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EUNOTIA (BACILLARIOPHYTA) IN THE HOLARCTIC: NEW SPECIES FROM THE RUSSIAN ARCTIC*

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Abstract. This paper describes six species of the genus *Eunotia* Ehrenberg new to science. The material from which these species are described originates from isolated and nearly inaccessible areas. The habitats sampled for this study are located in the middle course of the Anadyr River and surrounding areas on the Chukotka Peninsula at the northeastern limit of the Russian Federation. Data on the diversity and taxonomy of the genus *Eunotia* from the Russian Arctic are provided and compared with current research ongoing in neighboring areas and in the European part of Russia and in Mongolia. The morphology and taxonomy of the species are briefly discussed and compared with established and recently described species in *Eunotia*. We used the results of our study together with recently published data to update and expand the biogeographic information on the taxa described in this paper.

Key words: Diatoms, *Eunotia*, new species, morphology, taxonomy, distribution, Anadyr River, Chukotka, Russian Arctic

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INTRODUCTION

Diatom species of the genus *Eunotia* Ehrenberg differ from those of other genera by their very narrow ecological tolerance. Their occurrence is limited to oligotrophic and oligosaprobic waters. In consequence, *Eunotia* taxa are considered important ecological indicators (e.g., Alles *et al.* 1991; Kwandrans 2007).

The last two decades of research on European *Eunotia* species have yielded a huge amount of data which have been included in numerous publications (e.g., Lange-Bertalot & Metzeltin 1996; Lange-Bertalot & Genkal 1999; Krammer & Lange-Bertalot 2000; Lange-Bertalot *et al.* 2003; Werum & Lange-Bertalot 2004; Kulikovskiy 2007). This has suggested the need for a treatise on *Eunotia*, including all European or in the broader sense Holarctic taxa (Lange-Bertalot *et al.* 2008). Although several dozen new species of *Eunotia* are described in that European (Holarctic) treatise, we are aware that the diversity of taxa representing this genus in the tropics is much higher. Recently more than one hundred *Eunotia* species were described as new for science in the tropics in addition to the few hundred taxa discovered earlier (e.g., Moser *et al.* 1995, 1998; Metzeltin & Lange-Bertalot 1998, 2007).

As compared to similar work in other geographic regions, diatom studies in Chukotka were initiated fairly late. The first reports on diatom assemblages including *Eunotia* taxa in the Arctic and Chukotka in particular were published in the 1930s, pioneered by Voronihyn (1937), who studied diatoms from the Anadyr district. In his report he noted that diatoms were uncommon, though in more species-rich samples *Eunotia* were dominant. Later Charitonov (1978) published a paper on diatom assemblages from the Anadyr River, in which he presented the species composition and provided

* Dedicated to Dr. Kurt Krammer on the occasion of his 85th birthday

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a list of 18 *Eunotia* taxa: *E. lunaris* (Ehrenberg) Grunow, *E. tenella* (Grunow) Hustedt, *E. polydentula* Brun, *E. crista-galli* Cleve, *E. fallax* A. Cleve, *E. fallax* var. *gracillima* Krasske, *E. valida* Hustedt, *E. pectinalis* (Kützing) Rabenhorst, *E. pectinalis* var. *ventralis* (Ehrenberg) Hustedt, *E. parallela* Ehrenberg, *E. faba* (Ehrenberg) Grunow, *E. praerupta* Ehrenberg, *E. praerupta* var. *inflata*, *E. praerupta* var. *bidens* (W. Smith) Grunow, *E. robusta* Ralfs, *E. triodon* Ehrenberg, *E. tauntoniensis* var. *hankensis* Skvortsow and *E. monodon* var. *major* (W. Smith) Hustedt. Recently Charitonov (2005) published a list of species representing the family Eunotiaceae from different habitats of this area (including the whole of Beringia). His Eunotiaceae list contained 114 specific and intraspecific taxa.

The problem is that papers published on diatom assemblages not only from Chukotka but also from the Arctic part of Asia provide only species lists without microphotographs. This makes any comparisons using the most recent analytical methods practically impossible.

In this paper we describe six *Eunotia* species as new for science. They are characterized in terms of their morphology by light (LM) and scanning electron (SEM) microscopy. We compare the new entities with other taxa with which they can be confused. We also have tried to determine their biogeography. These species are described here as new to science but in the past they have been illustrated as unidentified *Eunotia* taxa, as in the case of *E. scandiorussica*. The new taxa all represent oligotrophic habitats, and prefer cold (high mountain, Arctic) geographic regions.

Material and methods

The material (*Sphagnum* spp.) used in the present study (36 samples) was collected from the middle course of the Anadyr River and various unnamed small tundra lakes in the region. Also included are collections from the Mamolina River, Markovka River and Anadyr River itself during various seasons of 1979 and 1980. These water bodies and watercourses are on the Chukotka Peninsula, the northeastern limit of the Russian Federation.

Hydrochemical characteristics and temperature were similar in all habitats sampled. The water was soft, with low mineralization (not exceeding 200 mg/l) and of hydrocarbonate type. In the wintertime these ecosystems exist due to flood-plain talik. During sampling the pH ranged from 6.4 to 6.7, and the water temperature from 11 to 15°C.

Samples were processed by standard methods, including 10% HCl treatment in order to remove calcium carbonate, followed by rinsing with distilled water. Samples were boiled in hydrogen peroxide (37%) and again washed with distilled water. Permanent diatom preparations were mounted in Naphrax®. Observations by LM employed a Nikon Eclipse E 600 equipped with a 100× Plan-apochromatic oil immersion objective and a Nikon DS-5M digital camera. Diatom valve ultrastructure was analyzed with a Hitachi S-4500 scanning electron microscope and an H-300 transmission electron microscope (Hitachi, Japan).

Results

A total 35 *Eunotia* species were identified in the study area. Many of them are well known taxa typical of oligotrophic habitats of Europe, Asia and North America, including *E. glacialifalsa* Lange-Bertalot, *E. triodon* Ehrenberg, *E. valida* Hustedt, *E. tetraodon* Ehrenberg, *E. incisa* Gregory, *E. praerupta* Ehrenberg, *E. lapponica* Grunow, *E. subarcuatoides* Alles, Nörpel & Lange-Bertalot, *E. bilunaris* (Ehrenberg) Schaarschmidt s.l. and *E. genuflexa* Nörpel-Schempp. Those taxa occur abundantly in *Sphagnum* ecosystems or in water bodies and watercourses with low pH (Krammer & Lange-Bertalot 2000; Kulikovskiy *et al.* 2010, Lange-Bertalot *et al.* submitted). In the material studied we also observed *E. mongolica* Kulikovskiy, Lange-Bertalot & Witkowski, previously known only from the Nur *Sphagnum* bog in Mongolia (Kulikovskiy *et al.* 2010). With that new finding we can determine its biogeography as an Asian element. Also interesting are *E. curtagrunowii* and *E. septentrionalis*, which are generally distributed in the Arctic. The second of those species was also identified during our studies in northern Mongolia. Also in the material was *E. parapraerupta* Lange-Bertalot & Metzeltin, known previously from Mongolia. It is closely related to *E. curtagrunowii* (Metzeltin *et al.* 2009; Kulikovskiy *et al.* 2010). *E. scandiorussica*, which we describe below as new to science, is also known

from northern Mongolia (Metzeltin *et al.* 2009: Pl. 20, 10–17), as (?)*Eunotia ursamaioris* Lange-Bertalot & Nörpel-Schempp. *E. scandiorussica* was common though left unnamed (*Eunotia* sp. 4) in a *Sphagnum* bog from the European forest-steppe zone of Russia (Kulikovskiy 2007). Below we describe six new species.

Eunotia scandiorussica Kulikovskiy, Lange-Bertalot, Genkal & Witkowski, ***sp. nov.*** Fig. 1: 1–32

Eunotia sp. 4 *in* Kulikovsky 2007.

Diagnosis differens versus Eunotia ursamaioris Lange-Bertalot & Nörpel-Schempp: *Valvae distincte dorsiventrales cum marginibus ventralibus dorsalibusque circiter parallelis quoad specimina media et longiora. Mergines ventrales minus concavae quam margines dorsales convexae quoad specimina minora. Apices paulo vel parum oblique protractis in omnibus statibus cycli cellularum* (*nec distincte rostratis vel capitatis protracti ex umeris dorsaliter magnopere convexis*). *Longitudo 22–53 µm, latitude 4.9–6.9 µm. Fissurae rophis terminals curte curvatae in faciem valvae. Striae transapicales 13–17 in 10 µm non vel vix densins sitae sub apices. Areolae non aspectabiles microscopio photonico, 33–36 in 10 µm versu microscopio electronico*.

TYPE: RUSSIA, Yugorsky Peninsula, Northern part of Europaean Russia, 69°35′N, 60°20′– 60°30′E, 1995, *leg. N. V. Vekhov* [HOLOTYPE: Praep. No. RUS 41 in Coll. Lange-Bertalot (FR), Germany, represented by Fig. 4: 19 in Lange-Bertalot & Genkal (1999); ISOTYPE: sub YU-2 in Coll. S. Genkal, Borok, Russia].

ETYMOLOGY: The epithet refers to the two countries where this new species has been observed so far, Russia and Finland.

Differetial diagnosis versus *Eunotia ursamaioris* Lange-Bertalot & Nörpel-Schempp: Valves distinctly dorsiventral; ventral and dorsal margins almost parallel in longer and medium-sized specimens, whereas in smaller specimens the ventral margins are less concave than the dorsal margins. Ends gently or barely protracted in all cell cycle stages (not distinctly rostrate or capitate protracted from broader shoulders on the dorsal side). Length 22–53 µm, breadth 4.9–6.9 µm. Terminal raphe fissures short in valve face. Striae 13–17 in 10 µm, not or very slightly denser near the apices. Areolae barely resolvable in LM, 33–36 in 10 µm seen in TEM or SEM (Fig. 1: 26–30).

DISTRIBUTION. So far found in Russia in Penza region (*Sphagnum* bogs of forest-steppe) and in Yugorsky Peninsula and a single specimen in Finnish Lapland, and another one in Greenland. Possibly single specimens have been overlooked elsewhere or mistaken for post-primary valves of *Eunotia ursamaioris* or other similar taxa. However, neither are frequent in places like peat bogs or other acidic habitats.

Eunotia subcapitata Kulikovskiy, Lange-Bertalot, Genkal & Witkowski, ***sp. nov.*** Fig. 2: 1–10

(?)*Synedra lunaris* var. β *capitata* Grunow 1862, p. 389; (?)*Eunotia lunaris* var. *capitata* (Grunow) Schönfeldt 1907, p. 119; *Eunotia lunaris* var. *capitata* sensu auct. nonnul.

TO BE EXLUDED FROM SYNONYMY: *Eunotia lunaris* var. *capitata sensu* Hustedt 1930, Fig. 250 and *sensu* A. Mayer (in litt.); *Eunotia curvata* var. *capitata* (Grunow) Patrick *in* Patrick & Reimer 1966, Fig. 10: 5.

Diagnosis differens versus Eunotia bilunaris (Ehrenberg) Schaarschmidt *et versus* Eunotia ambivalens Lange-Bertalot & Tagliaventi (*vide supra*)*: Valvae dorsiventrales curvatae ita ut* E. bilunaris *sed distincte magis quam* E. ambivalens*. Apices protracti oblique subcapitati fere similiter ut* E. ambivalens *sed inaqualiter* E. bilunaris*. Longitudo 66–88 µm quod adluc observanda, latitude 2.8–3.3 µm, id est comparate plus minusve angustius. Raphe cum fissures terminalibus generaliter similis. Striae transapicales 18–20 in 10 µm proximis partibus ita distincte densins sitae inter se quam 11.5–13.0 in* E. ambivalens *etiam densis quam ita 13–17. Striae prope apices comparate paulo densiores, 20–22 in 10 µm. Areolae solum aspectu ultramicroscopico discernendae, circiter 40 in 10 µm.*

Differential diagnosis versus *Eunotia bilunaris* (Ehrenberg) Schaarschmidt and versus *Eunotia ambivalens* Lange-Bertalot & Tagliaventi: Valves with parallel ventral and dorsal margins, valves strongly arcuate (comparable to *E. bilunaris* but more strongly than *E. ambivalens*). Ends protracted and inflated, distinctly subcapitate (similar to longer specimens of *E. ambivalens* but unlike *E. bilunaris*). Length 66–88 µm, breadth

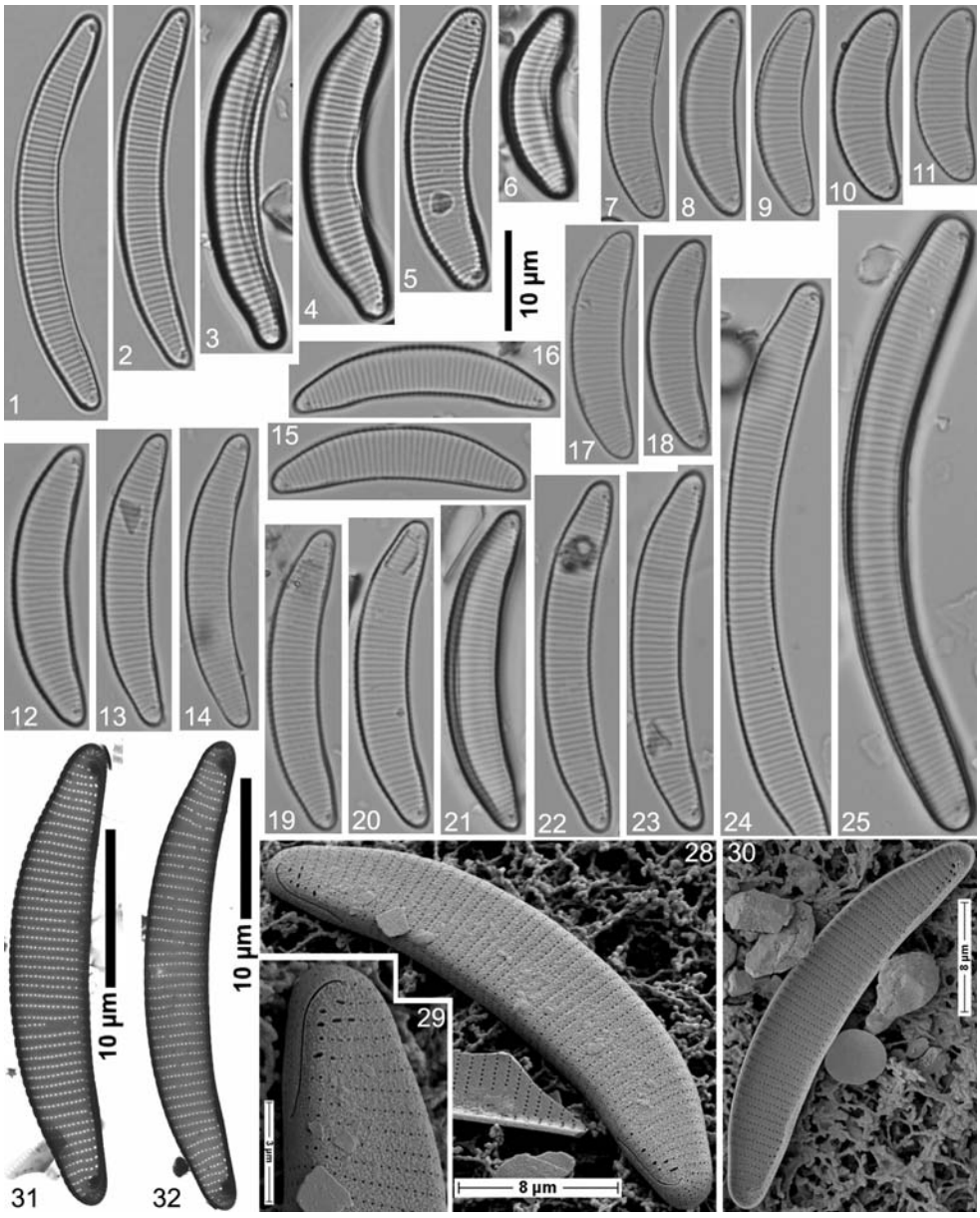

Fig. 1. *Eunotia scandiorussica* Kulikovskiy, Lange-Bertalot, Genkal & Witkowski *spec. nov.* (1–25 – LM, 26–28 – SEM, 29 & 30 – TEM). 1–25, 29 & 30 – valve view; 26 – external valve view; 27 – external view of valve end with raphe; 28 – internal valve view.

2.8–3.3 µm. Raphe with terminal fissures conforms to both compared species. Striae in 10 µm 18–20 in proximal parts, becoming only slightly more dense close to the apices, 20–22 (this is distinctly more densely spaced in proximal parts than 11.5–13.0 in *E. ambivalens* and 13–17 in *E. bilunaris*). SEM, external view (see Fig. 2: 8–10). Proximal raphe fissures do not differ significantly from the compared species but are shorter than in, for example, *E. naegelii* or *E. flexuosa*. Along the

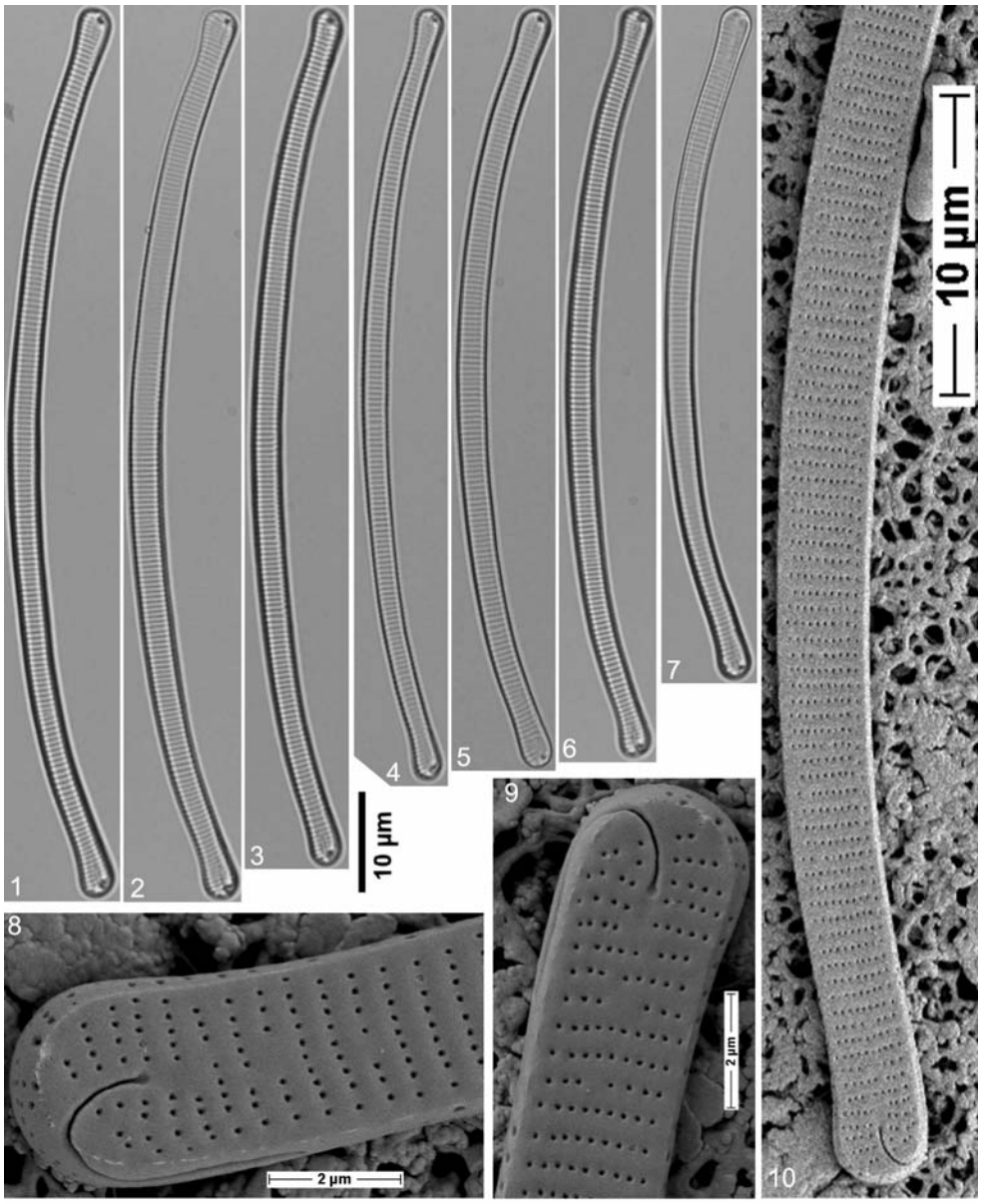

Fig. 2. *Eunotia subcapitata* Kulikovskiy, Lange-Bertalot, Genkal & Witkowski *spec. nov.* (1–7 – LM, 8–10 – SEM). 1–7 – valve view; 8 & 9 – external view of valve end with raphe; 10 – external valve view. 2 – holotype.

junction between the valve face and mantle, irregularly spaced narrow ridges are visible, roughly similar to *E. ambivalens* and to several lines of the taxa complex around *E. bilunaris*. Areolae *ca* 40 in 10 µm.

TYPE: RUSSIA, NE Siberia, Chukotka Peninsula, unnamed small lake on island within Anadyr River course close to the discharge of Mayn River, 13 August 1980, *leg. S. I. Genkal* [HOLOTYPE: slide no. 13914 (see Fig. 2: 2) in A. Witkowski collection, Institute of Marine Sciences, University of Szczecin

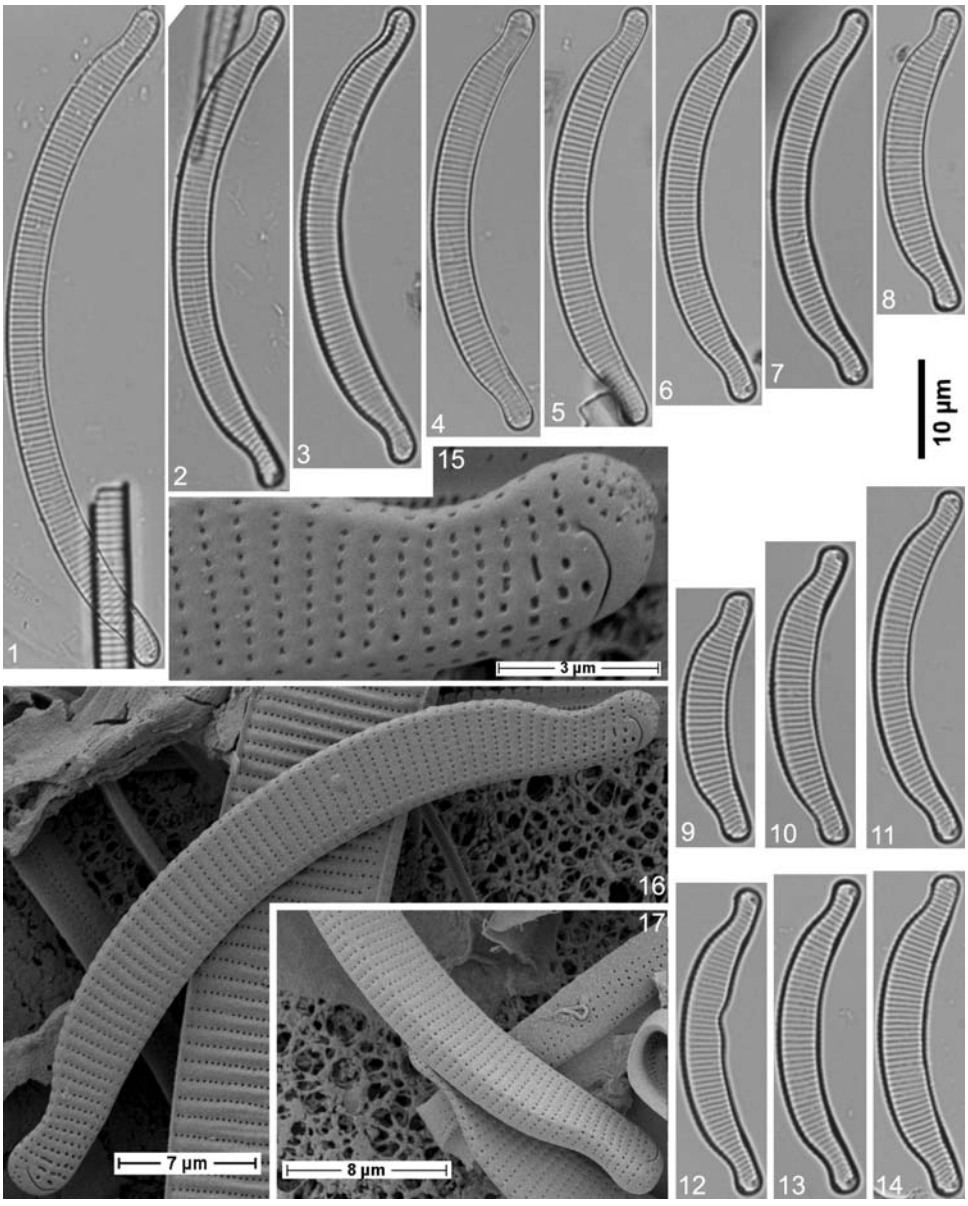

Fig. 3. *Eunotia anadariensis* Kulikovskiy, Lange-Bertalot, Genkal & Witkowski *spec. nov.* (1–14 – LM, 15–17 – SEM). 1–14 – valve view; 15 – external view of valve end with raphe; 16 & 17 – external valve view. 6 – holotype.

(SZCZ); ISOTYPE: slide no. 30 in M. Kulikovskiy collection, Institute for Biology of Inland Waters, Borok, Russia].

ETYMOLOGY: The Latin term *subcapitata* refers to the regularly inflated subcapitate ends.

DISTRIBUTION. Populations with this combination of characters, including relatively narrow valves with distinctly subcapitate ends and densely spaced striae, 18–20 in 10 µm, have very rarely been observed in any characteristic '*Eunotia* habitats' of Eurasia and North America.

Eunotia anadariensis Kulikovskiy, Lange-Bertalot, Genkal & Witkowski, ***sp. nov.*** Fig. 3: 1–17

Diagnosis differens versus Eunotia ursamaioris Lange-Bertalot & Nörpel-Schempp *in* Lange-Bertalot & Genkal 1999: *Valvae fortius arcuatae marginibus ventralibus fortius concavis cum marginibus dorsalibus convexis in mediis partibus parallelis quoad specimina media et longiora. Etiam quoad specimina curtiora marginibus ventralibus simper distincte concavis. Apices comparate distincte longius protracti rostrati sed denique cum polis subcapitatis. Longitudo 24–65 µm, latitudo 3.5–5.0 µm. Raphe cum fissures terminalibus curtis non significanter differentes. Striae transapicales 14–17 in 10 µm. Areolae aspectabiles etiam microscopio photonico, certe discernendae aspectu ultramicroscopico, 30–32 in 10 µm* (*id est distantins quam 35 in 10 µm*).

TYPE: RUSSIA, NE Siberia, Chukotka Peninsula, small unknown tundra lake near middle course of Anadyr River, 17 August 1980, *leg. S. I. Genkal* [HOLOTYPUS: slide no. 13916 (see fig. 3: 6) in A. Witkowski collection, Institute of Marine Sciences, University of Szczecin (SZCZ); ISOTYPE: slide no. 31 in M. Kulikovskiy collection, Institute for Biology of Inland Waters, Borok, Russia].

ETYMOLOGY: The epithet refers to the geography of the type locality near the Anadyr River (Chukotka Peninsula, Russian Arctic).

Diagnosis differens versus Eunotia ursamaioris Lange-Bertalot & Nörpel-Schempp in Lange-Bertalot & Genkal 1999: Valves more strongly arcuate, with strongly concave ventral margins and, except for the ends, parallel dorsal margins of all longer and medium-sized specimens. The ventral margins remain clearly concave also in shorter specimens, where the margins are not parallel. Ends comparatively longer protracted rostrate but finally more or less rounded subcapitate. Length 24–65 µm, breadth 3.5–5.0 µm. Raphe with terminal fissures not significantly different; neither are the striae, 14–17 in 10 µm. Areolae easier to resolve also in LM, 30–32 (instead of *ca* 35) in 10 µm. SEM, external view (see Fig. 3: 15–17).

DISTRIBUTION. As yet only found in the type locality. Associated with several other *Eunotia* species that are indicative of dystrophic waters with moderately low pH and low conductivity.

Eunotia orientis Kulikovskiy, Lange-Bertalot, Genkal & Witkowski, ***sp. nov.*** Figs 4: 1–16 & 5: 1–6

Valvae fere fortiter arcuatae marginibus ventralibus dorsalibusque parallelis. Apices oblique cuneatim rotundati plerumque modice inflate subcapitati. Longitudo 40–120 µm, latitudo 8.8–10.0 µm. Noduli terminales dense prope polos siti. Fissurae terminales raphis usque ad mediam polorum curvatae denique curte hamatae margines dorsales numquam allingentes. Striae transapicales 9–11 in 10 µm et circiter 15 ad apices. Areolae aspectabiles microscopio photonico, 24–28 in 10 µm. Spinae polares vel marginales absunt.

TYPE: RUSSIA, NE Siberia, Chukotka Peninsula, small unknown lake below Markovo Township, 18 August 1980, *leg. S. I. Genkal* [HOLOTYPE: slide no. 13899 (see Fig. 4: 16) in A. Witkowski collection, Institute of Marine Sciences, University of Szczecin (SZCZ); ISOTYPE: slide no. 32 in M. Kulikovskiy collection, Institute for Biology of Inland Waters, Borok, Russia].

ETYMOLOGY: Genitive of the Latin term *oriens* in this context means 'originating from the East' (Chukotka Peninsula).

DESCRIPTION: Valves, shorter and longer ones, conspicuously arcuate with parallel ventral and dorsal margins. Ends appearing obliquely cuneate rounded subcapitate. Length 40–120 µm, breadth 8.8–10.0 µm. Terminal nodules close to the poles. Terminal raphe fissures curving onto the valve face but ending with a little hook approximately at the middle of the poles, not reaching the dorsal valve margin. Striae rather evenly spaced, 9–11 in 10 µm except for the ends where they become condensed up to 15 in 10 µm. Areolae discernible in LM, 24–28 in 10 µm. SEM Fig. 5: 1–6.

DISTRIBUTION. As yet observed only in the type locality. Associated with several other *Eunotia* taxa and species representing a few other genera that are known as indicators of oligotrophic waters.

Eunotia problematica Kulikovskiy, Lange-Bertalot, Genkal & Witkowski, ***sp. nov.*** Fig. 6: 1–25

Diagnosis differens versus Eunotia minor (Kützing) Grunow *in* Van Heurck 1881: *Frustula catenas non*

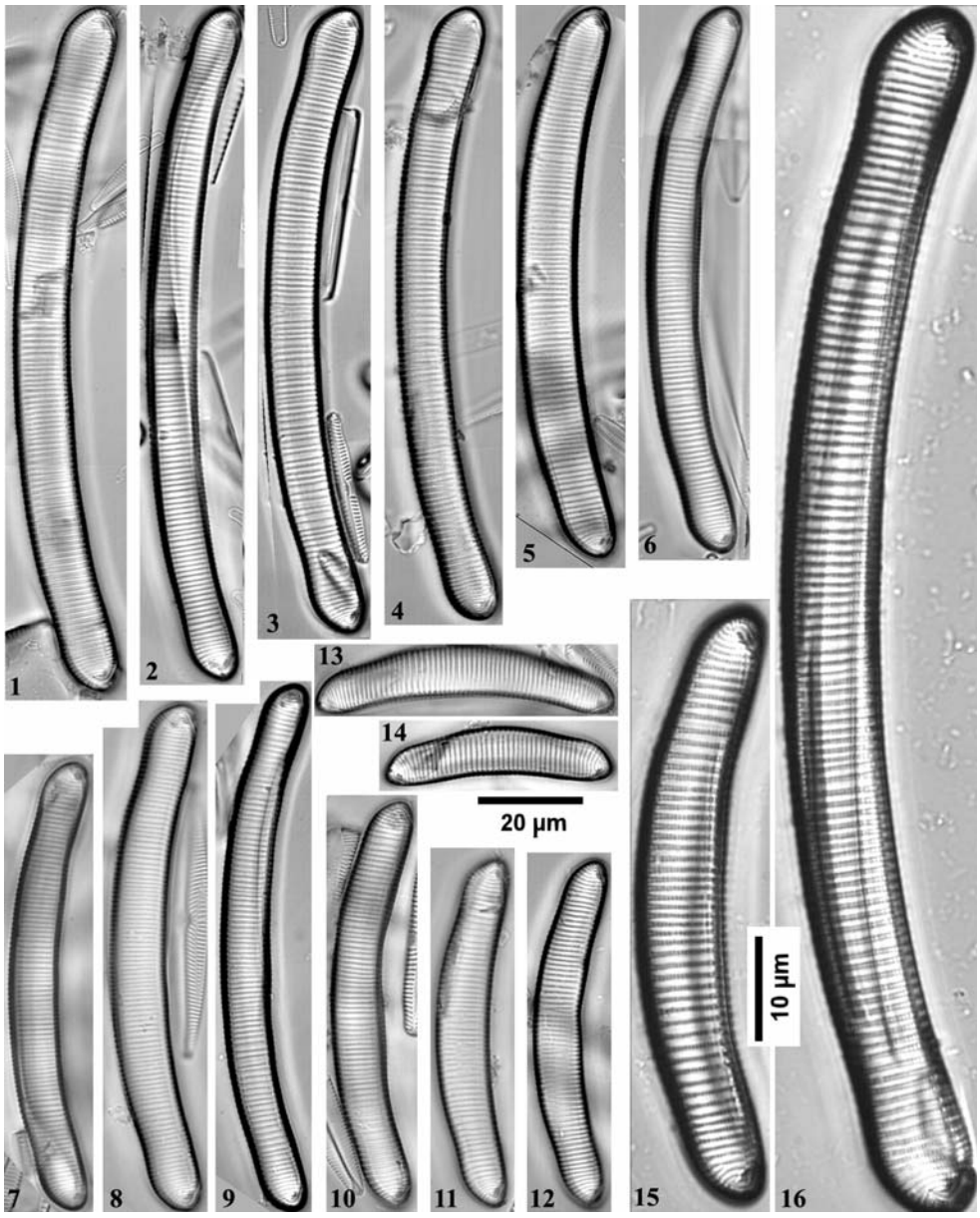

Fig. 4. *Eunotia orientis* Kulikovskiy, Lange-Bertalot, Genkal & Witkowski *spec. nov.* (1–16 – LM). 1–16 – valve view. 16 – holotype.

formantia quoad cognita. Valvae marginibus ventralibus leviter concavis marginibus dorsalibus magis convexis ita non vel vix parallelis. Apices plus minusve fere late et curte protracti ex margine dorsali solum denique obtuse rotundati. Longitudo 28–50 µm, latitude 5.3–7.3 µm. Raphe curtissime in facie valvae dense ad apicem visibilis. Striae transapicales in mediis partibus valvae fere inaequales sitae, 10–12 in 10 µm, prope polos abrupte conspicue condensatae, circiter 18–25 in 10 µm. Areolae etiam cum illuminatione oblique non aspectabiles microscopio photonico (*nec 30–35 in 10 µm*). *Areolae 40–45 in 10 µm. Series areolarum interraptae area ven-*

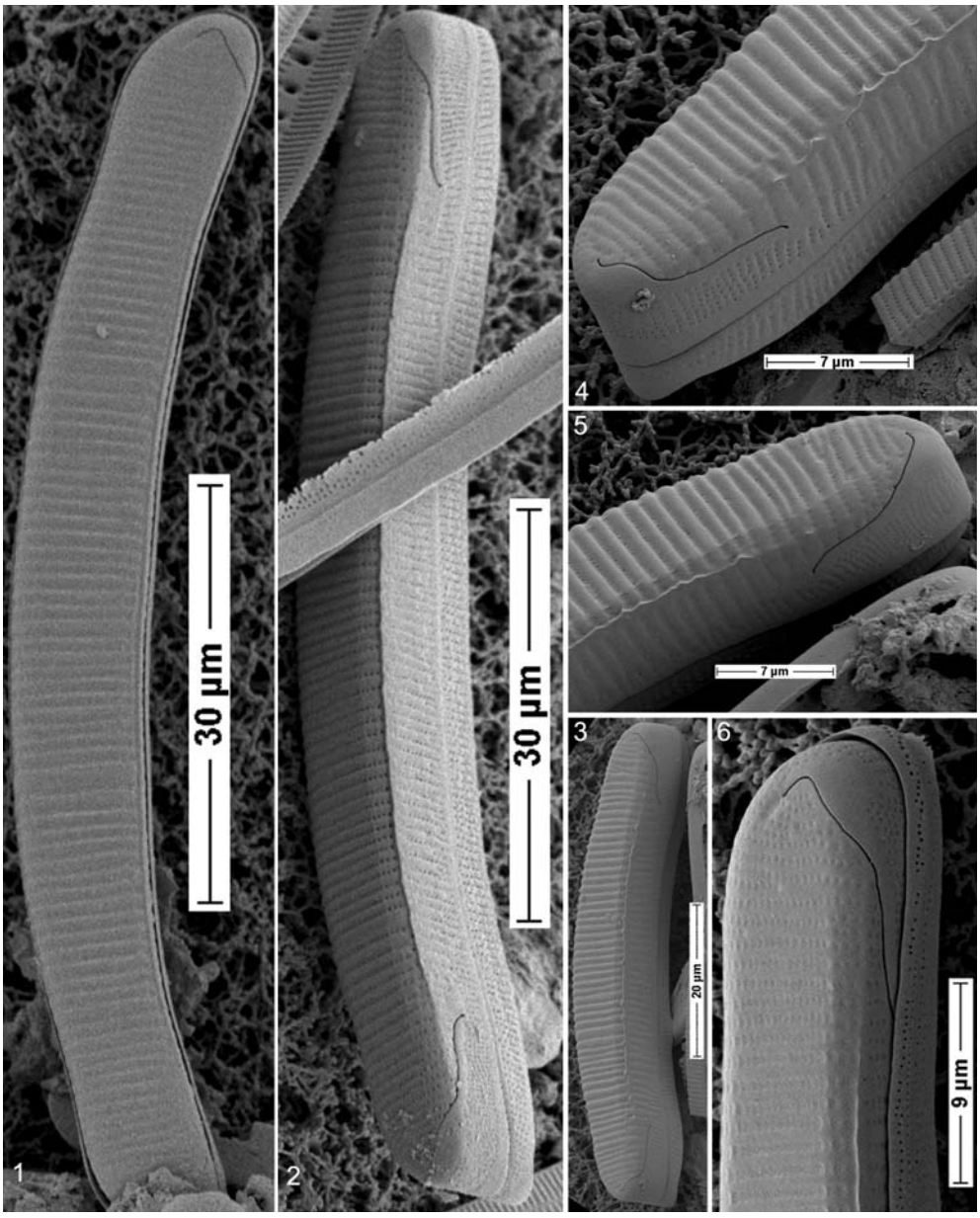

Fig. 5. *Eunotia orientis* Kulikovskiy, Lange-Bertalot, Genkal & Witkowski *spec. nov.* (1–6 – SEM). 1–3 – external valve view; 4–6 – external view of valve end with raphe.

trali angusta. Rimoportula ut communiter in genere ad polum unum adest ad alterum vacat.

TYPE: RUSSIA, NE Siberia, Chukotka Pennsula, small unnamed lake below Markovo Township, 18 August 1980, *leg. S. I. Genkal* [HOLOTYPE: slide no. 13899 (see fig. 6: 2) in A. Witkowski collection, Institute of Marine Sciences, University of Szczecin (SZCZ); ISOTYPE: slide no. 33 in M. Kulikovskiy collection, Institute for Biology of Inland Waters, Borok, Russia].

ETYMOLOGY: *problematica* refers to the diffi-

culty in understanding the taxonomical placement of this species.

Differential diagnosis versus *Eunotia minor* (Kützing) Grunow *in* Van Heurck 1881: Frustules forming ribbon-like aggregates could not be observed (in contrast to *E. minor*). Valves with slightly concave ventral margins and comparatively stronger convex dorsal margins. Ends rather broadly and shortly protracted from the shoulder-like dorsal margin, finally obtusely rounded. Length 28–50 µm, breadth 5.3–7.3 µm. Raphe terminal fissures shortly visible in valve face, rather close to the poles. Striae in the main body of the valve rather unevenly spaced and noticeably widely spaced, 10–12 in 10 µm, becoming quite abruptly densely spaced at the ends, 18–25 in 10 µm. The main distinguishing metric parameter is the conspicuously more densely spaced areolae, not discernible in LM even with oblique illumination (not 30–35 in 10 µm as in *Eunotia minor*). SEM, external view, see Fig. 6: 22–25. Areolae 40–45 in 10 µm. The areolated striae are interrupted by the ventral area (sternum) at the junction between the valve face and mantle as commonly seen in the genus. The presence of a single rimoportula at one or both poles also distinguishes it.

DISTRIBUTION. As yet known only from the type locality. Associated with several other *Eunotia* taxa and species representing genera that are known as indicators of oligotrophic waters.

Eunotia krammeri Kulikovskiy, Lange-Bertalot, Genkal & Witkowski, ***sp. nov.*** Fig. 7: 1–19

Diagnosis differens versus Eunotia mongolica Kulikovskiy, Lange-Bertalot & Witkowski *et* Eunotia juettnerae Lange-Bertalot: *Valvae sempes magis arcuatae quam specie E. juettnerae sed similes species* E. mongolica*. Margines ventrales concavae dorsalesque convexae parallelae in portibus proximis. Solum margo dorsalis est longe protracta ad apices deflexos dorsaliter. Longitudo 30–60 µm* (*non usque ad 100 µm ut* E. juettnerae)*, latitudo 2.8–3.3 µm prope apices circiter 2 µm* (*non 2.3– 2.7 ut E. mongolica*)*. Fissurae terminals raphis curtiores quam* E. juettnerae*. Striae transapicales 15–19 in 10 µm parum plus prope apices* (*ad est minus quam 19–28 speciet* E. mongolica)*. Areolae 35 in 10 µm aspectabiles aspectu ultramicroscopico.*

TYPE: RUSSIA, NE Siberia, Chukotka Peninsula, small unknown tundra lake near the middle course of the Anadyr River, 17 August 1980, *leg. S. I. Genkal* [HOLOTYPE: slide no. 13916 (see Fig. 7: 10) in A. Witkowski collection, Institute of Marine Sciences, University of Szczecin (SZCZ); ISOTYPE: slide no. 34 in M. Kulikovskiy collection, Institute for Biology of Inland Waters, Borok, Russia].

ETYMOLOGY: The epithet honors Dr. Kurt Krammer on the occasion of his 85th birthday.

Differential diagnosis versus *Eunotia mongolica* Kulikovskiy, Lange-Bertalot & Witkowski and *Eunotia juettnerae* Lange-Bertalot: Valves rather strongly arcuate as in *E. mongolica* but significantly more than in *E. juettnerae*; this is less noticeable in the shortest specimens but conspicuous when comparing medium-sized and longer cell cycle stages. Ventral and dorsal margins parallel in the main body of valves. Ends rather long and protracted from the dorsal margin, finally deflected dorsally. Length 30–60 µm (not up to 100 µm as in *E. juettnerae*), breadth 2.8–3.3 and at the ends *ca* 2 µm (not 2.3–2.7 as in *E. mongolica*). Terminal raphe fissures shorter than *E. juettnerae*. Striae 15–19 in 10 µm and only slightly more numerous at the ends (less than 19–23 and up to 28 in 10 µm in *E. mongolica*). Areolae not discernible in LM. SEM, see Fig. 7: 17–19. Areolae *ca* 35 in 10 µm.

DISTRIBUTION. As yet only observed from the type locality. Associated with several other *Eunotia* taxa.

DISCUSSION

Our study focusing on representatives of *Eunotia* from the Chukotka Peninsula revealed that despite the widespread belief that the best habitats for taxa belonging in this genus are in the tropics (Mezteltin & Lange-Beratlot 1998, 2007) the potential for finding new species in the Holarctic is still high. This is particularly true when sampling is done in barely accessible areas. The best examples of such areas are in general the Arctic and Sub-Arctic and regions such as the inland waters of Greenland (Lange-Bertalot *et al.* submitted) or the small lakes

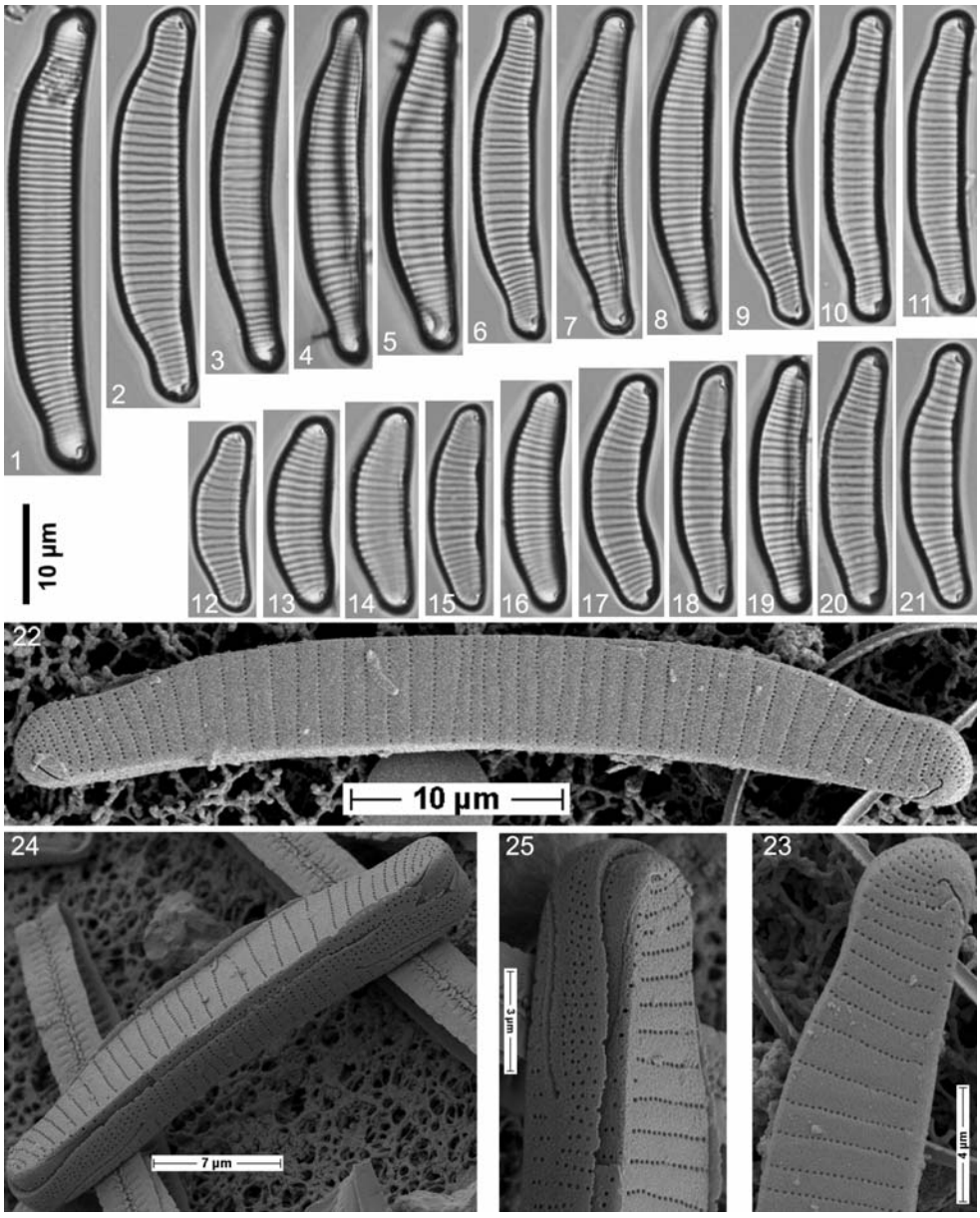

Fig. 6. *Eunotia problematica* Kulikovskiy, Lange-Bertalot, Genkal & Witkowski *sp. nov.* (1–21 – LM, 22–23 – SEM). 1–21 – valve view; 22 & 24 – external valve view; 23 & 25 – external view of valve end with raphe. 2 – holotype.

of Chukotka, the region included in this study. We agree that the species richness of *Eunotia* in the tropics is very high as compared to high latitudes, but as the waters of the high latitudes cover large areas (e.g., inland waters of the Arctic Ocean shores and of the Arctic Ocean islands) they must not be neglected if we are to gain the most complete knowledge of *Eunotia* species richness in general and in the Holarctic in particular.

Among the species described here as new,

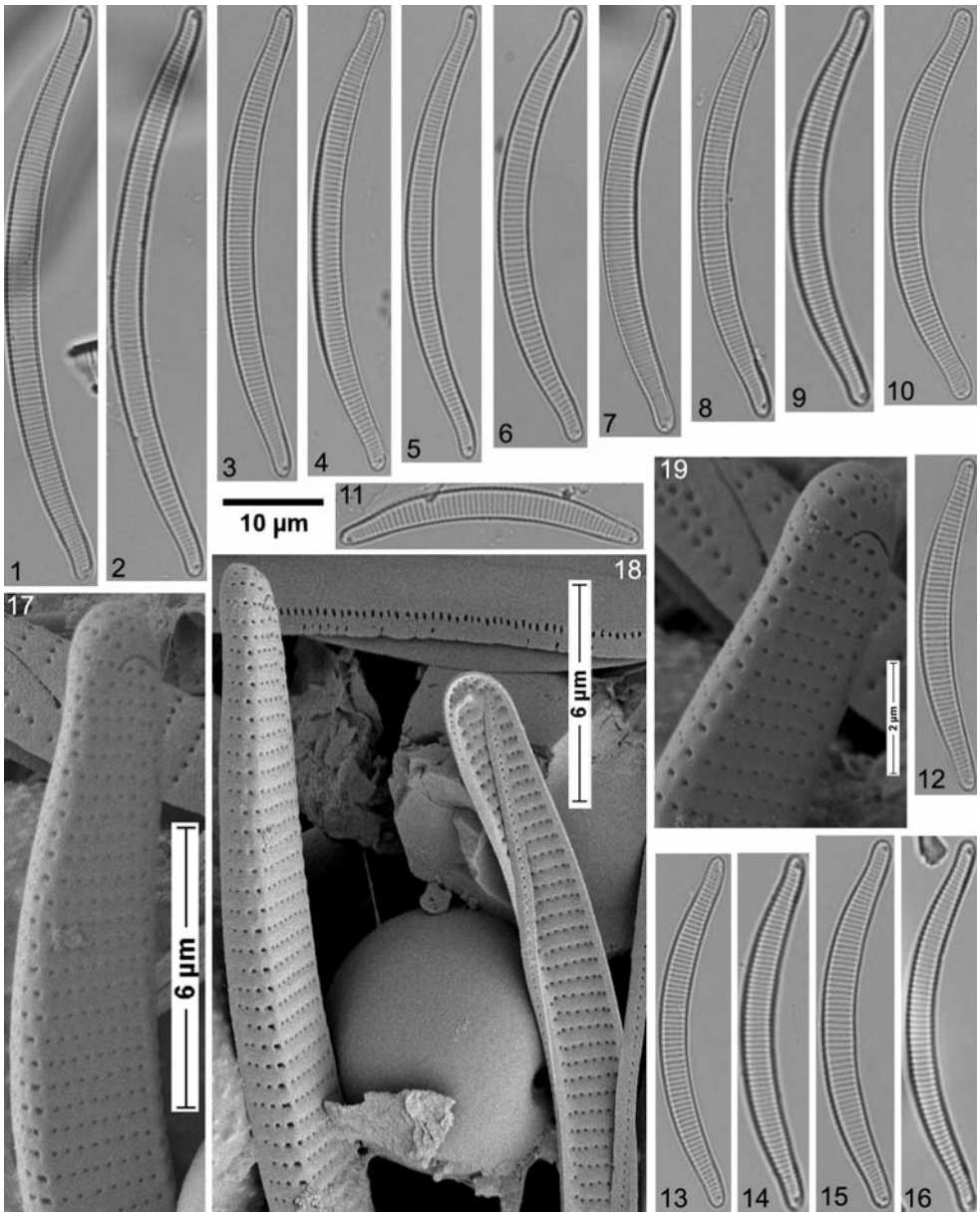

Fig. 7. *Eunotia krammeri* Kulikovskiy, Lange-Bertalot, Genkal & Witkowski *sp. nov.* (1–16 – LM, 17–19 – SEM). 1–16 – valve view; 17 – external valve view; 18 – external valve view (left) and internal valve view (right); 19 – external view of valve end with raphe. 10 – holotype.

some are established as new infraspecific taxa, and others have been misidentified in the past. The former includes *E. subcapitata*, and the latter *E. scandiorussica*.

Careful LM and SEM analyses revealed that *Eunotia curvata* var. *capitata* (Grunow) Patrick from the U.S.A., with valves 3–5 µm broad and possessing 13–16 striae in 10 µm, is not comparable with *E. subcapitata* described here. In our opinion *Eunotia lunaris* var. *capitata* Grunow illustrated

in Hustedt (1930, fig. 250) also differs by having more widely spaced striae, *ca* 14 in 10 µm. We noted some inconsistency in Hustedt's approach to this taxon. Stria density in *E. lunaris* var. *capitata* is significantly higher (*ca* 18 in 10 µm) in Hustedt (1932, fig. 769 c) than in Hustedt (1930). This concept conforms more to *E. curvata* var. *capitata* sensu Camburn & Charles (2000, fig. 12: a) from NY, U.S.A., but in that publication the valve ends appear much less conspicuously capitate or subcapitate. Grunow's description of this variety (see above) from wet habitats in the Vienna Prater is not precise, as it lacks even the size range and raphe fissure characteristics. Irrespective of its identity, the name *capitata* has no priority in species rank.

This work is intended to help clarify the species complex related to *Eunotia bilunaris*. A wide spectrum of morphological characters which in the past, based on LM or insufficient EM (SEM/TEM) observations, were included in the description of *E. bilunaris* sensu lato, have recently been revised and separated in independent species. Examples of species that would easily have been included in *E. bilunaris* are the newly described *Eunotia subcapitata* and *E. anadariensis*. At first glance, the longest specimens *E. anadariensis* (described here) appear to be more closely related to some lines of the complex around *E. bilunaris*, but they are clearly distinguished by having shortly curved terminal raphe fissures. *Eunotia krammeri*, described here as a new species, bears some resemblance to the species complex of *E. bilunaris* and *E. juettnerae* (Lange-Bertalot *et al.* submitted) and *E. mongolica* (Kulikovskiy *et al.* 2009). Like the taxa mentioned above, *E. krammeri* has more or less arcuate valves, but they differ with respect to metric parameters. The combination of characters as shown in the newly described *E. krammeri* from NE Russia cannot be found in any of the established species around *E. bilunaris* sensu lato or related taxa (cf. Krammer & Lange-Bertalot 2000; Lange-Bertalot *et al.* submitted).

Though described here as a species new for science, *Eunotia scandiorussica* already has some historical background. The specimens from the type locality (Yugorsky Peninsula, Arctic Ocean) were erroneously identified as longer specimens of *E. ursamaioris* (see Lange-Bertalot & Genkal 1999, fig. 4: 18–20). Probably the reason for this misidentification was that *E. ursamoiris* occurred in the same sample. Some years earlier, Lange-Bertalot & Metzeltin (1996, fig. 14: 13) erroneously identified a specimen representing newly established *Eunotia scandiorussica* as *Eunotia pseudoparalella* A. Berg 1939 sensu Cleve-Euler pro parte (non Cleve-Euler 1934).

The species *Eunotia orientis* described here resembles *E. metamonodon* Lange-Bertalot and *E. major* W. Smith. However, the valves of both of the latter are broader, ranging on average 10–15 µm. In addition, the major discriminating characters are the terminal raphe fissures which are prolonged to the edge of the dorsal valve mantle in these two and all other taxa with more or less similar valve outlines, size dimensions, and stria and areola densities (e.g., Krammer & Lange-Bertalot 2000).

As the specific epithet *problematica* suggests, we had a problem with proper identification of this species. It resembles *Himantidium minus* Kützing 1844, which is a basionym of *Eunotia minor*. Recent micrographs reveal that the population of *H. minus* (= *E. minor*) from the type locality possesses *ca* 30–35 areolae in 10 µm, which can be resolved in LM photographs though with some difficulty due to the small size of specimens and comparatively densely spaced striae (*ca* 15 in 10 µm in proximal parts of the valve). It is not possible to characterize precisely how much the valve outlines, size, stria and areola density may vary in other populations of *Himantidium minus*. As the 'iconotypes' of Kützing do not conform to the Siberian specimens, we have decided to propose the populations from Chukotka Peninsula as a new species. Our decision is based on significantly higher areola density and much lower stria density, even in the smallest specimens of the cell cycle of *E. problematica*. In Van Heurck (1881, figs 33: 20, 21), Grunow illustrated *E.* (*pectinalis* var.?) *minor* with distinctly punctate striae; the number in 10 µm may not be precisely given but it is likely that he could resolve the puncta with his optical equipment.

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