***Nupela marvanii* sp. nov., and *N. lapidosa* (KRASSKE) LANGE–BERTALOT in Poland with notes on the distribution and ecology of the genus *Nupela* (Bacillariophyta)**

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Abstract: Two species of *Nupela* were identified in a spring and in a small spring-fed pool in the Polish Tatra Mts, - these were *N. lapidosa* and *Nupela* sp. The second species is described as *N. marvanii*. The new species is characterized by heteropolar, narrowly elliptic valves with capitate apices. Sternum valve has very short, sometimes rudimental raphe branches. Under a light microscope transapical striae are not discernible. Externally both valves are covered with hymen. The central area of sternum valves has irregular silicate thickenings. Proximal raphe fissures are straight and terminate in small pores. Distal raphe fissures double-deflected into the same side of the valve, form ?-shaped structures that extend onto the mantle. Internally visible linear-lanceolate axial area, which forms unilateral fascia on raphe valve, which reaches valve margin. Proximal raphe fissures are T-shaped. Distal raphe fissures are straight, and terminate in small, linear helictoglossa. Sternum valve has large, clearly visible internally, asymmetrically lanceolate central area and discernible externally reinforced median costa. Raphe fissures are strongly reduced, rudimental. The areole are round to elliptical, expanded along the transapical axis, with the wider opening on the external surface. An irregular row of similar areoles is present along pleural side of valve. Both species are documented with LM and SEM micrographs and briefly discussed. The distribution and autecology of 46 *Nupela* members are summarized.

Key words: diatoms, distribution, oligotrophy, species nova, Tatra Mts, taxonomy

Introduction

Nupela is a freshwater genus that originally comprised only *N. giluensis* VYVERMAN et COMPÈRE and *N. hagensis* VYVERMAN, described from material collected in Papua New Guinea. The third species, mentioned by VYVERMAN & COMPÈRE (1991) as a possible member of the genus, was *Anomoeoneis paludigena* SCHERER [= *Nupela paludigena* (SCHERER) LANGE–BERTALOT], known from south-eastern part of the Atlantic Coastal Plain of North America. Since 1991 the genus has expanded to include over 40 worldwide taxa (MONNIER et al. 2003, METZELTIN & LANGE–BERTALOT 2007, SIVER et al. 2007, KULIKOVSKIY et al. (in press)). Most of them were described after 1991, as a result of a better recognition of diatom flora in the tropical zone (e.g. VYVERMAN 1991, MOSER et al. 1998, METZELTIN & LANGE–BERTALOT 2007), and the application of a scanning electron microscope for the identification of small and finely ornamented diatoms (e.g. RUMRICH et al.

2000, POTAPOVA et al. 2003, SIVER & HAMILTON 2005, SIVER et al. 2007).

Since the original description of the genus the morphological concept of *Nupela* has been broadened including distinctly isovalvar and heterovalvar species with respect to the degree of development of the raphe (SIVER et al. 2007) but both groups share the features specific for *Nupela*, e.g. areolae morphology, which is regarded as one of the most important and stable feature of the genus (POTAPOVA et al. 2003, SIVER et al. 2007). The inconspicuousness of most *Nupela* species and the frustules fine ornamentation make them difficult to identify, especially when only a light microscope is used. Additional inconvenience in estimating the species distribution is their sparseness and that they are easy to be overlooked. Only a few species, such as *Nupela lapidosa* (KRASSKE) LANGE–BERTALOT are known as quite common in certain areas (WERUM & LANGE–BERTALOT 2004).

The *Nupela* species occur mainly in oligotrophic environments that possess unique

diatom flora including threatened oligotraphentic *Kobayasiella*, *Brachysira*, *Eunotia*, and *Neidium* species. During an investigation of diatoms in springs in the Tatra Mts, *Nupela lapidosa* was found. The second species found is described as a new species.

Materials and methods

The squeezed water from submerged mosses in the spring and bottom sediment from a small pool, approximately 100 m below the spring were collected (30 September 2008) in the Dolina Bystrej Wody valley situated in the Polish Tatra Mts, 49° 14.841'N and 19° 58.289'E, at an elevation of 1289 m a.s.l. The samples were preserved in a 30% water solution of formaldehyde (formalin). Water properties from the spring temperature, conductivity and pH were measured using an ELMETRON CC-102 and CP-103 conductivity and pH meters, respectively. Other parameters were determined at the same time immediately after collection, with a Spectroquant Nova 60 (Merck). Alkalinity, fluor, bromine, and sulfates concentrations were measured by means of ion chromatography (Dionex 100) atomic absorption spectrophotometry (AAS) and flame AAS techniques in Institute of Botany laboratory in Szarów. The physical and chemical characteristics of the water in the spring were as follow: temperature = 7.0 °C, conductivity = 40 $\mu\text{S cm}^{-1}$; pH = 5.5; oxygen = 10.5 mg l⁻¹, Cl⁻ = 16.0 mg l⁻¹; NO₃⁻ = 2.7 mg l⁻¹, PO₄³⁻ = 0.2 mg l⁻¹; SO₄²⁻ = 0.92 mg l⁻¹; alkalinity = 1.11 mval l⁻¹; Ca²⁺ = 21 mg l⁻¹; F⁻ = 0.11 mg l⁻¹; Br = 0.43 mg l⁻¹.

The samples for diatom analysis were treated with 10% HCl, washed several times with distilled water, and thereafter boiled in concentrated acids (H₂SO₄, HNO₃), in order to remove organic matter. After washing several times with distilled water the cleaned diatom material was air-dried on coverslips and mounted in Naphrax®. Observations of the diatoms were performed with a Nikon Eclipse 600 light microscope equipped with Nomarski phase contrast. The micrographs were taken with a Nikon DS-Fi 1 camera. For SEM analysis the material was pipetted onto cover glasses, air-dried and affixed to an aluminium stub with double-sided transparent tape. The stubs were sputter coated with gold and viewed with a Hitachi S-4700 scanning electron microscope. SEM micrographs were taken in the Laboratory of Field Emission Scanning Electron Microscopy and Microanalysis at the Institute of Geological Sciences of the Jagiellonian University. Data on the distribution of the species and their ecology were obtained from cited literature and also from *Iconotheca of Algae* of Department of Phycology, W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.

The data on *Nupela* species include description

or transfer literature citation, basionym (if transferred), type locality information, general ecology and distribution data.

Results and discussion

During the initial stage of the study of the diatom flora in the Tatra Mts springs two *Nupela* members were found in the waters of the Dolina Bystrej valley. The first species – *Nupela lapidosa* belongs to the most common *Nupela* representatives, present in 56% of springs on metamorphic bedrock, 50% on basalt bedrock and 17% on granitic bedrock in Germany (WERUM & LANGE-BERTALOT 2004). In Poland it is reported to occur mainly in the Tatra Mts (KAWECKA 1970, 1971, 1977, 1980, WASYLIK 1971, KAWECKA & GALAS 2003), but also from one spring on the Wyżyna Krakowsko-Częstochowska upland (SKALSKA 1966a, 1966b).

Nupela lapidosa (KRASSKE) LANGE-BERTALOT Figs 1–5, 14–25.

Basionym: *Achnanthes lapidosa* KRASSKE 1929, *Botan. Arch.* 27, p. 350; fig. 9 a, b.

LM. Frustules heterovalvar. Valves slightly transapically curved, lanceolate, 18.5–22.6 μm long and 4.8–5.6 μm broad. Under light microscope transapical striae clearly visible on both valves, slightly radiate in the middle valve part and becoming strongly radiate towards apices. Axial area linear-lanceolate on raphe valve, and broadly lanceolate on sternum raphe. Central area asymmetrical, unilaterally expanded up to the valve margin (sternum valve) or almost up to valve margin (raphe valve).

SEM. Coarse ornamentation of the external valve surface clearly visible (Figs 14–17). The outside areola openings discernible despite hymen covering and pores occlusion by complex cribra (Fig. 17). Externally central area often covered with pit-like depressions (Fig. 15), visible in LM as shadows. Raphe filiform, with elongated drop-like central terminals. Polar terminals double-deflected into the same side of the valve, form ?-shaped structures that extend onto the mantle, where they terminate in pores. Internally raphe valve with central raphe terminals strongly deflected to the same side. Polar raphe terminals end in straight helictoglossa. Sternum valve without raphe or with raphe reduced to very short slit, discernible

Figs 1–5. *Nupela lapidosa* (KRASSKE) LANGE–BERTALOT. Figs 6–13. *N. marvanii* sp. nov.: (1,9,12) sternum valves; (2–8,10,11) raphe valves, (13) girdle view of two frustules; (11) holotypus, focus at raphe valve; (12) holotypus, focus at sternum valve. Light microscope (LM). Scale bar 10 μ m.

from the inner part of the valve in SEM. Internally visible linear-lanceolate axial area, which forms on raphe valve unilateral fascia, reaching the valve margin. Central area of sternum valves with irregular silicate thickenings visible externally. Valve face separated from the mantle with distinct crest. Transapical striae located in the depressions, interstriae are elevated. Striae slightly radial in the middle of the valve and becoming radial towards apices – 19–24 in 10 μ m.

The ecological optimum of the species is in oligotrophic, circumneutral waters of low up to moderate conductivity (WERUM & LANGE–BERTALOT 2004).

Nupela marvanii WOJTAŁ, sp. nov.

Figs 6–13, 26–43

Diagnosis. Valvae heteropolaris, leviter curvatae, angusto-ellipticae, apicibus distincte capitatis, 24.0–28.5 μ m longae et 5.0–6.0 μ m latae. Raphoalva cum raphe exterius proximalibus rectis in elevato centrali nodo positis. Areoalva cum ramis raphis brevissimis, aliquando rudimentalibus. Striae transapicales in LM invisibiles. Ambae valvae tectae hymene in SEM visibiles. Areoalva cum area centrali irregularibus siliceis interrogationis, in limbo transgredientes. Raphoalva a parte inferior visa cum area axilliarum lineari-lanceolata et fascia unilaterali. Proximales raphis fissurae instar litterae T. Distales raphis fissurae rectae in parva lineari helictoglossa terminatae. Areoalva cum area magna asymmetricè lanceolata et a parte interior distincta visa, et costa mediana externe incrassata. Fissurae raphis reductae, rudimentales. Striae transapicales in media parte valvae leniter radiatae, in parallelas et postea leniter convergentes transgredientes, 40–44 in 10 μ m. Striae transapicales in series longitudinales non dispositae. Areolae rotunda

vel ellipticae in directione antapicali elongatae, cum aperturae externe dilatata. Series irregularis areolarum iis supra descriptis similium iuxta limbum positum.

Description: Frustules heterovalvar. Valves slightly transapically curved, narrowly elliptic with distinctly capitate apices, 24.0–28.5 μ m long and 5.0–6.0 μ m broad. Raphe with straight proximal endings, situated on elevated central nodule. Sternum valve with very short, sometimes rudimental raphe branches. Under light microscope transapical striae not discernible.

Externally, under electron scanning microscope both valves covered with hymen (Figs 26–29, 36–39). Central area of sternum valves with irregular silicate thickenings. Proximal raphe fissures are straight and terminate as small teardrop-shaped pores. Distal raphe fissures double-deflected into the same side of the valve, form ?-shaped structures that extend onto the mantle.

Internally visible linear-lanceolate axial area, which forms on raphe valve unilateral fascia. Proximal raphe fissures T-shaped. Distal raphe fissures straight, terminate in small, linear helictoglossa. Sternum valve with large, clearly visible internally, asymmetrically lanceolate central area and discernible externally reinforced median costa. Raphe fissures strongly reduced, rudimental. Transapical striae slightly radial in the middle of the valve and become parallel, and then slightly convergent towards apices – 40–44 in 10 μ m. Transapical striae are not organized in longitudinal rows. The areolae are round to elliptical, expanded along the transapical axis, with the wider opening on the external surface. An irregular row of similar areolae is present

Figs 14–21. *Nupela lapidosa*: (15) central area with pit-like depressions; (16) polar terminals double-deflected into the same side of the valve, form ?-shaped structures, extend onto the mantle, where terminate in pores; (17) pores occlusion by complex cribra; (18) central raphe terminals strongly deflected to the same side; (19) polar raphe terminals in straight helictoglossa; (20,21) valve with raphe reduced to very short slit or without raphe. Scanning electron microscope (SEM) external (14–17) and internal (18–21) view of raphe valve (14–19) and sternum (20, 21) valves. Scale bars 5 μm (Fig. 14); 3 μm (Figs 15, 16, 18–21).

Figs 22–25. *Nupela lapidosa*: (22) linear–lanceolate axial area, which forms on raphe valve unilateral fascia, reaching the valve margin; (24, 25) valve face separated from the mantle with distinct crest, transapical striae located in the depressions, interstria elevated; Figs 26–31. *N. marvanii* sp. nov.: (28–29) proximal raphe fissures straight and terminate as small teardrop-shaped pores. Distal raphe fissures double-deflected into the same side of the valve, form ?-shaped structures that extend onto the mantle; (30) girdle view. Scanning electron microscope (SEM) internal (22) and external (23–30); (31) view of sternum valve in oblique position. Scale bars: 5 μ m (Fig. 22); 10 μ m (Figs 23, 26, 30, 31); 2 μ m (Figs 24, 29); 3 μ m (Figs 25, 27, 28).

Figs 32–39 . *Nupela marvanii* sp. nov.: (32–35) proximal raphe fissures T-shaped. Distal raphe fissures straight, terminate in small, linear helictoglossa; (36) distal raphe fissures double-deflected extend onto the mantle; (37, 38) sternum valve with reinforced median costa; (39) rudimental raphe fissure. Scanning electron microscope (SEM) internal (32–35) and external (36–39) view of raphe valve (32–36) and sternum raphe (37–39). Scale bars 10 μ m (Figs 32,36,37); 2 μ m (Figs 33,35,39); 3 μ m (Figs 34,38).

along pleural side of valve.

Holotypus: slide no. EU-ZTG-44 in Department of Phycology, W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, Poland, figs 11, 12.

Isotypes: Friedrich-Hustedt-Collection Alfred Wegener-Institut, Bremerhaven, Germany: ZU6/79; Academy of Natural Sciences, Philadelphia, USA, access number ANSP GC 14450; University of Szczecin, access number 14095.

Locus typicus: spring-fed pool in Polish Tatra Mts, leg. Jolanta Piątek, September 2008

Etymology: the species is dedicated to Dr. Petr Marvan, Institute of Botany, Academy of Sciences of the Czech Republic in Brno, for his great contribution to phycology and recognition of diatoms in Tatra Mts.

The most morphologically similar to *Nupela marvanii* is *N. brachysiroides* LANGE-BERTALOT, the species described in 1993 from Borneo

Figs 40–43. *Nupela marvanii*, sp. nov.: (40,41) linear-lanceolate axial area; (42,43) rudimentary raphe fissures. Scanning electron microscope (SEM) internal (40–43) view of sternum valve. Scale bars 10 µm (Fig. 40); 5 µm (Fig. 41); 2 µm (Figs 42,43).

(LANGE-BERTALOT 1993; p. 154, fig 39: 1–5). *N. marvanii* is however clearly broader and more densely striated. There is no information in the *Nupela brachysiroides* diagnosis about its polar terminals of raphe, nor about morphology of the sternum valve.

Another similar species is *Nupela impexiformis* (LANGE-BERTALOT) LANGE-BERTALOT (LANGE-BERTALOT & KRAMMER 1989, p. 68, figs 74: 7–9, 75: 2–4), described from an oligotrophic lake in Finland with circumneutral water of low conductivity. The species is however distinctly smaller, of more elliptical shape. Moreover, sternum valve of *N. impexiformis* possesses “fascioid” central area unilaterally expanded up to the valve margin, whereas *N. marvanii* has clearly lanceolate and only slightly asymmetric central area.

The third similar diatom is *Navicula gysingensis* FOGED (1952, p.167, fig II: 7). It is also finely ornamented, “exceedingly thin”, with more than 40 striae in 10 µm, but also clearly smaller. The whole knowledge about this diatom that might be related to the *Nupela* genus is limited to the original description and one drawing. It was described in presumably oligotrophic or mesotrophic running water (pH more than 7) in

Sweden. The species described in 2004 – *Adlafia multnomahii* MORALES et LE (MORALES & LE 2004) is also smaller and possesses quite different morphology, typical for the *Adlafia* genus, which is unfortunately discernible only under a scanning electron microscope.

Ecology and distribution of *Nupela* species

The genus *Nupela* which was described in 1991 (VYVERMAN & COMPÈRE 1991) on the basis of the material collected in Papua New Guinea comprised originally two species with some suggestions that a third one might also be a member of the genus. Since that time, over 40 representatives have been recognized, including nine species described in 1927–1948, ten species described in 1973–1991 and transferred recently into *Nupela* genus, and over 20 species described since 1991 (Table S1; (<http://fottea.czechphycology.cz>). Amongst 21 species, which have been transferred so far into the *Nupela* genus, one belonged originally to *Stauroneis* [*Nupela gracillima* (HUSTEDT) LANGE-BERTALOT], eight to *Achnanthes* [(e.g. *Nupela neogracillima* (HUSTEDT) KULIKOVSKIY et LANGE-BERTALOT], eight to *Navicula* [e.g. *Nupela thurstonensis* (KACZMARSKA) KULIKOVSKIY, LANGE-BERTALOT et WITKOWSKI], three to *Anomoeoneis* [e.g.

Nupela paludigena (SCHERER) LANGE–BERTALOT], and one to *Rhoicosphaenia* [*Nupela lesothensis* (SCHOEMAN) LANGE–BERTALOT]. Systematic position of *Nupela* still remains unclear (SIVER et al. 2007).

Nupela is a cosmopolitan genus, but it has the highest species richness in tropical areas (e.g. MONNIER et al. 2003, POTAPOVA et al. 2003). Its best representation in terms of species known at the moment, in Southern Hemisphere can be also related to the number of precise investigations in the area (e.g. VYVERMAN 1991, LANGE–BERTALOT & MOSER 1994, MOSER 1999, MOSER et al. 1998, METZELTIN & LANGE–BERTALOT 1998, RUMRICH et al. 2000). Recent studies revealed that *Nupela* might be also well represented in temperate and sub-polar zones (e.g. VAN DE VIJVER et al. 2002, POTAPOVA et al. 2003, SIVER & HAMILTON 2005, SIVER et al. 2007, KULIKOVSKIY et al. (in press)).

As with other minute taxa it is hard to assess their distribution at a species level, as they are difficult to identify under LM and several species might have been misidentified under a variety of names (MORALES & LE 2004). The literature data (Table S1; <http://fottea.czechphycology.cz>) correspond well with VANORMELINGEN et al (2008) opinion that diatoms distribution is influenced by general geographical factors independent of environmental conditions. Despite obvious undersampling, underreporting and poorly recognized areas and environments a present-day data suggest that several *Nupela* (morpho)taxa display restricted geographical ranges and only a few of them (*Nupela encyonopsis*, *N. lapidosa*, *N. vitiosa*) possess a wide distribution. Autecology of several species *inter alia* *Nupela astartiella*, *N. cymbelloidea*, *N. encyonopsis*, *N. tenuicephala*, *N. tenuistriata*, *N. vyvermanii*, *N. zizkae* and several other remains almost unknown. Despite the fact that some of *Nupela* species can inhabit alkaline, and even organically polluted waters (POTAPOVA et al. 2003), several *Nupela* members inhabit oligotrophic, acidic or circumneutral waters. Oligotraphentic diatoms like *Kobayasiella*, *Brachysira*, *Frustulia* (e.g. MOSER et al. 1998, BUCZKO et al. 2009) and several *Nupela* taxa can be regarded as good indicators of human caused eutrophication, since their distribution is clearly restricted to natural and near-natural areas. Several species are known from springs, aerophytic habitats and/or water rich in humic matter or shaded localities which might suggest their tolerance to conditions of light limitation and

might be considered as krenophilous diatoms.

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Supplementary material

the following supplementary material is available for this article:

Table S1. Ecology and distribution of *Nupela* species.

This material is available as part of the online article (<http://fottea.czechphycology.cz/contents>)

Table S1. Ecology and distribution of *Nupela* species.

Species	Basionym	Ecology	Distribution (* type locality)	Reference
<i>Nupela astartiella</i> METZELTIN et LANGE-BERTALOT		an effluent stream from a spring	Brazil, Est. São Paulo, stream near Santos *	METZELTIN & LANGE-BERTALOT 1998, p. 157, pl. 72: 46–55
<i>Nupela brachysiroides</i> LANGE-BERTALOT		karstic wetlands	Borneo, Sarawak, Bako Park*	LANGE-BERTALOT 1993, p. 154, pl. 39: 1–5
			Mexico	NOVELO et al. 2007
<i>Nupela butterflyfassiana</i> (LANGE-BERTALOT) LANGE-BERTALOT	<i>Achnanthes butterflyfassiana</i> LANGE-BERTALOT	wet rocks, waterfalls, aerophilous	Australia, Mt. Wilson (Blue Mts) New South Wales*	LANGE-BERTALOT & KRAMMER 1989, p. 34, pls 71: 15–29; 72: 2–5
<i>Nupela carolina</i> POTAPOVA et CLASON		small, slow rivers, rich in dissolved organic matter and nitrogen	USA, North Carolina: Contentnea Creek near Evansdale, Wilson County (35°38'N, 77°53'W)*	POTAPOVA et al. 2003, p. 298, figs 45–69
<i>Nupela chilensis</i> (KRASSKE) LANGE-BERTALOT	<i>Anomoeoneis chilensis</i> KRASSKE 1939	springs, rivers, mosses, water of low conductivity; aerophilous diatom. aerophilous wet mosses, pools, pH 6.0–6.5, conductivity 80 µS.cm ⁻¹	Chile*, Brasil, widespred, Chile, Alto Vilches, Lago Riso Patron, Rio Pascua, Reloncavi Fjord near Puyhue Possession Island	LANGE-BERTALOT & MOSER 1994 RUMRICH ET AL. 2000 LANGE-BERTALOT et al. 1996 VAN DE VIJVER et al. 2002
<i>Nupela comperei</i> MOSER		oligotraphentic, together with <i>Brachysira</i> , <i>Frustulia</i> , <i>Kobayasiella</i> .	New Caledonia, Plain des Laes*	MOSER et al. 1998, p. 211, fig. 31: 1–4
<i>Nupela cymbelloidea</i> METZELTIN et LANGE-BERTALOT			Guyana, Essequibo River*	METZELTIN & LANGE-BERTALOT 1998, p. 158, pls 72: 39–42; 73: 5

<i>Nupela deformis</i> LANGE-BERTALOT	with <i>Nupela rumrichorum</i> , circumneutral, oligotrophic water of low conductivity extremely acidic running water	Venezuela, Río Marichal Largo* Agrio River in Costa Rica	LANGE-BERTALOT & MOSER 1994, p. 76, pls 49: 23–34; 51: 6 WYDRZYCKA & LANGE-BERTALOT 2001
<i>Nupela devilensis</i> (FOGED) HAMILTON, SIVER et ANTONIADES	<i>Achnanthes devilensis</i> FOGED 1981	USA, Alaska, North Devil Mountain Lake (66°24'N, 164°30'W)* USA	FOGED 1981, p. 45, pl. 11: 13, 14 ANTONIADES et al. 2008
<i>Nupela encyonopsis</i> METZELTIN et LANGE-BERTALOT	creek rich in humic-matter (?)	Venezuela, Roraima Region, Avayan Tepui* Canada, Canadian Arctic, Alaska, Sweden Finland, circumpolar	METZELTIN & LANGE-BERTALOT 1998, p. 159, pls 72: 35–37; 74: 3–4 ANTONIADES et al. 2008
<i>Nupela exotica</i> MONNIER, LANGE-BERTALOT et BERTRAND	epilithon, acidic, nutrients and mineral richwaters, hypertrophy	France, Loiret: Mardie (in aquarium)*	MONNIER et al. 2003, p. 278, figs 1–8, 12–20
<i>Nupela fennica</i> (HUSTEDT) LANGE-BERTALOT	freshwater	Finland, small, deep lake, Suistamonjärvi*, West Germany	HUSTEDT 1962, p. 259, fig. 1387 LANGE-BERTALOT & METZELTIN 1996
<i>Nupela floridana</i> METZELTIN et LANGE-BERTALOT	peats and acidic lakes	USA, Florida Peat, Santa Rosa County, Florida*	METZELTIN & LANGE-BERTALOT 2007, p. 185, pl. 173: 11–15
<i>Nupela giluwensis</i> Vyverman et Compère	acidic waters	Papua New Guinea, small pond near Weri Weri, Mount Giluwe, subalpine tarn*, paleotropical diatom	VYVERMAN 1991, p. 178, figs 1–10
<i>Nupela gracillima</i> (HUSTEDT) LANGE-BERTALOT	with liverworts	Switzerland, Grialetschee (9°58' N, 46°43'W)*	HUSTEDT 1943, p. 154, figs 21–23

<i>Nupela hagensis</i> VYVERMAN		circumneutral waters of low conductivity	Papua New Guinea, Lake Kainga*	VYVERMAN 1991, p. 158, pl. 140b
<i>Nupela imperfecta</i> (SCHIMANSKI) LANGE-BERTALOT	<i>Achnanthes imperfecta</i> SCHIMANSKI 1978	moor soil springs	Germany, Bayern, Frankenwald, west from Kunreuth* Germany, Taunus Mts, Devonian sandstone	SCHIMANSKI 1978, p. 564, Fig. 1: 1–5 WERUM & LANGE-BERTALOT 2004
<i>Nupela impexiformis</i> LANGE-BERTALOT		oligotrophic, circumneutral water of low conductivity	Finland, near Mikkeli, Puulavesi Lake* North-west Siberia	LANGE-BERTALOT & KRAMMER 1989, p. 68, figs 74: 7–9; 75: 2–4 LANGE-BERTALOT & GENKAL 1999
<i>Nupela jahniae-reginae</i> LANGE-BERTALOT et METZELTIN		tolerant, oligo- eutrathentic	Venezuela, Laguna Negra*, Germany, Alpen, Taunus, canal in Berlin Central Europe, probably cosmopolitan	RUMRICH et al. 2000, p. 194, pl. 34: 1–8
<i>Nupela lapidosa</i> (KRASSKE) LANGE-BERTALOT	<i>Achnanthes lapidosa</i> KRASSKE 1929	oligotrophic, circumneutral, low conductivity, acidic, springs, upper streams circumneutral spring streams, rivers and lakes river	Germany, Sachsen, Königstein, Elbsgebirge*, Sachsen, Hessen, Alps, Chile, Anden Germany southern Poland southern Poland, Tatra Mts Macedonia, Brajinska River	KRASSKE 1929, p. 350, fig. 9 LANGE-BERTALOT et al. 1996 RUMRICH et al. 2000, WERUM & LANGE-BERTALOT 2004, SKALSKA 1966, KAWECKA 1970–1980, WASYLIK 1971, KAWECKA & GALAS 2003 LEVKOV et al. 2007
<i>Nupela lesothensis</i> (SCHOEMAN) LANGE-BERTALOT	<i>Rhoicosphaenia lesothensis</i> SCHOEMAN 1973	springs, streams	Lesotho, spring and its effluent stream at Paballong near 'Mamathe in the Berea district * Italy, Seychelles, Africa southern and south-western, Germany, Munich, Botanical Garden, probably cosmopolitan	SCHOEMAN & ARCHIBALD 1976, CSIR Special Report WAT 50, figs 1–29 RUMRICH et al. 2000

<i>Nupela marvanii</i> WOJTAŁ	Epipelon, oligotrophic small, shaded spring-fed pool, water slightly humic, acidic, of low alkalinity, conductivity	Poland, Tatra Mts, (66°24'N, 164°30'W)	
<i>Nupela matroschka</i> KULIKOVSKIY, LANGE-BERTALOT et WITKOWSKI	<i>Sphagnum</i> bogs, aerophilous, low pH,	Russia, Polistovo-Lovatsky <i>Sphagnum</i> bogs, Novogorod region	KULIKOVSKIY et al. <i>in press</i>
<i>Nupela neglecta</i> PONADER, LOWE et POTAPOVA	streams, small creeks, moderate conductivity, high silica and organic matter concentration, submerged or wet rocks, woody debris, soils	USA, New Jersey: Coles Brooks, Hackensack, Bergen County, urban areas, (40°54'N, 70°02'W)*	POTAPOVA et al. 2003, p. 294, figs 1–44
<i>Nupela neogracillima</i> (HUSTEDT) KULIKOVSKIY et LANGE-BERTALOT	epipelon	Japan, Aokiko lake, Japan*	HUSTEDT 1927, p. 161, figs 5: 10–11
<i>Nupela neotropica</i> LANGE-BERTALOT	low conductivity, oligotrophic-dystrophic water	Venezuela, Río Kukurital*tropical zone	LANGE-BERTALOT & MOSER 1994, p. 77, pls 49: 7–9; 51: 1–3
<i>Nupela obliqua</i> METZELTIN et LANGE-BERTALOT	stream rich in humic-matter (?)	Venezuela, Roraima Region, Avayan Tepui*	METZELTIN & LANGE-BERTALOT 1998, p. 160, pls 72: 42–45; 73: 2–4
<i>Nupela pallavicinii</i> (KRASSKE) LANGE-BERTALOT	mosses, aerophilous	Colombia, spring near Chapinero near Bogota, c.a. 2800 m a.s.l., <i>Sphagnum</i> from watercourse banks near El Boqueron 3400 m asl.	LANGE-BERTALOT et al. 1996, p. 135, fig. 11: 20, 21

<i>Nupela paludigena</i> (SCHERER) LANGE-BERTALOT	<i>Anomooneis paludigena</i> SCHERER 1988	dystrophic swamp oligotrophic, acidic, low conductivity water	USA, Georgia: Okefenokee Swamp*, New York and Florida acidic lakes boreal and alpine areas, North America, also fossil	SCHERER 1988, p. 149, figs 42–45, 72 LANGE-BERTALOT 1993
<i>Nupela praecipua</i> (REICHARDT) REICHARDT	<i>Achnanthes praecipua</i> REICHARDT 1988	tychoplankton, small river extremely acidic river cloud forest streams, moderate conductivity and alkalinity	Mexico, Cusatepec River* Venezuela, Laguna Negra, Costa Rica Costa Rica, Agrio River Boliwia, streams near Coroico	REICHARDT 1988, p. 391, figs 1–24 RUMRICH et al. 2000 WYDRZYCKA & LANGE-BERTALOT 2001 MORALES & VIS 2007
<i>Nupela rhetica</i> (WUTHRICH) LANGE-BERTALOT	<i>Anomooneis rhetica</i> WUTHRICH 1975		Switzerland, Swiss National Park: region of Macun; Sellasee, Massif du Gotthard*	Index Nominum Algarum, http:// ucjeps.berkeley.edu/INA.html
<i>Nupela rumrichorum</i> LANGE- BERTALOT		circumneutral, oligotrophic, waters of low conductivity	Venezuela, Río Morichal Largo*, tropical zone	LANGE-BERTALOT & MOSER 1994, p. 79, figs 49: 14–22; 50
<i>Nupela schoemanaiana</i> LANGE- BERTALOT		slightly acidic up to circumneutral running waters, of low conductivity	Borneo, South Africa, Dimade River*, Borneo, Sarawak	LANGE-BERTALOT 1993, 156, figs 36: 1–9; 37: 1–6.
<i>Nupela scissura</i> SIVER, HAMILTON & MORALES		acidic, oligotrophic to mesotrophic waters poor in dissolved salts, with a slightly humic colour	USA, North Carolina: Bay Tree Lake, Bladen County (34°40'59.36"N, 78°24'58.77"W)*	SIVER et al. 2007, 127, figs 1 A–M, 2, 3
<i>Nupela silvahercynia</i> (LANGE- BERTALOT) LANGE-BERTALOT		oligotrophic, acidic waters of specific conductivity lower than 100 µS/cm. common in springs common in springs on basaltic and granitic rocks	Germany, spring Reichenbachs near Tilsmanweg*, Hochtaunus, Schwarzwald, Germany, Hochtaunus near Königstein	LANGE-BERTALOT & KRAMMER 1989, p. 139, Figs 56: 11–12', 71: 30–37, 73: 30–37, 98: 45–50 WERUM & LANGE-BERTALOT 2004

<i>Nupela subinvicta</i> (KRASSKE) LANGE-BERTALOT	<i>Navicula subinvicta</i> KRASSKE 1939	aerophilous, occurs in mosses and wet rocks	Chile, Ufer des Rio Pasqua, Chusqueaquila, near Lago Riso Patron, Reloncavi Fjord	LANGE-BERTALOT et al. 1996, p. 147, fig. 11: 16–19
<i>Nupela subpallavicinii</i> METZELTIN et LANGE-BERTALOT		stream rich in humic-matter (?)	Venezuela, Roraima Region, stream on a peak of Avayan Tepui*	METZELTIN & LANGE-BERTALOT 1998, 161, figs 72: 23, 24; 73: 1; 74: 5
<i>Nupela tenuicephala</i> (HUSTEDT) LANGE-BERTALOT	<i>Navicula tenuicephala</i> HUSTEDT 1942		Sweden, Lappland, near Abisko*, Schwarzwald, Germany	Index Nominum Algarum, http://ucjeps.berkeley.edu/INA.html
<i>Nupela tenuistriata</i> (Hust.) METZELTIN et LANGE-BERTALOT	<i>Achnanthes tenuistriata</i> HUSTEDT 1937	rivers	Guyana, Demerara River*	METZELTIN & LANGE-BERTALOT 1998, p. 161, fig. 71: 1–10
<i>Nupela thurstonensis</i> (KACZMARSKA) KULIKOVSKIY, LANGE-BERTALOT et WITKOWSKI	<i>Navicula thurstonensis</i> KACZMARSKA 1984	aerophilous diatom, resistant to light deficiency, mucilage on wet wall, bryophytes	Hawaii, Thurston Lava Tube, Hawaii Volcanoes National Park, Hawaii County wet lava walls*	RUSHFORTH et al. 1984, p. 145, figs 81–83, 107–110, 125
<i>Nupela tristis</i> (KRASSKE) LANGE-BERTALOT	<i>Navicula tristis</i> KRASSKE 1939	oligotrophic, low conductivity springs spring and its effluent, mosses, rocks overgrown by Chlorophyta	Southern Chile* Germany, Spessart Mts Chile, near Coral, La Vega	LANGE-BERTALOT & MOSER 1994, WERUM & LANGE-BERTALOT 2004 LANGE-BERTALOT et al. 1996
<i>Nupela tropica</i> (HUSTEDT) LANGE-BERTALOT	<i>Achnanthes tropica</i> HUSTEDT 1937	spring, spring-fed pool, pond, probably creophilous diatom, pH about 7.5	Java, Ranu Lamongan, Ufer near Sindanglaja*, Indonesia	HUSTEDT 1937, p. 200, fig. 13: 28–32

<i>Nupela vitiosa</i> (SCHIMANSKI) SIVER et HAMILTON	<i>Navicula vitiosa</i> SCHIMANSKI 1978.	aquatic environment ponds, pH 5.1-7.1, conductivity 92 to 206 $\mu\text{S cm}^{-1}$, total phosphorus 8- 30 $\mu\text{g L}^{-1}$	Germany, Bavaria, Frankenwald, Ebersreuth* central and northern Europe northeastern USA, Cape Cod, , Quebec-Labrador, in temperate to subpolar regions	SCHIMANSKI 1978, p. 592, fig. 8: 1, 2 MONNIER et al. 2003 SIVER & HAMILTON 2005
<i>Nupela vyvermanii</i> LANGE- BERTALOT		volcanic rocks, an effluent stream from a spring	New Caledonia, Thio* Thaiti and Moorea Islands, French Polynesia, South Pacific	MOSER et al. 1998, p. 213, fig. 31: 7-10 WERUM & LANGE-BERTALOT 2004
<i>Nupela wellneri</i> (LANGE- BERTALOT) LANGE-BERTALOT	<i>Navicula wellneri</i> LANGE-BERTALOT 1987	α -meso- up to polysaprobic waters	Germany, Elbufer, Dresden Cuile, Patagonia, Laguna Las Melliaz	LANGE-BERTALOT & KRAMMER 1987, p. 123, fig. 40: 28-31 RUMRICH et al, 2000.
<i>Nupela zizkae</i> METZELTIN et LANGE-BERTALOT		acidic, rich in humic matter waters of low conductivity	Venezuela, Roraima Region, Rio Kukenan*, tropical southeastern	METZELTIN & LANGE-BERTALOT 1998, 162, pl. 71: 11-19