Phytotaxa 403 (3): 143–170
https://www.mapress.com/j/pt/

Article

ISSN 1179-3155 (print edition)
PHYTOTAXA
ISSN 1179-3163 (online edition)

https://doi.org/10.11646/phytotaxa.403.3.1

Newly Recorded Species of Diatoms in the Source of Han and Nakdong Rivers, South Korea

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Abstract

For floristic study on diatoms from the source of Han and Nakdong Rivers, we collected samples in February, April, and July 2016 from Geomryongso and Neodeolsam Ponds, South Korea. Geomryongso and Neodeolsam Ponds are sources of Han and Nakdong Rivers, respectively. Thirty-eight infrageneric taxa of freshwater diatoms were identified in the collected samples from study areas. The diatom species were classified into 25 genera, 17 families, 10 orders, 5 subclasses, and 2 classes based on the taxonomic system proposed by Round *et al*. (1990). Nine diatom taxa—*Achnanthes sinaensis*, *Achnanthidium atomus*, *Edtheriotia guizhoiana*, *Fragilaria recapitellata*, *Gyrosigma procerum*, *Navicula nipponica*, *Pinnularia pseudotabellaria*, *Pinnularia rabenhorstii*, and *Platessa barhlsii*—were newly recorded, whose taxonomic features have been described; they are indicated by asterisk. We presented the taxonomic information, including the systematics, and dimension in the source of two major rivers in Korea. This study might contribute to the understanding of diversity and flora of diatoms in various freshwater environments in Korea.

Keywords: Bacillariophyceae, Bacillariophyta, diatom, flora, freshwater, Han River, Nakdong River, new records, source of river

Introduction

Diatoms are a species rich group of eukaryotic unicellular microalgae and one of the most common organic matters in aquatic ecosystem (Wojtal 2009). They play an important role as the primary producers in freshwater and marine environments (Round *et al.* 1990, Ishii *et al.* 2011), and they contribute to approximately one fifth of the photosynthesis activity on Earth (Armbrust 2009). Furthermore, diatoms have been used as biological indicators of water quality in several countries (Whitton & Kelly 1995, Kelly *et al.* 1998, Potapova & Charles 2007, Delgado *et al*. 2012). Approximately 12,000 diatom species have been described from aquatic and some terrestrial environments, but there may be more than 100,000 diatom species worldwide (Round *et al*. 1990, van den Hoek *et al*. 1995, Hasle & Syvertsen 1996, Mann 1999).

The Han and Nakdong Rivers are comprised of four major river systems in Korea (Cho *et al*. 2014). The Han River, the largest river in Korea, is the primary water source for more than 20 million people in Seoul and the surrounding areas. It begins in Northeast Kangwon-Do and travels to the Yellow Sea through Seoul. The river is 469.7 km long with a watershed area of 26,200 km^2. The river is highly developed and has been straightened and channeled for flood control. All these modifications have reduced flow velocity, which has increased the chances of sediment accumulation in the lower reaches. The river also receives stormwater and urban runoff, and the total suspended solid and phosphorus loads are 70 %–80 %, which are attributable to non-point sources (Choi *et al*. 1994, Kim *et al*. 2004). The Nakdong River serves as an important water resource for the southeastern areas. The river drains an area of 23,817 km^2 and the

Accepted by Evan Thomas: 17 Apr. 2019; published: 13 May 2019

length of the main stream is over 525 km. Currently, approximately seven million people reside within the basin and more than 13 million people obtain drinking water from the river. During the last several decades, rapid population growth coupled with industrial and urban development has resulted in the serious deterioration of water quality in downstream area. The major pollution sources include domestic sewage, industrial wastewater, livestock discharge, and urban and agricultural runoffs (Park & Lee 2002).

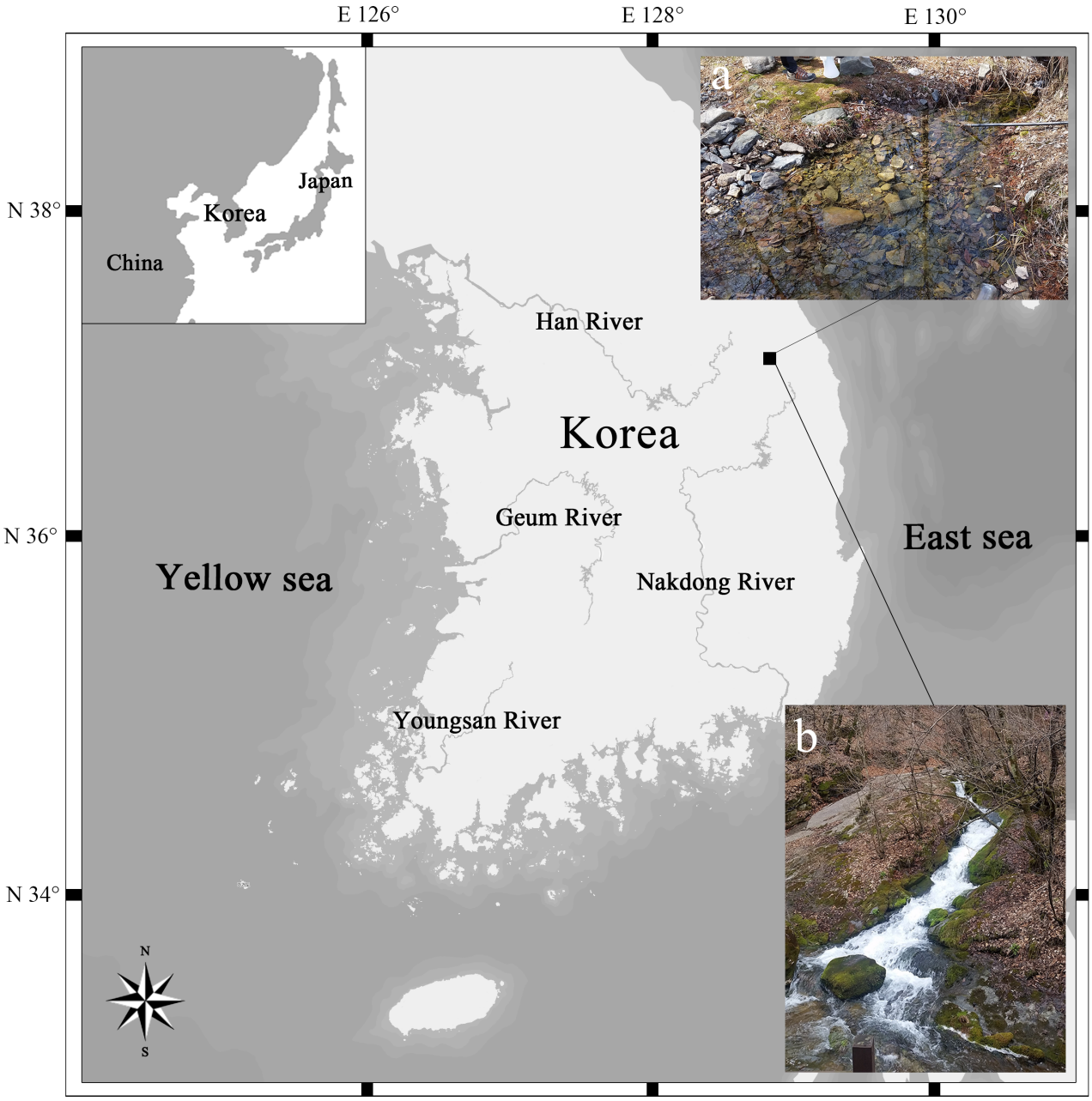


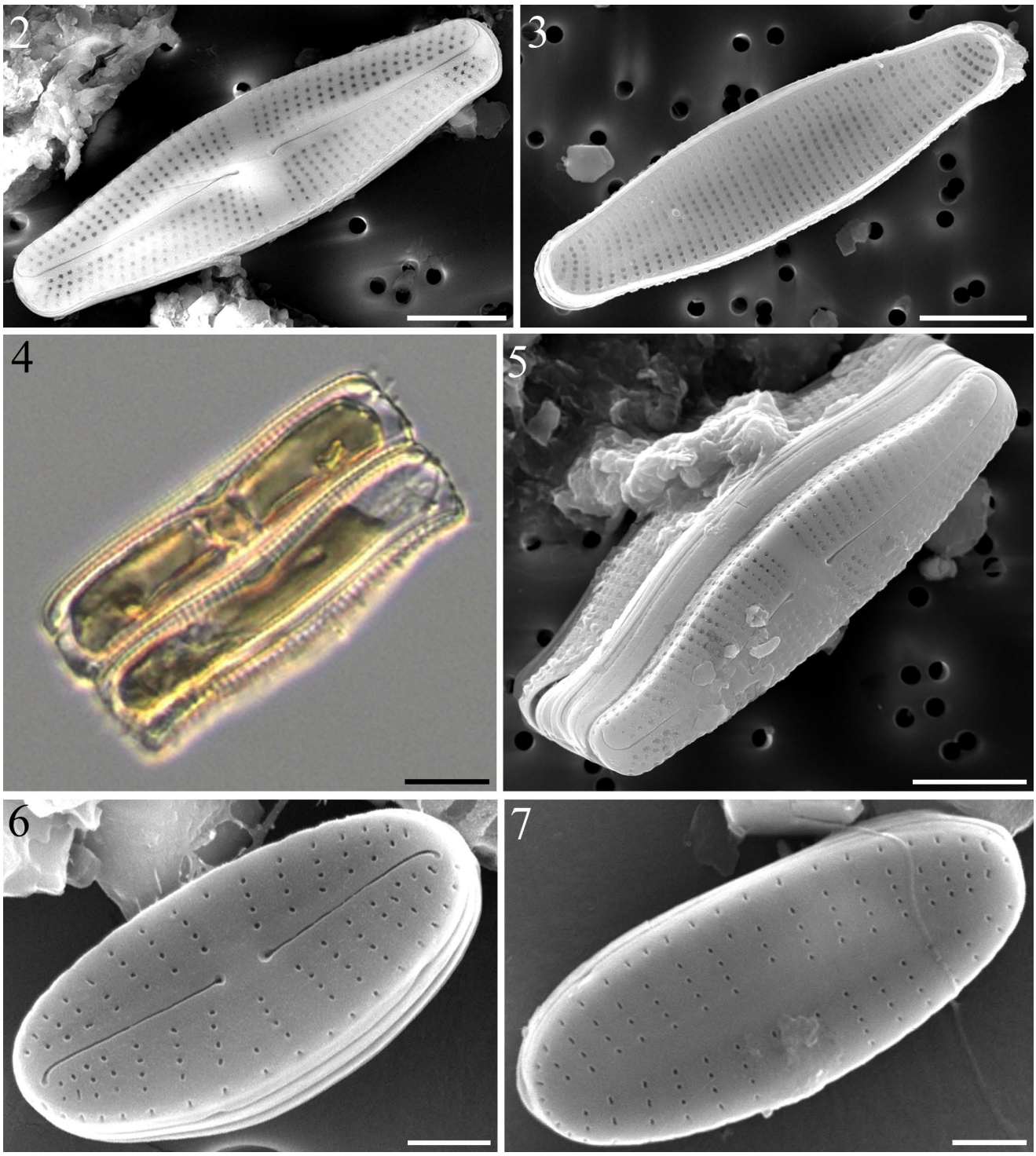
FIGURE 1. Map showing the study area with the sampling stations of this study (A, B).

The source (headwater) of a river is the furthest upstream of the watershed, and consists of swamps, ponds, small lakes, or wetlands (Guibal *et al*. 2017, Finn *et al*. 2011, Meyer *et al*. 2007, Lowe & Likens 2005). It plays an important role in maintaining high species diversity, protecting biodiversity, and maintaining water quality and quantity of downstream (Guibal *et al*. 2017, Finn *et al*. 2011, Lowe & Likens 2005, Meyer *et al*. 2007). The diatoms are the dominant algal taxa in headwaters (Meyer *et al*. 2007). However, until recently, taxonomic and ecological studies on diatoms have been rarely carried out in these areas of Korea. Geomryongso and Neodeolsam Ponds are the source of the Han and Nakdong Rivers, respectively.

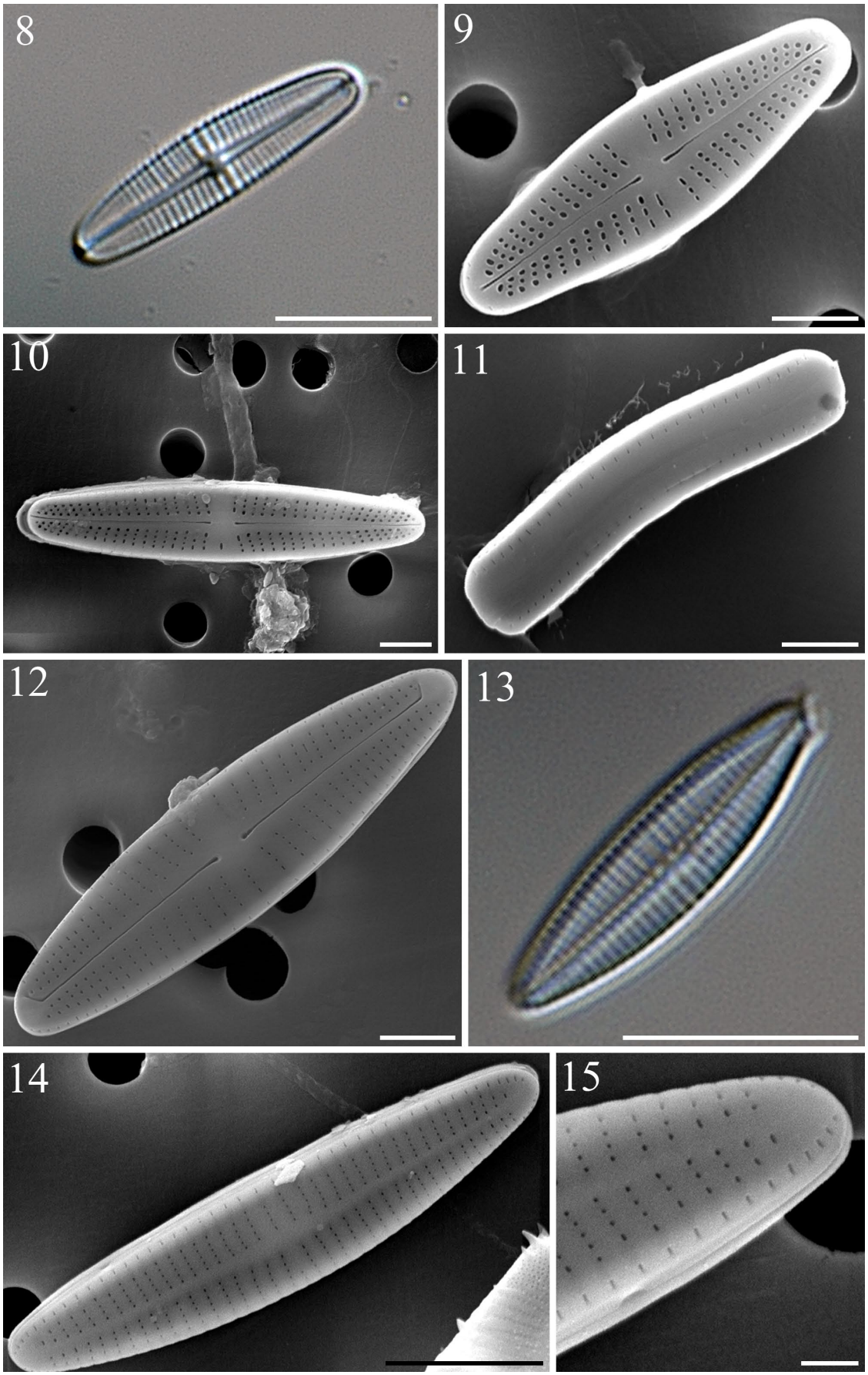
In Korea, two thousand fifteen species of diatoms have been reported by Korean diatomists (Lee & Cho 2015). However, taxonomic and floristic studies on diatoms in the sources of major rivers in Korea, including Geomryongso

and Neodeolsam Ponds, have not been completed. Recently, the identification of new species and the evaluation of biological diversity have been recognized as an important national task to establish bio-sovereignty in the world (Lee *et al*. 2015).

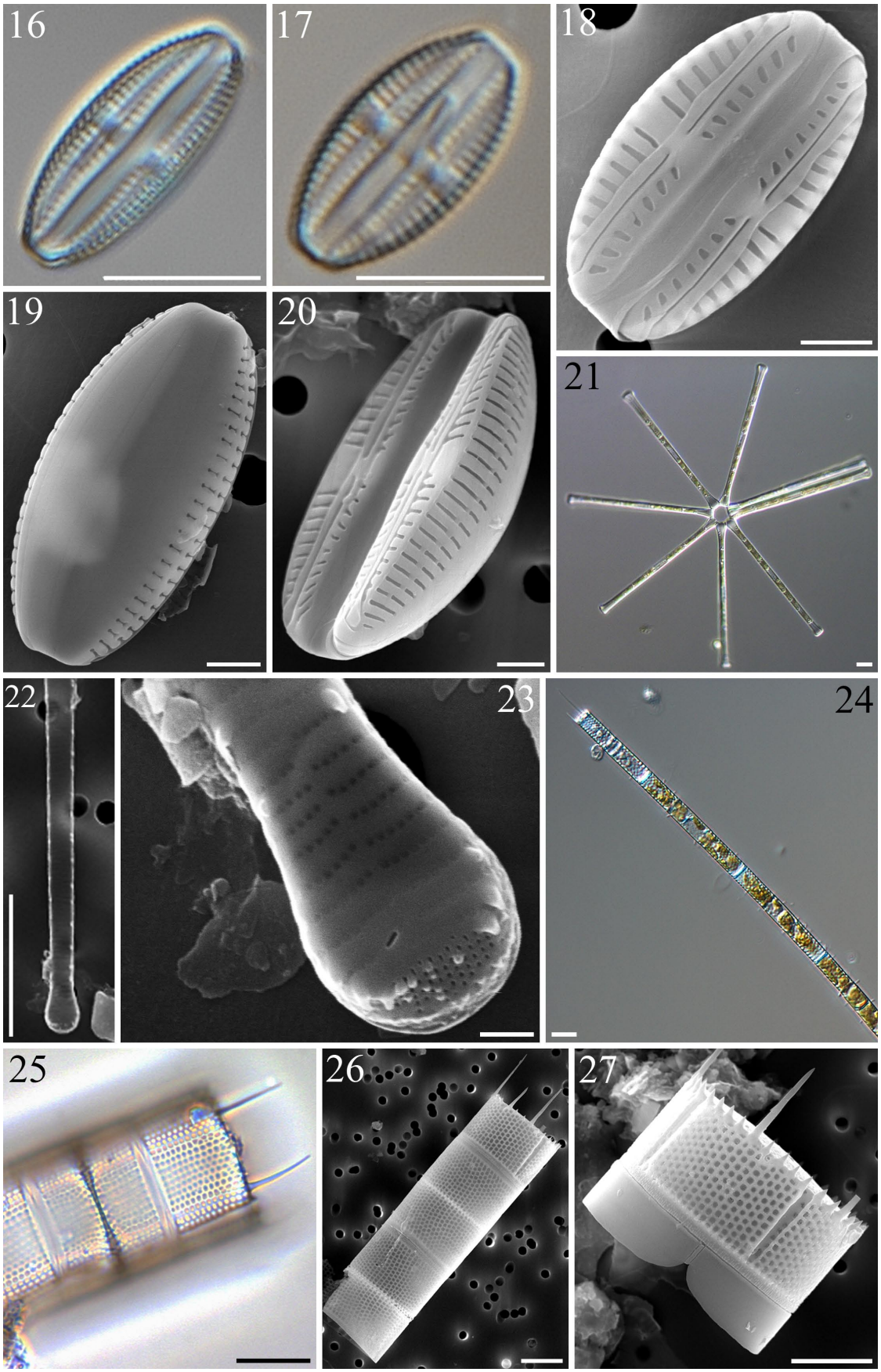
The project "The Survey and Finding of Freshwater Biological Resources" of the Nakdonggang National Institute of Biological Resources (NNIBR) under the Ministry of Environment of Korea has been in progress from 2015. In this project, we survey and identify diatom species in freshwater and brackish water in Korea. The purpose of this study is to identify newly recorded species and to provide floristic information of diatoms from the sources of Han and Nakdong Rivers in Korea.



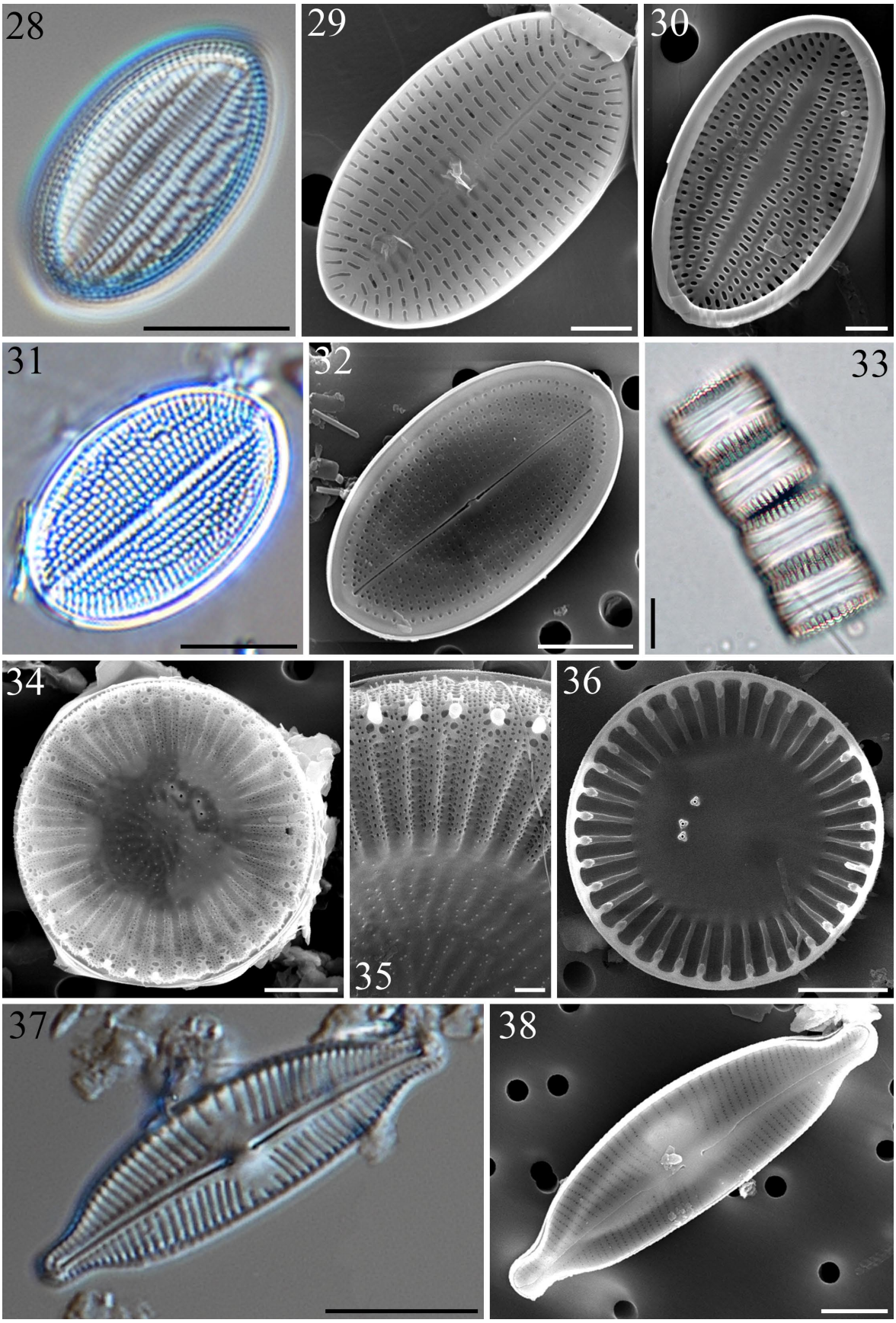
FIGURES 2–7. LM (4) and SEM (2, 3, 5–7) microphotographs. 2–5. *Achnanthes sinaensis*. 6, 7. *Achnanthidium atomus*. (Scale bars: 2–5 = 10 μm; 6, 7 = 1 μm).



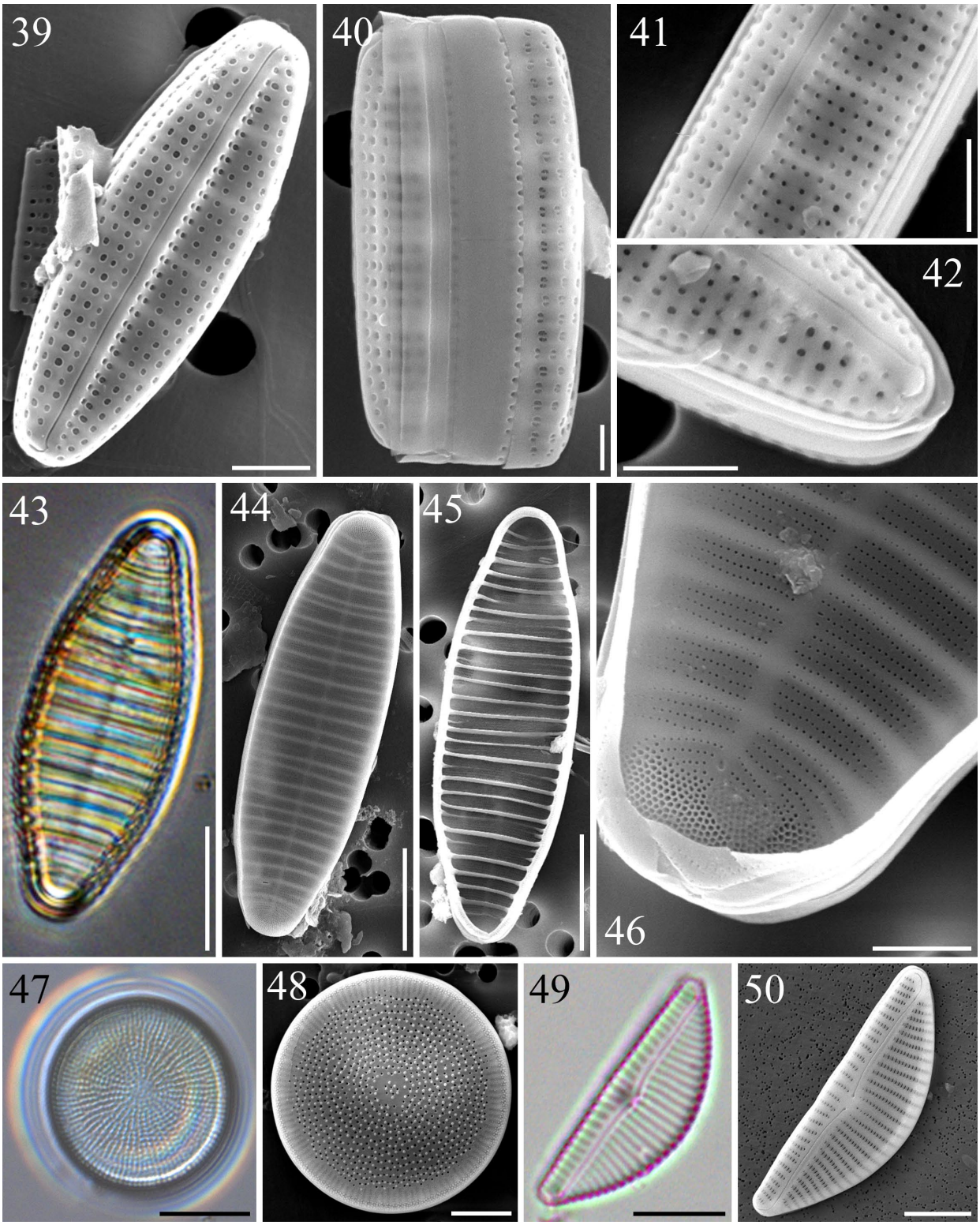
FIGURES 8–15. LM (8, 13) and SEM (9–12, 14, 15) microphotographs. 8–11. *Achnanthidium minutissimum***,** 12–15. *Achnanthidium pyrenaicum*. (Scale bars: 8, 13 = 10 µm, 9–12 = 2 µm; 14 = 5 µm; 15 = 1 µm).



FIGURES 16–27. LM (16, 17, 21, 24, 25) and SEM (18–20, 22, 23, 26, 27) microphotographs. 16–20. *Amphora inariensis*. 21–23. *Asterionella formosa*. 24. *Aulacoseira granulata*. 25–27. *Aulacoseria muzzanensis*. (Scale bars: 16, 17, 22, 24–27 = 10 µm; 18–20 = 2 µm; 21 = 5 µm; 23 = 1 µm).



FIGURES 28–38. LM (28, 31, 33, 37) and SEM (29, 30, 32, 34–36, 38) microphotographs. 28–30. *Cocconeis euglypta.* 31, 32. *Cocconeis lineata.* 33–36. *Cyclotella meneghiniana*. 37, 38. *Cymbopleura naviculiformis*. (Scale bars: 28, 31, 33, 37 = 10 µm; 29, 30 = 2 µm; 32, 34, 36 = 5 µm; 35 = 1 µm; 38 = 5 µm).



FIGURES 39–50. LM (43, 47, 49) and SEM (39–42, 44–46, 48, 50) microphotographs. 39–42. *Denticula tenuis*. 43–46. *Diatoma vulgaris*. 47, 48. *Edtheriotia guizhoiana.* 49, 50. *Encyonema silesiacum*. (Scale bars: 39, 41, 42, 46 = 2 μm; 40 = 1 μm; 43–45, 47 = 10 μm; 48–50 = 5 μm).

Materials and Methods

Samples were collected from four stations in the source of Han and Nakdong Rivers from February 2016 to July 2016 (Table 1). Geomryongso is the source of Han River as it passes by Seoul and flows to the western sea in Korea.

The surrounding area is rocky and moss covered and the total distance is approximately 1.5 km. Neodeolsam Pond is known as the geographical origin of the Nakdong River located in Hwajeon, Taebaek-si, Gangwon-do. The two sites are located in the alpine area. The distance between Geomryongso and Neodeolsam Pond is approximately 3.5 km. The planktonic diatoms were sampled using a plankton net of mesh size 20 μm by vertical and/or horizontal towing. The epilithic samples were scraped off the upper surface of the stones using a toothbrush or small chisel. The collected wild materials were immediately fixed with 4% neutralized formalin, Lugol's solution (Sournia 1968), or 2 % glutaraldehyde. To remove organic matter and organelles, the fixed samples were boiled in equal amounts of concentrated HCl and saturated $KMnO_4$ at 70 ºC until the samples were slightly colored, and then rinsed in distilled water to remove residual acid, following a modified method of Hasle and Fryxell (1970). The samples were then rinsed in distilled water to remove residual acid. To remove the organic matter without damaging the weakly silicified diatom species, some fixed samples were exposed a 1200-W mercury arc lamp using a UV-transilluminator (ETX-F20.M; VILBER LOURMAT, France) for 12 h, according to the modified method of Swift (1967) and Hasle & Fryxell (1970), with an equal amount of 30 % H_2O_2 in a small Petri dish (Lee *et al*. 2014). Some wild samples, fixed samples, acid-cleaned samples, and peroxide-cleaned samples were mounted in Pleurax (Mountmedia, Wako, Japan) for observation using a light microscope (LM) (Eclipse Ni; Nikon, Tokyo, Japan) equipped with Nomarski differential interference contrast optics (DIC) with a digital camera (DS-Ri2; Nikon, Tokyo, Japan). To examine the ultrastructure of diatoms, some remaining wild, fixed, acid-cleaned, and peroxide-cleaned samples were filtered using 2.0μm pore-size polycarbonate membrane filter (Nuclepore, Whatman, UK). The membranes were then air-dried and attached to an aluminum stub using carbon tape. The membrane on the stub was sputter coated with gold-palladium for examination with a field emission scanning electron microscope (FE-SEM) (MIRA 3; TESCAN, Czech) at the Nakdonggang National Institute of Biological Resources (NNIBR). The FE-SEM was operated with an accelerating voltage of 5 kV with a 15 mm working distance. The cells were measured using the ImageJ v1.32 software (Schneider *et al*. 2012, Park *et al*. 2016). The terminology was according to that of Anonymous (1975), Ross *et al*. (1979), and Round *et al*. (1990). Environmental parameters such as water temperature (ºC), pH, dissolved oxygen (mg/L) and electric conductivity (μs/cm^3) were measured using a portable multiparameter meter (Pro DSS, YSI, USA).

TABLE 1. Samples used in this study.

Station	Date	Locality	Latitude, Longitude	Tm (°C)	pH	DO (mg/L)	EC (μs/cm^3)
GP*-01	3 Feb. 2016	Geomryongso-gil, Taebaek-si, Gangwon-do, Korea	37°13'51.6"N 128°55'6.9"E	7.4	8.34	10.09	201.4
GP-02	7 Apr. 2016	Geomryongso-gil, Taebaek-si, Gangwon-do, Korea	37°13'51.6"N 128°55'6.9"E	6.8	8.05	13.52	185.3
NP**-01	8 Apr. 2016	Maenipjae 2-gil, Taebaek-si, Gangwon-do, Korea	37°12'9.3"N 128°54'48.9"E	4.8	8.35	14.3	35.2
NP-02	28 Jul. 2016	Maenipjae 2-gil, Taebaek-si, Gangwon-do, Korea	37°12'9.3"N 128°54'48.9"E	9.5	8.54	12.39	22.6

*Geomryongso Pond; **Neodeolsam Pond; Tm: temperature; DO: dissolved oxygen; EC: electric conductivity.

Results and Discussion

A total of 38 infrageneric taxa of freshwater diatoms were identified in the collected samples. The diatom species were classified into 25 genera, 17 families, 10 orders, 5 subclasses, and 2 classes based on the taxonomic system proposed by Round *et al*. (1990). Nine taxa—*Achnanthes sinaensis*, *Achnanthidium atomus*, *Edtheriotia guizhoiana*, *Fragilaria recapitellata*, *Gyrosigma procerum*, *Navicula nipponica*, *Pinnularia pseudotabellaria*, *Pinnularia rabenhorstii*, and *Platessa barhlsii*—were newly recoded, whose taxonomic features have been described; they are indicated by asterisk in this study.

Achnanthes sinaensis* (Hustedt) Levkov, Tofilovska et C.E. Wetzel 2014
Figures 2–5

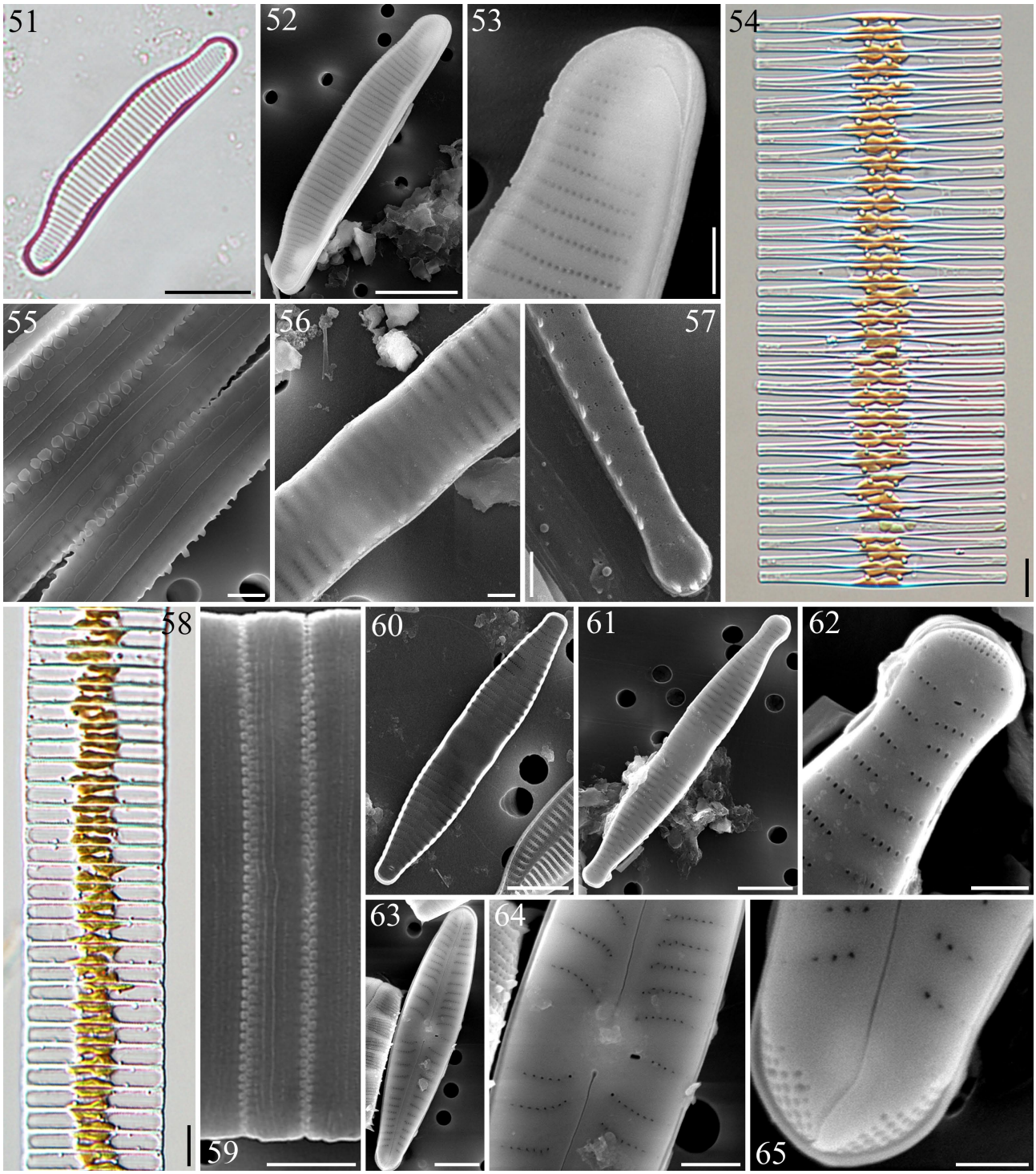
Basionym: *Achnanthes coarctata* var. *sinaensis* Hustedt 1949, p. 43, Figs 6, 7.

Original description: Tofilovska *et al*. (2014), p. 19.

Key literature: Tofilovska *et al*. (2014), p. 19.

Specimen examined: Tables 1, 2.

Dimension: Length 48.2–55.1 µm, width 12.3–14.4 µm; nine striae in 10 µm on the raphe valve and 10 in 10 µm on the rapheless valve.



FIGURES 51–65. LM (51, 54, 58) and SEM (52, 53, 55–57, 59–65) microphotographs. 51–53. *Eunotia circumborealis*. 54–57. *Fragilaria crotonensis*. 58–62. *Fragilaria recapitellata*. 63–65. *Gomphonema tergestinum*. (Scale bars: 51, 52, 54, 58 = 10 µm; 53, 55, 64 = 2 µm; 56, 57, 62, 65 = 1 µm; 59–61, 63 = 5 µm).

Description: The valves are linear to linear-lanceolate with broadly round to trunctate valve apices. The raphe valve is concave with narrow and slightly curved axial area. The central area is rectangular with broad stauros extending to the valve margin. The raphe is weakly lateral with slightly curved raphe branches. The proximal raphe fissures

expanded into large central pores, terminal raphe fissures unilaterally extending onto the valve mantle with polar hyaline areas. The transapical striae radiate with uniseriate, coarsely punctate throughout the valve. The rapheless valve convex with narrow and slightly curved axial area. The transapical striae parallel to the mid-valve, becoming strongly radiate near the apices. The frustule weakly flexed with a concave raphe valve and convex rapheless valve.

Distribution and ecology: *Achnanthes sinaensis* is freshwater, aerophytic species, and it usually occurs as epiphyte on wet mosses or rocks (Toflilovska *et al*. 2014).

Achnanthidium atomus* (Hustedt) Monnier, Lange-Bertalot & Ector in Monnier et al. 2004
Figures 6, 7

Original description: Monnier *et al*. (2004), p. 128, figs 1–41.

Key literature: Monnier *et al*. (2004), p. 128, figs 1–41.

Specimen examined: Tables 1, 2.

Dimension: Length 6.1–7.1 μm, width 2.7–2.9 μm; 26–28 striae in 10 μm on the raphe valve and 21–22 striae in 10 μm on the rapheless valve.

Description: The valves are slightly linear-elliptic with round ends. The raphe valve concave and rapheless valve convex along transapical axis. The striae are uniseriate, extending on the valve face. The foramen of the areolae small and circular on the valves. The raphe branches are filiform, simple slit in the middle part, small pin-hole at the central raphe ends, deflected in one direction in the proximal raphe endings. The striae are interrupted at the valve face and mantle junction by a weakly thickened hyaline area, parallel throughout the valve length, terminal short striae slightly radial. The areolae are small and round in valve view.

Remarks: *A. atomus* is closely related to *A. atomoides* from Java and Sumatra (Indonesia) (Monnier *et al*. 2004). It differs from commonly smaller valve sizes and by less spaced striae and areolae. *A. atomus* has 19–21 striae in 10 μm on the rapheless valve and 22–26 striae in 10 μm on the raphe valve, contrary to 22–28 and 25–32 striae in *A. atomoides*, respectively. *A. atomoides* has an average of 37 areolae in 10 μm in the rapheless valve and 45 striae in 10 μm in raphe valve, contrary to 50 areolae and 65 striae in *A. atomoides*, respectively (Monnier *et al*. 2004).

Distribution and ecology: This species was found in two regions within Central and Northern Appalachia from Noth America (Ponader & Potapova 2007). It mainly distributed in nutrient-poor rivers within a narrow pH range from 8 to 8.3 (Ponader & Potapova 2007), but over a wide range of conductivity levels with a preference towards higher values (Ponader & Potapova 2007). The pH and nutrients were major factors driving the distribution of *Achnanthidium atomus* in Appalachia (Ponader & Potapova 2007).

***Achnanthidium minutissimum* (Kützing) Czarnecki 1994**
Figures 8–11

Basionym: *Achnanthes minutissima* Kützing 1833.

Synonyms: *Achnanthes minutissima* Kützing 1833; *Achnanthidium microcephalum* Kützing 1844; *Achnanthes microcephala* (Kützing) Grunow 1880; *Microneis microcephala* (Kützing) Cleve 1895; *Achnanthes cryptocephala* (Grunow) Peragallo 1897; *Cocconeis minutissima* (Kützing) Schönfeldt 1907; *Microneis minutissima* (Kützing) Meister 1912.

Original description: Czarnecki (1994), p. 157.

Key literature: Cantonati *et al*. (2017).

Specimen examined: Tables 1, 2.

Dimension: Length 10.4–15.3 μm, width 3.1–3.2 μm. Twenty-seven striae in 10 μm on the raphe valve and 31–32 areolae in 10 μm on the valve mantle.

***Achnanthidium pyrenaicum* Kobayasi 1997**
Figures 12–15

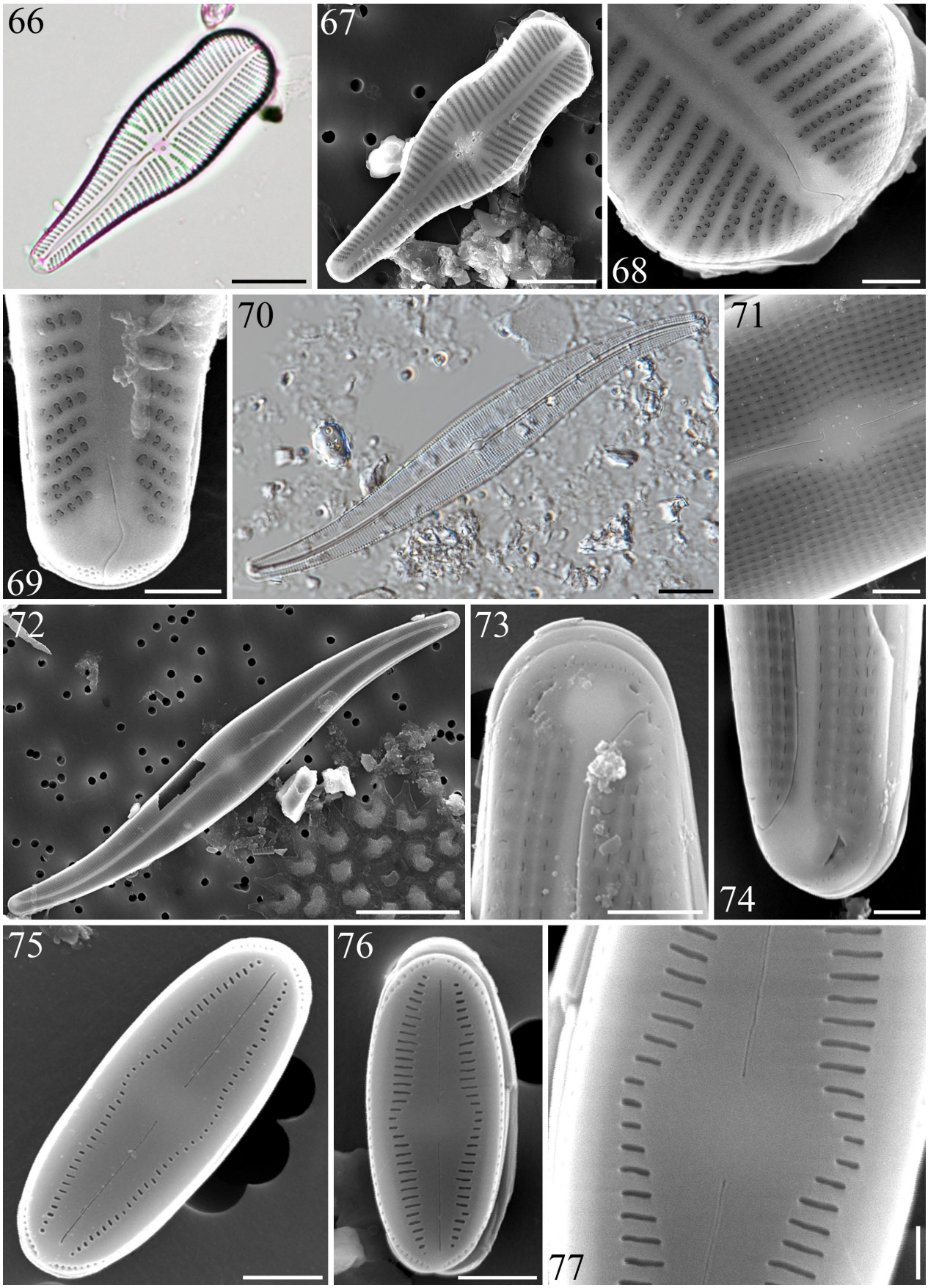
Basionym: *Achnanthes pyrenaica* Hustedt 1939.

Synonyms: *Synedra biasolettiana* Kützing 1844; *Achnanthes biasolettiana* Grunow 1880; *Microneis biasolettiana* (Kützing) Cleve 1895; *Microneis biasolettiana* (Kützing) Meister 1912; *Achnanthes pyrenaica* Hustedt 1939; *Achnanthes minutissima* var. *pyrenaica* (Hustedt) Cleve 1953; *Achnanthidium biasolettianum* (Grunow) Bukhtiyarova 1995.

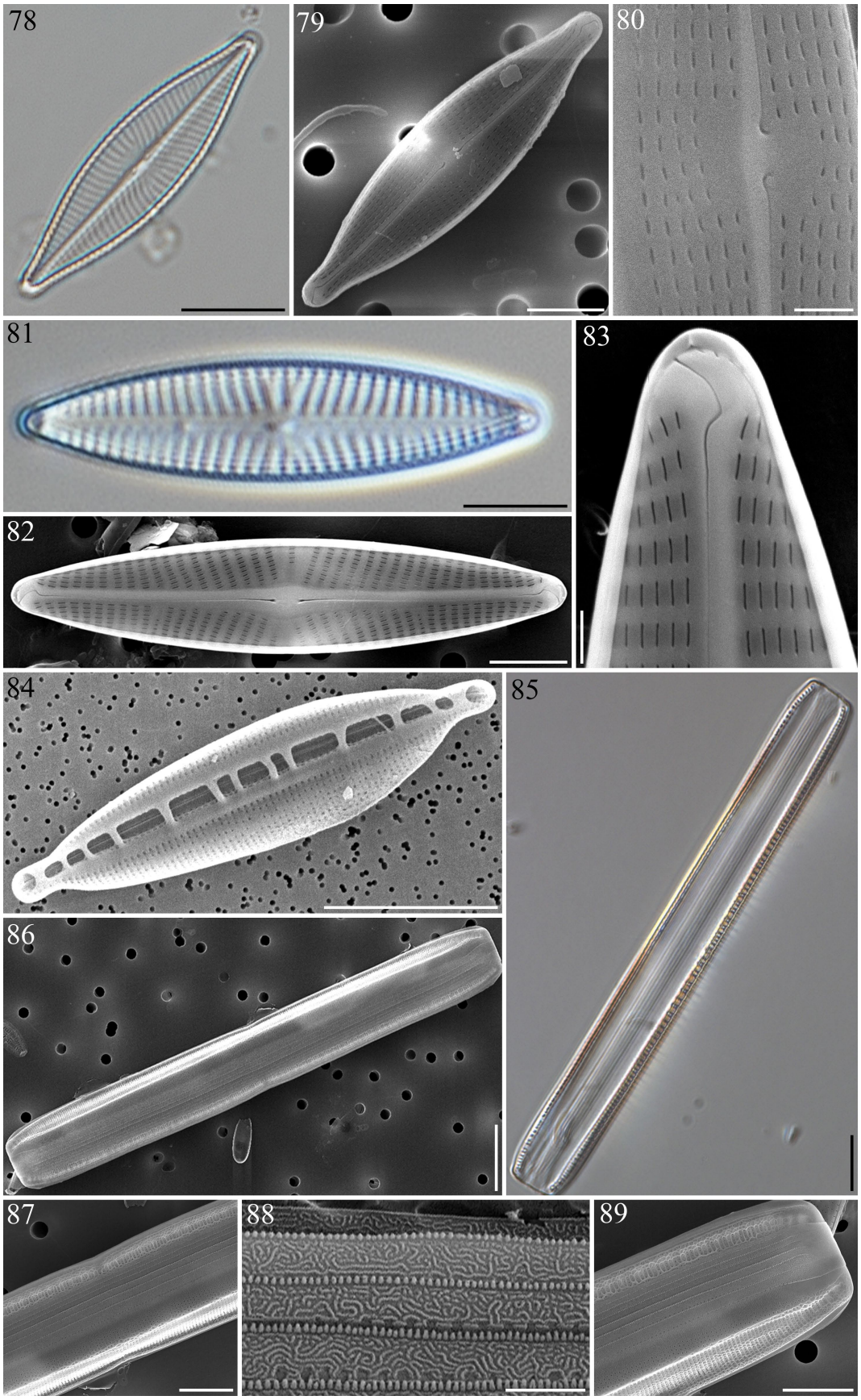
Original description: Kobayasi (1997), p. 148, figs 1–18.

Key literature: Cantonati *et al*. (2017).

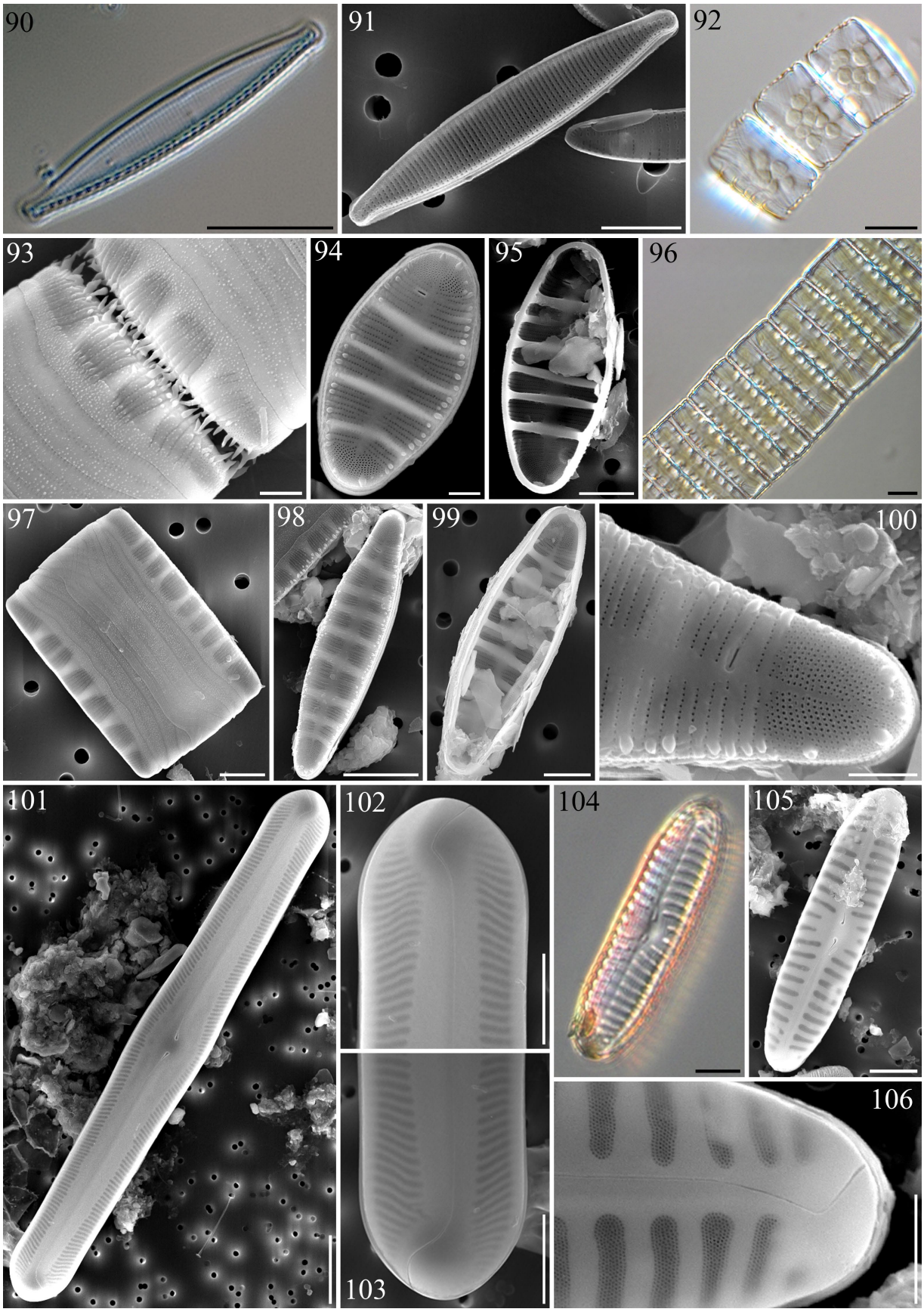
Specimen examined: Tables 1, 2.



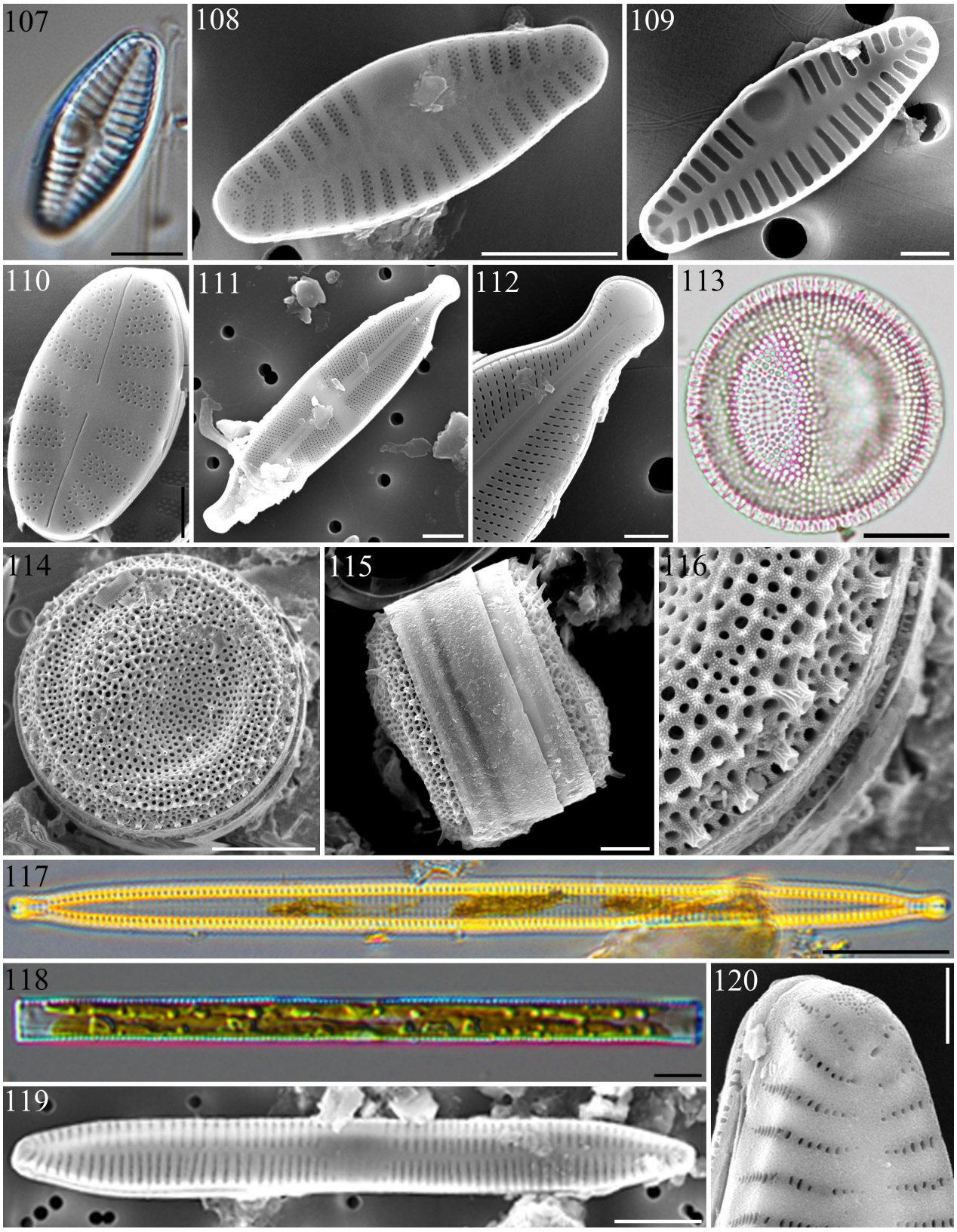
FIGURES 66–77. LM (66, 70) and SEM (67–69, 71–77) microphotographs. 66–69. *Gomphonema truncatum*. 70–74. *Gyrosigma procerum*. 75–77. *Humidophila perpusilla.* (Scale bars: 66, 67, 70 = 10 µm; 68, 69, 71, 73, 75, 76 = 2 µm; 72 = 20 µm; 74 = 1 µm; 77 = 0.5 µm).



FIGURES 78–89. LM (78, 81, 85) and SEM (79, 80, 82–84, 86–89) microphotographs. 78–80. *Navicula gregaria*. 81–83 *Navicula nipponica*. 84. *Nitzschia dissipata*. 85–89. *Nitzschia linearis*. (Scale bars: 78, 85, 86 = 10 μm; 79, 81, 82, 84, 87, 89 = 5 μm; 80, 83, 88 = 1 μm).



FIGURES 90–106. LM (90, 92, 96, 104) and SEM (91, 93–95, 97–103, 105, 106) microphotographs. 90, 91. *Nitzschia fonticola.* 92–95. *Odontidium mesodon.* 96–100. *Odontidium hyemale.* 101–103. *Pinnularia pseudotabellaria.* 104, 105. *Pinnularia rabenhorstii*. (Scale bars: 90, 92, 96, 98, 102–105 = 10 µm; 91, 95, 97, 99, 106 = 5 µm; 93, 94, 100 = 2 µm; 101 = 20 µm).



FIGURES 107–120. LM (107, 113, 117, 118) and SEM (108–112, 114–116, 119, 120) microphotographs. 107–109. *Planothidium laceolatum*. 110. *Platessa barhlsii*. 111, 112. *Stauroneis reichardtii*. 113–116. *Thalassiosira lacustris*. 117, 118. *Ulnaria ulna*. 119, 120. *Ulnaria contracta*. (Scale bars: 107, 108, 111, 115 = 5 µm; 109, 112, 120 = 2 µm; 110, 116 = 1 µm; 113, 114, 118, 119 = 10 µm; 117 = 20 µm).

Dimension: Length 14.5–18.8 µm, width 3.7–3.9 µm; 25–26 striae in 10 µm on the raphe valve, 21–22 striae in 10 µm on the rapheless valve, and 21–22 areolae in 10 µm on the valve mantle.

TABLE 2. Checklist of diatom species from the source of Han and Nakdong Rivers in Korea

Genus	Species	Station*				Habitat
		GP-01	GP-02	NP-01	NP-02	
Achnanthes	*sinaensis***		■			P, E
Achnanthidium	*atomus***	■				P, E
Achnanthidium	*minutissimum*	■				P, E
Achnanthidium	*pyrenaicum*	■				P, E
Amphora	*inariensis*	■	■			P, E
Asterionella	*formosa*				■	P
Aulacoseira	*granulata*				■	P
Aulacoseira	*muzzanensis*		■			P
Cocconeis	*euglypta*	■				E
Cocconeis	*lineata*	■	■			P, E
Cyclotella	*meneghiniana*				■	P
Cymbopleura	*naviculiformis*			■		P
Denticula	*tenuis*	■	■			E
Diatoma	*vulgaris*	■				P
Edtheriotia	*guizhoiana***	■				P, E
Encyonema	*silesiacum*		■			P
Eunotia	*circumborealis*				■	P, E
Flagilaria	*crotonensis*		■		■	P
Flagilaria	*recapitellata***	■	■	■		P
Gomphonema	*tergestinum*	■				P, E
Gomphonema	*truncatum*			■		P, E
Gyrosigma	*procerum***		■			P
Humidophila	*perpusilla*				■	P, E
Navicula	*gregaria*		■			P, E
Navicula	*nipponica***	■				P
Nitzschia	*dissipata*	■				P, E
Nitzschia	*linearis*		■			P, E
Nitzschia	*fonticola*			■		P, E
Odontidium	*mesodon*	■	■	■	■	E
Odontidium	*hyemale*	■		■		E
Pinnularia	*pseudotabellaria***			■	■	P
Pinnularia	*rabenhorstii***		■			P
Planothidium	*lanceolatum*	■			■	P, E
Platessa	*barhlsii***	■				P, E
Stauroneis	*reichardtii*				■	P
Thalassiosira	*lacustris*				■	P
Ulnaria	*ulna*			■		P
Ulnaria	*contracta*			■		P

*Station numbers correspond to those in Table 1; **Newly recorded species in Korea; ■: occurrence; P: planktonic habitat; E: Epilithic habitat.

***Amphora inariensis* Krammer 1980**

Figures 16–20

Original description: Krammer (1980), p. 211, pl. 4, figs 21–24; pl. 6, figs 36–37, 43–45.

Key literature: Cantonati *et al*. (2017).

Specimen examined: Tables 1, 2.

Dimension: Length 9.9–14.3 µm, width 5.5–6.9 µm. Seventeen striae in 10 µm.

***Asterionella formosa* Hassall 1850**

Figures 21–23

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

Original description: Hassall (1850).

Key literature: Siver *et al*. (2005).

Specimen examined: Tables 1, 2.

Dimension: Length 43.5–44.5 µm, width 1.6–2.9 µm; 38–40 striae in 10 µm.

***Aulacoseira granulata* Simonsen 1979**

Figure 24

Basionym: *Gaillonella granulata* Ehrenberg 1843.

Synonyms: *Gaillonella granulata* Ehrenberg 1843; *Lysigonium granulatum* (Ehrenberg) Kuntze 1891; *Melosira granulata* (Ehrenberg) Ralfs 1861; *Melosira polymorpha* subsp. *granulata* (Ehrenberg) H. Bethge 1925; *Melosira punctata* var. *granulata* (Ehrenberg) Cleve & Möller 1879; *Orthoseira granulata* (Ehrenberg) Schonfeldt 1907.

Original description: Simonsen (1979).

Key literature: Edlund *et al*. (2003).

Specimen examined: Tables 1, 2.

Dimension: Diameter 7.5–8.0 µm.

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

Figures 25–27

Basionym: *Melosira muzzanensis* F. Meister 1912.

Synonyms: *Melosira muzzanensis* F. Meister 1912; *Melosira granulata* var. *muzzanensis* (Meister) Hustedt 1930; *Melosira polymorpha* var. *muzzanensis* (Meister) Bethge 1925; *Aulacoseira granulata* var. *muzzanensis* (Meister) Simonsen 1979.

Original description: Krammer (1991), p. 98.

Key literatures: Edgar & Theriot (2004); Reavie & Kireta (2015).

Specimen examined: Tables 1, 2.

Dimension: Diameter 17.2–28.8 µm, 11–13 striae in 10 µm in girdle view.

***Cocconeis euglypta* Ehrenberg 1854**

Figures 28–30

Basionym: *Cocconeis euglypta* Ehrenberg 1854.

Synonyms: *Cocconeis euglypta* Ehrenberg 1854; *Cocconeis lineata* var. *euglypta* (Ehrenberg) Grunow 1880; *Cyclotella lineata* var. *euglypta* Gutwinski 1895; *Cocconeis placentula* f. *euglypta* (Ehrenberg) Hustedt 1957.

Original description: Ehrenberg (1854), pl. XXXIV [34], VI [6]-A: fig. 2.

Key literature: Cantonati *et al*. (2017).

Specimen examined: Tables 1, 2.

Dimension: Length 12.2–16.3 µm, width 7.2–9.5 µm, striae 26–28 in 10 µm on the rapheless valve.

***Cocconeis lineata* Ehrenberg 1849**

Figures 31, 32

Synonyms: *Cocconeis placentula* var. *lineata* (Ehrenberg) Van Heurck 1885; *Cocconeis placentula* f. *lineata* (Ehrenberg) Hustedt 1957.

Original description: Ehrenberg (1849), p. 301, pl. 5 (part 2), fig. 44.

Key literatures: Cantonati *et al*. (2017); Aboal *et al*. (2003).

Specimen examined: Tables 1, 2.

Dimension: Length 18.8–25.2 µm, width 10.9–15.5 µm. Striae 13–14 in 10 µm on the rapheless valve and 24–25 in 10 µm on the inner raphe valve.

***Cyclotella meneghiniana* Kützing 1844**

Figures 33–36

Synonyms: *Cyclotella kutzingiana* var. *meneghiniana* (Kützing) Brun 1880; *Stephanocyclus meneghinianus* (Kützing) Skabitschevsky 1975.

Original description: Kützing (1844), p. 50, pl. 30, fig. 68.

Key literature: Siver *et al*. (2005).

Specimen examined: Tables 1, 2.

Dimension: Diameter 17.8–20.9 µm. Costae 5–7 in 5 µm.

***Cymbopleura naviculiformis* Krammer 2003**

Figures 37, 38

Basionym: *Cymbella naviculiformis* Auerswald ex Heiberg 1863.

Synonyms: *Cymbella naviculiformis* Auerswald ex Heiberg 1863; *Cymbella cuspidata* Smith 1853; *Cymbella cuspidata* var. *naviculiformis* Auerswald 1864.

Original description: Krammer (2003), p. 56, pl. 76, figs 1–13, pl. 77, figs 1–13, pl. 78, figs 1–8, pl. 79, figs 1–14, pl. 80, fig. 12, pl. 82, fig. 1–12, pl. 83, figs 9–11.

Key literatures: Cantonati *et al*. (2017); Joh (2011).

Specimen examined: Tables 1, 2.

Dimension: Length 33.3 µm, width 9.3 µm. Striae 13–14 in 10 µm on the raphe valve.

***Denticula tenuis* Kützing 1844**

Figures 39–42

Synonyms: *Rhabdium tenue* (Kützing) Trevisan 1848; *Odontidium tenue* (Kützing) Pfitzer 1871; *Odontidium tenue* (Kützing) O'Meara 1875.

Original description: Kützing (1844), p. 43, pl. 17, fig. 8.

Key literatures: Aboal *et al*. (2003); Cantonati *et al*. (2017); Hamsher *et al*. (2014).

Specimen examined: Tables 1, 2.

Dimension: Length 9.6–13.8 µm, width 4.1–5.2 µm. Striae 27–28 in 10 µm on the raphe valve.

***Diatoma vulgaris* Bory 1824**

Figures 43–46

Synonyms: *Bacillaria vulgaris* (Bory) Ehrenberg 1836; *Diatoma vulgaris* f. *producta* (Grunow) Kurz 1922: 119.

Original description: Bory (1824), p. 461, fig. 1 [on pl. opposite].

Key literatures: Cantonati *et al*. (2017); Blanco & Williams (2015).

Specimen examined: Tables 1, 2.

Dimension: Length 32.4 µm, width 12.9 µm.

Edtheriotia guizhoiana* Kociolek, You, Stepanek, Lowe & Wang 2016

Figures 47, 48

Basionym: *Cyclotella shanxiensis* S.-Q. Xie & Y.-Z. Qi 1984.

Synonyms: *Cyclotella shanxiensis* S.-Q. Xie & Y.-Z. Qi 1984; *Theriotia shanxiensis* (Xie & Qi) Kociolek, Q.M. You, Stepanek, R.L. Lowe & Q.X. Wang 2016.

Original description: Kociolek *et al*. (2016), p. 276, figs 23–25.

Key literature: Kociolek *et al*. (2016), p. 276, figs 23–25.

Specimen examined: Tables 1, 2.

Dimension: Diameter 19.6–20.2 µm.

Description: Valves are circular with siliceous granule rows on the external valve face. The granule rows are located between the striae. A hyaline area located near the valve center and valve margin. Striae nearly straight with unequal length and arranged in radial rows around the valve center, 29–36 per 10 µm within a stria near the valve center, 44–60 per 10 µm toward the valve margin.

Remarks: Given the different patterns of granules on the valve, these species might be included in the genus *Cyclotella* sensu stricto (Xie & Qi 1984). *Edtheriotia* species have a perforated center and sessile rimoportulae; its morphology suggests a placement outside Thalassiosiraceae (Kociolek *et al*. 2016).

Distribution and ecology: *Edtheriotia guizhoiana* is known to occur in waters with high calcium content in South-central China, whereas, *Edtheriotia shanxiensis* is known to occur in eastern region toward Beijing and in Japan (Kociolek *et al*. 2016).

Encyonema silesiacum **Mann in Round, Crawford & Mann 1990**

Figures 49, 50

Basionym: *Cymbella silesiaca* Bleisch 1864.

Synonyms: *Cymbella silesiaca* Bleisch 1864; *Cymbella ventricosa* var. *silesiaca* (Bleisch in Rabenhorst) Cleve-Euler 1955; *Cymbella minuta* var. *silesiaca* (Bleisch) Reimer 1975.

Original description: Round *et al*. (1990), p. 667.

Key literatures: Aboal *et al*. (2003); Cantonati *et al*. (2017); Joh (2011).

Specimen examined: Tables 1, 2.

Dimension: Length 14.4–21.9 μm, width 4.9–7.5 μm; 14–15 striae in 10 μm on the valve.

Eunotia circumborealis **Lange-Bertalot & Nörpel in Lange-Bertalot 1993**

Figures 51–53

Original description: Lange-Bertalot (1993), p. 30.

Key literature: Lange-Bertalot *et al*. (2011)

Specimen examined: Tables 1, 2.

Dimension: Length 35.8–37.9 μm, width 5.8–6.8 μm in the valve centre; 11–14 striae in 10 μm on the valve.

Fragilaria crotonensis **Kitton 1869**

Figures 54–57

Synonyms: *Nematoplata crotonensis* (Kitton) Kuntze 1898; *Synedra crotonensis* (Kitton) Cleve & Möller 1878; *Synedra crotonensis* var. *prolongata* f. *belgica* Grunow 1881; *Fragilaria crotonensis* var. *prolongata* Grunow 1885.

Original description: Kitton (1869), p. 110, fig. 81.

Key literatures: Aboal *et al*. (2003); Lee (2010); Siver *et al*. (2005).

Specimen examined: Tables 1, 2.

Dimension: Length 32.2–70.1 μm, width 2.8–3.2 μm; 19–21 striae in 10 μm on the valve.

Fragilaria recapitellata **Lange-Bertalot & Metzeltin in Metzeltin, Lange-Bertalot & Nergui 2009***

Figures 58–62

Synonyms: *Synedra capitellata* Grunow 1881; *Synedra vaucheriae* var. *capitellata* (Grunow) Hustedt 1930; *Fragilaria intermedia* var. *capitellata* (Grunow) A. Cleve 1932; *Fragilaria capitellata* (Grunow) J.B. Petersen 1946; *Fragilaria vaucheriae* var. *capitellata* (Grunow) R. Ross 1947.

Original description: Metzeltin *et al*. (2009), p. 48.

Key literatures: Cantonati *et al*. (2017); Delgado *et al*. (2015); Tuji & Williams (2008).

Specimen examined: Tables 1, 2.

Dimension: Length 25.7–37.5 μm, width 4.2–5.1 μm; 15–17 striae in 10 μm on the valve.

Description: Valves are lanceolate, linear, and narrow with strongly rostrate to subcapitate ends. The central margin is unilaterally expanded. Valve face slightly flat, rimoportulae find near the poles, and the apical pore fields are grids. The colonies are attached by a mucilage pad on the frustule. The central area is unilateral, often expanded until the sternum. The striae are mostly parallel, to slightly radiate toward the valve ends, and alternate. Striae extend onto the valve mantle.

Remarks: The combination of the unilateral central area and capitate ends distinguishes this species from other representatives of the *F. capucina* complex with similar stria density (Delgado *et al*. 2015). *F. capucina* has valves of similar width but with a lower stria density (12–17 in 10 μm) (Cantonati *et al*. 2017). The cell length 20–39 μm, width 3–4 μm, striae 17–19 in 10 μm, 60–65 puncta in 10 μm described in type material (Tuji & Williams 2008).

Distribution and ecology: This species distributed in Oligotrophic to mesotrophic, electrolyte-poor streams and small rivers on siliceous substrate (Cantonati *et al*. 2017). The species widely distributed, locally in very high numbers in central Europe (Cantonati *et al*. 2017).

Gomphonema tergestinum **(Grunow) M. Schmidt 1902**

Figures 63–65

Basionym: *Gomphonema semiapertum* var. *tergestinum* Grunow 1880.

Synonyms: *Gomphonema semiapertum* var. *tergestinum* Grunow 1880; *Gomphonema lanceolatum* f. *tergestina* (Grunow) A. Cleve 1880; *Gomphonema parvulum* var. *tergestina* (Grunow) Cleve 1894; *Gomphonema lanceolatum* f. *tergestina* (Grunow) Cleve-Euler 1955.

Original description: Schimidt (1902), pl. 234, figs 39–43.
Key literatures: Cantonati *et al*. (2017); Lowe & Likens (2005).
Specimen examined: Tables 1, 2.
Dimension: Length 30.4 μm, width 6.7 μm; 10–11 striae in 10 μm on the raphe valve.

***Gomphonema truncatum* Ehrenberg 1832**
Figures 66–69
Synonyms: *Gomphonema constrictum* var. *truncatum* (Ehrenberg) Gutwinski 1887.
Original description: Ehrenberg (1832), p. 88.
Key literatures: Aboal *et al*. (2003); Cantonati *et al*. (2017); Joh (2011).
Specimen examined: Tables 1, 2.
Dimension: Length 43.3 μm, width 12.8 μm; 11–12 striae in 10 μm on the raphe valve.

Gyrosigma procerum* Hustedt 1956
Figures 70–74
Original description: Hustedt (1956), p. 118, fig. 48.
Key literatures: Watanabe *et al*. (2005), p. 237, pl. IIB3-4, fig. 1–3; Wang *et al*. (2010).
Specimen examined: Tables 1, 2.
Dimension. Length 103.1 μm, width 13.3 μm; 23–25 striae in 10 μm on the raphe valve.
Description: Valves are slender and sigmoid with smoothly tapering to acutely cuneate ends. The central area is longitudinally and small elliptical. The raphe is straight and central for half its length, and follows a sigmoid shape and is slightly eccentric toward each convex side.

Proximal raphe fissures strongly sinuous towards the opposite direction, proximal end expended, distal ends hooked in the opposite directions. Striae areolate, transverse and longitudinal.
Remarks: The cell length 70–130 μm, width 13–18 μm, striae 19–21 in 10 μm described by (Wang *et al*. 2010).
Distribution and ecology: *Gyrosigma procerum* appeared in the sediment core samples of Liyu Lake, a lowland natural lake situated at Hualen, eastern Taiwan (Wang *et al*. 2010).

***Humidophila perpusilla* (Grunow) Lowe, Kociolek, J.R. Johansen, Van de Vijver, Lange-Bertalot & Kopalová 2014**
Figures 75–77
Basionym: *Navicula perpusilla* Grunow 1860
Synonyms: *Navicula perpusilla* Grunow 1860; *Schizonema perpusillum* (Grunow) Kuntze 1898; *Navicula gallica* var. *perpusilla* (Grunow) Lange-Bertalot 1985; *Diadesmis perpusilla* (Grunow) D.G. Mann 1990; *Diadesmis gallica* var. *perpusilla* (Grunow) Bukhtiyarova 1995.
Original description: Lowe *et al*. (2014), p. 358.
Key literatures: Cantonati *et al*. (2017); Lowe *et al*. (2017).
Specimen examined: Tables 1, 2.
Dimension: Length 8.0–10.4 μm, width 3.7–4.0 μm; 5–6 areolae in 1 μm on the raphe valve.

***Navicula gregaria* Donkin 1861**
Figures 78–80
Synonyms: *Schizonema gregarium* (Donkin) Kuntze 1898; *Navicula gregalis* Cholnoky 1963.
Original description: Donkin (1861), p. 10, pl. 1, fig. 10.
Key literatures: Cantonati *et al*. (2017); Cox (1999); Lee (2012).
Specimen examined: Tables 1, 2.
Dimension: Length 27.1 μm, width 16.5 μm; three longitudinal striae in 1 μm on the raphe valve.

Navicula nipponica* (Skvortzov) Lange-Bertalot 1993
Figures 81–83
Synonyms: *Navicula radiosa* f. *nipponica* Skvortzov (1936).
Original description: Lange-Bertalot (1993).
Key literatures: Lange-Bertalot (1993); Ohtsuka & Tuji (2002); Ohtsuka *et al*. (2009); Watanabe *et al*. (2005).
Specimen examined: Tables 1, 2.

Dimension: Length 35.2 μm, width 7.1 μm; 13 striae in 10 μm on the raphe valve.

Description: Valves are elliptic-lanceolate to broadly lanceolate, with obtusely rounded and slightly acuminate apices. The raphe is weakly lateral. Proximal raphe ends are deflected to the secondary side. Distal raphe fissures are hooked to the secondary side. The axial area is narrow. The central area is moderately large, dilated and asymmetric. Striae are radiate, becoming convergent at the apices.

Remarks: Ohtsuka & Tuji (2002) referred to Lange-Bertalot (1993) thought *N. radiosa* f. *nipponica* Skvortzow to be an independant species distinct from *N. radiosa* Kützing and named it *N. nipponica* (Skvortzow) Lange-Bertalot.

Distribution and ecology: According to Skvortzow (1936), *Navicula nipponica* was found predominantly in epipelic algal assemblages in benthic environment in Lake Biwa and Lake Kizaki. This species prefers neutral water and saproxenous taxa (Watanabe *et al*. 2005).

***Nitzschia dissipata* (Kützing) Rabenhorst 1860**

Figure 84

Basionym: *Synedra dissipata* Kützing 1844.

Synonyms: *Synedra dissipata* Kützing 1844; *Nitzschia palea* f. *dissipata* (Kützing) Rabenhorst 1864; *Homoeocladia dissipata* (Kützing) Kuntze 1898; *Nitzschia palea* var. *dissipata* (Kützing) Schönfeldt 1907.

Original description: Rabenhorst (1860), p. 968.

Key literatures: Cantonati *et al*. (2017); Laing *et al*. (1999).

Specimen examined: Tables 1, 2.

Dimension: Length 15.1–17.8 μm, width 3.5–4.1 μm; 26–27 striae in 10 μm on the valve.

***Nitzschia linearis* (Agardh) Smith 1853**

Figures 85–89

Synonyms: *Homoeocladia linearis* (Smith) Kuntze 1898; *Frustulia linearis* Agardh 1853.

Original description: Smith (1853), p. 39, pl. XIII [13], fig. 110, pl. XXXI, fig. 110.

Key literatures: Aboal *et al*. (2003); Cantonati *et al*. (2017); Sims (1996).

Specimen examined: Tables 1, 2.

Dimension: Length 81.8–107.7 μm, width 10.1–11.1 μm.

Remarks: *Nitzschia linearis* have the vermiform silica ridges on the mantle and girdle on the exterior valve (Fig. 88). This characteristics was the distinctive feasture in this taxa (Lundholm & Moestrup 2000). The vermiform silica ridges was shown to both *N. navis-varingica* and *N. linearis* on the exterior valve mantle (Mann 1980; Kobayasi & Kobori 1988). *N. linearis* have the vermiform ridges on girdle bands, whereas *N. navis-varingica* own the girdle bands covered with silica warts (Lundholm & Moestrup 2000).

***Nitzschia fonticola* (Grunow) Grunow in Van Heurck 1881**

Figures 90, 91

Basionym: *Nitzschia palea* var. *fonticola* Grunow 1880.

Synonyms: *Nitzschia kützingiana* var. *fonticola* Grunow 1880; *Nitzschia kuetzingiana* var. *romana* Grunow 1880; *Nitzschia romana* Grunow 1881; *Homoeocladia romana* (Grunow) Kuntze 1898; *Nitzschia palea* var. *romana* (Grunow) *H. Peragallo* 1903; *Nitzschia minima* Meister 1935; *Nitzschia macedonica* Hustedt 1945; *Nitzschia subromana* Hustedt 1954; *Nitzschia manca* Hustedt 1957.

Original description: Van Heurck (1881), pl. LXIX [69], figs 15–20.

Key literature: Cantonati *et al*. (2017).

Specimen examined: Tables 1, 2.

Dimension: Length 23.7 μm, width 3.9 μm; 30–32 striae in 10 μm on the valve.

***Odontidium mesodon* Kützing 1849**

Figures 92–95

Basionym: *Fragilaria mesodon* Ehrenberg 1839.

Synonyms: *Fragilaria mesodon* Ehrenberg 1839; *Odontidium mesodon* Kützing 1849; *Diatoma mesodon* Kützing 1844; *Odontidium hyemale* var. *mesodon* (Ehrenberg) Grunow 1862; *Diatoma hiemalis* var. *mesodon* (Ehrenberg) Kirchner 1878: 204.

Original description: Kützing (1849), p. 12.

Key literatures: Aboal *et al*. (2003); Cantonati *et al*. (2017).

Specimen examined: Tables 1, 2.

Dimension: Length 13.1–23.8 μm, width 10.2–16.5 μm; 22–25 striae in 10 μm on the valve and 5 costae in 10 μm on the inner valve.

***Odontidium hyemale* Kützing 1844**

Figures 96–100

Basionym: *Fragilaria hiemalis* Lyngbye 1819.

Synonyms: *Fragilaria hiemalis* Lyngbye 1819; *Neodiatoma hiemale* Kuntze 1891, *Temachium hiemale* Wallroth 1833; *Diatoma hyemalis* Heiberg 1863.

Original description: Kützing (1844), p. 44, pl. 17, fig. 4.

Key literature: Jüttner *et al*. (2015).

Specimen examined: Tables 1, 2.

Dimension: Length 25.7–40.1 μm, width 8.7–9.5 μm; 22–25 striae in 10 μm on the valve.

Pinnularia pseudotabellaria* H. Kobayasi 1977

Figures 101–103

Original description: Kobayasi & Ando (1977).

Key literature: Makita & Tanaka (2018).

Specimen examined: Tables 1, 2.

Dimension: Length 164.3 μm, width 21.4 μm; 10–11 striae in 10 μm on the raphe valve.

Description: Valves are linear, with a slightly swollen center and broadly rounded apices. The axial area is linear and about one-third the breadth of the valve. The central area is rounded and somewhat asymmetrical. Raphe is filamentous and straight. Proximal raphe ends are weakly expanded, deflected to one side, and closely spaced. Terminal raphe fissures are deflected to the primary valve side. The terminal raphe fissures are sickle-shaped. Striae are slightly parallel or weakly radiate throughout most of the valve.

Remarks: *Pinnularia pseudotabellaria* is distinguished from *Pinnularia tabellaria* by the arrangement of the striae and by the dissimilar terminal fissures. This species is also similar to *Pinnularia hustedtii*, but differs in that the ultra-structure of the raphe is filamentous (Kobayasi & Ando 1977).

Distribution and ecology: This species was found on surface sediment in a lagoon Hamabun-numa of lake Biwa from Japan in November 2013 (Makita & Tanaka 2018).

Pinnularia rabenhorstii* Krammer 2000

Figures 104–106

Basionym: *Navicula rabenhorstii* Grunow 1860.

Synonyms: *Navicula rabenhorstii* Grunow 1860; *Navicula lata* var. *rabenhorstii* (Grunow) Prochazka 1923; *Pinnularia lata* var. *rabenhorstii* (Grunow) Cleve 1895; *Pinnularia lata* var. *thuringiaca* (Rabenhorst) Mayer 1917; *Pinnularia lata* f. *thuringiaca* Hustedt 1930.

Original description: Krammer (2000), p. 22, pl. 4, fig. 1, pl. 5, figs 1–11, pl. 6, figs 1–4, nom. illeg.

Key literature: Zindarova *et al*. (2016)

Specimen examined: Tables 1, 2.

Dimension: Length 61.7–64.2 μm, width 14.4–15.5 μm; 4–5 striae in 10 μm on the raphe valve.

Description: The valves are strongly silicified, linear or linear-elliptic with straight to slightly convex margins. The valve apices are broadly rounded. The axial area is more or less broad. The striae are distinct and wide, slightly radiate at the centre, becoming convergent near the poles. The central striae slightly shorter, forming a widened, round to squarish central area. The raphe somewhat curved, with comma-shaped terminal fissures. The proximal raphe ends are expanded, rounded, distinctly hooked, and distal ends curved in opposite direction. The striae are multiseriate, chambered, each chamber containing many rows of small rounded poroids, striae parallel, distantly placed from each other, widely spaced, more or less alternating on opposite sides of the valve.

Distribution and ecology: This species prefers cold oligotrophic waters in mountains (Krammer 2000).

***Planothidium lanceolatum* Lange-Bertalot 1999**

Figures 107–109

Basionym: *Achnanthidium lanceolatum* Brébisson ex Kützing 1846.

Synonyms: *Achnanthidium lanceolatum* Brébisson ex Kützing 1846; *Achnanthes lanceolata* (Brébisson ex

Kützing) Grunow 1880; *Planothidium lanceolatum* (Brébisson) Round et Bukhtiyarova 1996.

Original description: Lange-Bertalot (1999), p. 287.

Key literatures: Aboal *et al*. (2003); Cantonati *et al*. (2017); Round & Bukhtiyarova (1996).

Specimen examined: Tables 1, 2.

Dimension: Length 14.6–15.3 µm, width 5.2–5.6 µm; 12–13 striae in 10 µm on the rapheless valve.

Platessa bahlsii* Potapova 2012

Figure 110

Original description: Potapova (2012), p. 38, figs 84–96.

Key literature: Potapova (2012), p. 38, figs 84–96.

Specimen examined: Tables 1, 2.

Dimension: Length 5.8 µm, width 3.2 µm; 1–2 striae in 1 µm on the raphe valve.

Description: The valves are elliptical and broad toward valve center. The raphe valve has narrow linear axial area and small central area. The raphe is slightly filiform, straight, with slightly expanded distal. The external proximal raphe endings are straight. The striae are multiseriate and radiate. Three to four rows of areolae per stria on the raphe valve.

Remarks: *Platessa bahlsii* differs from *P. conspicua* by small central area on the raphe valve, smaller cell size, and having three to four rows of areolae in striae. The striae are evenly distributed on the valve face. *P. conspicua* has rectangular central area and biseriate striae. *P. bahlsii* can be easily confused with some small species of *Planothidium* (Potapova 2012).

Distribution and ecology: *Platessa bahlsii* appears to be widely distributed in North America, but it is difficult to estimate its range as it was most likely confused with *P. conspicua* in the past (Potapova 2012).

***Stauroneis reichardtii* Lange-Bertalot, Cavacini, Tagliaventi & Alfinito 2003**

Figures 111, 112

Original description: Lange-Bertalot *et al*. (2003), p. 142, pl. 36, pl. 37, figs 1–14, pl. 61, figs 6, 7.

Key literatures: Cantonati *et al*. (2017); Michelutti *et al*. (2013); Van de Vijver *et al*. (2004).

Specimen examined: Tables 1, 2.

Dimension: Length 42.7 µm, width 9.5 µm; 22–23 striae in 10 µm on the raphe valve.

***Thalassiosira lacustris* (Grunow) G.R. Hasle in Hasle & Fryxell 1977**

Figures 113–116

Basionym: *Coscinodiscus lacustris* Grunow 1880.

Synonyms: *Coscinodiscus lacustris* Grunow 1880; *Cyclotella punctata* Smith 1856; *Stephanodiscus punctatus* (Smith) Grunow 1878.

Original description: Hasle & Fryxell (1977), p. 40.

Key literature: Park *et al*. (2016).

Specimen examined: Tables 1, 2.

Dimension: Diameter 27.1–29.7 µm.

***Ulnaria ulna* (Nitzsch) Compère 2001**

Figures 117, 118

Basionym: *Bacillaria ulna* Nitzsch 1817.

Synonyms: *Bacillaria ulna* Nitzsch 1817; *Frustulia ulna* (Nitzsch) C. Agardh 1831; *Synedra ulna* (Nitzsch) Ehrenberg 1832; *Fragilaria ulna* (Nitzsch) Lange-Bertalot 1980; *Exilaria ulna* (Harvey) Jenner 1855; *Frustulia ulva* (Nitzsch) C. Agardh 1829.

Original description: Compère (2001), p. 100.

Key literatures: Aboal *et al*. (2003); Cantonati *et al*. (2017); Williams (2011).

Specimen examined: Tables 1, 2.

Dimension: Length 80.5–147.3 µm, width 9.1–9.5 µm in the centre. Striae 11–12 in 10 µm.

***Ulnaria contracta* (Østrup) E.A. Morales & M.L. Vis 2007**

Figures 119, 120

Basionym: *Synedra ulna* var. *contracta* Østrup 1901.

Synonyms: *Synedra ulna* var. *contracta* Østrup 1901; *Fragilaria ulna* var. *contracta* (Østrup) Main 1988.
Original description: Morales & Vis (2007).
Key literature: Morales & Vis (2007).
Specimen examined: Tables 1, 2.
Dimension: Length 80.5–147.3 µm, width 9.1–9.5 µm in the centre. Striae 11–12 in 10 µm.

Conclusions

Thirty-eight diatom species representing 2 classes, 5 subclasses, 10 orders, 17 families, and 25 genera were investigated from the source of Han and Nakdong Rivers in Korea. In GP-01, the highest number of infrageneric taxa (17 species) was found, and 13 taxa were found in GP-02. In NP-01, lower number of species (seven taxa) were identified. Eleven species were found in NP-02 (Table 2). The most species rich genus was *Achnanthidium* and *Nitzschia* with three taxa, respectively. The *Achnanthidium* species were found only in GP-01, but the *Nitzschia* species were identified from GP-01 (*Nitzschia dissipata*), GP-02 (*Nitzschia linearis*), and NP-01 (*Nitzschia fonticola*). The most frequent species was *Odontidium mesodon* in all stations (Table 2). Nine taxa—*Achnanthes sinaensis*, *Achnanthidium atomus*, *Edtheriotia guizhoiana*, *Fragilaria recapitellata*, *Gyrosigma procerum*, *Navicula nipponica*, *Pinnularia pseudotabellaria*, *Pinnularia rabenhorstii*, and *Platessa barhlsii*—were newly recorded diatoms. We presented the checklist of diatoms for each stations, and the description of the morphological characteristics based on the LM and SEM only for nine newly recorded species. Of these, *Achnanthes sinaensis*, *Achnanthidium atomus*, *Edtheriotia guizhoiana*, *Gyrosigma proceum*, *Navicula nipponica*, *Pinnularia rabenhorstii*, and *Platessa barhlsii* were found in GP-02, GP-01, GP-01, GP-02, GP-01, GP-02, and GP-01, respectively. *Fragilaria recapitellata* was identified in GP-01, GP-02, NP-01, and *Pinnularia pseudotabellaria* was found in NP-01, NP-02. We present the taxonomic information such as the systematics, dimension, distribution, and ecology in the source of two major rivers in Korea. This study might contribute to the understanding of diversity and flora of diatoms in various freshwater environments from Korea.

Acknowledgments

We thank Honorary Prof. Jin Hwan Lee for the assistance with SEM observations in Sangmyung University. We also thank the anonymous reviewers for providing helpful comments to this paper. This research was supported by a fund from the Nakdonggang National Institute of Biological Resources (NNIBR) in the Republic of Korea (NNIBR2016281, NNIBR2017282).

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