 22–26; Lange-Bertalot & Metzeltin 1996, p.55, pl. 7, figs. 8-12; Wojtal 2009, p. 212, pl. 2, fig. 22; Hofmann et al. 2011, p. 263, pl. 9, figs. 19-24; Lange-Bertalot & Ulrich 2014, p. 34, pl. 15, figs 1-10, 24; pl. 16, figs. 1-7.

Status of name: accepted taxonomically

Synonyms: *Fragilaria capucina* var. *gracilis* (Ostrup) Hustedt, 1950
Synedra rumpens var. *familiaris* (Kützing) Grunow 1881.

Diagnosis: Valves are linear-lanceolate, narrowed toward subcapitates to acute apices. The axial area is very narrow or indistinct. The central area is very weakly present, rectangular. Transapical striae are parallel along the valve margin, about 16-18 in 10 μm. Spines absent along valve margins. Rimoportula presents only on valve pole. Pore fields are well developed in both poles. Length of the valve 18-40 μm, and the breadth 2-3.5 μm.

Ecological preference: The species prefers oligosaprobic and oligotrophic to mesotrophic, slightly acidic to slightly alkaline waters, with low to moderate conductivity (Krammer & Lange-Bertalot, 1991a); a neutrophilous, oligosaprobous, oligo-mesotraphentic, and fresh brackish water species (Van Dam et al., 1994); it is classified as a circumneutral, fresh-brackish, eutrophic-mesosaprobic waters (Antón-Garrido et al., 2013); low water temperature (6.4–12.5 °C), low Conductivity (213–302 μS cm–1) and pH value 5.46–6.5 (Krizmanić et al., 2015); epiphytic on macrophytes in shallow freshwater, pH value 6.8-6.95 (Marra et al., 2016).

Occurrence: Frequently in the late Holocene sediments of Kamionka and Młynek Lakes and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species is recorded from the Wyżyna Krakowskoczęstochowska Upland. Kluczwoda stream (Nawrat, 1993); the high mountain lakes under the stress of acidification (Tatra Mts, Poland) (Kawecka & Galas, 2003); Zalew Szczeciński (Bąk et al., 2006); spring in Warta River valley (Żelazna-Wieczorek & Mamińska, 2006); Kobylanka stream, south Poland, and samples with filamentous algae from Spring (Wojtal, 2009); from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Matysówka stream a right-bank tributary of Struga River, district of Tyczyn, and Duszatyńskie Lakes, and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); spring at the Goprowska Pass (Bieszczady National Park), south eastern Poland (Żelazna-Wieczorek & Knysak 2017).

***Fragilaria imbramoviciana* Kaczmarska 1976**

(Pl. 41, figs. 1-10)

Ref. Kaczmarska 1976, p. 236, fig. 2, 6a-c

Diagnosis: Valves are elongate with parallel margins to elongate-narrowly lanceolate with subrostrate rounded apices. The axial area is narrow, linear to slightly lanceolate. Central area absent. Transapical striae are distinct, parallel along with the valve to slightly radiate towards the apices, about 10-11 striae in 10 µm. Length of the valve 34-50 µm, and the breadth 4.5-6 µm.

Ecology: This species is recorded only in the fossil state.

Occurrence: Common in the Eemian deposits of central Poland.

Distribution in Poland: This species was recorded from the Eemian interglacial shallow lake deposits at Imbramowice near Wroclaw, SW Poland (Kaczmarska, 1976).

***Fragilaria improbula* Witkowski & Lange-Bertalot 1995**

(Pl. 41, figs. 11-15)

Ref: Witkowski, Lange-Bertalot & Witak 1995, p. 34, figs. 28-38

Status of name: accepted taxonomically

Diagnosis: Valves are linear-elliptic to elliptic-lanceolate with subrounded apices. The axial area is narrow, linear. Central area absent. Transapical striae are distinct, alternate, parallel along with the valve to slightly radiate towards the apices, about 14-15 in 10 µm. Length of the valve 10-14 µm, and the breadth 4.5-5.5 µm.

Occurrence: Infrequently in the late Holocene sediments of Kamionka Lakes and the Eemian deposits of central Poland.

Distribution in Poland: It is reported from Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012), Gulf of Gdańsk and Vistula Lagoon (Witak, 2013)

***Fragilaria incisa* (Boyer) Lange-Bertalot 1980**

Ref. Patrick & Reimer 1966, p. 142, pl. 5, figs. 14-15; Lange-Bertalot 1980, p. 748

Status of name: accepted taxonomically

Synonym: *Synedra incisa* Boyer 1920

Diagnosis: Valves are linear-lanceolate with attenuated apices, asymmetrical with one margin constricted near the middle of the valve and the other margin being irregular in outline. The axial area is narrow and the central area is transverse and variable in size. Transapical striae are parallel, distinct, about 18-20 in 10 µm. Length of the valve 23-50 µm, and the breadth 3-4 µm.

Distribution in Poland: Found in Jagielnia stream, Podkarpacie province, south Poland (Peszek et al., 2015)

***Fragilaria interstincta* Hohn & Hellerman 1963**

(Pl. 41, figs. 16-19)

Ref. Hohn & Hellerman 1963, p. 281, pl.1, fig.12

Status of name: accepted taxonomically

Diagnosis: Valves are short, lanceolate with acutely rounded to subrostrate apices. The axial area is narrow, linear, and central area absent. Transapical striae are robust, generally parallel, alternated, about 10-11 in 10 µm; Length of the valve 10-12 µm, and the breadth 2.5-3 µm.

Ecological preference: This species is reported as a benthic from shallow eutrophic, alkaline freshwater of Jeziorak and Młynek Lakes.

Occurrence: Frequently in the surface sediments of Jeziorak Lake and the late Holocene sediments of Młynek Lake.

Distribution in Poland. New record.

***Fragilaria lenoblei* Manguin 1952**

(Pl. 41, figs. 20-32)

Ref. Manguim 1952, p. 14, fig.14 a-d

Status of name: accepted taxonomically

Diagnosis: Valves are short, elliptic-lanceolate to ovoid or subrounded outline with broadly rounded apices. The axial area is extremely wide; the central area absent. Transapical striae are distinct, marginal, uniseriate, parallel at the center and radiate at the apices, about 12–14 striae in 10 µm. Length of the valve 5–10 µm, and the breadth 3.5–4 µm.

Ecological preference: This species is reported as a benthic from shallow eutrophic, slight alkaline, low to moderate polluted freshwater environment of Kamionka Lake.

Occurrence: Frequently in the late Holocene sediments of Kamionka Lake and the Eemian deposits of central Poland.

Distribution in Poland. New record.

***Fragilaria magocsyi* Lacsny 1916**

(Pl. 42, figs. 4-6)

Ref. Lacsny 1916, p. 167, fig. 8 a, b; Hustedt 1932, p. 170, fig. 677; Proschkina-Lavrenko 1950, p. 42

Status of name: accepted taxonomically

Diagnosis: Valves are linear-lanceolate with slight biconstricted and distinct rostrate apices. The axial area is broadly lanceolate. Transapical striae are uniseriate, parallel in the middle to slightly radiate towards the apices, about 15-17 striae in µm 10. Length of the valve 20-25 µm, and the breadth 4.5-5 µm.

Remarks: This species shows the same features of *Pseudostaurosira brevistriata* var. *nipponica* under the LM.

Occurrence: Infrequently in the late Holocene sediments of Młynek Lake.

Distribution in Poland. New record.

***Fragilaria microvaucheriae* Wetzel & Ector 2015**

(Pl. 42, figs. 1-3)

Ref. Wetzel & Ector 2015, p. 282, figs 107-142; Marra et al., 2016, p.8, figs. 29-30; Peeters & Ector 2017; p. 190-191, figs.1-25.

Status of name: accepted taxonomically

Diagnosis: Valves are lanceolate to rhombic-lanceolate with slightly rostrate to cuneate apices. The axial area is narrow, linear. The central area is large, unilateral. Transapical striae are coarse, uniseriate, radiate throughout the valve, about 12-14 in 10 µm. Length of the valve 6–23 µm, and the breadth 2.5–4 µm.

Remarks: This species may be confused with *Fragilaria rinoi* Almeida & Delgado 2016, *Fragilaria pectinalis* (Müller) Lyngbye 1819, *Fragilaria vaucheriae* (Kützing) Petersen 1938 and *Fragilaria perminuta* (Grunow) Lange-Bertalot 2000. However, Almeida & Delgado 2016 explained that the geometric morphometric analysis and the comparison revealed that *Fragilaria rinoi* is wider (4.2–5.6 µm vs 2.5–3.8 µm) than *Fragilaria microvaucheriae*.

Ecological preference: The species was present in poorly mineralized rivers with low conductivity (170-230 µS c m–1), acid to neutral pH (6.7-7.4) and low nutrient concentration **(**Wetzel & Ector, 2015; Peeters & Ector, 2017); epiphytic on macrophytes in shallow freshwater, pH value 6.8-6.95 (Marra et al., 2016).

Occurrence: Frequently in the surface sediments of Jeziorak Lake.

Distribution in Poland. New record.

***Fragilaria montana* (Krasske) Lange-Bertalot 1980**

Ref. Hustedt 1932, p. 204, fig. 694; Krammer & Lange-Bertalot 1991 a, p. 131, pl. 116, figs. 6-7.

Status of name: accepted taxonomically

Synonym: *Synedra montana* Krasske ex Hustedt 1932

Diagnosis: Frustules in girdle view are very narrowly linear for most of their length, abruptly expanded near the center. Valves are very narrow except at the expanded central portion, more or less constricted at the center, with subcapitate ends. The axial area is relatively broad, lanceolate with the absent central area. Transapical striae are distinct, about 12-14 in 10 µm. Length of the valve 100-150 µm, and the breadth 3-4 µm at the center, 1.5-2 µm at the ends.

Occurrence: Recorded rare in the surface sediments of Radomno Lake.

Distribution in Poland. found in Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012)

Fragilaria neointermedia **Tuji & Williams 2013**

(Pl. 42, figs. 7-11)

Ref. Tuji & Williams 2013, p. 7, fig. 28-42; Delgado et al. 2015, p. 12, figs. 132-149; Heudre et al. 2019, p. 336, fig.7.

Status of name: accepted taxonomically

Synonym: *Fragilaria intermedia* sensu Grunow in Van Heurck 1881

Diagnosis: Valves are lanceolate, narrowing toward rostrate, acutely rounded apices. The axial area is linear, narrow. The central area is represented to one side of the valve. Transapical striae are parallel or slightly radiate, about 9-10 in 10 µm. One rimoportula is situated on valve face–mantle junction Valve length 25–35 µm, width 3.5–4.5 µm.

Remarks: This species is recorded as *Fragilaria vaucheriae* or *Fragilaria intermedia* in several literature.

Ecological preference: It is reported as *Fragilaria intermedia* sensu Grunow in warm alkaline freshwater with temperature 10.2-28.7 and pH value 7.22-8.35, low conductivity (Zalm, 2007). It is reported as a benthic from the shallow, eutrophic, alkaline freshwater environment of studied lakes.

Occurrence: Infrequently in the surface sediments of Jeziorak Lake, the late Holocene sediments of Radomno Lake, and frequently in the Eemian deposits of central Poland.

Distribution in Poland. New record.

Fragilaria pararumpens **Lange-Bertalot, Hofmann & Werum 2011**

(Pl. 42, fig. 14)

Ref: Hofmann et al. 2011, p. 269, pl. 8: figs 4-10**;** Heudre et al., 2019, p. 337, fig. 8.

Status of name: accepted taxonomically

Diagnosis: Valves are linear-lanceolate, with subcapitate acutely rounded apices. The axial area is relatively narrow, linear-lanceolate. The central area is weakly present, elliptic to rectangular. Transapical striae are parallel to slightly radiate close to the apices, about 16-18 striae in 10 µm. Rimoportula is present only on the valve pole. Length of the valve 25-50 µm, and the breadth 3-4 µm.

Ecological preference: Freshwater species observed in weak alkaline or alkaline springs with prevalent anions of carbonate and bicarbonate and high temperatures (Leira et al., 2017)

Occurrence: Infrequent in the late Holocene sediments of Radomno Lake.

Distribution in Poland. The species was reported from Duszatyńskie Lakes, and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); Żołynianka and Jagielnia streams, in the territory of the Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); Spring at the Goprowska Pass (Bieszczady National Park), south eastern Poland (Żelazna-Wieczorek & Knysak, 2017).

Fragilaria parva **(Grunow) Tuji & Williams 2008**

(Pl. 42, fig. 12-13)

Ref. Tuji & Williams 2008, p. 29, figs 13-28; Marra et al. 2016, p.3, figs.40-43.

Status of name: accepted taxonomically

Synonym: *Synedra familiaris* f. *parva* Grunow 1881

Diagnosis: Valves are linear-lanceolate, with narrowly attenuate to capitate apices. The axial area is narrow, linear-lanceolate. The central area is bilaterally or weakly identified. Transapical striae are parallel, distinctly alternate, and may be absent from the central area, about 14-16 striae in 10 µm. Length of the valve 30-45 µm and the breadth of about 2.5-3 µm.

Ecological preference: Epiphytic on macrophytes in shallow freshwater, pH 6.8-6.95 (Marra et al., 2016). It is reported as a benthic from the shallow, eutrophic, alkaline freshwater environment of studied Radomno and Jeziorak lakes.

Occurrence: Frequently distributed in the late Holocene sediments of Radomno and Jeziorak Lakes.

Distribution in Poland. New record.

Fragilaria perdelicatissima **Lange-Bertalot & Van de Vijver 2014**

(Pl. 42, fig. 15-17)

Ref. Lange-Bertalot & Ulrich 2014, p. 19, pl. 7, figs. 11-14; pl. 8, figs. 1-14.

Status of name: accepted taxonomically

Diagnosis: Valves are needle-like, linear, narrowly lanceolate with subcapitate to capitate acutely rounded apices. The axial area is relatively wide, linear-lanceolate; the central area is often offset to one side of the valve. Transapical striae are parallel to slightly radiate, alternated, about 15-17 in 10 µm. Length of the valve 50-85 µm, and the breadth 3 – 4 µm.

Ecological preference: Freshwater environment

Occurrence: Infrequently distributed in the Eemian deposits of central Poland.

Distribution in Poland. New record.

***Fragilaria perminuta* (Grunow) Lange-Bertalot 2000**

Ref: Krammer & Lange-Bertalot 1991b, p. 125, pl.109, figs. 1–5; Delgado et al. 2015, figs. 76–107; Kheiri et al., 2018, p.359, figs 15–16.

Status of name: accepted taxonomically

Synonyms: *Synedra perminuta* Grunow in Van Heurck 1881
Synedra vaucheriae var. *perminuta* (Grunow) Van Heurck 1885
Fragilaria vaucheriae var. *perminuta* (Grunow) Jørgensen 1948
Fragilaria capucina var. *perminuta* (Grunow) Lange-Bertalot 1991

Diagnosis: Valves are linear-lanceolate, with slightly rostrate apices. The axial area is narrow; the central area is strongly unilateral. Transapical striae are alternating, parallel to slightly radiate towards the apices, about 18-20 in 10 µm. Length of the valve 10-30 µm, and the breadth 3-3.5 µm.

Ecological preference: Freshwater species, oligo- to mesotrophic (Krammer & Lange-Bertalot, 1991), it prefers calcareous, meso- to eutrophic waters (Hofmann et al. 2011); epilithic in the freshwater river with low conductivity and pH value 6.2-8.5, (Kheiri et al., 2018).

Distribution in Poland. The species was reported from Duszatyńskie Lakes, south eastern Poland (Noga et al. 2013b); Holocene sediments in the SW Gulf of Gdańsk and the Vistula Lagoon, the southern Baltic Sea (Witak, 2013); Jagielnia stream, Podkarpacie province, south Poland (Peszek et al. 2015); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al. 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016).

***Fragilaria radians* (Kützing) Williams & Round** 1987

(Pl. 43, figs. 8-11)

Ref: Hustedt 1930, p.155, fig. 171; Skabichevskii 1960, p. 250, fig. 87a-b; Patrick & Reimer 1966, p. 137, pl. 5, fig. 4; Krammer & Lange-Bertalot 1991a, p. 122, pl. 109, figs. 17, 18.

Status of name: accepted taxonomically

Synonyms: *Synedra radians* Kützing 1844
Synedra splendens var. *radians* (Kützing) O'Meara 1875
Synedra acus var. *radians* (Kützing) Hustedt 1930
Synedra acus f. *radians* (Kützing) Hustedt 1957
Synedra acus subsp. *radians* (Kützing) Skabichevskii 1960
Fragilaria capucina var. *radians* (Kützing) Lange-Bertalot 1991

Diagnosis: Valves are narrowly linear, needle-shaped, gradually tapering to slightly rostrate acutely rounded apices. The axial area is very narrow, but distinct. Central area distinct with variable size, longer than wide, not reaching margins of the valve. Transapical striae are parallel throughout the valve, about 14-16 in 10 µm. Length of the valve 40-200 µm, and the breadth 2.5-4 µm.

Occurrence: Frequently distributed in the late Holocene sediments of Radomno and Zielone Lakes and Eemian deposits, central Poland.

Distribution in Poland: The species was recorded from Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019).

***Fragilaria recapitellata* Lange-Bertalot & Metzeltin 2009**

(Pl. 42, fig. 18)

Ref: Krammer & Lange-Bertalot 1991b, p. 124, pl.109, figs. 25–28; Metzeltin et al. 2009, p. 48; Delgado et al. 2015, figs 40–75; Kheiri et al., 2018; p.365, figs. 17–18.

Status of name: accepted taxonomically

Synonyms: *Synedra capitellata* Grunow 1881
Synedra vaucheriae var. *capitellata* (Grunow) Hustedt 1930
Fragilaria intermedia var. *capitellata* (Grunow) A. Cleve 1932
Fragilaria capitellata (Grunow) Petersen 1946
Fragilaria vaucheriae var. *capitellata* (Grunow) Ross 1947
Fragilaria capucina var. *capitellata* (Grunow) Lange-Bertalot 1991

Diagnosis: Valves are lanceolate with strongly apiculate apices. The axial area is relatively narrow and widens slightly near the central area. The central area is unilateral, often expanded just until the sternum. Transapical striae are alternate, parallel to slightly radiate towards the apices, about 14–16 in 10 µm. The rimoportulae occur near the poles. Length of the valve 20–30 µm, and the breadth 3-4 µm.

Ecological preference: A cosmopolitan species fairly common in alpha-mesosaprobic, eutrophic waters (Van Dam et al., 1994; Cantonati et al., 2017,); occurring frequently in high latitudes (Siberia, Alaska, Iceland) and temperate regions. Periphytic habitat in rivers and streams and lakes (Silva et al., 2010, Tremarin et al., 2014); often present in periphyton samples from lakes, rivers, and streams of temperate regions (Delgado et al., 2015); epilithic in the freshwater river with low conductivity and pH value 6.2-8.5, (Kheiri et al., 2018); oligotrophic waters, poor in nutrients, with slightly acid to circumneutral pH (6-6.85), and low conductivity (24-24.5 µS cm-1) (Silva-Lehmkuhl et al., 2019).

Occurrence: Infrequently in the surface sediments of Jeziorak Lake.

Distribution in Poland: it is reported as *Fragilaria capucina* var. *capitellata* (Grunow) Lange-Bertalot from Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, southern Poland (Wojtal et al., 2005).

***Fragilaria reicheltii* (Voigt) Lange-Bertalot 1993**

Ref: Lange-Bertalot 1993, p. 48; Echenique & Guerrero, 2004, p. 20-21, figs.1-9

Status of name: alternate representation

Synonyms: *Centronella reicheltii* Voigt 1902
Centronella rostafinskii Woloszynska 1922

Diagnosis: The valve is tri-radiate, with a discoidal to subtriangular center. The arms are 20- 35 µm long; their length is slightly unequal, the three arms being of different length or at least one of them shorter than the other two. The arms have a swelling at the basis and gradually taper towards capitate ends. The Axial area is narrow. The striae are parallel, about 22-30 in 10 µm.

Ecological preference: The species was regarded as a eurytopic organism inhabiting waters with different trophic levels; oligotrophic (Wojciechowski, 1964); slightly eutrophic (Marvan & Hindák, 1989), as well as eutrophic (Wysocka, 1959b); it has been reported often as a cosmopolitan planktonic component of limnetic environments (Wojciechowski, 1964; Krammer & Lange-Bertalot, 1991); acidic high-altitude extremely oligo-minerotrophic and ombrotrophic bogs as well as mountain and submontane springs and lowland eutrophic rivers (El-Shahed & Matuła, 2001).

Occurrence: Recorded infrequently in the sediments of Radomno Lake.

Distribution in Poland. The species was reported from small lakes near Gdańsk (Schultz, 1928); many lakes of the Pojezierze Mazurskie lakelands in northeast Poland (Wysocka, 1959a; Półtoracka, 1964; Chudyba, 1975, 1979) and in lakes of the Wielkopolska region (Dąmbska et al., 1978; Koczorowska & Wetula, 1984); Lublin district in eastern Poland (Wojciechowski, 1964); Karkonosze Mts, in the submontane area of the Sudety Mts and the lowland of Lower Silesia (El-Shahed & Matuła, 2001); Lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014).

***Fragilaria rhabdosoma* Ehrenberg 1832**

Ref. Krammer & Lange-Bertalot 1991a, p. 127. pl. 111, figs. 18-22; Metzeltin & Lange-Bertalot 1998, pl. 1, figs. 29, 30; Wojtal, 2009, p. 209, pl. 2, figs. 35, 36.

Status of name: accepted taxonomically

Synonyms: *Fragilaria bidens* Heiberg 1863
Staurosira bidens f. bidens Grunow in Cleve & Möller, 1877
Staurosira bidens (Heiberg) Grunow, 1882
Synedra rumpens var. *fragilarioides* f. *constricta* Hustedt 1937

Diagnosis: Frustules are rectangular in girdle view. Valves are linear-lanceolate, with rounded apices and swollen on each side of the central area. The axial area is narrow and linear. The central area is longer than broad, somewhat swollen. Transapical striae are almost parallel, about 14-17 in 10 μm. Length of the valve 15-35 μm, and the breadth at the swollen area 3-4 μm.

Ecological preference: The species is an oligo-mesotrophic taxon (Krammer & Lange-Bertalot, 1991); Euplanktonic (Denys, 1991); alkalophilous, β-mesosaprobous, eutraphentic and fresh brackish water taxon (Van Dam et al., 1994).

Occurrence: Recorded rare in the sediments of Młynek Lake.

Distribution in Poland: The species is reported from Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); the Kobylanka stream, south Poland (Wojtal, 2009); Lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); Wisłok river in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014)

***Fragilaria rumpens* (Kützing) Carlson 1913**

(Pl. 42, fig. 19)

Ref. Krammer & Lange-Bertalot 1991a, p. 122, pl. 109, figs. 16–21; pl. 110, figs. 1–6a; Lange-Bertalot & Metzeltin 1996, p. 132, pl. 7, figs. 17-20; Wojtal, 2009, p. 214, pl 2, figs. 19, 20; Tuji & Williams 2006 p.99, figs. 1-18; as *Synedra rumpens* Kützing 1844; Hustedt 1930, p. 156, fig. 175; Hustedt 1959, p. 207, fig. 697: a-b; Patrick & Reimer 1966, p. 143, pl. 5, fig. 19; Germain 1981, p. 82, pl. 28, figs. 22-30; Ehrlich 1995, p. 44, pl. 7, figs. 8-9.

Status of name: accepted taxonomically

Synonyms: *Synedra rumpens* Kützing 1844
Fragilaria capucina var. *rumpens* (Kützing) Lange-Bertalot 1991
Tabularia rumpens (Kützing) Aysel 2005

Diagnosis: Valves are linear-lanceolate, attenuated toward rostrate somewhat capitate or cuneate apices. The axial area is narrow, linear, widening near the central area. The central area is usually with distinct wide transverse fascia, longer than broad; sometimes irregular subfascial, striae shortened adjacent to the central area. Transapical striae are parallel in valve center, slightly radiate near the apices, alternated, about 14-16 in 10 μm. Marginal spines are irregular, located on the costae at the mantle-face junction. Length of the valve 25–45 μm, and the breadth 3– 4 μm.

Ecological preference: Cosmopolitan and common tychoplanktonic-benthic species, reported from many freshwater lakes, or ponds, or slow-flowing streams (Patrick & Reimer, 1966); a neutrophilous, oligo-mesotraphentic and fresh brackish water species (Van Dam et al., 1994); freshwater, periphytic on the macrophytes in the river (Bertolli et al., 2010); dilute waters of low alkalinity and ion concentration (Wojtal, 2013); Oligotrophic and oligo-mesotrophic conditions (Dembowska, 2014).

Occurrence: Infrequently in the Eemian deposits, central Poland.

Distribution in Poland: The species was reported from Fish ponds in Mydlniki (Siemińska, 1947); Vistula River (Turoboyski, 1962); Pilica River (Kadłubowska, 1964b); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Kobylanka stream, south Poland (Wojtal, 2009); from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); Springs of the high-mountain habitats in southern Poland (Tatra Mts) West Carpathians, south Poland (Wojtal, 2013); Lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); Spring at the Goprowska Pass (Bieszczady National Park), south eastern Poland (Żelazna-Wieczorek & Knysak, 2017).

***Fragilaria sinuata* Peragallo 1909**

(Pl. 43, figs. 1-2)

Ref. Patrick & Reimer 1966, p. 130, pl. 4, figs. 18-19

Status of name: accepted taxonomically

Diagnosis: Valves are linear with triundulate margins and attenuate-rostrate to subcapitate apices. Swelling in the middle portion of the valve is larger than near the apices. The axial area is distinct, becoming much wider toward the center of the valve to form an elliptical central area. Transapical striae are parallel to slight radiate, about 12-14 in 10 μm. Length of the valve 29-45 μm, and the breadth at the widest part 6-7 μm.

Occurrence: Frequently in the Eemian deposits, central Poland, and the late Holocene sediments of Kamionka Lake.

Distribution in Poland: New record.

***Fragilaria spectra* Almeida, Morales & Wetzel 2016**

(Pl. 43, fig. 12)

Ref. Almeida et al. 2016, p. 174, figs. 54-84

Status of name: accepted taxonomically

Diagnosis: Frustules are narrowly rectangular in girdle view. Valves are linear-lanceolate gradually narrowing towards the apices, which are acutely rounded. The axial area is narrow, linear-lanceolate. Central area broader, limited by short adjacent striae. Transapical striae very fine with indistinct areolae, alternate at the center of the valve, becoming opposite toward the ends, about 24-25 striae in 10 µm. Spines absent. Length of the valve 40–73 µm, and the breadth 1.5– 2.5 µm.

Ecological preference: This species observed as epiphytic and plankton, acidophilous, oligo- to mesotraphentic, with low pH and TP (Almeida et al., 2016)

Occurrence: Infrequently in Eemian deposits, central Poland.

Distribution in Poland: New record.

***Fragilaria spinarum* Lange-Bertalot & Metzeltin 1996**

Ref. Lange-Bertalot & Metzeltin 1996, p. 57, pl. 7: figs 33-35; Wojtal et al. 2005, pl. 2, fig.12.

Status of name: accepted taxonomically

Diagnosis: Valves are elliptic-lanceolate with acutely rounded apices. The axial area is linear-lanceolate to moderate lanceolate. The central area is absent. Transapical striae are alternate, parallel in the center to slightly radiate towards the apices, about 12-13 striae in 10 µm. Length of the valve 12–15 µm, and the breadth 4.5– 5.5 µm.

Ecological preference: The species Known from oligo-dystrophic Julma Ölkky Lake in Finland (Lange-Bertalot & Metzeltin, 1996)

Distribution in Poland: Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005).

***Fragilaria subconstricta* Østrup 1910**

(Pl. 43, fig. 3-5)

Ref. Østrup 1910, p. 192, pl. V [5], fig. 122; Heudre et al., 2019, p. 335, figs. 2-3; Kahlert et al., 2019, p. 18, fig. 7.

Status of name: accepted taxonomically

Synonyms: *Fragilaria tenuistriata* Østrup (Østrup 1910),
Fragilaria tenuistriata Østrup *sensu* Tuji & Williams (2008),
Fragilaria subconstricta Østrup *sensu* Tuji & Williams (2008).

Diagnosis: Valves are linear-lanceolate, with rostrate rounded apices. The valve face is flat, occasionally with a slight constriction at the valve center. The axial area is narrow, linear. The central area is rectangular, small to absent. Transapical striae are parallel, more or less alternating near central area, about 12–15 striae in 10 µm. Length of the valve 45–68 µm, and the breadth 3– 4 µm.

Remarks: According to Heudre et al., 2019, both of *Fragilaria subconstricta* and *Fragilaria tenuistriata* Østrup are very similar species. However, Tuji and Williams (2008) noted that *Fragilaria tenuistriata* and *Fragilaria subconstricta* cannot be separated under LM other than by the position of the rimoportula.

Ecological preference: This species occurs in a mesotrophic, slightly alkaline environment (Heudre et al., 2019).

Occurrence: Frequently distributed in the Eemian deposits, central Poland.

Distribution in Poland: Lake Wigry signed to the Wigierskie group, in Wigry National Park north-east Poland (Eliasz-Kowalska & Wojtal, 2020).

***Fragilaria taiaensis* Carter & Denny 1982**

(Pl. 43, fig. 6-7)

Ref. Carter & Denny 1982**,** p. 296, pl. 3, fig. 82.

International code: Valid

Diagnosis: Valves are linear with slightly undulate margins and broadly rounded apices. The axial area is linear to narrowly lanceolate. Transapical striae are parallel, alternate, about 8-9 in 10 µm. Length of the valve 22-25 µm, and the breadth width 5-6 µm.

Occurrence: Infrequently in the late Holocene sediments of Młynek Lake.

Distribution in Poland: New record.

***Fragilaria tenera* (W. Smith) Lange-Bertalot 1980**

(Pl. 43, fig. 13)

Ref. Williams & Round 1987, p. 269, fig. 9; Krammer & Lange-Bertalot 1991, p. 129, pl. 115, figs. 1-7; Lange-Bertalot & Metzeltin 1996, p. 132, pl. 7, figs. 1-5; Almeida et al., 2016, p. 168, figs. 2-22; Marra et al., 2016, p. 8, figs.35-37; *Synedra tenera* W. Smith; Hustedt 1930, p. 158, fig. 182; Hustedt 1959 a, p. 211, fig.703; Patrick & Reimer 1966, p. 137, pl. 5, fig. 5.

Status of name: accepted taxonomically

Synonym: *Synedra tenera* W. Smith 1856

Diagnosis: Frustules are rectangular in girdle view and wider at mid-valve. Valves are narrow, linear to linear-lanceolate, with attenuated subcapitate apices. The axial area is narrow, linear. The central area is expanded bilaterally with somewhat a distinct fascia. Transapical striae are distinct, alternating, parallel throughout the valve and extend midway onto the valve mantle, about 18-20 striae in 10 µm. Length of the valve 50-120 µm, and the breadth width 2.0-2.5 µm.

Remarks: Under LM *Fragilaria tenera* can be confused with species of the *Fragilaria neotropica* Almeida et al., 2016*, Fragilaria tenera* var. *lemanensis* Druart, Lavigne & Robert 2007 and *Fragilaria tenera* var. *nanana* (Lange-Bertalot) Lange-Bertalot & Ulrich 2014.

Ecological preference: This species was registered for oligo-mesotrophic environments (van Dam et al., 1994); epiphytic on macrophytes in shallow freshwater, pH 6.8-6.95 (Marra et al., 2016); freshwater, eutraphentic with pH value 7.69-8.11 (Witak et al., 2017); it occurred attached to the substrates in slightly acid to circumneutral pH (6-6.85), low conductivity (24-24.5 µS cm-1) and oligotrophic conditions (Silva-Lehmkuhl et al., 2019).

Occurrence: Frequently distributed in the late Holocene sediments of Radomno Lake.

Distribution in Poland: The species was reported from Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Duszatyńskie Lakes, south eastern Poland (Noga et al., 2013b); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015); Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); Spring at the Goprowska Pass (Bieszczady National Park), south eastern Poland (Żelazna-Wieczorek & Knysak, 2017).

***Fragilaria tenera* var. *nanana* (Lange-Bertalot) Lange-Bertalot & Ulrich 2014**

(Pl. 43, fig. 14)

Ref. Lange-Bertalot 1993, p.48, pl. 115, figs. 14-16**;** Lange-Bertalot & Metzeltin 1996, p. 336, pl. 109, fig. 7; Lange-Bertalot & Ulrich 2014, p. 7, pl. 2, figs. 7-11; pl. 4, figs. 7-11; as *Synedra nana* Meister 1912; Hustedt 1930, p. 158, fig. 183; Hustedt 1959, p. 212, fig. 704.

Status of name: accepted taxonomically

Synonyms: *Synedra nana* Meister 1912

Fragilaria nanana Lange-Bertalot 1993

Diagnosis: Valves are linear, gradually tapering from the valve center, with spatulate or subcapitate apices. The axial area is narrow, linear. The central area slightly widened, extending to the margin, with ghost striae. Transapical striae are parallel, fine, alternating, about 20-22 in 10 µm. Length of the valve 35-90 µm, and the breadth 2-2.5 µm.

Ecological preference: Common in freshwater, nutrient-enriched lakes **(**Reavie et al., 1995); Freshwater, eu-mesotraphentic with pH:7.69-8.11 (Witak et al., 2017).

Occurrence: Frequently distributed in the late Holocene sediments of Radomno Lake.

Distribution in Poland: The species was reported from Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Duszatyńskie Lakes, south eastern Poland (Noga et al., 2013b); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); it is reported as *Fragilaria nanana* from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Fragilaria vaucheriae* (Kützing.) Petersen 1938**

(Pl. 44, figs. 1-17**)**

Ref. Hustedt 1930, p. 139, fig. 130; Patrick & Reimer 1966, p. 120, pl. 3, figs. 14, 15; Krammer & Lange-Bertalot 1991a, p. 124, pl. 108, figs. 10–15; Kawashima & Kobayasi 1994, pl.13, fig. 4A-K; Ehrlich 1995, p. 42, pl. 6, figs. 20-22; Lange-Bertalot & Metzeltin 1996, p. 332, pl. 107, figs. 21-22; Wojtal, 2009, p. 210, pl. 2, figs. 14–17; pl. 52, figs. 3, 4; Hofmann et al. 2011, p. 277, pl. 9, figs. 1–7; Wetzel & Ector 2015, p. 275, figs. 2-23, 39-53; Delgado et al. 2016, p.10, figs. 2, 83-90.

Status of name: accepted taxonomically

Synonyms: *Synedra vaucheriae* (Kützing) Kützing 1844
Fragilaria intermedia Grunow in Van Heruck 1881
Synedra rumpens var. *meneghiniana* Grunow in Van Heruck 1881
Ctenophora vaucheriae (Kützing) Schönfeldt 1907
Fragilaria vaucheriae var. *parvula* (Kützing) A. Cleve 1953
Ceratoneis vaucheriae (Kützing) Kobayasi 1965
Fragilaria capucina var. *vaucheriae* (Kützing) Lange-Bertalot 1980

Diagnosis: Frustules are rectangular in girdle view with interruption of striation in the middle portion. Valves are linear to linear-lanceolate, narrowed toward rostrate subcapitate apices. The axial area is narrow, linear to slightly lanceolate. A central area slightly swelling, unilaterally expanded. Transapical striae are parallel to slightly radiate toward the valve apices, alternated, occasionally slightly shortened opposite to central area, and are often interrupted at the valve face/mantle junction, about 11-14 striae in 10 µm. A single rimoportula is found only at one valve pole. Length of the valve 15-40 µm, and the breadth 4-5 µm.

Ecological preference: Periphytic; oligohalobous (indifferent), alkaliphilous (Lowe, 1974). A tychoplanktonic, alkaliphilous, α-mesosaprobous, eutraphentic, and fresh to brackish water species (Lange-Bertalot, 1979; Denys, 1991; Håkansson, 1993; Hofmann, 1994; Van Dam et al., 1994), it is considered to be tolerant and resistant to organic water pollution (Szczepocka & Szulc, 2009); freshwater, periphytic on the macrophytes in the river (Bertolli et al., 2010); benthic, freshwater running water, with high Calcium concentrations, pH neutral to alkaline (from 6.6 to 8.4) and water temperature ranged annually between 12.5 and 19.1 ºC (Delgado et al., 2013); low water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH value 5.46–6.5 (Krizmanić et al., 2015); epilithic in the freshwater river with low conductivity and pH 6.2-8.5, (Kheiri et al., 2018).

Occurrence: Common in the Eemian deposits, central Poland, frequent in the late Holocene sediments of Radomno and Młynek Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from Vistula River (Starmach, 1938; Turoboyski, 1962); Młynowka stream (Gumiński, 1947); fish ponds in Mydlniki (Siemińska, 1947); Sanka stream (Kądziołka, 1963); Prądnik River (Stępień, 1963); Pilica River (Kadłubowska, 1964b); spring of Szklarka stream (Skalska, 1966a, b); springs of Kobylanka stream (Skalna, 1969); springs of Będkowka stream (Kubik, 1970); Kluczwoda stream (Nawrat, 1993); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); dominated in the Pilica River- Central Poland (Szczepocka & Szulc, 2009); Kobylanka stream, south Poland (Wojtal, 2009); from the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); Swibno-Vistula River estuary in northern Poland (Majewska et al., 2012); Duszatyńskie Lakes, and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); the Wisłoka, Ropa, Bielcza and San rivers, south eastern Poland (Noga, et al., 2014); The Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016).

***Fragilaria vaucheriae* var. *continua* (Cleve-Euler) Cleve-Euler, 1953**

(Pl. 44, figs. 18-21)

Ref. Cleve-Euler 1932, p.21, fig.28; 1953, p. 43, figs. 353

Status of name: accepted taxonomically

Synonym: *Fragilaria intermedia* var. *continua* Cleve-Euler, 1932

Diagnosis: Frustules are rectangular in girdle view. Valves are linear to linear-lanceolate, narrowed toward rostrate subcapitate apices. The axial area is very narrow, linear. Central area absent or very weakly defined. Transapical striae are subparallel to slightly radiate, distinctly alternated, about 12-14 striae in 10 µm. Length of the valve 25-40 µm, and the breadth 4-5 µm.

Occurrence: Common in the Eemian deposits, central Poland, frequent in the late Holocene sediments of Radomno and Młynek Lakes**.**

Distribution in Poland: New record.

Genus *Fragilariforma* Williams & Round 1987

Diagnosis: Frustules rectangular in the girdle. Valves are lanceolate, linear-elliptical with rostrate apices and constricted centrally. Transapical striae are uniseriate, extending across the valve and onto the mantle. Apical porefields are present at both ends of the valve.

Fragilariforma is reported mainly from dystrophic waters varying from slightly to strongly acidic, oligo to mesotrophic environments (Renberg, 1977; Kingston et al., 2001; Morales et al., 2012)

Holotype species *Fragilariforma virescens* (Ralfs) Williams & Round 1988

Fragilariforma bicapitata (Mayer) Williams & Round 1988

(Pl. 45, fig. 1)

Ref. Williams & Round 1987, p. 280; as *Fragilaria bicapitata* Mayer 1917; Hustedt 1930, p. 143, fig. 148; Hustedt 1959 a, p. 165, fig. 673; Krammer & Lange-Bertalot 1991 a, p. 141, pl. 118, figs. 11-16.

Status of name: accepted taxonomically

Synonyms: *Fragilaria bicapitata* Mayer 1917

Neofragilaria bicapitata (Mayer) Williams & Round 1987

Diagnosis: Valves are linear to lanceolate with rostrate apices. The axial area is very narrow. Transapical striae are relatively thick, uniseriate, irregularly spaced and do not align from opposite sides of the valve, about 13-16 striae in 10 µm. Large apical porefields are present at both ends of the valve. Two rimoportulae are present, one at each apex of the valve. Length of the valve 10-35 µm and the breadth 3-5 µm.

Ecological preference: It is recorded as *Fragilaria bicapitata* in warm alkaline freshwater with temperature 10.2-28.7 °C and pH value 7.22-8.35, low conductivity (Zalm, 2007).

Occurrence: Recorded infrequently in the late Holocene sediments of Młynek Lake.

Distribution in Poland: The species was reported from the Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015), and Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015).

***Fragilariforma constricta* (Ehrenberg) Williams & Round 1988**

(Pl. 45, fig. 2)

Ref. Williams & Round 1987, p. 282, fig. 46: 52-53; as *Fragilaria constricta* Ehrenberg 1843; Hustedt 1959, p. 166, fig. 647: a-c; Patrick & Reimer 1966, p. 122, pl. 3, fig. 13; Krammer & Lange-Bertalot 1991 a, p. 140, pl. 128, figs. 11-14; pl. 129, figs. 1- 2, 6; Lange-Bertalot & Metzeltin 1996, p. 134, pl. 7, figs. 1-5.

Status of name: accepted taxonomically

Synonyms: *Fragilaria constricta* Ehrenberg 1843

Neofragilaria constricta (Ehrenberg) Williams & Round 1987

Diagnosis: Valves are linear-lanceolate with a slightly constricted center resulting in bi-undulate margins, and attenuate rostrate to capitate bluntly rounded apices. The axial area is indistinct. Transapical striae are parallel throughout, sometimes slightly curved at the widest portion of the valve, about 16-18 in 10 µm. Spines occurring between striae along the valve face-mantle junction. Apical pore fields are present at both apices. Length of the valve 23-50 µm, and the breadth 8-15 µm.

Ecological preference: *Fragilariforma constricta* is widely distributed in the eastern United States in the water of low mineral content and slightly dystrophic (Patrick & Reimer, 1966).

Occurrence: Infrequently in the sediments of Zielone Lake.

Distribution in Poland: New record.

***Fragilariforma hungarica* (Pantocsek) Hamilton in Hamilton et al. 1992**

Ref. Pantocsek 1902, p. 99, pl. IX [9], fig. 226; Cleve-Euler 1953, p. 40, fig. 349 l-n; Molder & Tynni 1970, pl. 2, fig. 20; Hamilton et al. 1992, p. 30**;** as *Staurosira grigorszkyi* Ács et al. 2009, p. 475, figs 4-37.

Status of name: accepted taxonomically

Synonyms: *Fragilaria hungarica* Pantocsek 1901

Staurosira tabellaria (W.Smith) Leuduger-Fortmorel 1878

Staurosira grigorszkyi Ács, Morales & Ector in Ács et al. 2009

Diagnosis: Frustules are rectangular in girdle view, joined to form chains. Valves are rhomboid-lanceolate with broadly rounded, protracted apices The axial area is very narrow, linear, somewhat indistinct. Transapical striae are very fine, not distinctly punctate, parallel, uniseriate extending across the valve and onto the mantle, about 16-18 striae in 10 µm. Length of the valve 15-40 µm, and the breadth 6.5-12 µm.

Ecological preference: Freshwater epiphytic diatom (Winter et al., 2008); in oligotrophic freshwater, low conductivity, alkaline with pH value 7.98 -8.85 (Ács et al. 2009).

Occurrence: Infrequently in the sediments of Młynek Lake.

Distribution in Poland: Lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008)

Fragilariforma mesolepta **(Hustedt) Kharitonov 2005**

(Pl. 45, fig. 3-7)

Ref. Patrick & Reimer 1996, p. 119, pl. 3, fig. 6; Germain 1981, p. 64, pl. 19, figs. 17-19; Krammer & Lange-Bertalot 1991a, p. 123, pl. 110, figs. 14–21, 23, 24; Lange-Bertalot & Metzeltin 1996, p. 334, pl. 108, fig. 1; Tuji & Williams 2008, p. 506, figs. 1, 8-16, 18-30; Wojtal, 2009, p. 210, pl. 2, fig. 18; Hofmann et al. 2011, p. 267, pl. 8, figs. 22-27.

Status of name: accepted taxonomically

Synonyms: *Fragilaria mesolepta* Rabenhorst 1861
Fragilaria capucina var. *mesolepta* (Rabenhorst) Rabenhorst 1864
Staurosira mesolepta (Rabenhorst) Cleve & Möller 1879
Staurosira capucina var. *mesolepta* (Rabenhorst) Comère 1892
Fragilaria virescens var. *mesolepta* (Rabenhorst) Schönfelt 1907
Fragilaria capucina f. *mesolepta* (Rabenhorst) Hustedt 1957
Fragilariforma virescens var. *mesolepta* (Rabenhorst) Andresen, Stoermer & Kreis 2000

Diagnosis: Valves are linear to linear-lanceolate with attenuate to rostrate apices and slightly panduriform. The axial area is very narrow; the central area is rectangular, with slight constriction. Transapical striae are parallel, and somewhat indistinct, about 14-16 in 10 µm. Rimoportula on stria in mantle closed to valve junction near valve ends. Length of the valve 25-45 µm, and the breadth 4-5.5 µm.

Ecological preference: The species was observed in clean, slightly eutrophic waters (Krammer & Lange-Bertalot, 1991a), and it is regarded as a saproxenous, alkaliphilous α-mesoeutraphentic, mesosaprobous taxon (Hofmann, 1994); epiphytic on macrophytes in shallow freshwater, pH 6.8-6.95 (Marra et al., 2016).

Occurrence: Infrequently in the Eemian deposits, central Poland, and the late Holocene sediments of Radomno Lake.

Distribution in Poland: The species was reported from Kluczwoda stream (Nawrat, 1993); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Kobylanka stream, south Poland, in samples with filamentous algae from the spring (Wojtal, 2009); Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013d); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015).

Fragilariforma nitzschioides **(Grunow) Lange-Bertalot in Hofmann et al. 2011**

Ref. Hofmann et al. 2011, p. 268, pl. 6, figs. 9, 10; Bak et al., 2012, p. 159, pl.7

Status of name: accepted taxonomically

Synonyms: *Fragilaria nitzschioides* Grunow 1881
Nematoplata nitzschioides (Grunow) Kuntze 1898

Diagnosis: Frustules are rectangular in girdle view. Valves are linear with parallel margins to linear-elliptical with slightly rostrate to bluntly rounded apices. The axial area is linear, very narrow. Transapical striae are parallel throughout most of the valve but may be slightly radiate towards the apices, fine, extend around the margin of the valve onto the valve mantle, about 20-22 striae in 10 µm. A single rimoportula is present on one or both poles. Short spines on the margin of the valve are often seen in girdle view. Length of the valve 20-54 µm, and the breadth 3.5-5.5 µm.

Ecological preference: It is characteristic dilute waters of low alkalinity and ion concentration (Wojtal, 2013)

Distribution in Poland: Springs of the high-mountain habitats in southern Poland (Tatra Mts) West Carpathians, south Poland (Wojtal, 2013); the Gulf of Gdansk and surrounding waters, the southern Baltic Sea (Plinski & Witkowski, 2020).

Fragilariforma virescens **(Ralfs) Williams & Round 1987**

(Pl. 45, fig. 8)

Ref. Williams & Round 1987, p. 280, figs. 45, 48, 50, 51, 54-58; as *Fragilaria virescens* Ralfs 1843; Hustedt 1930, p. 142, fig. 144; Hustedt 1959, p. 162, fig. 672 A: a-b; Patrick & Reimer 1966, p. 119, pl. 3, figs. 7-9;

Germain 1981, p. 72, fig. 22; Krammer & Lange-Bertalot 1991 a, p. 135, pl. 126, figs. 1-10; Ehrlich 1995, p. 42, pl. 6, figs. 24-25; Lange-Bertalot & Metzeltin 1996, p. 134, pl. 8, figs. 13-14.

Status of name: accepted taxonomically

Synonyms: *Fragilaria virescens* Ralfs 1843
Diatoma virescens (Ralfs) Hassall 1845
Nematoplata virescens (Ralfs) Kuntze 1898
Neofragilaria virescens (Ralfs) Williams & Round 1987

Diagnosis: Frustules are rectangular in girdle view with undulate ends. Valves are linear to lanceolate with flat valve face and rostrate, broadly rounded apices. The axial area is very narrow, linear. Transapical striae are parallel throughout the valve, composed of round areolae and extend to the valve mantle, about 20-22 striae in 10 µm. Spines are positioned on the costae along the valve face edge. The porefields are present at each apex. One rimoportula is present on each valve, located along a stria close to the axial area. Length of the valve 15-50 µm, and the breadth 6.5-7.0 µm.

Ecological preference: Cosmopolitan, Oligotrophic, circumneutral, pH 6.48 (Krammer & Lange-Bertalot, 1991). The species was recorded from streams characterized by high gradient, strong current and low water temperature, pH ranging from 3. 5 to 6.0 and low phosphates values (Kwandrans, 1993); dilute waters of low alkalinity and ion concentration (Wojtal, 2013); low Water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH value 5.46–6.5 (Krizmanić et al., 2015).

Occurrence: Infrequent in the late Holocene sediments of Młynek Lake.

Distribution in Poland: The species was recorded from the Polish acidic mountain streams in the Silesian Beskid (section of the Western Carpathians), the Świętokrzyskie Mts, and in the Karkonosze range (in the Sudetic Mts) (Kwandrans, 1993); the sediments of Mały Staw lake in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2005, 2016); Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013d); Springs of the high-mountain habitats in southern Poland (Tatra Mts) West Carpathians, south Poland (Wojtal, 2013); Found in Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015).

Genus *Hannaea* Patrick in Patrick & Reimer 1966

Diagnosis: Frustules are arcuate. Valves are arcuate with convex dorsal margin, concave ventral margin with swollen on each side of the central area. Transapical striae are finely areolae. Rimoportulae are very distinct internally, one at each pole.

Holotype species *Hannaea arcus* (Ehrenberg) Patrick.

***Hannaea arcus* (Ehrenberg) Patrick 1966**

(Pl. 45, figs. 9-11)

Ref: Patrick & Reimer 1966, p. 132, pl. 4, fig. 20; Round et al. 1990, p. 366, fig. a-k. as *Fragilaria arcus* (Ehrenberg) Cleve 1898; Hustedt 1930, p. 134, fig. 122; Germain 1981, p. 58, pl. 17, figs. 3-6; Krammer & Lange-Bertalot, 1991 a, p. 134, pl. 117, figs. 8-13; Metzeltin & Witkowski 1996, p. 106, pl. 37, figs. 20-21; Kheiri et al., 2018; p.365, figs 19–20; as *Ceratoneis arcus* (Ehrenberg) Kützing; Hustedt 1959, p. 179, fig. 684 a-c; Metzeltin & Witkowski 1996, p. 172, pl. 70, fig. 33.

Status of name: accepted taxonomically

Synonyms: *Ceratoneis arcus* (Ehrenberg) Kützing 1844
Cymbella arcus (Ehrenberg) Hassall 1845
Fragilaria arcus (Ehrenberg) Cleve 1898

Diagnosis: Valves are very slightly curved, with a slightly convex dorsal margin and straight to slightly concave ventral margin except the swelling of the unilateral central area. Apices of the valve are attenuate rostrate to somewhat capitate. The axial area is distinct, narrow. The central area is distinctly swollen, only on the ventral side. Transapical striae are parallel to slightly radiate towards the apices, about 12-14 striae in 10 µm. Length of the valve 30-60 µm, and the breadth 6-7 µm.

Ecological preference: The species was reported from the fast-moving mountain streams, oligotrophic, circumneutral pH ≥ 6.5 and low nitrates (Krammer & Lange-Bertalot, 1991), oligotrophic, running water, neutral to slightly acidic waters (Bixby & Jahn, 2005); oligo-mesotraphentic diatom (Wojtal, 2013); low water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH value 5.46–6.5 (Krizmanić et al., 2015); epilithic in freshwater river with low conductivity and pH 6.2-8.5, (Kheiri et al., 2018).

Occurrence: Infrequent in the late Holocene sediments of Radomno Lake and the Eemian deposits, central Poland.

Distribution in Poland: The species was recorded from the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Low-pH Lake Piaski in Western Pomerania, north-west Poland (Witkowski et al., 2011); the high-mountain streams in southern Poland (Tatra Mts) (Wojtal, 2013); San (near Jarosław), in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016).

Genus *Martyana* Round 1990

Diagnosis: Frustules are small, solitary, wedge-shaped to rectangular in girdle view. Valves are cuneiform, linear-elliptic, or lanceolate with one apex is narrower than the other, symmetrical to the apical axis, asymmetrical to the transapical axis. Apices of the valve rounded; Axial area variable in width; striae uniseriate, arranged on both sides of the valve, broad and occur between distinct transapical ridges. Apical axis heteropole, pervalvar and transapical axes isopole.

Holotype species *Martyana martyi* (Hèribaud) Round 1990

***Martyana schulzii* (Brockmann) Snoeijs 1991**

Ref. Simonsen 1962, p. 33, pl. 1, figs. 3, 4; Snoeijs et al., 1991, p. 166, figs. 19-22, 26-27; Gogorev & Lange 2014, p. 71**.**

Status of name: accepted taxonomically

Synonyms: *Fragilaria schulzii* Brockmann 1950
Opephora schulzii (Brockmann) Simonsen 1962
Stauroforma schulzii (Brockmann) Gogorev 2014

Diagnosis: Valves are linear-lanceolate, to elliptical-lanceolate, with rounded apices, symmetrical on the apical axis, relatively asymmetrical on the transapical axis. The axial area is indistinct. Transapical striae are distinct, areolated, parallel, about 5-7 striae in 10 µm. A single apical pore field is present at the foot pole. The length of the valve is 10 – 20, and the breadth is 5 – 6 µm.

Ecological preference: Mesohaobous, preferring more saline waters (Witak, 2013)

Distribution in Poland: The species was reported from Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012)**;** Holocene sediments of Vistula Lagoon, the southern Baltic Sea (Witak, 2013).

Genus *Meridion* Agardh 1824

Diagnosis: Frustules are rectangular to wedge-shaped in girdle view, joined by valve faces to form straight to fan-shaped colonies. Valve outline is either wedge-shaped or linear with rounded, sub-capitate to capitate apices. Thickened costae cross valve at irregular intervals. Transapical striae are fine and hardly resolvable under light microscopy. The axial area is very narrow and has no central area. Small spines are present along the margins of the valve face. A rimoportula occurs towards the head pole.

Holotype species *Meridion vernale* Agardh 1824

Meridion circulare (Greville) Agardh 1831

(Pl. 45, figs. 12-13; Pl. 46, figs. 1-17)

Ref. Hustedt 1930, p. 130, fig. 118; Hustedt 1959, p. 93, fig. 627: a-f; Patrick & Reimer 1966, p. 113, pl. 2, fig.15; Germain 1981, p. 54, pl. 15, fig. 7; pl. 16, figs. 1-16; Krammer & Lange-Bertalot 1991 a, p. 101, pl. 100, figs. 1-3; pl. 101, figs. 1-14; pl. 102, figs. 1-3; Ehrlich 1995, p. 48, pl. 8, figs. 7-8; Wojtal 2009, p. 238, pl. 4, figs. 1–7; Hofmann et al. 2011, p. 359, pl. 1, figs. 1–14.

Status of name: accepted taxonomically

Synonyms: *Echinella circularis* Greville 1822
Exilaria circularia (Greville) Greville 1827
Frustulia circularis (Greville) Duby 1830

Diagnosis: Frustules are wedge-shaped, united to form fan-shaped colonies. Valves are heteropolar with narrow foot and wide head poles. The axial area is very narrow. Transapical costae are strongly developed, entirely or partly crossing valve face, about 3-5 in 10 µm; transapical striae are fine, about 14- 16 in 10 µm. Length of the valve 25-80 µm, and the breadth 5-8 µm.

Ecological preference: The species shows a wide distribution in freshwaters of the world; cosmopolitan, oligohalobous-indifferent, alkaliphilous, especially in running water (Foged, 1959); it prefers the cool and flowing waters, where it attaches to stones and plants (Krejci & Lowe, 1987); its maximum abundances in winter in the Llobregat River of Spain (Tomas & Sabater, 1985), and in three alpine streams in Kosciusko National Park of Australia (Chapman & Simmons, 1990); it regarded as a cosmopolitan, widespread, tychoplanktonic, calcium-rich spring waters (Lange-Bertalot, 1979; Krammer & Lange-Bertalot, 1991a); it is classified as an alkaliphilous diatom (Håkansson, 1993); the species was recorded from streams characterized by high gradient, strong current and low water temperature, (pH ranging from 3. 5 to 6.0) and low phosphates values (Kwandrans, 1993); alkaliphilous, β-mesosaprobous and oligo- to eutraphentic fresh brackish water species (Van Dam et al., 1994); benthic, running freshwater, with high Calcium concentrations, pH neutral to alkaline (from 6.6 to 8.4) and water temperature ranged annually between 12.5 and 19.1 ºC (Delgado et al., 2013); benthic, fresh-brackish, eutrophic-oligotrophic, β-mesosaprobic (Zgrundo et al., 2008); slightly polluted, of beta-mesosaprobic zones (Szczepocka et al., 2014); epilithic in freshwater river with low conductivity and pH 6.2-8.5, (Kheiri et al., 2018).

Occurrence: Frequently in the late Holocene sediments of Młynek and Radomno Lakes.

Distribution in Poland: The species was reported from Vistula River (Starmach, 1938; Turoboyski, 1956, 1962; Kyselowa & Kysela, 1966; Uherkovich, 1970); Młynowka stream (Gumiński, 1947); fish ponds in Mydlniki (Siemińska, 1947); Pilica River (Cabejszek, 1951; Kadłubowska, 1964b); Prądnik River (Stępień, 1963); Sanka stream (Kądziołka, 1963; Hojda, 1971); spring of Szklarka stream (Skalska, 1966a); springs of Kobylanka stream (Skalna, 1969); Biała Przemsza River (Wasylik, 1985); Polish acidic mountain streams in the Silesian Beskid (section of the Western Carpathians), the Świętokrzyskie Mts, and in the Karkonosze range (in the Sudetic Mts) (Kwandrans, 1993); Kluczwoda stream (Nawrat, 1993); Mały Staw lake, located in a post-glacial cirque in the northeastern part of Karkonosze Mts, west Poland (Sienkiewicz, 2005); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); peat bog in Modlniczka (Piątek, 2007); Gulf of Gdańsk (Zgrundo et al., 2008); Kobylanka stream, south Poland; abundant, especially in periphyton (Wojtal, 2009); Bzura River, Central Poland (Rakowska & Szczepocka, 2011); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Duszatyńskie Lakes, Matysówka stream a right-bank tributary of Strug River, district of Tyczyn and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Linda River central Poland (Szczepocka et al., 2014); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); dominant in the upper part of the Ner River, central Poland (Szczepocka et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); Spring at the Goprowska Pass (Bieszczady National Park), south eastern Poland (Żelazna-Wieczorek & Knysak, 2017).

***Meridion constrictum* Ralfs 1843**

(Pl. 47, figs.1-17)

Ref. Hustedt 1930, p. 131, fig. 119; Hustedt 1959 a, p. 93, fig. 627: g-h; Patrick & Reimer 1966, p. 114, pl. 2, fig. 16; Germain 1981, p. 56, pl.16, figs. 15-16; Krammer & Lange-Bertalot 1991a, p. 102, pl. 101, figs. 6-12; pl. 102, fig. 1; Lange-Bertalot & Metzeltin 1996, p. 130, pl. 6, figs. 22-25.

Status of name: accepted taxonomically

Synonyms: *Eumeridion constrictum* (Ralfs) Kützing 1844
Meridion circulare var. *constrictum* (Ralfs) Brun 1880
Meridion circulare f. *constricta* (Ralfs) Cleve-Euler 1932

Diagnosis: Frustules are thick, linear-clavate. Valve is heteropolar with narrower rostrate or capitate foot-pole and wider, rounded head-pole. The axial area is narrow, linear. Transapical costae 4-6 in 10 µm, while the striae 16-18 in 10 µm. A single rimoportula is present near the head pole. Length of the valve 15-75 µm, and the breadth 4-8 µm.

Ecological preference: This species is commonly found in association with *Meridion circulare*, it is common in a flowing freshwater environment. Both two species have been described as cosmopolitan taxa (Hustedt, 1949; Foged,1978, 1981; Krammer & Lange-Bertalot, 1991a, b, 1997a, b); dilute waters of low alkalinity and ion concentration (Wojtal, 2013).

Occurrence: Common in the late Holocene sediments of Młynek Lake and infrequently in the Radomno Lake.

Distribution in Poland: The species was reported from Matysówka stream a right-bank tributary of Strug River, district of Tyczyn and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013a, d); Springs of the high-mountain habitats (Tatra Mts) West Carpathians, south Poland (Wojtal, 2013); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016).

Genus *Nanofrustulum* Round, Hallsteinsen & Paasche, 1999

Diagnosis: Valves are circular to slightly elliptical with striae on the valve surface formed by 2-4 rectangular, radially elongate, or circular areolae. The central zone of the valve is plain or with warts. The valve mantle is sloping and deeper with one areola beneath the spines and a small apical pore at each end of the sternum surrounded by a few small warts. The marginal spines are spatulate to triangular, simple.

Holotype species *Nanofrustulum shiloi* (Lee, Reimer & McEnery) Round, Hallsteinsen & Paasche 1999

***Nanofrustulum krumbeinii* (Witkowski, Witak & Stachura) Morales 2019**

Ref. Lange-Bertalot & Genkal 1999, p. 80, pl. 4, figs 1-3; Morales et al. 2019, p. 275

Status of name: accepted taxonomically

Synonym: *Opephora krumbeinii* Witkowski, Witak & Stachura 1999

Diagnosis: Frustules are rectangular in girdle view, forming long chains. Valve is broadly elliptic to almost circular, with rounded apices. The axial area is distinct and zigzag-shaped. Transapical striae are relatively robust, parallel to slight radiate at the apices, about 18-25 in 10µm. The length of the valve is 2-5µm, and the breadth is 1.5-4 µm.

Ecological preference: This is a marine species (Morales et al. 2019).

Distribution in Poland. The species was reported from Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012); the Gulf of Gdansk, and surrounding waters, the southern Baltic Sea (Plinski & Witkowski, 2020).

***Nanofrustulum sopotense* (Witkowski & Lange-Bertalot) Morales, Wetzel & Ector 2019**

(Pl. 48, figs. 1-8)

Ref. Witkowski & Lange-Bertalot 1993, p. 67, fig. 6 a-p; Witkowski et al. 2000, p. 54, pl. 17, figs. 27-31; pl. 28, figs. 36-39; Wetzel et al. 2013, p. 60-61; Żelazna-Wieczorek et al. 2015, p. 55, fig. 9 A1-A7.

Status of name: accepted taxonomically

Synonyms: *Fragilaria sopotensis* Witkowski & Lange-Bert. 1993

Pseudostaurosira sopotensis (Witkowski & Lange-Bertalot) Morales, Wetzel & Ector 2013

Diagnosis: Frustules are rectangular in girdle view, joined by interlocking linking spines. Valves are round to slightly elliptical, with a flat valve face. The axial area is relatively wide. Transapical striae are distinct, slightly radiate in the valve center to strongly radiate toward the apices and are composed of round to oval areolae, about 15-17 striae in 10 µm. Length of the valve 6-9 µm and the breadth 5.5-7 µm.

Ecological preference: *Fragilaria sopotensis* has been mainly reported for the Baltic Sea but also for the Mediterranean (Witkowski et al., 2000). Benthic, brackish water, eutrophic, α- mesosaprobic (Zgrundo et al., 2008); mesohalobous species (Witak, 2013); Low temperature (6.7-8.2 °C), alkaline saline water, with pH value 6.4-7.99 (Żelazna-Wieczorek et al., 2015); Fresh-brackish species, found in high water temperature (Rzodkiewicz et al., 2017).

Occurrence: Frequent in the Eemian deposits, central Poland, and infrequently in the sediments of Radomno and Młynek Lakes.

Distribution in Poland: The species was reported as *Fragilaria sopotensis* from the Gulf of Gdańsk (Zgrundo et al., 2008); Dolgie Wielkie lake on the Gardno-Leba Coastal Plain within the Slowinski National Park, North Poland (Lutyńska, 2008a); Górki Zachodnie and Swibno – Vistula River estuary in northern Poland (Majewska et al., 2012); the SW Gulf of Gdańsk, Puck lagoon, and the Vistula Lagoon, the southern Baltic Sea (Witak, 2013); abundant in saline waters of Pełczyska village, Łęczyca in the Łodź province, central Poland (Żelazna-Wieczorek et al., 2015); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019).

***Nanofrustulum trainori* (Morales) Morales 2019**

(Pl. 48, figs. 9-28)

Ref. Morales 2001, p.113-114, figs 6a–l; Morales et al. 2019, p. 275.

Status of name: accepted taxonomically

Synonym: *Pseudostaurosira trainori* Morales 2001

Diagnosis: Frustules are rectangular in girdle view, forming a chain by linking spines. Valves are round to slightly elliptical. The valve face is flat or slightly undulate due to raised costae. Valve face/mantle junction forms a sharp angle. The axial area is narrow, linear to widely lanceolate. Transapical striae are distinct, uniseriate, alternate, parallel to slightly radiate, and composed of round areola, about 20-25 striae in 10 µm. Costae are broad and wider than striae. Spines are positioned within the striae at the valve face/mantle junction. Length of the valve 2-9 µm, and the breadth 2-4 µm.

Occurrence: Frequent in the late Holocene sediments of Kamionka Lake and the Eemian deposits, central Poland.

Distribution in Poland: New record.

Genus *Odontidium* Kützing 1844

Diagnosis: Frustules are rectangular in girdle view. Valves are linear, linear-elliptic to elliptic-rhombic, or linear-lanceolate with somewhat attenuated, rostrate or subcapitate rounded apices. The axial area is linear, somewhat wider and diffuse. Transapical ribs are nearly all primary, perpendicular, or at a slight angle to the axial area. Striae between ribs appear parallel. One rimoportula per valve, located near pore field, within a stria. A simple apical pore field at each pole, composed of round porelli.

Lectotype species *Odontidium hyemale* (Roth) Kützing 1844

***Odontidium anceps* (Ehrenberg) Ralfs in Pritchard 1861**

(Pl. 47, fig. 18)

Ref. Patrick & Reimer 1966, p. 106, pl. 2, figs. 1-3; Ehrlich 1995, p. 46, pl. 8, figs. 2-3; Lange-Bertalot & Metzeltin 1996, p. 130, pl. 6, figs. 16-18, Bąk et al. 2012, p. 97, pl. **5.**

Status of name: accepted taxonomically

Synonyms: *Fragilaria anceps* Ehrenberg 1841
Diatoma anceps (Ehrenberg) Kirchner 1878
Neodiatoma anceps (Ehrenberg) Kuntze 1891
Diatoma hyemale var. *anceps* (Ehrenberg) A.Cleve 1953
Meridion anceps (Ehrenberg) Williams 1985

Diagnosis: Frustules jointed to form zig-zag colonies. Valves are apically and transapically symmetrical; slightly lanceolate to linear with capitate obtuse apices. Small valves may be more elliptical with reduced capitate ends than larger valves. Valves possess both primary and secondary costae, about 3.5-5 in 10 µm. The axial area is very narrow to indistinct. Transapical striae are distinct, about 19-22 in 10 µm. Each valve has a single, sub-apical rimoportula. Length of the valve 23-50 µm, with a breadth of about 5-8 µm.

Ecological preference: *Diatoma anceps* prefers cool water of low mineral content, often found in mountainous regions (Patrick & Reimer, 1966); epilithic in warm, circumneutral freshwater with pH 6.8 (Jena et al., 2006).

Occurrence: Infrequent in the late Holocene sediments of Młynek Lake.

Distribution in Poland: It is recorded from Poland by Bąk et al. (2012).

***Odontidium hyemale* (Roth) Kützing 1844**

(Pl. 47, fig. 19)

Ref. Patrick & Reimer 1966, p. 107, pl. 2, fig. 7; Germain 1981, p. 54, pl. 15, figs. 1-8; Krammer & Lange-Bertalot 1991 a, p. 99, pl. 97, figs. 6-10; pl. 98, figs. 1-6; Lange-Bertalot & Metzeltin 1996, p. 130, pl. 6, fig. 21.

Status of name: accepted taxonomically.

Synonyms: *Conferva hyemalis* Roth 1800
Fragilaria hyemalis (Roth) Lyngb. 1819
Nematoplata subquadrata Bory 1827
Temachium hiemale (Lyngbye) Wallroth 1831
Candollella hyemalis (Roth) Gaillon 1833
Lysigonium hyemale (Roth) Trevisan 1848

Diatoma hyemalis (Roth) Heiberg 1863
Neodiatoma hiemalis (Lyngbye) Kuntze 1891

Diagnosis: Valves are narrow, linear to linear-lanceolate, with broadly rounded somewhat attenuated, rostrate apices. The axial area is linear to lanceolate, broad in the center, narrowing toward the apices. Transapical striae are parallel to weakly radiate, finely punctate, about 22-25 striae in 10 µm. Costae are parallel, about 3-4 in 10 µm. A single rimoportula is present. Length of the valve 27-60 µm, with a breadth of about 7-10 µm.

Ecological preference: Cosmopolitan cold-water form, oligohalobous-indifferent, alkaliphilous (Foged, 1959). The species seems to prefer cool freshwater (Patrick & Reimer, 1966); shallow warm freshwater lakes, pH value 6.9-7.7, low conductivity, alkalinity (meq L^{-1}) from 3.1-4.4 (Jasprica & Hafner, 2005); Low water temperature (6.4–12.5 °C), low conductivity (213–302 µS cm–1) and pH value 5.46–6.5 (Krizmanić et al., 2015).

Occurrence: Infrequently in the late Holocene sediments of Kamionka Lake**.**

Distribution in Poland: New record.

***Odontidium mesodon* (Kützing) Kützing 1849**

(Pl. 47, fig. 20-22)

Ref. Hustedt 1930, p. 129, fig. 116; Patrick & Reimer 1966, p. 108, pl. 2, fig. 8; Krammer & Lange-Bertalot 1991a, p. 100, pl. 91, fig. 1; pl. 92, figs. 1–4; pl. 98, fig. 7; pl. 99, figs. 1–12; Wojtal, 2009, p. 192, pl. 3, figs. 14–19; pl. 54, figs. 8, 9; pl. 55, figs. 1–6; Hofmann et al. 2011, p. 173, pl. 2, figs. 1–5; Kheiri et al., 2018; p. 368, figs. 91–92.

Status of name: accepted taxonomically

Synonyms: *Fragilaria mesodon* Ehrenberg 1839.
Diatoma mesodon (Ehrenberg) Kützing 1844
Diatoma hiemale var. *mesodon* (Ehrenberg) Grunow in Van Heurck 1881

Diagnosis: Valves are linear-elliptical to lanceolate with rounded apices. The axial area is linear and very narrow. Transapical striae are very fine, about 22-27 striae in 10 µm. The central portion of the valve is crossed by strong ribs, 4-6 in 10 µm. A rimoportula is present at one apex. Length of the valve 12-30 µm, with a breadth of about 7-10 µm.

Ecological preference: Probably cosmopolitan cold-water form, especially found in mountain rivulets, oligohalobous-indifferent, alkaliphilous (Foged, 1959); Cosmopolitan diatom, widespread, oligo- or oligo-meso-saprobous, cold-water species (Krammer & Lange-Bertalot, 1991a; Hofmann, 1994); Periphytic; epiphytic (?). Oligohalobous (indifferent); alkaliphilous (Foged, 1979); it is classified as an alkaliphilous diatom (Håkansson, 1993), and a circumneutral, oligosaprobous, meso-eutraphentic, and fresh water species (Van Dam et al., 1994). The species was recorded from streams characterized by high gradient, strong current and low water temperature, pH ranging from 3. 5 to 6.0 and low phosphates values (Kwandrans, 1993); oligo-ß-mesotraphentic or mesotraphentic diatom (Wojtal, 2013); low water temperature (6.4–12.5 °C), low conductivity (213–302 µS cm–1) and pH value 5.46–6.5 (Krizmanić et al., 2015); freshwater, meso-oligotraphentic with pH value 7.69-8.11 (Witak et al., 2017); epilithic in the freshwater river with low conductivity and pH 6.2-8.5, (Kheiri et al., 2018).

Occurrence: Infrequently in the late Holocene sediments of Młynek and Francuskie Lakes**.**

Distribution in Poland: The species is reported from Sanka stream (Kądziołka, 1963); Prądnik River (Stępień, 1963); Pilica River (Kadłubowska, 1964b); spring of Szklar ka stream (Skalska, 1966a, b, 1967); springs of Kobylanka stream, spring in Jerzmanowice (Skalna, 1969, 1973); springs of Będkowka stream (Kubik, 1970); Kluczwoda stream (Nawrat, 1993); Polish acidic mountain streams in the Silesian Beskid (section of the Western Carpathians), the Świętokrzyskie Mts, and in the Karkonosze range (in the Sudetic Mts) (Kwandrans, 1993); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); the sediments of Mały Staw lake in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2005, 2016); Kobylanka stream, south Poland (Wojtal, 2009); Springs and riverhead stream sections in the upper part of the San river, south Poland (Żelazna-Wieczorek, 2012); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Duszatyńskie Lakes, south eastern Poland (Noga et al., 2013b); the high-mountain streams in southern Poland (Tatra Mts) (Wojtal, 2013); from rivers and streams of Wisłok, Zalew Rzeszowski, Łubienka, San (near Jarosław) and Różanka, in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); Spring at the Goprowska Pass (Bieszczady National Park), south eastern Poland (Żelazna-Wieczorek & Knysak, 2017).

Genus *Opephora* Petit 1888

Diagnosis: Frustules are narrowly rectangular in girdle view. Valve is heteropolar like a wedge, club, and clavate forms to be asymmetrical to transverse axes. The apices of valves are rounded. Transapical striae are strongly broad and present along the margins of the valve. The genus can be differentiated from similar taxa by valve shapes and the structure of striae.

Lectotype species *Opephora pacifica* (Grunow) Petit 1888.

***Opephora marina* (Gregory) Petit 1888**

(Pl. 48, figs. 29-38)

Ref. Hustedt 1930, p. 136, fig. 656; Hendey, 1964, p. 160; Jensen, 1985, p. 128, fig. 656**;** Witkowski et al. 2010, figs. 79-93.

Status of name: accepted taxonomically

Synonyms: *Meridion marinum* Gregory 1857
Sceptroneis marina (Gregory) Lagersted 1876
Grunoviella marina (Gregory) H. Peragallo & M. Peragallo 1901

Diagnosis: Valves are heteropolar, clavate with broadly rounded head pole and acutely rounded foot pole. The axial area is broad, linear-lanceolate. Transapical striae are short confined to valve margin only, parallel in middle becoming slightly radiate towards apices, about 8-9 in 10 µm. Pore field present at both apices. Length of the valve 15- 25 µm, and the breadth 4-6 µm.

Ecological preference: Epipsammic; Mesohalobous/polyhalobous. In the littoral of the entire European coastal area; widely distributed and not rare (Hustedt, 1930); frequent on sandy beaches on all North Sea coasts (Hendey, 1964); alkaliphilous pH over 7, marine euryhaline, mesopolythermic (>18-35 C°) (Moreno-Ruiz et al., 2011).

Occurrence: Infrequently in the Eemian deposits of central Poland.

Distribution in Poland: It is reported from the Gulf of Gdansk and surrounding waters, the southern Baltic Sea (Plinski & Witkowski, 2020).

***Opephora olsenii* Möller 1950**

(Pl. 48, figs. 39-47)

Ref. Krammer & Lange-Bertalot 1991, p. 166, pl. 134, figs. 9-20; Witkowski 1994, p. 173, pl. 12, figs. 1-8; Sabbe & Wyverman 1995, p. 241, figs. 13-28, 61-63; Witkowski 1994, p. 174, figs. 11/4-6, 12/14-17; Witkowski et al. 2000, p. 70-72, pl. 25, figs. 27-30; Żelazna-Wieczorek et al. 2015, p. 59, fig. 9 E.

Status of name: alternate representation

Synonyms: *Sceptroneis mutabilis* Grunow 1879
Sceptroneis marina var. *parva* Grunow 1881
Grunoviella parva (Grunow) H. Peragallo & M. Peragallo 1897
Opephora parva (Grunow) Krasske 1939
Opephora horstiana Witkowski 1994
Opephora mutabilis (Grunow) Sabbe & Wyverman, 1995

Diagnosis: Frustules are rectangular to weakly wedge-shaped with rounded ends in girdle view. Valve is heteropolar, ovate to clavate with elliptical outline and cuneate to broadly rounded apices. The axial area is linear, narrow. Transapical striae are coarse, alternate, parallel at the center, parallel to convergent at the apices, about 8-10 in 10 µm. Spines are present along the valve margin. Length of the valve 10- 60 µm, and the breadth 3-7 µm.

Ecological preference: The species was frequently observed in brackish or marine areas, as the epipsammic or epiphytic diatoms in the brackish water (Sundbäck, 1987); cosmopolitan, epipsammic and epiphytic; in sandy, intertidal sediments, salinity range 5-33 ppt (Sabbe & Vyverman, 1995); epipsammic species, cosmopolitan and widespread in brackish waters, being abundant in the Baltic Sea and the North Sea (Witkowski et al., 2000); it showed a wide distribution in the littoral zone of the coastal and brackish waters as well as Saline waters (Żelazna-Wieczorek et al., 2015).

Occurrence: Infrequently in the Eemian deposits of central Poland, and the surface sediments of Jeziorak Lake.

Distribution in Poland: Gulf of Gdansk, Southern Baltic Sea (Witkowski, 1994; Plinski & Witkowski, 2020); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); abundant in Puck Bay, Southern Baltic Sea, Poland (Witkowski, 2007). It is reported as *Opephora mutabilis* from the Gulf of Gdańsk (Zgrundo et al., 2008), Holocene sediments of the SW Gulf of Gdańsk (Witak & Dunder, 2007); abundant in Górki Zachodnie – Vistula

River estuary in Northern Poland (Majewska et al., 2012); Saline waters of Pełczyska village, Łęczyca in the Łodź province, central Poland (Żelazna-Wieczorek et al., 2015).

Genus *Pseudostaurosira* Williams & Round 1987

Diagnosis: Frustules are symmetrical, rectangular in girdle view, joined tightly to form chains. Valves are cruciform, lanceolate, rhombic, or elliptical to linear, often undulate. The axial area is variable width and shape, often wide. Transapical striae are uniseriate composed of a few large elliptical areolae associated with smaller rounded ones. Apical pore fields are not always present. Spines are situated along the valve edge. The most characteristic feature of this genus is sparse marginal areolae (Round et al. 1990).

Holotype species *Fragilaria brevistriata* Grunow in Van Heurck 1885

= *Pseudostaurosira brevistriata* Williams & Round 1987

Remarks: This genus was split from *Fragilaria* by Williams and Round (1987) to include a group of small species that usually form ribbon-like colonies and that are characterized by a broad sternum and by marginal areolae with branched areolar occlusions.

***Pseudostaurosira americana* Morales 2005**

(Pl. 49, figs. 1-12)

Ref. Morales 2005, p. 115, figs 1–20, 80–85; Cejudo-Figueiras et al. 2011, p. 70-72, figs 74-93, 112-115

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view. Valves are linear-lanceolate to elliptic, with cuneate to rounded apices. The axial area is narrow, linear or slightly linear-lanceolate. Transapical striae are distinctly punctate, uniseriate, alternate, parallel or slightly radiate toward apices, about 16-18 striae in 10 µm. The striae are interrupted at the valve face/mantle junction by spines. Costae are broader than the striae. Length of the valve 6-30 µm, and the breadth 4.5-5 µm.

Ecological preference: The species has been reported from circumneutral water (pH 7.5), with moderate conductivity (238 µS/cm) (Morales, 2005).

Occurrence: Common in the Eemian deposits, central Poland, and frequently in the late Holocene sediments of Młynek and Radomno Lakes.

Distribution in Poland: New record.

***Pseudostaurosira bardii* Beauger, Wetzel & Ector in Beauger et al., 2018**

(Pl. 49, figs.13-16)

Ref. Beauger et al., 2018, p. 5, figs. 2-56

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view, forming chains with the aid of spines. Valves are isopolar, circular to sub-elliptical with broadly rounded apices. The axial area is generally wide without a central area. Transapical striae are alternate, parallel to slightly radiate towards the apices, about 12-16 in 10 µm. Length of the valve 4-6.5 µm, and the breadth 3.5-5 µm.

Remarks: In LM, this species can be confused with *Pseudostaurosira trainorii* Morales 2001 in the shape of the outline

Ecological preference: The species was recorded from the spring water that has a slightly acidic pH (6.53), an elevated conductivity level (6510 µS cm–1), the temperature is about 15°C, and is enriched with sodium-chloride and bicarbonate (Beauger et al., 2018).

Occurrence: Frequently distributed in the Eemian deposits, central Poland.

Distribution in Poland: New record.

***Pseudostaurosira borealis* (Foged) García, Morales, Ector & Maidana 2017**

(Pl. 49, figs. 17-27)

Ref. Foged 1974, p. 56, pl. III, fig. 6; Witon et al. 2004, p. 127, figs 11-16; Garcia et al. 2017, p. 112

Status of name: accepted taxonomically

Synonyms: *Fragilaria construens* f. *borealis* Foged 1974

Staurosira borealis (Foged) Witkowski, Lange-Bertalot & Witon 2004

Diagnosis: Valves are linear, slight bi-undulate with distinct rostrate acutely rounded apices. The axial area is relatively broad, lanceolate. The central area is not clearly differentiated from the axial area. Transapical striae are distinct, subparallel in the middle to slightly radiate towards the apices, about 14-16 in 10 µm. Length of the valve 16-20 µm, and the breadth 4.5–5 µm.

Remarks: This species is distinguished from *Staurosira binodis* (Ehrenberg) Lange-Bertalot by having straight to slight undulate margins and distinct relatively opposite striae and distinct rostrate apices.

Occurrence: Common in the late Holocene sediments of Młynek and Kamionka Lakes, infrequently in the Radomno Lake.

Distribution in Poland: New record.

***Pseudostaurosira brevistriata* (Grunow) Williams et Round 1987**

(Pl. 50, figs. 1-28; pl. 51, figs. 1-27)

Ref. Hustedt 1930, p. 145, fig. 151; Hustedt 1959, p. 168, fig. 676: a-e; Patrick & Reimer 1966, p. 128, pl. 4, fig. 15; Okuno 1974, p. 5, figs. 832-833; Germain 1981, p. 68, pl. 20, figs. 22-31; Williams & Round 1987, p. 276, figs. 28-31; Krammer & Lange-Bertalot 1991 a, p. 162, pl. 130, figs. 9-17; pl. 131, fig. 7; Ehrlich 1995, p. 40, pl. 6, figs. 9-11; Wojtal 2009, p. 304, pl. 2, figs. 25–29; pl. 52, fig. 2; Hofmann et al. 2011, p. 258, pl. 9, figs. 25–29.

Status of name: accepted taxonomically

Synonyms: *Fragilaria brevistriata* var. *subacuta* Grunow in Van Heurck 1881
Fragilaria brevistriata var. *pusilla* Grunow in Van Heurck 1881
Fragilaria brevistriata var. *subcapitata* Grunow in Van Heurck 1881
Staurosira brevistriata (Grunow) Grunow 1884
Fragilaria brevistriata Grunow in Van Heurck 1885
Nematoplata brevistriata (Grunow) Kuntze 1898

Diagnosis: Frustules are rectangular in girdle view, joined by linking spines forming chains. Valves are lanceolate in larger specimens to elliptical in smaller specimens with rostrate apices and flat valve face. The axial area is broad and lanceolate. Transapical striae are short, distinct, uniseriate, restricted to the valve margin, composed of wide, round to oval areolae; about 13-16 striae in 10 µm. Striae are parallel to radiate in the central of the valve to slightly radiate toward the valve ends. Spines are situated along the valve edge. Length of the valve 8-30 µm, and the breadth 2-5 µm.

Ecological preference: Cosmopolitan, preferring oligosaprobic, oligo- to mesoeutrophic water with low electric conductivity (Krammer & Lange-Bertalot, 1991a); tychoplanktonic, alkaliphilous, oligosaprobous, eury-traphentic and fresh brackish water species, mesosaprobous and mesotraphentic species (Denys, 1991; Hofmann, 1994; Van Dam et al., 1994); Oligohalobous-indifferent (Witak & Dunder, 2007); periphytic, alkalophilic, tolerant to a wide range of conductivity, oligosaprobic-oligo-eutrophic waters (Antón-Garrido et al., 2013); slightly alka-line, pH value 7.1-7.6, meso-eutrophic and oxygen-saturated (Toporowska et al., 2008); benthic, oligohalobous, alkaliphilous, eu-mesotraphenthic, oligosaprobous (Witak & Jankowska, 2014); freshwater, meso-oligotraphentic with pH value 7.69-8.11 (Witak et al., 2017).

Occurrence: Common in the Eemian deposits, central Poland, late Holocene sediments of Kamionka, Młynek and Radomno Lakes, infrequently in Francuskie and Zielone Lakes and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from Vistula River (Turoboyski, 1962); Sanka stream (Kądziołka, 1963); Prądnik River (Stępień, 1963); Late Quaternary sediments of Przedni Staw Lake (Polish Tatra Mountains) (Marciniak, 1986a); from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); the Gulf of Gdańsk (Zgrundo et al., 2008); the sediments of Mały Staw and Wielki Staw lakes in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2005, 2016); Holocene sediments of the SW Gulf of Gdańsk (Witak & Dunder, 2007); Dolgie Wielkie lake on the Gardno-Leba Coastal Plain within the Slowinski National Park, North Poland (Lutyńska, 2008a); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); the submerged macrophytes in Lake Skomielno, Łęczyńsko-Włodawskie Lakeland, eastern Poland. (Toporowska et al., 2008); lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); dominated in the Pilica River- central Poland, considered to be tolerant and resistant with respect to organic water pollution (Szczepocka & Szulc, 2009); Kobylanka stream, south Poland (Wojtal, 2009); from Low-pH Lake Piaski in Western Pomera-nia, north-west Poland (Witkowski et al., 2011); Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); Lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); Holocene sediments of Lake Suchar IV in the area of Wigry National Park in the range of the Pomeranian Phase north-east Poland (Zawisza et al., 2019).

***Pseudostaurosira brevistriata* var. *capitata* (Héribaud) Andresen et al., 2000**
(Pl. 52, figs. 1-16)
Ref. Patrick & Reimer 1966, p. 129, pl. 4, fig. 15; Andresen, et al., 2000, p. 416
Status of name: accepted taxonomically
Synonyms: *Fragilaria brevistriata* var. *capitata* Héribaud 1903
Fragilaria brevistriata var. *subcapitata* Grunow in Van Heurck 1881
Diagnosis: Frustules are rectangular in girdle view. Valves are linear, linear-lanceolate with rostrate-capitate apices. The axial area is broad lanceolate. Transapical striae are marginal, subparallel to slightly radiate, about 14-16 in 10 µm. Length of the valve 14-24 µm, and the breadth 3-5.5 µm.
Occurrence: Frequent in the Eemian deposits, central Poland, and the late Holocene sediments of Kamionka and Młynek Lakes.
Distribution in Poland: New record

***Pseudostaurosira brevistriata* var. *inflata* (Pantocsek) Edlund 1994**
(Pl. 52, figs. 17-20)
Ref. Hustedt 1930, p. 145, fig. 152; Patrick & Reimer 1966, p. 129, pl. 4, fig.16; Edlund 1994, p. 12, fig. 32.
Status of name: accepted taxonomically
Synonyms: *Fragilaria inflata* Pantocsek 1902
Fragilaria brevistriata var. *inflata* (Pantocsek) Hustedt 1930
Diagnosis: Frustules are rectangular in girdle view. Valves are linear to broadly lanceolate with attenuated rostrate apices and inflation central portion of the valve. The axial area is broad lanceolate. Transapical striae are marginal, slightly radiate, about 12-14 in 10 µm. Length of the valve 10-20 µm, and the breadth 4-7 µm.
Ecological preference: slightly alkaline water and high conductivity (Patrick & Reimer, 1966)
Occurrence: Frequent in the Eemian deposits, central Poland, and the late Holocene sediments of Radomno and Młynek Lakes.
Distribution in Poland: New record**.**

***Pseudostaurosira brevistriata* var. *nipponica* (Skvortsov) Kobayasi in Mayama et al. 2002**
(Pl. 52, figs. 21-31)
Ref. Skvortsov 1936, p. 17, pl. 16, fig. 7; Mayama et al. 2002, p. 90
Status of name: accepted taxonomically
Synonym: *Fragilaria brevistriata* var. *nipponica* Skvortsov 1936
Diagnosis: Frustules are rectangular in girdle view. Valves are linear to linear-lanceolate with slightly bi-constricted margins and attenuated rostrate apices. The axial area is broad lanceolate. Transapical striae are marginal, parallel in the middle of the valve, slightly radiate towards the apices, about 14-16 in 10 µm. Length of the valve 20-24 µm, and the breadth 4.5-5 µm.
Occurrence: Frequent in the late Holocene sediments of Kamionka Lake.
Distribution in Poland: New record**.**

***Pseudostaurosira brevistriata* var. *papillosa* (A. Cleve) Zimmerman, Poulin & Pierritz 2010**
(Pl. 53, figs. 1-3)
Ref. Cleve-Euler 1953, p. 32, fig. 343 h-j; Zimmerman et al. 2010, p. 143
Status of name: accepted taxonomically
Synonym: *Fragilaria brevistriata* var. *papillosa* A. Cleve 1953
Diagnosis: Frustules are rectangular in girdle view. Valves are linear to lanceolate with rostrate to subcapitate apices. The axial area is broad lanceolate. Transapical striae are marginal, slightly radiate throughout the valve, about 15-17 in 10 µm. Length of the valve 12-15 µm, and the breadth 5-5.5 µm.

Occurrence: Infrequent in the late Holocene sediments of Kamionka and Radomno Lakes.
Distribution in Poland: New record**.**

Pseudostaurosira brevistriata **var.** ***trigibba*** **(Pantocsek) Haworth & Kelly 2002**
(Pl. 53, figs. 12-13; pl. 54, figs. 1-14)
Ref. Hustedt 1930, p. 145, fig. 153; Caljon & Cocquyt 1992, p. 41, pl. 1, figs. 17-19
Status of name: alternate representation
Synonyms: *Fragilaria trigibba* Pantocsek 1902
Fragilaria brevistriata var. *trigibba* (Pantocsek) Hustedt 1930
Diagnosis: Valves with tri-undulate margins and rostrate to rostrate-capitate apices. The middle part of the valve is swelling larger than near the apices. The axial area is distinct and relatively wide in the center than the apices. Transapical striae are parallel to slightly radiate, about 12-14 in 10 µm. length of the valve 30-50 µm, and the breath at the widest area in the middle 7-9 µm.
Remarks: This variety is relatively similar to *Fragilaria sinuata* Perag 1910
Occurrence: Common in the Eemian deposits of central Poland and infrequent in the late Holocene sediments of Kamionka Lake.
Distribution in Poland: New record.

Pseudostaurosira brevistriata **var.** ***turgida*** **(Pantocsek) Haworth & Kelly 2002**
(Pl. 53, figs. 4-7)
Ref. McCall 1933, p. 292, fig. 36; Haworth & Kelly 2002, p. 6
Status of name: accepted taxonomically
Synonym: *Fragilaria brevistriata* var. *turgida* McCall 1933
Diagnosis: Valves are broadly lanceolate with rostrate to subcapitate apices. The axial area is broad lanceolate. Transapical striae are marginal, radiate throughout the valve, about 12-14 in 10 µm. Length of the valve 15 µm, and the breadth 7 µm.
Occurrence: Frequent in the late Holocene sediments of Kamionka and Młynek Lakes.
Distribution in Poland: New record.

Pseudostaurosira brevistriata **var.** ***vidarbhensis*** **(Sarode & Kamat) Zalat & Pidek comb. nov.**
(Pl. 53, figs. 8-11)
Ref. Sarode & Kamat 1984, p. 236, fig. 18 a, b
Synonym: *Fragilaria brevistriata* var. *vidarbhensis* Sarode & Kamat 1984
Diagnosis: Valves are linear-lanceolate with strongly tumid in the middle portion and attenuated sinuate acutely rounded apices. The axial area is linear, moderately wide-lanceolate. Transapical striae are parallel, alternated, about 11-13 in 10 µm. Length of the valve 55 µm, and the breadth 4-6 µm.
Occurrence: Infrequently distributed in the Eemian deposits, central Poland.
Distribution in Poland: New record.

Pseudostaurosira bronkei **(Witkowski, Lange-Bertalot & Metzeltin) Wetzel & Morales in Morales et al. 2019**
Ref. Witkowski et al. 2000, p. 48, pl. 12, figs. 1-12; Morales et al. 2019, p. 276
Status of name: accepted taxonomically
Synonym: *Fragilaria bronkei* Witkowski, Lange-Bertalot & Metzeltin 2000
Diagnosis: Valves are narrowly-lanceolate to lanceolate with obtusely rounded or slightly rostrate, subcapitate apices. The axial area is very broad, lanceolate. Transapical striae are parallel in the middle becoming radiate towards the apices, about 17-24 striae in 10 µm. The striae are composed of solitary areolae located at the junction between the valve face and the mantle. No rimoportulae are present. Length of the valve 8-15.5 µm, and the breadth 1.75-2.5 µm.
Ecological preference: Freshwater form
Distribution in Poland: The species is reported from the Gulf of Gdańsk, Poland (Witkowski et al., 2000; Witak, 2013)

***Pseudostaurosira clavatum* Morales 2002**

(Pl. 55, figs. 1-36)

Ref. Morales 2002, p. 107, pl. 1, figs. 22-34; pl. 4, figs. 1-6.

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view, forming chains utilizing the spines. Valves are clavate with rostrate acutely rounded apices. The axial area is narrow-lanceolate. Transapical striae are uniseriate, about 10-12 striae in 10 µm, and composed of two rounds to ovoid areolae, one located on the valve face and the other on the valve mantle. Apical pore fields are well developed at both valve poles. Length of the valve 8-20 µm, and the breath 2.5-3.5 µm.

Remarks: This taxon may have been confused with taxa in the genus *Opephora* (e.g., *Opephora olsenii* Möller 1950 and *Opephora pacifica*). However, *Pseudostaurosira clavatum* differs from species in *Opephora* in several aspects. *P. clavatum* has spines interrupting the striae, a characteristic of several species in the genus *Pseudostaurosira* (Morales, 2001; Round et al., 1990; Williams & Round, 1987).

Occurrence: Common in the Eemian deposits of central Poland, late Holocene sediments of Radomno, Kamionka and Młynek Lakes, and frequently in the surface sediments of Jeziorak Lake.

Distribution in Poland: New record.

***Pseudostaurosira decipiens* Morales, Chávez & Ector 2012**

(Pl. 56, figs. 1-7)

Ref. Morales et al., 2012, p.44, figs. 2–11,39–44

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view with a curved surface in the middle portion and jointed to form chains by the spines. Valve is isopolar, with rostrate apices. The axial area is almost wide, lanceolate. Valve mantle steep with edge parallel to valve face/mantle junction. Transapical striae are uniseriate, slightly radiate, about 13-15 in 10 µm, and composed of 1–2 areolae on valve face and 1–2 areolae on valve mantle. Length of the valve 7–30 µm, and the breadth 4–6 µm, striae density 13–15.

Ecological preference: Epipsammic, alkaline freshwater with a pH of 10.4 and a water temperature of 7.7 ºC (Morales et al., 2012)

Occurrence: Frequent in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Pseudostaurosira elliptica* (Schumann) Edlund, Morales & Spaulding 2006**

(Pl. 56, figs. 8-27)

Ref. Williams & Round 1987, p. 272, figs. 18-20; Krammer & Lange-Bertalot 1991, p. 155, pl. 130, figs. 31-42; Morales 2005, p. 114, figs. 1-20; Edlund et al., 2006, p. 58; Kobayasi et al. 2006, p. 75, pl. 93.

Status of name: accepted taxonomically

Synonyms: *Fragilaria elliptica* Schumann 1867
Fragilaria mutabilis var. *elliptica* (Schumann) Grunow 1881
Fragilaria pinnata var. *elliptica* (Schumann) Carlson 1913
Fragilaria construens var. *elliptica* (Schumann) Frenguelli 1945
Staurosira elliptica (Schumann) Williams & Round 1987

Diagnosis: Frustules are rectangular in girdle view, forming ribbon-like colonies with connecting spines. Valves are elliptical to broad lanceolate with acute to broadly or even round apices in valve view. The axial area is broad lanceolate. Transapical striae are short and usually composed of one, rarely two round areolae on the valve face, parallel to slightly radiate near valve apices, about 14-16 striae in 10 µm. Apical pore fields are more or less developed, located at valve face/ mantle junction. Length of the valve 6-22 µm, and the breadth 3-5 µm.

Ecological preference: The species is worldwide in temperate freshwaters; it is meso-saprobous (Kobayasi et al., 2006); it is recorded as an epiphytic taxon on leaf tissues of seagrasses from Geoje Island on the southern coast of Korea (Chung & Lee, 2008).

Occurrence: Common in the Eemian deposits of central Poland, frequent in the late Holocene sediments of Radomno and Młynek Lakes, and the surface sediments of Jeziorak Lake

Distribution in Poland: The species was reported as *Fragilaria elliptica* from Late Quaternary sediments of Przedni Staw Lake (Polish Tatra Mountains) (Marciniak, 1986a); as *Staurosira elliptica* from Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012); Duszatyńskie Lakes, south eastern Poland

(Noga et al., 2013b), and Wisłok river and Żołynianka stream, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015).

***Pseudostaurosira floweri* Morales in Garcia et al. 2017**
(Pl. 56, figs. 28-29)
Ref. Flower 2005, p. 66, fig. 15; Garcia et al. 2017, p. 113
Status of name: accepted taxonomically
Synonym: *Staurosira aventralis* var. *asymmetrica* Flower 2005

Diagnosis: Valves are linear to sub-lanceolate with slight asymmetry rostrate-rounded laterally deflected apices. The axial area is narrow, slightly expanded centrally. Transapical striae are subparallel in the middle to slightly radiate towards the apices, about 18-20 in 10 µm. Length of the valve 8-15 µm and the breadth 4-4.5 µm.

Ecological preference: Freshwater environment
Occurrence: Infrequently in the late Holocene sediments of Kamionka Lake.
Distribution in Poland: New record

***Pseudostaurosira laucensis* (Lange-Bertalot & Rumrich) Morales & Vis 2007**
(Pl. 56, figs. 30-34)
Ref. Rumrich et al., 2000, p. 222, pl. 13, figs. 10-20, 22, 23; Morales & Vis 2007, p. 125
Status of name: accepted taxonomically
Synonym: *Staurosira laucensis* Lange-Bertalot & Rumrich in Rumrich et al., 2000

Diagnosis: Frustules are rectangular in girdle view. Valves are lanceolate with rostrate to subcapitate or acute rounded apices. The axial area is less widely lanceolate with a more gently curved inflated central area. Transapical striae are distinct, subparallel to slight radiate, alternated, and composed of wide, round to oval areolae, about 14-16 striae in 10 µm. Spines are located on the costae at the valve margin. Length of the valve 6-20 µm, and the breadth 4 -5.5 µm.

Occurrence: Frequently in the late Holocene sediments of Radomno, Kamionka and Młynek Lakes.
Distribution in Poland: New record.

***Pseudostaurosira linearis* (Pantocsek) Morales, Buczkó & Ector, 2019**
(Pl. 57, figs. 1-10)
Ref. Pantocsek 1913, p. 30, pl. 2, figs. 65-68; Morales et al., 2019, p. 276, figs.3, 4.
Status of name: accepted taxonomically
Synonyms: *Fragilaria pinnata* var. *linearis* Pantocsek 1913: 30, pl. 2: figs 65, 68
Fragilaria pinnata var. *ovalis* Pantocsek 1913: 30, pl. 2: figs 66, 67

Diagnosis: Frustules are rectangular in girdle view. Valves are linear with parallel sides to linear-lanceolate with more broadly rounded to almost cuneate apices. The axial area is broadly wide. Transapical striae are marginal, subparallel in the center to slightly radiate toward the apices, about 12–14 striae in 10 µm. Length of the valve 10–35 µm, and the breadth 3.5–5 µm

Remarks: According to Morales et al. 2019, *Pseudostaurosira linearis* may resemble *Pseudostaurosira polonica* (Witak & Lange-Bertalot) Morales & Edlund 2003, but the striae density in *P. linearis* is 13 and that for *P. polonica* is 16. Also, the areolae in *P. polonica* are more transapically elongated, while they are round in *P. linearis.* On the other hand, smaller forms of *P. linearis* could be confused with *P. elliptica*, but they can be distinguished mainly by the striae density.

Occurrence: Frequent in the Eemian deposits of central Poland, and infrequently in the late Holocene sediments of Radomno Lake.

Distribution in Poland: The species was reported from Low-pH Piaski Lake in Western Pomerania – northwest Poland (Witkowski et al., 2011).

***Pseudostaurosira marciniakae* Ector, Morales, Wetzel in. Morales et al. 2019**
(Pl. 57, figs. 11-18)
Ref. Marciniak 1982, p. 164, pl. 2, fig. 5**;** Marciniak 1986a, p. 258, pl. 2, figs. 5, 6; Morales et al. 2019, p. 276.
Status of name: accepted taxonomically
Synonym: *Fragilaria pseudoconstruens* var. *rhombica* Marciniak 1982

Diagnosis: Valves are short, rhombic shape with inflation and slightly elongated broadly to obtusely rounded s apices. The axial area is nearly lanceolate. Transapical striae are slightly radiate, about 14-16 in 10 µm. Length of the valve 8-10 µm*,* and the breadth 6-7 µm.

Occurrence: Frequent in the Eemian deposits of central Poland, and the late Holocene sediments of Kamionka Lake.

Distribution in Poland: Lake sediments of the Przedni Staw Tatra Mountains (Marciniak, 1982); Late Quaternary sediments of Przedni Staw Lake (Polish Tatra Mountains) (Marciniak, 1986a).

***Pseudostaurosira microstriata* (Marciniak) Flower 2005**

Ref. Marciniak 1982: 165, pl. 2, figs 5, 6; Rumrich et al. 2000, p. 225; Flower 2005, p. 65

Status of name: accepted taxonomically

Synonym: *Fragilaria microstriata* Marciniak 1982
Staurosira microstriata (Marciniak) Lange-Bertalot in Rumrich et al. 2000: 225

Diagnosis: Frustules are rectangular in girdle view. Valves are small, slight rhombic shape to lanceolate, and widened at the middle, with slightly or more elongated obtusely or capitate rounded apices. The axial area is nearly lanceolate. Transapical striae are short, slightly radiate, about 9-11 in 10 µm. The length of the valve is 5.5-7.5 µm, and the breadth is 2.1-3.3 µm.

Ecological preference: The species is reported as a benthic freshwater taxon, indifferent, alkaliphilous, oligotrophic, to oligo-mesotrophic, pH from slightly acidic to neutral (Sienkiewicz et al., 2021)

Distribution in Poland: Late-glacial and Holocene sediments of Przedni Staw Lake (Polish Tatra Mountains) (Marciniak, 1986a); Tatra Mountain lakes, south Poland (Sienkiewicz et al., 2021)

***Pseudostaurosira neoelliptica* (Witkowski) Morales 2002**

(Plate 57, figs. 19-21)

Ref. Witkowski 1994, p. 128, pl. 10, figs. 1-13; Metzeltin & Witkowski 1996, pl. 48, fig. 30; Morales 2002, p. 105, pl. 1, figs. 10-21; pl. 3, figs. 1-6.

Status of name: accepted taxonomically

Synonyms: *Fragilaria neoelliptica* Witkowski 1994
Opephora neoelliptica (Witkowski) Witkowski, Metzeltin & Lange-Bertalot in Metzeltin & Witkowski 1996

Diagnosis: Frustules are rectangular in girdle view. Valves are elliptical to broadly lanceolate with rounded apices. The axial area is relatively broad lanceolate. Transapical striae are uniseriate, parallel, about 14-16 in 10 µm, and composed of round areolae. Reduced apical pore fields are present at both valve poles and are composed of several rows of round poroids. Length of the valve 10-18 µm, and the breadth 3-4.5 µm.

Remarks: Witkowski (1994) suggested that *Fragilaria elliptica* could be made a synonym of *F. neoelliptica.*

Ecological preference: The species was more abundant in eutrophic, with a slightly alkaline pH (7.5) and a conductivity of 458 µS/cm (Morales, 2002); oligohalobous- halophilous (Witak & Dunder, 2007).

Occurrence: Frequently in the Eemian deposits of central Poland

Distribution in Poland: It is reported from Gulf of Gdańsk (Zatoka Gdańsk)**,** Poland (Witkowski, 1994; Witak 2013)**;** Holocene sediments of the SW Gulf of Gdańsk (Witak & Dunder, 2007).

***Pseudostaurosira oliveraiana* Grana, Morales, Maidana & Ector, 2018**

(Pl. 57, figs. 22-32)

Ref. Grana et al., 2018, p. 63, figs.2-24.

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view, forming chains. Valves are linear to lanceolate, with subcapitate, sometimes cuneate apices. The axial area is wide, linear-lanceolate. Transapical striae are short, uniseriate, alternate, parallel in the valve center to slightly radiate towards the apices, about 12-14 in 10 µm. Striae are interrupted at the valve face/mantle junction region by solid and spatulate linking spines. Length of the valve 20-40 µm, and the breadth 3.5-5.5 µm.

Ecological preference: This is a brackish water species (Grana et al., 2018).

Occurrence: Frequently in the Eemian deposits of central Poland and the late Holocene sediments of Młynek and Radomno Lakes.

Distribution in Poland: New record.

***Pseudostaurosira parasitica* (W. Smith) Morales in Morales & Edlund 2003**

(Pl. 58, figs. 1-27)

Ref. Krammer & Lange-Bertalot 1991 a, p. 133, pl. 130, figs. 1-8; Lange-Bertalot & Metzeltin 1996, p. 324, pl. 103, fig. 9. *Synedra parasitica* (W. Smith) Hustedt 1930; Hustedt 1930, p. 161, fig. 195; Hustedt 1959, p. 204, fig. 695: a-b; Patrick & Reimer 1966, p. 140, pl. 5, fig. 12; Wojtal 2009, p. 212, pl. 2, figs. 32, 33; pl. 54, figs. 3, 4; Kheiri et al., 2018; p.365, Figs 25–26.

Status of name: accepted taxonomically

Synonyms: *Odontidium parasiticum* W. Smith 1856
Fragilaria parasitica (W. Smith) Heiberg 1863
Staurosira parasitica (W. Smith) Petit 1877
Fragilaria parasitica (W. Smith) Grunow in Van Heurck 1881
Staurosira construens var. *parasiticum* (W. Smith) Petit 1892
Nematoplata parasitica (W. Smith) Kuntze 1898
Synedra parasitica (W. Smith) Hustedt 1930
Synedrella parasitica (W. Smith) Round & Maidana 2001

Diagnosis: Frustules are rectangular in girdle view. Valves are lanceolate with subrostrate to subcapitate apices in larger specimens, cuneate in smaller specimens. The axial area is widely lanceolate. Transapical striae are distinct, parallel to slightly radiate toward the valve ends, and composed of wide, round to oval areolae, about 18-20 striae in 10 µm. The costae are broad. Well-developed apical pore fields with round poroids are present on the transition between valve face/mantle. Length of the valve 10-20 µm, and the breadth 4 -6 µm.

Ecological preference: Freshwater, usually epiphytic on other diatoms, in circumneutral, slightly alkaline water mesotrophic to eutrophic (Patrick & Reimer, 1966); cosmopolitan, occurring in mesotrophic to eutrophic circumneutral waters (Krammer & Lange-Bertalot, 1991a), benthic, oligohalobous, eu- mesotraphenthic, β-mesosaprobous (Witak & Jankowska, 2014)**;** epilithic in freshwater river with low conductivity and pH 6.2-8.5, (Kheiri et al., 2018); alkaliphilous, fresh-brackish water, nitrogen-autotrophic taxon, β-mesosaprobous, meso-eutraphentic (Malinowska–Gniewosz et al., 2018).

Occurrence: Frequent in the Eemian deposits of central Poland, the late Holocene sediments of Radomno, Kamionka, and Młynek Lakes.

Distribution in Poland: The species was reported from Młynowka stream (Gumiński, 1947); fish ponds in Mydlniki (Siemińska, 1947); Pilica River (Kadłubowska, 1964b); Sanka stream (Hojda, 1971); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); Kobylanka stream, south Poland, in mud samples from below Kobylany village (Wojtal, 2009); from Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Duszatyńskie Lakes, Matysówka stream a right-bank tributary of Strug River, district of Tyczyn, and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); from some rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); the industrial water biotopes of Trzuskawica S.A. in the southern Poland (Malinowska–Gniewosz et al., 2018)

***Pseudostaurosira parasitoides* (Lange-Bertalot, Schmidt & Klee) Morales, García & Maidana 2017**

(Plate 59, figs. 1-24)

Ref. Schmidt et al. 2004 p. 3, figs. 1-5, 15-17*;* Garcia et al. 2017, p. 113; Peeters & Ector 2017, p. 250, figs. 1-6.

Status of name: accepted taxonomically

Synonym: *Staurosira parasitoides* Lange-Bertalot, Schmidt & Klee 2004

Diagnosis: Valves are broadly lanceolate with convex margins and rostrate to subcapitate apices. The axial area is widely lanceolate marked in the central area. Transapical striae are ghost, distinct, subparallel to slightly radiate toward the valve apices, about 18-20 striae in 10 µm. The costae are broad. Length of the valve 8-12 µm, and the breadth 3.5-4.5 µm.

Remarks: This species differs from *Pseudostaurosira microstriata* (Marciniak) Flower by its broadly fusiform bulbous shape, small conical, densely crowded marginal spines, and additional areolae in the enlarged part of the valve surface (Schmidt et al., 2004).

Ecological preference: Freshwater, found in circumneutral to slightly alkaline water (pH =7.1), slight conductivity (Peeters & Ector, 2017)

Occurrence: Common in the Eemian deposits of central Poland, frequent in the late Holocene sediments of Kamionka and Młynek Lakes.

Distribution in Poland: New record.

***Pseudostaurosira perminuta* (Grunow) Sabbe & Wyverman 1995**

(Pl. 60, figs. 1-3)

Ref. Witkowski 1994, p. 128, figs. 10/1-13; Sabbe & Wyverman 1995, p. 237, figs 1-12, 54-60**;** Witkowski et al. 2000, p. 76, figs.25/35-37

Status of name: accepted taxonomically

Synonyms: *Sceptroneis mutabilis* var. *minuta* Grunow 1879
Grunoviella perminuta (Grunow) Peragallo & Peragallo 1897
Opephora perminuta (Grunow) Frenguelli 1938
Fragilaria neoelliptica Witkowski 1994

Diagnosis: Frustules are rectangular in girdle view. Valves are more or less heteropolar with cuneate to obtusely rounded apices. The valve face is flat, gradually tapering to the mantle. The axial area is quite variable, narrowly to broadly lanceolate. Transapical striae are parallel to slightly radiate in the center, becoming more radiate at the apices; more or less alternate about 16-18 striae in 10 µm. An apical pore field is present in the cuneate foot-pole. Length of the valve 6-18 µm, and the breadth 2.5- 4 µm.

Remarks: According to Sabbe & Wyverman (1995), *Pseudostaurosira perminuta* shows some resemblance to *Staurosira elliptica* (Schuman) Williams & Round 1987 and displays great affinity, with *Pseudostaurosira zeilleri* (Héribaud) Williams & Round 1987.

Ecological preference: *Pseudostaurosira perminuta* prefers higher salinities, being more abundant in poly- and euryhaline reaches of the Westerschelde estuary (Sabbe, 1997); it is referred for brackish and marine sediments in the North Sea coasts and the Baltic Sea (Witkowski et al., 2000).

Occurrence: Infrequently in the late Holocene sediments of Młynek Lake.

Distribution in Poland: New record.

***Pseudostaurosira polonica* (Witak & Lange-Bertalot) Morales & Edlund 2003**

(Pl. 60, figs. 4-15)

Ref. Witak & Lange-Bertalot 1995, p. 736, figs 39-45; Morales & Edlund 2003, p. 235, figs. 25-32, 45-50.

Status of name: accepted taxonomically

Synonym: *Fragilaria polonica* Witak & Lange-Bertalot in Witkowski et al. 1995

Diagnosis: Frustules are rectangular in girdle view. Valves are broadly elliptical with slightly tapering apices in larger forms and broadly rounded apices in smaller ones. The axial area is broadly lanceolate, tapering toward the apices of the valve. Transapical striae are alternate, uniseriate, about 13–15 in 10 µm, and composed of two large areolae, which are elongated along the transapical axis of the valve face and a shorter one on the valve mantle. Length of the valve 10-30 µm, and the breadth 3.5-5 µm.

Remarks: *Pseudostaurosira polonica* shows similarity with *Pseudostaurosira linearis* in their valve dimensions and striae, but, the areolae in *P. polonica* are more transapically elongated, while they are round in *P. linearis* (Morales et al., 2019). As well as, *Pseudostaurosira polonica* may confuse with *Opephora naveana* Le Cohu, 1988.

Ecological preference: Freshwater, benthic, oligohalobous (Witak & Jankowska, 2014)

Occurrence: Common in the Eemian deposits of central Poland, frequent in the late Holocene sediments of Kamionka and Młynek Lakes and the surface sediments of Jeziorak Lake.

Distribution in Poland: *Fragilaria polonica* was originally described in Witkowski et al. (1995) from recent and fossil material collected from the Gulf of Gdansk (Puck Bay), Poland. The species was reported also from Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015).

Pseudostaurosira quasielliptica **Witkowski, Riaux-Gobin, Daniszewska-Kowalczyk 2010**

(Pl. 60, figs. 20-27)

Ref. Witkowski, Riaux-Gobin, Daniszewska-Kowalczyk 2010**,** p. 270, figs. 15-27.

Status of name: accepted taxonomically

Diagnosis: Valves are linear elliptic, with broadly rounded apices to heteropolar, clavate with obtusely rounded foot pole and broadly rounded head pole. The axial area is linear, narrow, distinguishable. Transapical striae are parallel in the middle becoming radiate towards apices, they composed of areolae, barely distinguishable, about 11-13 in 10 µm. Length of the valve 10-30 µm, and the breadth 5-7 µm.

Ecological preference: Freshwater environment

Occurrence: Infrequently in the late Holocene sediments of Radomno and Kamionka Lakes.

Distribution in Poland: New record.

Pseudostaurosira robusta **(Fusey) Williams & Round 1987**

(Pl. 61, figs. 1-24; pl. 62, figs. 1-25)

Ref. Williams & Round 1987, p. 278, fig. 32; Krammer & Lange-Bertalot 1991 a, p. 164, pl. 130, fig. 20; Lange-Bertalot & Metzeltin 1996, p. 270, pl. 76, figs. 16-17; Rivera-Rondón & Catalan 2017, p. 176, figs. 9-11; p. 178, figs. 1-4.

Status of name: accepted taxonomically

Synonyms: *Fragilaria construens* f. *robusta* Fusey 1951
Fragilaria construens var. *binodis* f. *robusta* Fusey 1951
Fragilaria robusta (Fusey) Manguin 1954
Staurosira robusta (Fusey) Lange-Bertalot in Krammer & Lange-Bertalot 2000

Diagnosis: Valves are bi-undulate, with rounded sub-capitate to capitate apices. The axial area is linear to lanceolate and somewhat broad as the central constriction. Transapical striae are uniseriate, parallel to slightly radiate, composed of round, coarse areolae, about 14-16 striae in 10 µm and. Length of the valve 10-22 µm, and the breadth 4-8 µm.

Ecological preference: Freshwater, in oligotrophic to mesotrophic water in Europe (Bąk et al., 2012)

Occurrence: Common in the Eemian deposits of central Poland, frequent in the late Holocene sediments of Radomno, Kamionka, and Młynek Lakes.

Distribution in Poland: The species was reported from Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Holocene sediments of SW Gulf of Gdańsk and the Vistula Lagoon, the southern Baltic Sea (Witak, 2013); Żołynianka stream, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015).

Pseudostaurosira sajamaensis **Morales & Ector in Morales et al. 2012**

(Pl. 60, figs. 16-19)

Ref. Morales et al. 2012, p. 45, figs 12–26, 45–56

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view, forming chains with the aid of spines. Valves are elliptic to lanceolate and elliptical to rounded with broadly rounded apices in smaller forms. The axial area is relatively wide lanceolate. Transapical striae are uniseriate, parallel, composed of 1–2 rounded areolae, about 12–14 striae in 10 µm. Length of the valve 2–18 µm, and the breadth 2–4 µm.

Occurrence: Infrequently in the late Holocene sediments of Młynek Lake.

Distribution in Poland: New record.

Pseudostaurosira subconstricta **(Grunow) Kulikovskiy & Genkal 2011**

(Pl. 63, figs. 1-11)

Ref. Hustedt 1930, p. 161, fig. 196; Hustedt 1959, p. 205, fig. 695: c; Patrick & Reimer 1966, p. 140, pl. 5, fig. 13; Krammer & Lange-Bertalot 1991 a, p. 133, pl. 130, figs. 6-8; Lange-Bertalot & Metzeltin 1996, p. 324, pl. 103, fig. 8; Wojtal, 2009, p. 214, pl. 2, fig. 34; pl. 54, figs. 1, 2; Hofmann et al. 2011, p. 271, pl. 9, figs 39-43;

Status of name: accepted taxonomically

Synonyms: *Fragilaria parasitica* var. *subconstricta* (W. Smith) Grunow in Van Heurck 1881
Fragilaria parasitica var. *constricta* Mayer 1912

Synedra parasitica var. *subconstricta* (Grunow) Hustedt 1930
Synedrella subconstricta (Grunow) Round & Maidana 2001
Pseudostaurosira parasitica var. *subconstricta* (Grunow) Morales 2003
Punctastriata subconstricta (W. Smith) Kulikovskiy & Genkal 2011

Diagnosis: Valve is linear-lanceolate with markedly bi-constricted and attenuated capitate apices. The axial area is linear-lanceolate. Transapical striae radiate to almost parallel, about 16-18 in µm 10. Length of the valve 16-25 µm, and the breadth 4-5 µm.

Ecological preference: Cosmopolitan, occurring in circumneutral mesotrophic to eutrophic waters (Krammer & Lange-Bertalot, 1991a).

Occurrence: Frequently in the late Holocene sediments of Młynek and Radomno Lakes, infrequently in the Eemian deposits of central Poland.

Distribution in Poland: This variety was reported from Sanka stream (Hojda, 1971); springs of Będkowka stream (Kubik, 1970); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Kobylanka stream, south Poland. Sparse, in samples with filamentous algae from Kobylany village (Wojtal, 2009); Duszatyńskie Lakes and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015).

***Pseudostaurosira versiformae* Witkowski, Riaux-Gobin & Daniszewska-Kowalczyk 2010**

(Pl. 63, figs. 12-21)

Ref. Witkowski et al. 2010, p. 274, figs. 56-67

Status of name: accepted taxonomically

Diagnosis: Valves are heteropolar, almost elliptic to linear with broadly rounded head pole and acutely rounded foot pole. The axial area is usually broad, to linear-lanceolate. Transapical striae are short, composed of oblong, areolae located in valve margin, parallel at the middle, becoming radiate towards apices, about 18-20 striae in 10 µm. Length of the valve 5-15 µm, and the breadth 2-3 µm.

Occurrence: Frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

Genus *Punctastriata* Williams & Round 1987

Diagnosis: Frustules are rectangular in girdle view, sometimes forming short chains. Valves are linear elliptic and may possess central inflation. The striae are composed of a rectangular net of transapical and apical bars. Spines are variable in form, present at the valve face/mantle junction on the costae, interrupting the striae, or both positions. One apical pore field is present, usually small.

Holotype species *Punctastriata linearis* Williams & Round 1988

***Punctastriata glubokoensis* Williams, Chudaev & Gololobova 2009**

(Pl. 64, figs. 1-9)

Ref. Williams, Chudaev & Gololobova 2009, p. 480-481, figs. 1-24; Vélez-Agudelo et al. 2017, p. 144, figs.24-28.

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view. Valves are widely elliptical, slightly heteropolar, with rounded apices. The axial area is linear-lanceolate. Transapical striae are coarse, subparallel to radiate, extending to the mantle, about 9-10 striae in 10 µm. Spines located on the costae. Length of the valve 5-8 µm, and the breadth 4-5 µm.

Remarks: According to Williams et al., 2009**,** under LM *Punctastriata glubokoensis* can be confused with *Staurosirella pinnata* (Ehrenberg) Williams & Round 1988**,** *Punctastriata ovalis* Williams & Round 1988 and *Punctastriata discoidea* Flower 2005, but the variation between them in the structure and position of their spines. In *P. ovalis*, the bifurcate hollow spines are situated along the valve face/mantle junction across the striae, while in *P. glubokoensis* and *P. discoidea,* the spines are located on the virgae. In addition, *P. glubokoensis* has an apical depression that is lacking in *P. discoidea* (Williams & Round 1987, Flower 2005, Williams et al. 2009).

Occurrence: Frequently in the late Holocene sediments of Radomno, Kamionka and Młynek Lakes, infrequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

Punctastriata lancettula **(Schumann) Hamilton & Siver 2008**

(Pl. 64, figs. 10-23)

Ref. Hustedt in Schmidt 1913, pl. 297: figs 51, 59-64; Cleve-Euler 1915, p. 55; pl. 4, fig. 94; Patrick & Reimer 1966, p. 128, pl. 4, fig. 12; Siver et al. 2005, p. 197, pl. 11, figs. 1-14; pl. 15, figs. 3-4; Hamilton & Siver 2008, p. 363, figs. 1-7, 43-51; Vélez-Agudelo et al. 2017, p. 146, figs.33-38.

Status of name: accepted taxonomically

Synonyms: *Fragilaria lancettula* Schumann 1867
Nematoplata lancettula (Schumann) Kuntze 1898
Fragilaria pinnata var. *lancettula* (Schumann) Hustedt in Schmidt 1913
Fragilaria mutabilis var. *lancettula* (Schumann) A. Cleve 1915
Staurosirella pinnata var. *lancettula* (Schumann) Siver in Siver et al. 2005

Diagnosis: Frustules are linear-rectangular, almost square to rectangular in girdle view. Valve is cruciform, rhomboid, elliptical to linear-lanceolate with attenuate-rostrate to attenuate-acute rounded apices. The axial area is narrow, linear, sometimes widened to a small lanceolate area at the center of the valve. Transapical striae are almost parallel, to slight radiate, composed of pronounced lineolate areolae, about 8-10 striae in 10 µm. Length of the valve 8-15 µm, and the breadth 4-6 µm.

Ecological preference: Fresh to slightly brackish water or water of high conductivity (Patrick & Reimer, 1966); oligohalobous "indifferent", alkaliphilous (Foged, 1980).

Occurrence: Common in the late Holocene sediments of Kamionka Lake**,** frequently in the Eemian deposits of central Poland, late Holocene sediments of Radomno and Młynek Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: It is recorded as *Staurosirella pinnata* var. *lancettula* from the lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008).

Punctastriata linearis **Williams & Round 1988**

(Pl. 64, figs. 24-27)

Ref. Williams & Round 1988, p. 278, figs 38-44

Status of name: accepted taxonomically

Diagnosis: Valves are linear-elliptical. The axial area is linear to linear-lanceolate. Transapical striae coarse, subparallel to slight radiate towards the apices, about 1-3 in 10 pm. Marginal spines situated along the valve face/mantle junction on the interstriae and across the striae; spines short, pointed, usually paired. Single apical pore-field present. Length of the valve 12-20 µm, and the breadth 1.5-3 µm.

Occurrence: Infrequently in the late Holocene sediments of Radomno Lake.

Distribution in Poland: It is reported from low pH-Piaski Lake, Western Pomerania in northwest Poland (Witkowski et al., 2011).

Punctastriata mimetica **Morales 2005**

(Pl. 64, figs. 28-34)

Ref. Morales 2005, p. 128, figs. 59-73, 115-120; Bertolli et al. 2010, p. 1066, figs. 16-18, 128-131.

Status of name: accepted taxonomically

Diagnosis: Valve is cruciform, rhomboid, elliptical to linear-lanceolate with subrostrate, rostrate to cuneate or rounded apices. The axial area is narrow, linear to lanceolate. Transapical striae are distinct, composed of several rows of small round areolae, about 9-11 striae in 10 µm. Striae extend continuously from valve face to mantle. Costae are wider than the striae. Length of the valve 7-22.5 µm, and the breadth 5-7 µm.

Ecological preference: freshwater, periphytic on the macrophytes in the river (Bertolli et al., 2010); found in alkaline water, pH value 8.2, moderately low conductivity (179 mS/cm) (Morales, 2005)

Occurrence: Frequently in the late Holocene sediments of Kamionka, Radomno, and Młynek Lakes.

Distribution in Poland: New record.

Punctastriata ovalis **Williams & Round 1988**

Ref. Williams & Round 1988, p. 278, figs 43, 44

Status of name: accepted taxonomically

Diagnosis: Valves elliptical with broadly rounded apices. The axial area is linear-lanceolate. Transapical striae 1-2 in 10 µm with 5 cross-members per striae. Spines are short, pointed, possibly bifurcate and hollow, situated along the valve face/mantle junction across the striae. Length of the valve 5-7 µm, and the breadth 2-3 µm.

Occurrence: Infrequently in the Eemian deposits of central Poland.

Ecological preference: Freshwater species

Distribution in Poland: It is reported from the lacustrine fluvial swamp deposits in the profile at Domuraty, north-eastern Poland (Winter et al., 2008)

Genus *Stauroforma* Flower, Jones & Round 1996

Diagnosis: Frustules are small, rectangular in girdle view, with an elliptic to lanceolate valve outline. The valves are not centrally expanded. The transapical striae are continuous across the valve face. Rimoportulae are absent and the apical pore field is present at the foot-pole.

Holotype species *Stauroforma exiguiformis* (Lange-Bertalot) Flower, Jones & Round 1996

***Stauroforma atomus* (Hustedt) Talgatti, Wetzel, Morales & Torgan 2014**

Ref. Hustedt 1931, p. 164, fig. 672 B**;** Snoeijs et al. 1991, p. 166, figs. 1–18, 23–25; Hofmann et al. 2011, p. 257**.**

Status of name: alternate representation

Synonyms: *Fragilaria atomus* Hustedt 1931
Fragilariforma atomus (Hustedt) Lange-Bertalot 2011
Martyana atomus (Hustedt) Snoeijs 1991
Stauroforma atomus (Hustedt) Talgatti, Wetzel, Morales & Torgan 2014

Diagnosis: Frustules are rectangular in girdle view. Valves are heteropolar, clavate to ovate, nearly elliptic in smaller individuals with rounded apices. The axial area is absent or very narrow and linear. Transapical striae are uniseriate, parallel at the center, slightly radiate toward apices, about 25–30 striae in 10 µm. Apical pore field present at foot-pole Length of the valve 4.5–7 µm, and the breadth 2.5–3.5 µm.

Ecological preference: The species has been recorded in fresh, brackish and marine coastal waters (Hustedt, 1931); common in oligohaline to mesohaline waters, in wide ranges of temperature (0–24 ºC) and pH (6–8) (Austin et al., 2007; Witak & Dunder, 2007; Majewska et al., 2012).

Distribution in Poland. The species was reported from the Gulf of Gdańsk (Zgrundo et al., 2008); Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012); as *Fragilaria atomus* from the Holocene sediments of the SW Gulf of Gdańsk (Witak & Dunder, 2007).

***Stauroforma exiguiformis* (Lange-Bertalot) Flower, Jones & Round 1996**

Ref. Flower et al. 1996, p. 53-54, figs 16-22; Hofmann et al. 2011, p. 262, pl. 6, figs 4-8; as *Fragilaria exigua* Grunow in Cleve & Möller 1878; Krammer & Lange-Bertalot 1991 a, p. 137, pl. 126, figs. 11- 220; pl. 125, fig. 4; Lange-Bertalot & Metzeltin 1996, p. 132, pl. 7, figs. 48-50; as *Fragilaria virescens* var. *exigua* Grunow in Van Heurck 1881; Hustedt 1959 b, p. 163.

Status of name: accepted taxonomically

Synonyms: *Fragilaria virescens* var. *exigua* Grunow in Van Heurck 1881
Fragilaria exigua Grunow in Cleve & Möller 1878
Fragilaria exiguiformis Lange-Bertalot 1993

Diagnosis: Frustules are rectangular in girdle view, joined by linking spines to form short ribbon-like colonies. Valves are lanceolate with convex central margins and broadly rounded apices. The axial area is narrow and linear. Transapical striae are parallel at the valve center, becoming slightly radiate toward the apices, extending continuously onto the valve mantle, about 16-20 in 10 µm. Spines are present along the valve face edge. Apical pore fields and rimoportulae are absent. Length of the valve 8-22 µm, and the breadth 3-4 µm.

Distribution in Poland: The species was recorded from Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015); Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); Lake Wigry signed to the Wigierskie group, in Wigry National Park north-east Poland (Eliasz-Kowalska & Wojtal, 2020).

***Stauroforma reimeri* (Morales, Manoylov & Bahls) Morales in Garcia et al. 2017**

(Pl. 63, figs. 22-25)

Ref. Morales, Manoylov & Bahls 2010, p. 31, figs 1-11, 33-38; Garcia et al. 2017, p. 113

Status of name: accepted taxonomically

Synonym: *Staurosira reimeri* Morales, Manoylov & Bahls 2010

Diagnosis: Valves are rhomboid to elliptical with cuneate to truncate rounded apices. The axial area is narrow and linear. Transapical striae are alternate, subparallel in the central area to radiate toward apices, uniseriate, composed of round areolae, interrupted in transition from valve face to valve mantle by a small clear area**,** about 22-24 striae in 10 µm. Length of the valve 4-9 µm*,* and the breadth 3-4 µm.

Ecological preference: Freshwater habitat. It is reported from the streams range from fresh (125 piS/cm) to brackish (10,020 piS/cm) with a mean conductivity of about 1,900 piS/cm, alkaline waters range in pH from 6.81 to 9.60. As well as, it appears to be eurythermal, occurring at temperatures ranging from 3 to over 31 °C, and occurs in waters that are moderate to well-oxygenated (Morales et al., 2010).

Occurrence: Infrequently in the late Holocene sediments of Kamionka and Radomno Lakes.

Distribution in Poland: New record.

Genus *Staurosira* Ehrenberg 1843

Diagnosis: Frustules are rectangular in girdle view with ribbed valve face. Valves are elliptical and expanded centrally. The axial area is narrow except at the center. Transapical striae are uniseriate, with elliptical to linear areolae. Apical pore fields are present and no rimoportulae are present.

Lectotype species *Staurosira construens* Ehrenberg 1843

Remarks: This genus differs from *Fragilaria* by the absence of rimoportulae, non-areolate copulae, wide valvocopulae, and relatively narrow copulae (Round et al., 1990). *Staurosira* differs from *Martyana* since the latter has no marginally linking spines, but has an apical pore field at one end only, a step in the valve at the other end, and a silt areole (Round et al., 1990; Idei & Nagumo, 1995).

***Staurosira aventralis* Lange-Bertalot & Rumrich, 2000**

(Pl. 65, figs. 1-8)

Ref. Lange-Bertalot & Rumrich in Rumrich et al. 2000, p. 221–222, pl. 11, figs. 1–8

Status of name: accepted taxonomically

Diagnosis: Valves are isopolar, elliptic, linear-elliptic to elliptical-lanceolate with blunt to widely rounded apices. The axial area is narrow, linear, or slightly expanded centrally in larger forms. Transapical striae are uniseriate, alternate, subparallel in the middle to slightly radiate toward the apices, about 14-17 in 10 µm. Length of the valve 6-15 µm and the breadth 4-5 µm.

Remarks: This species can be confused with *Staurosira venter* sensu Hustedt and *Staurosirella canariensis* (Lange-Bertalot) Morales, Ector, Maidana & Grana 2018.

Occurrence: Frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Staurosira berolinensis* (Lemmerman) Lange-Bertalot 2000**

Ref. Lange-Bertalot 1993, p. 43, pl. 134, figs. 21-25; Bukhtiyarova 1995, p. 418; Krammer & Lange-Bertalot 2000, p. 587

Status of name: alternate representation

Synonyms: *Synedra berolinensis* Lemmermann 1900
Fragilaria berolinensis (Lemmermann) Lange-Bertalot 1993
Staurosirella berolinensis (Lemmermann) Bukhtiyarova 1995
Belonastrum berolinense (Lemmermann) Round & Maidana 2001

Diagnosis: Valves are linear, linear-lanceolate to linear-elliptic or elliptical-lanceolate with bluntly rounded apices and a slight tumid center in larger specimens. The axial area is narrow, linear. Transapical striae are alternated, parallel throughout the valve to slightly radiate at the apices, about 11-12 in 10 µm. Length of the valve 12-26 µm and the breadth 1.8-2.3 µm.

Ecological preference: Freshwater environment

Distribution in Poland: The species is reported from the lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008).

***Staurosira binodis* (Ehrenberg) Lange-Bertalot in Hofmann et al., 2011**

(Pl. 65, figs. 9-29; pl. 66, figs. 1-28; pl. 67, figs. 1-32)

Ref. Hustedt 1930, p. 141, fig. 137; Hustedt 1959, p. 158, fig. 670: d-g; Patrick & Reimer 1966, p. 125, pl. 4, fig. 7; Germain 1981, p. 70, pl. 21, figs. 28-32; Krammer & Lange-Bertalot 1991a, p. 153, pl. 132, figs. 23–27;

Lange-Bertalot & Metzeltin 1996, p. 270, pl. 76, figs. 18-19; Morales 2005, p. 118, figs. 26-40, 86-91; Wojtal, 2009, p. 306, pl. 2, fig. 31. Hofmann et al., 2011 p. 260, pl. 10, figs 41-57.

Status of name: accepted taxonomically

Synonyms: *Fragilaria construens* var. *binodis* (Ehrenberg) Grunow 1862
Fragilaria subconstricta Oestrup 1910
Fragilaria tenuistriata Oestrup 1910
Fragilaria construens f. *binodis* (Ehrenberg) Hustedt 1957
Synedra binodis (Ehrenberg) Chang & Steinberg 1988
Staurosira construens var. *binodis* (Ehrenberg) Hamilton in Hamilton et al.1992
Pseudostaurosira construens var. *binodis* (Ehrenberg) Edlund 1994
Pseudostaurosira binodis (Ehrenberg) Edlund in Endlud et al. 2001

Diagnosis: Frustules are rectangular with undulate relief in girdle view. Valves are linear, bi-undulate with rostrate to subrostrate apices. The smaller specimens are lanceolate to cruciform. The axial area is broad, linear, or slightly lanceolate. Transapical striae are distinct, alternate, and composed of lineolae, continual from valve face to valve mantle. The striae are parallel to radiate in the central area, slightly radiate at the apices, about 15-18 in 10 µm. The spines are located on the costae along the valve face edge. Length of the valve 12-25 µm, and the breadth 4–6 µm.

Remarks: The species is very similar in its outer appearance to *Pseudostaurosira robusta* (Fusey) Williams and Round. However, the areolar structure and some micro-characteristics under SEM show that *P. robusta* should be included in the genus *Pseudostaurosira* (Williams and Round, 1987).

Ecological preference: A fresh and brackish water form, alkaliphilous with pH 7.5 – 8.0 (Ehrlich, 1973); Tychoplanktonic (Denys, 1991); an alkaliphilous, oligosaprobous, meso-eutraphentic and fresh brackish water species (Van Dam et al., 1994); the species is distinguished by high vitality in a wide range of trophic states and electrolyte levels (Hofmann et al., 2011); it is also reported as a freshwater species that does not tolerate the full salinity gradient of the area from the Southern Baltic Proper, the Gulf of Gdańsk, the Gulf of Riga, and the Gulf of Finland (Hällfors, 2004; Zgrundo et al., 2009); benthic, oligohalobous, alkaliphilous, eu-mesotraphenthic, β-mesosaprobous (Witak & Jankowska, 2014).

Occurrence: Common in the Eemian deposits of central Poland, frequently in the late Holocene sediments of Radomno, Kamionka, Młynek, and Francuskie Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from Vistula River (Turoboyski, 1962); fish ponds in Mydlniki (Siemińska, 1947); Sanka stream (Kądziołka, 1963); Pilica River (Kadłubowska, 1964b); spring of Szklarka stream (Skalska, 1966a, b); springs of Będkowka stream (Kubik, 1970); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Dolgie Wielkie lake on the Gardno-Leba Coastal Plain within the Slowinski National Park, North Poland (Lutyńska, 2008a); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); Kobylanka stream, south Poland (Wojtal, 2009); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Wisłok river and Żołynianka stream, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015); The Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015).

***Staurosira circula* Van de Vijver & Beyens 2002**

(Pl. 68, figs. 1-4)

Ref. Van de Vijver & Beyens 2002, p. 325, figs. 41-57

Diagnosis: Valves almost circular with an asymmetrical depression at one apex. The axial area is narrow linear. Transapical striae are irregular, consist of one or two rows of rounded areolae, about 20-24 in 10 µm. Thick marginal spines present, alternating with short spines, are placed irregularly on the striae. Length of the valve 4.5-7 µm, and the breadth 4.5-6 µm.

Ecological preference: It is characterized by a high pH (maximum 9.2) and moderate specific conductance (200-400µS/cm) **(**Van de Vijver & Beyens, 2002).

Occurrence: Frequently in the late Holocene sediments of Radomno and Kamionka Lakes.

Distribution in Poland: New record.

Staurosira construens **Ehrenberg 1843**

(Pl. 68, figs. 5-28; pl. 69, figs. 1-21; pl. 70, figs. 1-11)

Ref. Hustedt 1959 a, p. 156, fig. 670: a-c; Patrick & Reimer 1966, p. 125, pl. 4, fig. 4; Germain 1981, p. 68, fig. 21; Williams & Round 1987, p. 278, figs. 15-17. Krammer & Lange-Bertalot 1991a, p. 153, pl. 129, figs. 21-27; pl. 131, figs. 5-6; pl. 132, figs. 1–5, 29; Ehrlich 1995, p. 40, pl. 6, figs. 1-2; Lange-Bertalot 1996, p. 332, pl. 107, fig. 18; Wojtal 2009, p. 306, pl 2, fig. 30; pl. 52, fig. 1.

Status of name: accepted taxonomically

Synonym: *Odontidium tabellaria* W. Smith 1856.
Fragilaria construens (Ehrenberg) Grunow 1862.
Nematoplata construens (Ehrenberg) Kuntze 1898

Diagnosis: Frustules are rectangular in girdle view but show the prominent inflation and form ribbon-like colonies, joined by linking spines. Valves are cruciform, strongly swollen in the middle portion, often asymmetrical, with rostrate to subcapitate rounded apices. Valve face is flat or slightly undulate due to raised costae. The axial area is distinct, linear to linear-lanceolate, much wider at the central area in some specimens. Transapical striae are alternate, radiate throughout most of the valve, somewhat parallel to radiate in the central area, composed of lineolae, extend onto the valve mantle, and about 14-16 striae in 10 µm. Spines are present along the valve face edge, except at the apices, and always located on the costae, between striae. Apical pore fields are present. Length of the valve 10-22 µm, and the breadth 5-9 µm.

Remarks: It is very similar to *Staurosirella leptostauron* in shape, but differs in having much finer striae.

Ecological preference: Eurytopic, often in the littoral zone of stagnant eutrophic waters (Hustedt, 1938); fresh and slight salty waters, meso to eutrophic seas, in plankton (Cleve-Euler, 1953), littoral and pelagic, in meso to eutrophic water, pH values 69, and optimum at pH 7.08.5 (Van Der Werff & Huls, 195774); meio to mesoeuryhaline (Simonsen, 1962); it seems to prefer slightly alkaline water, often found to be indifferent to chlorides, in the plankton and benthic zones (Patrick & Reimer, 1966); halobien "indifferent", alkaliphilous (Foged, 1970); planktonic or epiphytic, in fresh and brackish water, alkaliphilous with pH values 7.58.0 (Ehrlich, 1973); Cosmopolitan diatom, preferring stagnant, oligosaprobic waters of a wide trophic range (Krammer & Lange-Bertalot, 1991a); tychoplanktonic (Denys, 1991); it is considered as tolerant to different water conditions (Hofmann, 1994); an alkaliphilous, β-mesosaprobous, meso-eutraphentic, strictly aquatic and fresh brackish water species (Van Dam et al., 1994); widespread in shallow freshwater environments of low to medium conductivity and alkalinity with pH 7.0-7.5, and frequently in slightly brackish water habitats (Zalat & Servant-Vildary, 2005); freshwater, periphytic on the macrophytes in river (Bertolli et al., 2010); benthic, oligohalobous, eu- mesotraphenthic, β-mesosaprobous (Witak & Jankowska, 2014)**;** it occurred in slightly acid pH (6), low conductivity (24.5 µS cm-1) and oligotrophic conditions, only in winter (temperature 16°C) (Silva-Lehmkuhl, et al., 2019).

Occurrence: Common in the Eemian deposits of central Poland, late Holocene sediments of Radomno, Kamionka, and Młynek Lakes; frequently in the Francuskie and Zielone Lakes and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from Młynowka stream (Gumiński, 1947); Prądnik River (Stępień, 1963); Pilica River (Kadłubowska, 1964b, Szulc, 2007); spring of Szklarka stream (Skalska, 1966a); springs of Będkowka stream (Kubik, 1970); from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Holocene sediments of the SW Gulf of Gdańsk (Witak & Dunder, 2007); Dąbrówka water body in the central part of the Wielkopolska region (Oborniki district), western Poland (Celewicz-Gołdyn & Kuczyńska-Kippen, 2008); the Gulf of Gdańsk (Zgrundo et al., 2008); Dolgie Wielkie lake on the Gardno-Leba Coastal Plain within the Slowinski National Park, North Poland (Lutyńska, 2008a); the submerged macrophytes in Lake Skomielno, Łęczyńsko-Włodawskie, eastern Poland (Toporowska et al., 2008); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); Kobylanka stream in epipelon and periphyton, south Poland (Wojtal, 2009); Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); found in Swibno-Vistula River estuary in northern Poland (Majewska et al., 2012); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); from some rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al. 2015); Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); Holocene sediments of Lake Suchar IV in the area of Wigry National Park in the range of the Pomeranian Phase north-east Poland (Zawisza et al., 2019).

***Staurosira construens* var. *asymmetrica* (A. Cleve) Zalat & Welc comb. nov.**

(Pl. 70, figs. 12-26)

Ref. Cleve-Euler 1953, p. 34, fig. 346 f-h

Synonyms: *Fragilaria mutabilis* var. *asymmetrica* Cleve-Euler 1922
Fragilaria construens var. *asymmetrica* (A. Cleve) Cleve-Euler 1932

Diagnosis: Valves s are cruciform, asymmetrical, strongly swollen in one margin and convex in the other margin, with rostrate to subcapitate rounded apices. The axial area is distinct, linear to linear-lanceolate much wider at the valve central area. Transapical striae are alternate, subparallel in the middle of the valve and radiate towards the apices, about 14-16 striae in 10 µm. Spines are located on the costae at the margin. Length of the valve 8-20 µm, and the breadth 5-9 µm.

Occurrence: Frequent in the late Holocene sediments of Kamionka and Młynek Lakes, and the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Staurosira construens* var. *baltalensis* (Gandhi, Vora & Mohan) Zalat & Nitychoruk comb. nov.**

(Pl. 71, figs. 1-15)

Ref. Gandhi et al. 1985, p. 65, fig. 9. 19(8)

Synonym: *Fragilaria construens* var. *baltalensis* Gandhi, Vora & Mohan, 1985

Diagnosis: Valves are linear-lanceolate with protracted capitate apices. The axial area is linear to linear-lanceolate, slightly wide at the center, narrowed near the apices. Transapical striae are lineolate, subparallel in the middle of the valve to radiate towards the apices, about 12-14 striae in 10 µm. Length of the valve 8-22 µm, and the breadth 4-5 µm.

Remarks: This taxon differs from the *Fragilaria bicapitata* A. Mayer 1917, in having widely lanceolate axial area, and protracted capitate apices

Occurrence: Frequent in the Eemian deposits of central Poland and the late Holocene sediments of Kamionka Lake.

Distribution in Poland: New record.

***Staurosira construens* var. *exigua* (W. Smith) Kobayasi 2002**

Ref. Schulz 1920, p. 750, figs. 9-16; Hustedt 1930, p. 141, fig. 140; **Krammer and Lange-Bertalot 1991a, pl. 117, figs. 4-7;** Mayama et al. 2002, p. 90**.**

Status of name: accepted taxonomically

Synonyms: *Triceratium exiguum* W. Smith 1856
Fragilaria exigua (W. Smith) Lemmermann 1908
Fragilaria construens var. *exigua* (W. Smith) Schulz 1920

Diagnosis: Valves are lanceolate with marked convex central margins and slightly protracted, broadly rounded apices. The axial area is narrow, linear. Transapical striae are parallel at the valve center, to slightly radiate toward the apices, extending continuously onto the valve mantle, about 16-18 in 10 µm. Spines are present along the valve face edge. Length of the valve 10-18 µm, and the breadth 3-4 µm

Distribution in Poland: Abundant in the lower Vistula River at Dybowo, central Poland (Dembowska, 2014)

***Staurosira construens* var. *nipponica* (Skvortsov) Zalat & Welc comb. nov.**

(Pl. 71, figs. 16-18)

Ref. Skvortsov 1936, p. 18, pl. 10, fig. 15; pl. 16, fig. 13

Synonym: *Fragilaria construens* var. *nipponica* Skvortsov 1936

Diagnosis: Valve is broadly lanceolate with rostrate apices, constricted from one or both sides. The axial area is linear-lanceolate. Transapical striae are parallel in the middle of the valve, slightly radiate towards the apices, about 14-16 striae in 10 µm. The spines are located on the costae along the valve face edge. Length of the valve 9-13 µm, and the breadth 4–6 µm.

Occurrence: Infrequent in the late Holocene sediments of Kamionka Lake.

Distribution in Poland: New record.

***Staurosira construens* var. *pumila* (Grunow) Kingston 2000**

(Pl. 72, figs. 1-50)

Ref. Michelutti et al. 2002, p. 380, figs.2 (q-t); Kingston 2000, p. 409

Status of name: accepted taxonomically

Synonym: *Fragilaria construens* var. *pumila* Grunow in van Heurck 1881

Diagnosis: Valves are short, lanceolate, to rhombic with rostrate acutely rounded apices. The axial area is narrow to slightly widely lanceolate. Transapical striae are distinct, alternate, radiate throughout the valve, about 15–17 striae in 10 µm. Spines are located on the costae along the valve face edge. Length of the valve 6-12 µm, and the breadth 4-5 µm.

Ecological preference: This taxon was dominant during periods of higher nutrient concentrations in the freshwater environment (Michelutti et al., 2002)

Occurrence: Common in the Eemian deposits of central Poland, the late Holocene sediments of Kamionka, Mlynek, and Radomno Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: New record.

***Staurosira construens* var. *triundulata* (Reichelt) Bukhtiyarova 1995**

(Pl. 73, figs. 1-14; pl. 74, figs. 1-20)

Ref. Hustedt 1930, p. 141, fig. 136; 1959, p. 159, fig. 670 n, o; Bukhtiyarova 1995, p. 418

Status of name: accepted taxonomically

Synonyms: *Fragilaria construens* var. *triundulata* Reichelt 1899
Staurosira construens var. *triundulata* (Reichelt) Haworth & Kelly 2002

Diagnosis: Valves are linear with tri-undulate margins with swelling in the middle portion of the valve larger than near the ends. Apices are rounded rostrate to capitate. The axial area is linear-lanceolate, becoming wider in the center of the valve. Transapical striae are parallel to slightly radiate towards the apices, about 12-14 striae in 10 µm. Length of the valve 20-30 µm, and the breadth of the valve at the widest part 6-7 µm.

Ecological preference: It is reported as benthic in the shallow eutrophic, slightly alkaline freshwater environment of studied lakes.

Occurrence: Common in the Eemian deposits of central Poland, frequently in the late Holocene sediments of Kamionka, Radomno, and Młynek Lakes.

Distribution in Poland: New record.

***Staurosira* aff. *contorta* Flower 2005**

(Pl. 75, figs. 1-3)

Ref. Flower 2005, p. 66, figs 10, 11

Status of name: accepted taxonomically

Diagnosis: Valves are quasi-rhomboidal to sigmoidal shape with one margin more swollen than the other and rounded apices. The axial area is slightly expanded in the central area. Transapical striae are radiated throughout, about 13-14 in 10 µm. Length of the valve 8-12 µm, and the breadth 6-7 µm.

Occurrence: Infrequently in the late Holocene sediments of Kamionka Lake.

Distribution in Poland: New record.

***Staurosira dimorpha* Morales, Edlund & Spaulding 2010**

(Pl. 75, figs. 4-8)

Ref. Morales et al. 2010, p. 103, figs. 20-29, 42-53

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view forming chains. Valves are elliptical with bluntly rounded apices. The axial area is narrow, linear. Transapical striae are composed of a single row of areolae, becoming larger and more elongate elliptical toward the valve margin. Striae are parallel to slightly radiate, alternate, about 17-19 striae in 10 µm. Spines short and located on the costae at valve face/ mantle junction. Length of the valve 6.5-8 µm, and the breadth 4.3-5.4 µm.

Ecological preference: It is reported as benthic in the shallow eutrophic, slightly alkaline, and moderately polluted freshwater environment of Kamionka Lake.

Occurrence: Infrequently in the late Holocene sediments of Kamionka Lake.

Distribution in Poland: New record.

Staurosira incerta **Morales 2006**

(Pl. 75, figs. 9-15)

Ref. Morales 2006, p. 137, figs. 1-24

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view. Valves are cruciform-lanceolate with inflation in the central part and subrostrate to rostrate apices. The axial area is narrow and linear-lanceolate. Transapical striae are subparallel or slightly radiate toward the apices, about 12-14 striae in 10 µm. Spines are located on the costae. Length of the valve 8-17 µm, and the breadth 4-6 µm.

Remarks: *Staurosira incerta* differs from *S. inflata* by its smaller valve length and width and the shape of the areolae, with subrostrate apices (Morales, 2006; Rusanov et al. 2018).

Ecological preference: It is reported as benthic in the shallow eutrophic, slightly alkaline, and moderately polluted freshwater environment of Kamionka lake.

Occurrence: Infrequently in the late Holocene sediments of Kamionka Lake.

Distribution in Poland: New record.

Staurosira inflata **(Heiden) Rusanov, Ács, Morales & Ector in Rusanov et al. 2018**

(Pl. 75, figs. 16-29; pl. 76, figs. 1-21)

Ref. Hustedt 1931, p. 156, fig. 669 a, b, d, f-I; Edlund 1994, p. 12, fig. 32; Witkowski et al. 2011, p. 27, fig. 13 a-c; Rusanov et al. 2018, 341, figs 3, 20-25, 30-43

Status of name: accepted taxonomically

Synonyms: *Synedra inflata* Heiden 1900
Fragilaria heidenii Østrup 1910
Fragilaria virescens var. *inflata* (Heiden) Schulz 1926
Fragilaria inflata (Heiden) Hustedt 1931
Staurosira heidenii (Østrup) Witkowski, Pliński & Kulikovskiy in Plinski & Witkowski 2011

Diagnosis: Frustules are rectangular in girdle view and usually forming linear colonies. Valve varies from rhomboid to broadly lanceolate with attenuated, rostrate, narrowly rounded apices. The axial area is linear to narrow lanceolate. Transapical striae are uniseriate, composed of elliptical or round areolae, alternate, radiate throughout, and extended onto the valve mantle, about 12-14 striae in 10 µm. Spines are located on the interstriae at the junction of the valve face and mantle. Rimoportula absent. Length of the valve 10-20 µm, and the breadth 4-10 µm.

Ecological preference: The taxon is likely to be cosmopolitan (Krammer & Lange-Bertalot, 2000), freshwater form, more common in larger lakes (Hustedt, 1931, 1959), euryhaline, perhaps even mesohalobous (Hustedt, 1939), common in brackish habitats (Brockmann, 1950), planktonic or epiphytic, indifferent to pH, "neutral" (Ehrlich, 1973), it is classified as a brackish/freshwater tychoplankton species (Vos & de Wolf, 1993). The species was recorded frequently in the freshwater environments of low conductivity, low to medium alkalinity, and pH value 6.8-7.5 (Zalat & Servant-Vildary, 2005); benthic, oligohalobous, alkaliphilous, eutraphenthic (Witak & Jankowska, 2014).

Occurrence: Abundant in the Eemian deposits of central Poland, infrequently in the late Holocene sediments of Kamionka and Radomno Lakes.

Distribution in Poland: It is recorded as *Fragilaria heidenii* from Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014).

Staurosira inflata **var.** ***istvanffyi*** **(Hustedt) Zalat & Nitychoruk comb. nov.**

(Pl. 77, figs. 1-20; pl. 78, figs. 1-18; pl. 79, figs. 1-7)

Ref. Pantocsek 1902, p. 79, pl. 9, fig. 225; Hustedt 1959, p. 156, fig. 669 c, e, k; Stoermer & Yang 1969, p. 82

Synonyms: *Fragilaria istvanffyi* Pantocsek 1902
Fragilaria inflata var. *istvanffyi* (Pantocsek) Hustedt, 1931
Fragilaria heidenii var. *istvanffyi* (Pantocsek) Stoermer & Yang 1969

Diagnosis: Frustules are rectangular in girdle view with a curved surface in the middle portion. Valves are lanceolate shape with tri-undulate margins, inflated central area, that decreased slightly towards acutely rounded, subcapitate, rostrate apices. The axial area is distinct, lanceolate, and broad at the center of the valve. Transapical striae are uniseriate, subparallel in the center and slightly radiate towards the apices, about 12-14 striae in 10 µm. Valve mantle steep with edge parallel to valve face/mantle junction. Spines located on the costae at the junction of valve face and mantle. Length of the valve 15-40 µm, and the breadth 4-10 µm.

Ecological preference: Similar to the nominate species**,** benthic, oligohalobous, alkaliphilous, eutraphenthic (Witak & Jankowska, 2014). It is reported as benthic in the shallow eutrophic, slightly alkaline freshwater environment of the studied Kamionka, Radomno, and Młynek Lakes.

Occurrence: Abundant in the Eemian deposits of central Poland, frequently in the late Holocene sediments of Kamionka, Radomno, and Młynek Lakes.

Distribution in Poland: It is recorded from Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak, 2013; Witak & Jankowska, 2014); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015).

Staurosira leptostauron **(Ehrenberg) Kulikovskiy & Genkal in Kulikovskiy et al. 2011**

(Pl. 79, figs. 8-19; pl. 80, figs. 1-16)

Ref. Hustedt 1959 a, p. 153, fig. 668: a-f; Patrick & Reimer, 1966, p. 124**,** pl. 4, fig. 2; Foged 1979, p. 53, pl. 7, fig. 26; Foged, 1981, p. 93, pl. 4, fig. 26; Jensen, 1985, p. 143, fig. 668; Williams & Round 1987, p. 276, figs. 22, 23; Laws 1988, p. 162, pl. 16, fig. 24; Krammer & Lange-Bertalot 1991 a, p. 159, pl. 131, figs. 1-2; pl. 133, figs. 24-31, 33-41; Lange-Bertalot & Metzeltin 1996, p. 270, pl. 76, figs. 28-29; Kulikovskiy et al. 2011, p. 363, pl. 2, figs 1-6; pl. 8, fig. 1

Status of name: accepted taxonomically

Synonyms: *Staurosira harrisonii* (Roper) Grunow 1877
Fragilaria leptostauron (Ehrenberg) Hustedt 1931
Staurosirella leptostauron (Ehrenberg) Williams & Round 1987

Diagnosis: Frustules are rectangular in girdle view. Valves are cruciform with rounded ends. The valve face is flat or slightly undulate due to raised costae. The axial area is linear to lanceolate with a broad central area. Transapical striae are distinct, parallel in the central area, becoming radiate near the valve ends and composed of lineolae, about 6-8 striae in 10 µm. Spines are spatulate and present along the valve face edge. Apical pore fields are located at the junction between the valve face/mantle. Rimoportulae are absent. Length of the valve 10-30 µm, and the breadth 10-18 µm.

Ecological preference: Cosmopolitan and common in shallow freshwater water (Patrick & Reimer, 1966); epipelic, epilithic, oligohalobous **(**indifferent), alkaliphilous, littoral and bottom form (Foged, 1959, 1981); alkaliphilous pH over 7, limnobiontic-slightly euryhaline 0.5-3 psu, mesopolythermic (>18-35 C°) (Moreno-Ruiz et al., 2011); dilute waters of low alkalinity and ion concentration (Wojtal, 2013).

Occurrence: Common in the Eemian deposits of central Poland and the late Holocene sediments of Młynek Lake; frequently in the late Holocene sediments of Kamionka and Radomno Lakes.

Distribution in Poland: The species was reported from Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); Duszatyńskie Lakes, south eastern Poland (Noga et al., 2013b); Springs of the high-mountain habitats in southern Poland (Tatra Mts) West Carpathians, south Poland (Wojtal, 2013); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); Żołynianka stream, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015).

Staurosira longwanensis **Rioual, Morales & Ector 2014**

(Pl. 81, figs. 1-7)

Ref. Rioual, Morales & Ector 2014, p. 92, figs 2-155

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view, forming chains. Valves are isopolar, linear-lanceolate, with an inflated central area and rostrate apices. The axial area is very narrow but sometimes linear-lanceolate. Transapical striae are alternate, parallel to slightly radial towards the apices, about 12–15 striae in 10 µm. Spines are located between the striae. Length of the valve 4.6-17.8 µm, and the breadth 2-3.9 µm.

Remarks: *Staurosira longwanensis* is relatively similar to *Staurosira oldenburgioides* (Lange–Bertalot) Lange–Bertalot et al., but *S. oldenburgioides* differs from *S. longwanensis* in having a higher striae density, wider valve, and more raised costae (Lange–Bertalot et Metzeltin, 1996).

Ecological preference: Freshwater habitat.

Occurrence: Frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Staurosira neoproducta* (Lange-Bertalot) Chudaev & Gololobova 2012**

(Pl. 81, figs. 8-10)

Ref: Krammer & Lange- Bertalot 1991a. p. 136, pl. 127, figs. 1–5A, 78; Lange-Bertalot 1993, p. 48; *Staurosira neoproducta* (Lange-Bertalot) Chudaev & Gololobova 2012, p.74, pl. 2, figs. 2–7; pl. 4, figs. 1–3; pl. 5, fig. 11.

Status of name: accepted taxonomically

Synonyms: *Fragilaria producta* (Lagerstedt) Grunow 1881
Staurosira aequalis var. *producta* (Lagerstedt) Grunow 1881
Staurosira producta (Lagerstedt) Grunow 1882
Fragilaria virescens var. *producta* (Lagerstedt) De Toni 1892
Nematoplata producta (Lagerstedt) Kuntze 1898
Fragilaria capucina var. *producta* (Lagerstedt) A. Cleve 1900
Fragilariforma neoproducta (Lange-Bertalot) Williams & Round 1988
Fragilaria neoproducta Lange-Bertalot 1993

Diagnosis: Valves are isopolar, linear-lanceolate with parallel margins of the larger forms to elliptic-lanceolate of smaller ones, with bluntly rounded apices. The axial area is relatively narrow-linear. Transapical striae are alternate, parallel to slightly radial towards the apices, about 16-18 striae in 10 µm. Spines are located between the striae. Length of the valve 7-30 µm, and the breadth 4-5.5 µm.

Occurrence: Frequently in Eemian deposits of central Poland.

Distribution in Poland. It is reported from Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012)**.**

***Staurosira pottiezii* Van de Vijver 2014**

(Pl. 81, figs. 11-22)

Ref. Van de Vijver et al. 2014, p. 257, figs 1-25**;** Sterken et al., 2015, p. 450, fig. 2 I-J.

Status of name: accepted taxonomically

Diagnosis: Valves are linear with subparallel margins, and protracted, rostrate to capitate apices. The axial area is linear to linear-lanceolate with a lacking central area. Transapical striae are alternating, subparallel at the center to slightly radiate near the apices, about 12-14 striae in 10 µm. Length of the valve 12-21 µm, and the breadth 2.5-4 µm.

Remarks: This species resembles *Fragilariforma bicapitata* (Mayer) Williams & Round 1988, but it differs from the latter species by having distinct linear to linear-lanceolate axial area. The species differs also from *Staurosira construens* var. *baltalensis* (Gandhi) comb nov. by having relatively parallel margins and slightly constricted capitate apices**.**

Ecological preference: It is reported as benthic in the shallow eutrophic, slightly alkaline freshwater environment of Kamionka and Młynek Lakes.

Occurrence: Infrequently in the late Holocene sediments of Kamionka and Młynek Lakes.

Distribution in Poland: New record

***Staurosira pseudoconstruens* (Marciniak) Lange-Bertalot 2000**

(Pl. 82, figs. 1-15)

Ref. Marciniak 1982, p. 163, pl. 1, figs. 1, 2; pl. 2, fig. 4; Krammer & Lange-Bertalot 1991 a, p. 163, pl. 130, figs. 25-30; Lange-Bertalot & Metzeltin 1996, p. 132, pl. 7, fig. 5; Krammer & Lange-Bertalot 2000, p. 587.

Status of name: accepted taxonomically

Synonyms: *Fragilaria pseudoconstruens* Marciniak 1982
Pseudostaurosira pseudoconstruens (Marciniak) Williams & Round 1987

Diagnosis: Frustules are rectangular with distinct central inflation in girdle view. Valves are cruciform, with circular to rhombic inflation and broadly rounded rostrate to slightly capitate apices. The axial area is relatively broad, nearly lanceolate. Transapical striae are mostly restricted to the margins by round to elliptical areola, parallel to slightly radiate, about 12-14 in 10 µm. Length of the valve 10-17 µm, and the breadth 4-7 µm.

Ecological preference: It is reported as benthic in the shallow eutrophic, slight alkaline freshwater environment of the studied lakes.

Occurrence: Frequently in the Eemian deposits of central Poland, the late Holocene sediments of Kamionka, Radomno, and Młynek Lakes.

Distribution in Poland: The species was reported from Late Glacial and Holocene sediments of a glacial Lake Przedni Staw in the Przedni Stawów Polskich Valley, Polish Tatra Mts (Marciniak, 1982; Marciniak, 1986a), Holocene sediments of the SW Gulf of Gdańsk and the Vistula Lagoon, the southern Baltic Sea (Witak, 2013); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015).

***Staurosira pseudoconstruens* var. *bigibba* (Marciniak) Zalat & Chodyka comb. nov.**

(Pl. 82, figs. 16-18)

Ref. Marciniak 1982, p. 164, pl. 1, figs. 3-6; Marciniak 1986a, p. 258, fig. 3.

Synonym: *Fragilaria pseudoconstruens* var. *bigibba* Marciniak 1982

Diagnosis: Valves are linear with slightly to strongly constricted in the center and slightly elongated, rostrate to capitate, or obtusely rounded apices. The axial area is broad, lanceolate. Transapical striae are marginal, parallel to slightly radiate, about 12-14 in 10 µm. Length of the valve 14-22 µm, and the breadth 5-6 µm.

Ecological preference: It is reported as benthic from the shallow eutrophic, slight alkaline, moderately polluted freshwater environment of Kamionka Lake.

Occurrence: Frequently in the Eemian deposits of central Poland and the late Holocene sediments of Kamionka Lake.

Distribution in Poland: The species was reported from Late Glacial and Holocene sediments of a glacial Lake Przedni Staw in the Przedni Stawów Polskich Valley, Polish Tatra Mts (Marciniak, 1982; Marciniak, 1986a).

***Staurosira subsalina* (Hustedt) Lange-Bertalot in Krammer & Lange-Bertalot 2004**

(Pl. 83, figs. 1-22)

Ref. Hustedt 1925, p. 106, figs 5–8; Morales 2005, p. 115, figs. 1–20, 80-85; Cejudo-Figueiras et al. 2011, p. 69, figs 2–33, 94–99, 107, 109, 111.

Status of name: accepted taxonomically

Synonyms: *Fragilaria construens* f. *subsalina* (Hustedt) Hustedt 1925
Staurosira construens f. *subsalina* (Hustedt) Bukhtiyarova 1995
Staurosira construens var. *subsalina* (Hustedt) Andresen, Stoermer & Kreis 2000
Pseudostaurosira subsalina (Hustedt) Morales 2005

Diagnosis: Frustules are rectangular in girdle view, forming chains with the aid of interlocking spines. Valves are linear narrowly lanceolate with acute to subrostrate apices in larger forms and elliptical-lanceolate in smaller forms. The axial area is linear, broadly to narrowly lanceolate. Transapical striae are punctate, uniseriate, alternate, parallel, to slightly radiate towards the apices, composed of one to four areolae on the valve face, about 14-16 striae in 10 µm. Length of the valve 10-35 µm, and the breadth 4-5 µm.

Ecological preference: The species was originally described as a brackish water variety of *Staurosira construens* (Hustedt, 1925); alkaliphilous, meso-eutraphentic, it observed in slightly alkaline waters (Lowe, 1974; Van Dam et al., 1994; Rakowska, 2001). It was found in waters with a conductivity of 238 mS/cm, circumneutral pH (7.46), and low to medium concentrations of P (orthophosphate) and total N (0.024 mg/L and 0.490 mg/L, respectively) (Morales, 2005); It is recorded from warm freshwater with conductivity between 928 and 9071 µS cm–1, pH ranged between 7.86 and 8.55, and surface water temperature 9.81 and 27.26 °C (Pérez et al., 2009).

Occurrence: Common in the Eemian deposits of central Poland, frequently in the late Holocene sediments of Radomno, Kamionka, and Młynek Lakes, and infrequently in the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was recorded as Fragilaria subsalina from Dolgie Wielkie lake on the Gardno-Leba Coastal Plain within the Slowinski National Park, North Poland (Lutyńska, 2008a); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015).

Staurosira sviridae **Kulikovskiy, Genkal & Mikheeva 2011**

(Pl. 84, figs.1-15)

Ref. Kulikovskiy, Genkal & Mikheeva 2011, p. 363, fig. 2: 15–17; fig. 8: 8

Status of name: accepted taxonomically

Diagnosis: Valves are elliptic-lanceolate with an inflated middle portion and elongate rostrate to protract apices. The axial area is narrow to lanceolate and widened in the valve center. Transapical striae are subparallel to slightly radiate towards the apices, about 14-16 striae in 10 µm. Spines are located on the marginal portion of the costae. Apical pore fields are well developed. Length of the valve 15-18 µm, and the breadth 5- µm.

Remarks: *Staurosira sviridae* is relatively similar to *Staurosira inflata*, but it differs by the smaller dimension than *Staurosira inflata* in both length and width.

Occurrence: Common in the Eemian deposits of central Poland, infrequently in the late Holocene sediments of Kamionka Lake.

Distribution in Poland: New record.

Staurosira sviridae **var. *rostrata*** **Zalat nov. var.**

(Pl. 84, figs.16-21; pl. 85, figs. 1-28)

Diagnosis: Valves are elongate-lanceolate with relatively parallel margins and protracted rostrate apices. The axial area is lanceolate, narrowed at the apices, and slightly broad at the center. Transapical striae are slightly radiate throughout the valve, about 14-15 striae in 10 µm. Spines are present on the marginal portion of the costae. Length of the valve 17-22 µm, and the breadth 6-7 µm.

Remarks: This variety differs from the nominate species by having relatively parallel margins and protracted rostrate apices.

Etymology. The epithet of the new variety refers to the rostrate apices.

Holotype: the specimens illustrated in plate 84, figures 16-21.

Type locality: The Eemian deposits from the Struga site in central Poland.

Occurrence: Frequently distributed in the Eemian deposits of central Poland.

Distribution in Poland: New record

Staurosira vandenbusscheana **Van de Vijver in Van de Vijver et al., 2020**

(Pl. 86, figs. 1-9)

Ref. Van de Vijver et al., 2020, p. 5, figs. 26–48

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view, forming long band-like colonies. Valves are linear with parallel margins, and distinctly protracted, rostrate to subcapitate apices. The longer valves often with weakly constricted center. The axial area is moderately broad, linear. lacking central area. Transapical striae are alternating, parallel throughout, becoming very weakly radiate near apices, about 14–15 striae in 10 µm. Length of the valve 15-32 µm, and the breadth 3-4 µm.

Ecological preference: The species has been observed on all sub-antarctic islands in the southern Indian Ocean, it was found in circumneutral (pH 7.2–7.4) to very alkaline (pH 8.9–9.2) lakes and moss vegetation alongside rivers and lakes, and it seems to prefer low to moderate conductivity values (Van de Vijver et al., 2020).

Occurrence: Infrequently in the late Holocene sediments of Kamionka and Młynek Lakes.

Distribution in Poland: New record

Staurosira venter (Ehrenberg) Cleve & Möller 1879

(Pl. 86, figs. 10-24; pl. 87, figs. 1-40)

Ref. Hustedt 1930, p. 141, fig. 138; Hustedt 1959 a, p. 158, fig. 670: h-m; Patrick & Reimer 1966, p. 126, pl. 4, figs. 8-9; Germain 1981, p. 70, pl. 21, figs. 6-14; Laws 1988, p. 162, pl. 16, fig. 12; Krammer & Lange-Bertalot 1991a, p.153, pl. 129, figs. 21-27; pl. 131, figs. 5, 6; pl. 132, figs. 9-16; Ehrlich 1995, p. 41, pl. 6, figs. 3-7; Lange-Bertalot & Metzeltin 1996, p. 270, pl. 76, figs. 12-25; Wojtal 2009, p. 308, pl. 3, figs. 1–3; pl. 51, figs. 3–6.

Status of name: accepted taxonomically

Synonyms: *Fragilaria venter* Ehrenberg 1854
Fragilaria construens var. *venter* (Ehrenberg) Grunow 1881
Fragilaria construens var. *pumila* Grunow 1881
Fragilaria construens f. *subrotunda* Mayer 1917

Fragilaria construens var. *subrotunda* (Mayer) Mayer 1919
Fragilaria construens f. *venter* (Ehrenberg) Hustedt 1957
Staurosira construens var. *venter* (Ehrenberg) Hamilton in Hamilton et al.1992
Staurosira construens f. *venter* (Ehrenberg) Bukhtiyarova 1995

Diagnosis: Frustules are rectangular in girdle view and form ribbon-like colonies joined by linking spines. Valves are linear-lanceolate, to rhombic with rostrate apices and elliptical-lanceolate with broadly rounded apices. The axial area is narrow to widely lanceolate. Transapical striae are distinct, alternate, parallel in the central area to radiate toward the apices, about 14–16 striae in 10 µm. Spines are present on the costae along the valve face edge, except at the apices. Apical pore fields are located at both poles. Rimoportula are absent. Length of the valve 6-20 µm, and the breadth 4-7 µm.

Ecological preference: The species often found in the littoral zone of stagnant eutrophic waters (Hustedt, 1938); meio to mesoeuryhaline (Simonsen, 1962); it seems to prefer water of fairly low nutrient content, oligotrophic to mesotrophic (Patrick & Reimer, 1966); oligohalobous "indifferent", alkaliphilous, limnobiontic, and oligosaprobic (Van Landingham, 1970); in fresh and brackish water, planktonic and epiphytic, alkaliphilous with pH values 7.5-8.0 (Ehrlich, 1973); Periphytic, tychoplanktonic, oligohalobous (indifferent), alkaliphilous (Lowe, 1974); cosmopolitan, occurring worldwide in temperate freshwaters, preferring stagnant, oligosaprobic waters, of a wide trophic range (Krammer & Lange-Bertalot, 1991a); an alkaliphilous, β-mesosaprobous, meso-eutraphentic strictly aquatic and fresh brackish water species (Van Dam et al., 1994), it is observed in the fresh to slight brackish, slight alkaline, meso- to eutrophic water (Zalat & Servant-Vildary, 2005); warm alkaline freshwater with temperature 18.7 – 26.8 °C and pH value 7.5-8.1 (Cantoral-Uriza & Sanjurjo, 2008); benthic, oligohalobous, eu-mesotraphenthic, β-mesosaprobous (Witak & Jankowska, 2014); slightly polluted, of beta-mesosaprobic zones (Szczepocka et al., 2014); freshwater, meso-oligotraphentic with pH value 7.69-8.11 (Witak et al., 2017).

Occurrence: Common in the Eemian deposits of central Poland, the late Holocene sediments of Kamionka, Radomno, and Młynek Lakes, frequently in the surface sediments of Jeziorak Lake.

Distribution in Poland: Vistula River (Turoboyski, 1962); fish ponds in Mydlniki (Siemińska, 1947); Sanka stream (Kądziołka, 1963); Pilica River (Kadłubowska, 1964b); spring of Szklarka stream (Skalska, 1966a, b); springs of Będkowka stream (Kubik, 1970); Mały Staw lake, in a post-glacial cirque in the northeastern part of Karkonosze Mts, south-west Poland (Sienkiewicz, 2005, 2016); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Dąbrówka water body in the central part of the Wielkopolska region (Oborniki district), western Poland (Celewicz-Gołdyn & Kuczyńska-Kippen, 2008); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); Kobylanka stream, south Poland (Wojtal, 2009); the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Duszatyńskie Lakes, south eastern Poland (Noga et al., 2013); the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); the Linda River central Poland (Szczepocka et al., 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015); from the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); Spring at the Goprowska Pass (Bieszczady National Park), south eastern Poland (Żelazna-Wieczorek & Knysak, 2017).

Genus *Staurosirella* Wiliams & Round 1987

Diagnosis: Frustules are rectangular in girdle view. Valves are elliptical to linear, occasionally cruciform. Transapical striae are uniseriate and composed of lineolate areolae. The axial area is wide. Apical pore fields are present and usually large. Rimoportulae are absent. Spines are often complexly branched.

Remarks: This genus encompasses the previous *Fragilaria* species. It differs from *Staurosira* in the nature of the areolae, apical pore plates, and the structure of spines. The thick ribs separating the areolae are a very distinctive characteristic of this taxon (Round et al., 1990).

Holotype species *Staurosirella lapponica* Williams and Round.

***Staurosirella alpestris* (Krasske) Le Cohu 1999**

Ref. *Fragilaria alpestris* Krasske in Hustedt 1931, p. 165, fig. 673 B; Mölder & tynni 1970, p.129, pl. 1, fig. 1; Krammer & Lange-Bertalot 1991a, pl. 111, figs. 25-28; Van de Vijver et al. 2002, p. 114; Van de Vijver et al. 2020, p. 3, figs.1-25.

Status of name: accepted taxonomically

Synonyms: *Fragilaria alpestris* Krasske in Hustedt 1931
Staurosira alpestris (Krasske ex Hustedt) Van de Vijver 2002

Diagnosis: Frustules are rectangular in girdle view. Valves are linear, narrow, with parallel margins, weakly constricted at center, and slight round capitate to subcapitate apices. The axial area is linear to linear-lanceolate; the central area is occasionally extending to the margins, with slight bilateral swelling and composed of several reduced striae. Transapical striae are nearly parallel, about 13-15 in 10 µm. Length of the valve 28-35 µm and the breadth 3-3.5 µm.

Ecological preference: Freshwater species (Krammer & Lange-Bertalot, 1991a); it is reported from the eutrophic lakes and rivers (Cleve-Euler, 1953).

Distribution in Poland: Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015).

***Staurosirella canariensis* (Lange-Bertalot) Morales, Ector, Maidana & Grana 2018**

(Pl. 88, figs. 1-8)

Ref. Lange-Bertalot 1993, p. 43, pl. 14, figs 1-6; Grana et al. 2018, p. 69

Status of name: accepted taxonomically

Synonym: *Fragilaria canariensis* Lange-Bertalot 1993

Diagnosis: Valves are elliptic to elliptical-lanceolate or ovate with obtusely rounded apices. The axial area is broad. Transapical striae are uniseriate, alternate, slightly radiate throughout the valve, about 13-15 in 10 µm. Spines are located on the costae at the marginal area. Rimoportula are absent. Length of the valve 4-7 µm and the breadth 3-4 µm.

Occurrence: Infrequently distributed in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Staurosirella crassa* (Metzeltin & Lange-Bertalot) Ribeiro & Torgan 2010**

(Pl. 88, figs. 9-12)

Ref. Metzeltin & Lange-Bertalot 1998, p. 89, pl. 1, figs. 20-23; pl. 2, fig. 1; Metzeltin et al. 2005, p. 270; Ribeiro et al. 2010, p. 24; Nardelli et al. 2014, p. 136, figs. 59-65; Ruwer & Rodrigues 2018, p. 435, figs. 6-9, 65.

Status of name: accepted taxonomically

Synonyms: *Fragilaria crassa* Metzeltin & Lange-Bertalot 1998
Staurosira crassa (Metzeltin & Lange-Bertalot) Metzeltin, Lange-Bertalot & García-Rodríguez 2005

Diagnosis: Frustules are rectangular in girdle view. Valves are elliptic-lanceolate with obtusely rounded to subrostrate apices. The axial area is moderately wide to narrow, linear. Transapical striae are coarse, alternate, parallel in the middle and slightly radiate towards the apices, about 6-7 striae in 10 µm. Length of the valve 10-35 µm and the breadth 4-8.5 µm.

Ecological preference: The species was recorded as an epipsammic species (Ribeiro et al., 2008); freshwater, periphytic on the macrophytes in the river (Bertolli et al., 2010); in lentic, oligotrophic to mesotrophic environments (Dunck et al., 2012).

Occurrence: Infrequently in the late Holocene sediments of Radomno Lake.

Distribution in Poland: New record.

***Staurosirella dubia* (Grunow) Morales & Manoylov 2006**

(Pl. 88, figs. 13-16)

Ref. Hustedt 1931, p. 154, fig. 668 h-I; Hustedt 1959 a, p. 154, fig. 668 g; Patrick & Reimer 1966, p. 124, pl. 4, fig. 3; Krammer & Lange-Bertalot 1991 a, p. 160, pl. 133, figs. 24-27; Wojtal, 2009, p. 212, pl. 3, figs. 9, 10; pl. 51, fig. 1; Edlund 1994, p. 12, fig. 31; Morales & Manoylov 2006, p. 348; Bąk et al. 2012, p. 315, pl. 10.

Status of name: accepted taxonomically

Synonyms: *Fragilaria harrisonii* var. *dubia* Grunow 1862
Staurosira harrisonii var. *dubia* (Grunow) Cleve in Cleve & Grunow 1880

Fragilaria leptostauron var. *dubia* (Grunow) Hustedt 1931
Staurosirella leptostauron var. *dubia* (Grunow) Edlund 1994

Diagnosis: Valves are heavily silicified, lanceolate with rostrate apices in larger specimens and elliptical with rounded apices in smaller specimens. Valve face is flat or slightly undulate due to raised costae. The axial area is narrow-lanceolate. Transapical striae are distinct, subparallel in the central area to radiate toward the valve ends, composed of lineolae, about 8-10 striae in 10 µm. Apical pore fields are located on the valve mantle. Rimoportula are absent. Length of the valve 10-35 µm, and the breadth 6-10 µm.

Ecological preference: Cosmopolitan, oligohalobous-indifferent, alkaliphilous (Foged, 1959); an alkaliphilous and fresh brackish water species (Van Dam et al., 1994).

Occurrence: Frequently in the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from Vistula River (Turoboyski, 1962); Kobylanka stream, south Poland, sparse in mud samples from above Kobylany village (Wojtal, 2009); Duszatyńskie Lakes, southeastern Poland (Noga et al., 2013).

***Staurosirella elegantula* Morales & Manoylov 2010**

(Pl. 88, figs. 17-30)

Ref. Morales et al. 2010, p. 34, figs. 12-23, 39-44

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view with tumid central region, forming chains with the aid of spines. Valves are sub-heteropolar, lanceolate with acutely rounded apices. The axial area is narrow linear to narrow-lanceolate. Transapical striae are alternate, parallel, sometimes slight radiate, uniseriate, composed of apically elongated areolae, about 6-8 striae in 10 µm. Spines are located on the costae at the valve face/mantle junction. Apical pore fields are well developed at both apices. Length of the valve 10-76 µm, and the breadth 6-10 µm.

Occurrence: Frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record

***Staurosirella frigida* Van de Vijver & Morales 2014**

(Pl. 89, figs. 1-7)

Ref. Van de Vijver et al. 2014, p. 261, figs 52-76

Status of name: accepted taxonomically

Diagnosis: Valves are heteropolar with acutely rounded to cuneate apices. The axial area is narrow linear to narrowly lanceolate. Transapical striae are parallel to slight radiate, alternate, about 10-12 striae in 10 µm. Length of the valve 10-15 µm, and the breadth 3-4 µm.

Ecological preference: An alkaliphilous and freshwater species found at pH 7.2-7.9 (Van de Vijver et al., 2014). It is reported as a benthic species from the shallow, slightly alkaline, eutrophic freshwater environment of Młynek Lake.

Occurrence: Infrequently in the late Holocene sediments of Młynek Lake.

Distribution in Poland: New record

***Staurosirella guenter-grassii* (Witkowski & Lange-Bertalot) Morales et al. 2019**

(Pl. 89, figs. 8-20)

Ref. Witkowski 1994, p. 127, figs. 5/27-31,8/1-5; Witkowski & Lange-Bertalot 1993, p.65, figs 5 a-h; Sabbe & Vyverman 1995, p. 241, figs. 29-42, 66-71; Witkowski et al. 2000, p. 70, figs. 24/40-44; Morales et al., 2019, p. 281

Status of name: accepted taxonomically

Synonyms: *Fragilaria guenter-grassii* Witkowski & Lange-Bertalot 1993
Opephora guenter-grassii (Witkowski & Lange-Bertalot) Sabbe & Vyverman 1995
Gedaniella guenter-grassii (Witkowski & Lange-Bertalot) Chunlian Li, Sato & Witkowski 2018

Diagnosis: Frustules are wide and more or less cuneate in girdle view. Valves are usually heteropolar with acutely to bluntly rounded or cuneate apices. The axial area is linear to narrowly lanceolate. Transapical striae are parallel at the center, parallel to convergent at the apices, alternate, composed of apically elongated areolae, about 12-16 striae in 10 µm. Apical pore fields are present at both poles. No rimoportulae. Length of the valve 4-20 µm, and the breadth 2-3.5 µm.

Remarks: This species can easily be confused with the recently described species *Fragilaria gedanensis* Witkowski (Witkowski, 1993; Witkowski & Lange-Bertalot, 1993).

Ecological preference: Epipsammic species has been commonly reported from sandy sediments in brackish water to marine sediments in the Baltic Sea and the North Sea coasts (Witkowski et al., 2000)**;** Mesohalobous (Witak & Dunder, 2007); Holocene sediments of SW Gulf of Gdańsk and the Vistula Lagoon, the southern Baltic Sea (Witak, 2013).

Occurrence: Infrequently in the late Holocene sediments of Radomno, Kamionka, and Młynek Lakes, surface sediments of Jeziorak Lake and the Eemian deposits of central Poland.

Distribution in Poland: Puck Bay (Zatoka Pucka), Poland (Witkowski, 1992; Sabbe & Vyverman, 1995); Holocene sediments of the SW Gulf of Gdańsk (Witak & Dunder, 2007), Dolgie Wielkie lake on the Gardno-Leba Coastal Plain within the Slowinski National Park, North Poland (Lutyńska, 2008a).

***Staurosirella krammeri* Morales, Wetzel & Ector 2010**

(Pl. 89, figs. 21-29)

Ref. Morales et al. 2010, p. 109, figs. 1–18 & 33–38

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view, forming chains with the aid of spines. Valves are isopolar, rhomboid with narrowly rounded apices in larger specimens, becoming elliptical with broader rounded apices in smaller ones. The axial area is wide, lanceolate. Transapical striae are alternate, uniseriate, sometimes parallel in the center, becoming radiate toward the apices, about 12–14 striae in 10 µm. Length of the valve 8–14 µm, and the breadth 3–5 µm.

Ecological preference: The species was found in low electrolyte content (53 µS · cm–1), slightly alkaline (pH 7.6), low concentrations of nitrogen (0.008 mg/l) and phosphorous (0.07 mg/l), low temperature (7.9°C) and occurs in high-discharge waters that are well oxygenated. (Morales et al., 2010)

Occurrence: Frequently in the late Holocene sediments of Radomno and Młynek Lakes, and the Eemian deposits of central Poland.

Distribution in Poland: New record.

Staurosirella lanceolata (Hustedt) Morales, Wetzel & Ector 2010

(Pl. 89, figs. 30-42)

Ref. Morales, Wetzel & Ector 2010, p. 112, figs. 19–32 & 39–44.

Status of name: accepted taxonomically

Synonyms: *Fragilaria lapponica* f. *lanceolata* Hustedt 1942
Fragilaria lapponica var. *lanceolata* (Hustedt) Zhang & Qi 1994

Diagnosis: Frustules are rectangular and usually deep in girdle view. Valves are isopolar, narrowly elliptical, with narrowly rounded apices. The axial area is wide and lanceolate. Transapical striae are alternate, uniseriate-lineolate, slightly parallel in the center to radiate toward the apices, about 8–10 striae in 10 µm. Length of the valve 5–12 µm, and the breadth 3.5–5.5 µm.

Remarks: *Staurosirella lanceolata* can be confused with smaller forms of *Staurosirella lapponica*, but the latter species differs in having parallel valve sides, short striae pointed on the valve face and mantle

Ecology: Zhang and Qi (1994) found it in brackish pools in Haikou, Hainan Province (China)

Occurrence: Frequently in the late Holocene sediments of Radomno and Młynek Lakes, and the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Staurosirella lapponica* (Grunow) Williams & Round 1987**

(Pl. 90, figs. 1-24; pl. 91, figs. 1-24)

Ref. Williams & Round 1987, p. 274, pl. 21, figs. 26, 27; Krammer and Lange-Bertalot 1991a, pl. 134, figs. 1-7.

Status of name: accepted taxonomically

Synonyms: *Fragilaria lapponica* Grunow 1881
Staurosira brevistriata var. *lapponica* (Grunow) Grunow 1882
Nematoplata lapponica (Grunow) Kuntze 1898
Fragilaria pinnata var. *lapponica* (Grunow) Frenguelli 1924
Staurosira lapponica (Grunow) Lange-Bertalot 2000

Diagnosis: Frustules are rectangular in girdle view. Valves are linear, elongated elliptical with parallel sides and broadly rounded apices. The axial area is wide, linear. Transapical striae are marginal, uniseriate, parallel in the center to slightly radiate toward the apices, about 8–10 striae in 10 µm. Length of the valve 10–30 µm, and the breadth 3.5–6 µm.

Ecological preference: Low alkaline freshwater environment (Żelazna- Wieczorek & Ziułkiewicz, 2009); benthic, oligohalobous, alkaliphilous, eu-mesotraphenthic (Witak & Jankowska, 2014). The species is reported from the shallow, alkaline, eutrophic freshwater environment of the studied lakes.

Occurrence: Common in the Eemian deposits of central Poland, frequently in the late Holocene sediments of Radomno, Kamionka, and Młynek Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from Łódź Hills scarp, between Ozorków, Stryków and Brzeziny (Żelazna- Wieczorek & Ziułkiewicz, 2004; Ziułkiewicz, 2005); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Żołynianka stream, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al. 2015); Holocene sediments of Lake Suchar IV in the area of Wigry National Park in the range of the Pomeranian Phase north-east Poland (Zawisza et al., 2019).

***Staurosirella lapponica* var. *maior* (Tynni) Zalat & Pidek comb. nov.**

(Pl. 92, figs. 1-7)

Ref. Tynni 1982, p. 34, pl. 20, figs. 19, 20.

Synonym: ***Fragilaria lapponica* var. *maior* Tynni 1982**

International code: Valid (fossil)

Diagnosis: Valves are linear with parallel margin and cuneate to bluntly rounded apices. The axial area is linear, moderately wide. Transapical striae are distinct, short, marginal, parallel in the center to slightly radiate toward the apices, about 6–7 striae in 10 µm. Length of the valve 35-65 µm, and the breadth 6-7 µm.

Remarks: This variety differs from the type species by its greater size and low density of the transapical striae.

Occurrence: Frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Staurosirella lapponica* var. *marciniakae* (Kaczmarska) Zalat & Pidek comb. nov.**

(Pl. 93, figs. 1-8; pl. 94, figs. 1-7)

Ref. Kaczmarska 1976, p. 235, fig.1, 5a-c; McLaughlin & Stone 1986, p. 47, pl. 5, fig. 82

Synonyms: *Fragilaria lapponica* var. *marciniakae* Kaczmarska 1976
Fragilaria lapponica var. *inflata* McLaughlin & Stone 1986

International code: Valid (fossil)

Diagnosis: Valves are elongate-linear, with inflated middle portion and cuneate to more or less rounded apices. The axial area is linear, wide. Transapical striae are short, coarse, marginal, parallel in the center to slightly radiate toward the apices, about 8–10 striae in 10 µm. Length of the valve 28-85 µm, and the breadth 4-6µm.

Occurrence: Frequently in the Eemian deposits of central Poland.

Distribution in Poland: The species was reported from Imbramowice near Wroclaw, Poland, Eemian interglacial shallow lake deposits (Kaczmarska, 1976).

***Staurosirella lapponica* var. *rostrata* (Krasske) John 2018**

(Pl. 92, figs. 8-16)

Ref. Krasske 1938, p. 526, pl. 11, fig.1; John 2018, p. 91, fig. 56

Status of name: alternate representation

Synonym: *Fragilaria lapponica* var. *rostrata* Krasske 1938

Diagnosis: Valves are elongate-linear, with subparallel margins and cuneate to rostrate, acutely rounded apices. The axial area is linear, moderately wide. Transapical striae are marginal, parallel in the middle portion of the valve to slightly radiate toward the apices, about 8–10 striae in 10 µm. Length of the valve 28-35 µm, and the breadth 4-5µm.

Occurrence: Frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

Staurosirella magna **Morales & Manoylov in Morales et al. 2010**

(Pl. 95, figs. 1-6)

Ref. Morales et al. 2010, p. 34, fig. 26-32, 45-50

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view with obviously tumid central region, forming chains with the aid of spines. Valves are heteropolar, lanceolate with broadly rounded apices. The axial area is narrow, linear to lanceolate. Transapical striae are parallel in the central area to radiate toward the apices, alternated on each side of the valve axis, about 6-7 in 10 µm. Spines are located on the costae at the valve face/mantle junction. Apical pore fields are well developed at both apices. Length of the valve 13-52 µm, and the breadth 6-15 µm.

Ecological preference: The species was recorded from the freshwater environment of low electrolyte content (53//S/cm) and slightly alkaline (pH 7.6); Nitrogen and phosphorus concentrations are generally low 0.008 mg/L and 0.07 mg / L, at low temperature (7.9 °C) and it occurs in high discharge waters that are well oxygenated (Morales et al., 2010)

Occurrence: Infrequently in the Eemian deposits of central Poland and the late Holocene sediments of Kamionka Lake.

Distribution in Poland: New record.

Staurosirella martyi **(Héribaud-Joseph) Morales & Manoylov 2006**

(Pl. 95, figs. 7-18; pl. 96, figs. 1-19; pl. 97, figs. 1-18; pl. 98, figs. 1-27)

Ref. Hustedt 1930, p. 132, fig. 120; Hustedt 1959 a, p. 135, fig. 654; Patrick & Reimer 1966, p. 115, pl. 3, fig. 3; Germain 1981, p. 58, pl. 17, figs. 1-2; Lange-Bertalot 1989, p. 94, pl. 7, figs. l13; Krammer & Lange-Bertalot 1991a, p. 160, pl. 133, figs. 28-31; Ehrlich 1995, p. 46, pl. 6, fig. 26; Witkowski et al. 1996, p. 282, figs. 1-82; Lange-Bertalot & Metzeltin 1996, p. 270, pl. 76, fig. 22; Morales & Manoylov 2006, p. 354.

Status of name: accepted taxonomically

Synonyms: *Opephora martyi* Héribaud-Joseph 1902
Fragilaria mutabilis f. *martyi* (Héribaud-Joseph) A. Cleve 1932
Fragilaria mutabilis var. *intercedens* (Héribaud-Joseph) A. Cleve 1932
Fragilaria leptostauron var. *martyi* (Héribaud-Joseph) Lange-Bertalot 1991
Martyana martyi (Héribaud-Joseph) Round in Round et al. 1990
Fragilaria martyi (Héribaud-Joseph) Lange-Bertalot 1993
Staurosira martyi (Héribaud-Joseph) Lange-Bertalot 2000

Diagnosis: Frustules are quadrate in girdle view. Valves are typically heteropolar in valve view, symmetrical on the apical axis, asymmetrical on the transapical axis. Valve outline is clavate, ovate, elliptic to narrow club-shaped, with broadly rounded head pole and acutely rounded foot pole. The axial area is narrow linear to lanceolate. Transapical striae are coarse and distinctive, uniseriate and prolong onto the mantle, parallel to slight radiate, lineolate, about 6-7 striae in 10 µm. The pore field is always distinct at the foot pole. The length of the valve is 15 – 30, and the breadth is 5 – 7 µm.

Remarks: According to Witkowski et al. (1996), the linking spines were detected in some specimens in others they were absent.

Ecological preference: Cosmopolitan species, alkaliphilous, saproxen, distributed in standing or slowly running waters of Europe (Hustedt, 1957); oligohalobous pleioeuryhaline, 0.0-20‰ (Simonsen, 1962); halobien "indifferent", alkaliphilous, with pH value 7 (Foged, 1970); fresh to brackish water, epiphytic, alkalibiontic, with pH value 8 (Ehrlich, 1973); alkaliphilous to alkalibiontic, in eutrophic to mesotrophic waters (Lowe, 1974); oligohalobous "indifferent", alkaliphilous (Foged, 1993). The modern representatives of the species were observed commonly in the freshwater environments of low conductivity and low alkalinity, pH 6.8-7.4 and unpolluted waters (Zalat & Servant-Vildary, 2005); benthic, fresh-brackish, eutrophic-oligotrophic, β/oligosaprobic (Zgrundo et al., 2008); benthic, oligohalobous, alkaliphilous, eu- mesotraphenthic, oligosaprobous (Witak & Jankowska, 2014).

Occurrence: Common in the Eemian deposits of central Poland, the late Holocene sediments of Radomno, Kamionka, and Mlynek Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from the early medieval port of Wolin, southeastern of Wolin Island, at the bank of the Dziwna river NW Poland (Latalowa et al., 1995); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Holocene sediments of the SW Gulf of Gdańsk (Witak & Dunder, 2007); Gulf of Gdańsk (Zgrundo et al., 2008); lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); from Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012)**;** periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015).

***Staurosirella minuta* Morales & Edlund 2003**
(Pl. 99, figs. 1-7)
Ref. Morales & Edlund 2003, p. 226, figs. 3-12, 33-38
Status of name: accepted taxonomically
Diagnosis: Frustules are rectangular to clavate with rounded ends in girdle view. Valves are narrowly elliptical to slightly clavate with acutely to bluntly rounded apices. The axial area is narrow. Transapical striae are parallel, alternate and uniseriate composed of elongated areolae, about 13-14 striae in 10 µm. Apical pore fields are well developed at both apices. Length of the valve 5-15.5 µm, and the breadth 2-2.5 µm.
Ecological preference: The species is reported as benthic epipsammic in the shallow, slightly alkaline, eutrophic freshwater environment of the studied lakes.
Occurrence: Infrequently in the Eemian deposits of central Poland, the late Holocene sediments of Radomno and Kamionka Lakes, and the surface sediments of Jeziorak Lake.
Distribution in Poland: New record.

***Staurosirella mutabilis* (W. Smith) Morales & Van de Vijver 2015**
(Pl. 99, figs. 8-20)
Ref. W. Smith 1856, p. 17, pl.34, fig. 290; Morales et al. 2015, p. 468
Status of name: accepted taxonomically
Synonyms: *Odontidium mutabile* W. Smith 1856
Dimeregramma mutabile (W. Smith) Ralfs 1861
Fragilaria mutabilis (W. Smith) Grunow 1862
Diatoma mutabilis (W. Smith) Heiberg 1863
Staurosira mutabilis (W. Smith) Pfitzer 1871
Staurosira mutabilis (W. Smith) Leuduger-Fortmorel 1878
Nematoplata mutabilis (W. Smith) Kuntze 1898
Diagnosis: Valves are isopolar, elongate oval to elliptic shape with broadly rounded apices. The axial area is wide as high as the virgae in both inner and outer views and has a zig-zag shape due to the alternate nature of the striae, somewhat internally raised with respect to the striae. Transapical striae are short, formed by long lineolae that run continuously from valve face to mantle, about 8-9 striae in 10 µm. The apical pore fields are well represented at both apices. Length of the valve 8.5-26 µm, and the breadth 4.5-6 µm.
Occurrence: Frequently in the Eemian deposits of central Poland and the late Holocene sediments of Radomno and Kamionka Lakes.
Distribution in Poland: New record.

***Staurosirella neopinnata* Morales, Wetzel, Haworth & Ector 2019**
(Pl. 99, figs. 21-41)
Ref. Morales et al. 2019, p. 82, figs. 1-187
Status of name: accepted taxonomically
Diagnosis: Frustules are rectangular in girdle view, joined together by interlocking spines. Valves are linear elliptical to elliptic, most frequently isopolar with bluntly rounded apices. The axial area is narrowly linear to linear-lanceolate. Transapical striae are parallel to slightly radiate towards the apices, about 8-10 striae in 10 µm. Spines are located on the interstriae. Apical pore fields are developed on both valve apices. Length of the valve 4-25 µm, and the breadth 4-4.7 µm.
Ecological preference: Freshwater environment
Occurrence: Frequently distributed in the Eemian deposits of central Poland.
Distribution in Poland: New record.

Staurosirella oldenburgiana **(Hustedt) Morales 2005**

Ref. Hustedt 1959, p. 173, pl. 1, figs. 20-21; Krammer & Lange-Bertalot 1991a, pl. 134, figs. 26-28, 31; Morales 2005, p. 118, figs. 41-53,92-97.

Status of name: accepted taxonomically

Synonyms: *Fragilaria oldenburgiana* Hustedt 1959
Staurosira oldenburgiana (Hustedt) Lange-Bertalot in Krammer & Lange-Bertalot 2000

Diagnosis: Frustules are rectangular in girdle view. Valves are linear to lanceolate with rostrate to subcapitate apices. The axial area is narrow, linear to narrowly lanceolate. Transapical striae are parallel, alternate, and composed of small elliptical areolae, about 12–14 striae in 10 µm. The costae are thickened and raised. Apical pore fields are well developed at both apices. Length of the valve 15-25 µm, and the breadth 2.5-4 µm.

Ecological preference: The species was recognized as acidophilous and oligo-mesotraphentic (Van Dam et al., 1994); it was found in slightly acid water with pH value 6.7, a conductivity of 36.1 mS/cm and P (orthophosphate), and total N concentrations of 0.02 mg/L and 0.028 mg/L, respectively (Morales, 2005).

Distribution in Poland: The species was reported from the lacustrine fluvial swamp deposits from the profile at Domuraty, north-eastern Poland (Winter et al., 2008); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015).

Staurosirella ovata **Morales 2006**

(Pl.100, figs. 1-27; pl. 101, figs. 1-9)

Ref. Morales & Manoylov 2006, p. 357, figs. 44-56, 108-113

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view. Valves are ovoid in outline with broadly rounded head pole and relatively acutely rounded foot pole. The axial area is narrow, linear to lanceolate. Transapical striae are parallel to slightly radiate towards the apices, alternate and composed of small elongated areolae, about 6–9 striae in 10 µm. The costae are thickened and raised concerning the striae. Apical pore fields are well developed at both apices. Length of the valve 6.5-38 µm, and the breadth 3.5-7 µm.

Remarks: The species resembles *Staurosirella martyi, S. pinnata* and *S. subrobusta* under LM. *Staurosirella ovata* is distinguished from *Staurosirella martyi* by a higher stria density (6-9 in 10 µm) and separates from *Staurosirella pinnata* by having a consistently heteropolar valve outline, which is less evident in the smaller forms and less stria density since striae about 10-12 in 10 µm in *Staurosirella pinnata*. Moreover, *Staurosirella subrobusta* is broadly lanceolate, with a wider, more lanceolate axial area and tendency for more radiate striae at the poles.

Ecological preference: The species is reported as benthic epipsammic in the shallow, slightly alkaline, eutrophic freshwater environment of the studied lakes.

Occurrence: Common in the Eemian deposits of central Poland, frequently in the late Holocene sediments of Radomno, Kamionka, and Młynek Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: New record.

Staurosirella pinnata **(Ehrenberg) Williams & Round 1987**

(Pl. 101, figs. 10-27; pl. 102, figs. 1-25)

Ref. Hustedt 1930, p. 142, fig. 141; Hustedt 1959 a, p. 160, fig. 671: a-i; Patrick & Reimer 1966, p. 127, pl. 4, fig. 10; Germain 1981, p. 72, pl. 21, figs. 44-52; pl. 156, fig. 3; Krammer & Lange-Bertalot 1991 a, p. 156, pl. 112, figs. 15-16; pl. 117, fig. 3; pl. 131, figs. 3-4; Lange- Bertalot & Metzeltin 1996, p. 132, pl. 7, figs. 5-6; Wojtal 2009, p. 306, pl. 3, figs. 4–8; pl. 50, figs. 4–8; pl. 51, fig. 2; Hofmann et al. 2011, p. 272, pl. 10, figs. 30–35.

Status of name: accepted taxonomically

Synonyms: *Staurosira pinnata* Ehrenberg 1843
Odontidium mutabile W. Smith 1856
Fragilaria pinnata var. *lancettula* (Schumann) Hustedt in Schmidt et al. 1913
Fragilaria pinnata var. *subrotunda* Mayer 1937
Fragilaria pinnata f. *lancettula* (Schumann) Hustedt 1957
Odontidium martyi var. *polymorpha* (Jouravleva) Proschkina-Lavrenko 1959
Punctastriata pinnata (Ehrenberg) Williams & Round 1987

Diagnosis: Frustules are linear-rectangular, almost square in girdle view. Valves are elliptical to linear with rounded apices. The axial area is narrow, sometimes widened to a small lanceolate central area. Transapical striae are robust, almost parallel at the center to radiate near the apices, composed of pronounced lineolate areolae, about

10-12 striae in 10 µm. Spines are distinct and located on the costae at the valve face marginal area. Length of the valve 5-15 µm, and the breadth 3-5 µm.

Ecological preference: Eurytopic, common in the littoral part of eutrophic waters (Hustedt, 1938); oligohalobous ''indifferent'', eurytopic form, in rivers and stagnant water (Bourrelly & Manguin, 1952); in planktonic, freshwater and in slightly brackish water (Cleve-Euler, 1953); oligohalobous "indifferent", mesoeuryhaline (Simonsen, 1962); alkaline water with pH values 7.6-7.8, its optimum in well aerated waters (Cholnoky, 1968); fresh and brackish water, plankton or epiphytic, alkaliphilous, with pH value 7.5-8.0 (Ehrlich, 1973); preference for oligotrophic water with relatively low conductivity (Krammer & Lange-Bertalot, 1991 a); but also in large and beta-mesosaprobic, polluted rivers with high amplitude of conductivity (Hofmann, 1993); alkaliphilous, β-mesosaprobous, eurytraphentic, fresh brackish water taxon, tychoplanktonic (Denys, 1991; Håkansson, 1993; Hofmann, 1994; Van Dam et al., 1994); it is considered an indicator of well oxygenated water with temperatures between 11-16 °C (Silva-Benavides, 1996). The species was observed in fresh shallow water environments of low conductivity, low to medium alkalinity, pH 7-8 and in unpolluted to moderately polluted waters, temperatures 19-21 °C (Zalat & Servant-Vildary, 2005); slightly polluted, of beta-mesosaprobic zones (Szczepocka et al., 2014). benthic, oligohalobous, alkaliphilous, eutraphenthic, β-mesosaprobous (Witak & Jankowska, 2014); low Water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH 5.46–6.5 (Krizmanić et al., 2015); It occurred in slightly acid pH (6), low conductivity (24.5 µS cm-1) and oligotrophic condition, only in winter (Silva-Lehmkuhl, et al., 2019).

Occurrence: Common in the Eemian deposits of central Poland, the late Holocene sediments of Radomno, Kamionka, and Młynek Lakes, and frequently in the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from Vistula River (Starmach, 1938; Turoboyski, 1962); fish ponds in Mydlniki (Siemińska, 1947); Sanka stream (Kądziołka, 1963; Hojda 1971); Pilica River (Kadłubowska, 1964b; Szulc, 2007); spring of Szklarka stream (Skalska, 1966a); springs of Kobylanka stream (Skalna, 1969), springs of Będkowka stream (Kubik, 1970); Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); springs in the area of the Łódź Hills scarp, between Ozorków, Stryków and Brzeziny (Żelazna- Wieczorek & Ziułkiewicz, 2004; Ziułkiewicz, 2005); Mały Staw lake, in a post-glacial cirque in the northeastern part of Karkonosze Mts, south-west Poland (Sienkiewicz, 2005, 2016); Holocene sediments of the SW Gulf of Gdańsk (Witak & Dunder, 2007); dominant in limnocrenic spring- Piękne Spring vicinity of Łódź in the Moszczenica River catchment basin-Central Poland (Żelazna-Wieczorek & Ziułkiewicz, 2007); Dolgie Wielkie lake on the Gardno-Leba Coastal Plain within the Slowinski National Park, North Poland (Lutyńska, 2008a); from the submerged macrophytes in Lake Skomielno, Łęczyńsko-Włodawskie, eastern Poland (Toporowska et al., 2008); the palaeolake at Ruszkówek near Konin (Kujawy Lakeland), central Poland (Mirosław-Grabowska et al., 2009); dominated in the Pilica River- Central Poland (Szczepocka & Szulc, 2009); Kobylanka stream, south Poland (Wojtal, 2009); the Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Duszatyńskie Lakes, south eastern Poland, Matysówka stream a right-bank tributary of Strug River, district of Tyczyn (Noga et al., 2013b); the sediments of Lake Skaliska. northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); abundant in the lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); the Linda River central Poland (Szczepocka et al., 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Lake Łebsko in coastal lowland belt, southern Baltic coast, Poland (Staszak-Piekarska & Rzodkiewicz, 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); Holocene sediments of Lake Suchar IV in the area of Wigry National Park in the range of the Pomeranian Phase north-east Poland (Zawisza et al., 2019); Lake Wigry signed to the Wigierskie group, in Wigry National Park north-east Poland (Eliasz-Kowalska & Wojtal, 2020).

***Staurosirella pinnata* var. *intercedens* (Grunow) Hamilton 1994**

(Pl. 103, figs. 1-7)

Ref. Hustedt 1959, p. 161; Patrick & Reimer 1966, p. 127, pl. 4, fig. 11; Krammer & Lange-Bertalot 1991 a, p. 157, pl. 133, figs. 19-23.

Status of name: accepted taxonomically

Synonyms: *Fragilaria mutabilis* var. *intercedens* Grunow 1881
Staurosira mutabilis var. *intercedens* (Grunow) Grunow 1882
Fragilaria pinnata var. *intercedens* (Grunow) Frenguelli 1923

Diagnosis: Valve is linear, heteropolar or isopolar with rounded apices. The axial area is linear to a broad lanceolate with an unclear central area. Transapical striae are coarse, lineolate, parallel to slight radiate, about 9-10 striae in 10 µm. Spines are located on the interstriae at the valve face marginal area. Length of the valve 15-30 µm, and the breadth 4-6 µm.

Occurrence: Frequently in the Eemian deposits of central Poland and the late Holocene sediments of Kamionka Lake.

Distribution in Poland: This variety was reported from Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Wisłok river and Żołynianka stream, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015).

***Staurosirella pinnata* var. *minutissima* (Grunow) Zalat & Pidek comb. nov.**

(Pl. 103, figs. 8-14)

Synonym: *Fragilaria pinnata* var. *minutissima* (Grunow) A. Cleve–Euler 1953

Diagnosis: Valve is linear, heteropolar or isopolar with acutely rounded apices. The axial area is narrow linear to linear-lanceolate. Transapical striae are distinct, alternate, lineolate, parallel to slight radiate, about 10-12 striae in 10 µm. Spines are located on the costae along the margin. Length of the valve 10-17 µm, and the breadth 3-3.5 µm.

Occurrence: Frequent in the Eemian deposits of central Poland.

Distribution in Poland: New record.

***Staurosirella pinnata* var. *subrotunda* (Mayer) Flower 2005**

(Pl. 103, figs. 15-29)

Ref. Mayer 1937, p. 65, pl. 3, figs. 6, 11**;** Flower 2005, p. 66

Status of name: accepted taxonomically

Synonyms: *Fragilaria elliptica* var. *subrotunda* Mayer 1937
Fragilaria pinnata var. *subrotunda* Mayer, 1937

Diagnosis: Valves isopolar, elliptical to subround with broadly rounded apices. The axial area is linear to linear-lanceolate with an indistinct central area. Transapical striae are distinct, lineolate, parallel to slight radiate, about 8-10 striae in 10 µm. Spines are located on the interstriae at the valve margin. Length of the valve 5-10 µm, and the breadth 4-6 µm.

Occurrence: Frequent in the Eemian deposits of central Poland, the late Holocene sediments of Radomno, Młynek, and Kamionka Lakes.

Distribution in Poland: New record.

***Staurosirella pinnata* var. *turgidula* (A. Cleve) Zalat & Chodyka comb. nov.**

(Pl. 104, figs. 1-6)

Ref. Cleve-Euler 1953, p. 38, figs. 348z-oo, l, I A-B

Synonyms: *Odontidium turgidulum* Schumann 1864
Fragilaria mutabilis var. *turgidula* (Schumann) A. Cleve 1932
Fragilaria pinnata var. *turgidula* (Schumann) A. Cleve 1953

Diagnosis: Valve is rhomboid, linear elliptical to linear-lanceolate with attenuate-acute rounded apices. The axial area is narrow, linear, Transapical striae are almost parallel to slightly radiate, composed of lineolate areolae, about 8-10 striae in 10 µm. Spines are located on the costae at the marginal area. Length of the valve 15-22 µm, and the breadth 3-4 µm.

Occurrence: Frequent in the Eemian deposits of central Poland and the late Holocene sediments of Młynek Lake.

Distribution in Poland: New record.

***Staurosirella pinnata* var. *ventriculosa* (Schumann) Zalat & Nitychoruk comb. nov.**
(Pl. 104, figs.7-12)
Ref. Cleve-Euler 1953, p. 37, fig. 348 b, bb, l
Synonyms: *Odontidium ventriculosum* Schumann 1862
Fragilaria pinnata var. *ventriculosa* (Schumann) Mayer 1937
Fragilaria pinnata f. *ventriculosa* (Schumann) A. Cleve 1953

Diagnosis: Valves are linear isopolar to slight heteropolar with rounded apices. The axial area is narrow-linear. Transapical striae are distinct, lineolate, alternate, parallel to slight radiate towards the apices, about 7-9 striae in 10 µm. Spines are distinct and located on the costae at the marginal area. Length of the valve 20-46 µm, and the breadth 4-6 µm.

Occurrence: Infrequently in the Eemian deposits of central Poland and the surface sediments of Jeziorak Lake.

Distribution in Poland: New record.

***Staurosirella rhomboides* (Grunow) Morales & Manoylov 2010**
(Pl. 105, figs. 1-12)
Ref. Hustedt 1931, p. 154, fig. 668 h-I; Bukhtiyarova 1995, p. 418; Morales et al. 2010, p. 43
Status of name: accepted taxonomically
Synonyms: *Fragilaria harrisonii* var. *rhomboides* Grunow 1862
Fragilaria leptostauron var. *rhomboides* (Grunow) Hustedt 1931
Staurosirella leptostauron var. *rhomboides* (Grunow) Bukhtiyarova 1995

Diagnosis: Frustules are rectangular in girdle view. Valves are rhomboid and slightly heteropolar with rounded apices. The valve face is slight to clearly undulate due to raised costae. The axial area is lanceolate with a slight broad central area. Transapical striae are distinct, composed of lineolae, radiate and extend continuously onto the valve mantle, about 7-9 in 10 µm. Spines are present along the valve face margin, and are located on the costae between striae. Length of the valve 15-55 µm, and the breadth 5-9 µm.

Occurrence: Infrequently in the late Holocene sediments of Młynek, Radomno, and Kamionka Lakes.

Distribution in Poland: New record.

***Staurosirella spinosa* (Skvortsov) Kingston 2000**
(Pl. 105, figs. 13-15)
Ref. Skvortsov 1937, p. 307, pl. 1, figs 13, 37; pl. 4, figs 13, 19; pl. 5, figs 54, 59; Kingston 2000, p. 409
Status of name: accepted taxonomically
Synonyms: *Fragilaria spinosa* Skvortsov 1937
Fragilaria mutabilis var. *robusta* Skvortsov & Meyer 1928

Diagnosis: Valves are elliptic-lanceolate with gibbous in the middle part and attenuate towards the subacute rounded apices. The axial area is lanceolate, gradually attenuating to the apices. Transapical striae are distinct, slight radiate, about 6-8 in 10 µm. Length of the valve 24 µm, and the breadth 6-7 µm.

Occurrence: Infrequently distributed in the surface sediments of Jeziorak Lake.

Distribution in Poland: New record.

***Staurosirella subrobusta* Morales 2006**
(Pl. 105, figs. 16-18; pl. 106, figs. 1-24)
Ref. Manguin 1964**, p. 60, pl. 4, fig. 4 a, b;** Morales & Manoylov 2006, p. 359, figs. 80-89, 116-121.
Status of name: accepted taxonomically
Synonym: *Fragilaria pinnata* var. *robusta* Manguin 1964

Diagnosis: Frustules are rectangular in girdle view. Valves are linear-elliptic to broadly elliptical with acute to broadly rounded apices. The axial area is linear to wide and lanceolate. Transapical striae are robust, alternate, parallel to slightly radiate towards the apices, composed of slit-like areolae and running continuously to the valve mantle, about 5-7 striae in 10 µm. The apical pore fields are present on both apices. Length of the valve 8-38 µm, and the breadth 6-10 µm.

Ecological preference: The species was reported from the freshwater of relatively high conductivity, slightly alkaline with pH value 7.6, and warm water (Morales & Manoylov, 2006).

Occurrence: Frequent in the Eemian deposits of central Poland, the late Holocene sediments of Radomno, Kamionka, and Młynek Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: New record.

Genus *Synedra* Ehrenberg 1830

Diagnosis: Frustules may occur singly or in colonies, never forming long filaments; in girdle view linear, to rectangular. In valve view, very slender, linear, or lanceolate, somewhat with undulated margins at the middle portion of the valve, and the valve may or may not be swollen at the central area. Axial area present, more or less narrow; central area present or absent; valve face with fine punctate transapical striae, which are aligned in an opposite arrangement, and sometimes the valves have a region of alternate striae usually present near the poles. Striae are composed of simple rounded or elongated areolae that continue onto the valve mantle. The rimoportulae are represented at both apices. A jelly pore is also present at one end of the valve. The valve is usually symmetrical to the apical and transapical axes.

Lectotype species *Synedra balthica* Ehrenberg 1832

***Synedra famelica* Kützing 1844**

Ref. Hustedt 1959, p. 210, fig. 701; Patrick & Reimer 1966, p. 139, pl. 5, fig. 9; Germain 1981, p. 82, pl. 28, figs. 31-32; Krammer & Lange-Bertalot 1991a, p. 128, pl. 111, figs. 4-17; Witkowski et al. 2000, p. 49, pl. 28, figs. 28-34; Bąk et al. 2012, p. 152, pl. 7.

Status of name: accepted taxonomically

Synonyms: *Synedra minuscule* Grunow in Van Heruck 1881
Fragilaria famelica (Kützing) Lange-Bertalot 1980
Fragilaria minuscula (Grunow) Williams & Round 1988

Diagnosis: Frustules are linear, narrower toward ends in girdle view. Valves are linear to lanceolate, attenuated toward rostrate to obtusely rounded apices. The axial area is straight and very narrow. The central area is variable, not distinctly swollen and may ovoid and short striae are typically found at one or both sides of the central area. Transapical striae are parallel, about 15-17 in 10 µm. Length of the valve 25-40 µm, and the breadth 2.5-4 µm.

Ecological preference: The species prefers eutrophic water of high mineral content (Patrick & Reimer, 1966); alkalophilic, fresh-brackish, mesotrophic oxygenated waters (Antón-Garrido et al., 2013); Low temperature (6.7-8.2 °C), alkaline saline water, with pH value 6.4-7.99 (Żelazna-Wieczorek et al., 2015); epiphytic diatom in the freshwater shallow lake, pH 8-9.5, eutrophic (Sanal & Demir, 2018).

Distribution in Poland: The species is reported from the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999); Wisłok river and Żołynianka stream, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015); abundant in saline waters of Pełczyska village, Łęczyca in the Łodź province, central Poland (Żelazna-Wieczorek et al., 2015); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019).

Genus *Ulnaria* (Kützing) Compère 2001

Diagnosis: Frustules are linear and rectangular in girdle view. Valves are slender, linear, needlelike, and lanceolate with rounded, capitate and rostrate apices. The axial area is narrow-linear or lanceolate. The central area may or may not present and the shape is squarish or oval to rectangular and extends to the valve margins. Transapical striae are parallel, composed of rows of simple round to elongated areolae with uniseriate or biseriate areolation. One to two rimoportulae are present, at one or both apices.

Holotype species *Ulnaria ulna* (Nitzsch) Compère

***Ulnaria acus* (Kützing) Aboal in Aboal et al. 2003**

(Pl. 107, figs. 1-6)

Ref. Hustedt 1930, p. 155, fig. 170; Hustedt 1959, p. 201, fig. 693 a; Patrick & Reimer 1966, p. 135, pl. 5, fig. 1; Lange-Bertalot 1980, p. 144, pl. 122, figs. 11-13; Germain 1981, p. 78, pl. 27, figs. 1-12; Gasse 1986, p. 174, pl. 6, figs. 18-20; Krammer & Lange-Bertalot 1991 a, p. 144, pl. 122, figs. 11-13; pl. 119, fig. 8; Ehrlich 1995, p. 43, pl. 7, fig. 14; Aboal et al. 2003. P. 105.

Status of name: accepted taxonomically

Synonyms: *Synedra tenuis* Kützing 1844
Synedra acus Kützing 1848

Synedra affinis var. arcus (Kützing) Grunow in Van Heurck 1881
Synedra ulna var. *acus* Mayer 1913
Synedra goulardi var. *acus* (Kützing) Frenguelli 1925
Fragilaria ulna var. *acus* (Kützing) Lange-Bertalot 1980
Fragilaria ulna f. *acus* (Kützing) Krammer & Lange-Bertalot 1991
Fragilaria acus (Kützing) Lange-Bertalot in Krammer & Lange-Bertalot 2000

Diagnosis: Frustules are slender, linear in girdle view. Valves are narrow-lanceolate, often with subrostrate to subcapitate protracted apices. The axial area is narrow, becoming a little wider towards the middle of the valve. The central area is distinct, reaches to the margins of the valve, nearly square shape, and slightly longer than the broad. Transapical striae are fairly delicate, mostly occurring opposite or occasionally alternate, parallel, about 12-14 striae in 10 µm. Rimoportulae are present at the apices. Length of the valve 90-180 µm, and the breadth 4-7 µm.

Remarks: *Synedra acus* is characterized by its needle shape, and the terminal area shows rounded or slightly capitate apices. This species is most closely related to *Synedra delicatissima* and *Synedra radians*. Hustedt (1930) has described these species as variety of *Synedra acus*.

Ecological preference: It is considered as oligohalobous, and alkaliphilous species (Hustedt, 1957; Foged, 1980); halobian "indifferent", alkaliphilous, littoral form, which is most frequent in temperate regions (Foged, 1959); it seems to prefer circumneutral freshwater and it is more often found in the water of medium hardness (Patrick & Reimer, 1966); optimum pH of the species lies between 7.4-7.8 (Cholnoky, 1968). The species is recorded as common in shallow freshwater habitats of low conductivity and alkalinity with pH 6.8-7.4, and temperatures 20-23 °C (Zalat & Servant-Vildary, 2005); mesotrophic, cold freshwater with pH value 7.4-8.1 (Pasztaleniec & Lenard, 2008); benthic, running freshwater, with high Calcium concentrations, pH neutral to alkaline (from 6.6 to 8.4) and water temperature ranged annually between 12.5 and 19.1 ºC (Delgado et al., 2013); epiphytic on macrophytes in shallow freshwater, pH 6.8-6.95 (Marra et al., 2016); freshwater, eutraphentic with pH value 7.69-8.11 (Witak et al., 2017); epiphytic diatom in the freshwater shallow lake, pH 8-9.5, eutrophic (Sanal & Demir, 2018).

Occurrence: Frequently in the late Holocene sediments of Mlynek, Kamionka, and Radomno Lakes.

Distribution in Poland: The species was reported from Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); mesotrophic Rogóźnó, Lake, Łęczna-Włodawa Lakeland, east central Poland (Pasztaleniec & Lenard, 2008); Dąbrówka water body in the central part of the Wielkopolska region (Oborniki district), western Poland (Celewicz-Gołdyn & Kuczyńska-Kippen, 2008); Late Holocene sediments of Pilica Piaski spring-fed pond in the Krakowsko-Częstochowska upland, southern Poland (Wojtal et al., 2009); from Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012); Matysówka stream a right-bank tributary of Strug River, district of Tyczyn, and Duszatyńskie Lakes, and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); Spring at the Goprowska Pass (Bieszczady National Park), south eastern Poland (Żelazna-Wieczorek & Knysak, 2017).

Ulnaria amphirhynchus **(Ehrenberg) Compère & Bukhtiyarova 2006**
(Pl. 107, figs. 7-9)

Ref. Hustedt 1930, p. 154, fig. 167; Hustedt 1959, p. 186, fig. 691; Cleve-Euler 1953, p. 62, fig. 382; Patrick & Reimer 1966, p. 149. pl. 7, figs. 6, 7; Valeva & Temniskova-Topalova 1993, p. 74, pl. 2, fig. 22; Aboal et al. 2003, 113.

Status of name: accepted taxonomically

Synonyms: *Synedra vitrea* Bory ex Kützing 1844
Synedra amphirhynchus Ehrenberg 1843
Synedra ulna var. *amphirhynchus* (Ehrenberg) Grunow 1862
Synedra ulna var. *vitrea* (Bory ex Kützing) Van Heurck 1885
Fragilaria ulna var. *amphirhynchus* (Ehrenberg) Kalinsky 1982
Fragilaria ulna var. *amphirhynchus* (Ehrenberg) Herbst & Maidana 1989
Ulnaria ulna var. *amphirhynchus* (Ehrenberg) Aboal 2003

Diagnosis: Valves are slender linear, needle-like in shape, constricted to form attenuate-rostrate or sometimes slightly capitate apices. The axial is distinct, very narrow, linear. The central area is nearly square shape and slightly longer than the broad and somewhat absent. Transapical striae are distinct, parallel, about 10-12 striae in 10 µm. Length of the valve 150-250 µm, and the breadth 6-8 µm.

Ecological preference: This taxon was recorded in circumneutral, usually mesotrophic to eutrophic freshwater (Patrick & Reimer, 1966); epilithic in warm, slight alkaline freshwater waterfall and the stream with temperature 25-27 and pH value 7.2-7.9 (Jena et al., 2006); warm alkaline freshwater with temperature 10.2-28.7 and pH value 7.22-8.35, low conductivity (Zalm, 2007); alkaliphilous pH over 7, limnobiontic-slightly euryhaline 0.5-8 psu, mesopolythermic (>18-35 C°) (Moreno-Ruiz et al., 2011).

Occurrence: Frequently in the late Holocene sediments of Kamionka and Radomno Lakes.

Distribution in Poland: New record

Ulnaria biceps **(Kützing) Compère 2001**

(Pl. 108, figs. 1-8; pl. 109, figs. 1-7)

Ref. Hustedt 1930, p. 154, fig. 166; Hustedt 1959, p. 200, fig. 691 A: g; Patrick & Reimer 1966, p. 151, pl. 8, fig. 2 a-b; Krammer & Lange-Bertalot 1991 a, p. 146, pl. 121, figs. 1-5; Compère 2001, p. 100; Kheiri et al. 2018, p. 365, figs. 31–32

Status of name: accepted taxonomically

Synonyms: *Synedra biceps* Kützing 1844
Synedra longissima W. Smith, 1853
Synedra ulna var. *biceps* (Kützing) Schönfeldt 1913
Synedra ulna f. *biceps* (Kützing) Hustedt 1957
Synedra ulna f. *biceps* (Kützing) Skabichevskii 1960
Fragilaria ulna var. *biceps* (Kützing) Compère 1991
Fragilaria biceps (Kützing) Lange-Bertalot 1993

Diagnosis: Frustules and valves are slightly curved. The valve is linear, very long, narrowed towards the swollen, rounded apices. The axial area is narrow, linear. The central area is small, or usually absent. Transapical striae are coarse, distinct, parallel, about 8-10 in l0 µm. Length of the valve 160 240 µm, and the breadth 5-6 µm.

Ecological preference: Alkaliphilous, fresh-brackish water, eutraphentic (Malinowska–Gniewosz et al., 2018), β -mesosaprobes **(**Zębek et al., 2012); low Water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH value 5.46–6.5 (Krizmanić et al., 2015); epilithic in the freshwater river with low conductivity and pH value 6.2-8.5, (Kheiri et al., 2018).

Occurrence: Frequently in the Eemian deposits of central Poland, the late Holocene sediments of Radomno, Kamionka, and Młynek Lakes, and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from Low-pH Lake Piaski in Western Pomerania, northwest Poland (Witkowski et al., 2011); Periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012); Duszatyńskie Lakes, and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); Fallow soil in Pogórska Wola near Tarnów (southern Poland) (Stanek-Tarkowska et al., 2015); Wisłok river, San (near Jarosław), Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Noga et al., 2014; Peszek et al., 2015); from the industrial water biotopes of Trzuskawica S.A. in the southern Poland (Malinowska–Gniewosz et al., 2018).

Ulnaria capitata **(Ehrenberg) Compère 2001**

(Pl. 110, figs. 1-7; pl. 111, figs. 1-10)

Ref. Hustedt 1959, p. 201, fig. 692; Patrick & Reimer 1966, p. 147, pl. 6, fig. 15; Foged 1974, p. 110, pl. 4, figs. 5, 6; Lange-Bertalot 1980, p. 221, pl.3, fig. 3 (1); Germain 1981, p. 74, pl. 23, figs. 1-2; Krammer & Lange-Bertalot 1991 a, p. 147, pl. 123, figs. 1-3; Ehrlich 1995, p. 43, pl. 7, fig. 4; Lange-Bertalot & Metzeltin 1996, p. 270, pl. 76, fig. 8.

Status of name: accepted taxonomically

Synonyms: *Synedra capitata* Ehrenberg 1836
Frustulia dilatata Brébisson 1838
Epithemia capitata (Ehrenberg) Brébisson 1838
Exilaria capitata (Ehrenberg) Hassall 1845
Synedra ulna f. *capitata* (Ehrenberg) Skabichevskii 1960

Fragilaria capitata (Ehrenberg) Lange-Bertalot 1980
Fragilaria dilatata (Brébisson) Lange-Bertalot 1993

Diagnosis: Frustules are linear in girdle view. Valves are linear, with parallel margins and widened capitatewedge-shaped apices. The axial area is distinct, narrow, linear. The central area is absent. Transapical striae are parallel throughout most of the valve, slightly radiate at the apices, distinctly punctate, composed of rounded areolae, extend to the mid-point of the vertical mantle wall; about 8-10 striae in 10 μm. The transapical costae between the areolated striae are thick. The jelly pore is distinct. The length of the valve usually extends to 500 μm, and the breadth 7-10 μm.

Ecological preference: Common in fresh, eutrophic waters (Cleve-Euler, 1953); halobian "indifferent", alkaliphilous, littoral form, especially in eutrophic, freshwater (Foged, 1959); planktonic or epiphytic, alkaliphilous, with pH values 7.5-8.0 (Ehrlich, 1973). the species was observed in the freshwater environments of low conductivity, low and medium alkalinity with pH values 7.0-7.5 and unpolluted waters (Zalat & Servant-Vildary, 2005); epiphytic diatom in the freshwater shallow lake, pH 8-9.5, eutrophic (Sanal & Demir, 2018).

Occurrence: Frequently in the late Holocene sediments of Radomno Lake and the surface sediments of Jeziorak Lake. Infrequently in the Eemian deposits of central Poland.

Distribution in Poland: It is reported as *Fragilaria dilatata* from Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Duszatyńskie Lakes, south eastern Poland (Noga et al., 2013); Żołynianka stream, Podkarpacie province, south Poland (Peszek et al., 2015); Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); from the industrial water biotopes of Trzuskawica S.A. in the southern Poland (Malinowska–Gniewosz et al., 2018)

***Ulnaria capitata* var. *cuneata* (Poretzky & Proschkina-Lavrenko) Compère & Bukhtiyarova 2006**

(Pl. 112, figs. 1-6)

Ref. Proschkina-Lavrenko 1950, p. 48; Poretzky, 1953, p. 31-32, fig. 4; Bukhtiyarova & Compère 2006, p. 280

Status of name: accepted taxonomically

Synonym: *Synedra capitata* var. *cuneata* Poretzky 1953

Diagnosis: Valves are linear, with parallel margins and obtusely cuneate apices. The axial area is distinct, linear, relatively narrow. The central area is not recognized. Transapical striae are parallel throughout most of the valve, slightly radiate at the apices, composed of rounded areolae, about 9-10 striae in 10 μm. The jelly pore is distinct. The length of the valve usually extends to 500 μm, and the breadth is 6.5-9 μm.

Occurrence: Frequently in the Eemian deposits of central Poland and the late Holocene sediments of Radomno Lake.

Distribution in Poland: New record.

***Ulnaria contracta* (Østrup) Morales & Vis 2007**

(Pl. 115, figs. 1-3)

Ref. Hustedt 1930, p. 199, fig. 691 B, s; Foged 1959, p. 42, pl. I, fig. 11; Patrick & Reimer 1966, p. 150, pl. 7, fig.3; Morales & Vis 2007, p. 125, figs. 9-11, 29-32.

Status of name: accepted taxonomically

Synonyms: *Synedra ulna* var. *contracta* Østrup 1901
Fragilaria ulna var. *contracta* (Østrup) Main 1988

Diagnosis: Valves are elongate and linear, with a slight constricted central margin and gradually attenuate to rostrate or sub-capitate apices. The axial area is narrow and linear, expanding slightly near the central area. The central area is distinct, almost square to rectangular and contains ghost striae throughout. Transapical striae are coarse, distinct, punctate, parallel throughout the valve, slightly radiate at the apices, and clearly opposite in arrangement, about 8-10 striae in 10 μm. Two large rimoportulae are present, one at each apex of the valves. Length of the valve 80 –150 μm and the breadth 7-8 μm.

Ecological preference: Halobian-indifferent, alkaliphilous (Foged, 1959). The species was common and abundant in streams, which are shallow with cold water (10 and 11°C), alkaline pH (7.9 and 8.7) and low conductivity (30 and 40 μS/cm) (Morales & Vis, 2007).

Occurrence: Infrequently in the Eemian deposits of central Poland and the late Holocene sediments of Radomno Lake.

Distribution in Poland: New record.

***Ulnaria danica* (Kützing) Compère & Bukhtiyarova 2006**

(Pl. 113, figs. 1-9)

Ref. Hustedt 1930, p. 154, fig. 168; Hustedt 1959, p. 187, fig. 691; Cleve-Euler 1953, p. 62, fig. 382; Patrick & Reimer 1966, p. 151, pl. 7, fig. 10; Germain 1981, p. 78, pl. 25, figs. 7-8; Lange-Bertalot & Metzeltin 1996, p. 54, pl. 7, fig. 1; pl. 109, fig. 1, 1; Bukhtiyarova & Compère 2006, p. 281.

Status of name: accepted taxonomically

Synonyms: *Synedra danica* Kützing 1844
Synedra ulna var. *danica* (Kützing) Grunow 1885
Synedra splendens var. *danica* Grunow 1862
Synedra longissima var. *acicularis* Meister 1912
Synedra danica f. *typica* Cleve-Euler 1953
Synedra ulna f. *danica* (Kützing) Hustedt 1957
Fragilaria ulna var. *danica* (Kützing) Kalinsky 1982
Fragilaria danica (Kützing) Lange-Bertalot 1996

Diagnosis: Valve is narrow linear-lanceolate, almost needle-shaped, narrowing gradually from the center towards the ends forming sub-capitate apices. The axial area is narrow. The central area is transverse, usually not extending the margins of the valve. Transapical striae are parallel, 8-10 in 10 µm. Length of the valve 100 – 200 µm, and the breadth 5-7 µm.

Ecological preference: Cosmopolitan, halobian-indifferent, alkaliphilous (Foged, 1959). This taxon is often distributed as a plankton form in eutrophic lakes (Hustedt, 1959); found in plankton, in circumneutral freshwater, indifferent to small amounts of salts (Patrick & Reimer, 1966); shallow warm freshwater lakes, pH value 6.9-7.7, low conductivity, alkalinity (meq L^{-1}) from 3.1-4.4 (Jasprica & Hafner, 2005); oligohalobous "indifferent", pH: circumneutral (Foged, 1980). It was observed in freshwater habitats of low conductivity and low alkalinity with pH ranges between 6.8-7.5 (Zalat & Servant-Vildary, 2005).

Occurrence: Frequently in the Eemian deposits of central Poland, and the late Holocene sediments of Radomno and Młynek Lakes.

Distribution in Poland: The species was reported from Low pH-Piaski Lake, Western Pomerania in northwest Poland (Witkowski et al. 2011).

***Ulnaria delicatissima* (W. Smith) Aboal & Silva 2004**

(Pl. 114, figs. 1-9)

Ref. Patrick & Reimer 1966, p. 136, pl. 5, fig. 2; Lange-Bertalot 1980, p. 129. pl. 115, figs. 11-13, pl. 114, figs. 1-8; Aboal & Silva 2004, p. 361; Bertolli et al. 2010, p. 1073, fig.21.

Status of name: accepted taxonomically

Synonyms: *Synedra delicatissima* W. Smith 1853
Synedra acus var. *delicatissima* (W. Simth) Grunow 1862
Synedra delicatissima var. *mesoleia* Grunow 1881
Synedra acus f. delicatissima (W. Smith) Krieger 1927
Synedra acus var. *radians* Hustedt 1930
Fragilaria delicatissima (W. Smith) Lange-Bertalot 1980
Ulnaria delicatissima (W. Smith) Aboal & Silva 2004

Diagnosis: Valve is narrow, linear, needle-shaped, sometimes weakly curved and gradually tapering to protracted rostrate or rounded apices. The axial area is very narrow, linear. The central area is distinct, longer than wide, with ghost striae and short striae at the margins. Transapical striae are parallel, 11-13 in 10 µm. Length of the valve 150-200 µm, and the breadth 4.5-5 µm.

Remarks: This species is most closely related to *Synedra acus*, which is more nearly squarish and only slightly longer than wide. *Ulnaria delicatissima* differed from *F. nanoides* Lange-Bertalot by more distinct capitate apices, less dense striae (<18/10 µm). According to Krammer & Lange-Bertalot (1991), *Ulnaria delicatissima* differs by the more spindle-like form and the less dense (14-16/10µm), finer, striae from *F. tenera* (W. Smith) Lange-Bertalot.

Ecological preference: common in oligo-mesotrophic environments (Hofmann, 1994); mesotrophic lake (Van Dam et al., 1994, Poulickova et al., 2004), it occurred in slightly acid to circumneutral pH (6-6.85), and develop in the widest temperature range (Zębek, 2007); freshwater, periphytic on the macrophytes in river (Bertolli et al., 2010); alkaliphilous pH over 7, limnobiontic-stenohaline <0.5 psu, mesopolythermic (>18-35 C°) (Moreno-

Ruiz et al., 2011); oligo-α-mesotraphent, oligosaprob/ β-mesosaprob (Zębek et al., 2012**);** low conductivity (24-24.5 µS cm-1) and oligotrophic conditions (Silva-Lehmkuhl, et al., 2019).

Occurrence: Frequently in the late Holocene sediments of Radomno and Młynek Lakes, infrequently in the Eemian deposits of central Poland and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported dominant in the urban Lake Jeziorak Mały, within the Iława Lake District, north eastern Poland (Zębek, 2007); Low pH-Piaski Lake, Western Pomerania in north-west Poland (Witkowski et al., 2011); Periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012); the Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Ulnaria delicatissima* var. *angustissima* (Grunow) Aboal & Silva 2004**

(Pl. 114, fig. 10)

Ref. Hustedt 1930, p. 155, fig. 172; Hustedt 1959, p. 189, fig. 693; Patrick & Reimer 1966, p.136, pl. 5, fig. 3; Lange-Bertalot 1981, p. 144, pl. 121, figs. 15, 16; pl. 114, fig. 21; Krammer & Lange-Bertalot 1991, p. 144, fig. 21; Bąk et al. 2012, p. 331, p. 6.

Status of name: accepted taxonomically

Synonyms: *Synedra delicatissima* var. *angustissima* Grunow in Van Heurck 1881
Synedra acus var. *angustissima* (Grunow in Van Heurck) Van Heurck 1885.
Fragilaria delicatissima var. *angustissima* (Grunow) Lange-Bertalot 1981
Fragilaria ulna f. *angustissima* (Grunow) Krammer & Lange-Bertalot 1991

Diagnosis: Valve is needle shape, very long, narrow by its delicate structure, often sinuous. The axial area is very narrow but distinct. The central area is much longer than wide, sometimes clearly rectangular, or with irregular shape and it has very short striae on each margin. Striae are parallel throughout the valve, about 12-14 striae in 10 µm. Length of the valve 200-420 µm, and the breadth 3.5-4.5 µm.

Remarks: *Ulnaria delicatissima* var. *angustissima* has longer and more tapering valves with a higher stria density. According to Hustedt (1959), *Synedra radians* Kützing and *Synedra delicatissima* W. Smith are identical and represent only one variety of *Synedra acus*.

Ecological preference: This variety is a typical plankton form, quite commonly found among plankton of inland waters (Hustedt, 1959). It is found in plankton in the water of medium hardness (Patrick & Reimer, 1966).

Occurrence: Infrequently in the late Holocene sediments of Młynek and Radomno Lakes and the surface sediments of Jeziorak Lake.

Distribution in Poland: It is reported from Poland by Bąk et al., 2012.

***Ulnaria oxyrhynchus* (Kützing) Aboal in Aboal et al. 2003**

(Pl. 115, figs. 4-6)

Ref. Hustedt 1930, p. 152, fig. 160; Hustedt 1959, p. 184, fig. 691B. q.; Krammer & Lange-Bertalot 1991 a, p.144, fig.10; Sims 1996, p. 582, fig. 13; Aboal et al. 2003, p. 110; Jena et al., 2006, pl. 1, figs. 17-18; Bąk et al. 2012, p. 332, pl. 6.

Status of name: accepted taxonomically

Synonyms: *Synedra oxyrhynchus* Kützing 1844
Synedra oxyrhynchus var. *amphicephala* Grunow 1862
Synedra oxyrhynchus var. *undulata* Grunow 1862
Synedra acuta var. *oxyrhynchus* (Kützing) Rabenhorst 1864
Synedra ulna var. *oxyrhynchus* (Kützing) O'Meara 1875
Fragilaria ulna var. *oxyrhynchus* (Kützing) Lange-Bertalot 1991
Ulnaria ulna var. *oxyrhynchus* (Kützing) Aboal 2003

Diagnosis: Valve is linear to linear-lanceolate or slightly constricted in the middle portion, somewhat widened toward distinct rostrate to narrow roundly capitate apices. The axial area is narrow and distinct. The central area is usually squarish or rectangular. Transapical striae are parallel, about 10-12 in 10 µm. Length of the valve 80-150 µm and the breadth 8-10 µm in the central area.

Remarks: *Synedra ulna* var. *oxyrhynchus* is distinguished by the shape of long rostrate and wedge shape ends, and appears to be somewhat constricted or widen in the middle portion of the valve. This variety is similar to *Ulnaria ulna* and *Ulnaria ulna* var. *contracta* and it is reported in some literature as *Ulnaria ulna*.

Ecological preference: Cosmopolitan, halobian-indifferent, alkaliphilous (Foged, 1959). This species usually occurs in free-living or epiphytic forms, found in water with pH 6.8-7.1, it seems to prefer circumneutral water (Krammer & Lange-Bertalot, 1991); epilithic and epiphytic in a warm, slight alkaline freshwater waterfall, stream, river, and planktic in the pond with temperature 21-27°C and pH 7.2-7.9 (Jena et al., 2006); warm alkaline freshwater with temperature 10.2-28.7 and pH value 7.22-8.35, low conductivity (Zalm, 2007); shallow freshwater streams with pH value 7.6-8.4 (Noga et al., 2016).

Occurrence: Frequently in the late Holocene sediments of Radomno, Młynek, and Kamionka Lakes.

Distribution in Poland: Lower Vistula River between Wyszogrod and Dybowo, central Poland (Dembowska, 2014), Wisłok river in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); it is reported from the suburban stream of the Rzeszów city in south-east Poland (Noga et al., 2016).

***Ulnaria sinensis* Liu & Williams 2017**

(Pl. 115, figs. 7-8)

Ref. Liu et al. 2017, p. 243, fig. 2-29

Status of name: accepted taxonomically

Diagnosis: Frustules are rectangular in girdle view, connected by interlocking linking spines. Valves are linear, with parallel margins, narrowing gradually to form protracted apices. The axial area is distinct, narrow linear. Central area absent. Transapical striae are uniseriate, broad, mostly parallel, radiating only at the apices, uniform, situated opposite each other, continuing onto valve mantle, about 8-9 striae in 10 µm. A single rimoportula is present at each pole. Length of the valve 200-250 µm and the breadth 6-8 µm.

Remarks: This species appears similar to *Ulnaria pseudogaillonii* (Kobayasi & Idei) Idei 2006 and is identified in many literatures as *Ulnaria ulna*.

Ecological preference: Freshwater species found in water with conductivity 54.9 µS/cm, pH 7.6, and water temperature 10.4 °C. The species can be considered an epilithic diatom characteristic of poor electrolyte content freshwater (Liu et al., 2017).

Occurrence. Frequently in the Eemian deposits of central Poland, the late Holocene sediments of Radomno, Młynek, and Kamionka Lakes.

Distribution in Poland: New record.

***Ulnaria ulna* (Nitzsch) Compère 2001**

(Pl. 116, figs. 1-9; pl. 117, figs. 1-3)

Ref. Hustedt 1930, p. 154, fig. 166; Hustedt 1959, p. 195, fig. 691 a-c, Patrick & Reimer 1966, p. 148, pl. 7, figs. 1-2; LangeBertalot 1980, p. 745, pl. 8, figs. 185196; Germain, 1981, p. 76, pl. 24, figs. 1-6; pl. 168, fig.8; Krammer & Lange-Bertalot 1991a, p.143, pl. 122, figs. 1–8; Wojtal, 2009, p. 214, pl. 2, figs. 37, 38; pl. 54, figs. 5–7; Hofmann et al. 2011, p. 276, pl. 5, figs. 6–11.

Status of name: accepted taxonomically

Synonyms: *Synedra ulna* (Nitzsch) Ehrenberg 1832
Synedra lanceolata Kützing 1844
Synedra ulna var. *undulata* Grunow 1862
Synedra ulna var. *notata* Grunow in Van Heurck 1881
Synedra ulna var. *subaequalis* Grunow in Van Heurck 1881
Synedra ulna var. *splendens* (Kützing) Van Heurck 1885
Synedra ulna var. *curta* A. Mayer 1912
Synedra ulna var. *longirostris* (Grunow) Cleve-Euler 1948
Synedra ulna var. *notata* f. *crassa* (Østrup) Cleve-Euler 1953
Synedra ulna var. *balatoneis* f. *pantocsekii* Cleve-Euler 1953
Fragilaria ulna (Nitzsch) Lange-Bertalot 1980

Diagnosis: Frustules are linear in girdle view; valves are linear to linear-lanceolate, gradually tapering to small rostrate, somewhat rostrate-wedge-shaped, nearly acutely rounded apices. The axial area is narrow, linear. Central area is formed by lack of marginal striae; it may be small, or large or absent, often almost square. Transapical striae are coarse, distinct, punctate, parallel, and opposite in arrangement in the center of the valve, about 8-10 striae in 10 µm. Length of the valve 65 –165 µm and may reach up to 350 µm, and the breadth 5-8 µm.

Ecological preference: Worldwide distribution, it is widely distributed in freshwater, meso to eutrophic lakes and streams (CleveEuler, 1953); in the littoral stagnant water of eutrophic lakes (Hustedt, 1959); its pH optimum is about 7.8 (Cholnoky, 1968); oligohalobous "indifferent", alkaliphilous, and indifferent with respect to the current spectrum (Van Landingham, 1970); planktonic, epiphytic and benthonic, alkaliphilous, with pH values 7.58.0 (Ehrlich, 1973); oligohalobous "indifferent", alkaliphilous, eutrophic and eurythermal "oligo to mesothermal" (Lowe, 1974); oligohalobous, mesoeuryhaline, benthonic (Pankow, 1976); highly tolerant to pollution (Lange-Bertalot, 1979); oligohalobous "indifferent", pH circumneutral (Foged, 1993); an alkaliphilous, α-mesosaprobous to polysaprobous and fresh brackish water species indifferent to trophic state. Tychoplanktonic and meso-polysaprobous species (Denys, 1991; Hofmann, 1994; Van Dam et al., 1994). it was observed as abundant and widespread in freshwater habitats of low conductivity and low alkalinity with pH ranges between 6.8-7.5 and in unpolluted to moderately polluted water of temperatures 21-24 °C (Zalat & Servant-Vildary, 2005); freshwater, periphytic on the macrophytes in river (Bertolli et al., 2010); benthic, freshwater running water, with high Calcium concentrations, pH neutral to alkaline (from 6.6 to 8.4) and water temperature ranged annually between 12.5 and 19.1 ºC (Delgado et al., 2013); low Water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH 5.46–6.5 (Krizmanić et al., 2015); epiphytic on macrophytes in shallow freshwater, pH 6.8-6.95 (Marra et al., 2016); freshwater, eutraphentic with pH value 7.69-8.11 (Witak et al., 2017); epiphytic diatom in freshwater shallow lake, pH 8-9.5, eutrophic (Sanal & Demir, 2018); it occurred in circumneutral pH (6.75), low conductivity (24.5 µS cm-1) and oligotrophic conditions, only in summer (temperature of 27°C and accumulated rainfall 326.9 mm) (Silva-Lehmkuhl, et al., 2019).

Occurrence: Common in the Eemian deposits of central Poland, the late Holocene sediments of Radomno, Młynek, and Kamionka Lakes. Frequently in the late Holocene sediments of Francuskie and Zielone Lakes and the surface sediments of Jeziorak Lake.

Distribution in Poland: The species was reported from Vistula River (Starmach, 1938; Turoboyski, 1956, 1962; Kyselowa & Kysela, 1966); Młynowka stream (Gumiński, 1947); fish ponds in Mydlniki (Siemińska ,1947); Pilica River (Cabejszek, 1951; Kadłubowska, 1964a, b); spring of Szklarka stream (Skalska, 1966a, b); ponds near Krakow (Hanak-Szmagier, 1967), Prądnik River (Stępień, 1963; Pudo & Kurbiel, 1970); springs of Będkowka stream (Kubik, 1970); Sanka stream (Kądziołka, 1963; Hojda, 1971); Biała Przemsza River (Wasylik, 1985); Kluczwoda stream (Nawrat, 1993); from the "Bór na Czerwonem" raised peat-bog in the Nowy Targ Basin, Southern Poland (Wojtal et al., 1999); Wolnica Bay (Dobczyce dam reservoir) and Zakliczanka stream, Southern Poland (Wojtal et al., 2005); Dąbrówka water body in the central part of the Wielkopolska region (Oborniki district), western Poland (Celewicz-Gołdyn & Kuczyńska-Kippen, 2008); dominated in the Bzura River- Central Poland (Szczepocka & Szulc, 2009); in Kobylanka stream, south Poland (Wojtal, 2009); Low-pH Lakes in Western Pomerania- Lake Kąpielowe and Lake Żółwia Błoć, Lake Piaski (NW Poland) (Witkowski et al., 2011); Periphyton of the littoral zone of lake Jeziorak Mały – Masurian Lake District, north-eastern Poland (Zębek et al., 2012); found in Swibno- – Vistula River estuary in Northern Poland (Majewska et al., 2012); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Matysówka stream a right-bank tributary of Strug River, district of Tyczyn and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); the sediments of Lake Skaliska, northern part of Mazury Lake District, north-eastern Poland (Sienkiewicz, 2013); Holocene sediments of Suwalki Landscape Park north-eastern Poland, (Gałka, et al., 2014); from the rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the Biała Tarnowska River, a right-bank tributary of Dunajec, south Poland (Noga et al., 2015); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); Terebowiec stream, south-eastern part of the Bieszczady National Park, and suburban Przyrwa stream of Wisłok River in the Rzeszów city in south-east Poland (Noga et al., 2016); dominant in the upper part of the Ner River, central Poland (Szczepocka et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017).

***Ulnaria ulna* var. *aequalis* (Kützing) Aboal in Aboal et al. 2003**
(Pl. 117, figs. 4-6)
Ref. Hustedt 1959, p. 199, fig. 691 A, d; Aboal et al. 2003, p. 112; Jena et al., 2006, pl. 1, fig. 14.
Status of name: accepted taxonomically
Synonyms: *Frustulia aequalis* Kützing 1833
Synedra aequalis (Kützing) Kützing 1844
Synedra obtusa W. Smith 1853
Synedra splendens var. *aequalis* (Kützing) Grunow 1862
Synedra ulna var. *aequalis* (Kützing) Hustedt 1914
Fragilaria ulna var. *aequalis* (Kützing) Pankow, Haendel & Richter 1991

Diagnosis: Valve is very long, linear with broadly rounded apices. The axial area is narrow and distinct. Central area is variable in size; squarish, rectangular, or absent. Transapical striae are parallel, about 8-10 in 10 µm. Length of the valve 170-250 µm, and the breadth 6-8 µm.

Remarks: *Ulnaria ulna* var. *aequalis* is distinguished by its broad apices,

Ecological preference: Cosmopolitan, halobian-indifferent, alkaliphilous (Foged, 1959); epiphytic in warm, slight alkaline freshwater streams and logged rice field, with temperature 23-27°C and pH 7.7-7.9 (Jena et al., 2006); warm alkaline freshwater with temperature 10.2-28.7 and pH value 7.22-8.35, low conductivity (Zalm, 2007); alkaliphilous pH over 7, limnobiontic-slightly euryhaline 0.5-3 psu, mesopolythermic (>18-35 C°) (Moreno-Ruiz et al., 2011).

Occurrence. Frequent in the Eemian deposits of central Poland, infrequently in the late Holocene sediments of Radomno and Mlynek Lakes.

Distribution in Poland: Duszatyńskie Lakes, south eastern Poland (Noga et al. 2013b).

***Ulnaria ulna* var. *spathulifera* (Grunow) Aboal in Aboal et al. 2003**

(Pl. 117, figs. 7-8)

Ref. Hustedt 1959, p. 199, fig. 691 A, h; Patrick & Reimer 1966, p. 153, pl. 7, fig. 8; Aboal et al. 2003, p. 114.

Status of name: accepted taxonomically

Synonyms: *Synedra ulna* var. *spathulifera* (Grunow) Grunow in Van Heurck 1885
Synedra balatonis Pantocsek 1902
Synedra rostata Pantocsek 1902
Synedra joursacensis Héribaud 1903
Fragilaria ulna var. *spathulifera* (Grunow) Main 1988

Diagnosis: Valves are linear with swollen near the ends. Apices are wedge-shaped, and appear as spatulate in shape. The axial area is linear, narrow, distinct. Central area is variable in size, squarish to rectangular. Transapical striae are parallel throughout the valve to slightly radiate at apices, about 9-10 in 10 µm. Length of the valve 100-250 µm., and the breadth 6-8 µm.

Ecological preference: Cosmopolitan, oligohalobous "indifferent", alkaliphilous or pH: circumneutral (Foged, 1959, 1980); It seems to prefer cool, freshwater (Patrick & Reimer, 1966). The modern representatives of the variety were recorded frequently in association with the nominate in shallow freshwater habitats of low conductivity and alkalinity (Zalat & Servant-Vildary, 2005).

Occurrence: Frequently in the late Holocene sediments of Radomno and Kamionka Lakes.

Distribution in Poland: New record.

Order *Tabellariales* Round 1990

Family *Tabellariaceae* Kützing 1844

Genus *Tabellaria* Ehrenberg ex Kützing 1844

Diagnosis: Frustules are square or rectangular in girdle view. Valves are elongate, linear with capitate apices, and somewhat generally wider at the center than at the apices. Transapical striae are irregularly spaced and either parallel or slightly radiate. A rimoportula is present in the center of the valve face and an apical pore field is found at both poles of the valve.

Holotype species *Tabellaria flocculosa* (Roth) Kützing 1844

Tabellaria binalis (Ehrenberg) Grunow in V. Heurck 1880

Ref. Hustedt 1930, p. 30, fig. 559; Patrick & Reimer 1966, p. 103, pl. 1, fig. 6; Foged 1973, pl. 2, figs. 8, 9; 1980, p. 665, pl. 2, fig. 11.

Status of name: alternate representation

Synonyms: *Fragilaria binalis* Ehrenberg 1854
Striatella binalis (Ehrenberg) Kuntze 1898
Tetracyclus lewisianus Østrup 1910
Oxyneis binalis (Ehrenberg) Round in Round et al. 1990

Diagnosis: Frustules are rectangular in girdle view. Valves are broad, linear-elliptic, with margins slightly constricted in the middle and rounded, somewhat wedge-shaped apices. The Axial area is narrow. Transapical striae are parallel in the valve center and become slightly curved and radiate at the apices, about 16-18 striae in 10 µm. Length of the valve 10-18 µm, and the breadth 4-6 µm.

Ecological preference: The species lives in water of low mineral content, oligotrophic (Patrick & Reimer, 1966); it is regarded as halophobous, acidophilous (Foged, 1980).

Distribution in Poland: It is reported from the Gulf of Gdansk and surrounding waters, the southern Baltic Sea (Plinski & Witkowski, 2020).

Tabellaria fenestrata (Lyngbye) Kützing 1844

(Pl. 118, figs. 1-3)

Ref. Hustedt 1930, p. 26, fig. 554; Patrick & Reimer 1966, p. 103, pl. 1, figs. 1-2; Foged 1980, p. 665, pl. 2, fig. 13; Krammer & Lange-Bertalot 1991, p. 106, pl. 105, fig. 2; Bąk et al. 2012, p. 327, pl. 5.

Status of name: accepted taxonomically

Synonyms: *Diatoma fenestratum* Lyngbye 1819
Tabellaria flocculosa var. *fenestrata* (Lyngbye) Rabenhorst 1847
Striatella fenestrata (Lyngbye) Kuntze 1898

Diagnosis: Frustules are rectangular in girdle view with rounded corners and four or fewer septa, which are bent away from the valve for a short distance below the point of insertion. Valves are linear, swollen at the center with distinctly capitate, rounded apices. The axial area is linear, narrow, and distinct, sometimes wider at the center of the valve forming a small central area of variable shape. Transapical striae are delicate but distinct, parallel, and alternate, about 16-18 striae in 10 µm. Length of the valve 60-90 µm, and the breadth 6-10 µm.

Ecological preference: The species seems to prefer lakes or ponds that are mesotrophic to eutrophic; usually in shallow circumneutral water, often attached to the substrate (Patrick & Reimer, 1966); it is regarded as halophobous, acidophilous (Foged, 1980); shallow warm freshwater lakes, pH value 6.9-7.7, low conductivity, alkalinity (meq L_1) from 3.1-4.4 (Jasprica & Hafner, 2005); mesotrophic, cold freshwater with pH value 7-8.3 ((Pasztaleniec & Lenard, 2008). Epiphytic in warm circumneutral freshwater streams with pH 6.8 (Jena et al., 2006).

Occurrence: Infrequently in the late Holocene sediments of Kamionka, Francuskie, and Zielone Lakes.

Distribution in Poland: The species was reported from mesotrophic Piaseczno Lake in Łęczna-Włodawa Lakeland, east central Poland (Pasztaleniec & Lenard, 2008); Low-pH Piaski Lake in Western Pomerania- northwest Poland (Witkowski et al., 2011); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Duszatyńskie Lakes, south eastern Poland (Noga et al., 2013b); Wisłok river, Gołębiówka, and Szuwarka streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); the sediments of Wielki Staw lake in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2016).

Tabellaria flocculosa (Roth) Kützing 1844

(Pl. 118, figs. 4-15; pl. 119, figs. 1-13)

Ref. Hustedt 1930, p. 28, fig. 558; Patrick & Reimer 1966, p. 104, pl. 1, figs. 4, 5; Foged 1980, p. 665, pl. 2, fig. 12; Krammer & Lange-Bertalot 1991a, p. 108, pl. 106, figs. 1–13; pl.107, figs. 7, 11, 12; Wojtal, 2009, p. 311, pl. 4, fig. 8.

Status of name: accepted taxonomically

Synonyms: *Conferva flocculosa* Roth 1797
Bacillaria flocculosa (Roth) Leiblein 1827
Bacillaria flocculosa (Roth) Ehrenberg 1832
Candollella flocculosa (Roth) Gaillon 1833
Tabellaria amphicephala Ehrenberg 1840
Tabellaria gastrum Ehrenberg 1843
Striatella flocculosa (Roth) Kuntze 1898

Diagnosis: Frustules are tabular-rectangular in girdle view and united to the corners to form zigzag colonies. The septa are usually more than four and not straight. Rudimentary septa are usually present. Valves with a strong swollen central area, often wider than the swollen ends, which are capitate, rounded apices. Valve is slightly asymmetrical to either the transapical or apical axes. The axial area is narrow, linear, wider slightly in the middle to form a small central area. Transapical striae are parallel throughout the valve, slightly radiate at the apices; about 16-18 striae in 10 µm. Length of the valve 15-100 µm, and the breadth 6-13 µm.

Ecological preference: The species is regarded as halophobous, acidophilous (Foged, 1980); tychoplanktonic (Denys, 1991); it was recorded from streams characterized by high gradient, strong current and low water temperature, (pH ranging from 3. 5 to 6.0) and low phosphates values (Kwandrans, 1993); freshwater species, an acidophilous, β-mesosaprobous, mesotraphentic, and subaerophilous (Van Dam et al., 1994). The species was dominant in many acidotrophic- oligotrophic lakes in North America and a member of the important in the oligotrophic lakes of Finland (Lepistö & Rosenström, 1998). Common in freshwaters in the world and occasionally blooms in standing waters, dominant throughout Holocene sediment of slight acidic lakes in the diatom records of Canada (Prather & Hickman, 2000); dilute waters of low alkalinity and ion concentration (Wojtal, 2013); benthic, oligohalobous halophobous, acidophilous, oligotraphenthic-dystraphenthic, oligosaprobous (Witak & Jankowska, 2014); low Water temperature (6.4–12.5 °C), low Conductivity (213–302 µS cm–1) and pH 5.46–6.5 (Krizmanić et al., 2015).

Occurrence: Frequent in the late Holocene sediments of Kamionka Lake, infrequently in the sediments of Radomno, Młynek, Francuskie, and Jeziorak Lakes and the Eemian deposits of central Poland.

Distribution in Poland: The species was reported from Wyżyna Krakowsko-Częstochowska Upland; Vistula River (Starmach, 1938; Turoboyski, 1962); fish ponds in Mydlniki (Siemińska, 1947); Pilica River (Kadłubowska, 1964b); Sanka stream (Hojda, 1971); Polish acidic mountain streams in the Silesian Beskid (section of the Western Carpathians), the Świętokrzyskie Mts, and in the Karkonosze range (in the Sudetic Mts) (Kwandrans, 1993); the sediments of Mały Staw and Wielki Staw lakes in glacial cirques in the north-eastern part of the Karkonosze Massif, south west Poland (Sienkiewicz, 2005, 2016); Kobylanka stream, south Poland (Wojtal, 2009); Low-pH Kąpielowe and Piaski Lakes in Western Pomerania, north-west Poland (Witkowski et al., 2011); Korzeń National Nature Reserve in the central Poland (Szulc & Szulc, 2012); Duszatyńskie Lakes, Matysówka stream a right-bank tributary of Struga River, district of Tyczyn and Baryczka stream, left bank tributary of the River San, south-eastern Poland (Noga et al., 2013b, d); Springs and streams of the high-mountain habitats in (Tatra Mts) West Carpathians, south Poland (Wojtal, 2013); from some rivers and streams in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Holocene sediment from the south-western part of the Gulf of Gdańsk, between Hel Peninsula and Gdańsk – Gdynia south-western region (Witak & Jankowska, 2014); Żołynianka and Jagielnia streams, Podkarpacie province, south Poland (Peszek et al., 2015); Holocene sediments of Lake Suminko northern Poland (Pędziszewska et al., 2015); the Terebowiec stream, south-eastern part of the Bieszczady National Park, south Poland (Noga et al., 2016); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); Holocene sediments of Lake Suchar IV in the area of Wigry National Park in the range of the Pomeranian Phase north-east Poland (Zawisza et al., 2019); Lake Wigry signed to the Wigierskie group, in Wigry National Park north-east Poland (Eliasz-Kowalska & Wojtal, 2020).

***Tabellaria quadriseptata* Knudson 1952**

Ref. Knudson 1952, p. 436, figs I-N

Status of name: accepted taxonomically

Diagnosis: Frustules are more robust forming Zig-zag colonies, with 2, 3, or 4 septa. Valves are linear with three approximately equal inflations. Terminal inflations gradually tapering towards the shafts. Transapical striae of about 14-16 in 10 µm. The apical and central valve inflations are always of very similar size. The valve margins are conspicuously ornamented with an array of spines. Length of the valve 23-130 µm, and the breadth 6-9 µm.

Ecological preference: The species was reported attached to substrata in dystrophic and very oligotrophic waters (Knudson 1952); it was found in acid waters of low conductivity and it is classified as an acidobiontic species (van Dam et al., 1981); common epilithic diatom in waters with pH < 5 and very low calcium content (Flower & Battarbee 1985). A freshwater species occurs at pH<5.5 (Acidobiontic), oligosaprobous (Van Dam et al., 1994).

Occurrence: Infrequent in the sediments of Młynek Lake.

Distribution in Poland: It is reported from the Atlantic peat bogs in the area of Białogóra i Bielawskie Błota, north Poland (Pliński & Witek 1976); Sediments of Lake Żabińskie, in the Masurian Lake District northeastern Poland (Witak et al., 2017); reported from the peat post-excavation pit, Central Poland (Rakowska, 2000)

***Tabellaria ventricosa* Kützing 1844**

Ref. Krammer, Lange-Bertalot, 1991a, pl. 107, figs. 1–7; Bąk et al. 2012, p. 328, pl. 5.

Status of name: accepted taxonomically

Synonym: *Tabellaria flocculosa* var. *ventricosa* (Kützing) Grunow 1862

Diagnosis: Frustules are rectangular-tabular in girdle view, due to numerous intercalary bands, with rounded corners. Valves are linear with a marked swollen middle portion than the terminal inflations, which are considerably smaller in width which forming capitate, rounded apices. The axial area is narrow, linear, wider slightly in the middle to form a small central area. Transapical striae fine, about 17-18 in 10 µm, perpendicular to the midline, slightly radiate at the apices. Length of the valve 12-35 µm, and the breadth 5-15 µm.

Ecological preference: The species was reported from dilute waters of low alkalinity and ion concentration (Wojtal, 2013).

Occurrence: Infrequent in the sediments of Radomno and Jeziorak Lakes

Distribution in Poland: It is recorded from Mały Staw lake, located in a post-glacial cirque in the northeastern part of Karkonosze Mts, west Poland (Sienkiewicz, 2005); Korzeń National Nature Reserve in central Poland (Szulc & Szulc, 2012); Springs of the high-mountain habitats in southern Poland (Tatra Mts) West Carpathians, south Poland (Wojtal, 2013).

Genus *Tabularia* (Kützing) Williams & Round 1986

Diagnosis: Cells are needle-like; solitary or in clusters. Valve is elongate, linear to linear-lanceolate with a very wide axial area and absent central area. Transapical striae are marginal, consisting of one or two areolae. A single rimoportula occurs at one end.

Holotype species *Tabularia barbatula* (Kützing) Williams & Round 1986

***Tabularia chandolensis* (Gandhi) Vigneswaran, Williams & Karthick 2020**

(Pl. 120, figs. 1-4)

Ref. Gandhi, 1964, p. 354-355, pl. 1(62), figs. 13-14; p. 357, pl. 62(1), fig. 28; Vigneswaran et al. 2020, p.191

Status of name: accepted taxonomically

Synonyms: *Fragilaria fonticola* var. *chandolensis* Gandhi, 1964
Synedra chandolensis Gandhi 1964

Diagnosis: Valve is linear with cuneate, sub-protracted acutely rounded apices. The axial area is moderate, linear with absent central area. Transapical striae are distinct, marginal, parallel, about 15-16 in 10µm. Length of the valve 30-40 µm, and the breadth 4-5 µm.

Occurrence: Frequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

Tabularia fasciculata (Agardh) Williams & Round 1986

(Pl. 120, figs. 5-7)

Ref. Hustedt 1959, p. 218, fig. 710: i-l; Patrick & Reimer, 1966, p. 141, pl. 5, figs. 17-18; Lange-Bertalot 1980, p. 750, figs. 155 -167; Germain, 1981, p. 78, pl. 26, figs. 5-10; Krammer & Lange-Bertalot, 1991a, p. 150, pl. 135, figs. 11- 18; pl. 124, fig. 3; Ehrlich 1995, p. 44, pl. 7, figs. 12-13; Hartley et al. 1996, p. 586, pl. 285, fig. 1; Witkowski et al. 2000, p. 80, pl. 30, figs. 4-5; Bąk et al. 2012, p. 329, pl. 6.

Status of name: accepted taxonomically

Synonyms: *Diatoma fasciculata* Agardh 1812
Diatoma tabulatum Agardh 1832
Synedra tabulata (Agardh) Kützing 1844
Synedra affinis Kützing 1844
Synedra fasciculata (Agardh) Kützing 1844
Fragilaria tabulata (Agardh) Lange-Bertalot 1980
Fragilaria fasciculata (Agardh) Lange-Bertalot 1980
Tabularia fasciculata (Agardh) Williams & Round 1986

Diagnosis: Valve is linear to linear-lanceolate, flared a little towards the center and narrower towards acutely rounded or slightly rostrate apices. The axial area is distinct, broad, lanceolate without central area. Transapical striae are short, marginal, parallel, broad, absent from the tip of the valve thereby forming a clear area; about 13-15 striae in 10 µm. Length of the valve 85-200 µm, and the breadth 3-7 µm.

Ecological preference: It is considered as halophilous "euryhaline", alkaliphilous, littoral form (Foged, 1959); in the water of high conductivity, sometimes slightly brackish water (Patrick & Reimer, 1966); an euryhaline brackish and saltwater species occurring epiphytically on other algae (Mölder & Tynni, 1970); marine, euryhaline (Ehrlich, 1975). The species was recorded as common in shallow brackish water, coastal marine habitats of medium alkalinity (Zalat & Servant-Vildary, 2005); epiphytic taxon on leaf tissues of seagrasses (Chung & Lee, 2008); slightly alkaline, pH value 7.1-7.6, meso-eutrophic and oxygen-saturated (Toporowska et al., 2008); benthic, brackish water, eutrophic, α-β- mesosaprobic (Zgrundo et al., 2008); freshwater, periphytic on the macrophytes in the river (Bertolli et al., 2010); low temperature (6.7-8.2 °C), alkaline saline water, with pH value 6.4-7.99 (Żelazna-Wieczorek et al., 2015).

Occurrence: Frequent in the Holocene sediments of Kamionka and Radomno Lakes

Distribution in Poland: The species was reported from Szczecin lagoon, south western Baltic Sea (Witkowski et al., 2004); the submerged macrophytes in Lake Skomielno, Łęczyńsko-Włodawskie, eastern Poland (Toporowska et al., 2008); from the Gulf of Gdańsk (Zgrundo et al., 2008); Górki Zachodnie and Swibno – Vistula River estuary in Northern Poland (Majewska et al., 2012); from river and streams including Wisłok, Zalew Rzeszowski, San (near Jarosław), Gołębiówka, Szuwarka in the territory of the Podkarpacie Province, south Poland (Noga et al., 2014); Pełczyska village, Łęczyca in the Łodź province, central Poland (Żelazna-Wieczorek et al., 2015); post-mine reservoirs in the Łódzkie and Wielkopolskie voivodeships, central Poland (Olszyński et al., 2019).

***Tabularia fonticola* (Hustedt) Wetzel & Williams in Vigneshwaran et al. 2020**

(Pl. 120, figs. 8-11)

Ref. Hustedt 1937, p. 151, pl. 10, figs. 61,62; Simonsen 1987, pl. 320, figs. 21-26; Vigneshwaran et al. 2020, p. 191

Status of name: accepted taxonomically

Synonym: *Fragilaria fonticola* Hustedt 1937

Diagnosis: Frustules are rectangular in girdle view. Valves are linear to slightly lanceolate with subcapitate acutely rounded apices. The axial area is linear to lanceolate, moderate with absent central area. Transapical striae are parallel to slightly radiate towards the apices, about 13-15 in 10µm, intercalated with those of the opposite margin. Length of the valve 20-35 µm, and the breadth 4-5 µm.

Occurrence: Frequently in the late Holocene sediments of Mlynek and Kamionka Lakes.

Distribution in Poland: New record.

***Tabularia waernii* Snoeijs 1991**

Ref. Snoeijs & Kuylenstierna 1991, p. 352, figs 1-34f

Status of name: accepted taxonomically

Diagnosis: Valves are linear-lanceolate with protracted rostrate apices. The axial area is very narrow. Transapical striae are dense parallel to slight radiate at the apices, about 23-25 striae in 10 µm. A single rimoportula is present at one apex. Length of the valve 11-40 µm, and the breadth 2-3 µm.

Ecological preference: The species was recorded from marine and brackish water environment, in salinities ranging from 2 to 20‰ on the Swedish west coast (Snoeijs & Kuylenstierna, 1991), epiphytic, during prolonged periods of calm weather with optimum salinity appeared to be 7‰, and common in June and July when the daily irradiance and water temperature were at their highest (Leskinen & Hällfors, 1997).

Distribution in Poland: Found in Górki Zachodnie – Vistula River estuary in Northern Poland (Majewska et al., 2012)

Genus *Tetracyclus* Ralfs 1843

Diagnosis: Frustules are rectangular or oblong in girdle view, forming zigzag or straight chains. Valves are isopolar, elongate to elliptical, with capitate, and centrally expanded and/or constricted. The valve face is flat with a distinct and high mantle. Transapical striae are uniseriate. Valves may have zero to three rimoportulae, situated near the valve center, arranged transapically along the sternum but can be polar, even on the mantle edge.

Holotype Species *Tetracyclus lacustris* Ralfs 1843

***Tetracyclus glans* (Ehrenberg) Mills 1935**

(Pl. 120, fig. 12)

Ref. Cleve-Euler 1939, p. 18, fig. 37; Cleve-Euler 1953, p. 5, fig. 292 k

Status of name: accepted taxonomically

Synonyms: *Navicula glans* Ehrenberg 1838
Odontidium glans (Ehrenberg) Kützing 1844
Biblarium glans (Ehrenberg) Ehrenberg 1845
Tetracyclus elegans (Ehrenberg) Ralfs in Pritchard 1861
Tetracyclus lacustris var. *ovlais* Holmboe 1901
Tetracyclus lacustris var. *rhombicus* Hustedt 1911
Tetracyclus lacustris var. *elegans* (Ehrenberg) Hustedt 1914
Tetracyclus lacustris var. *baicalensis* Skvortzov & Meyer 1928

Tetracyclus lacustris var. *undulatus* Cleve-Euler 1939
Tetracyclus lacustris var. *platycephalus* Cleve-Euler 1953

Diagnosis: Valves are elliptic-lanceolate with large central inflation and broadly rounded apices. Transapical costae are thick and evenly spaced at 2-3 in 10 µm. The striae are faint compared to the costae, hardly observed. The axial area is narrow and linear, sometimes with poorly defined margins. Length of the valve 20-35 *µm*, and the breadth 14-20 µm.

Ecological preference: This taxon has been found in cool, oligotrophic water bodies, particularly growing in moist zones in association with mosses and liverworts (Bishop & Spaulding, 2015).

Occurrence: Infrequently in the Eemian deposits of central Poland.

Distribution in Poland: This species was reported from Poland by Bąk et al. (2012).

***Tetracyclus rupestris* (Kützing) Grunow in Van Heurck 1881**

Ref. Bąk et al. 2012, p. 330, pl. 5

Status of name: accepted taxonomically

Synonym: *Denticula thermalis* var. *rupestris* Kützing 1849

Diagnosis: Valves are elliptic-lanceolate, with broadly rounded apices. The axial area is wide and indistinct. Transapical striae are parallel, with individual erratic striae that intrude into the axial area, faint, about 20-24 in 10 µm. Transapical costae are robust, and become inflated and relatively indistinct in the axial area; about 3-4 costae in 10 µm. A single rimoportula is present at one apex. Length of the valve 8-25 *µm*, and the breadth 4.5-8.5 µm.

Ecological preferences: The species is reported from slightly acidic to slightly alkaline, dilute waters of low ion concentration and high dissolved oxygen concentrations (Wojtal, 2013)

Distribution in Poland: Springs of the high-mountain habitats in southern Poland (Tatra Mts) West Carpathians, south Poland (Wojtal, 2013)

Genus Williamsella Graeff, Kociolek and Rushforth 2013

Diagnosis: Frustules are rectangular in girdle view. Valves are linear, narrow, with a very narrow axial area, becoming slightly wider toward the center, but without a central area. Striae are opposite, irregularly punctate, more or less parallel, comprised of five to eight areolae across the valve face. A pore field is present at both apices. A single rimoportula is present at one end of the valve.

Holotype species *Williamsella angusta* Graeff, Kociolek & Rushforth 2013

***Williamsella angusta* Graeff, Kociolek & Rushforth 2013**

(Pl. 120, fig. 13)

Ref. Graeff et al. 2013, p. 7, figs. 19-37; Rioual et al. 2017, p. 44; Kociolek et al. 2015, p. 683, fig. 13A.

Status of name: alternate representation

Synonym: *Fragilaria crenophila* Rioual 2017

Diagnosis: Frustules are rectangular in girdle view. Valves are linear, narrow with bluntly rounded somewhat subcapitate apices. The axial area is very narrow, linear, indistinct. Transapical striae are opposite, irregularly punctate, parallel, about 8-10 striae in 10 µm. A pore field is present at both apices with a single rimoportula is present at one apex of the valve. Length of the valve 130 µm, and the breadth 4 µm.

Occurrence: Infrequently in the Eemian deposits of central Poland.

Distribution in Poland: New record.

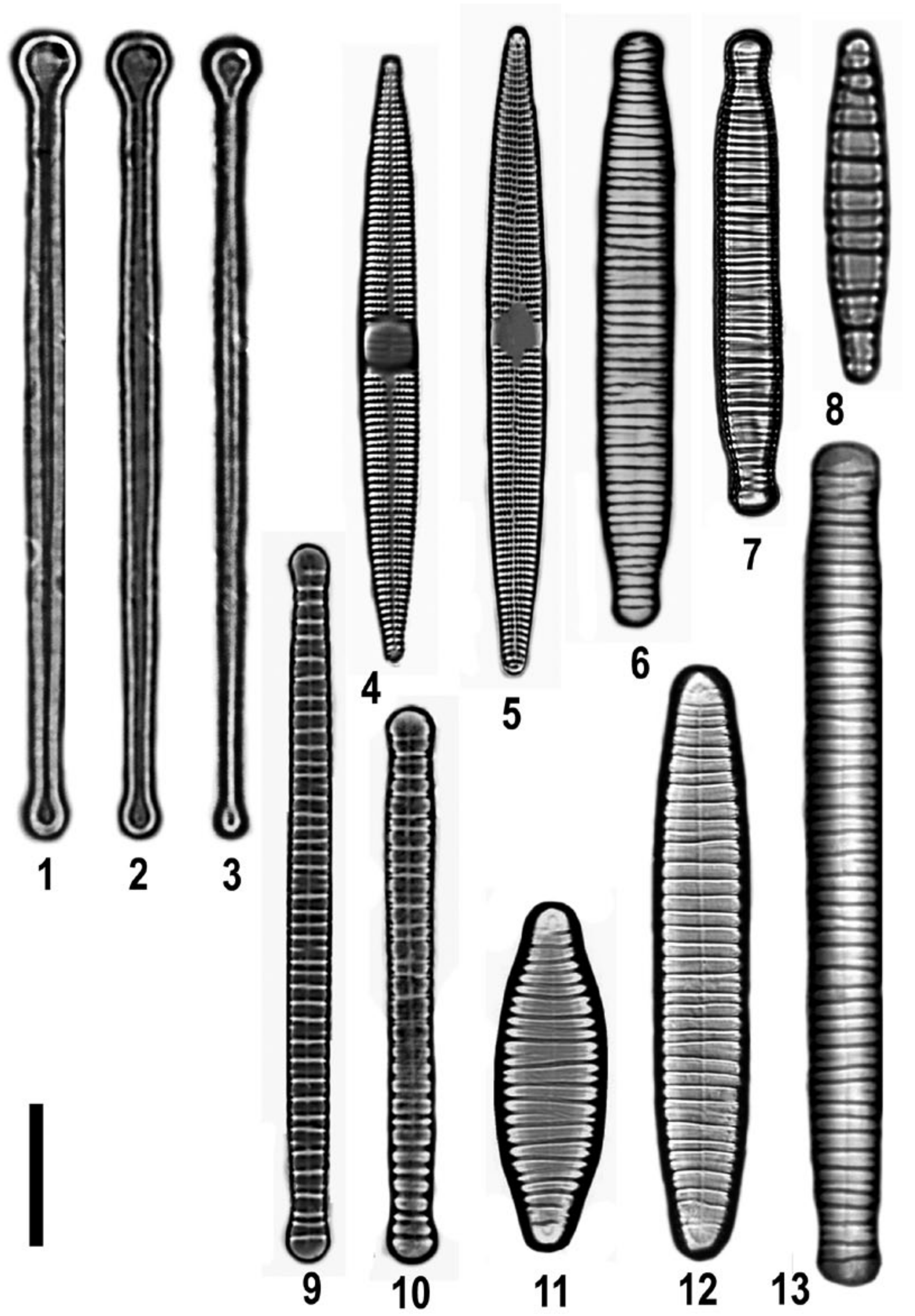

Plate 38. 1-3. *Asterionella formosa* Hassall 1850, *Młynek* Lake; 4-5. *Ctenophora pulchella* (Ralfs ex Kützing) Williams & Round 1986, Radomno Lake; 6-7. *Diatoma ehrenbergii* Kützing 1844, Kamionka Lake; 8. *Diatoma moniliformis* (Kützing) Williams 2012, *Młynek* Lake; 9-10. *Diatoma tenuis* Agardh 1812, Jeziorak Lake; 11-12. *Diatoma vulgaris* Bory 1824, Kamionka Lake; 13. *Diatoma vulgaris* var. *linearis* Grunow in Van Heurck 1881, Francuskie Lake. Scale bar 10 µm.

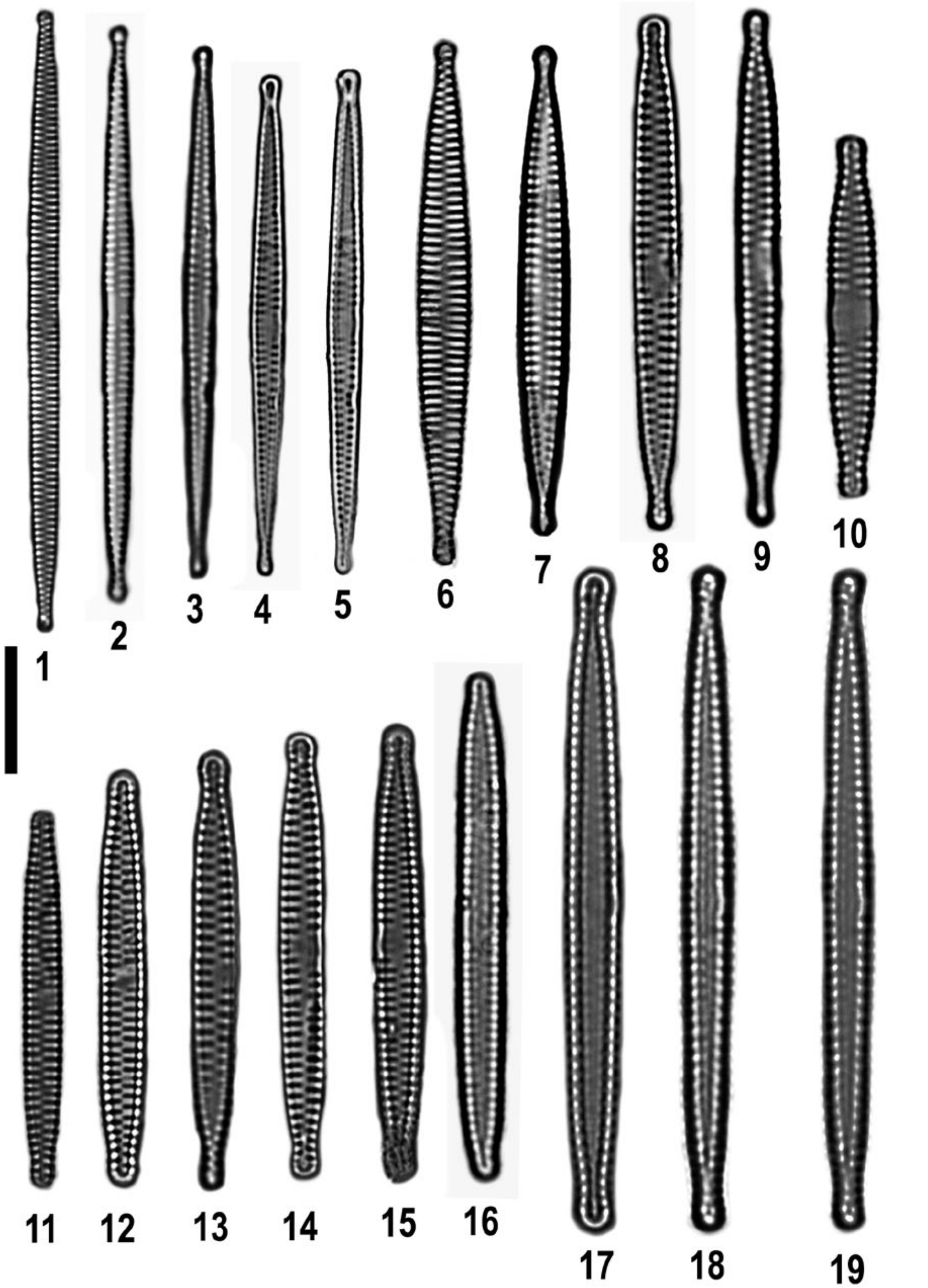

Plate 39. 1. *Fragilaria acidoclinata* Lange-Bertalot & Hofmann 1993, Radomno Lake; 2-5. *Fragilaria amphicephaloides* Lange-Bertalot 2013, 2. Radomno Lake, 3-5. Eemian deposits; 6-7. *Fragilaria austriaca* (Grunow) Lange-Bertalot 2000, Eemian deposits; 8-10. *Fragilaria capucina* Desmaziéres 1830, Eemian deposits; 11-15. *Fragilaria distans* (Grunow) Bukhtiyarova 1995, 1. Radomno Lake, 2. Jeziorak Lake, 3-5. Eemian deposits; 16-19. *Fragilaria gracilis* Østrup 1910, Kamionka Lake. Scale bar 10 µm.

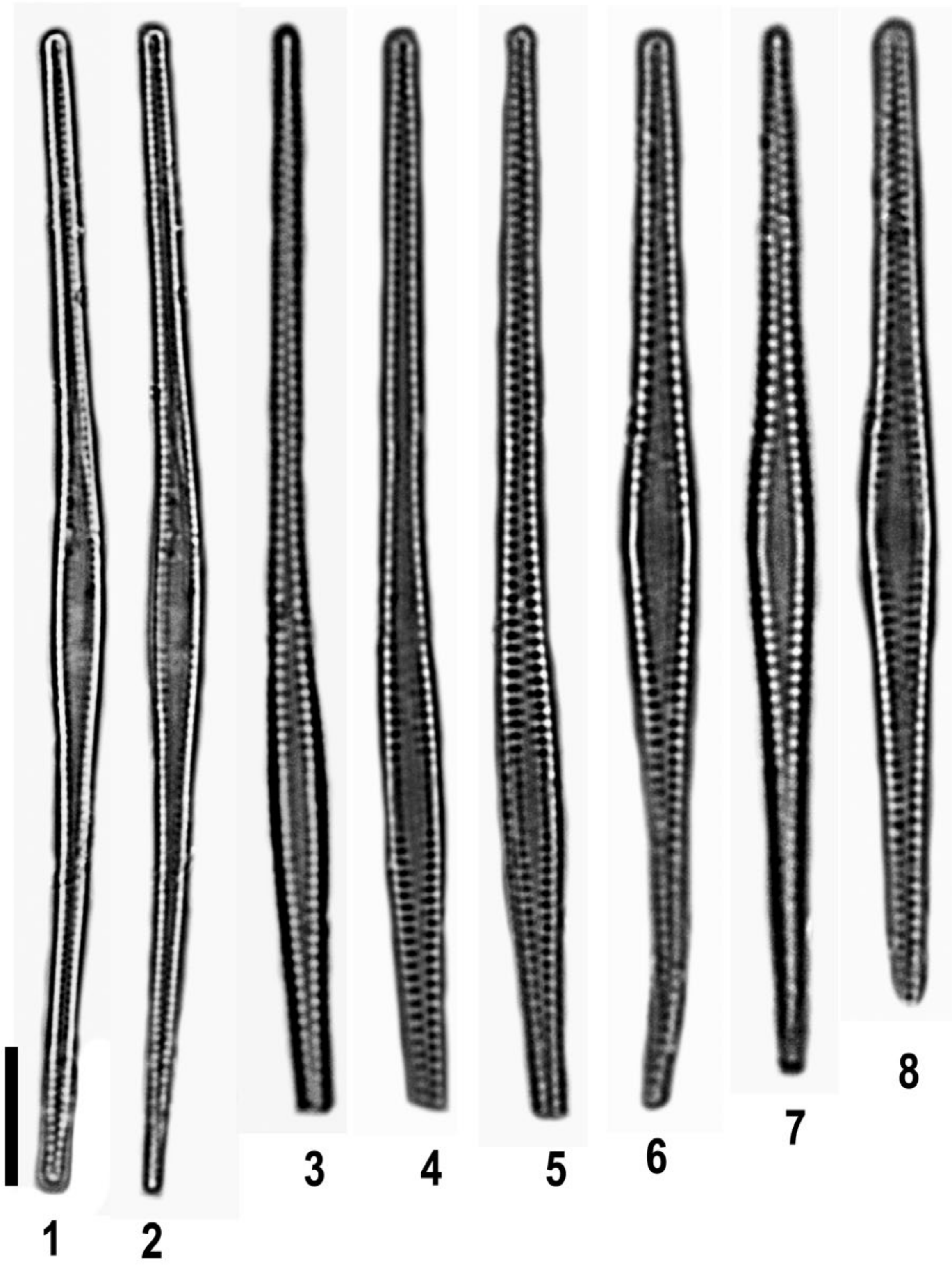

Plate 40. 1-8. *Fragilaria crotonensis* Kitton 1869, Eemian deposits. Scale bar 10 µm.

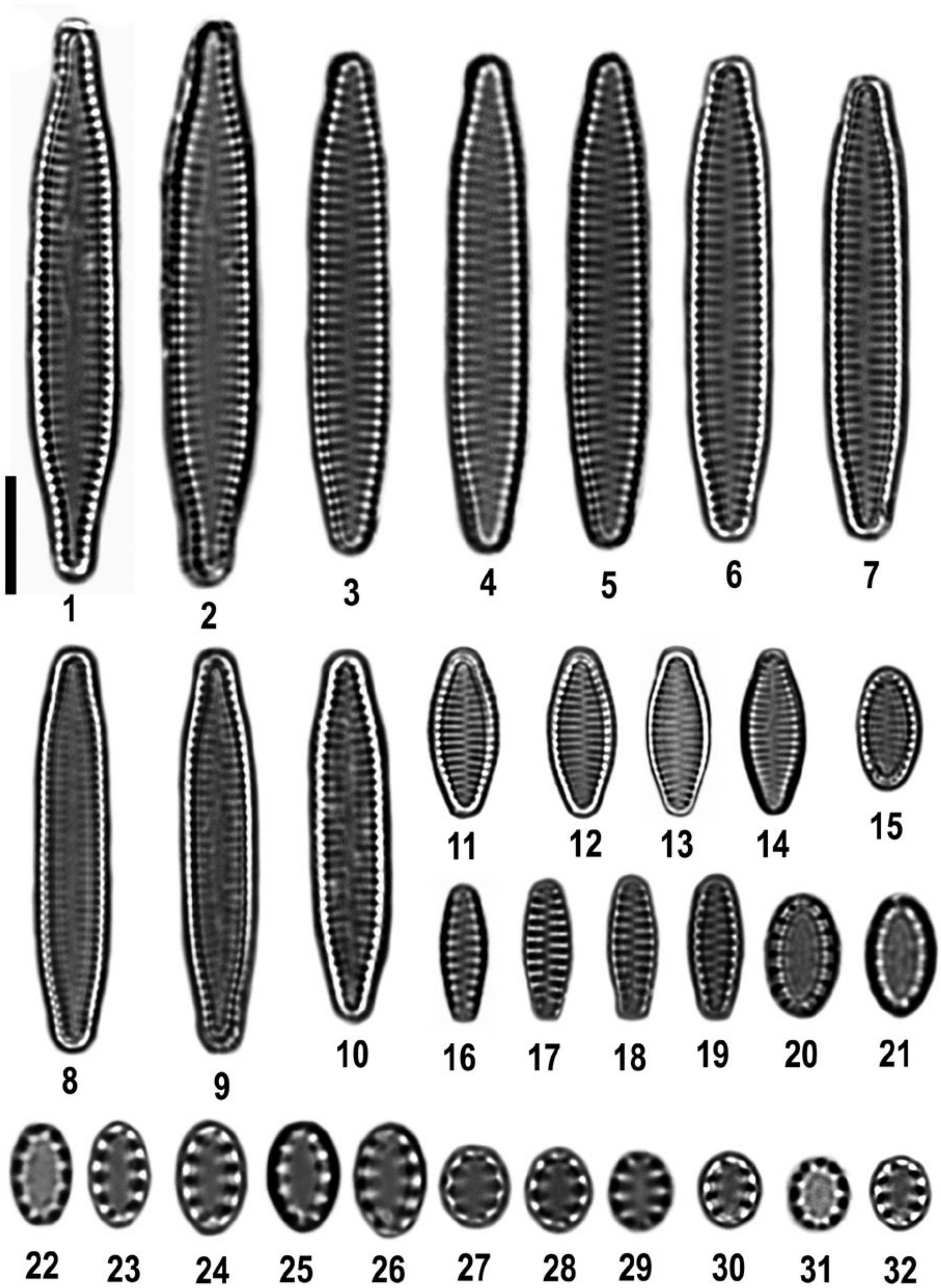

Plate 41. 1-10. *Fragilaria imbramoviciana* Kaczmarska 1976, Eemian deposits; 11-15. *Fragilaria improbula* Witkowski & Lange-Bertalot 1995, 11-14, Eemian deposits, 15. Kamionka Lake; 16-19. *Fragilaria interstincta* Hohn & Hellerman 1963, Jeziorak Lake; 20-32. *Fragilaria lenoblei* Manguin 1952, 20-21. Kamionka Lake, 22-32. Eemian deposits. Scale bar 10 µm.

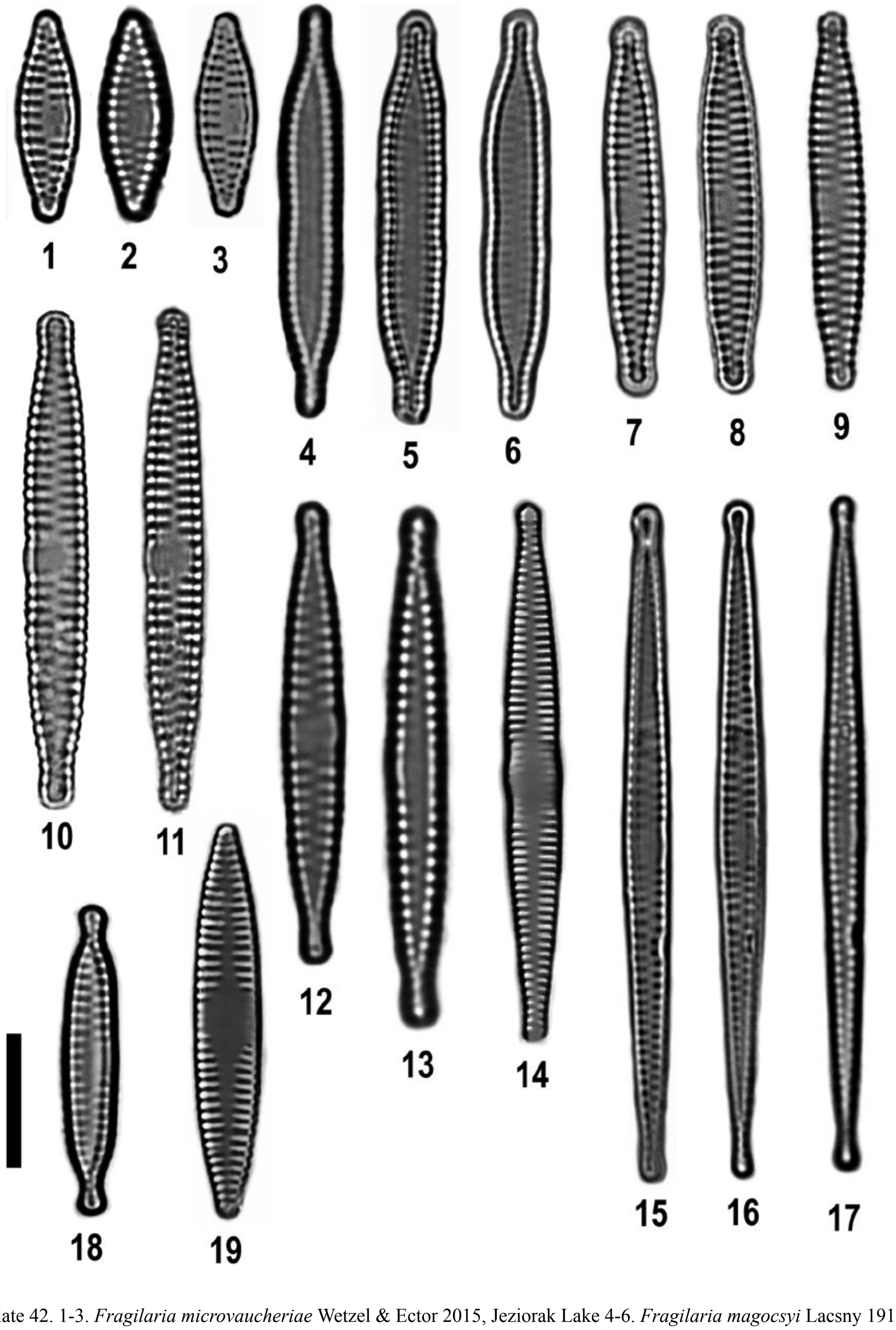

Plate 42. 1-3. *Fragilaria microvaucheriae* Wetzel & Ector 2015, Jeziorak Lake 4-6. *Fragilaria magocsyi* Lacsny 1916**,** *Młynek* Lake**;** 7-11. *Fragilaria neointermedia* Tuji & Williams 2013, 7-9. Eemian deposits; 10-11. Radomno Lake**;** 12-13. *Fragilaria parva* (Grunow) Tuji & Williams 2008, Radomno Lake; 14. *Fragilaria pararumpens* Lange-Bertalot, Hofmann & Werum 2011, Radomno Lake; 15-17. *Fragilaria perdelicatissima* Lange-Bertalot & Van de Vijver 2014, Eemian deposits; 18. *Fragilaria recapitellata* Lange-Bertalot & Metzeltin 2009, Jeziorak Lake, 19. *Fragilaria rumpens* (Kützing) Carlson 1913**,** Eemian deposits. Scale bar 10 µm.

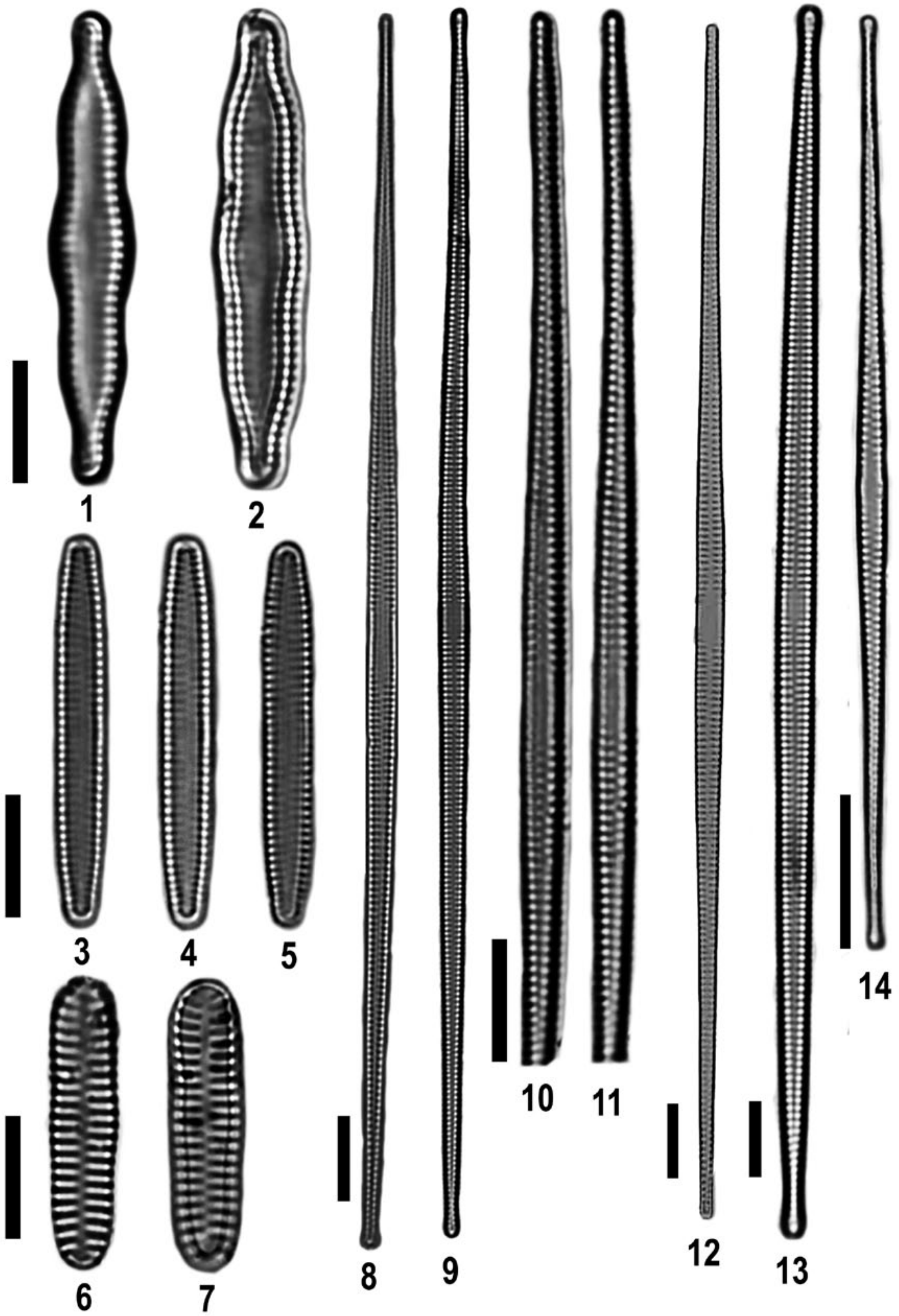

Plate 43. 1-2. *Fragilaria sinuata* Peragallo 1909, Kamionka Lake; 3-5. *Fragilaria subconstricta* Østrup 1910, Eemian deposits; 6-7. *Fragilaria taiaensis* Carter & Denny 1982, Młynek Lake**;** 8-11. *Fragilaria radians* (Kützing) Williams & Round 1987, 8. Radomno Lake, 9. Zielone Lake, 10-11. Eemian deposits; 12. *Fragilaria spectra* Almeida, Morales & Wetzel 2016, Eemian deposits. 13. *Fragilaria tenera* (W. Smith) Lange-Bertalot 1980, Radomno Lake; 14. *Fragilaria tenera* var. *nanana* (Lange-Bertalot) Lange-Bertalot & Ulrich 2014, Radomno Lake. Scale bar 10 µm.

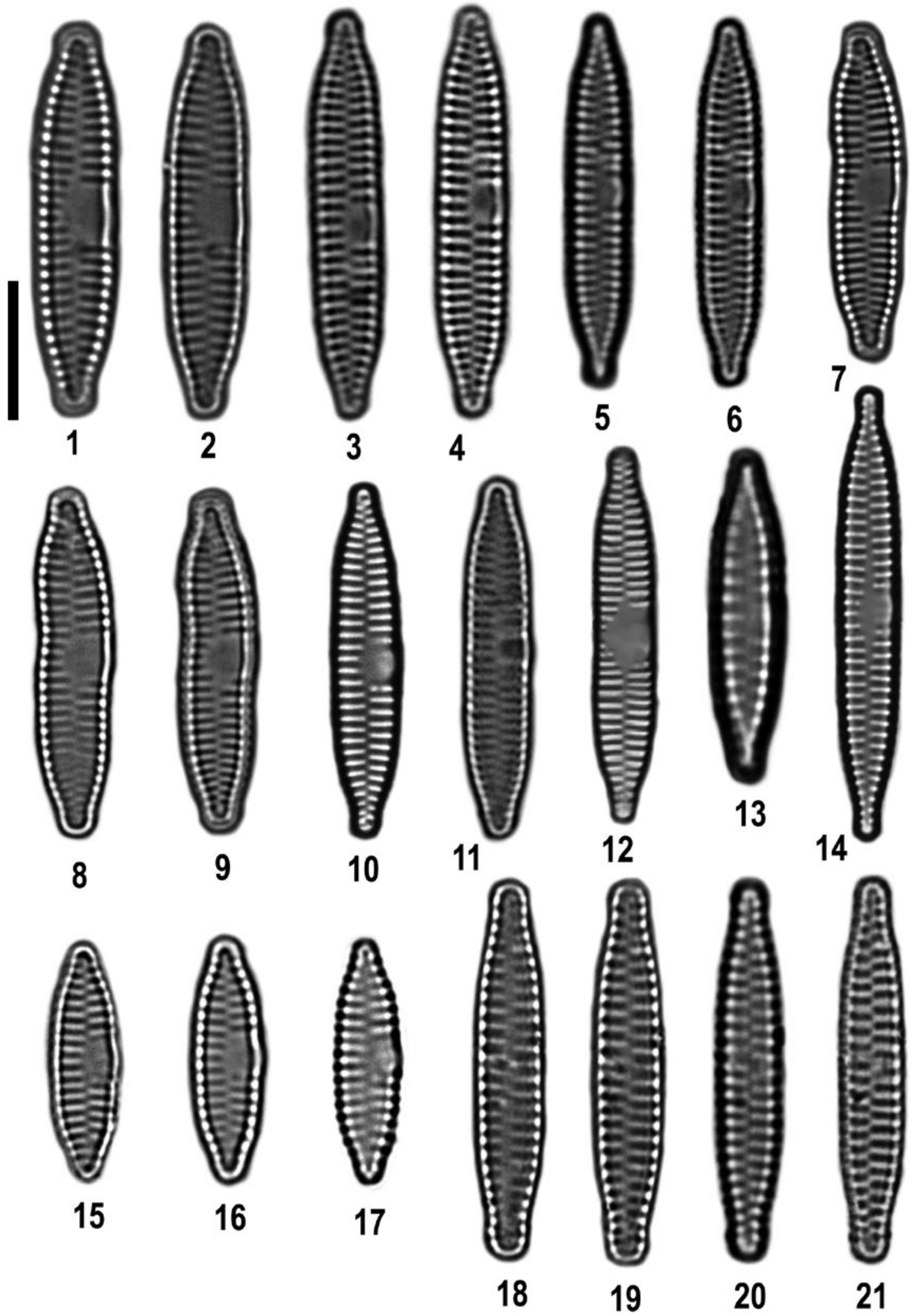

Plate 44. 1-17. *Fragilaria vaucheriae* (Kütz.) Petersen 1938**,** 1-9. Eemian deposits, 10-11. Młynek Lake, 12-14. Radomno Lake, 15-17. Jeziorak Lake; 18-21. *Fragilaria vaucheriae* var. *continua* (Cleve-Euler) Cleve-Euler, 1953, Eemian deposits. Scale bar 10 µm.

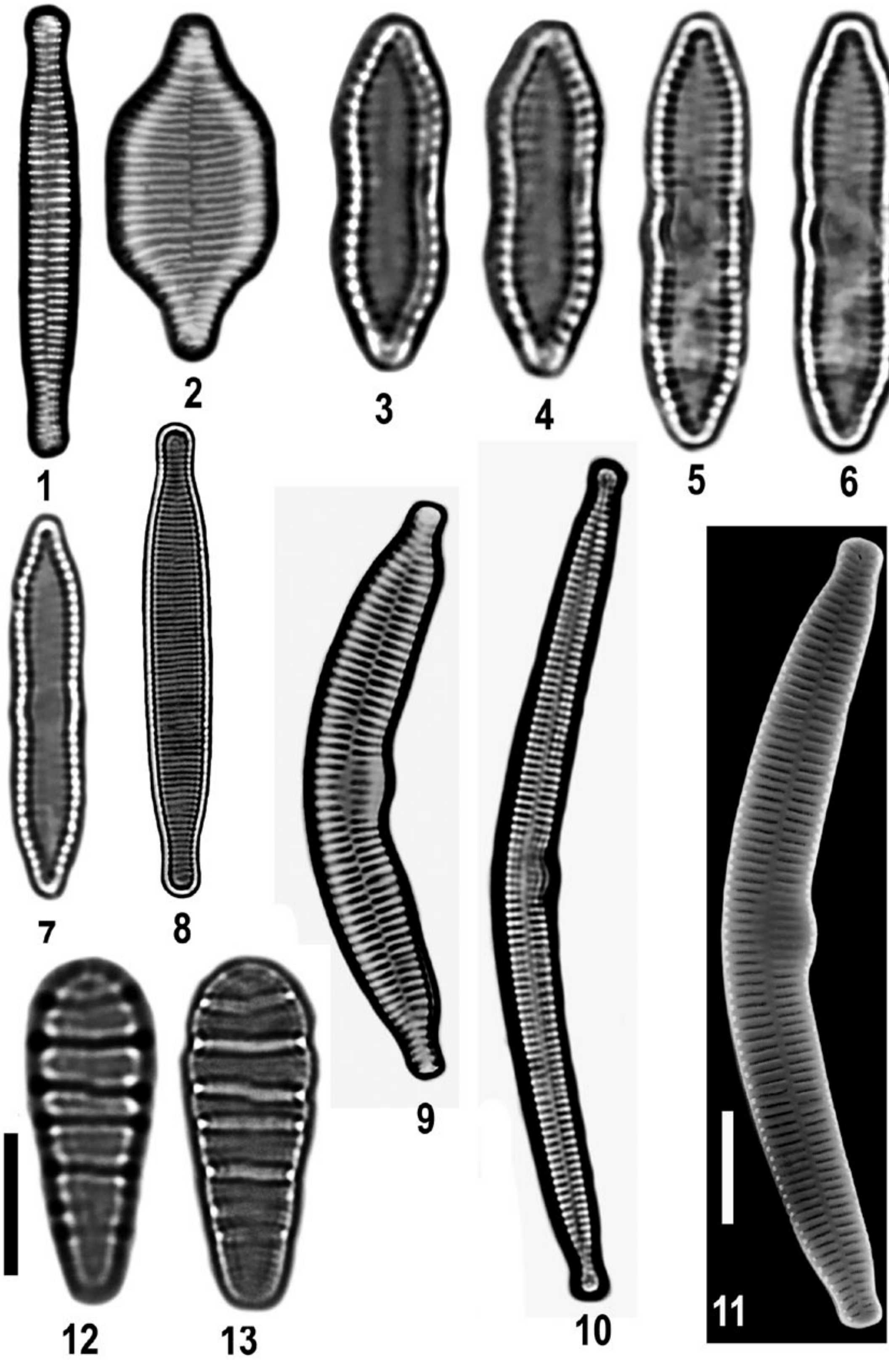

Plate 45. 1. *Fragilariforma bicapitata* (Mayer) Williams & Round 1988, Młynek Lake; 2. *Fragilariforma constricta* (Ehrenberg) Williams & Round 1988, Zielone Lake; 3-7. *Fragilariforma mesolepta* (Hustedt) Kharitonov 2005, 3-6. Eemian deposits; 7. Radomno Lake; 8. *Fragilariforma virescens* (Ralfs) Williams & Round 1987, Młynek Lake; 9-11. *Hannaea arcus* (Ehrenberg) Patrick 1966, 9. Radomno Lake, 10-11. Eemian deposits; 12-13. *Meridion circulare* (Greville) Agardh 1831, Młynek Lake. Scale bar 10 µm.

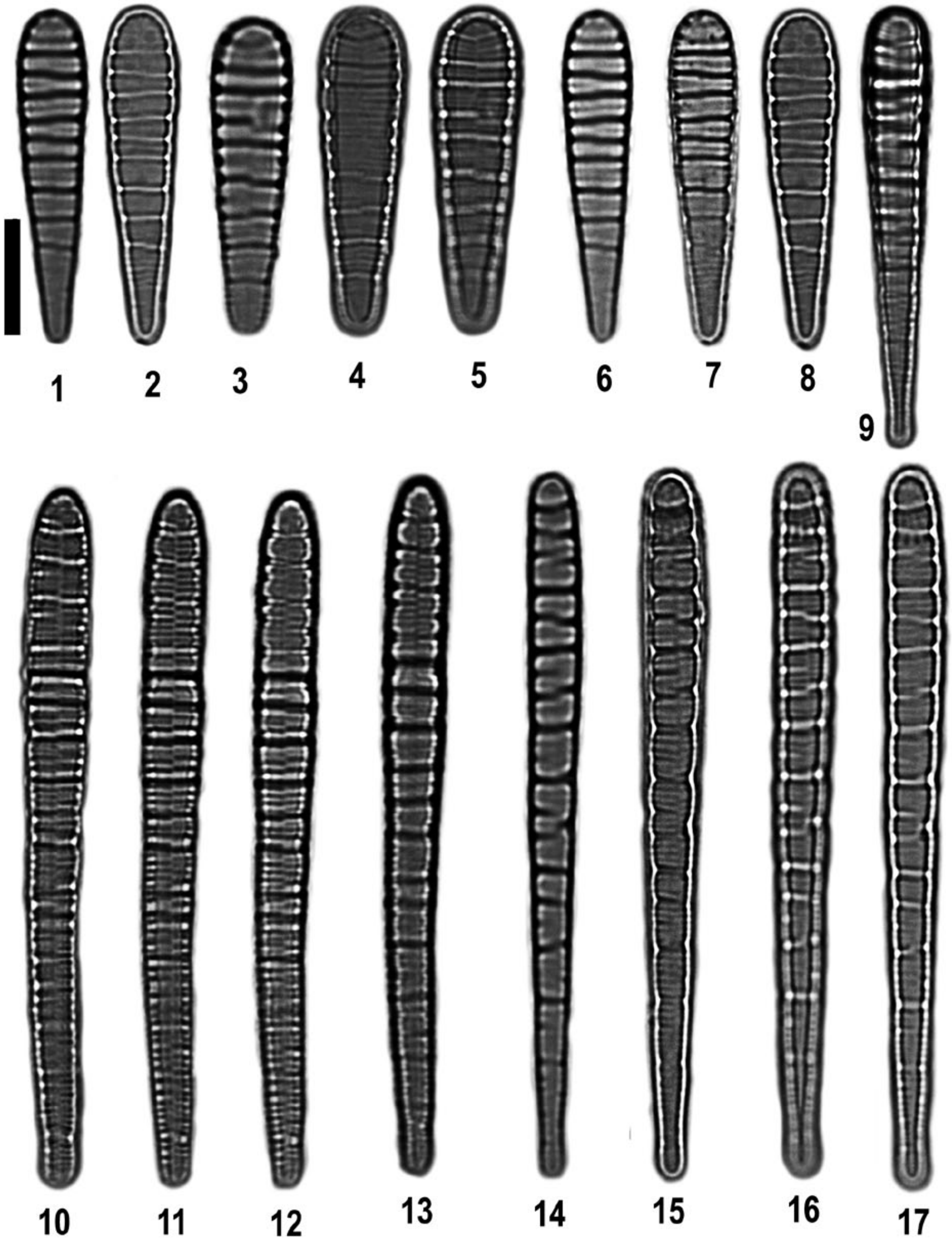

Plate 46. 1-17. *Meridion circulare* (Greville) Agardh 1831, 1-8, 10-17. Młynek Lake; 9. Radomno Lake. Scale bar 10 µm.

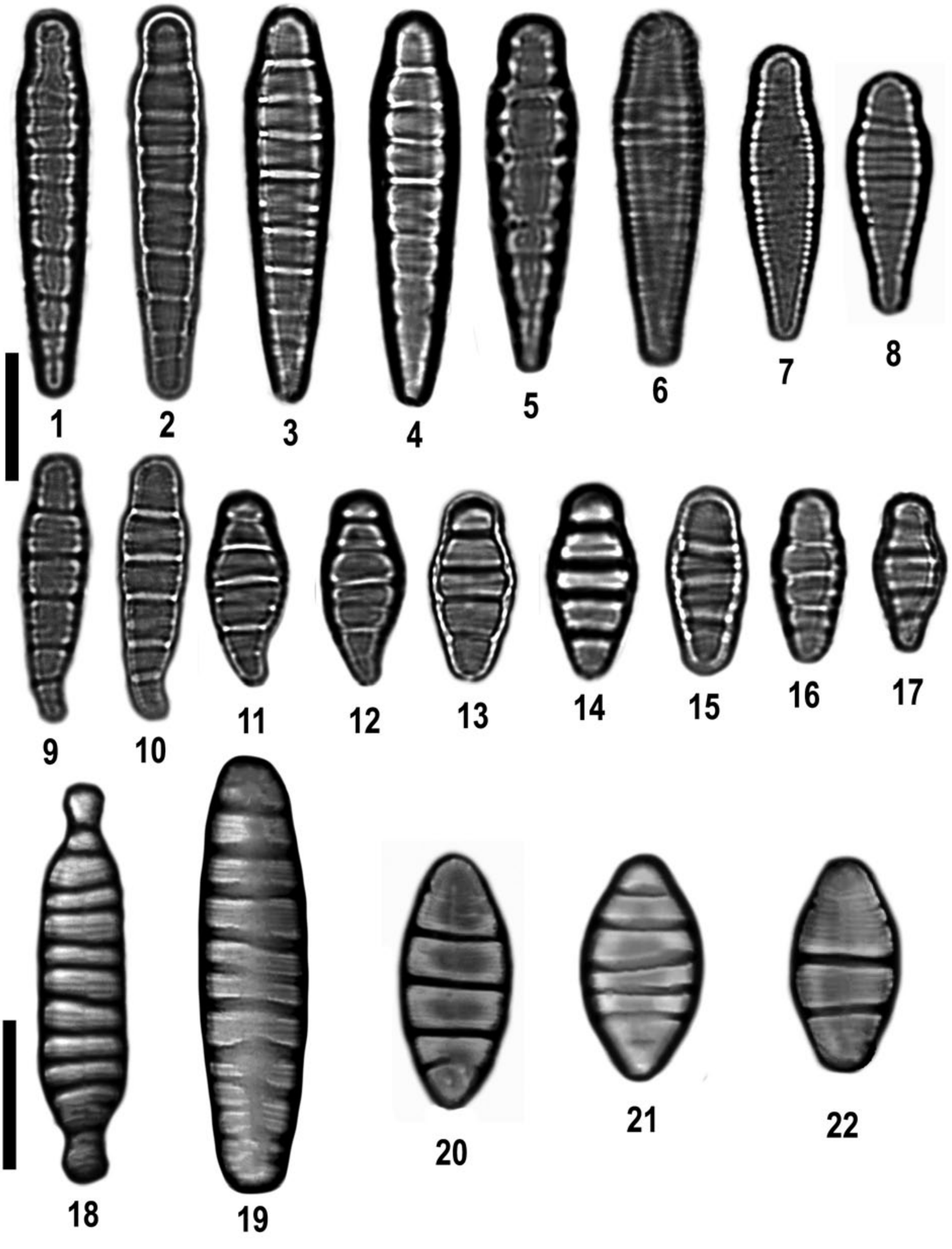

Plate 47. 1-17. *Meridion constrictum* Ralfs 1843, Młynek Lake; 18. *Odontidium anceps* (Ehrenberg) Kirchner 1878, *Młynek* Lake; 19. *Odontidium hyemalis* (Roth) Heiberg 1863 Kamionka Lake; 20-22. *Odontidium mesodon* (Ehrenberg) Kützing 1844, Francuskie Lake. Scale bar 10 µm.

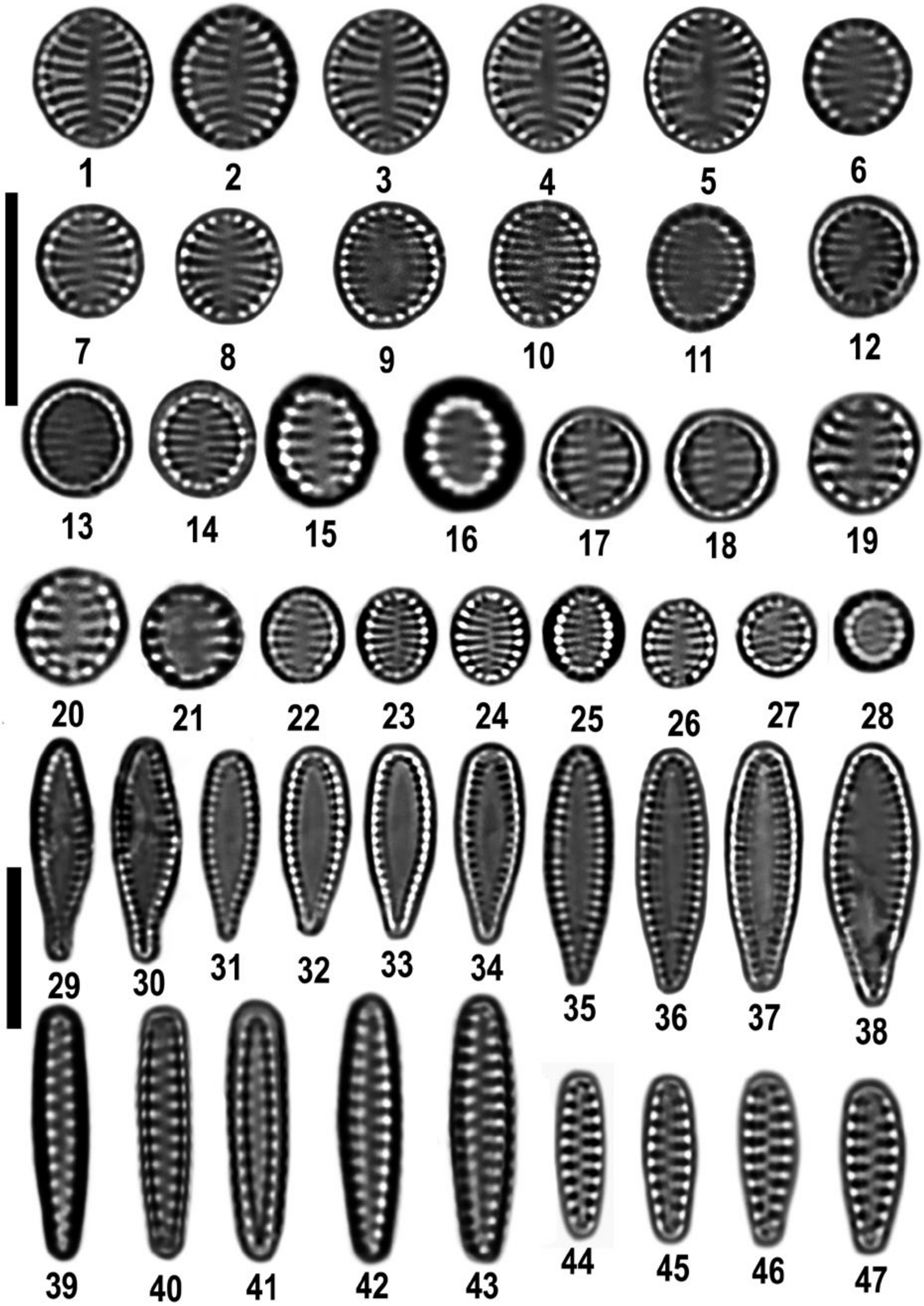

Plate 48. 1-8. *Nanofrustulum sopotense* (Witkowski & Lange-Bertalot) Morales, Wetzel & Ector 2019, Eemian deposits; 9-28. *Nanofrustulum trainori* (Morales) Morales 2019, 9-12. Eemian deposits; 13-28. Kamionka Lake; 29-38. *Opephora marina* (Gregory) Petit 1888, Eemian deposits; 39-47. *Opephora olsenii* Möller 1950, Jeziorak Lake. Scale bar 10 µm.

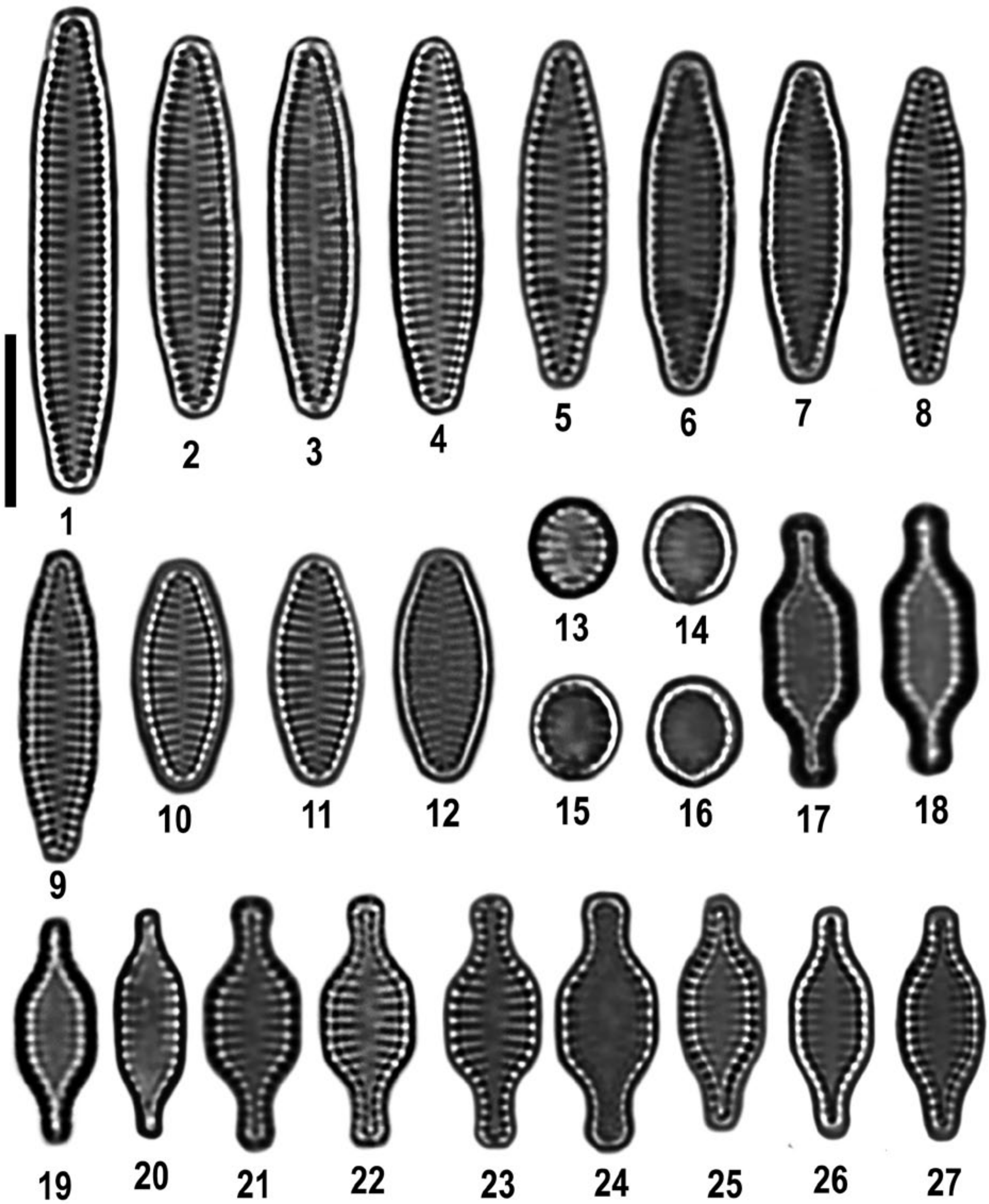

Plate 49. 1-12. *Pseudostaurosira americana* Morales 2005, 1-6, 10-12. Eemian deposits, 7-9. Młynek Lake**;** 13-16. *Pseudostaurosira bardii* Beauger, Wetzel & Ector 2018, Eemian deposits; 17-27. *Pseudostaurosira borealis* (Foged) García, Morales, Ector & Maidana 2017; 17-24. Kamionka Lake, 25-27. Młynek Lake. Scale bar 10 µm.

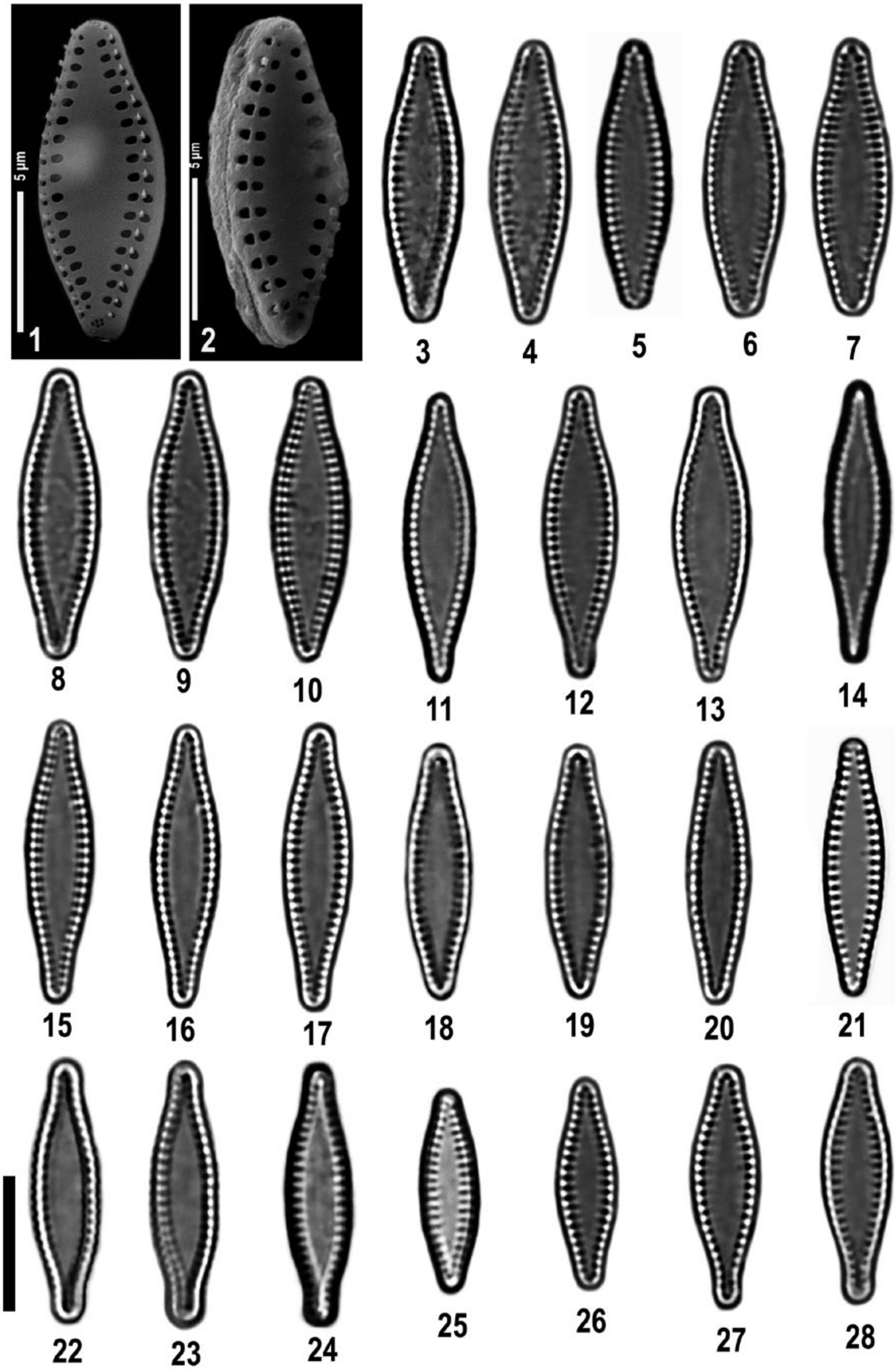

Plate 50. 1-28. *Pseudostaurosira brevistriata* (Grunow) Williams et Round 1987, Eemian deposits, central Poland. 1-2. SEM micrograph showing the external valve view. Scale bar 10 µm, except otherwise mentioned.

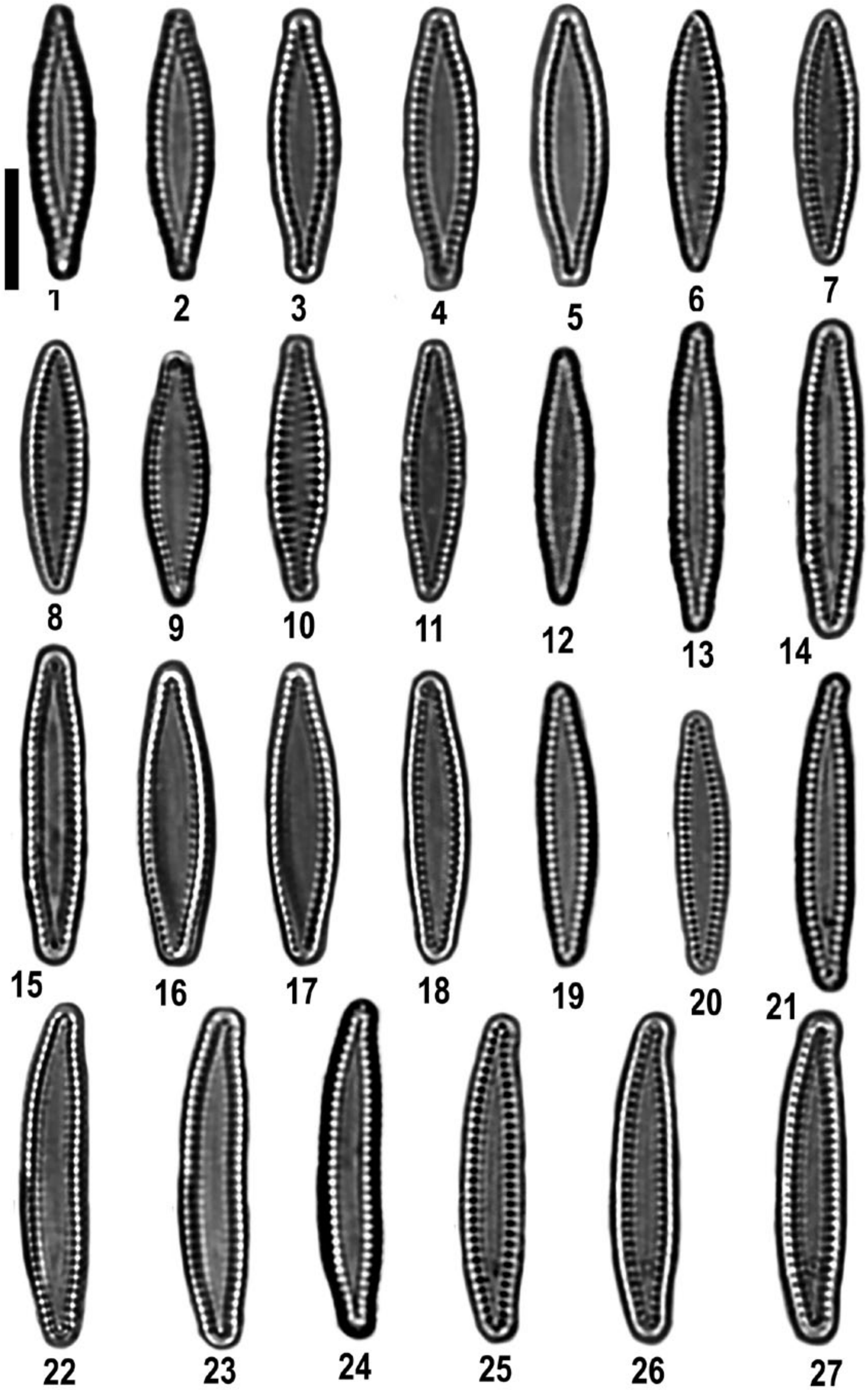

Plate 51. 1-27. *Pseudostaurosira brevistriata* (Grunow) Williams et Round 1987, 1-10. Kamionka Lake; 11-17. Radomno Lake; 18-20. Jeziorak Lake; 21-27, Kamionka Lake. Scale bar 10 µm.

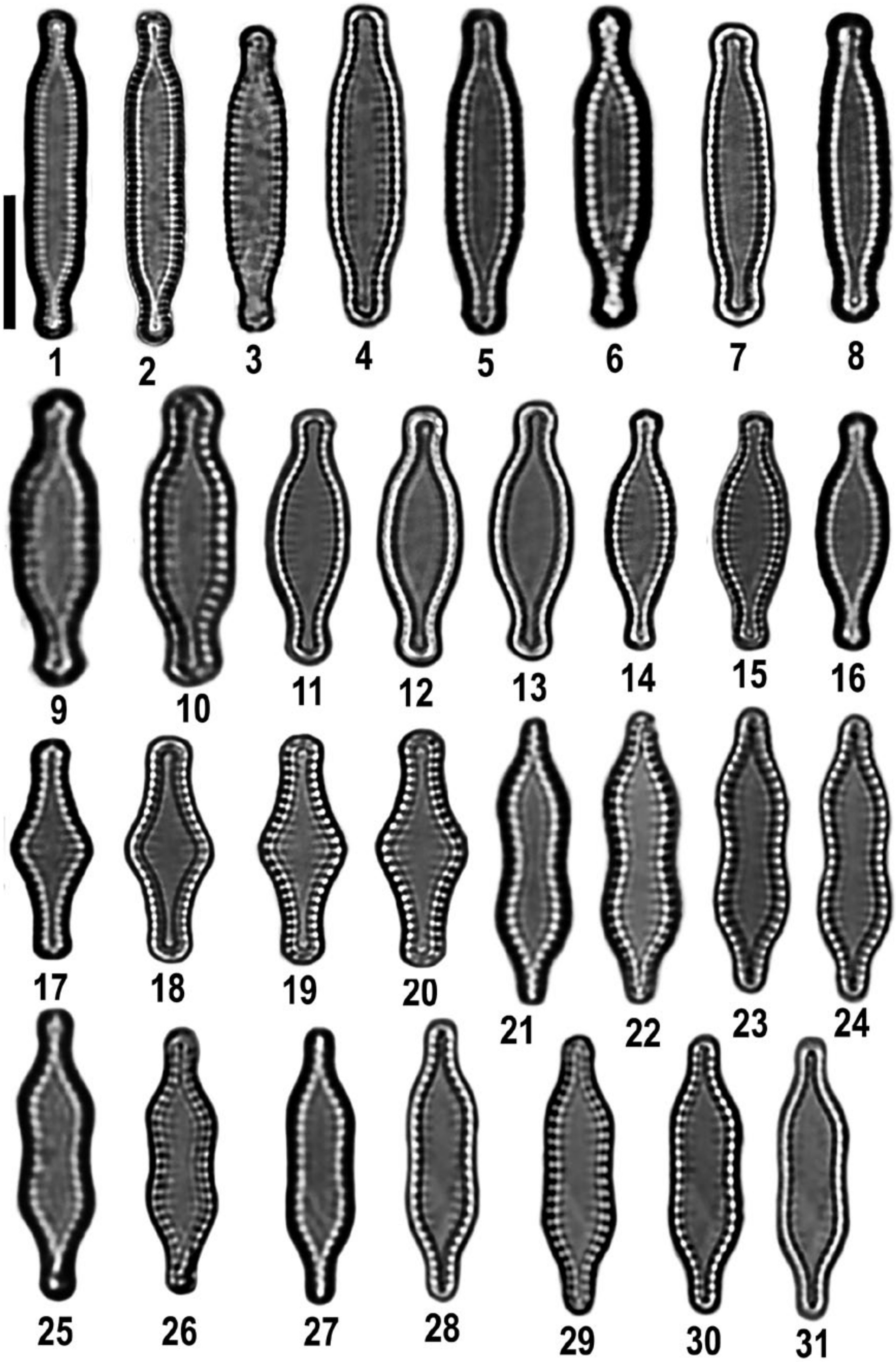

Plate 52. 1-16. *Pseudostaurosira brevistriata* var. *capitata* (Héribaud) Andresen et al., 2000, Młynek Lake; 17-20. *Pseudostaurosira brevistriata* var. *inflata* (Pantocsek) Edlund 1994**,** Radomno Lake; 21-31. *Pseudostaurosira brevistriata* var. *nipponica* (Skvortsov) Kobayasi 2002, Kamionka Lake. Scale bar 10 µm.

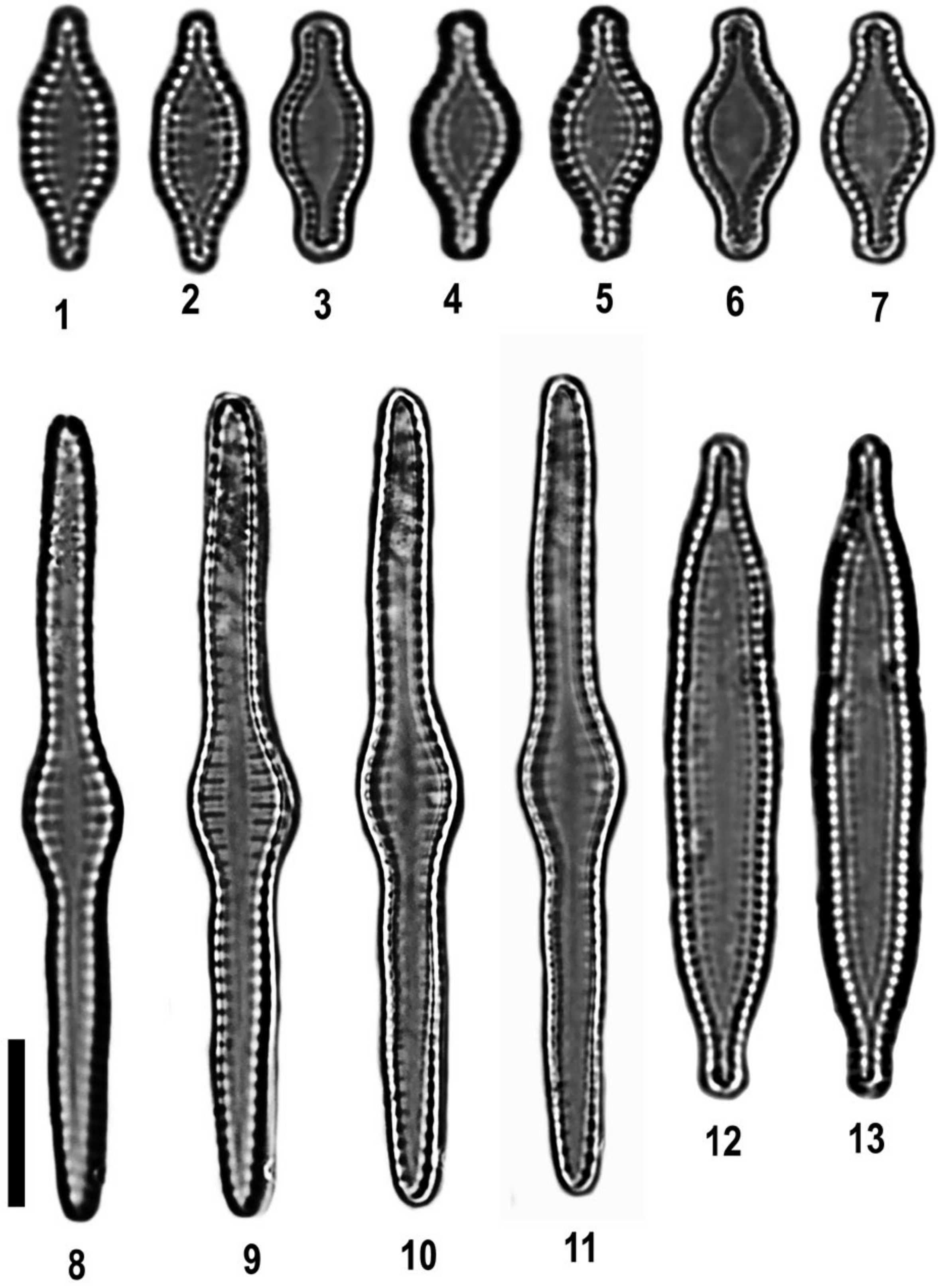

Plate 53. 1-3. *Pseudostaurosira brevistriata* var. *papillosa* (A. Cleve) Zimmerman, Poulin & Pierritz 2010, 1-2. Radomno Lake, 3. Kamionka Lake; 4-7. *Pseudostaurosira brevistriata* var. *turgida* (Pantocsek) Haworth & Kelly 2002, Kamionka Lake; 8-11. *Pseudostaurosira brevistriata* var. *vidarbhensis* (Sarode & Kamat) Zalat & Pidek comb. nov., Eemian deposits; 12-13. *Pseudostaurosira brevistriata* var. *trigibba* (Pantocsek) Haworth & Kelly 2002, Młynek Lake. Scale bar 10 µm.

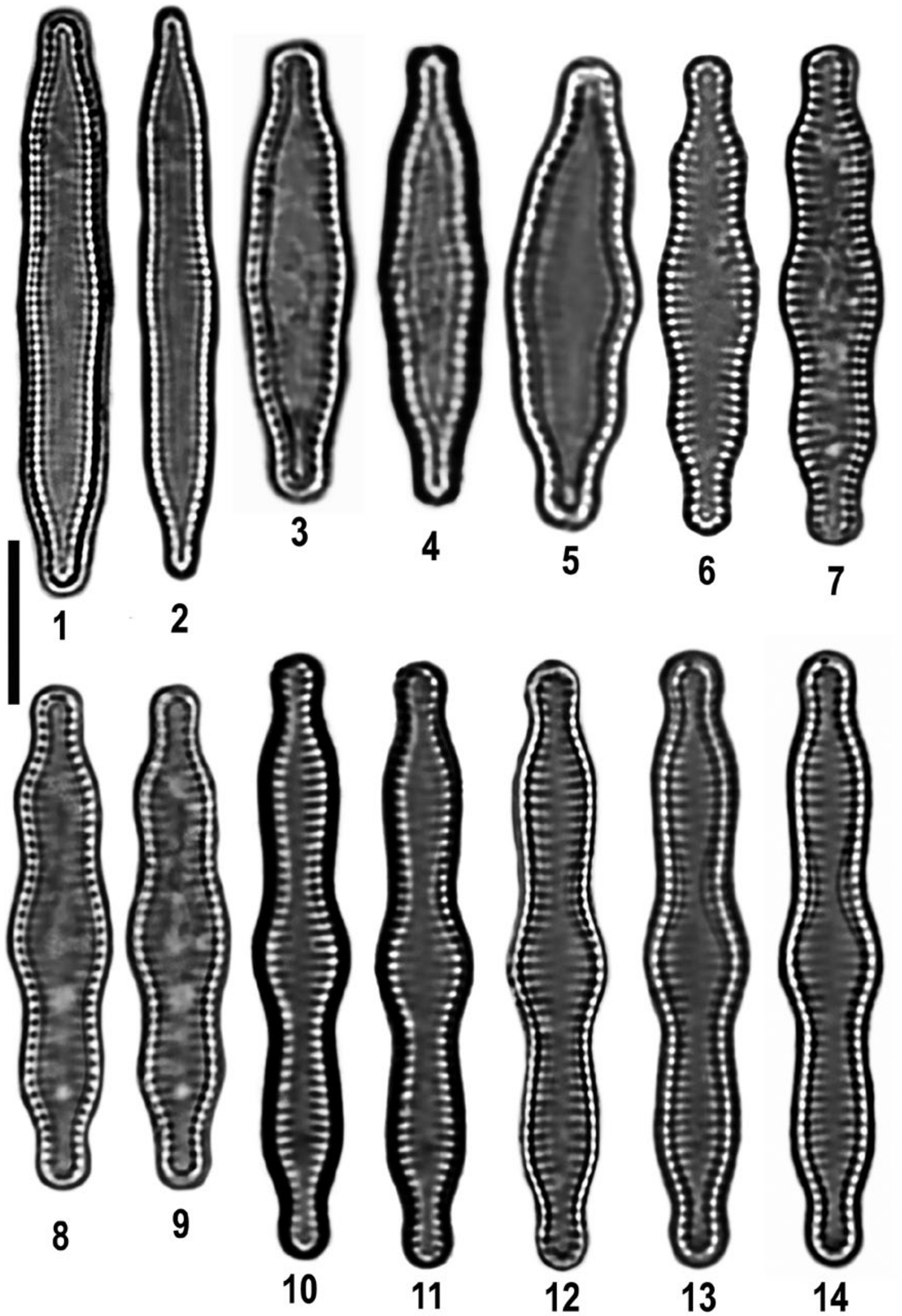

Plate 54. 1-14. *Pseudostaurosira brevistriata* var. *trigibba* (Pantocsek) Haworth & Kelly 2002, 1-4. Kamionka Lake, 5-14. Eemian deposits. Scale bar 10 µm.

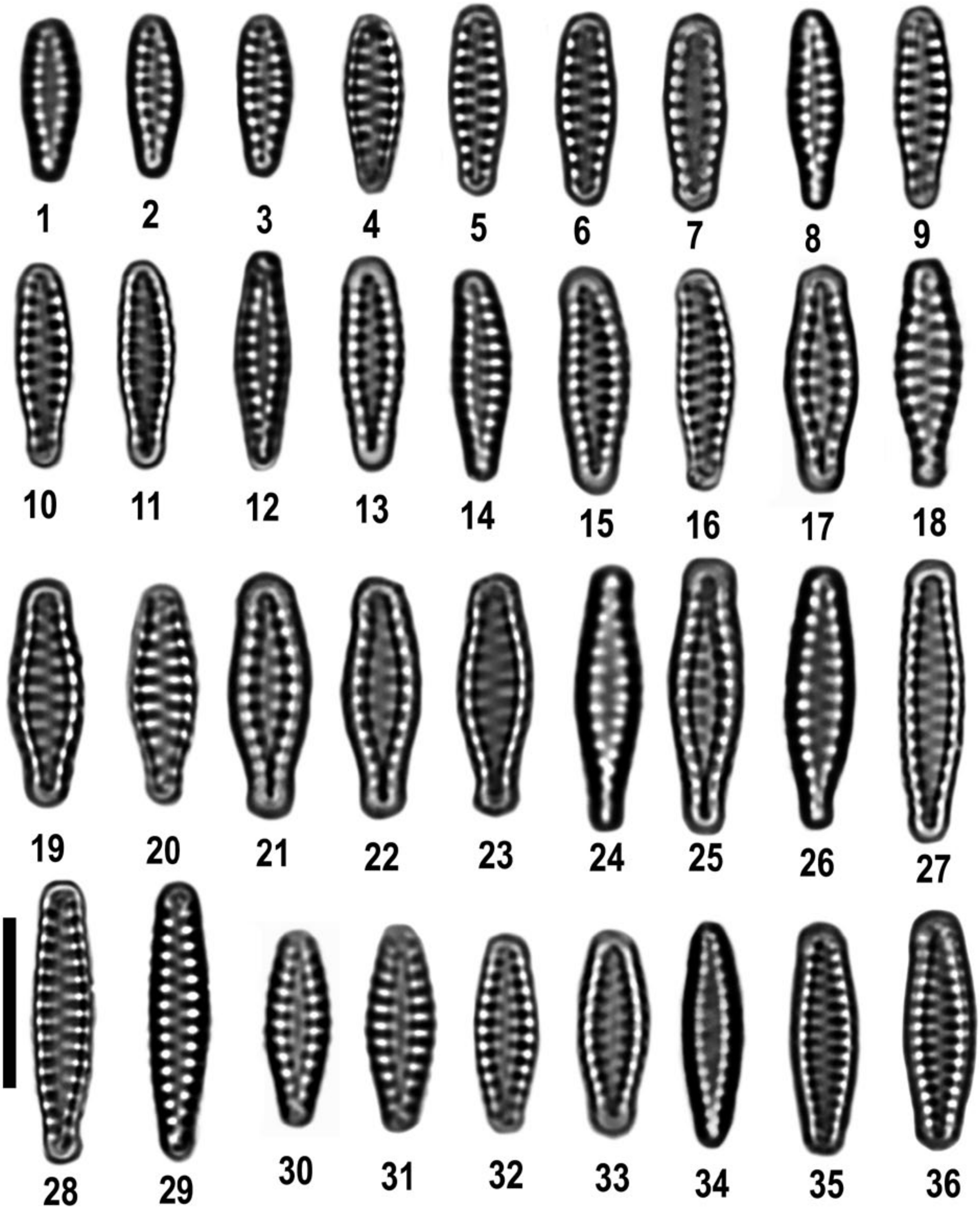

Plate 55. 1-36. *Pseudostaurosira clavatum* Morales 2002**,** 1-29. Jeziorak Lake; 30-33. Radomno Lake; 34-36. Eemian deposits. Scale bar 10 µm.

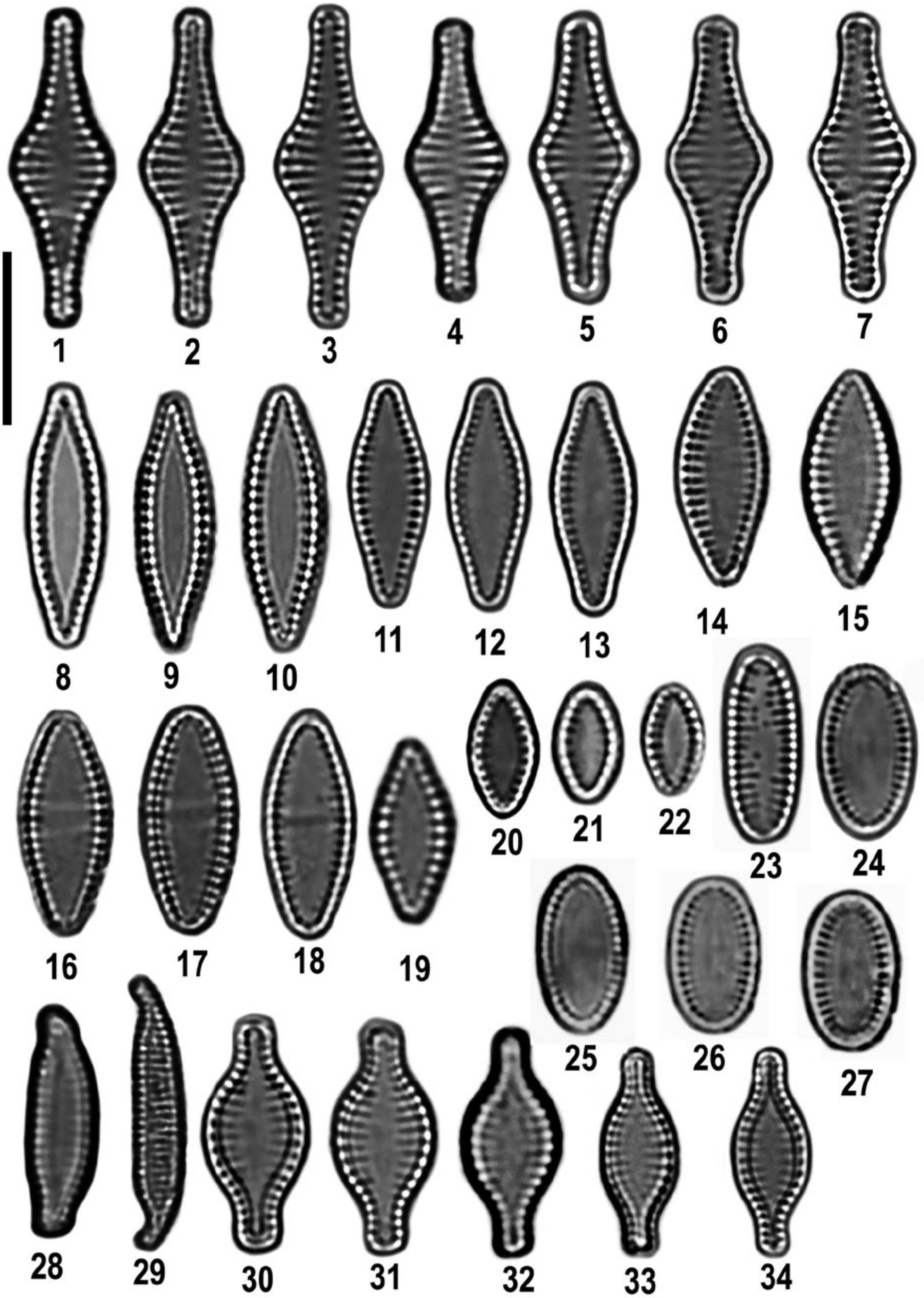

Plate 56. 1-7. *Pseudostaurosira decipiens* Morales, Chávez & Ector 2012, 1-4. Eemian deposits; 5-7. Radomno Lake; 8-27. *Pseudostaurosira elliptica* (Schumann) Edlund, Morales & Spaulding 2006, 8-12. Radomno Lake, 13-27. Eemian deposits; 28-29. *Pseudostaurosira floweri* Morales 2017, Kamionka Lake; 30-34. *Pseudostaurosira laucensis* (Lange-Bertalot & Rumrich) Morales & Vis 2007, 30-32. Radomno Lake, 33-34. Kamionka Lake. Scale bar 10 µm.

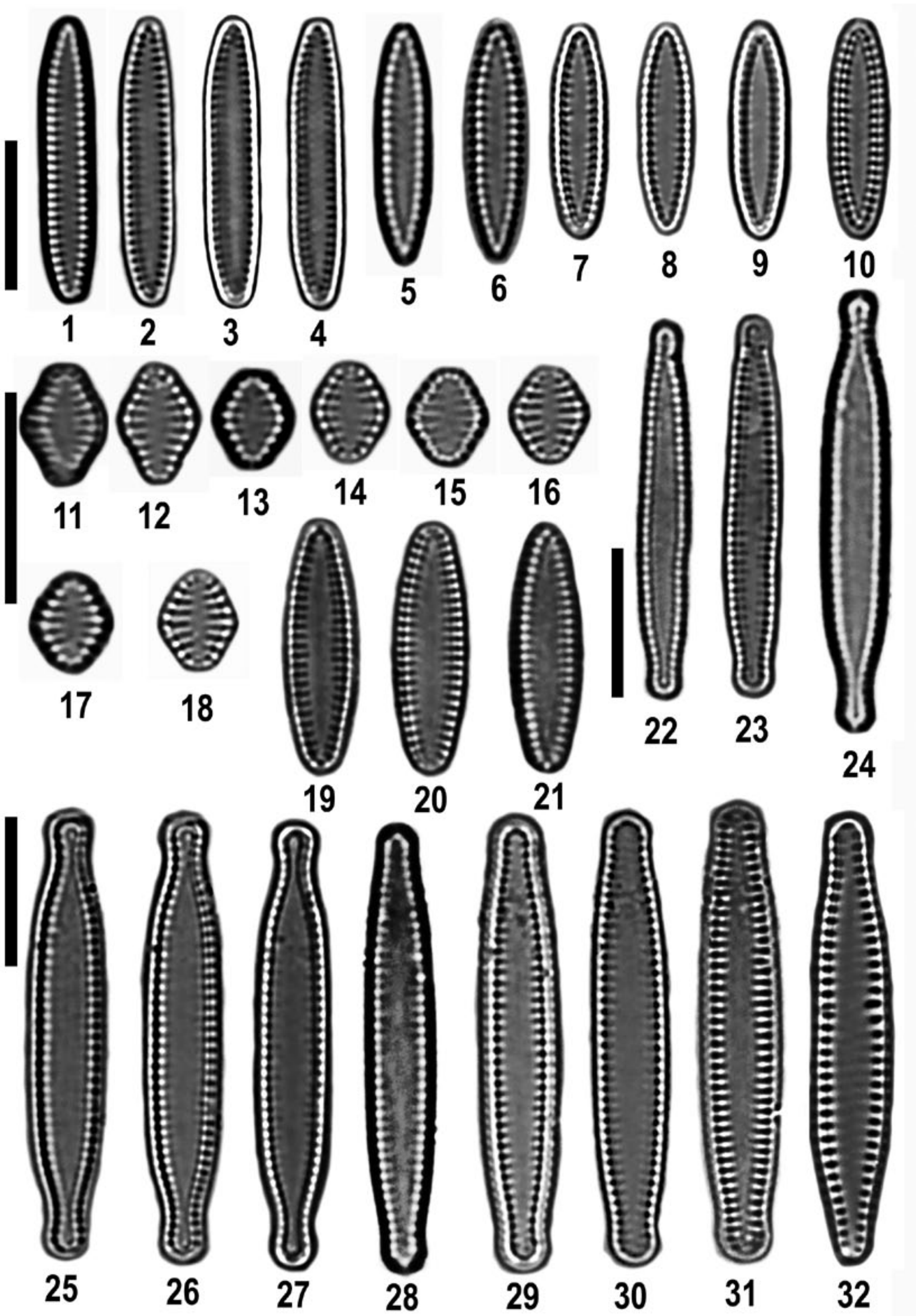

Plate 57. 1-10. *Pseudostaurosira linearis* (Pantocsek) Morales, Buczkó & Ector, 2019, Eemian deposits; 11-18. *Pseudostaurosira marciniakae* Ector, Morales, Wetzel 2019, 11-14. Kamionka Lake; 15-18. Eemian deposits; 19-21. *Pseudostaurosira neoelliptica* (Witkowski) Morales 2002, Eemian deposits; 22-32. *Pseudostaurosira oliveraiana* Grana, Morales, Maidana & Ector, 2018, 22-23. Eemian deposits; 24-27. Młynek Lake, 28-32. Radomno Lake. Scale bar 10 μm.

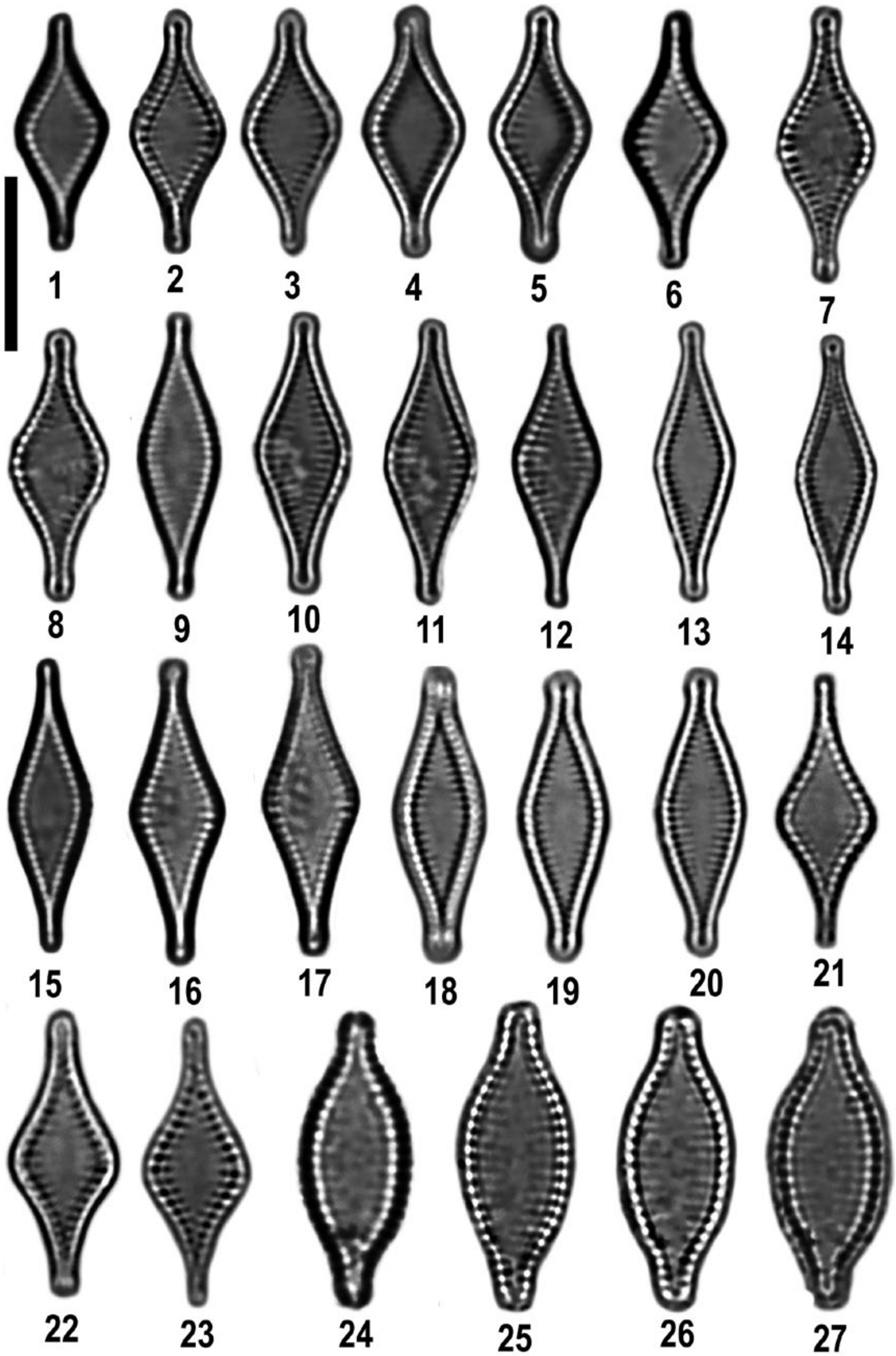

Plate 58. 1-27. *Pseudostaurosira parasitica* (W. Smith) Morales in Morales & Edlund 2003, 1-14. Eemian deposits; 15-21. Radomno Lake; 21-27. Młynek Lake. Scale bar 10 µm.

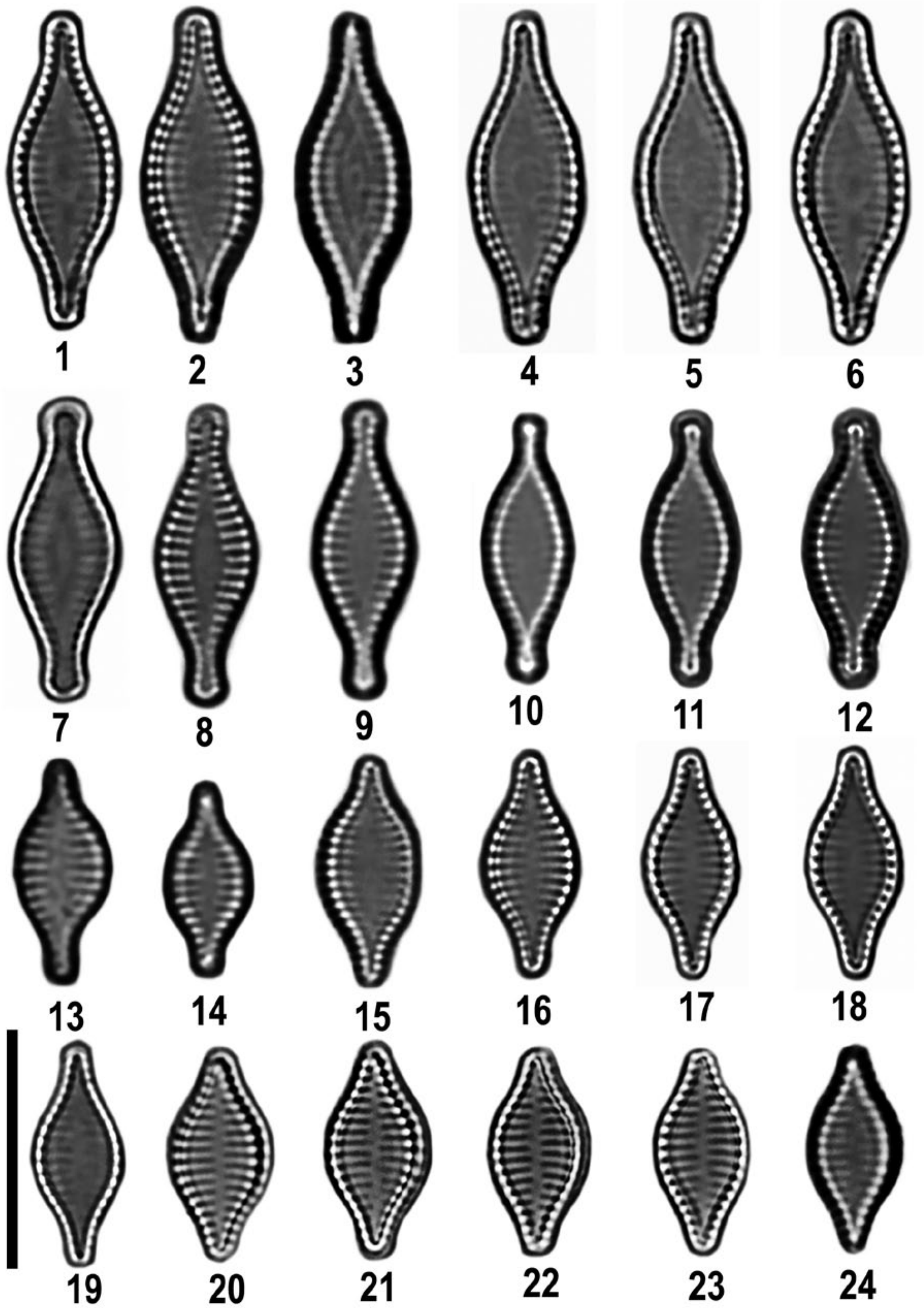

Plate 59. 1-24. *Pseudostaurosira parasitoides* (Lange-Bertalot, Schmidt & Klee) Morales, García & Maidana 2017, 1-9. Eemian deposits, 10-14. Kamionka Lake, 15-19. Młynek Lake, 20-24. Eemian deposits. Scale bar 10 µm.

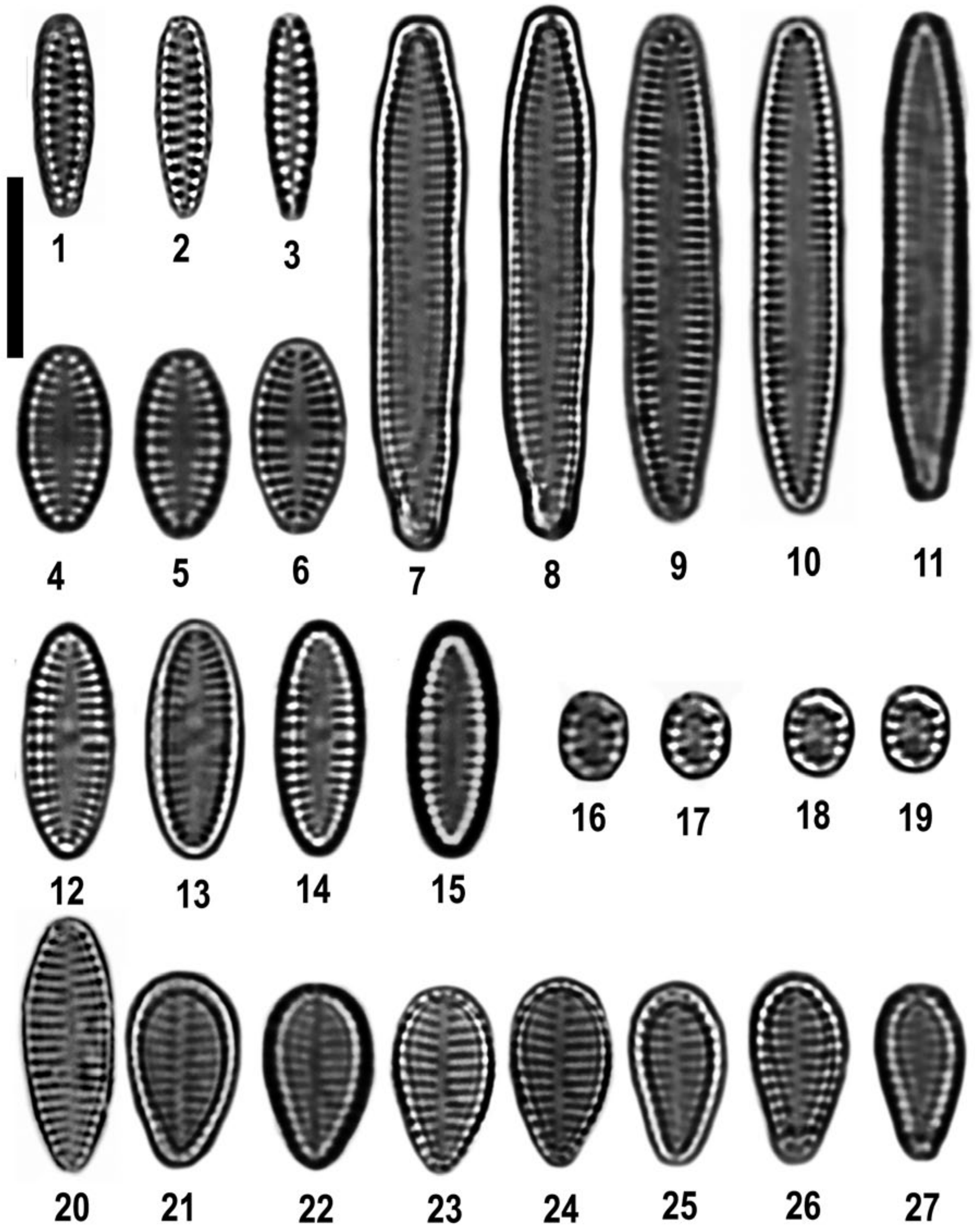

Plate 60. 1-3. *Pseudostaurosira perminuta* (Grunow) Sabbe & Wyverman 1995, Młynek Lake; 4-15. *Pseudostaurosira polonica* (Witak & Lange-Bertalot) Morales & Edlund 2003, 4-8. Eemian deposits; 9-11. Kamionka Lake; 12-15. Jeziorak Lake; 16-19. *Pseudostaurosira sajamaensis* Morales & Ector in Morales et al. 2012, Młynek Lake; 20-27. *Pseudostaurosira quasielliptica* Witkowski, Riaux-Gobin, Daniszewska-Kowalczyk 2010. 20. Radomno Lake, 21-27. Kamionka Lake. Scale bar 10 µm.

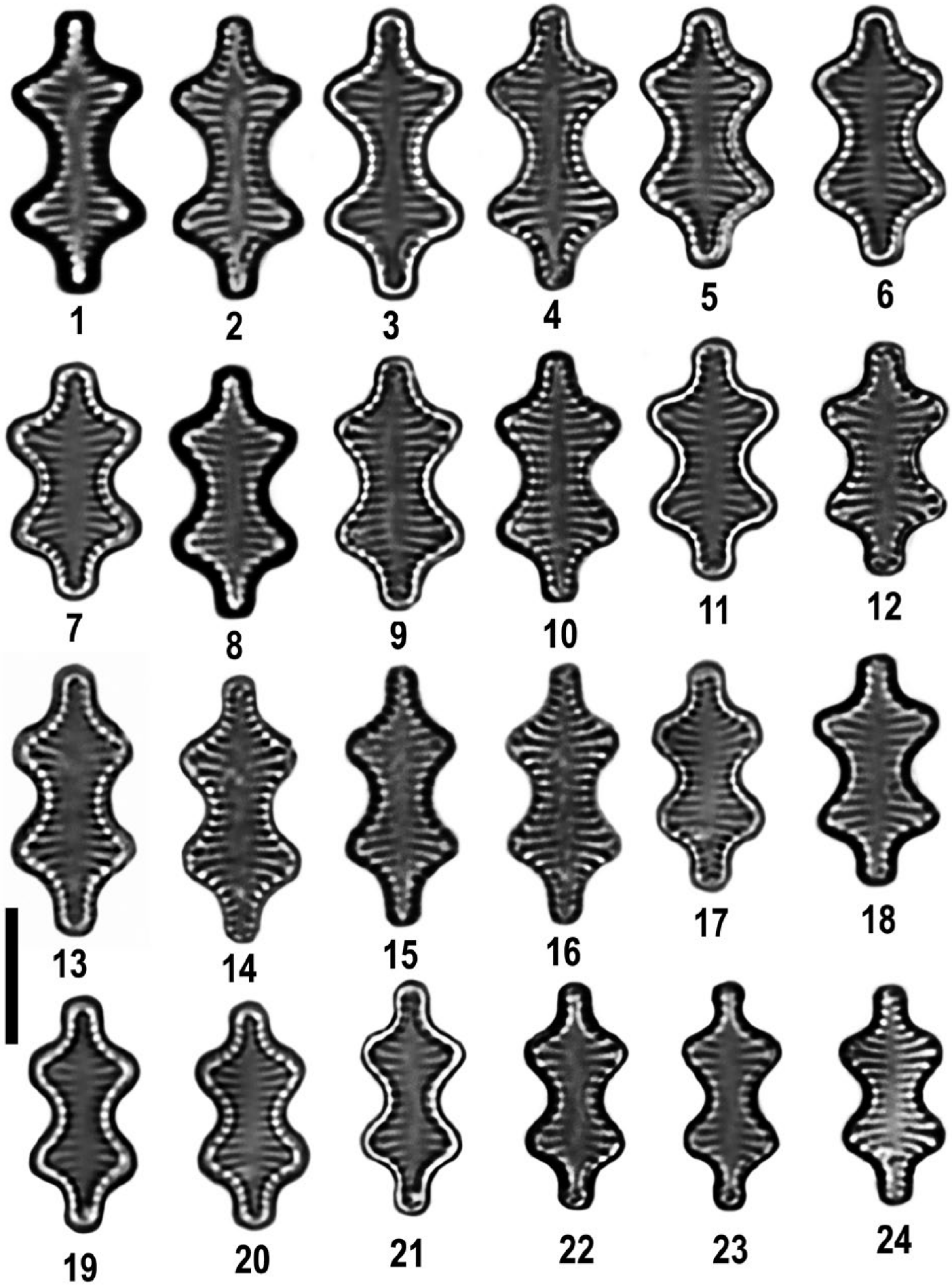

Plate 61. 1-24. *Pseudostaurosira robusta* (Fusey) Williams & Round 1987, Eemian deposits. Scale bar 10 µm.

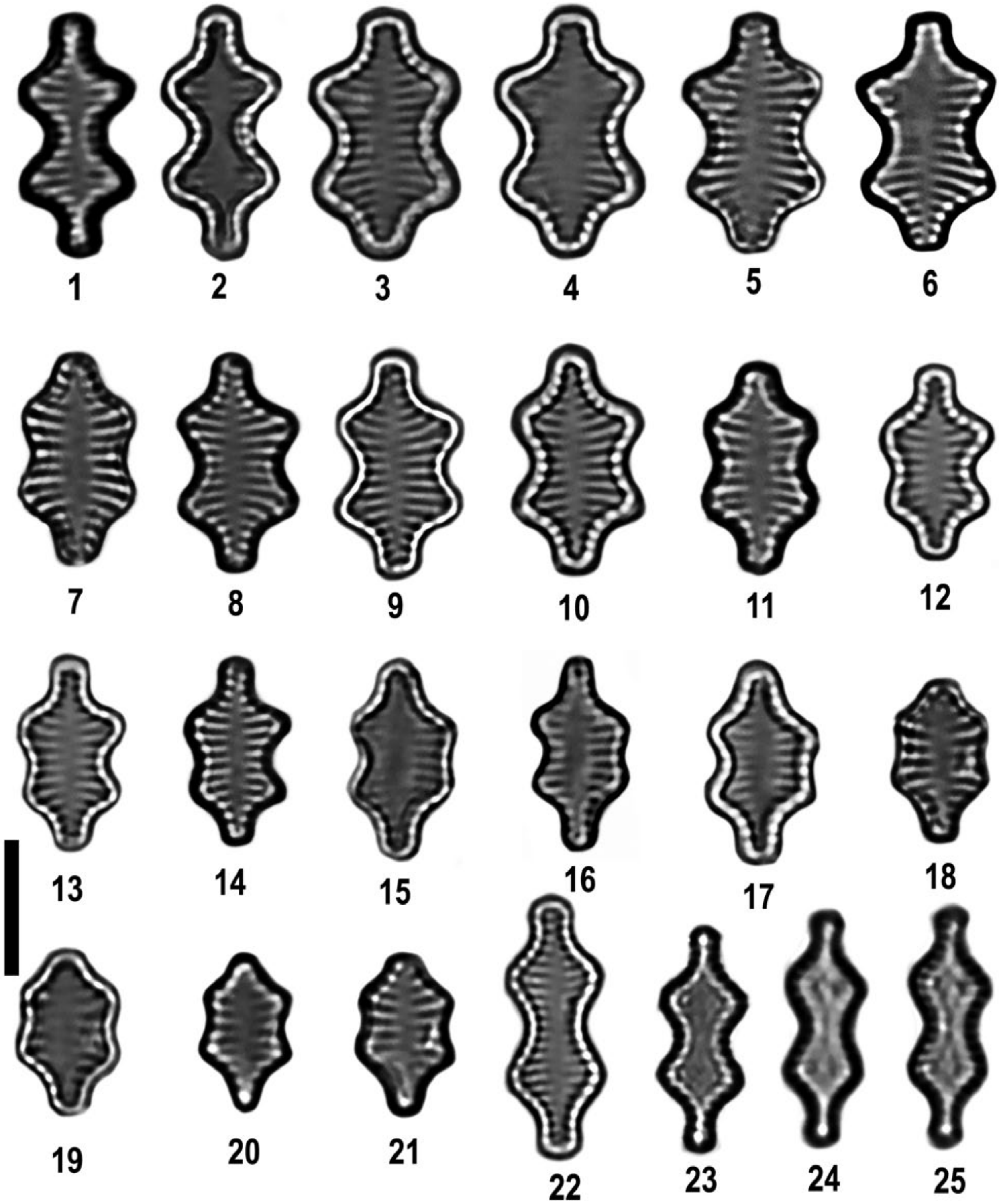

Plate 62. 1-25. *Pseudostaurosira robusta* (Fusey) Williams & Round 1987, 1-22. Eemian deposits, 23-25. Kamionka Lake. Scale bar 10 μm.

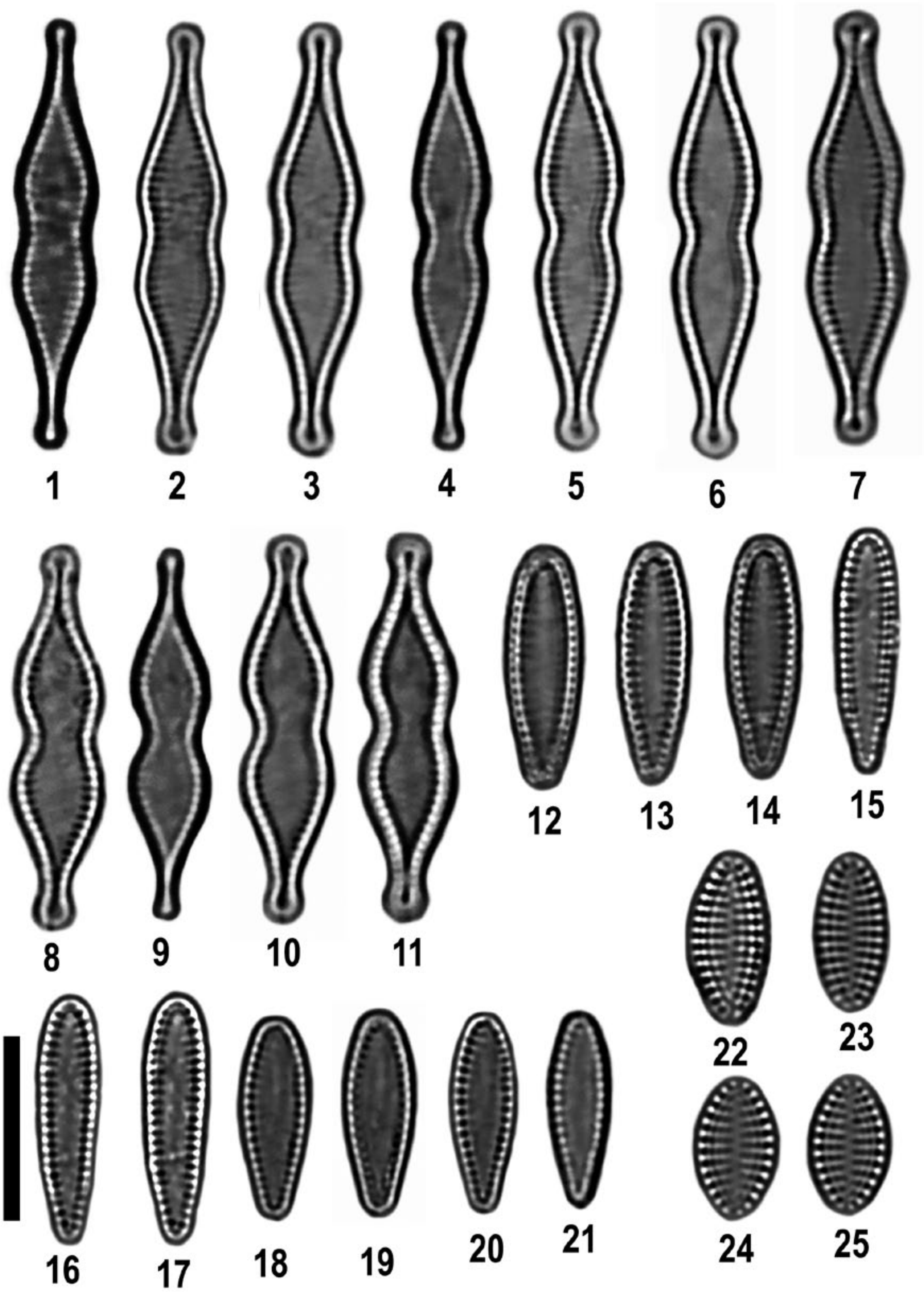

Plate 63. 1-11. *Pseudostaurosira subconstricta* (Grunow) Kulikovskiy & Genkal 2011, Młynek Lake; 12-21. *Pseudostaurosira versiformae* Witkowski, Riaux-Gobin & Daniszewska-Kowalczyk 2010, Eemian deposits; 22-25. *Stauroforma reimeri* (Morales, Manoylov & Bahls) Morales in Garcia et al. 2017, 22-23. Kamionka Lake, 24-25. Radomno Lake. Scale bar 10 µm.

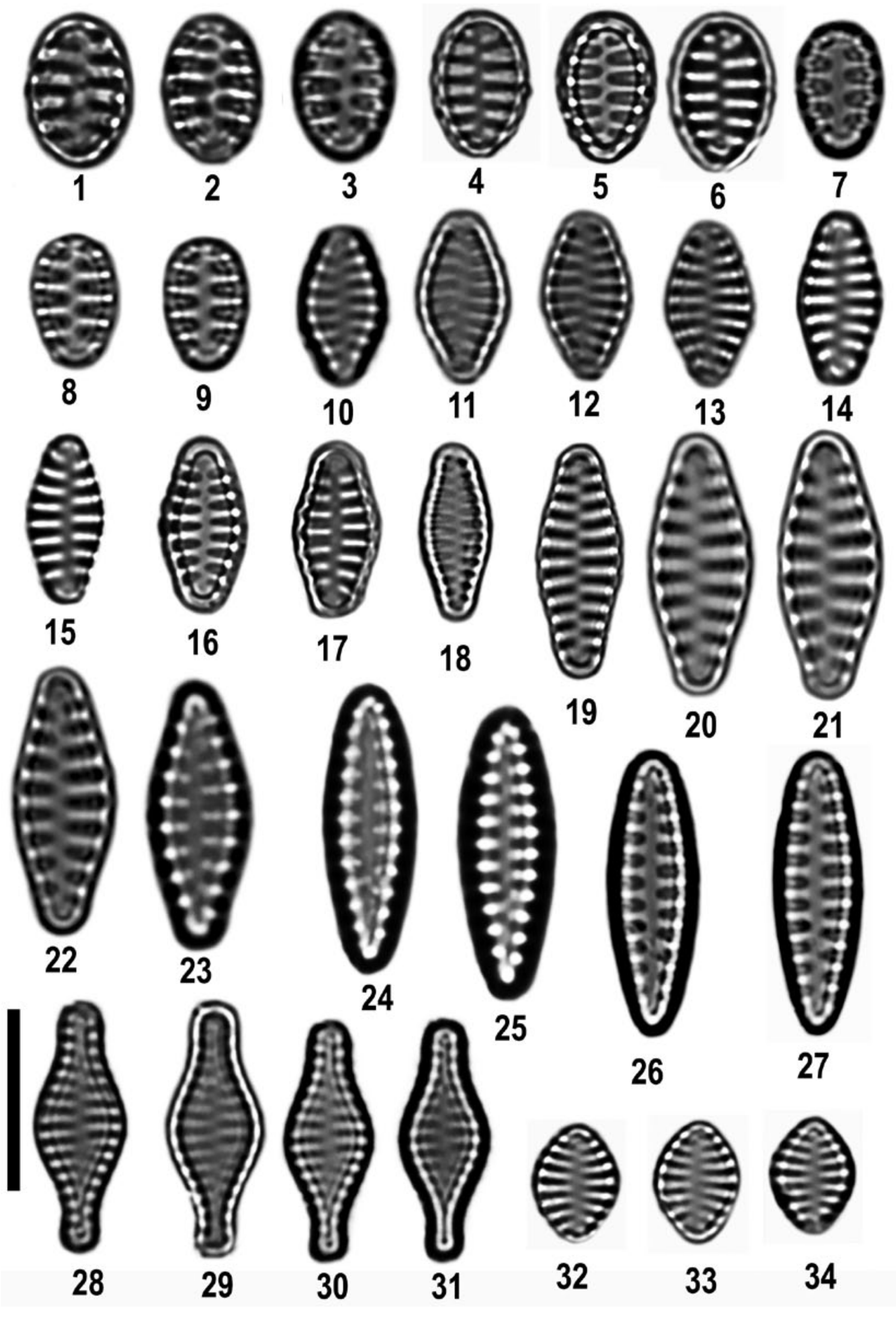

Plate 64. 1-9. *Punctustriutu glubokoensis* Williams, Chudaev & Gololobova 2009, 1-6. Kamionka Lake; 7-9. Radomno Lake; 10-23. *Punctastriata lancettula* (Schumann) Hamilton & Siver 2008, 10-19. Kamionka Lake; 20-23. Jeziorak Lake; 24-27. *Punctastriata linearis* Williams & Round 1988, Radomno Lake; 28-34. *Punctastriata mimetica* Morales 2005**,** Kamionka Lake. Scale bar 10 µm.

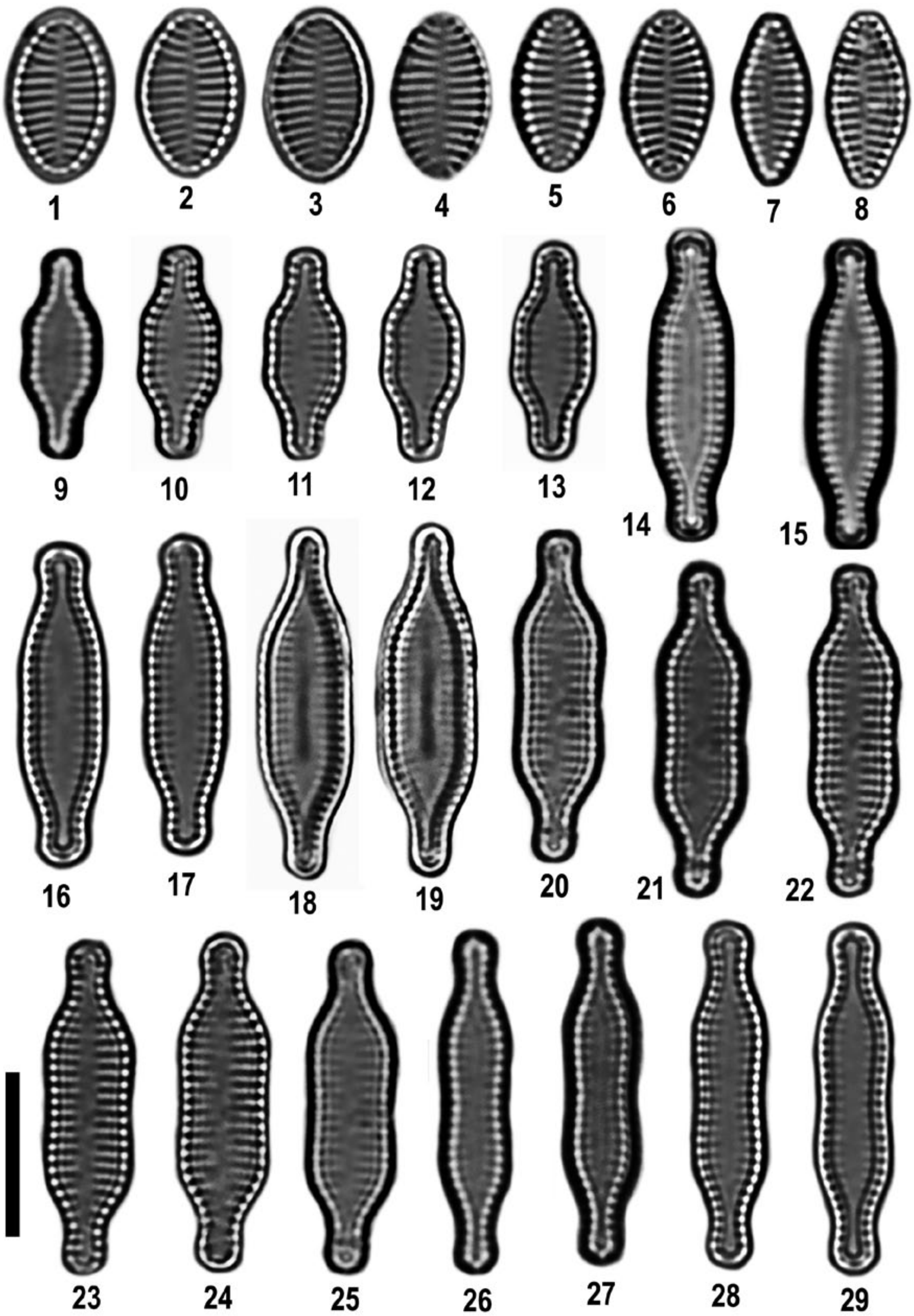

Plate 65. 1-8. *Staurosira aventralis* Lange-Bertalot & Rumrich, 2000**,** Eemian deposits; 9-29. *Staurosira binodis* (Ehrenberg) Lange-Bertalot in Hofmann et al., 2011, 9-13. Kamionka Lake; 14-17. Młynek Lake, 18-19. Eemian deposits, 20-29. Kamionka Lake. Scale bar 10 µm.

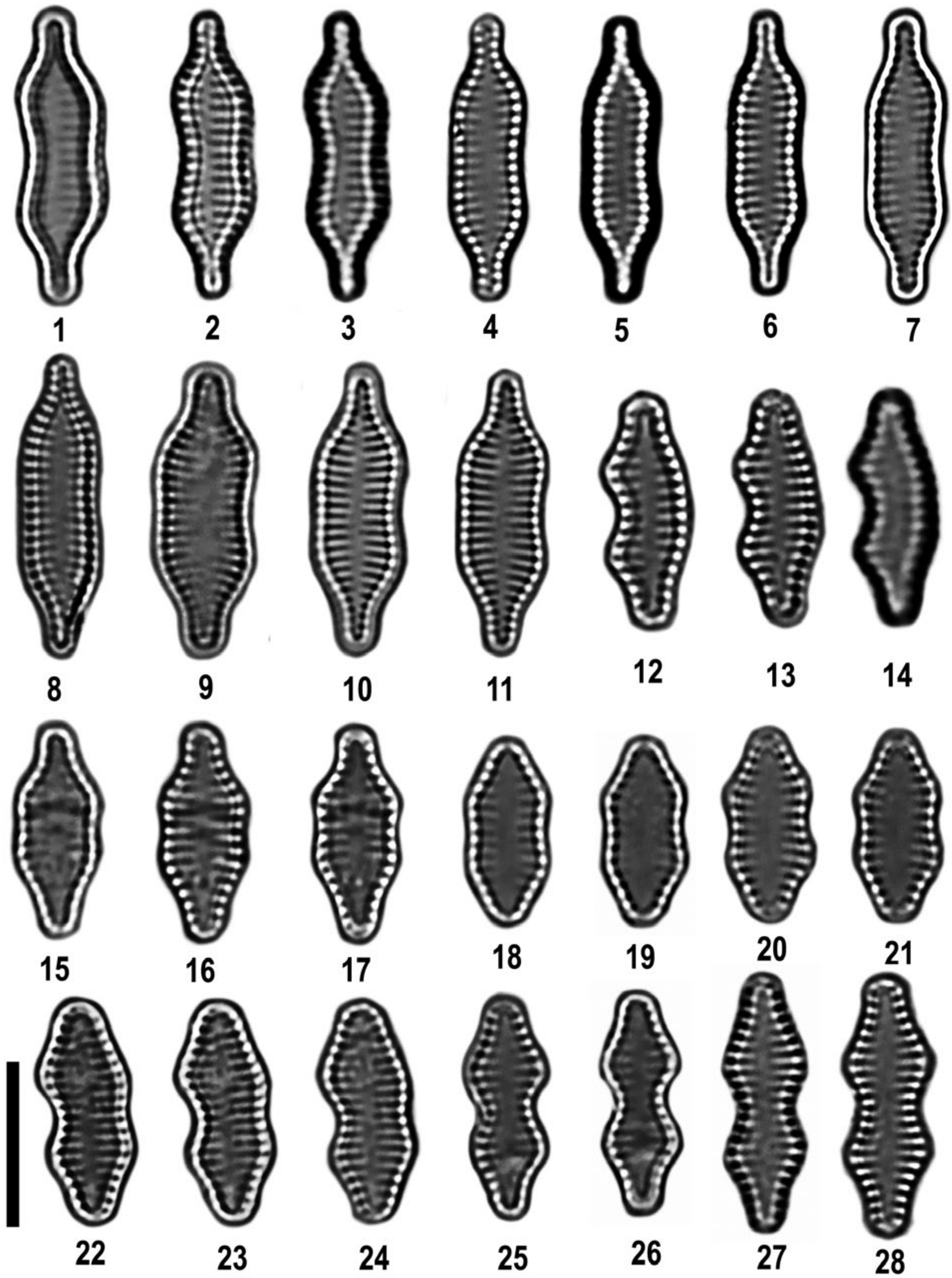

Plate 66. 1-28. *Staurosira binodis* (Ehrenberg) Lange-Bertalot in Hofmann et al., 2011; Eemian deposits. Scale bar 10 µm.

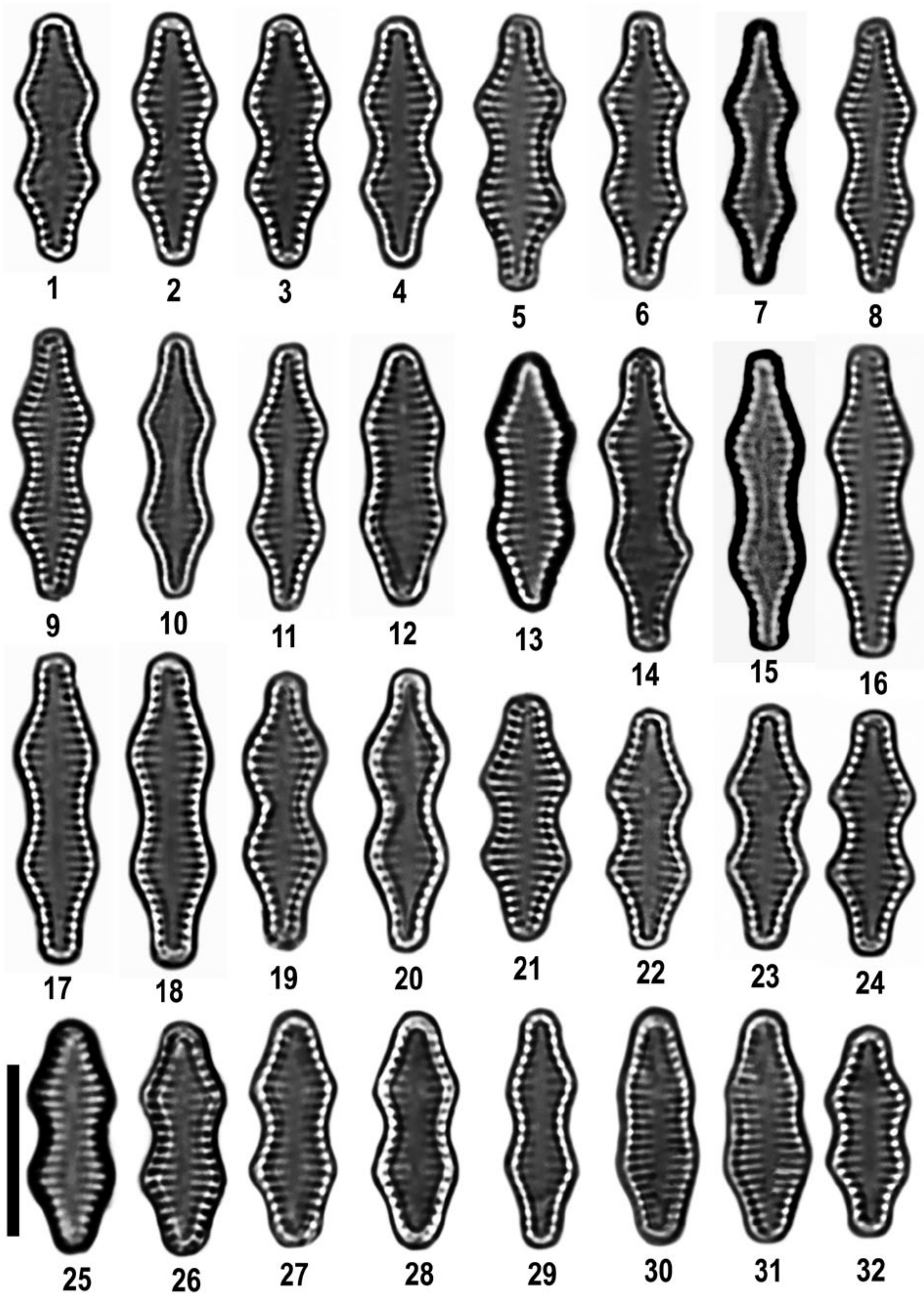

Plate 67. 1-32. *Staurosira binodis* (Ehrenberg) Lange-Bertalot in Hofmann et al., 2011; Eemian deposits. Scale bar 10 µm.

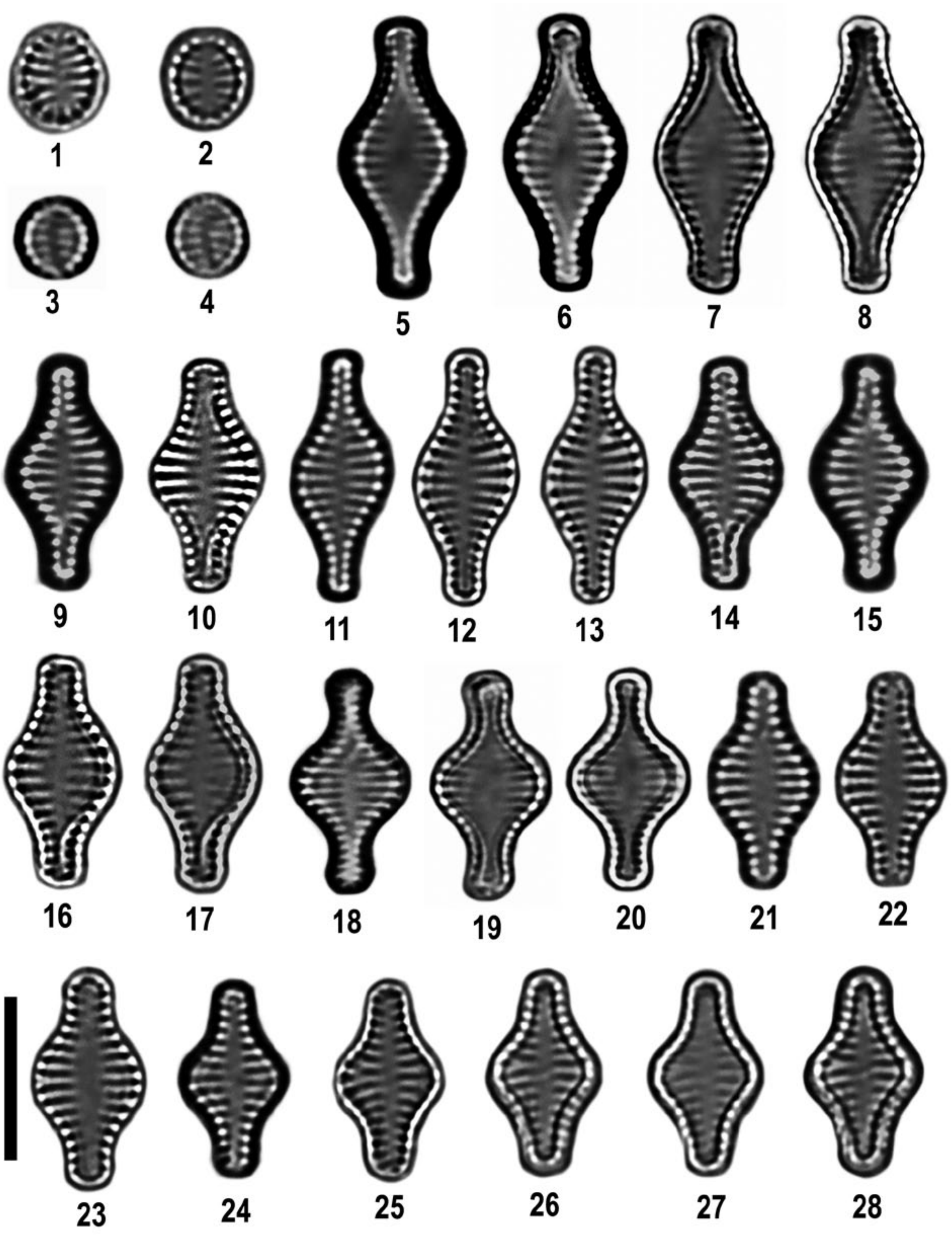

Plate 68**.** 1-4. *Staurosira circula* Van de Vijver & Beyens 2002, Radomno Lake; 5-28. *Staurosira construens* Ehrenberg 1843**,** Eemian deposits. Scale bar 10 µm.

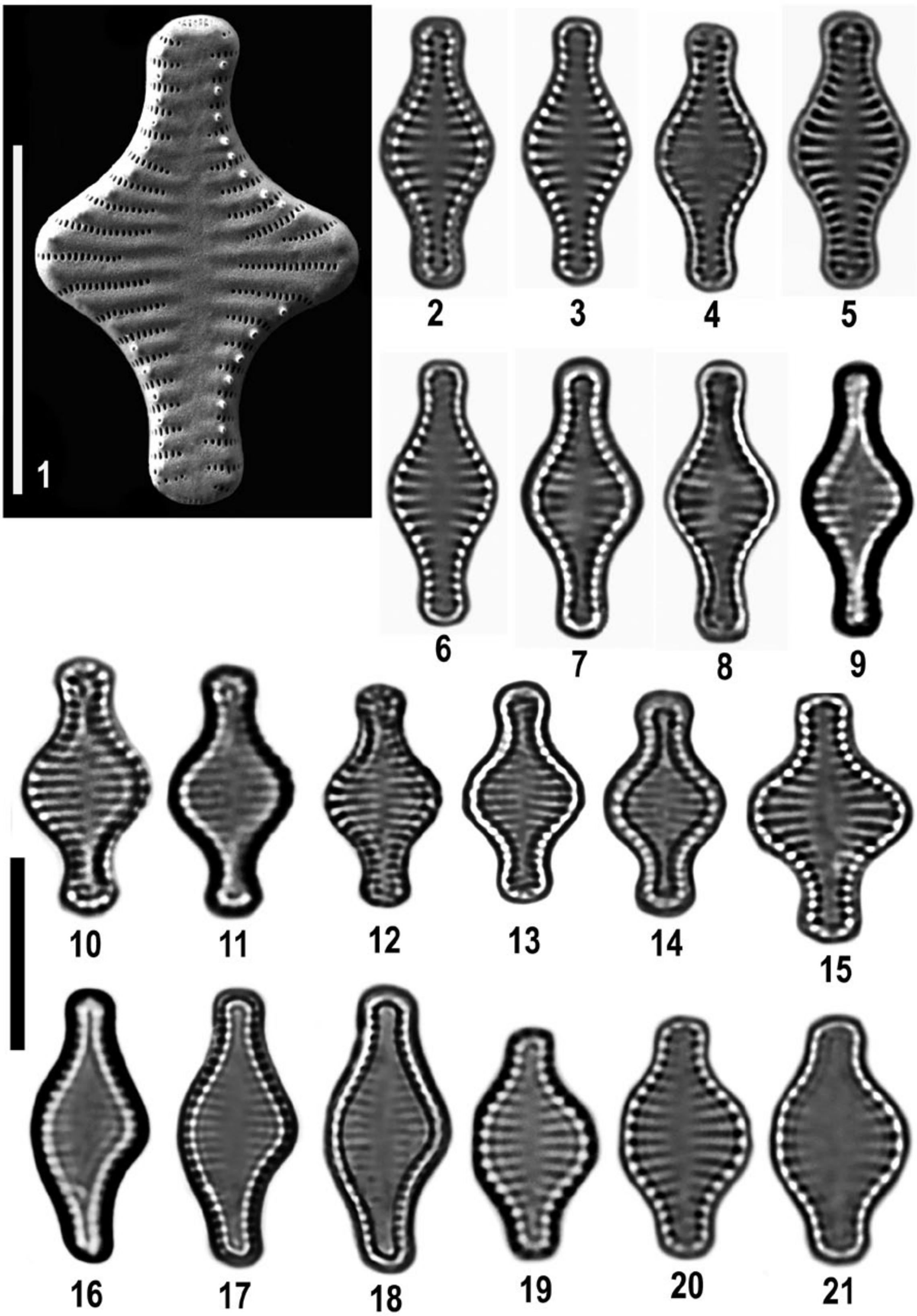

Plate 69. 1-21. *Staurosira construens* Ehrenberg 1843, 1. SEM micrograph of external valve view, Kamionka Lake; 2-9. Eemian deposits; 10-12. Jeziorak Lake; 13-21. Kamionka Lake. Scale bar 10 µm.

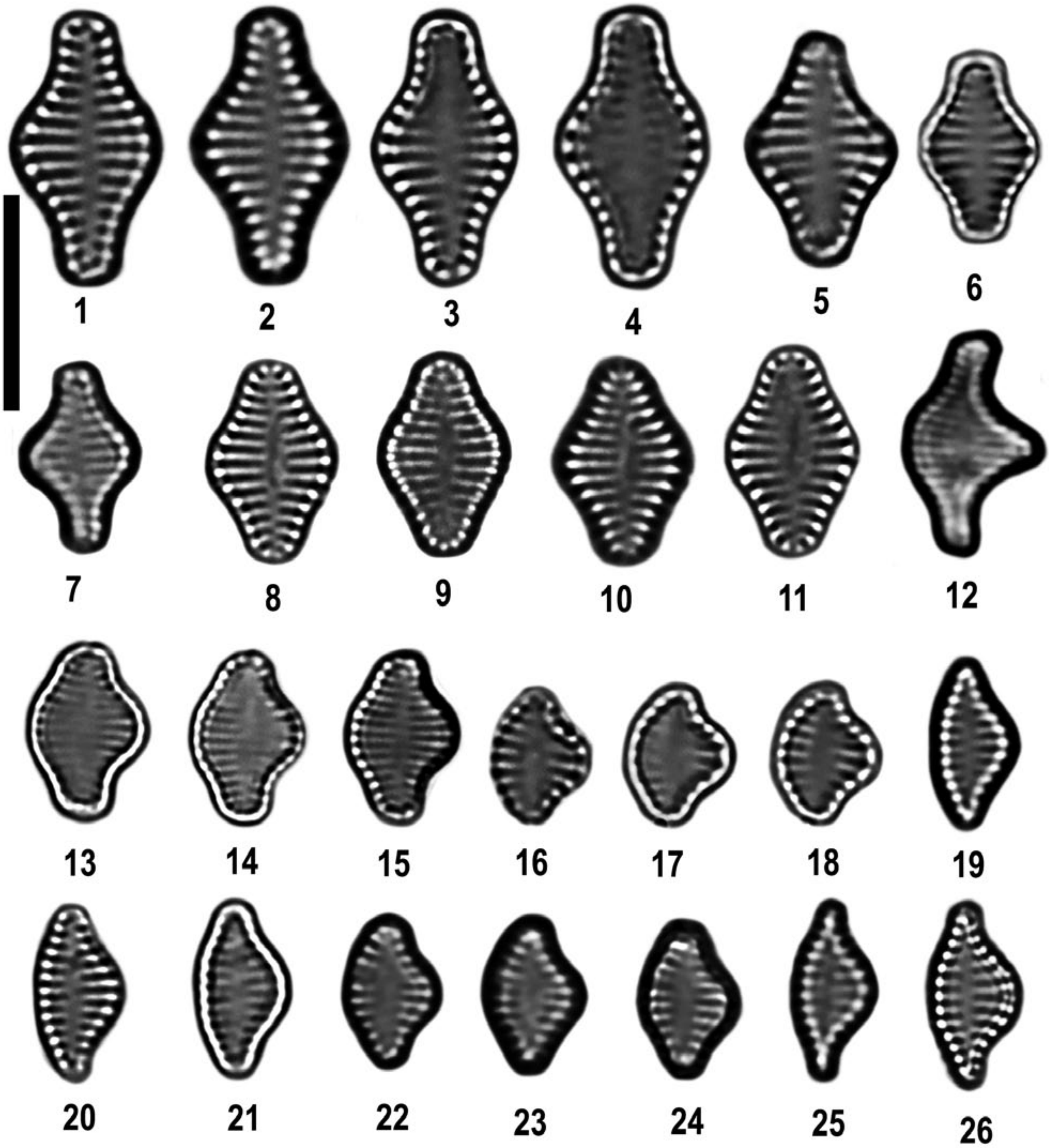

Plate 70**.** 1-11. *Staurosira construens* Ehrenberg 1843, Eemian deposits; 12-26. *Staurosira construens var. asymmetrica (A. Cleve)* Zalat & Welc *comb. nov., 12-19.* Eemian deposits; 20-22. Młynek Lake, 23-26. Kamionka Lake. Scale bar 10 µm.

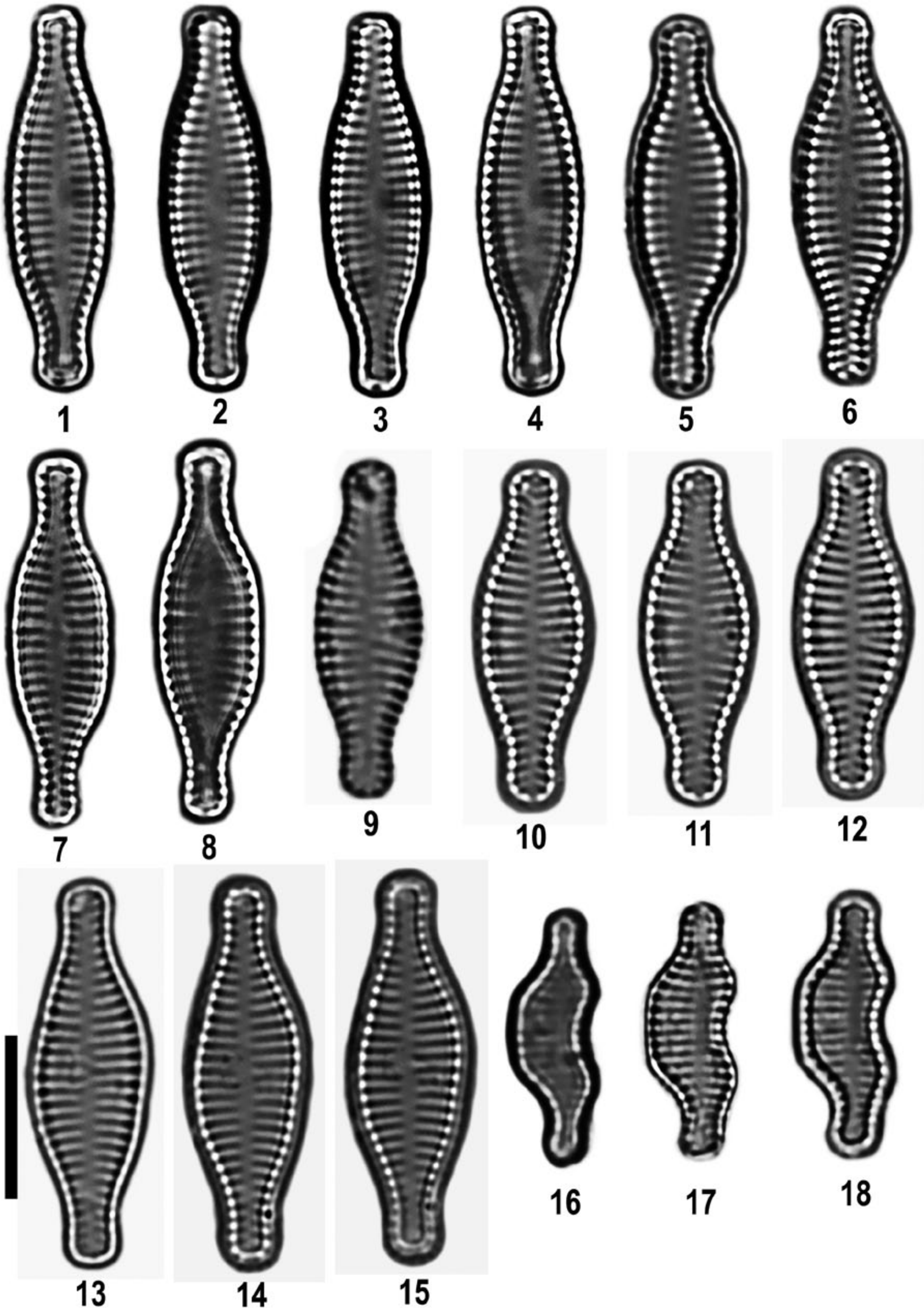

Plate 71. 1-15. *Staurosira construens var*. *baltalensis (*Gandhi, Vora & Mohan*)* Zalat & Nitychoruk *comb. nov.* Eemian deposits; *16-18. Staurosira construens* var. *nipponica* (Skvortsov) Zalat & Welc comb. nov. Kamionka Lake. Scale bar 10 µm.

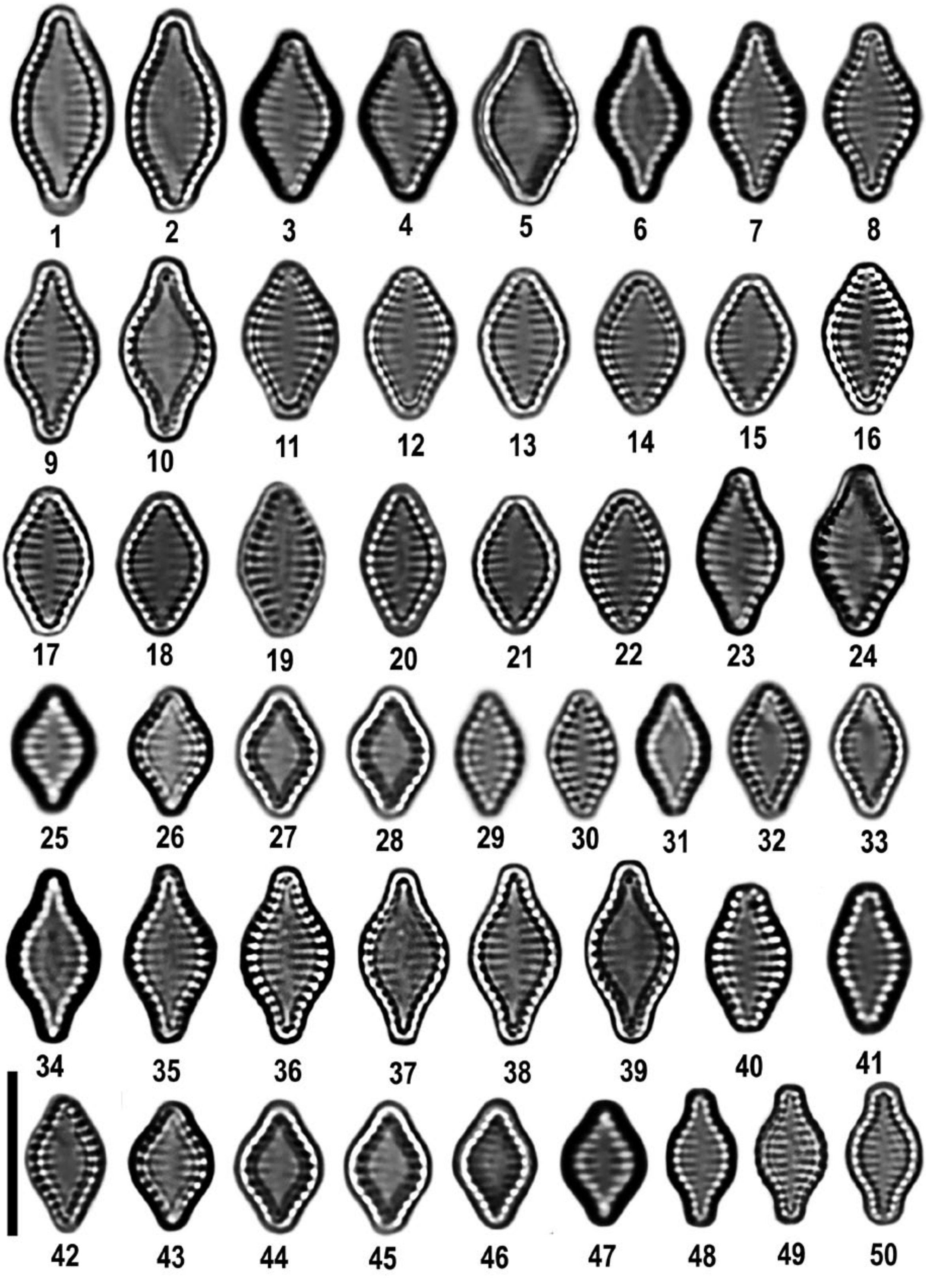

Plate 72. 1-50. *Staurosira construens* var. *pumila* (Ehrenberg) Cleve & Möller 1879. 1-22. Eemian deposits, central Poland; 6-10. Jeziorak Lake; 23-33. Młynek Lake; 34-50. Kamionka Lake. Scale bar 10 µm.

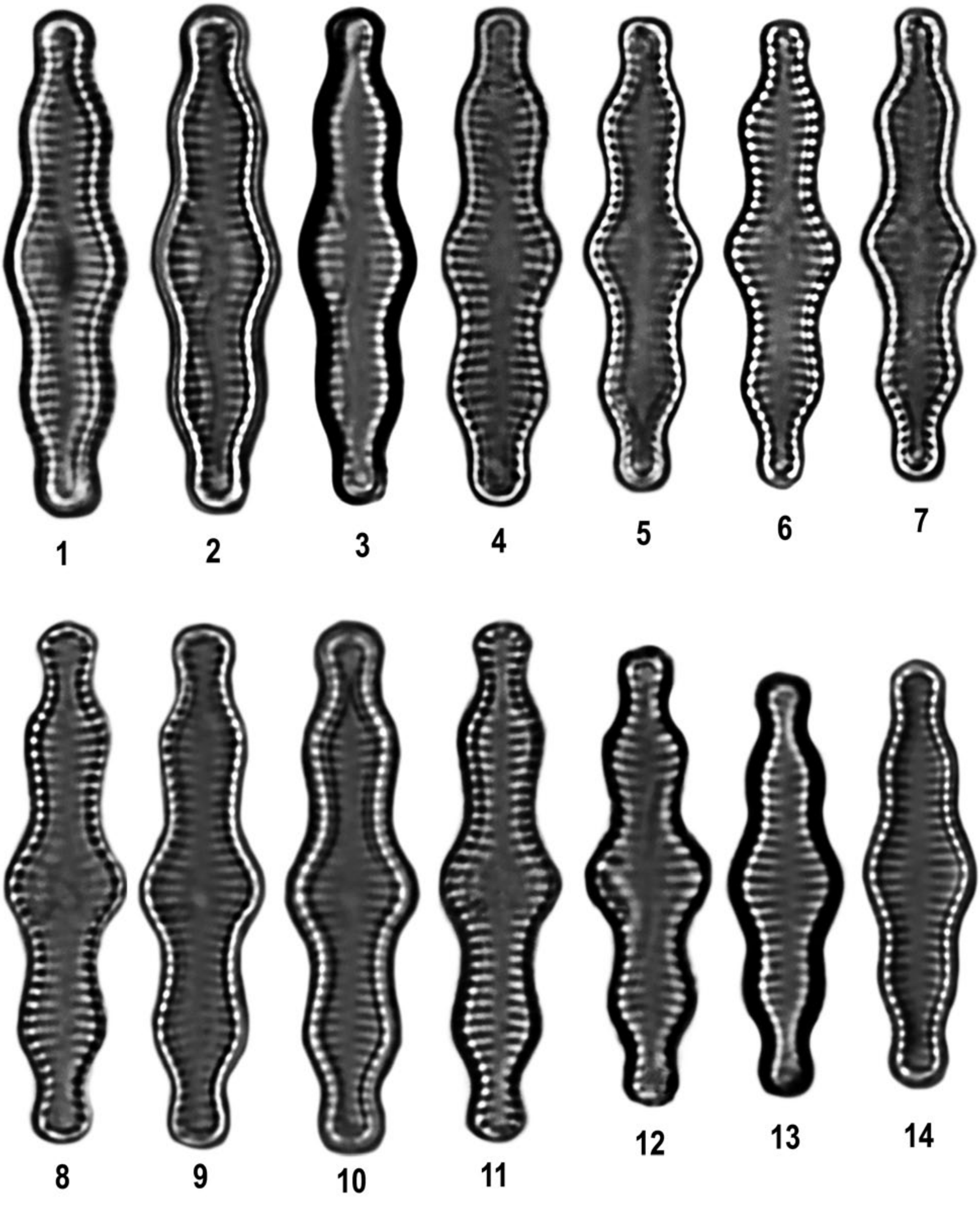

Plate 73. 1-14. *Staurosira construens* var. *triundulata* (Reichelt) Bukhtiyarova 1995, Eemian deposits. Scale bar 10 µm.

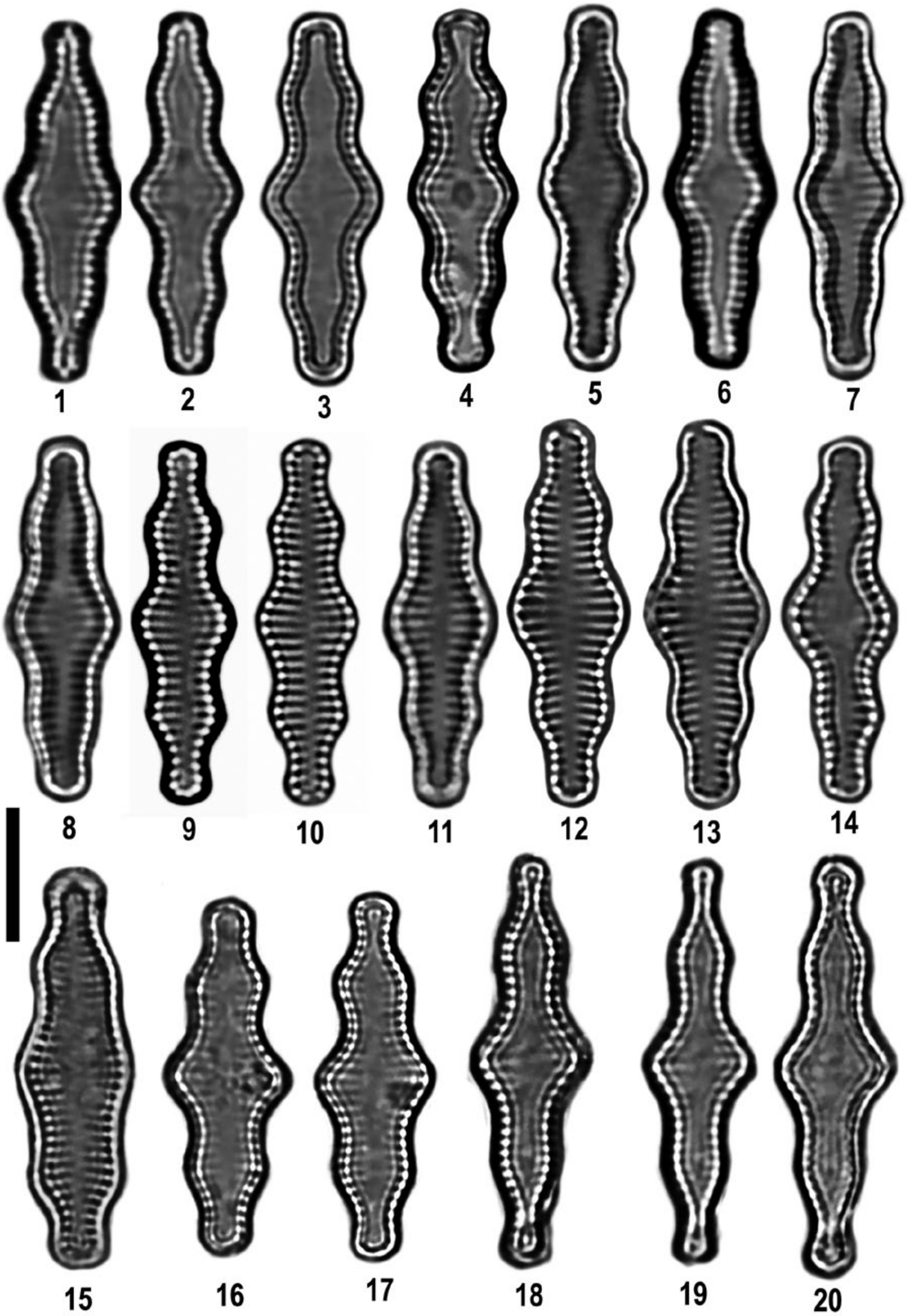

Plate 74. 1-20. *Staurosira construens* var. *triundulata* (Reichelt) Bukhtiyarova 1995, 1-13. Eemian deposits, 14-15. Młynek Lake, 16-20. Kamionka Lake. Scale bar 10 µm.

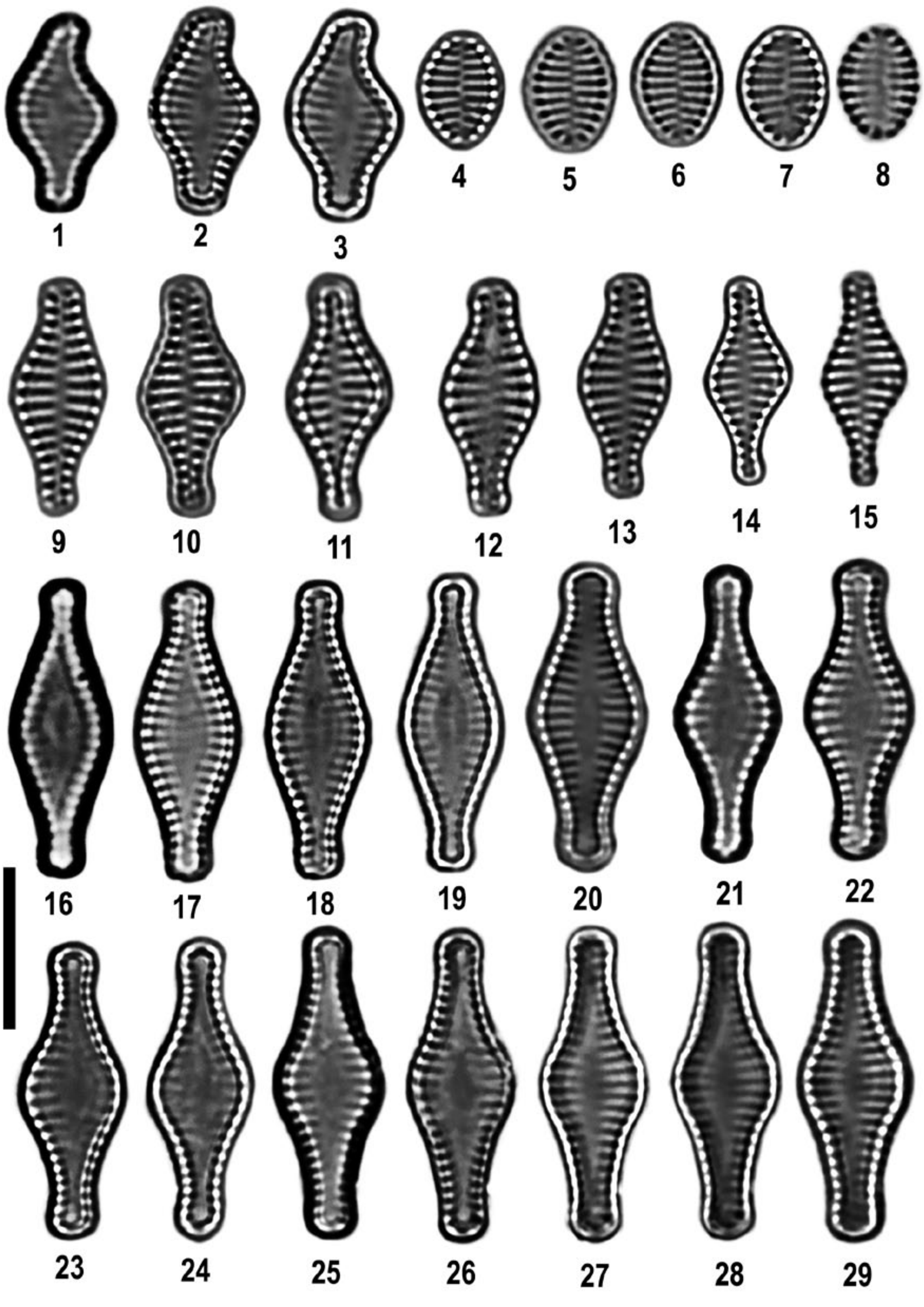

Plate 75. 1-3. *Staurosira* aff. *contorta* Flower 2005, Kamionka Lake; 4-8. *Staurosira dimorpha* Morales, Edlund & Spaulding 2010, Kamionka Lake; 9-15. *Staurosira incerta* Morales 2006, Kamionka Lake; 16-29. *Staurosira inflata* (Heiden) Rusanov, Ács, Morales & Ector 2018, Eemian deposits. Scale bar 10 µm.

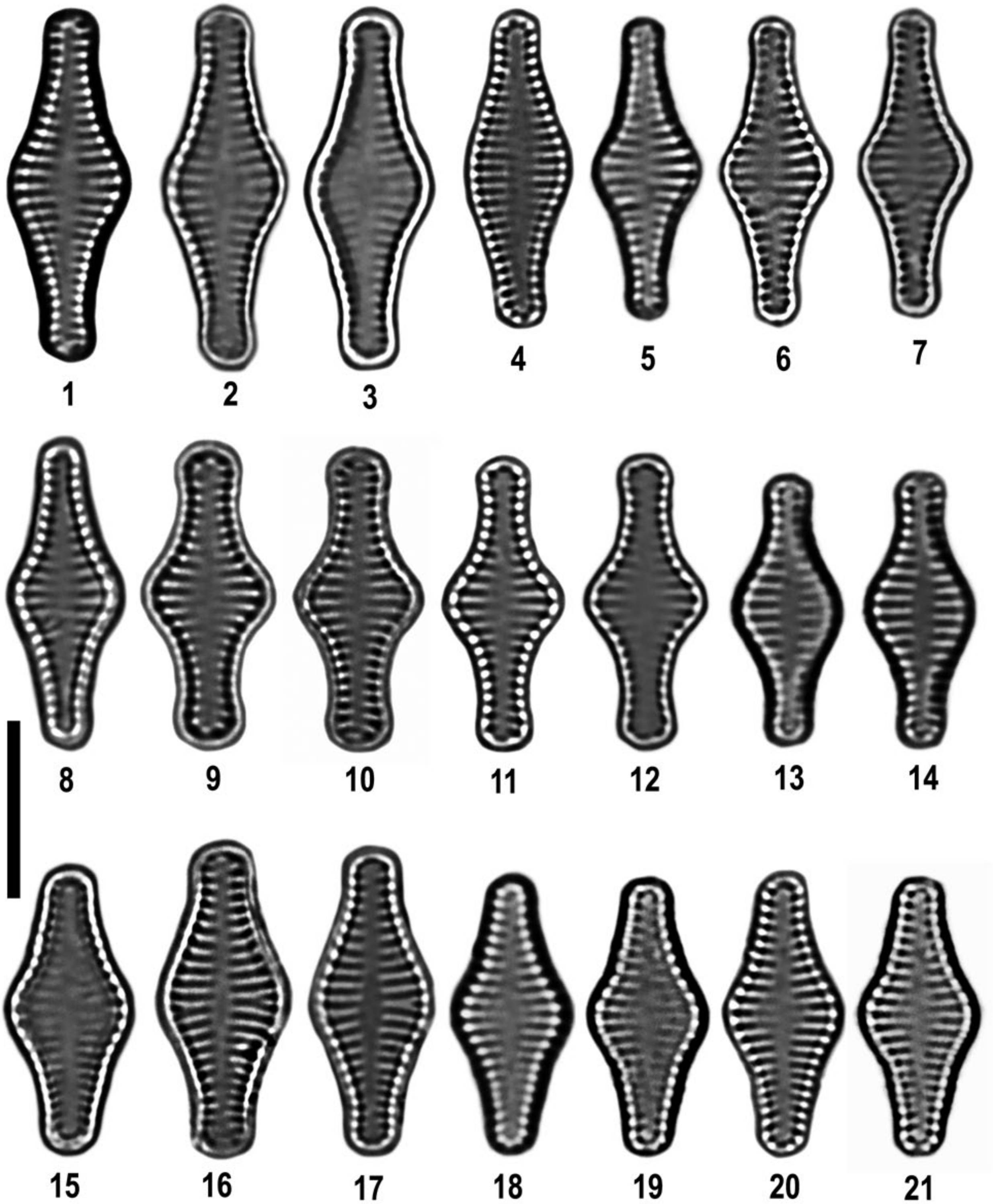

Plate 76. 1-21. *Staurosira inflata* (Heiden) Rusanov, Ács, Morales & Ector 2018, Eemian deposits. Scale bar 10 µm.

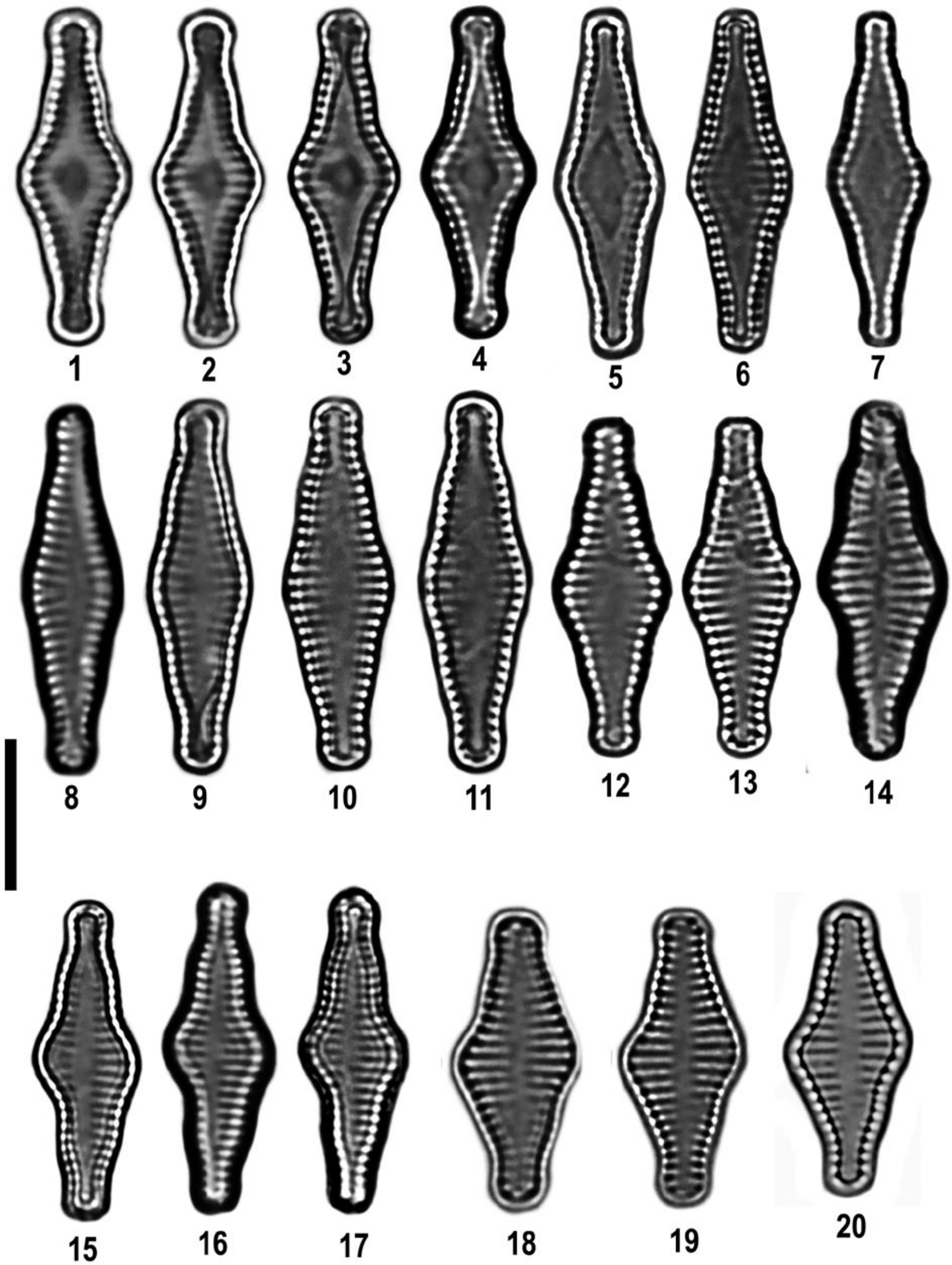

Plate 77. 1-20. *Staurosira inflata* var. *istvanffyi* (Hustedt) Zalat & Nitychoruk comb. nov. 1-14. Eemian deposits; 15-20. Kamionka Lake. Scale bar 10 µm.

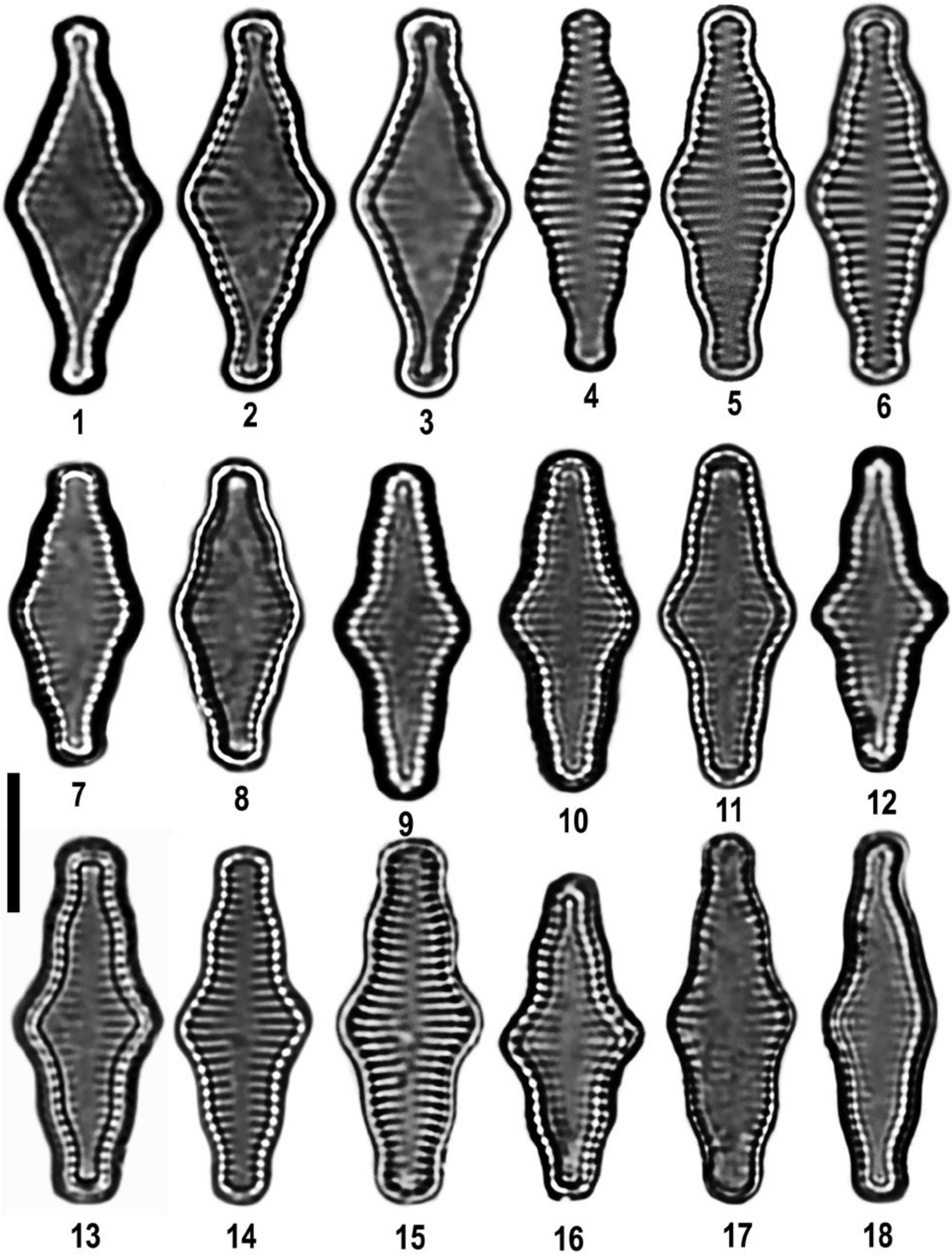

Plate 78. 1-18. *Staurosira inflata* var. *istvanffyi* (Hustedt) Zalat & Nitychoruk comb. nov. 1-6. Kamionka Lake, 7-18. Eemian deposits. Scale bar 10 µm.

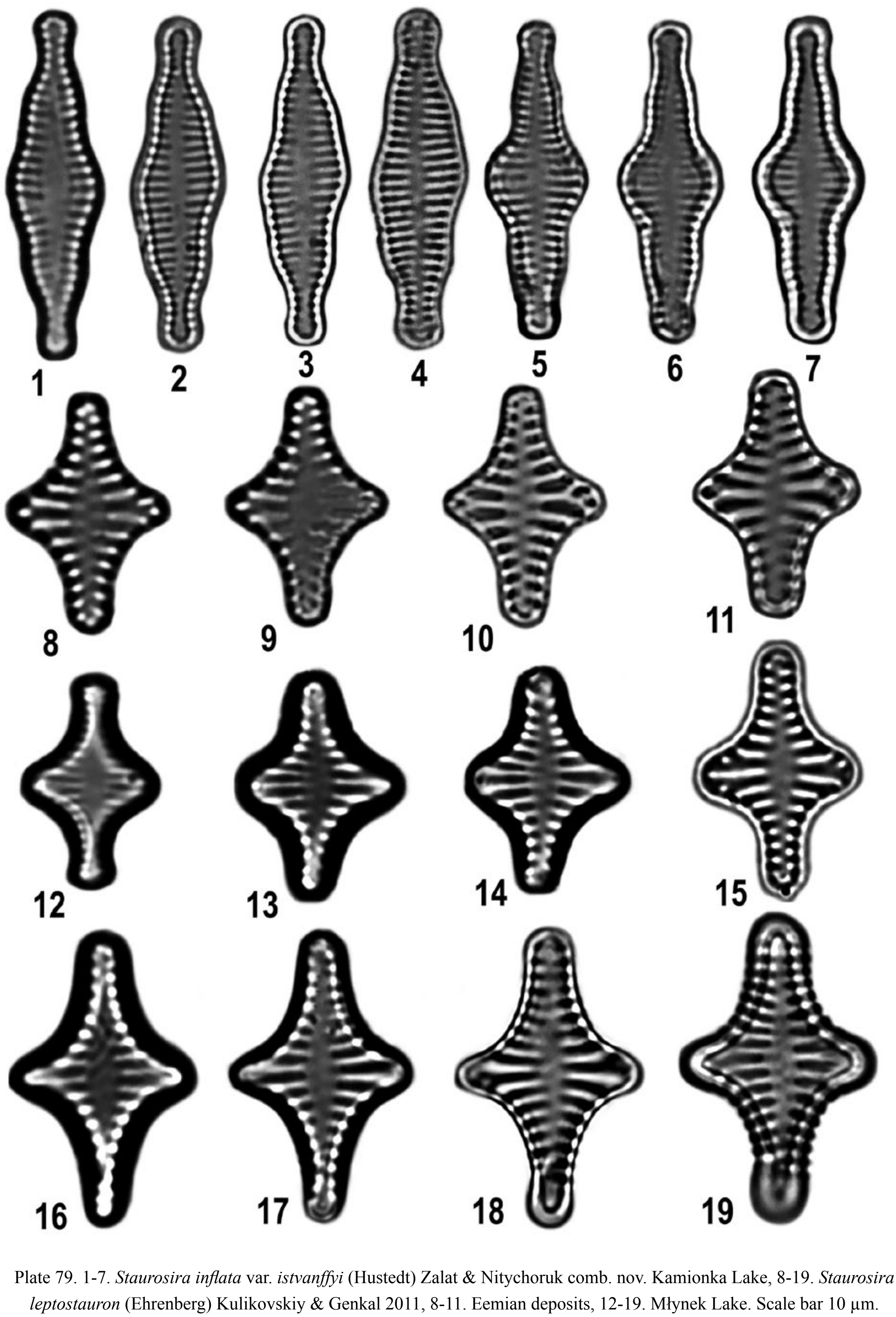

Plate 79. 1-7. *Staurosira inflata* var. *istvanffyi* (Hustedt) Zalat & Nitychoruk comb. nov. Kamionka Lake, 8-19. *Staurosira leptostauron* (Ehrenberg) Kulikovskiy & Genkal 2011, 8-11. Eemian deposits, 12-19. Młynek Lake. Scale bar 10 µm.

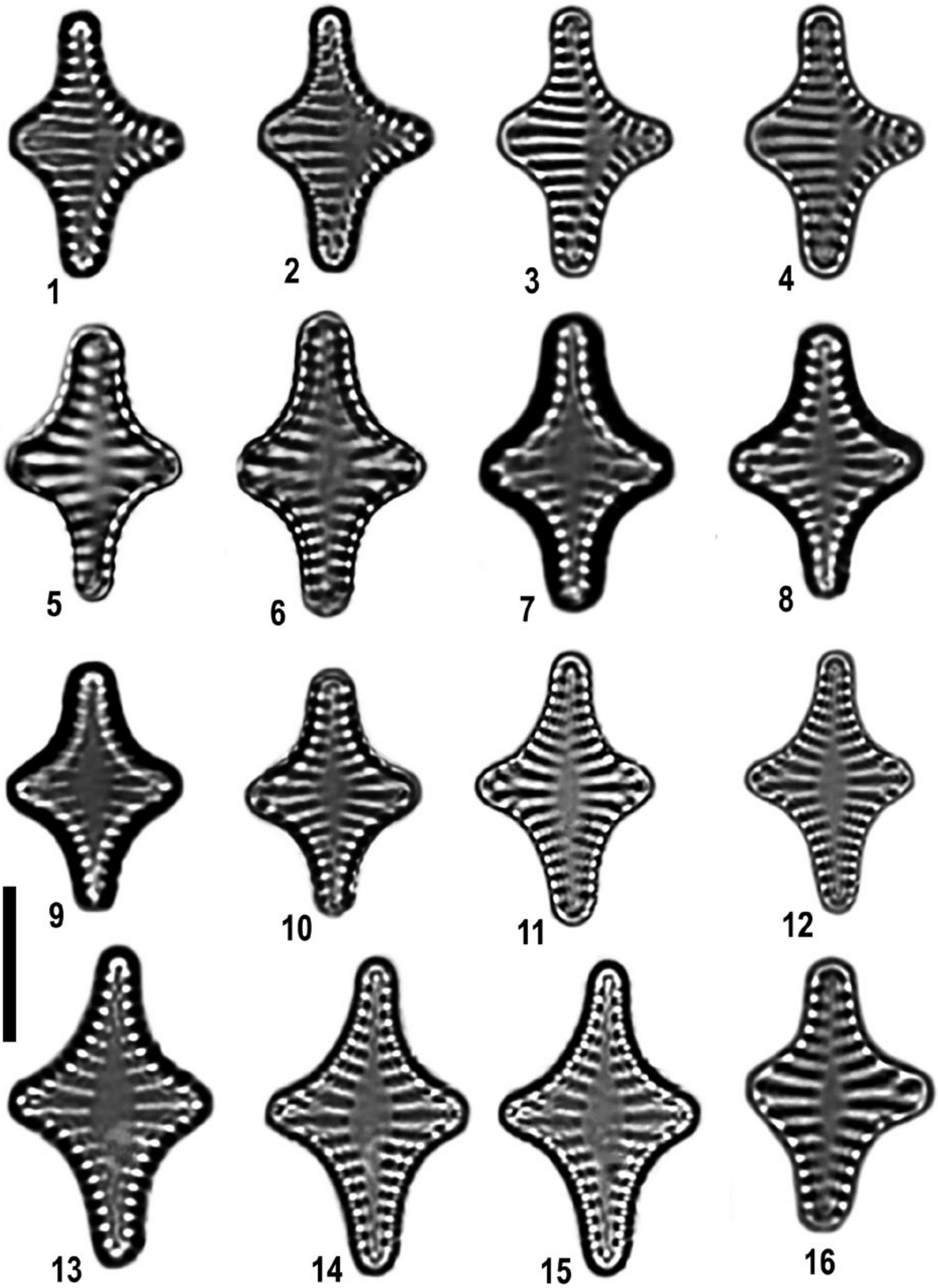

Plate 80. 1-16. *Staurosira leptostauron* (Ehrenberg) Kulikovskiy & Genkal 2011, Młynek Lake. Scale bar 10 µm.

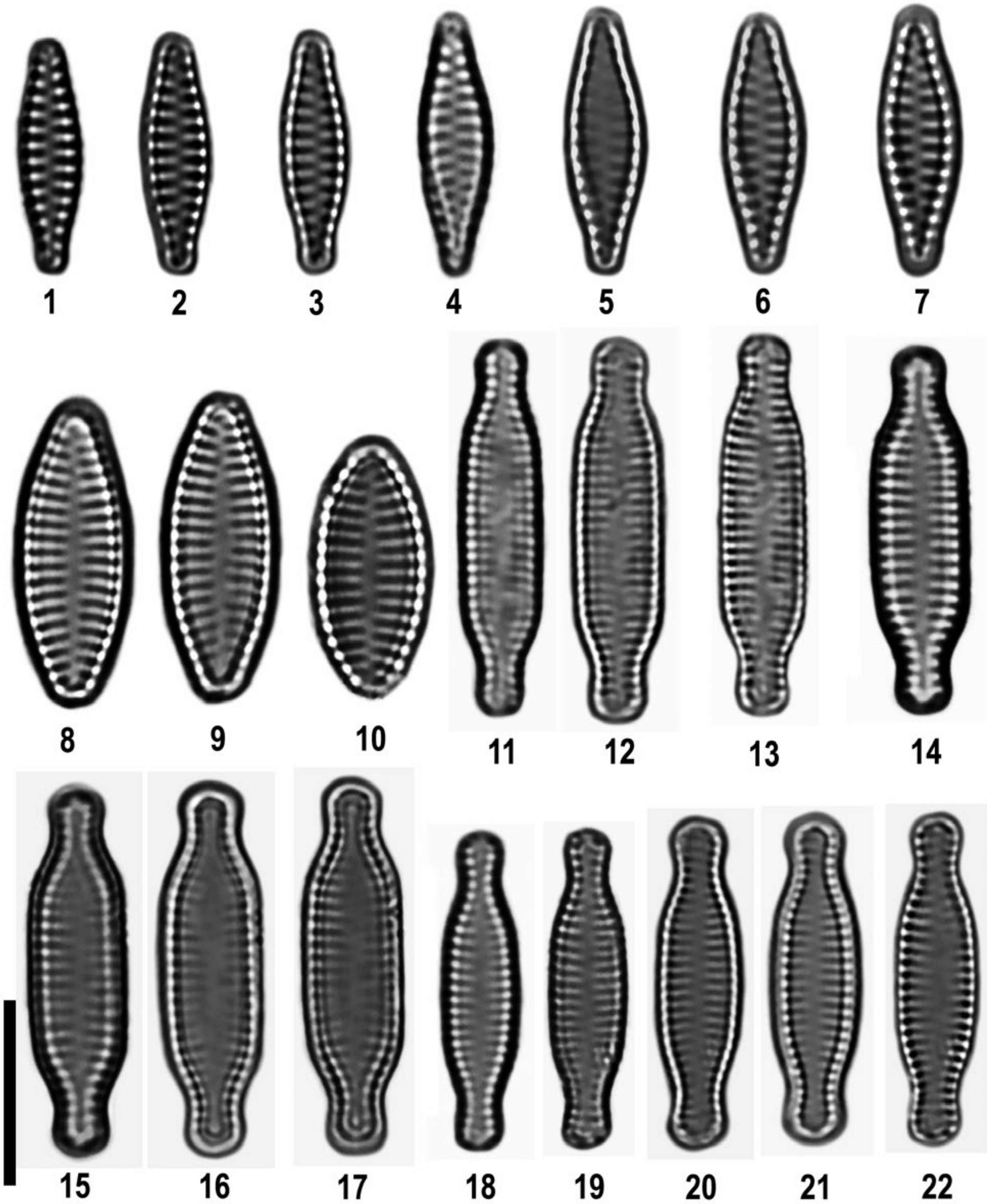

Plate 81. 1-7. *Staurosira longwanensis* Rioual, Morales & Ector 2014, Eemian deposits; 8-10. *Staurosira neoproducta* (Lange-Bertalot) Chudaev & Gololobova 2012, Eemian deposits; 11-22. *Staurosira pottiezii* Van de Vijver 2014**,** Kamionka Lake. Scale bar 10 µm.

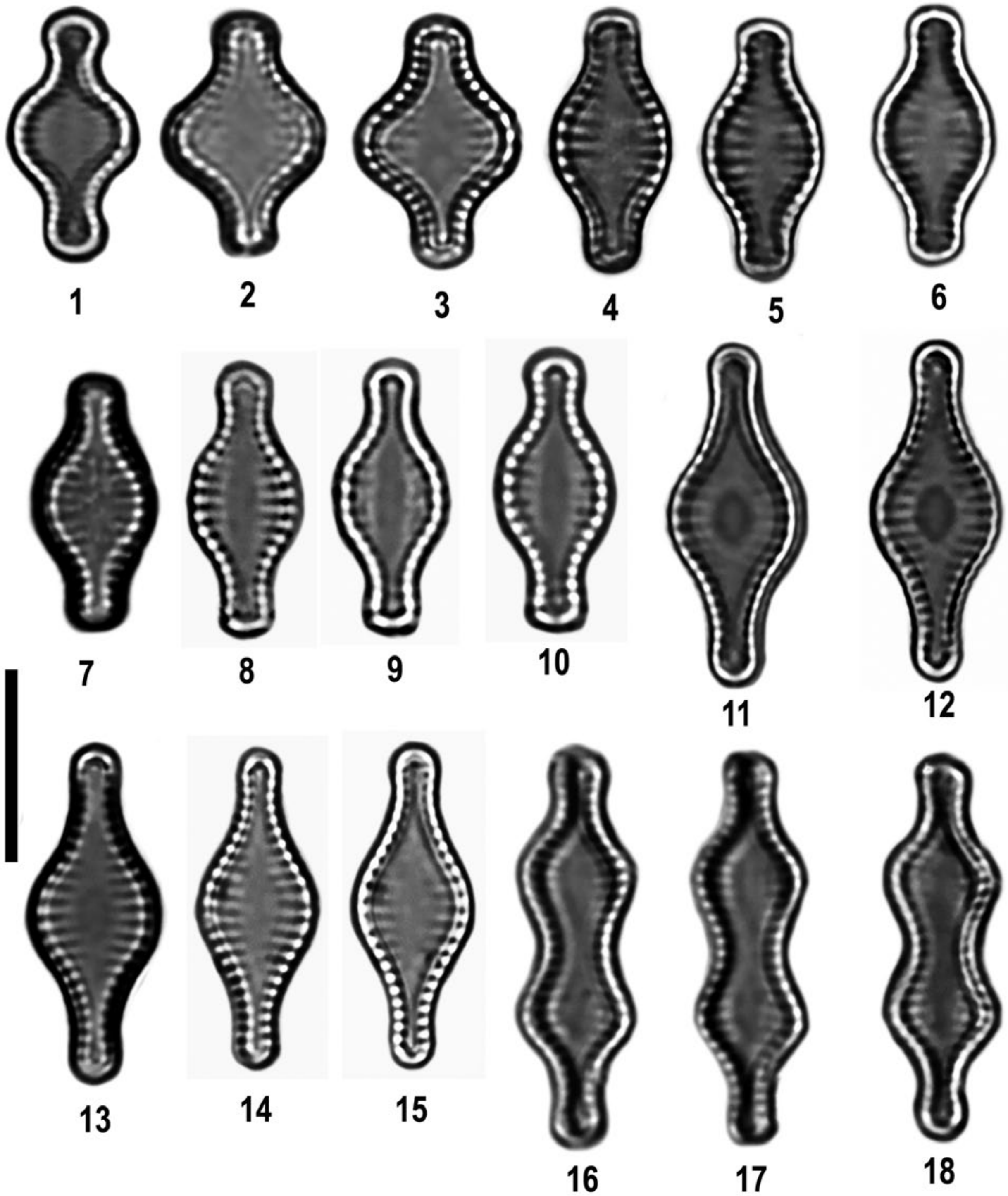

Plate 82. 1-15. *Staurosira pseudoconstruens* (Marciniak) Lange-Bertalot 2000, 1. Jeziorak Lake, 2-3. Kamionka Lake; 4-15. 12-19. Eemian deposits; 16-18. *Staurosira pseudoconstruens* var. *bigibba* (Marciniak) Zalat & Chodyka comb. nov. Eemian deposits. Scale bar 10µm.

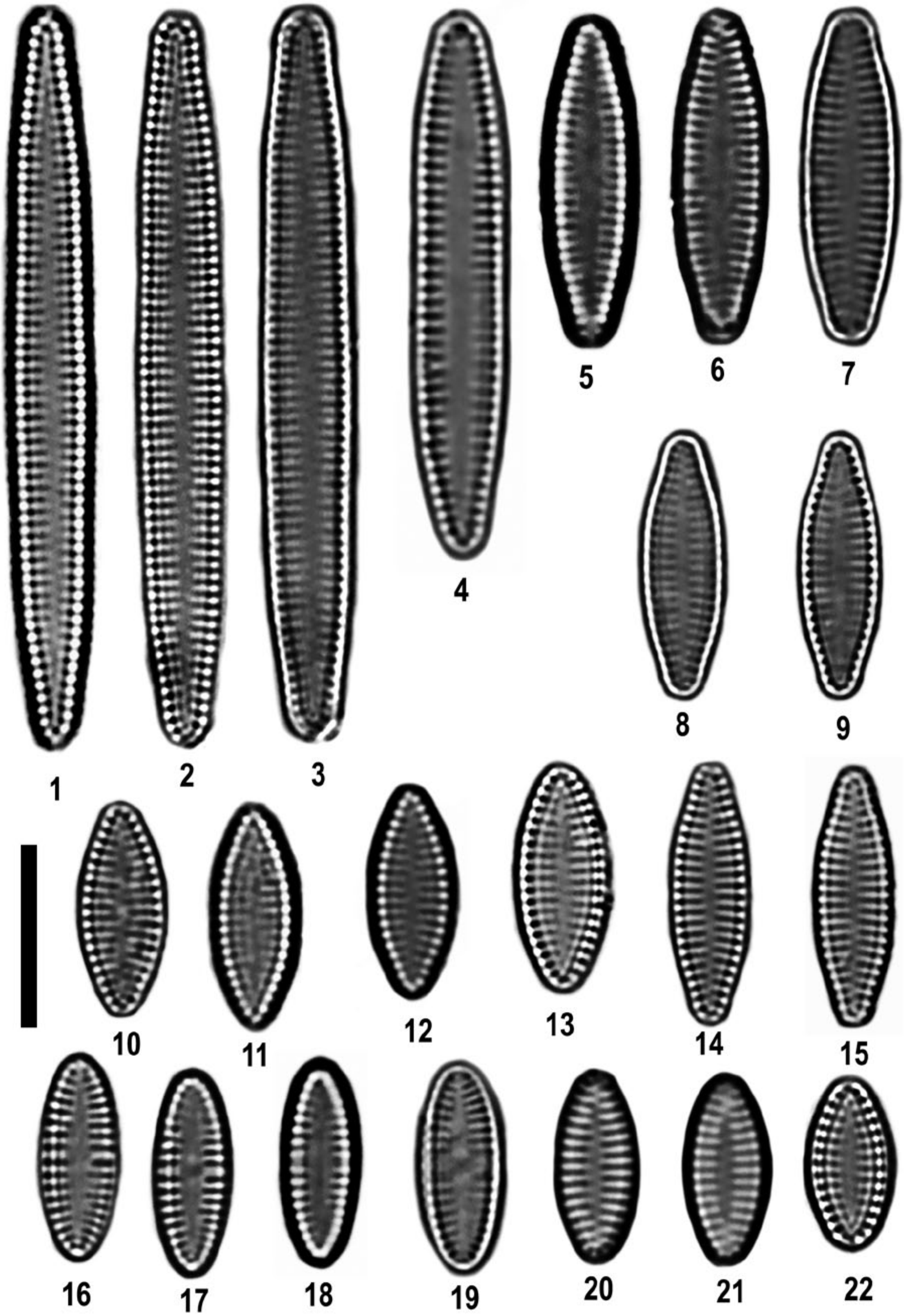

Plate 83. 1-22. *Staurosira subsalina* (Hustedt) Lange-Bertalot 2004, 1-3. Radomno Lake, 4. Kamionka Lake, 5-15., 20-22. Eemian deposits, 16-19. Jeziorak Lake. Scale bar 10μm.

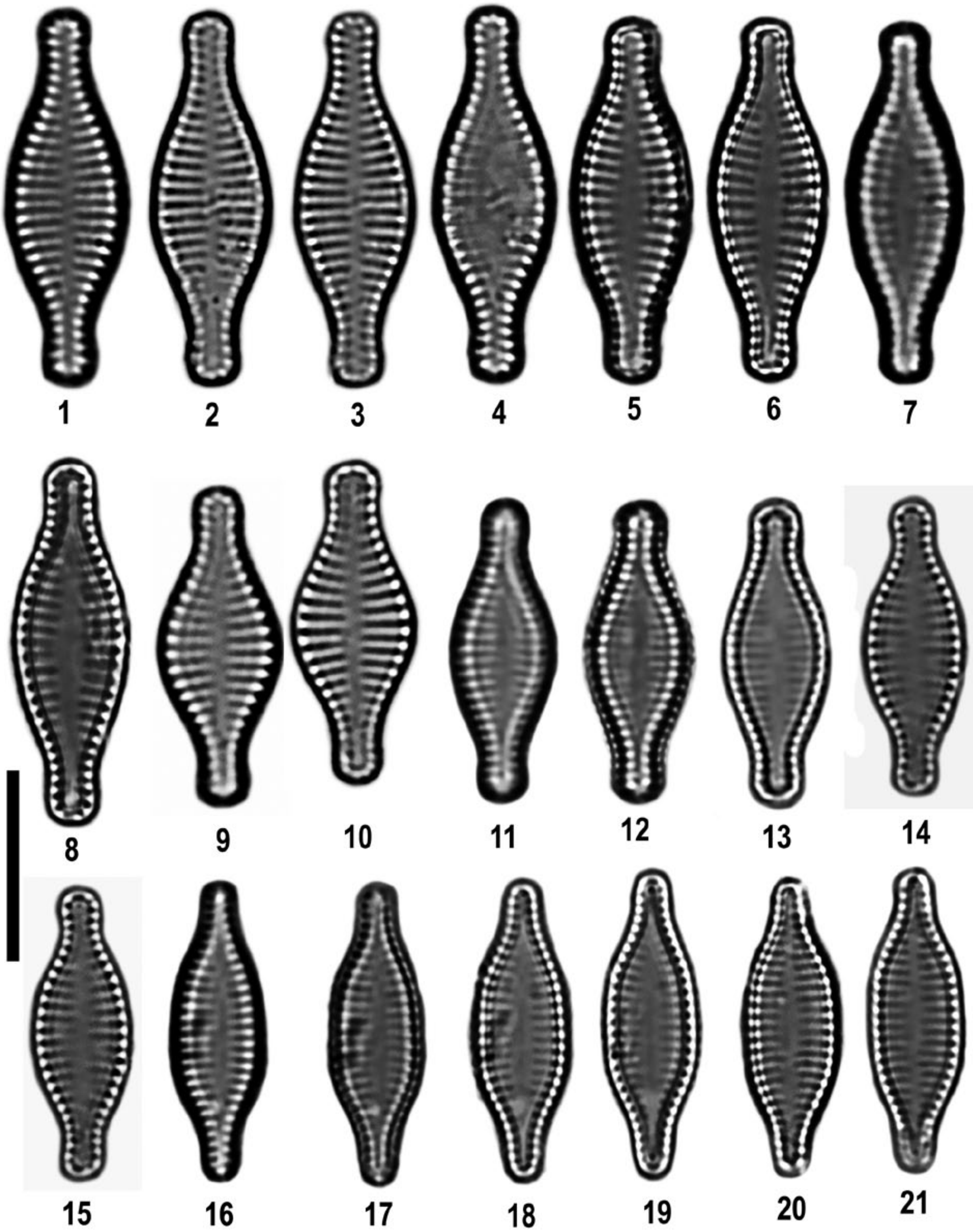

Plate 84. 1-15. *Staurosira sviridae* Kulikovskiy, Genkal & Mikheeva 2011, Eemian deposits; 16-21; *Staurosira sviridae* var. *rostrata* Zalat nov. var. Eemian deposits. Scale bar 10µm.

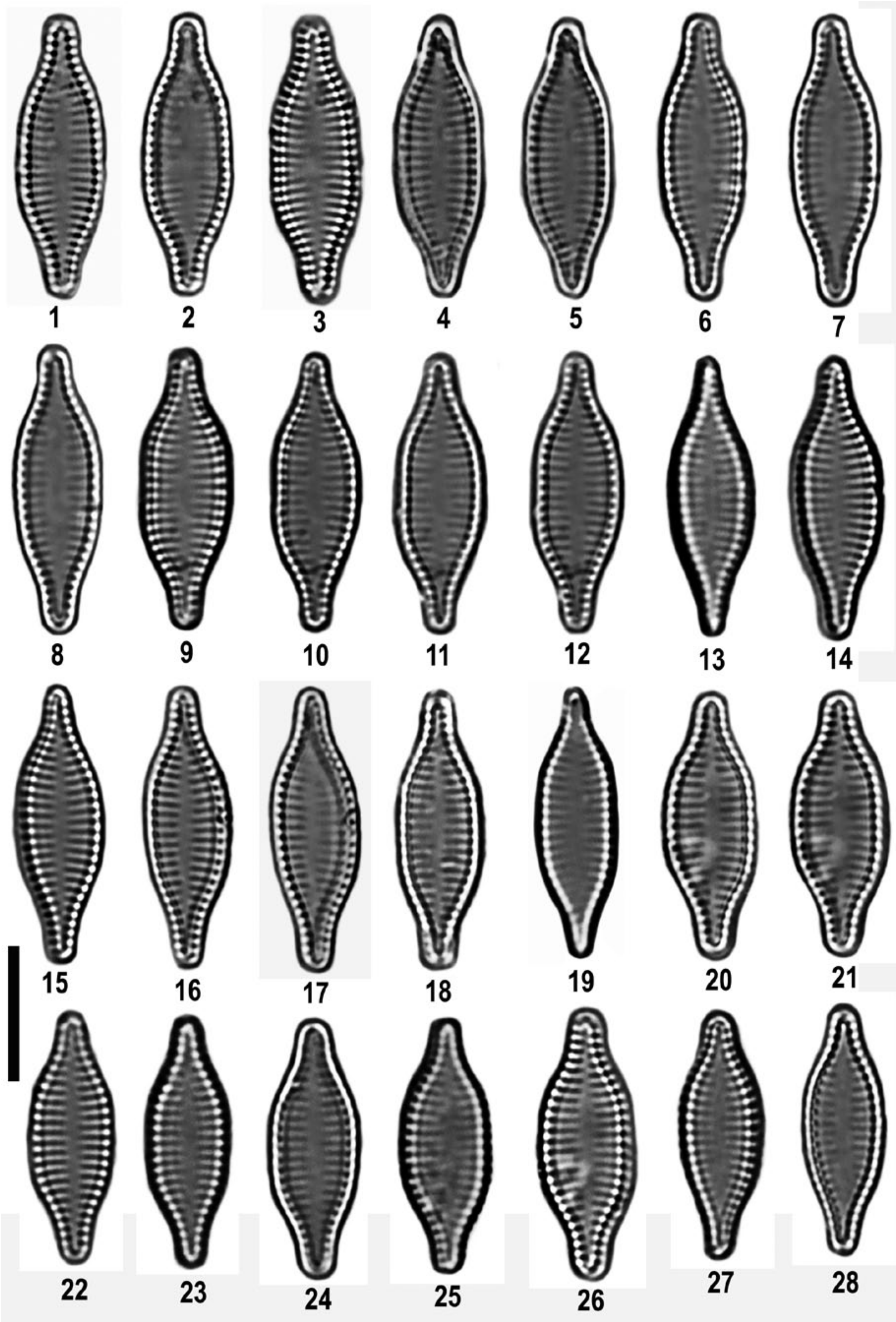

Plate 85. 1-28; *Staurosira sviridae* var. *rostrata* Zalat nov. var. Eemian deposits. Scale bar 10µm.

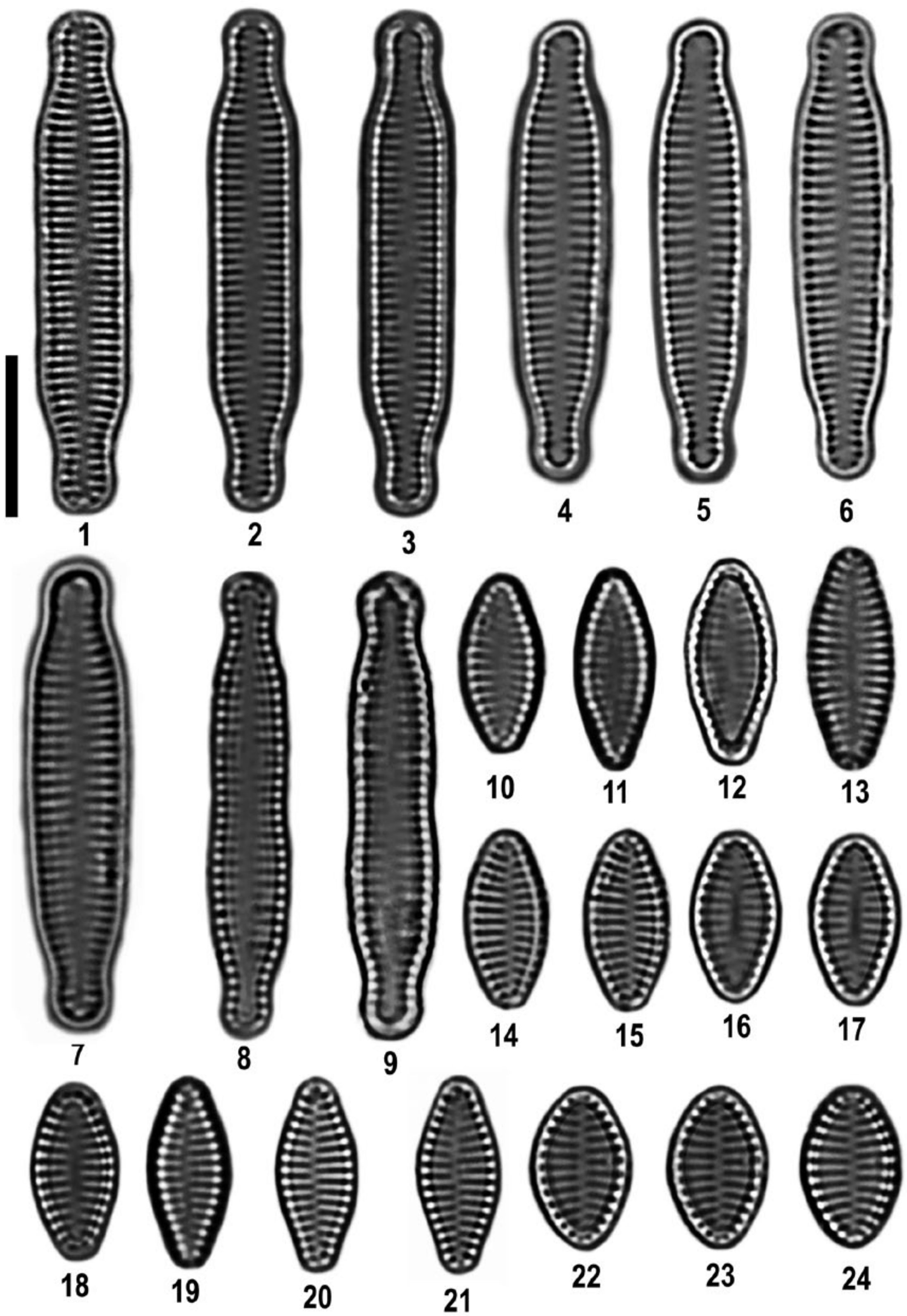

Plate 86. 1-9. *Staurosira vandenbusscheana* Van de Vijver in Van de Vijver et al., 2020, 1-7. Kamionka Lake, 8-9. Młynek Lake; 10-24. *Staurosira venter* (Ehrenberg) Cleve & Möller 1879, Eemian deposits. Scale bar 10µm.

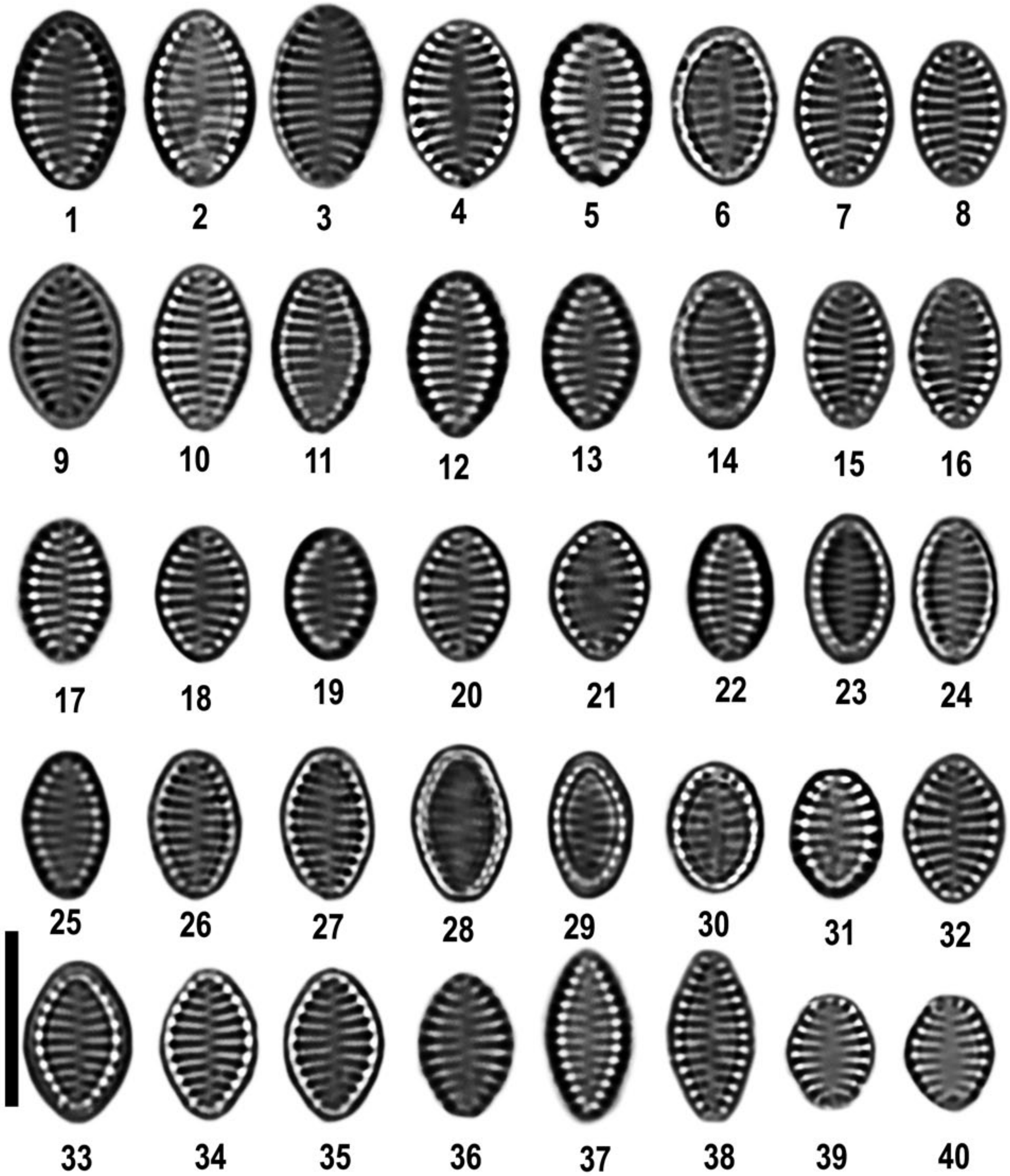

Plate 87. 1-40. *Staurosira venter* (Ehrenberg) Cleve & Möller 1879, 1-30. Eemian deposits, 31-40. Kamionka Lake. Scale bar 10µm.

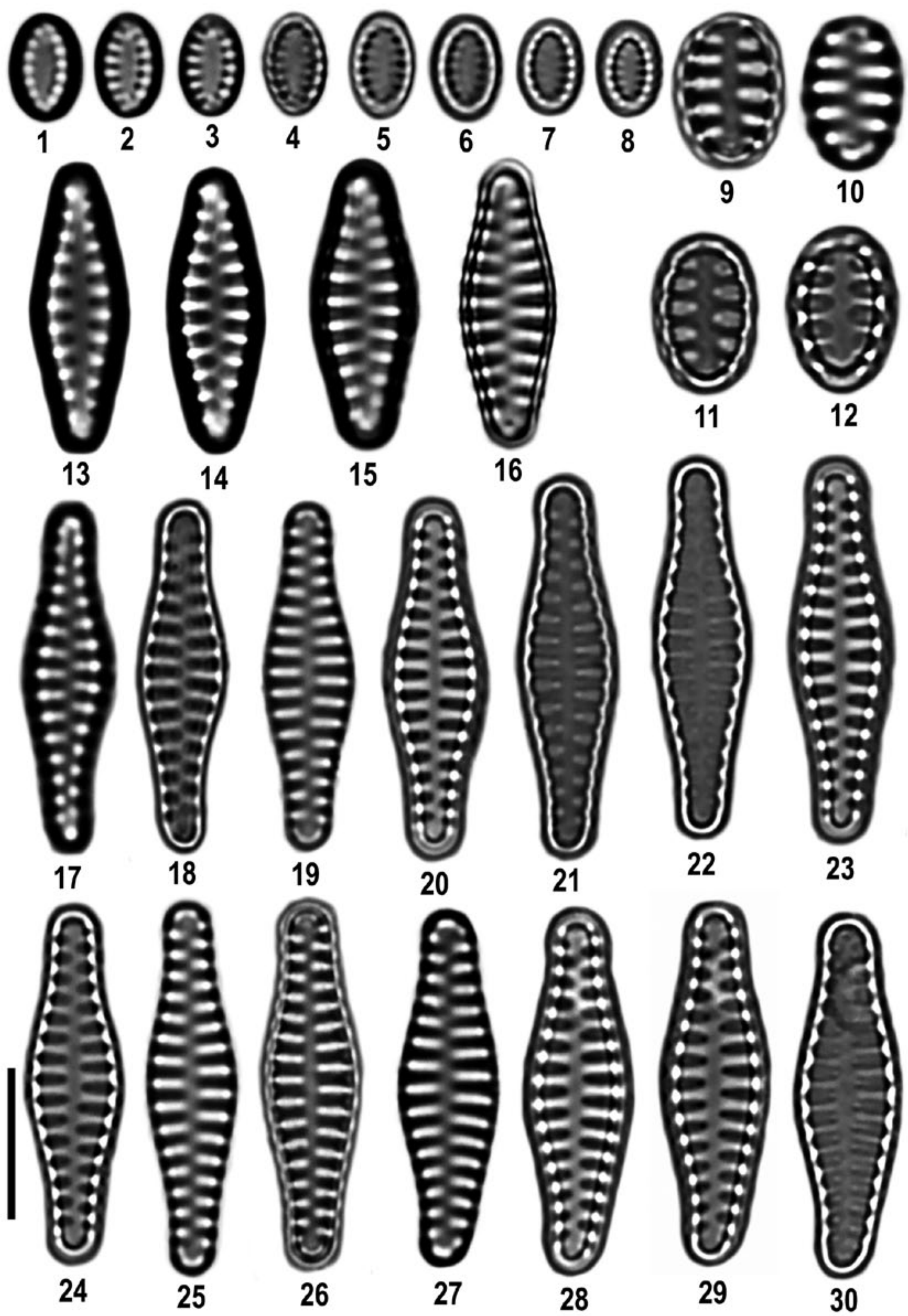

Plate 88. 1-8. *Staurosirella canariensis* (Lange-Bertalot) Morales, Ector, Maidana & Grana 2018, Eemian deposits; 9-12. *Staurosirella crassa* (Metzeltin & Lange-Bertalot) Ribeiro & Torgan 2010, Radomno Lake; 13-16. *Staurosirella dubia* (Grunow) Morales & Manoylov 2006, Jeziorak Lake; 17-30. *Staurosirella elegantula* Morales & Manoylov 2010, Eemian deposits. Scale bar 10µm.

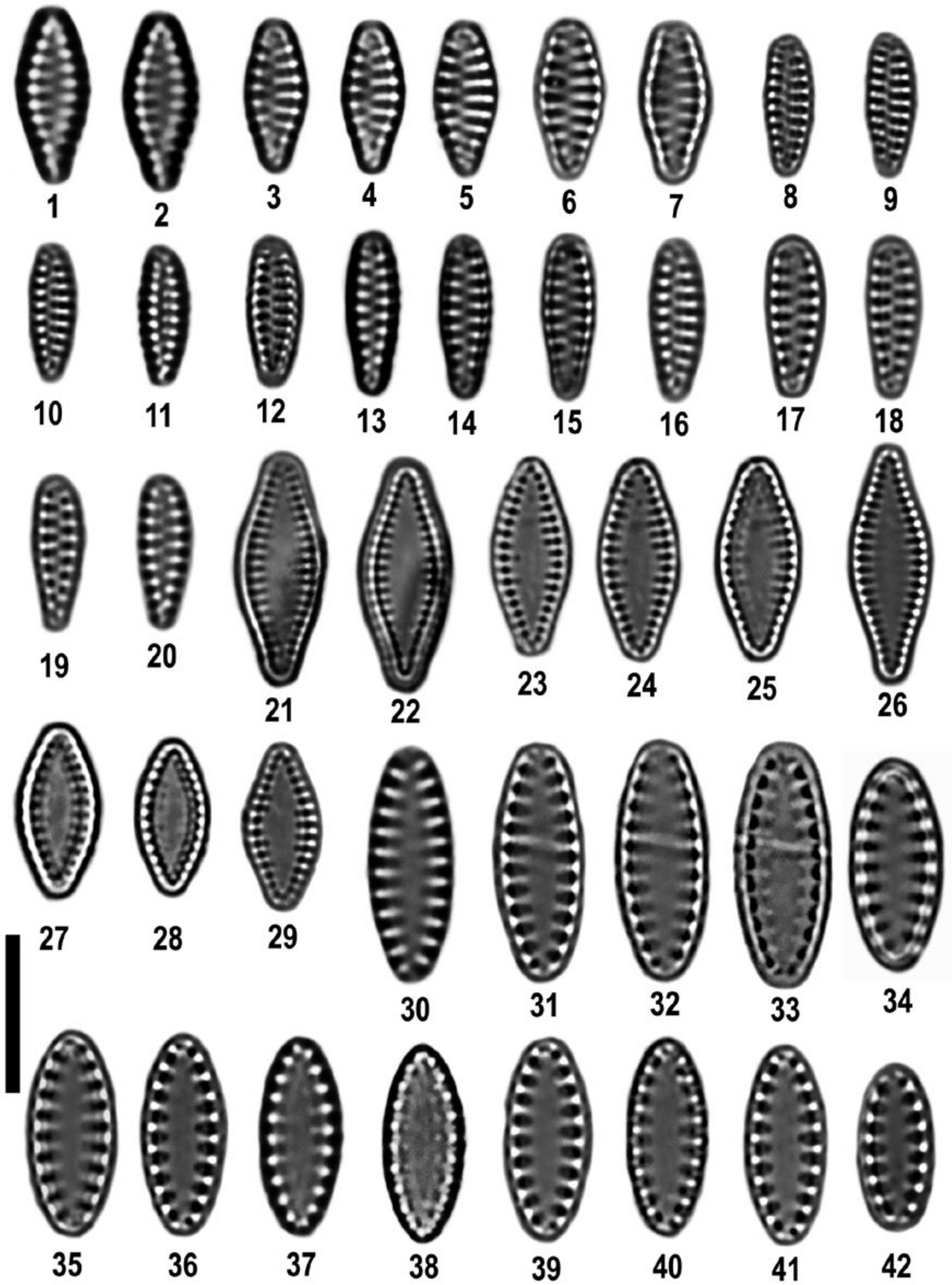

Plate 89. 1-7. *Staurosirella frigida* Van de Vijver & Morales 2014, Młynek Lake; 8-20. *Staurosirella guenter-grassii* (Witkowski & Lange-Bertalot) Morales et al. 2019, 8-12. Kamionka Lake, 13-16. Eemian deposits, 17-20. Jeziorak Lake; 21-29. *Staurosirella krammeri* Morales, Wetzel & Ector 2010, Eemian deposits; 30-42. *Staurosirella lanceolata* (Hustedt) Morales, Wetzel & Ector 2010, Eemian deposits. Scale bar 10µm.

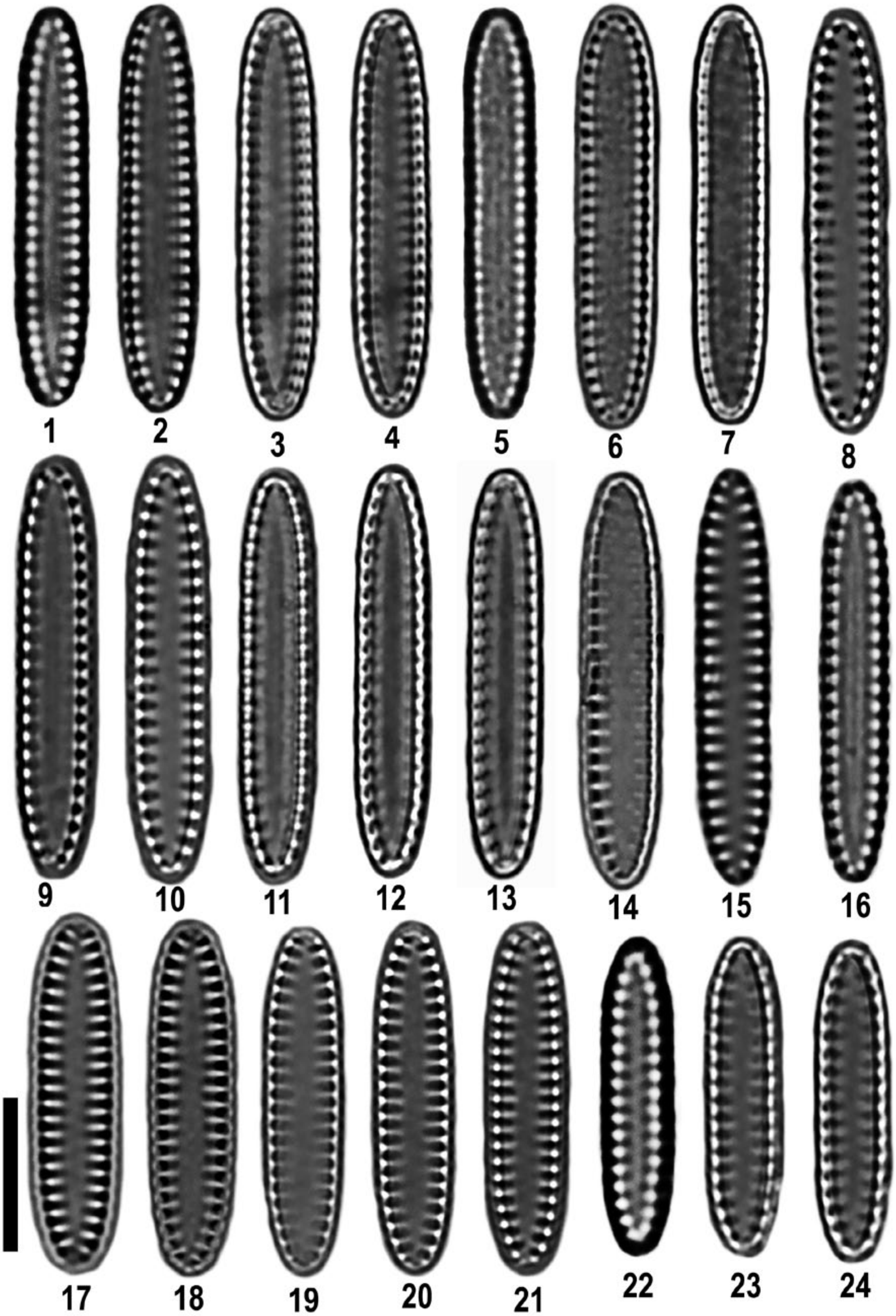

Plate 90. 1-24. *Staurosirella lapponica* (Grunow) Williams & Round 1987, Eemian deposits. Scale bar 10 µm.

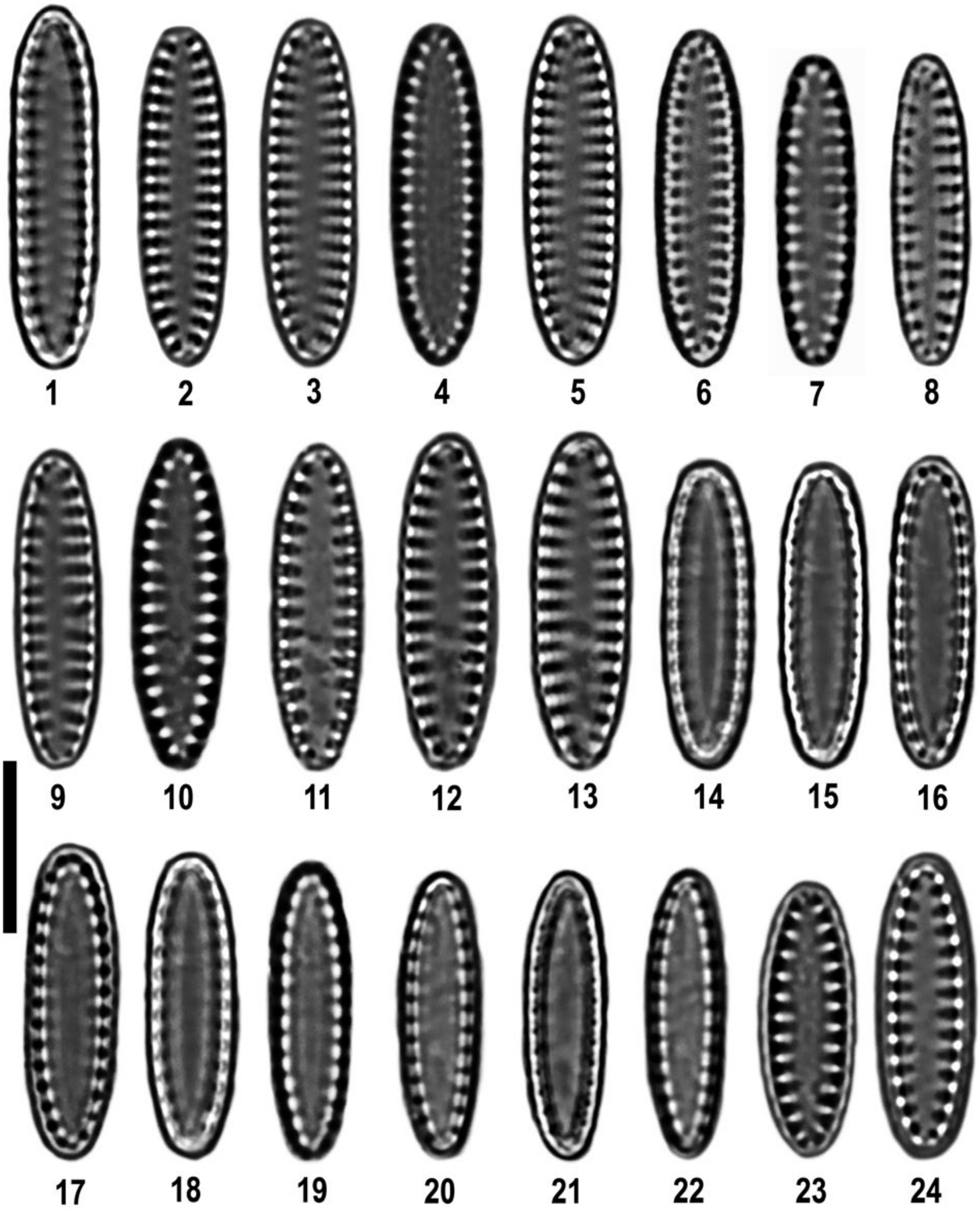

Plate 91. 1-24. *Staurosirella lapponica* (Grunow) Williams & Round 1987, Eemian deposits. Scale bar 10 µm.

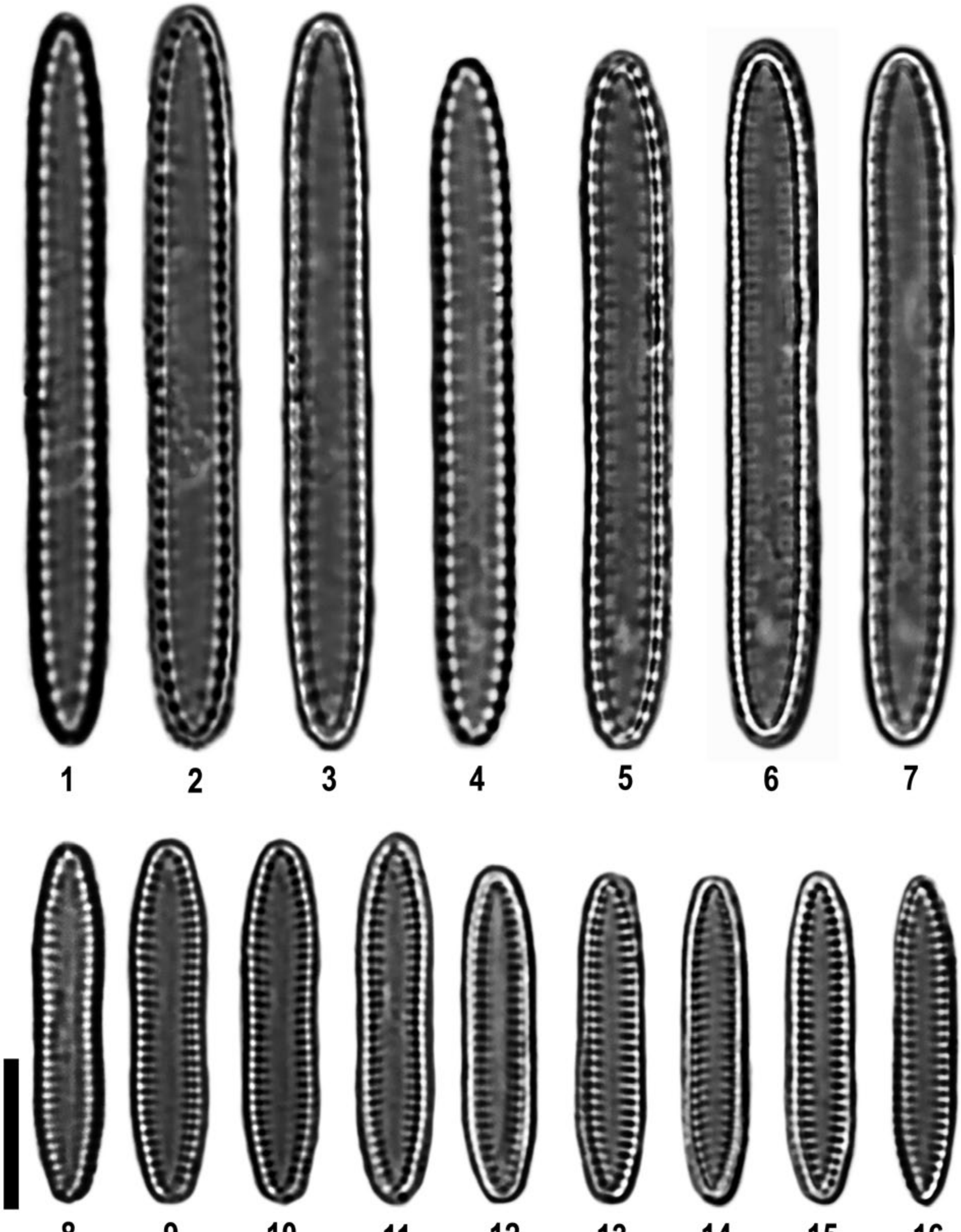

Plate 92. 1-7. *Staurosirella lapponica* var. *maior* (Tynni) Zalat & Pidek comb. nov., 8-16. *Staurosirella lapponica* var. *rostrata* (Krasske) John 2018, Eemian deposits. Scale bar 10 µm.

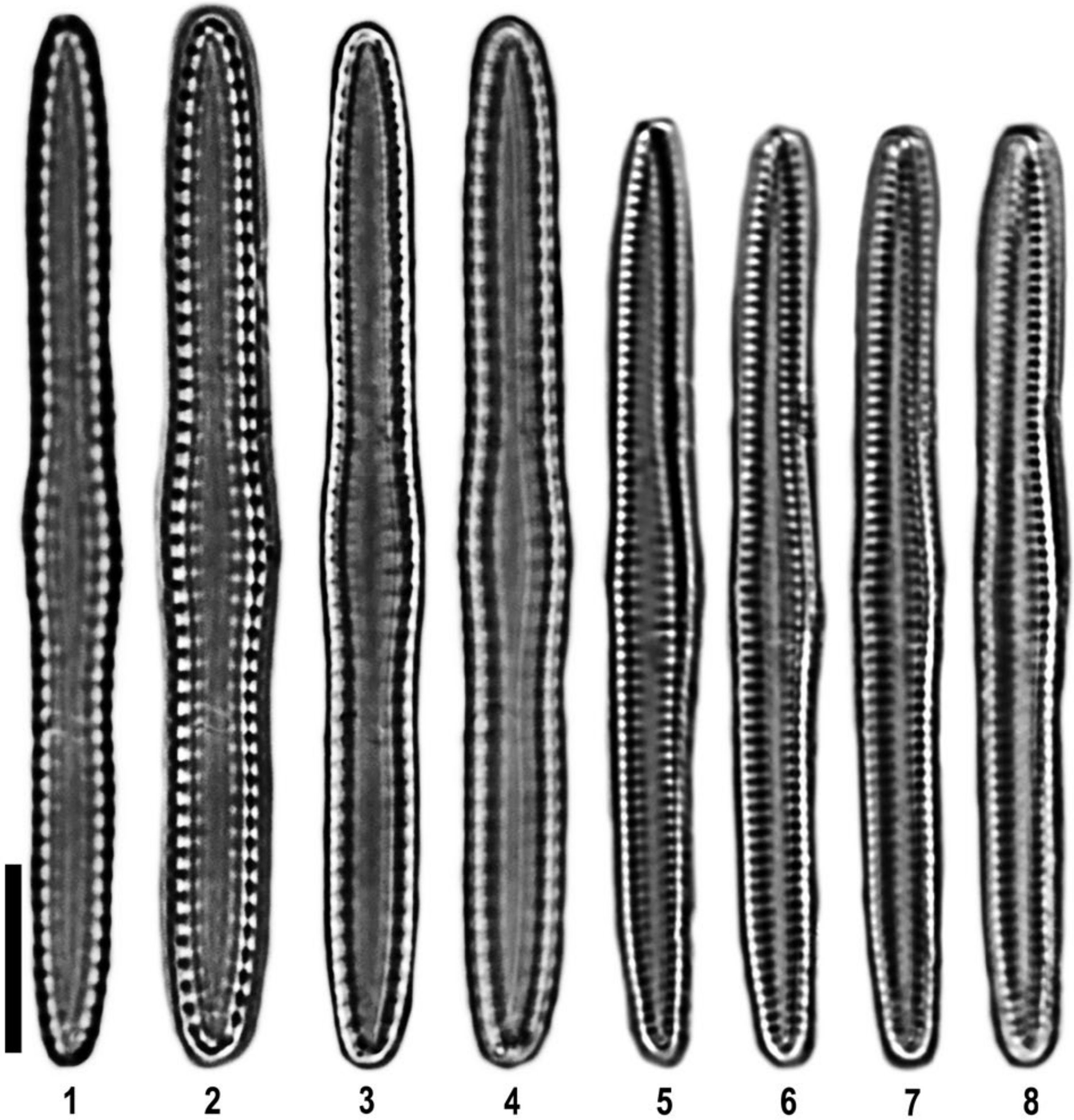

Plate 93. 1-8. *Staurosirella lapponica var. marciniakae* (Kaczmarska) Zalat & Pidek comb. nov., Eemian deposits. Scale bar 10 µm.

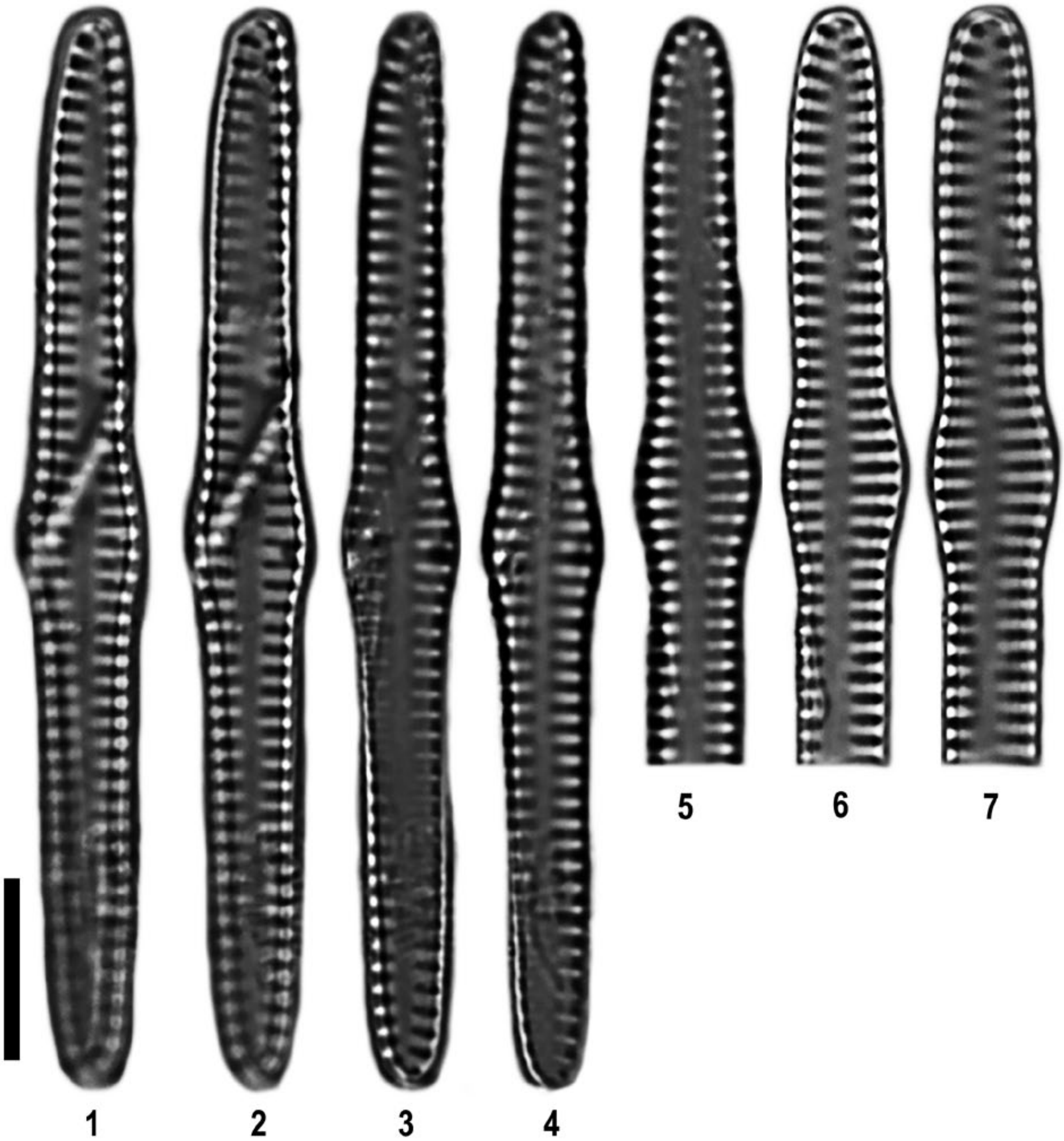

Plate 94. 1-7. *Staurosirella lapponica var. marciniakae* (Kaczmarska) Zalat & Pidek comb. nov., Eemian deposits. Scale bar 10 μm.

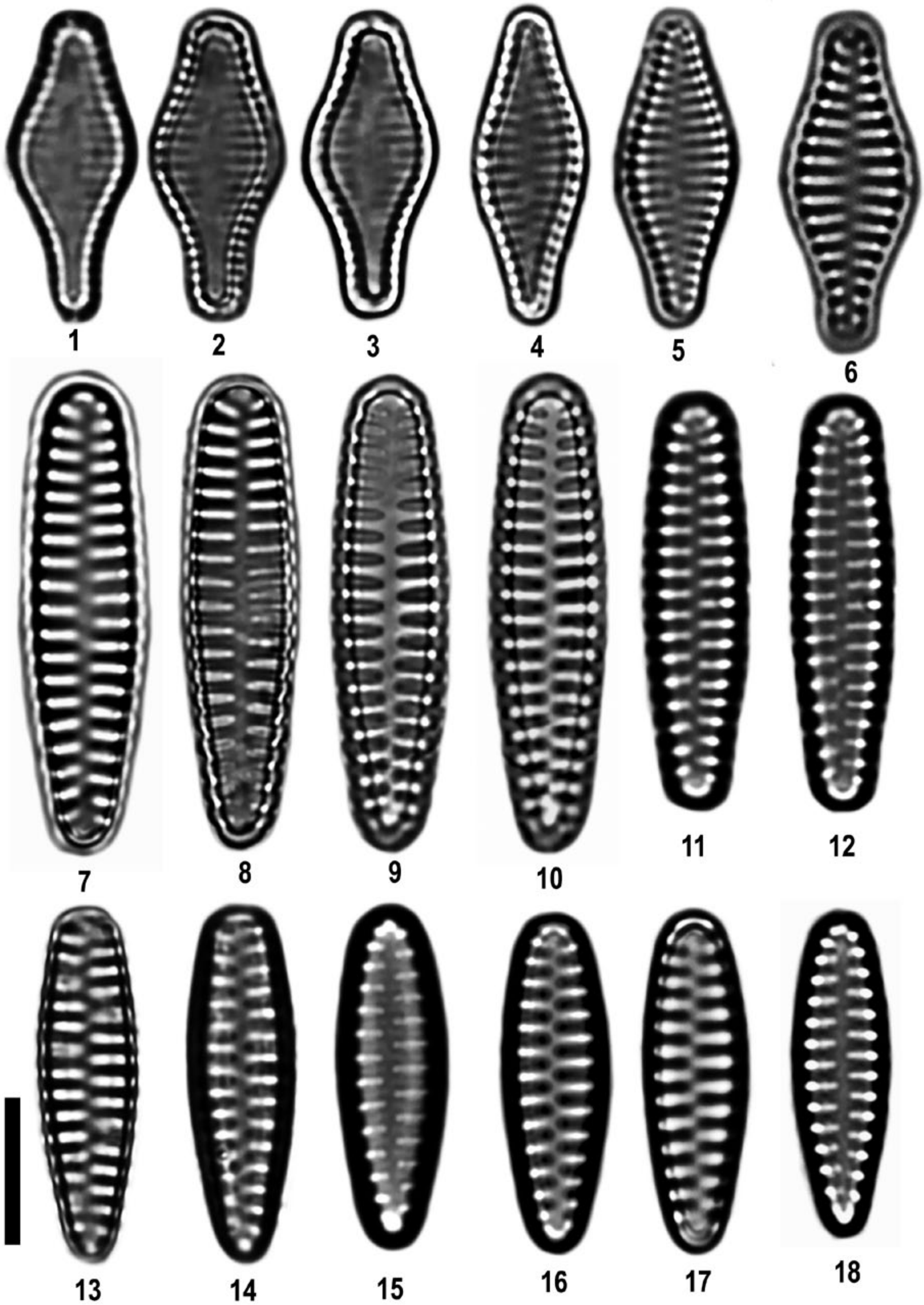

Plate 95. 1-6. *Staurosirella magna* Morales & Manoylov 2010; 1-3. Kamionka Lake, 4-6. Eemian deposits; 7-18. *Staurosirella martyi* (Héribaud-Joseph) Morales & Manoylov 2006, 7-10. Kamionka Lake, 11-12. Jeziorak Lake, 13-18. Kamionka Lake. Scale bar 10 µm.

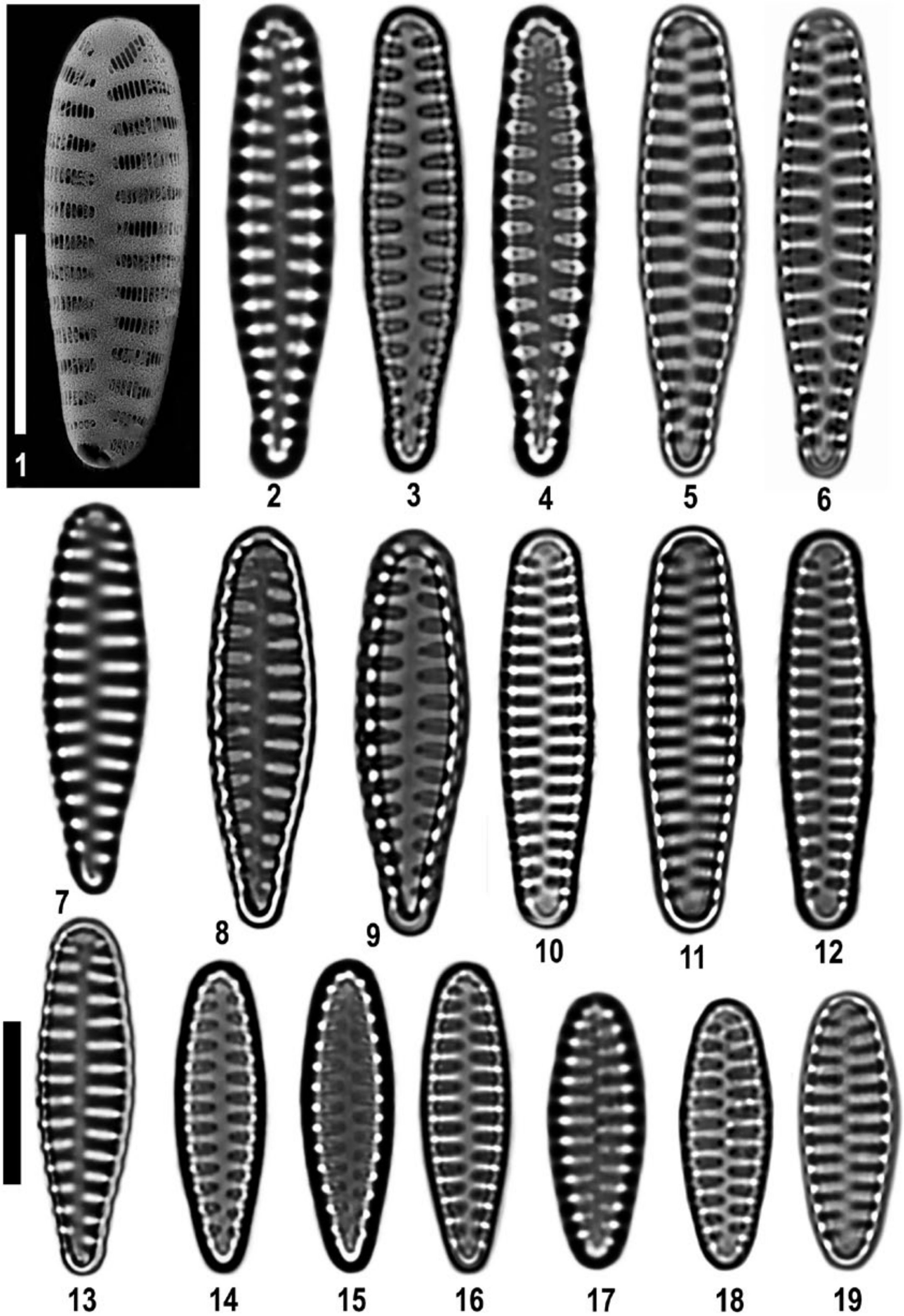

Plate 96. 1-19. *Staurosirella martyi* (Héribaud-Joseph) Morales & Manoylov 2006, 1-9. Radomno Lake, 10-12. Jeziorak Lake, 13-19. Kamionka Lake. 1.SEM micrograph of the external valve view. Scale bar 10 µm.

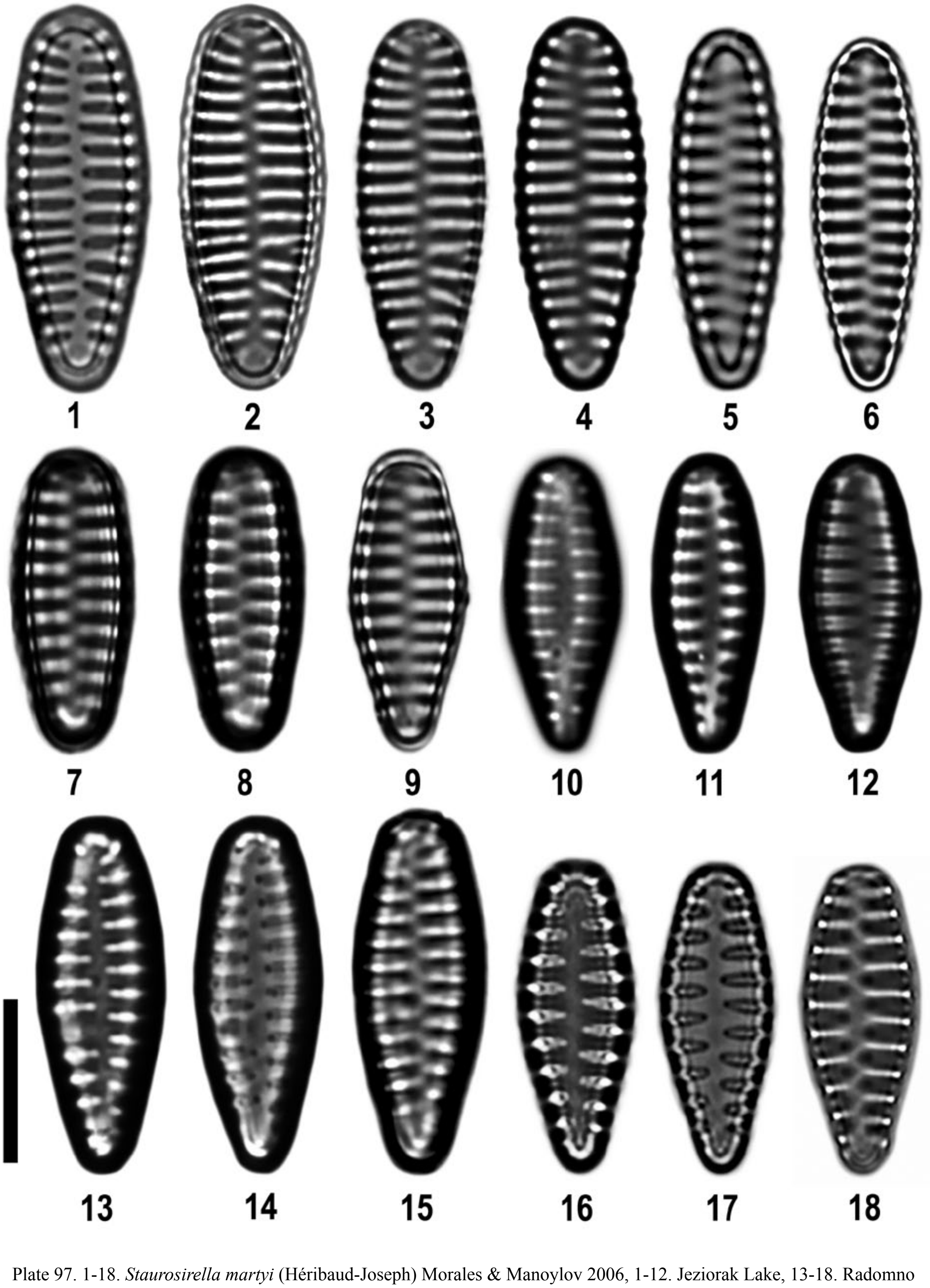

Plate 97. 1-18. *Staurosirella martyi* (Héribaud-Joseph) Morales & Manoylov 2006, 1-12. Jeziorak Lake, 13-18. Radomno Lake. Scale bar 10 µm.

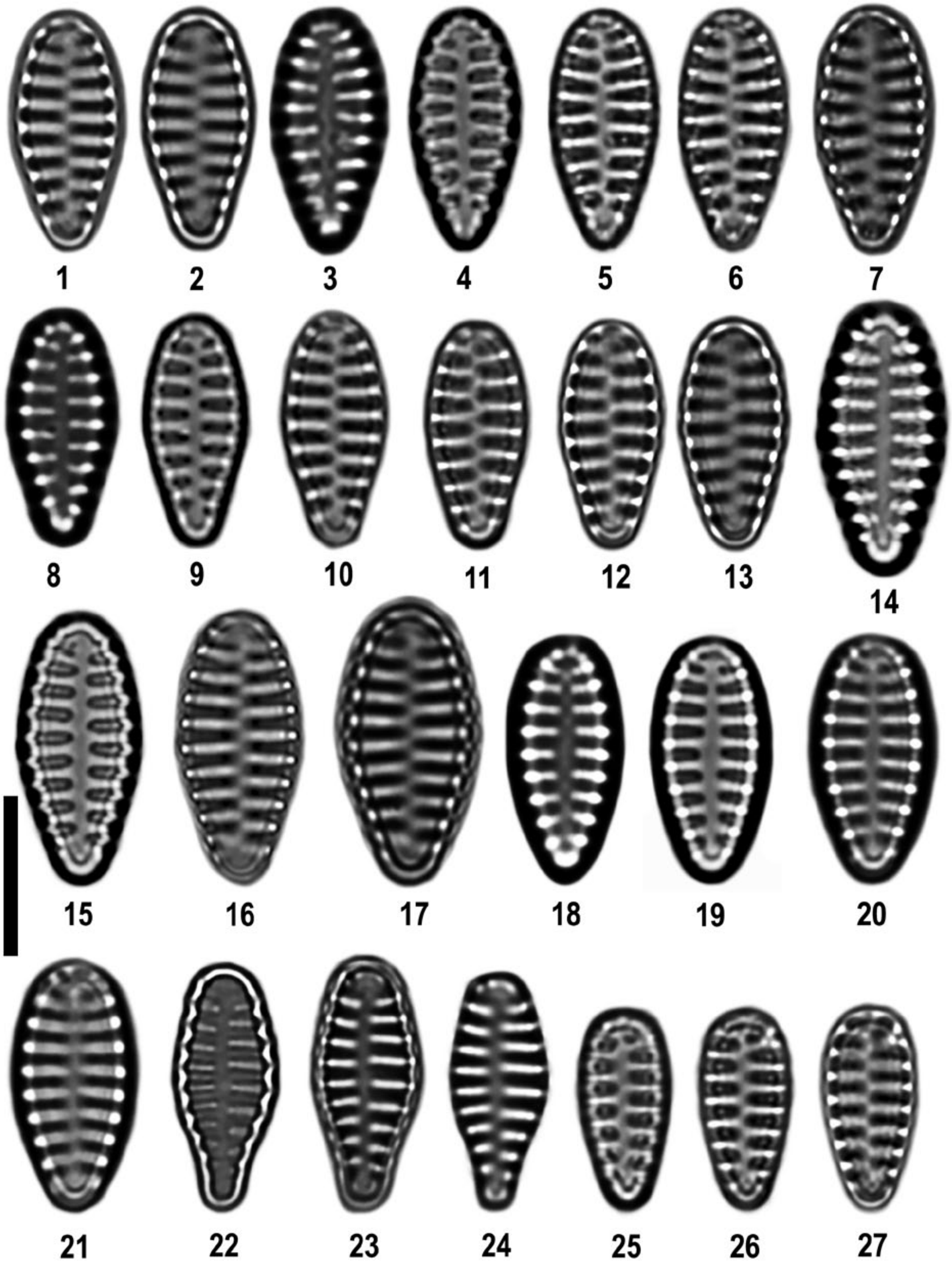

Plate 98. 1-27. *Staurosirella martyi* (Héribaud-Joseph) Morales & Manoylov 2006, 1-13. Jeziorak Lake, 14-21. Radomno Lake, 22-27. Kamionka Lake. Scale bar 10 µm.

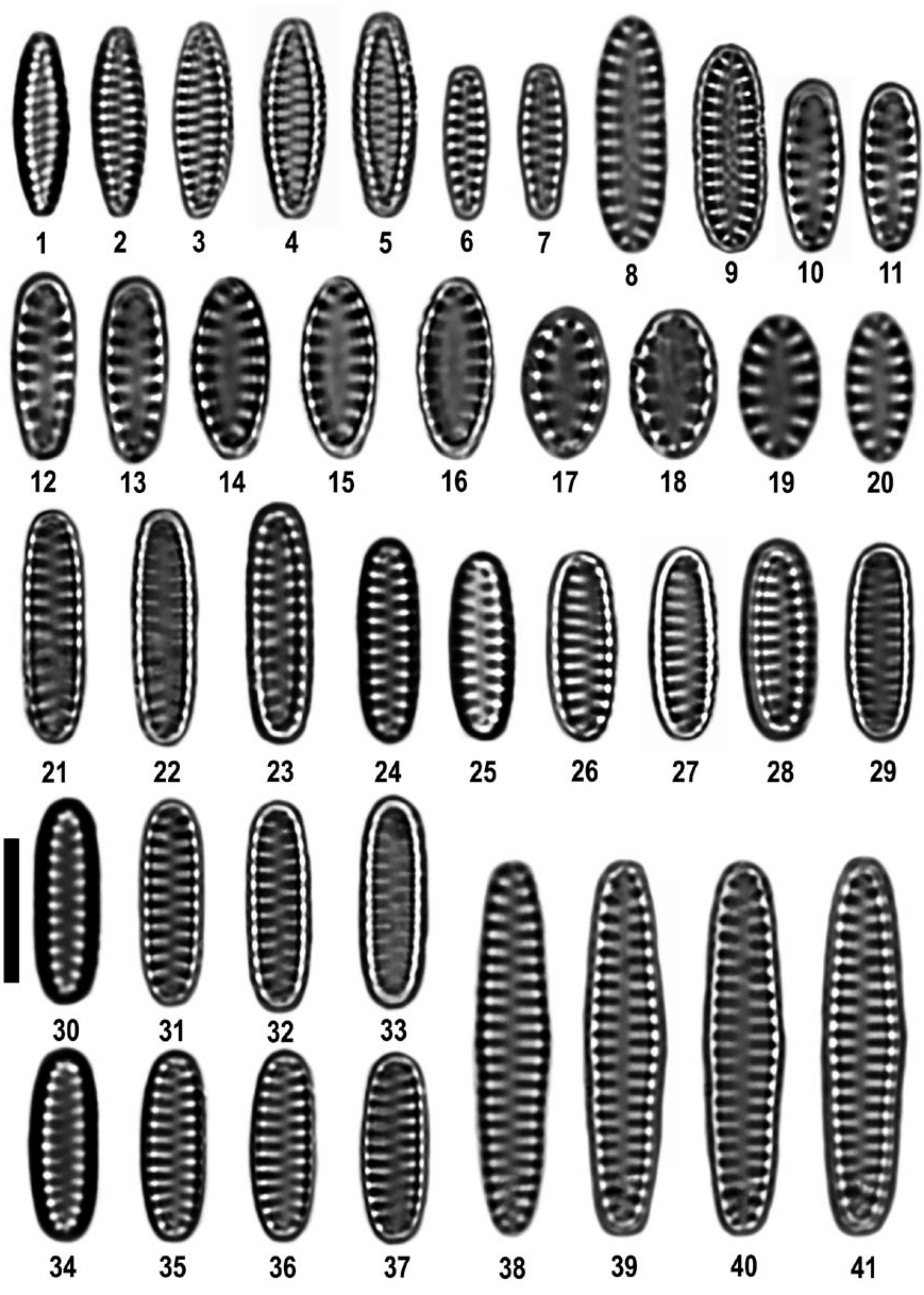

Plate 99. 1-7. *Staurosirella minuta* Morales & Edlund 2003, 1-5. Kamionka Lake, 6-7. Jeziorak Lake; 8-20. *Staurosirella mutabilis* (W. Smith) Morales & Van de Vijver 2015, 8. Kamionka Lake, 9-20. Eemian deposits; 21-41. *Staurosirella neopinnata* Morales, Wetzel, Haworth & Ector 2019, Eemian deposits. Scale bar 10 µm.

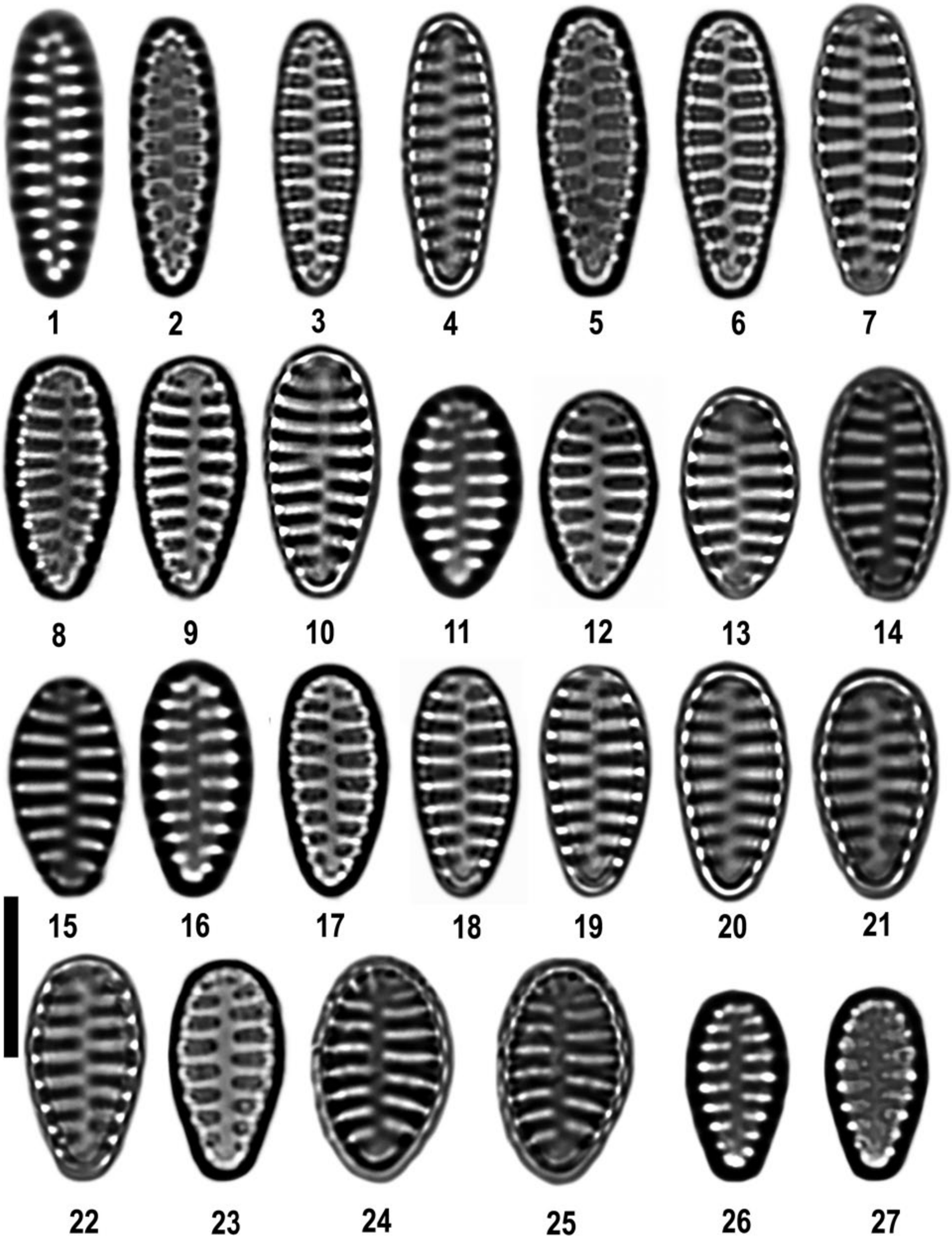

Plate 100. 1-27. *Staurosirella ovata* Morales 2006, 1-7. Radomno Lake, 8-15. Eemian deposits, 16-27. Jeziorak Lake. Scale bar 10 µm.

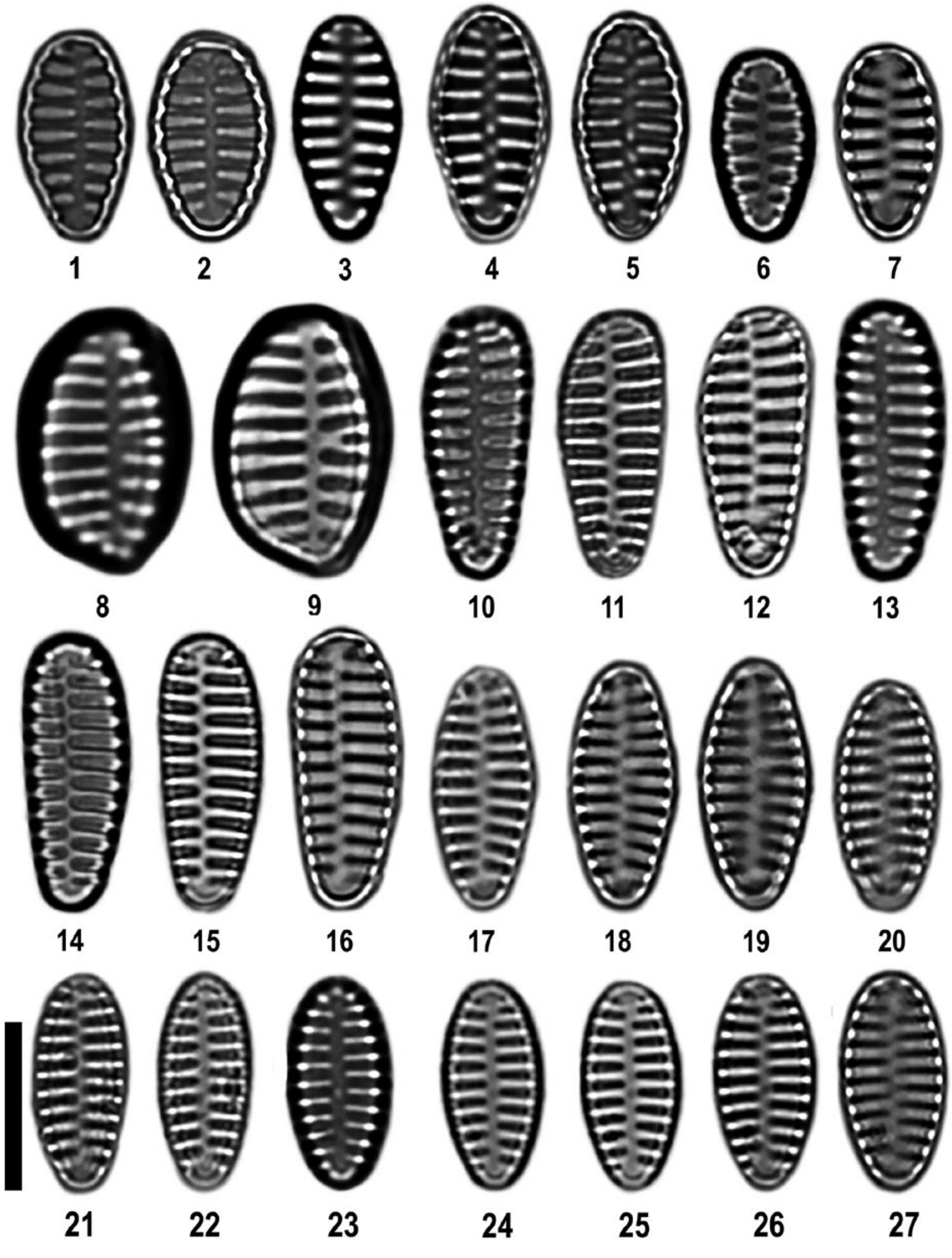

Plate 101. 1-9. *Staurosirella ovata* Morales 2006, 1-7. Eemian deposits; 8-9. Jeziorak Lake, 10-27. *Staurosirella pinnata* (Ehrenberg) Williams & Round 1987, 10-19. Eemian deposits, 20-27. Młynek Lake. Scale bar 10 µm.

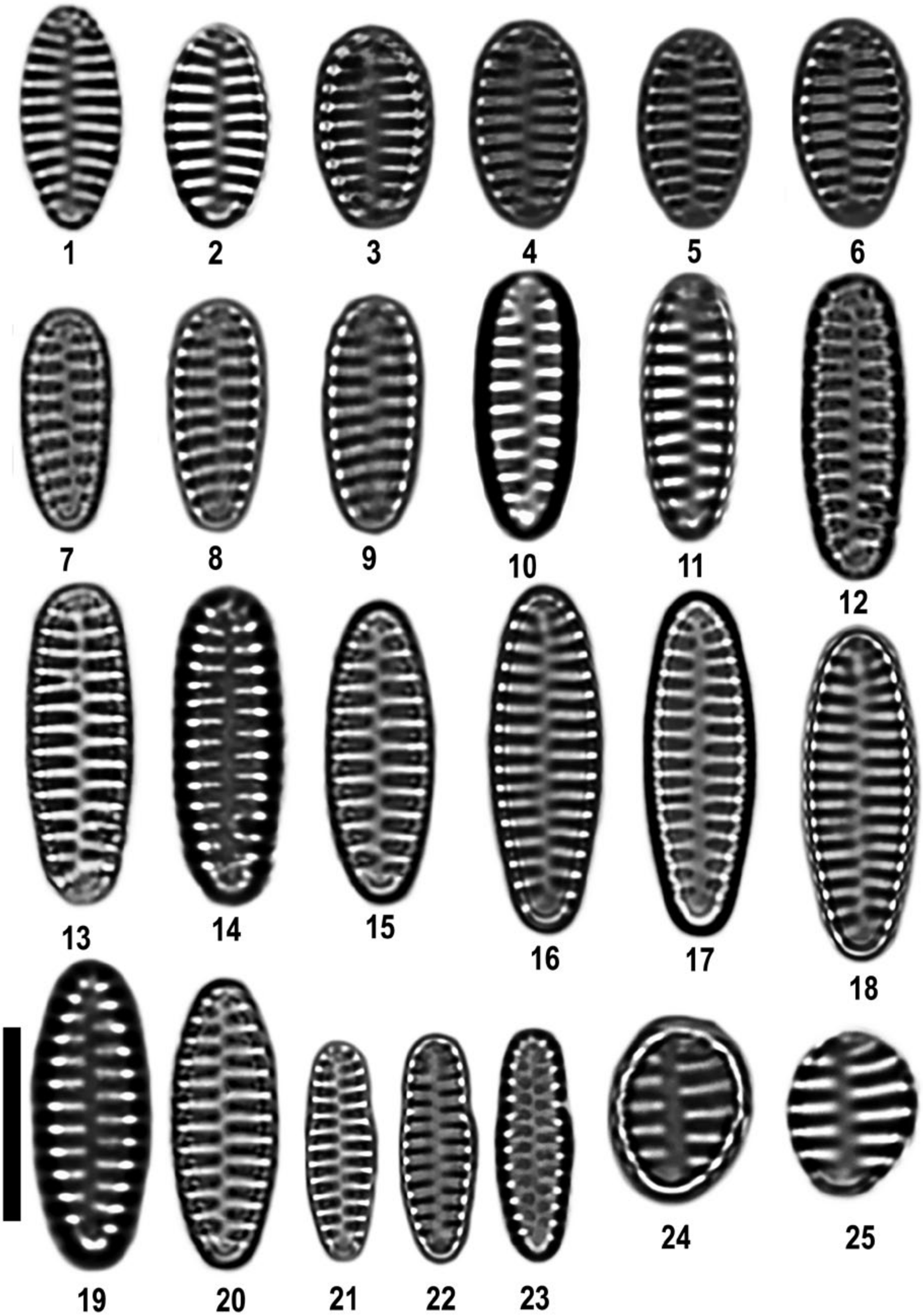

Plate 102. 1-25. *Staurosirella pinnata* (Ehrenberg) Williams & Round 1987, 24-25. Jeziorak Lake. Scale bar 10 µm.

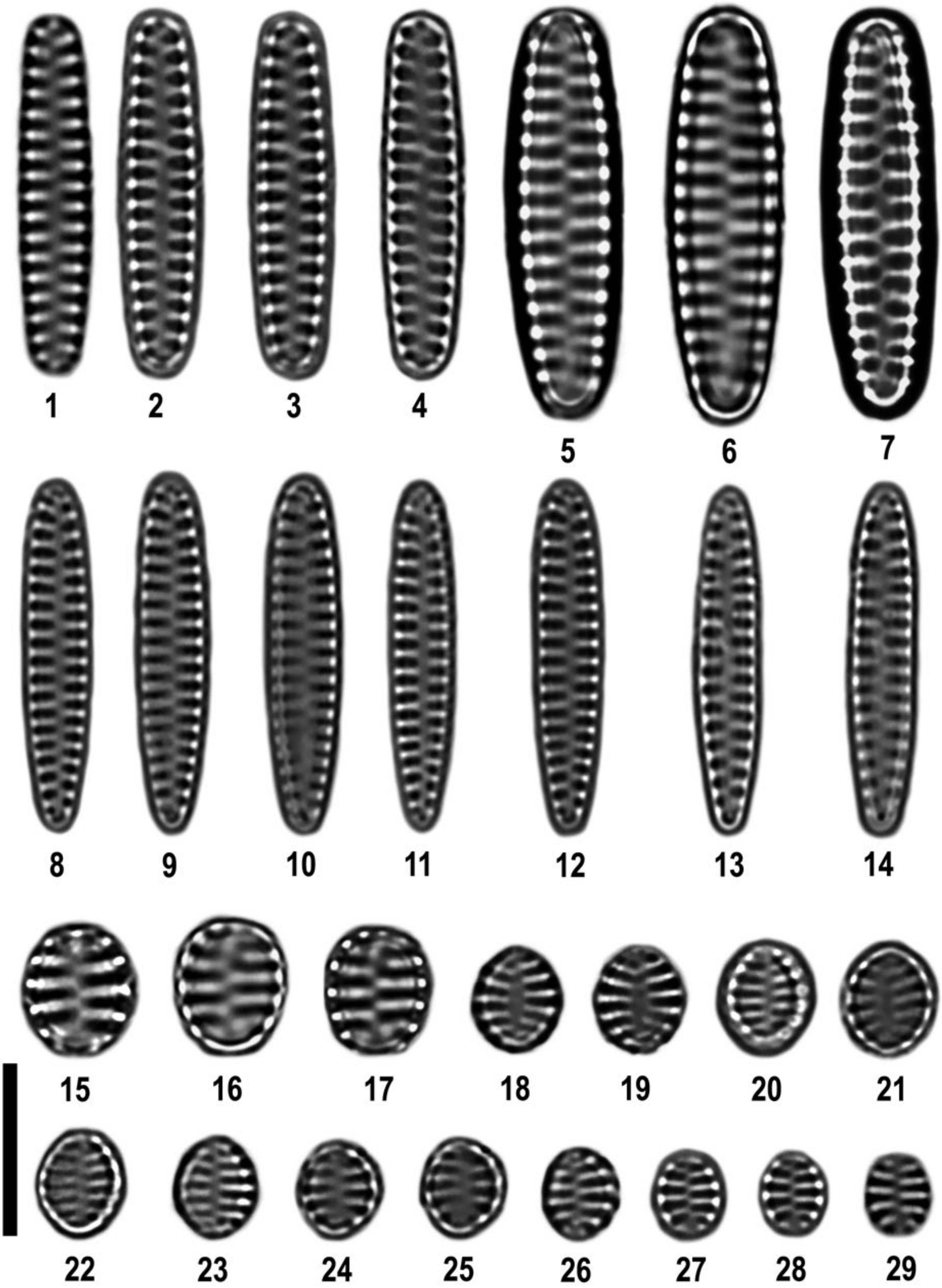

Plate 103. 1-7. *Staurosirella pinnata* var. *intercedens* (Grunow) Hamilton 1994, 1-4. Eemian deposits, 5-7. Kamionka Lake; 8-14. Staurosirella *pinnata* var. *minutissima* (Grunow) Zalat & Pidek comb. nov. Eemian deposits; 15-29. *Staurosirella pinnata* var. *subrotunda* (Mayer) Flower 2005, 15-17. Kamionka Lake, 18-29. Eemian deposits. Scale bar 10 µm.

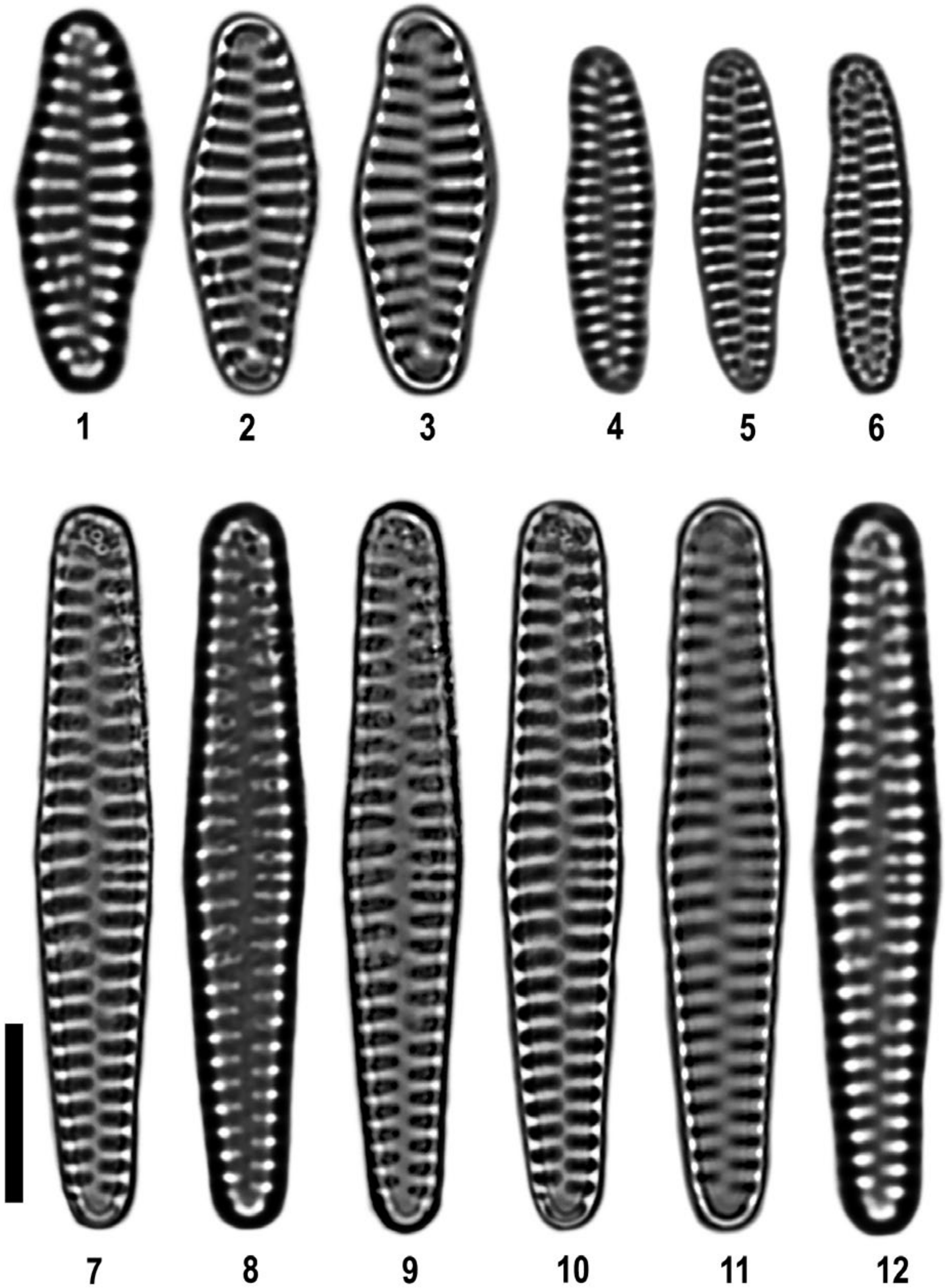

Plate 104. 1-6. *Staurosirella pinnata* var. *turgidula* (A. Cleve) Zalat & Chodyka comb. nov., 1-3. Eemian deposits, 4-6. Młynek Lake; 7-12. *Staurosirella pinnata* var. *ventriculosa* (Schumann) Zalat & Nitychoruk comb. nov. Jeziorak Lake. Scale bar 10 µm.

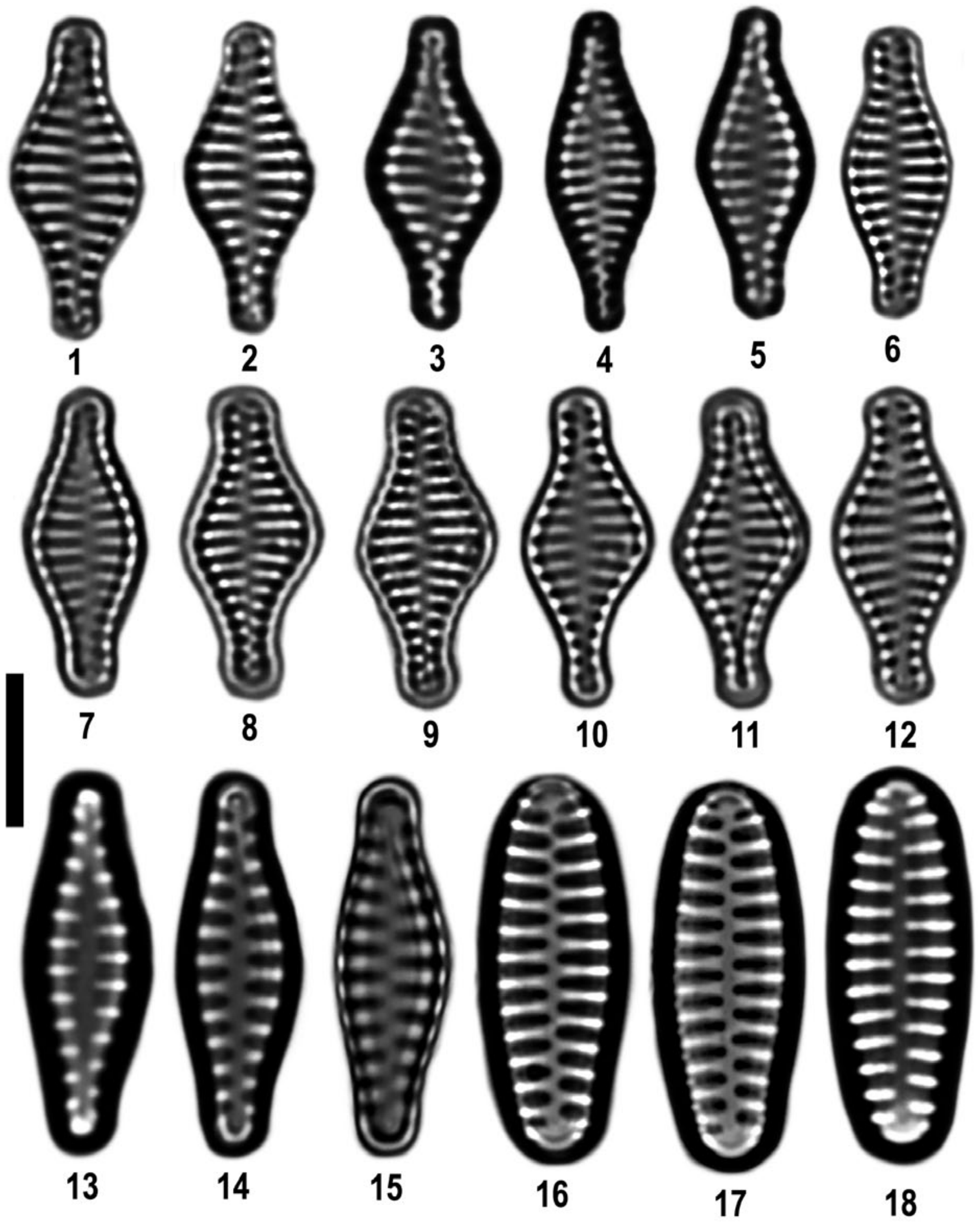

Plate 105. 1-12. *Staurosirella rhomboides* (Grunow) Morales & Manoylov 2010, 1-4. Młynek Lake, 5-12. Kamionka lake; 13-15. *Staurosirella spinosa* (Skvortsov) Kingston 2000, Jeziorak Lake; 16-18. *Staurosirella subrobusta* Morales 2006, Eemian deposits. Scale bar 10 µm.

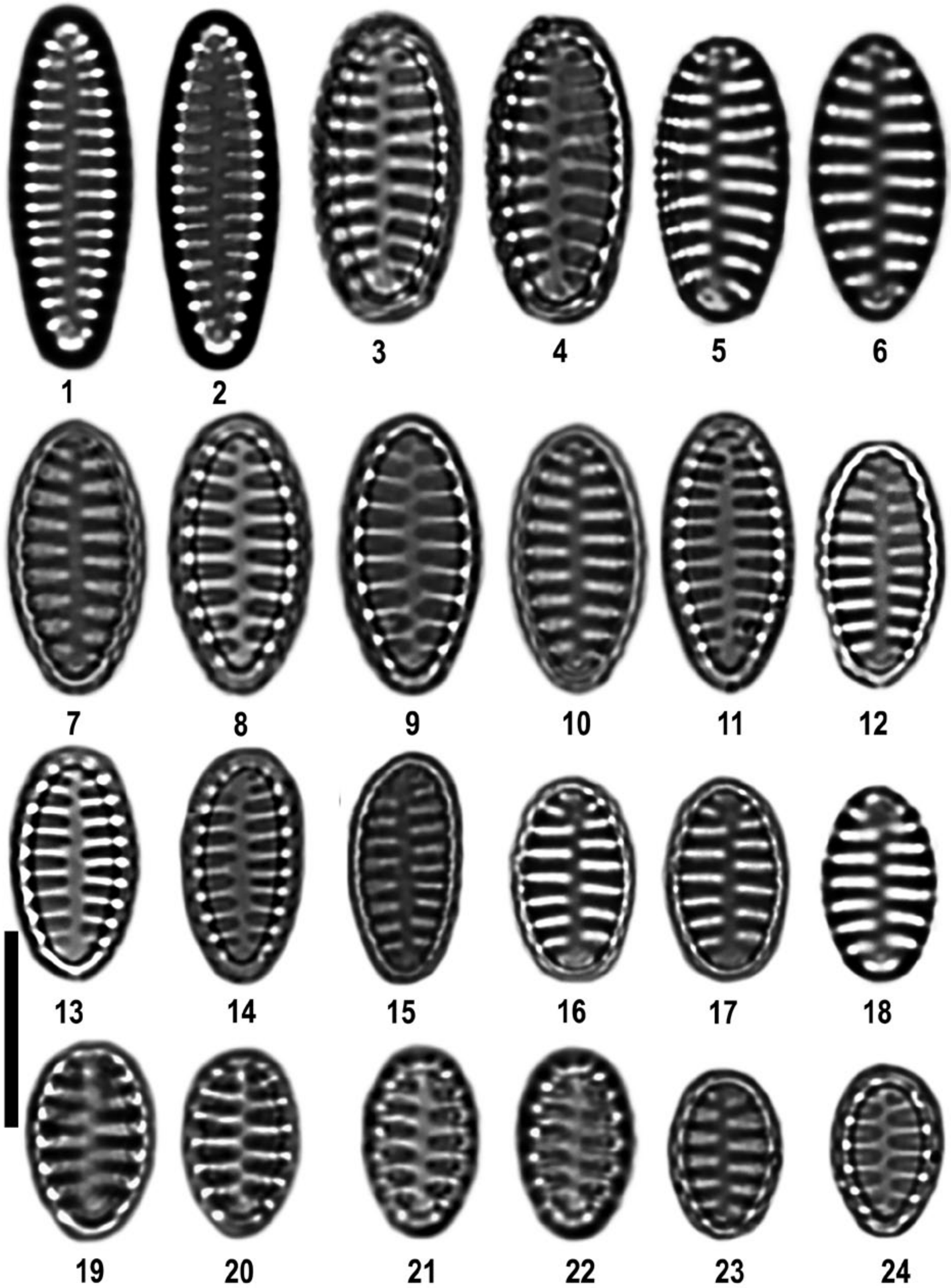

Plate 106. 1-24. *Staurosirella subrobusta* Morales 2006, 1-5. Kamionka Lake, 6-12. Młynek Lake, 13-18. Radomno Lake, 19-24. Kamionka Lake. Scale bar 10 µm.

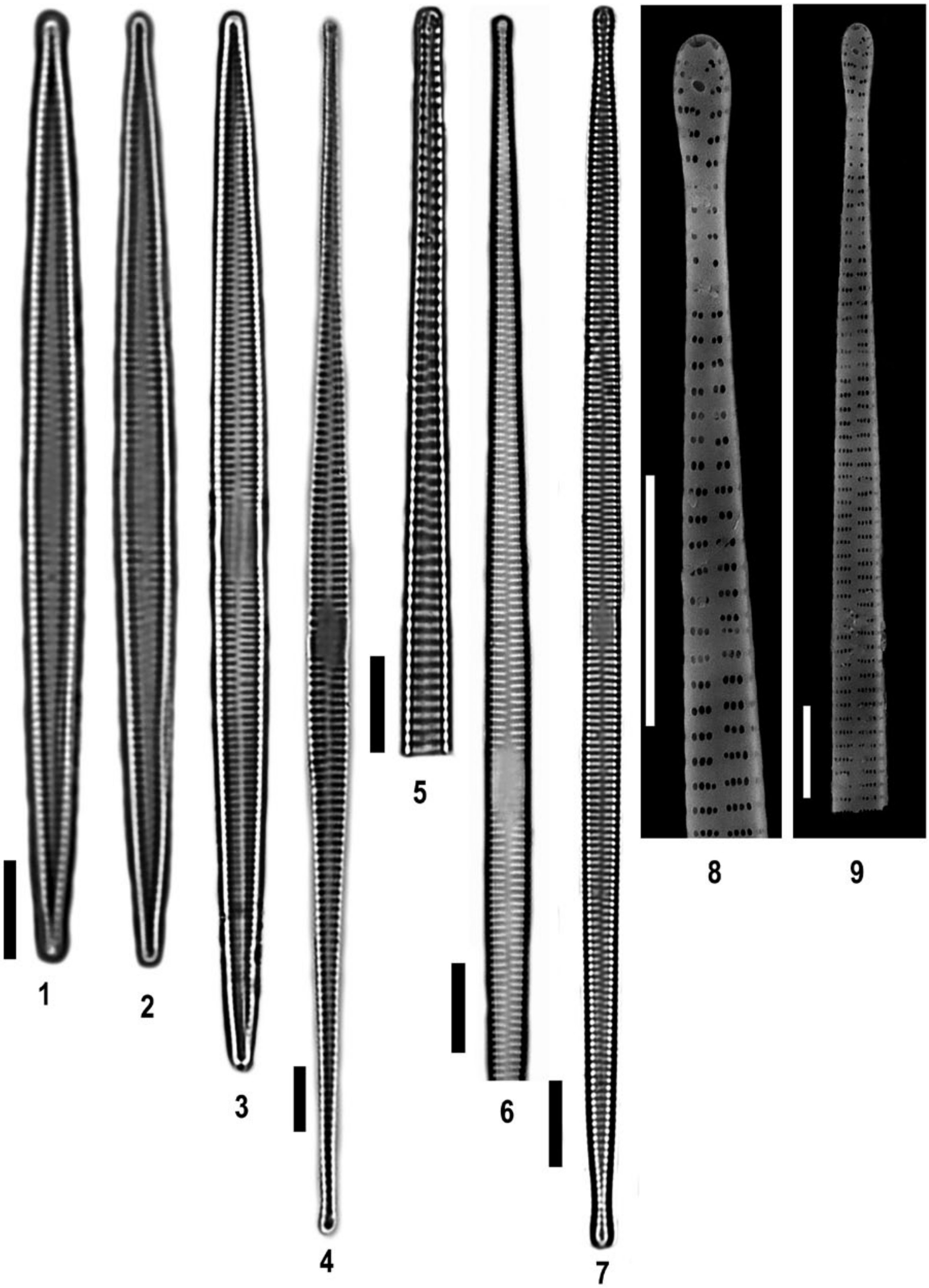

Plate 107. 1-6. *Ulnaria acus* (Kützing) Aboal in Aboal et al. 2003, 1-3. Eemian deposits, 4-5. Młynek Lake, 6. Radomno Lake; 7-9. *Ulnaria amphirhynchus* (Ehrenberg) Compère & Bukhtiyarova 2006, Radomno Lake. Scale bar 10 µm.

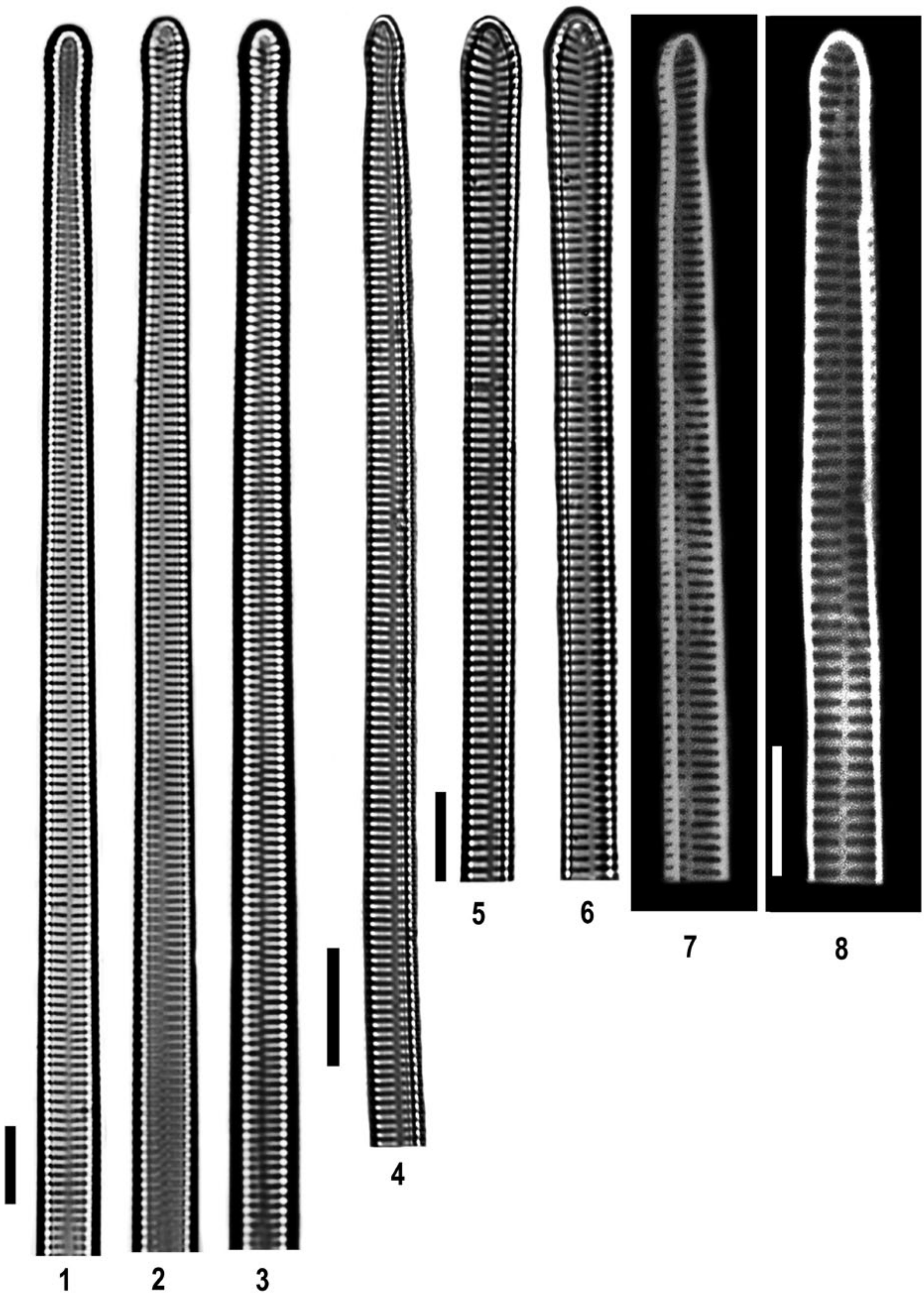

Plate 108. 1-8. *Ulnaria biceps* (Kützing) Compère 2001, 1-4. Radomno Lake, 5-6. Młynek Lake, 7-8 SEM micrograph, Radomno Lake. Scale bar 10 µm.

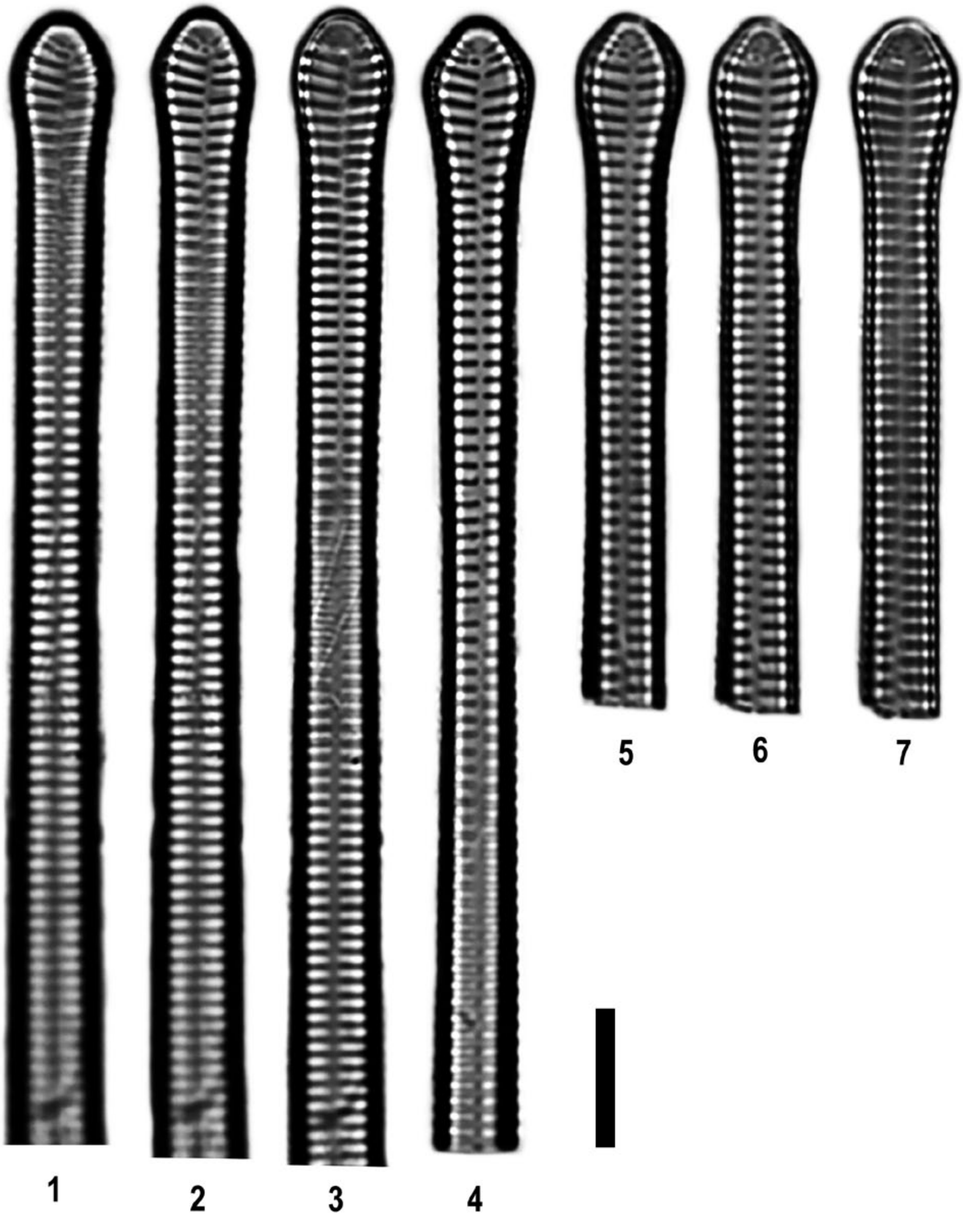

Plate 109. 1-7. *Ulnaria biceps* (Kützing) Compère 2001, Eemian deposits. Scale bar 10 µm.

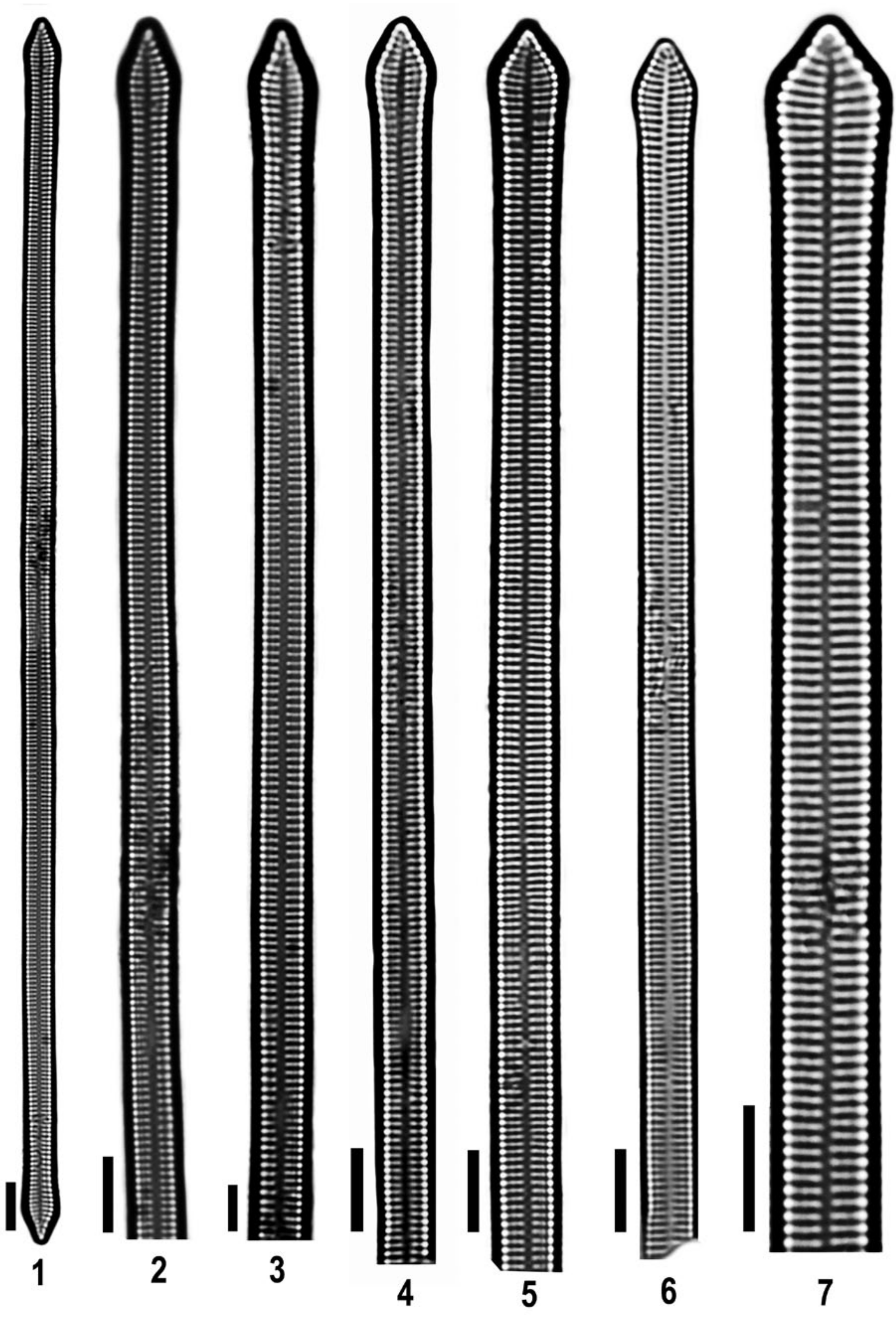

Plate 110. 1-7. *Ulnaria capitata* (Ehrenberg) Compère 2001, 1-5. Radomno Lake, 6-7. Jeziorak Lake. Scale bar 10 µm.

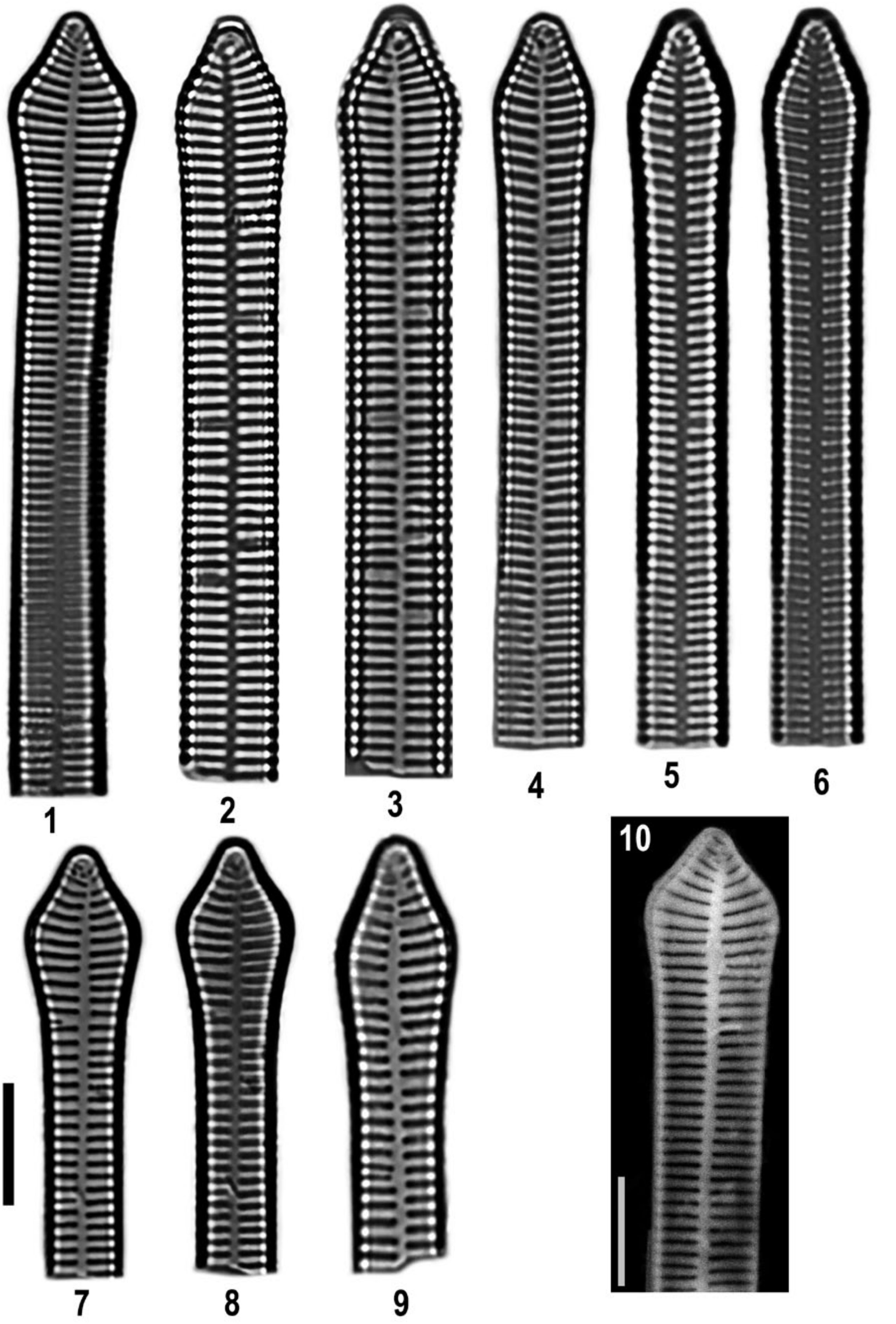

Plate 111. 1-10. *Ulnaria capitata* (Ehrenberg) Compère 2001, 1, 7-9. Eemian deposits, 2-3. Jeziorak Lake, 4-6, 10. Radomno Lake. Scale bar 10 µm.

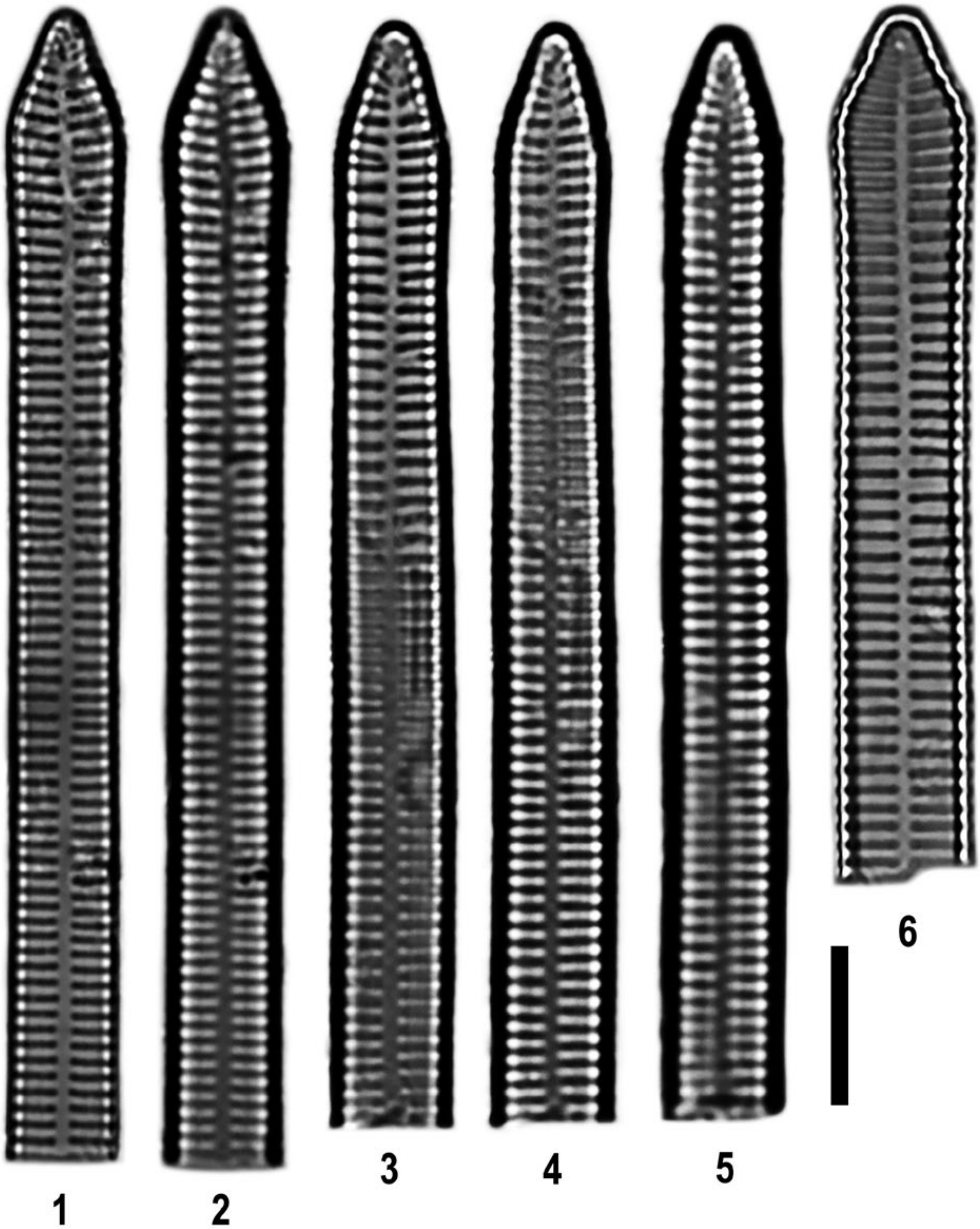

Plate 112. 1-6. *Ulnaria capitata* var. *cuneata* (Poretzky ex Proschkina-Lavrenko) Compère & Bukhtiyarova 2006, Eemian deposits. Scale bar 10 µm.

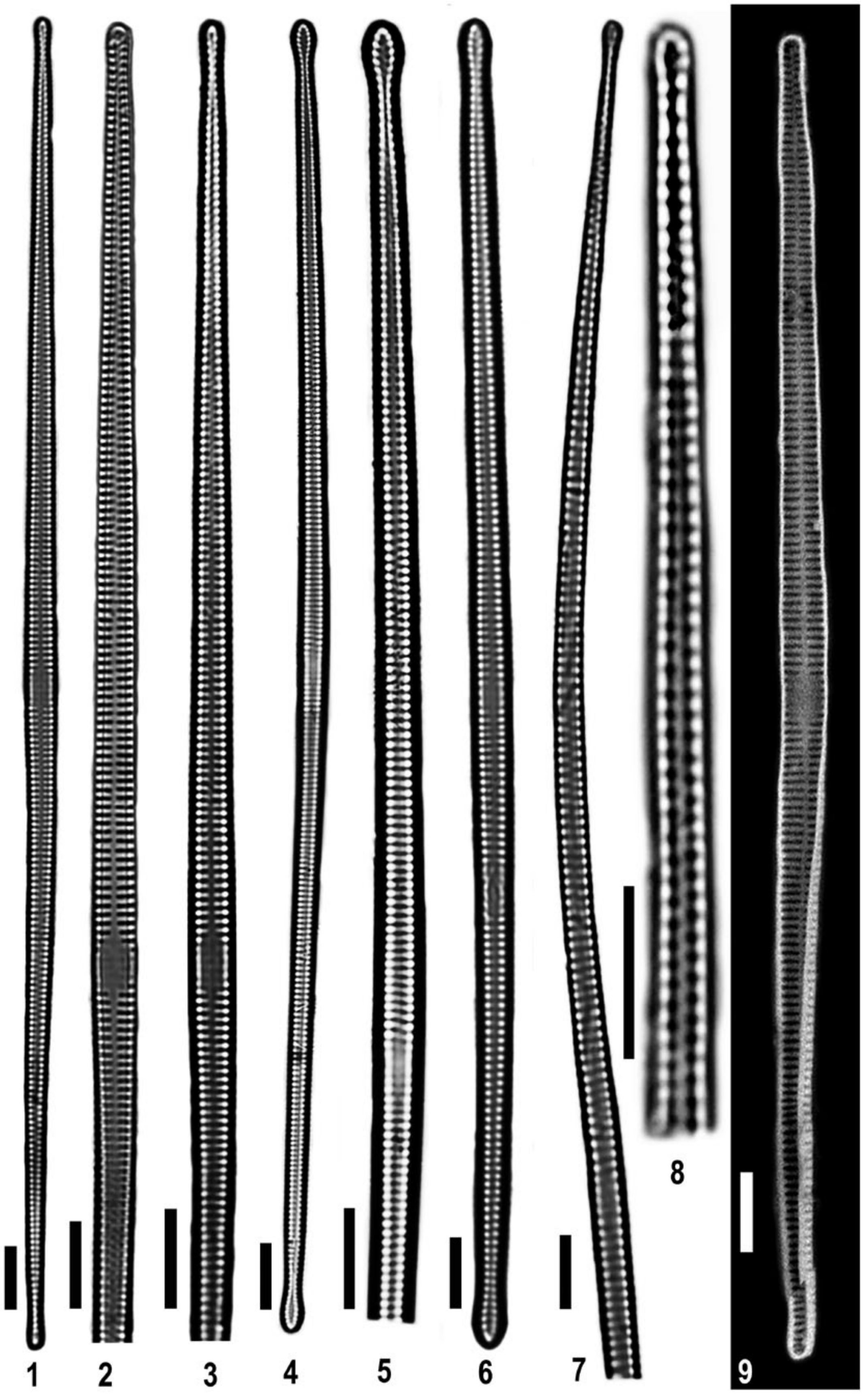

Plate 113. 1-9. *Ulnaria danica* (Kützing) Compère & Bukhtiyarova 2006, 1-3, 9. Młynek Lake, 4-6. Radomno Lake, 7-8. Eemian deposits. Scale bar 10 µm.

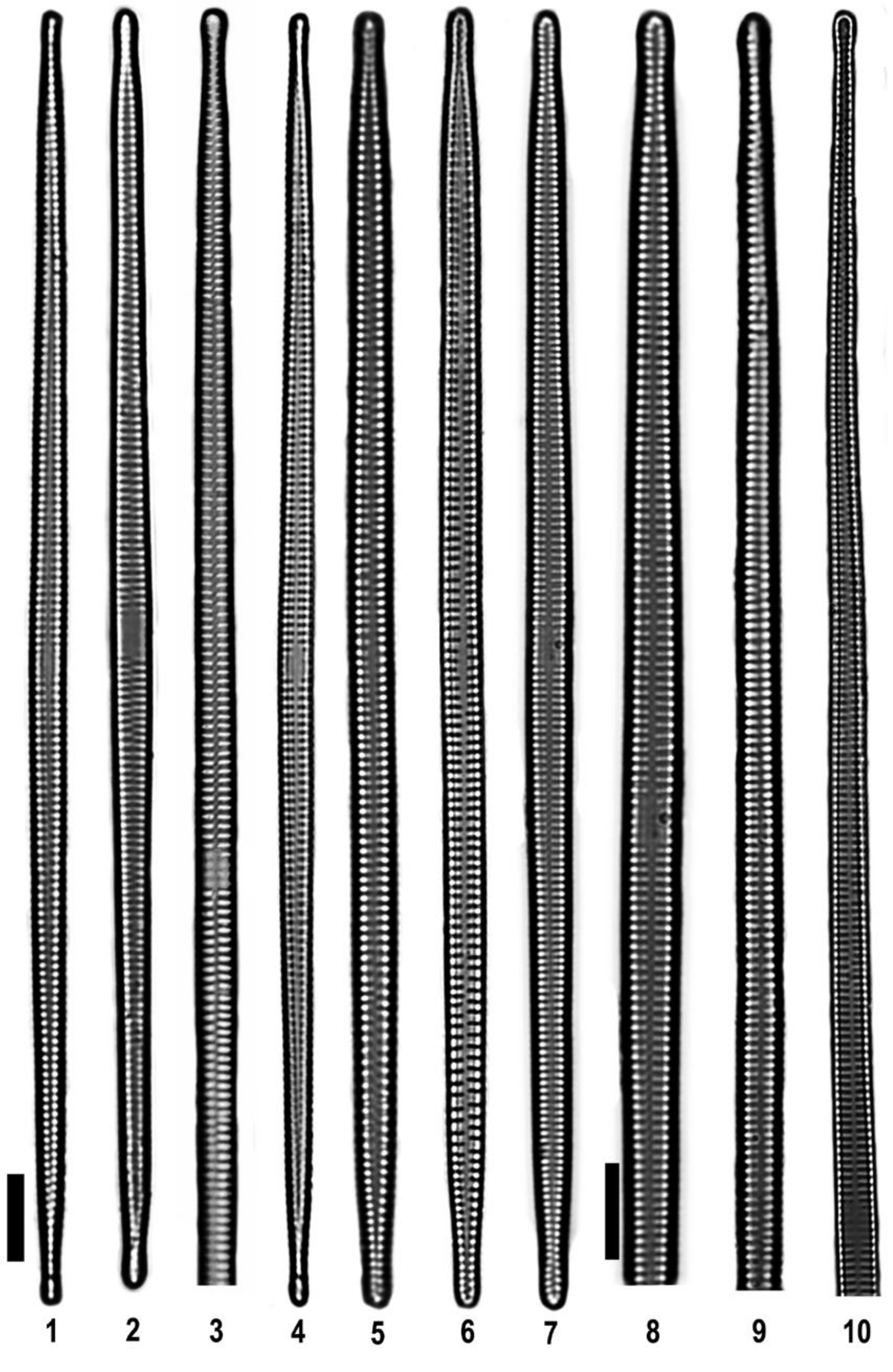

Plate 114. 1-9. *Ulnaria delicatissima* (W. Smith) Aboal & Silva 2004, 1-6. Radomno Lake;7-8. Jeziorak Lake, 9. Eemian deposits; 10. *Ulnaria delicatissima* var. *angustissima* (Grunow) Aboal & Silva 2004, Młynek Lake. Scale bar 10 µm.

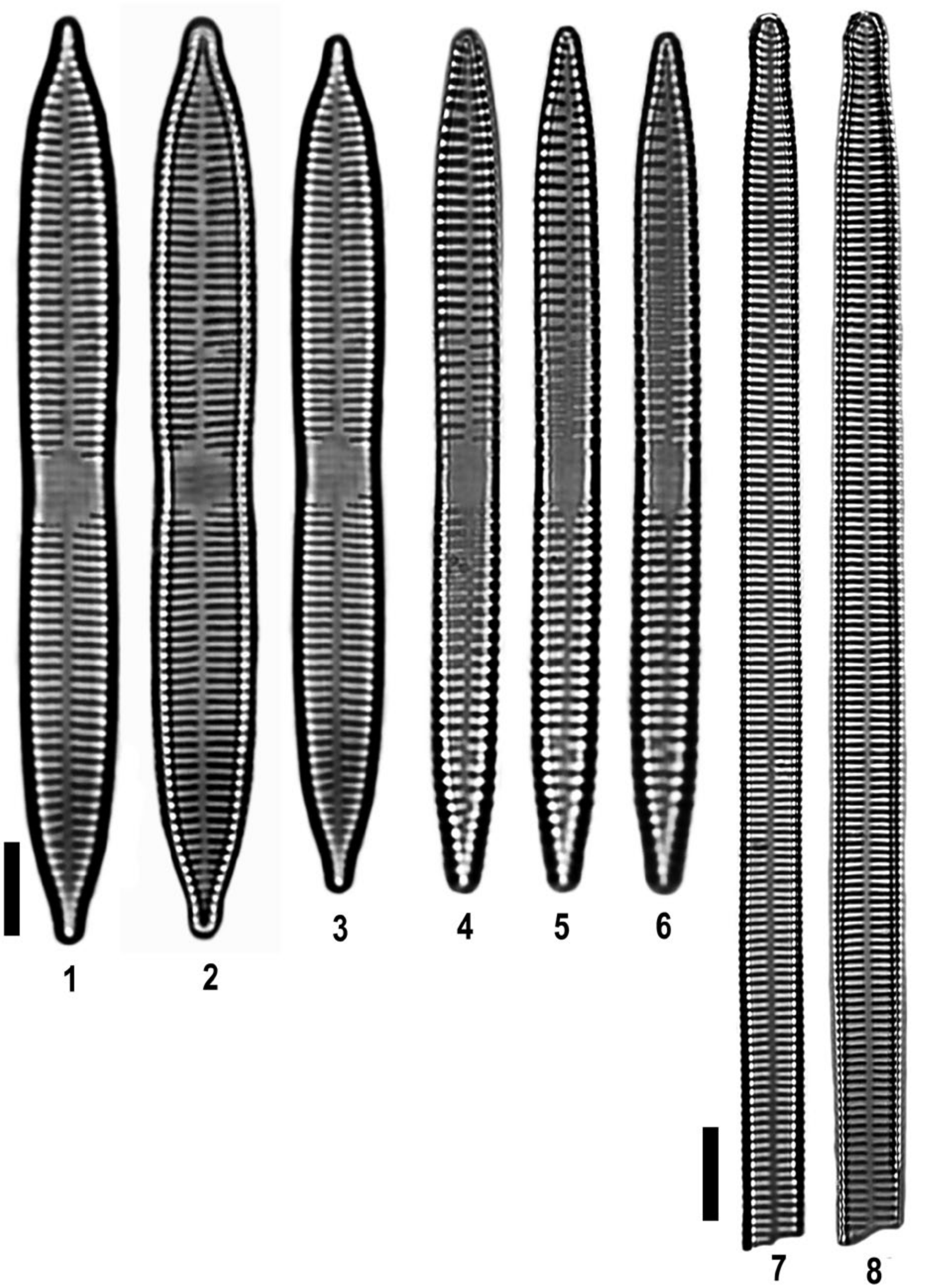

Plate 115. 1-3. *Ulnaria contracta* (Østrup) Morales & Vis 2007, Eemian deposits; 4-6. *Ulnaria oxyrhynchus* (Kützing) Aboal in Aboal et al. 2003, Radomno Lake; 7-8. *Ulnaria sinensis* Liu & Williams 2017, Radomno Lake. Scale bar 10 µm.

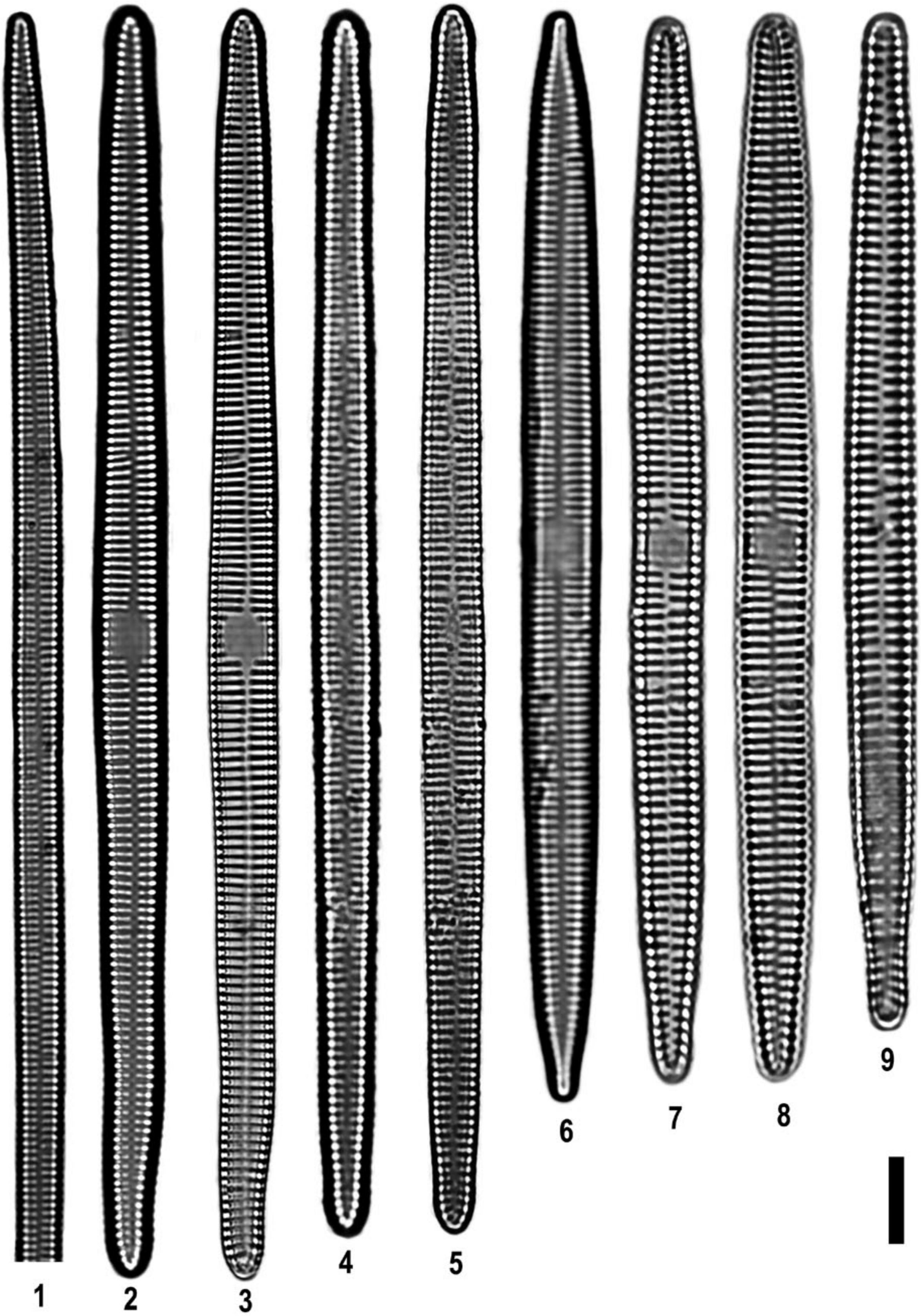

Plate 116. 1-9. *Ulnaria ulna* (Nitzsch) Compère 2001, 1-2. Młynek Lake, 3-9. Radomno Lake. Scale bar 10 μm.

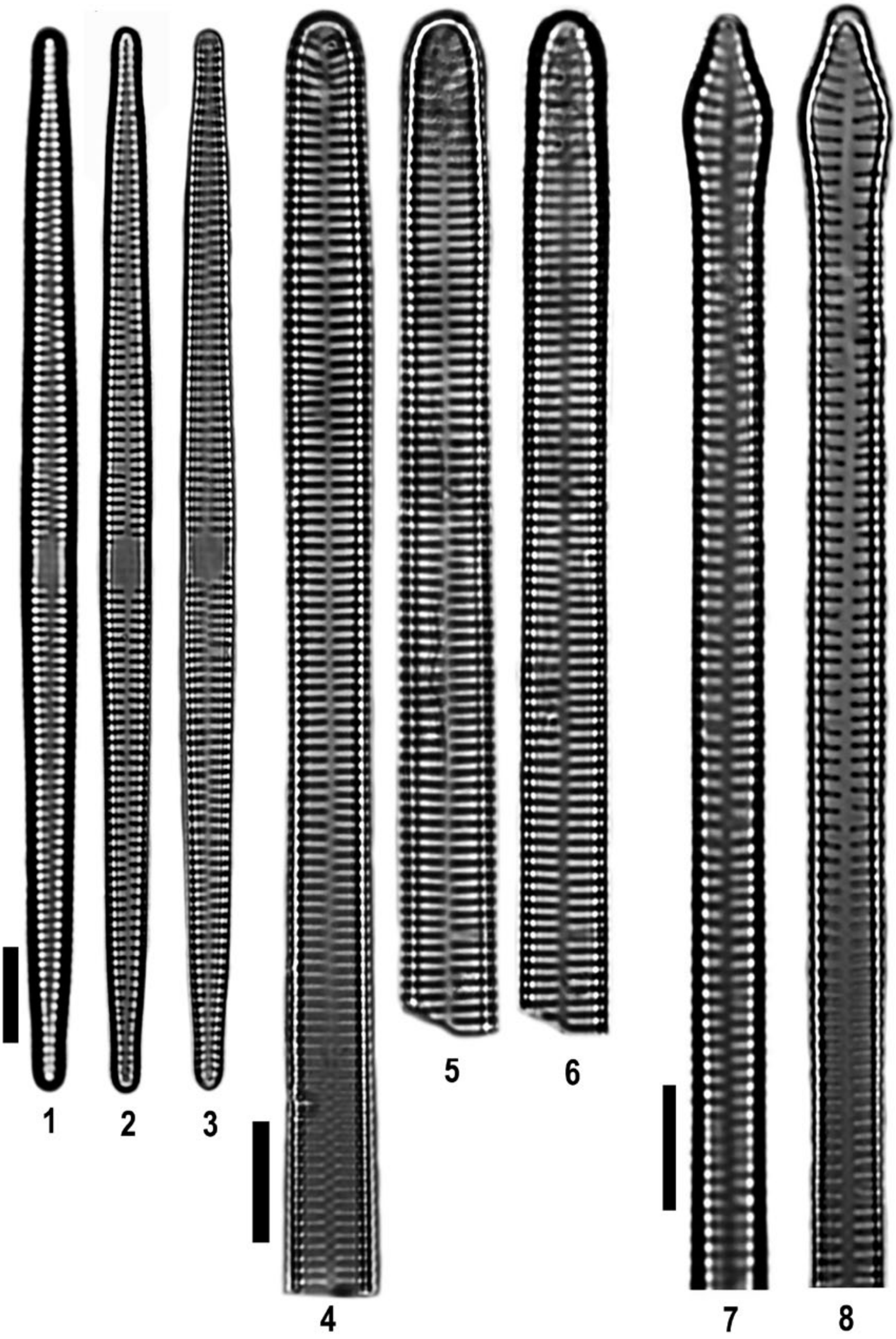

Plate 117. 1-3. *Ulnaria ulna* (Nitzsch) Compère 2001, Radomno Lake; 4-6. *Ulnaria ulna* var. *aequalis* (Kützing) Aboal in Aboal et al. 2003, Eemian deposits; 7-8. *Ulnaria ulna* var. *spathulifera* (Grunow) Aboal in Aboal et al. 2003, Radomno Lake. Scale bar 10 µm.

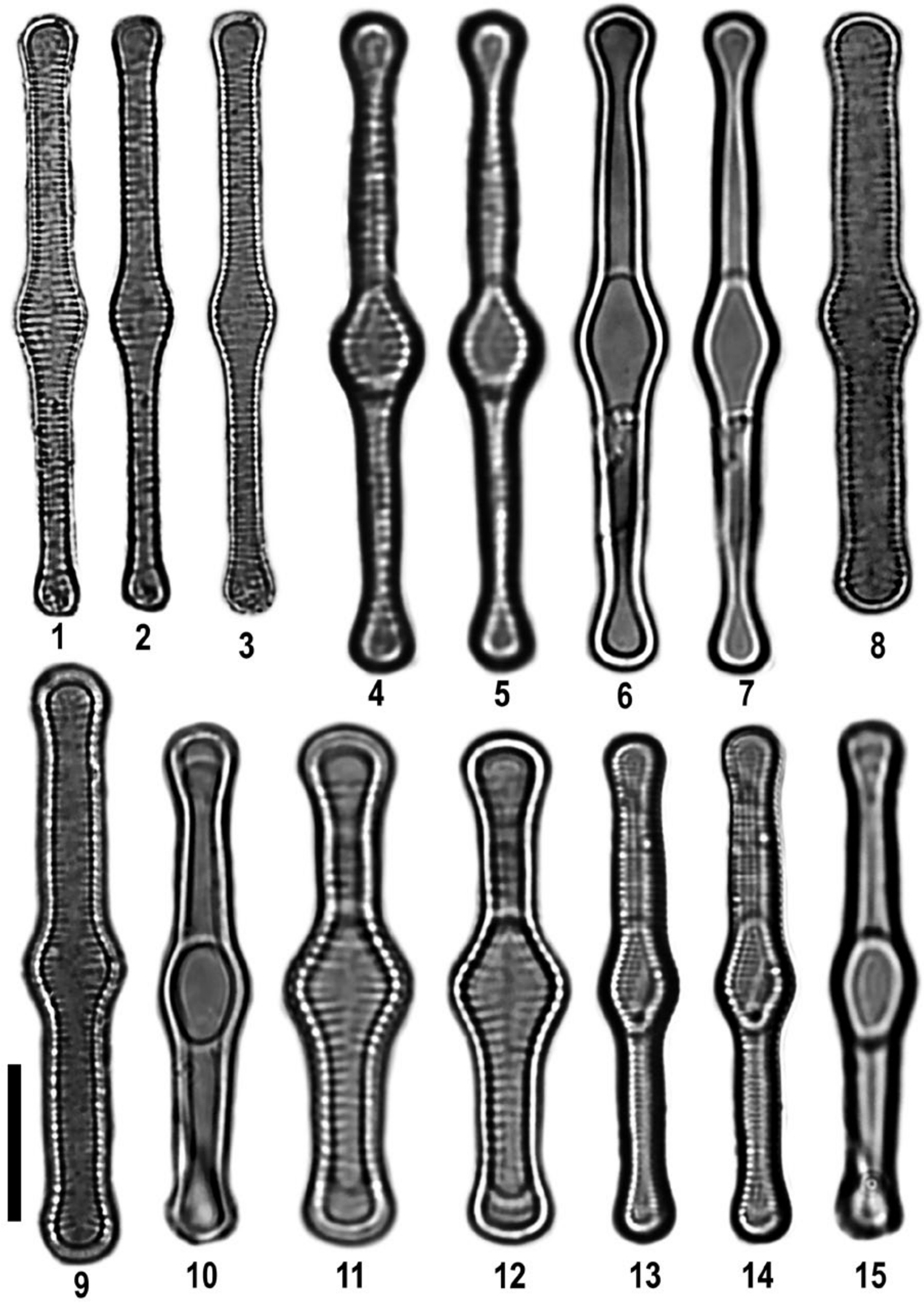

Plate 118. 1-3. *Tabellaria fenestrata* (Lyngbye) Kützing 1844, Kamionka Lake; 4-15. *Tabellaria flocculosa* (Roth) Kützing 1844, 4-12. Kamionka Lake, 1315. Młynek Lake. Scale bar 10 µm.

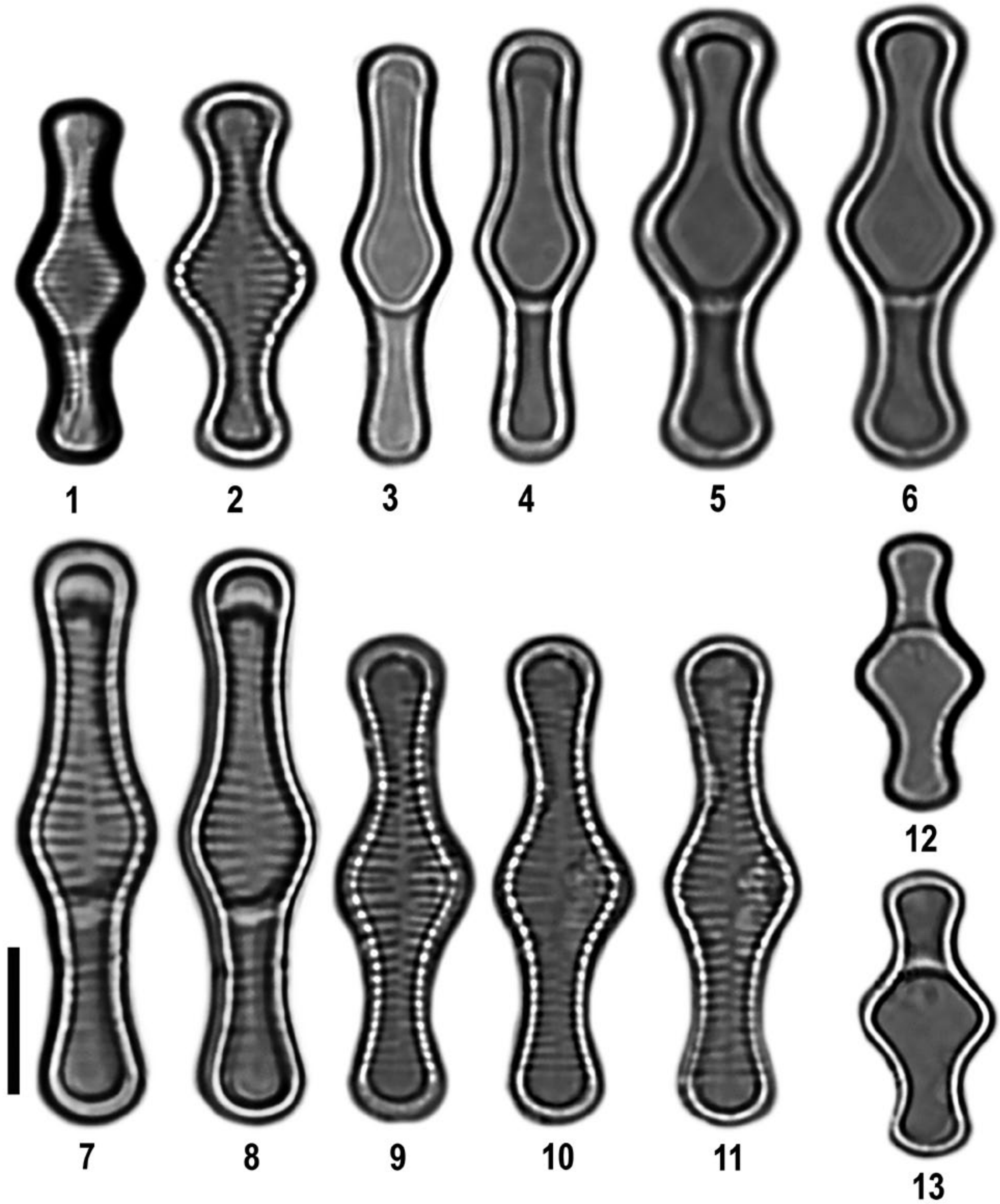

Plate 119.1-13. *Tabellaria flocculosa* (Roth) Kützing 1844, 1. Jeziorak Lake, 2-6. Kamionka Lake, 7-13. Eemian deposits. Scale bar 10 µm.

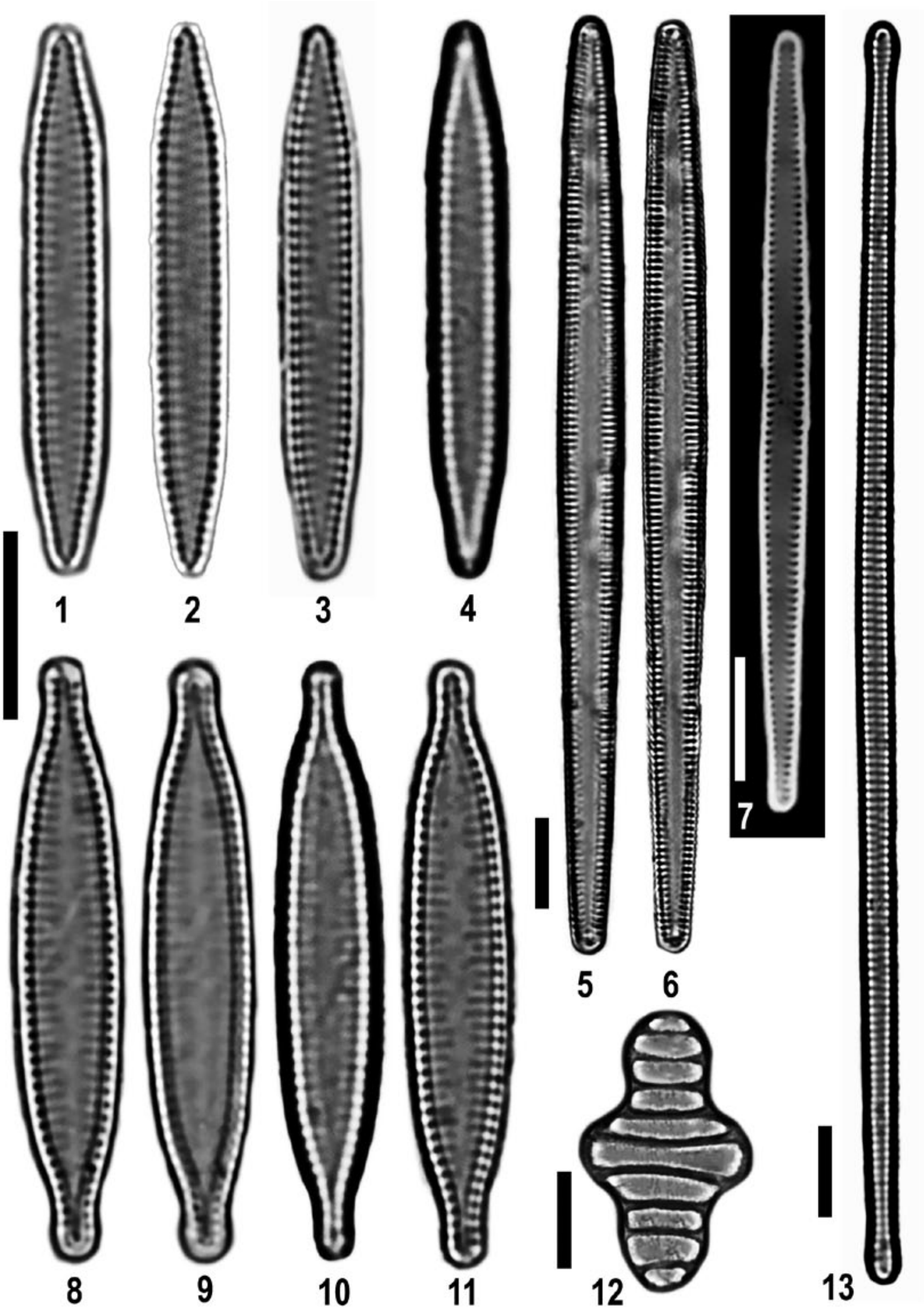

Plate 120. 1-4. *Tabularia chandolensis* (Gandhi) Vigneswaran, Williams & Karthick 2020, Eemian deposits; 5-7. *Tabularia fasciculata* (Agardh) Williams & Round 1986, 5-6. Kamionka Lake, 7. Radomno Lake; 8-11. *Tabularia fonticola* (Hustedt) Wetzel & Williams in Vigneshwaran et al. 2020, Mlynek Lake; 12. *Tetracyclus glans* (Ehrenberg) Mills 1935, Eemian deposits; 13. *Williamsella angusta* Graeff, Kociolek & Rushforth 2013, Eemian deposits. Scale bar 10 µm.

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- *Aulacoseira agassizii* (Ostenfeld) Simonsen 1979
- *Aulacoseira alpigena* (Grunow) Krammer 1990
- *Aulacoseira ambigua* (Grunov) Simonsen 1979
- *Aulacoseira canadensis* (Hustedt) Simonsen 1979
- *Aulacoseira crassipunctata* Krammer 1991
- *Aulacoseira crenulata* (Ehrenberg) Thwaites 1848
- *Aulacoseira distans* (Ehrenberg) Simonsen 1979
- *Aulacoseira granulata* (Ehrenb.) Simonsen 1979
- *Aulacoseira granulata* var. *angustissima* (O. Müller) Simonsen 1979
- *Aulacoseira humilis* (Cleve) Genkal & Trifonova in Trifonova & Genkal 2001
- *Aulacoseira islandica* (O. Müller) Simonsen 1979
- *Aulacoseira italica* (Ehrenberg) Simonsen 1979
- *Aulacoseira lacustris* (Grunow) Krammer 1991
- *Aulacoseira lirata* (Ehrenberg) Ross in Hartley 1986
- *Aulacoseira muzzanensis* (Meister) Krammer 1991
- *Aulacoseira pfaffiana* (Reinsch) Krammer 1991
- *Aulacoseira pseudomuzzanensis* Olszynski & Zelazna-Wieczorek 2018
- *Aulacoseira subarctica* (O. Müller) Haworth 1988
- *Aulacoseira valida* (Grunow) Krammer 1991

Angusticopula Houk, Klee & Tanaka 2017
- *Angusticopula dickiei* (Thwaites) Houk, Klee & Tanaka 2017

Melosira Agardh 1824
- *Melosira lineata* (Dillwyn) Agardh 1824
- *Melosira moniliformis* (O. Müller) Agardh 1824
- *Melosira nummuloides* (Dillwyn) Agardh 1824
- *Melosira undulata* (Ehrenberg) Kützing 1844
- *Melosira varians* Agardh 1827
- *Melosira* sp.

Ellerbeckia Crawford 1988
- *Ellerbeckia arenaria* (Moore) Crawford 1988

Paralia Heiberg 1863
- *Paralia sulcata* (Ehrenberg) Cleve 1873

Thalassiosira P.T. Cleve 1873
- *Thalassiosira baltica* (Grunow) Ostenfeld 1901
- *Thalassiosira duostra* Pienaar 1990
- *Thalassiosira guillardii* Hasle 1978

Skeletonema Greville 1865
- *Skeletonema potamos* (Weber) Hasle in Hasle & Evensen 1976

Cyclostephanos Round in Theriot et al. 1987
- *Cyclostephanos delicatus* (Genkal) Casper & Scheffler 1990
- *Cyclostephanos dubius* (Fricke) Round in Theriot et al., 1987
- *Cyclostephanos invisitatus* (Hohn & Hellerman) Theriot et al. 1987

Cyclotella (Kützing) Brebisson 1838
- *Cyclotella atomus* Hustedt 1937
- *Cyclotella cryptica* Reimann, Lewin & Guillard 1963
- *Cyclotella cyclopuncta* Håkansson & Carter 1990
- *Cyclotella distinguenda* Hustedt 1927
- *Cyclotella distinguenda* var. *unipunctata* (Hustedt) Håkansson & Carter 1990
- *Cyclotella iris* Brun & Héribaud-Joseph in Héribaud-Joseph 1893

Cyclotella lenoblei Manguin 1949
Cyclotella meduanae Germain 1981
Cyclotella paradistinguenda Katrantsiotis & Risberg, in Katrantsiotis et al. 2016
Cyclotella planctonica Brunnthaler in Brunnthaler, Prowazek & Wettstein 1901
Discostella Houk & Klee 2004
Discostella nana (Hustedt) Chang in Chang & Chang Schneider 2008
Discostella pseudostelligera (Hustedt) Houk & Klee 2004
Discostella stelligera (Cleve & Grunow) Houk & Klee 2004
Discostella woltereckii (Hustedt) Houk & Klee 2004
Lindavia (Schutt) De Toni & Forti 1900
Lindavia affinis (Grunow) Nakov et al., 2015
Lindavia baicalensis (Skvortzow & Meyer) Nakov et al., 2015
Lindavia bodanica (Eulenstein ex Grunow) Nakov et al. 2015
Lindavia fottii (Hustedt) Nakov et al. 2015
Lindavia glomerata (Bachmann) Adesalu & Julius 2017
Lindavia khinganensis Rioual 2017
Lindavia intermedia (Manguin ex Kociolek & Reviers) Nakov et al. 2016
Lindavia praetermissa (Lund) Nakov et al. 2015
Lindavia radiosa (Grunow) De Toni and Forti 1900
Pantocsekiella Kiss & Ács 2016
Pantocsekiella comensis (Grunow) Kiss & Ács in Ács *et al.* 2016
Pantocsekiella costei (Druart & Straub) Kiss & Ács in Ács et al. 2016
Pantocsekiella delicatula (Hustedt) Kiss & Ács in Ács et al. 2016
Pantocsekiella hinziae (Houk, König & Klee) Kiss et al. 2016
Pantocsekiella iranica (Nejadsattari et al.) Kiss et al. 2016
Pantocsekiella kuetzingiana (Thwaites) Kiss & Ács 2016
Pantocsekiella ocellata (Pantocsek) Kiss & Ács 2016
Pantocsekiella paleo-ocellata (Vossel & Van de Vijver) Kiss, Ector & Ács, 2016
Pantocsekiella paraocellata (Cvetkoska et al.) Kiss & Ács 2016
Pantocsekiella polymorpha (Meyer & Håkansson) Kiss & Ács in Ács et al. 2016
Pantocsekiella pseudocomensis (Scheffler) Kiss & Ács in Ács et al. 2016
Pantocsekiella rossii (Håkansson) Kiss & Ács 2016
Puncticulata Håkansson 2002
Puncticulata balatonis (Pantocsek) Wojtal & Budzyńska 2011
Stephanocyclus Skabichevskij 1975
Stephanocyclus meneghiniana (Kützing) Skabichevskii 1975
Stephanodiscus Ehrenberg 1845
Stephanodiscus aegyptiacus Ehrenberg 1854
Stephanodiscus agassizensis Håkansson & Kling 1989
Stephanodiscus alpinus Hustedt in Huber-Pestalozzi 1942
Stephanodiscus binatus Håkansson & Kling 1990
Stephanodiscus hantzschii Grunow in Cleve & Grunow 1880
Stephanodiscus medius Håkansson 1986
Stephanodiscus minutulus (Kützing) Cleve & Möller 1882
Stephanodiscus neoastraea Hakansson & Hickel 1986
Stephanodiscus niagarae Ehrenberg 1845
Stephanodiscus niagarae var. *insuetus* Khursevich et Loginova 1986
Stephanodiscus parvus Stoermer & Håkansson 1984
Stephanodiscus rotula (Kützing) Hendey 1964
Stephanodiscus tenuis Hustedt 1939
Pleurosira (Meneghini) Trevisan 1848
Pleurosira laevis (Ehrenberg) Compère 1982
Asterionella Hassall 1850
Asterionella formosa Hassall 1850
Ctenophora Brebisson ex Kützing 1849

Ctenophora pulchella (Ralfs ex Kützing) Williams & Round 1986
Diatoma Bory 1824
Diatoma ehrenbergii Kützing 1844
Diatoma ehrenbergii f. *capitulata* (Grunow) Lange-Bertalot 1993
Diatoma moniliformis (Kützing) Williams 2012
Diatoma polonica Bąk et al., 2014
Diatoma tenuis Agardh 1812
Diatoma vulgaris Bory 1824
Diatoma vulgaris var. *linearis* Grunow in Van Heurck 1881
Fragilaria Lyngbye 1819
Fragilaria acidoclinata Lange-Bertalot & Hofmann in Lange-Bertalot 1993
Fragilaria amphicephaloides Lange-Bertalot 2013
Fragilaria austriaca (Grunow) Lange-Bertalot in Krammer & Lange-Bertalot 2000
Fragilaria capucina Desmaziéres 1830
Fragilaria cassubica Witkowski & Lange-Bertalot 1993
Fragilaria crotonensis Kitton 1869
Fragilaria distans (Grunow) Bukhtiyarova 1995
Fragilaria gracilis Østrup 1910
*Fragilaria imbramovician*a Kaczmarska 1976
Fragilaria improbula Witkowski & Lange-Bertalot 1995
Fragilaria incisa (Boyer) Lange-Bertalot 1980
Fragilaria interstincta Hohn & Hellerman 1963
Fragilaria lenoblei Manguin 1952
Fragilaria magocsyi Lacsny 1916
Fragilaria microvaucheriae Wetzel & Ector 2015
Fragilaria montana (Krasske) Lange-Bertalot 1980
Fragilaria neointermedia Tuji & Williams 2013
Fragilaria pararumpens Lange-Bertalot, Hofmann & Werum 2011
Fragilaria parva (Grunow) Tuji & Williams 2008
Fragilaria perdelicatissima Lange-Bertalot & Van de Vijver 2014
Fragilaria perminuta (Grunow) Lange-Bertalot 2000
Fragilaria radians (Kützing) Williams & Round 1987
Fragilaria recapitellata Lange-Bertalot & Metzeltin 2009
Fragilaria reicheltii (Voigt) Lange-Bertalot 1993
Fragilaria rhabdosoma Ehrenberg 1832
Fragilaria rumpens (Kützing) Carlson 1913
Fragilaria sinuata Peragallo 1909
Fragilaria spectra Almeida, Morales & Wetzel 2016
Fragilaria spinarum Lange-Bertalot & Metzeltin 1996
Fragilaria subconstricta Østrup 1910
Fragilaria taiaensis Carter & Denny 1982
Fragilaria tenera (W. Smith) Lange-Bertalot 1980
Fragilaria tenera var. *nanana* (Lange-Bertalot) Lange-Bertalot & Ulrich 2014
Fragilaria vaucheriae (Kützing.) Petersen 1938
Fragilaria vaucheriae var. *continua* (Cleve-Euler) Cleve-Euler, 1953
Fragilariforma Williams & Round 1987
Fragilariforma bicapitata (Mayer) Williams & Round 1988
Fragilariforma constricta (Ehrenberg) Williams & Round 1988
Fragilariforma hungarica (Pantocsek) Hamilton in Hamilton et al. 1992
Fragilariforma mesolepta (Hustedt) Kharitonov 2005
Fragilariforma nitzschioides (Grunow) Lange-Bertalot in Hofmann et al. 2011
Fragilariforma virescens (Ralfs) Williams & Round 1987
Hannaea Patrick 1966
Hannaea arcus (Ehrenberg) Patrick 1966

Martyana Round 1990
Martyana schulzii (Brockmann) Snoeijs 1991
Meridion Agardh 1824
Meridion circulare (Greville) Agardh 1831
Meridion constrictum Ralfs 1843
Nanofrustulum Round, Hallsteinsen & Paasche 1999
Nanofrustulum krumbeinii (Witkowski, Witak & Stachura) Morales 2019
Nanofrustulum sopotense (Witkowski & Lange-Bertalot) Morales, Wetzel & Ector 2019
Nanofrustulum trainori (Morales) Morales 2019
Odontidium Kützing 1844
Odontidium anceps (Ehrenberg) Ralfs in Pritchard 1861
Odontidium hyemale (Roth) Kützing 1844
Odontidium mesodon (Kützing) Kützing 1849
Opephora Petit 1888
Opephora marina (Gregory) Petit 1888
Opephora olsenii Möller 1950
Pseudostaurosira Williams & Round 1987
Pseudostaurosira americana Morales 2005
Pseudostaurosira bardii Beauger, Wetzel & Ector in Beauger et al., 2018
Pseudostaurosira borealis (Foged) García, Morales, Ector & Maidana 2017
Pseudostaurosira brevistriata (Grunow) Williams et Round 1987
Pseudostaurosira brevistriata var. *capitata* (Héribaud) Andresen et al., 2000
Pseudostaurosira brevistriata var. *inflata* (Pantocsek) Edlund 1994
Pseudostaurosira brevistriata var. *nipponica* (Skvortsov) Kobayasi in Mayama et al. 2002
Pseudostaurosira brevistriata var. *papillosa* (A. Cleve) Zimmerman, Poulin & Pierritz 2010
Pseudostaurosira brevistriata var. *trigibba* (Pantocsek) Haworth & Kelly 2002
Pseudostaurosira brevistriata var. *turgida* (Pantocsek) Haworth & Kelly 2002
Pseudostaurosira brevistriata var. *vidarbhens*is (Sarode & Kamat) Zalat & Pidek comb. nov.
Pseudostaurosira bronkei (Witkowski, Lange-Bertalot & Metzeltin) Wetzel & Morales 2019
Pseudostaurosira clavatum Morales 2002
Pseudostaurosira decipiens Morales, Chávez & Ector 2012
Pseudostaurosira elliptica (Schumann) Edlund, Morales & Spaulding 2006
Pseudostaurosira floweri Morales in Garcia et al. 2017
Pseudostaurosira laucensis (Lange-Bertalot & Rumrich) Morales & Vis 2007
Pseudostaurosira linearis (Pantocsek) Morales, Buczkó & Ector, 2019
Pseudostaurosira marciniakae Ector, Morales, Wetzel in. Morales et al. 2019
Pseudostaurosira microstriata (Marciniak) Flower 2005
*Pseudostaurosira neoelliptic*a (Witkowski) Morales 2002
Pseudostaurosira oliveraiana Grana, Morales, Maidana & Ector, 2018
Pseudostaurosira parasitica (W. Smith) Morales in Morales & Edlund 2003
Pseudostaurosira parasitoides (Lange-Bertalot, Schmidt & Klee) Morales,
Pseudostaurosira perminuta (Grunow) Sabbe & Wyverman 1995
Pseudostaurosira polonica (Witak & Lange-Bertalot) Morales & Edlund 2003
Pseudostaurosira quasielliptica Witkowski, Riaux-Gobin, Daniszewska- Kowalczyk 2010
Pseudostaurosira robusta (Fusey) Williams & Round 1987
Pseudostaurosira sajamaensis Morales & Ector in Morales et al. 2012
Pseudostaurosira subconstricta (Grunow) Kulikovskiy & Genkal 2011
Pseudostaurosira versiformae Witkowski, Riaux-Gobin & Daniszewska- Kowalczyk 2010
Punctastriata Williams & Round 1987
Punctastriata glubokoensis Williams, Chudaev & Gololobova 2009
Punctastriata lancettula (Schumann) Hamilton & Siver 2008
Punctastriata linearis Williams & Round 1988
Punctastriata mimetica Morales 2005
Punctastriata ovalis Williams & Round 1988

Stauroforma Flower, Jones & Round 1996
- *Stauroforma atomus* (Hustedt) Talgatti, Wetzel, Morales & Torgan 2014
- *Stauroforma exiguiformis* (Lange-Bertalot) Flower, Jones & Round 1996
- *Stauroforma reimeri* (Morales, Manoylov & Bahls) Morales in Garcia et al. 2017

Staurosira Ehrenberg 1843
- *Staurosira aventralis* Lange-Bertalot & Rumrich, 2000
- *Staurosira berolinensis* (Lemmerman) Lange-Bertalot 2000
- *Staurosira binodis* (Ehrenberg) Lange-Bertalot in Hofmann et al., 2011
- *Staurosira circula* Van de Vijver & Beyens 2002
- *Staurosira construens* Ehrenberg 1843
- *Staurosira construens* var. *asymmetri*ca (A. Cleve) Zalat & Welc comb. nov.
- *Staurosira construens* var. *baltalensi*s (Gandhi, Vora & Mohan) Zalat & Nitychoruk comb. nov.
- Staurosira construens var. exigua (W. Smith) Kobayasi 2002
- *Staurosira construens* var. *nipponica* (Skvortsov) Zalat & Welc comb. nov.
- *Staurosira construens* var. *pumila* (Grunow) Kingston 2000
- *Staurosira construens* var. *triundulata* (Reichelt) Bukhtiyarova 1995
- *Staurosira* aff. *contorta* Flower 2005
- *Staurosira dimorpha* Morales, Edlund & Spaulding 2010
- *Staurosira incerta* Morales 2006
- *Staurosira inflat*a (Heiden) Rusanov, Ács, Morales & Ector in Rusanov et al. 2018
- *Staurosira inflata* var. *istvanffy*i (Hustedt) Zalat & Nitychoruk comb. nov.
- *Staurosira leptostauron* (Ehrenberg) Kulikovskiy & Genkal in Kulikovskiy et al. 2011
- *Staurosira longwanensis* Rioual, Morales & Ector 2014
- *Staurosira neoproducta* (Lange-Bertalot) Chudaev & Gololobova 2012
- *Staurosira pottiezii* Van de Vijver 2014
- *Staurosira pseudoconstruens* (Marciniak) Lange-Bertalot 2000
- *Staurosira pseudoconstruens* var. *bigibba* (Marciniak) Zalat & Chodyka comb. nov.
- *Staurosira subsalina* (Hustedt) Lange-Bertalot in Krammer & Lange-Bertalot 2004
- *Staurosira sviridae* Kulikovskiy, Genkal & Mikheeva 2011
- *Staurosira sviridae* var. *rostrat*a Zalat nov. var.
- *Staurosira vandenbusscheana* Van de Vijver in Van de Vijver et al., 2020
- *Staurosira venter* (Ehrenberg) Cleve & Möller 1879

Staurosirella Wiliams & Round 1987
- *Staurosirella alpestris* (Krasske) Le Cohu 1999
- *Staurosirella canariensis* (Lange-Bertalot) Morales, Ector, Maidana & Grana 2018
- *Staurosirella crassa* (Metzeltin & Lange-Bertalot) Ribeiro & Torgan 2010
- *Staurosirella dubia* (Grunow) Morales & Manoylov 2006
- *Staurosirella elegantula* Morales & Manoylov 2010
- *Staurosirella frigida* Van de Vijver & Morales 2014
- *Staurosirella guenter-grassii* (Witkowski & Lange-Bertalot) Morales et al. 2019
- *Staurosirella krammeri* Morales, Wetzel & Ector 2010
- *Staurosirella lanceolata* (Hustedt) Morales, Wetzel & Ector 2010
- *Staurosirella lapponica* (Grunow) Williams & Round 1987
- *Staurosirella lapponica* var. *maio*r (Tynni) Zalat & Pidek comb. nov.
- *Staurosirella lapponica* var. *marciniaka*e (Kaczmarska) Zalat & Pidek comb. nov.
- *Staurosirella lapponica* var. *rostrata* (Krasske) John 2018
- *Staurosirella magna* Morales & Manoylov in Morales et al. 2010
- *Staurosirella martyi* (Héribaud-Joseph) Morales & Manoylov 2006
- *Staurosirella minuta* Morales & Edlund 2003
- *Staurosirella mutabilis* (W. Smith) Morales & Van de Vijver 2015
- *Staurosirella neopinnata* Morales, Wetzel, Haworth & Ector 2019
- *Staurosirella oldenburgiana* (Hustedt) Morales 2005
- *Staurosirella ovata* Morales 2006
- *Staurosirella pinnata* (Ehrenberg) Williams & Round 1987

Staurosirella pinnata var. *intercedens* (Grunow) Hamilton 1994
Staurosirella pinnata var. *minutissi*ma (Grunow) Zalat & Pidek comb. nov.
Staurosirella pinnata var. *subrotunda* (Mayer) Flower 2005
Staurosirella pinnata var. *turgidul*a (A. Cleve) Zalat & Chodyka comb. nov.
Staurosirella pinnata var. *ventriculos*a (Schumann) Zalat & Nitychoruk comb. nov.
Staurosirella rhomboides (Grunow) Morales & Manoylov 2010
Staurosirella spinosa (Skvortsov) Kingston 2000
Staurosirella subrobusta Morales 2006
Synedra Ehrenberg 1830
Synedra famelica Kützing 1844
Ulnaria (Kützing) Compère 2001
Ulnaria acus (Kützing) Aboal in Aboal et al. 2003
Ulnaria amphirhynchus (Ehrenberg) Compère & Bukhtiyarova 2006
Ulnaria biceps (Kützing) Compère 2001
*Ulnaria capitat*a (Ehrenberg) Compère 2001
Ulnaria capitata var. *cuneata* (Poretzky & Proschkina-Lavrenko) Compère & Bukhtiyarova 2006
Ulnaria contracta (Østrup) Morales & Vis 2007
Ulnaria danica (Kützing) Compère & Bukhtiyarova 2006
Ulnaria delicatissima (W. Smith) Aboal & Silva 2004
Ulnaria delicatissima var. *angustissima* (Grunow) Aboal & Silva 2004
Ulnaria oxyrhynchus (Kützing) Aboal in Aboal et al. 2003
Ulnaria sinensis Liu & Williams 2017
Ulnaria ulna (Nitzsch) Compère 2001
Ulnaria ulna var. *aequalis* (Kützing) Aboal in Aboal et al. 2003
Ulnaria ulna var. *spathulifera* (Grunow) Aboal in Aboal et al. 2003
Tabellaria Ehrenberg ex Kützing 1844
Tabellaria binalis (Ehrenberg) Grunow in V. Heurck 1880
Tabellaria fenestrata (Lyngbye) Kützing 1844
Tabellaria flocculosa (Roth) Kützing 1844
Tabellaria quadriseptata Knudson 1952
Tabellaria ventricosa Kützing 1844
Tabularia (Kützing) Williams & Round 1986
Tabularia chandolensis (Gandhi) Vigneswaran, Williams & Karthick 2020
Tabularia fasciculata (Agardh) Williams & Round 1986
Tabularia fonticola (Hustedt) Wetzel & Williams in Vigneshwaran et al. 2020
Tabularia waernii Snoeijs 1991
Tetracyclus Ralfs 1843
Tetracyclus glans (Ehrenberg) Mills 1935
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