

Navicula teodora, a new raphid diatom species (Naviculaceae, Bacillariophyceae) from thermomineral springs in Serbia

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ABSTRACT

During a survey of the diatom flora of thermomineral springs in Serbia, an unknown *Navicula* taxon was observed that could not be identified using the currently available literature. Based on detailed light and scanning electron microscopy observations, the unknown species, characterised by its narrowly lanceolate valve outline, distinctly different valve dimensions, and strongly hooked terminal raphe fissures, is described as *Navicula teodora*. Morphologically, *N. teodora* can be differentiated from similar species such as *Navicula cryptotenella*, *N. breitenbuchi* and *N. veneta* by a combination of valve shape, size, and stria characteristics. The new species seems to prefer moderately warm, alkaline, mineral-rich waters, and was (sub-)dominant in epilithic and epipelagic samples from several thermomineral springs. The discovery of this taxon highlights the biodiversity potential of thermomineral springs in the Balkan region.

KEYWORDS

biodiversity, morphology, *Navicula*, new species, Serbia, thermomineral springs

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INTRODUCTION

The genus *Navicula* Bory was originally described to include bilaterally symmetrical, biraphid species with a boat-shaped morphology, hence the name *Navicula* meaning ‘little boat’ in Latin (Hustedt, 1962; Lange-Bertalot, 2001). The genus is considered one of the most taxon-rich diatom genera. AlgaeBase currently (Guiry & Guiry, 2023) reports 1798 accepted species names, 4 accepted subspecies, 522 accepted varieties, and 171 accepted formae (accessed on 13 January, 2026). In addition, more than 5000 *Navicula*

names have either been transferred to other genera or still await further analysis (Kulikovskiy *et al.*, 2023). Extensive taxonomic revisions in recent decades have redefined the genus *Navicula*, restricting it to species exhibiting a specific combination of morphological features, including uniseriate striae composed of slit-like areolae, a relatively simple raphe system with an internal accessory rib, and two plate-like, girdle-appressed plastids (Cox, 1999; Lange-Bertalot, 2001; Van de Vijver *et al.*, 2011). Detailed morphological analyses, often combined with advances in molecular phylogenetics, showed that *Navicula* sensu

lato was polyphyletic, leading to the separation of several new or reinstated genera, including *Sellaphora*, *Geissleria*, *Craticula*, *Luticola*, *Kobayasiella*, *Humidophila*, and *Placoneis* (Lange-Bertalot, 2001; Lange-Bertalot *et al.*, 2017; Mann *et al.*, 2004; Round *et al.*, 1990;). As part of these revisions, Lange-Bertalot (2001) divided the genus *Navicula* into two sections, *Alinea* and *Navicula*, based on the direction of deflection of the central raphe endings. Section *Alinea* groups taxa with central raphe endings (often only slightly) deflected towards the primary side of the valve, whereas in section *Navicula* the deflection turns towards the secondary side, as shown by the Voigt discordance. In his monograph, Lange-Bertalot (2001) revised and described over 120 *Navicula* s.s. taxa from European freshwater habitats (excluding brackish water). Since then, additional *Navicula* species have been identified in European waters, often by refining species concepts and re-examining the original type material (Beauger *et al.*, 2015; Jüttner *et al.*, 2020; Levkov *et al.*, 2007; Van de Vijver *et al.*, 2011; Van de Vijver & Lange-Bertalot, 2009; Reichardt, 2018; Sagnet *et al.*, 2022). In the Balkan region in particular, many new *Navicula* taxa have been discovered. Levkov *et al.* (2007) described fourteen new taxa, most of which considered endemic to Lake Prespa or Lake Ohrid (Republic of North Macedonia).

Navicula species are widely distributed in freshwater, brackish and marine habitats. In the freshwater environments, the genus is particularly abundant in stagnant and slow-flowing waters, where it contributes to periphytic biofilms and benthic communities (Kanavillil *et al.*, 2012). Despite their wide distribution and frequent abundance, many *Navicula* taxa remain poorly known, especially from unusual, often extreme or ecologically distinctive habitats such as temporary pools, springs, and karstic wetlands (Beauger *et al.*, 2015), or are simply overlooked due to taxonomic drift or the force-fitting of aberrant populations into generally well-known names (Sagnet *et al.*, 2022).

This study focuses on the morphological characterisation of an unknown *Navicula* taxon observed in a thermomineral spring in central Serbia. Detailed light and scanning electron microscopy observations, along with comparison to all currently available literature, revealed that the observed population could not be identified and is therefore described as a new species: *Navicula teodora* Milićević, Jakovljević, Popović *et* Van de Vijver, *sp. nov.* This study contributes to a better understanding of the diversity, distribution and ecological preferences of the genus *Navicula* in distinct habitats.

MATERIALS AND METHODS

The new *Navicula* species was first observed in a thermomineral spring in central Serbia - Omoljica which is a natural spring. More information about the sampling locality can be found in Milićević *et al.* (2025).

During a field survey in November 2023, sterile sampling of biofilms from submerged surfaces and splash zones in the different springs was conducted. Epilithic diatom samples were obtained

by scraping off five submerged stones at the point where water emerged from the pool, while sediment samples were collected from the muddy bottom using a sterile glass pipette. Each sample was immediately transferred to 50 ml PVC vials and preserved in formaldehyde at a final concentration of 4% to maintain sample integrity for subsequent laboratory analyses. Water temperature (T), pH, total dissolved solids (TDS), electrical conductivity (EC) and dissolved oxygen (O₂), were measured *in situ* using Eutech Instruments Oakton® digital field instruments and the YSI ProODO Optical Dissolved Oxygen Meter. In addition, water samples were transported immediately after fieldwork, for further processing according to standard protocols.

Subsamples of the selected materials were prepared following the method described by Taylor *et al.* (2007). Organic matter was removed using hot HCl and KMnO₄. Cleaned diatom frustules were mounted in Naphrax® and examined with an Olympus BX53 microscope at 1000x magnification (UPlan FL N 100× oil objective, N.A. 1.30), equipped with Differential Interference Contrast (Nomarski) optics and the Olympus UC30 Imaging System connected to the cellSens Standard program. At least 25 valves of the new species are illustrated using LM to assess its morphological variability. Diatom relative abundances were calculated as the percentage of taxa among 400 counted valves per permanent slide.

The ultrastructure of the new species was analysed using SEM. Part of the suspension was filtered through polycarbonate membrane filters with a pore diameter of 5 µm, pieces of which were affixed to aluminum stubs after air-drying. The stubs were sputter-coated with a Platinum/Palladium layer of 15 nm and studied in a JEOL JSM-7100F SEM at 1.5 kV and a working distance of 4 mm (Meise Botanic Garden, Belgium). Plates were prepared using Photoshop CS5.

Terminology used to describe the various structures of the siliceous cell wall is based on Ross *et al.* (1979, areola structure), Cox & Ross (1981, stria structure), and Lange-Bertalot (2001, *Navicula* genus features). For taxonomic comparisons, the following papers were consulted: Bahls (2012); Fukushima *et al.* (2002); Krammer & Lange-Bertalot (1985); Lange-Bertalot (1980, 1993, 2001); Lange-Bertalot *et al.* (2003, 2017); Levkov *et al.* (2007); Metzeltin *et al.* (2005, 2009); Reichardt (2018); Sagnet *et al.* (2022); Van de Vijver *et al.* (2010) Werum & Lange-Bertalot (2004); and Witkowski *et al.* (2000).

For the typification of new species, we use the entire slide as the holotype, following the usual interpretation of Article 8.2 of the International Code for Botanical Nomenclature (Turland *et al.*, 2025) by diatomists. Although the typified name is illustrated by all other figures, which in a strict sense illustrate isotypes, we selected an appropriate image linked to the designated holotype specimen by stating, “The holotype is illustrated by Figure 1–35.” In this way, the identity of the species can be fixed to a valve that does not exclusively show the typified name, but may be most characteristic for the taxon. All novelties are registered proactively according to Article 42.4 (Turland *et al.*, 2025).

RESULTS

***Navicula teodora* Milićević, Jakovljević, Popović *et* Van de Vijver *sp. nov.* (Figures 1–35)**

Description

LM (Figures 1–30): Frustules in girdle view rectangular (Figure 1). Valves narrowly lanceolate in larger specimens (Figures 1–18), more elliptic-lanceolate in smaller valves (Figures 19–30), with strictly convex margins and acutely rounded, very weakly protracted apices. Valve dimensions (n=50): length 13–25 µm,

width 5.0–5.5 μm . Axial area narrow, linear, slightly widening towards central area. Central area relatively small, almost rectangular, not forming a fascia due to 2 (rarely 1 or 3) shortened striae bordering the area. Central raphe endings enlarged, almost straight to very weakly deflected towards secondary side. Striae weakly radiate near central area, gradually becoming convergent towards the apices, 15–16 in 10 μm . Voigt is discordance distinctly visible (Figures 5–6, white arrows). Lineolae not discernible in LM.

SEM (Figures 31–35): Valve face flat. Raphe sternum externally not to only very slightly raised (Figures 31–32). External raphe branches curved, weakly eccentric on sternum. Central raphe endings distinctly expanded, hardly deflected towards the secondary side (Figures 31–32), with a small silica outgrowth at raphe ending (Figure 33, white arrow). Terminal raphe fissures predominantly located on the valve face, strongly hooked towards the secondary side and extending onto the valve mantle only at their very distal ends (Figures 31–32). Striae uniseriate, composed of elongated, slit-like lineolae (Figures 31–32). Lineolae externally as long as or slightly shorter than adjacent virgae, the longest bordering the axial area, ca 35 in 10 μm . Near apices, irregular slits bordering last striae (Figure 32, white arrows). Internally, raphe branches running weakly lateral of the raphe sternum. Raphe slit opening on the side of the central raphe endings in the middle of the central area (Figures 34–35).

Holotype: TM0005 (BEOU, wet collection Department of Algology and Mycology, University of Belgrade, Faculty of Biology, Institute of Botany and Botanical Garden „Jevremovac“, Belgrade, Serbia). Figures 1–35 illustrates the holotype specimen.

Isotype: BR-4934 (Meise Botanic Garden, Belgium).

Type locality: Serbia. Thermomineral spring - Omoljica, 44°45'39.84"N, 20°45'10.62"E, leg. Ana Milićević, coll. date 26.xi.2023.

Registration: <http://phycobank.org/>

Etymology: The new species is named in honour of Teodora Milićević, sister of the first author, in gratitude for her constant support and inspiration.

Ecology and associated diatom flora: *Navicula teodoraе* was found in epilithic and epipellic samples collected from the Omoljica thermomineral spring. This natural spring had a water temperature of 22 °C, an alkaline pH (8.1), high conductivity (1804 $\mu\text{S}\cdot\text{cm}^{-1}$) and high total dissolved solids (TDS, 1.2 ppt) values, indicating a mineral-rich habitat. The sample is dominated by *Nitzschia palea* (Kützing) W.Smith, *Navicula veneta* Kützing and *N. teodoraе*. Other frequent, though never dominant species include *Achnanthisdium exiguum* (Grunow) Czarnecki and *Gomphonema parvulum* (Kützing) Kützing.

Distribution: The new species was also present in the other springs (Bukovička spa, Ovčanska spa, Poljane and Vrujci) and appears to have a preference for habitats

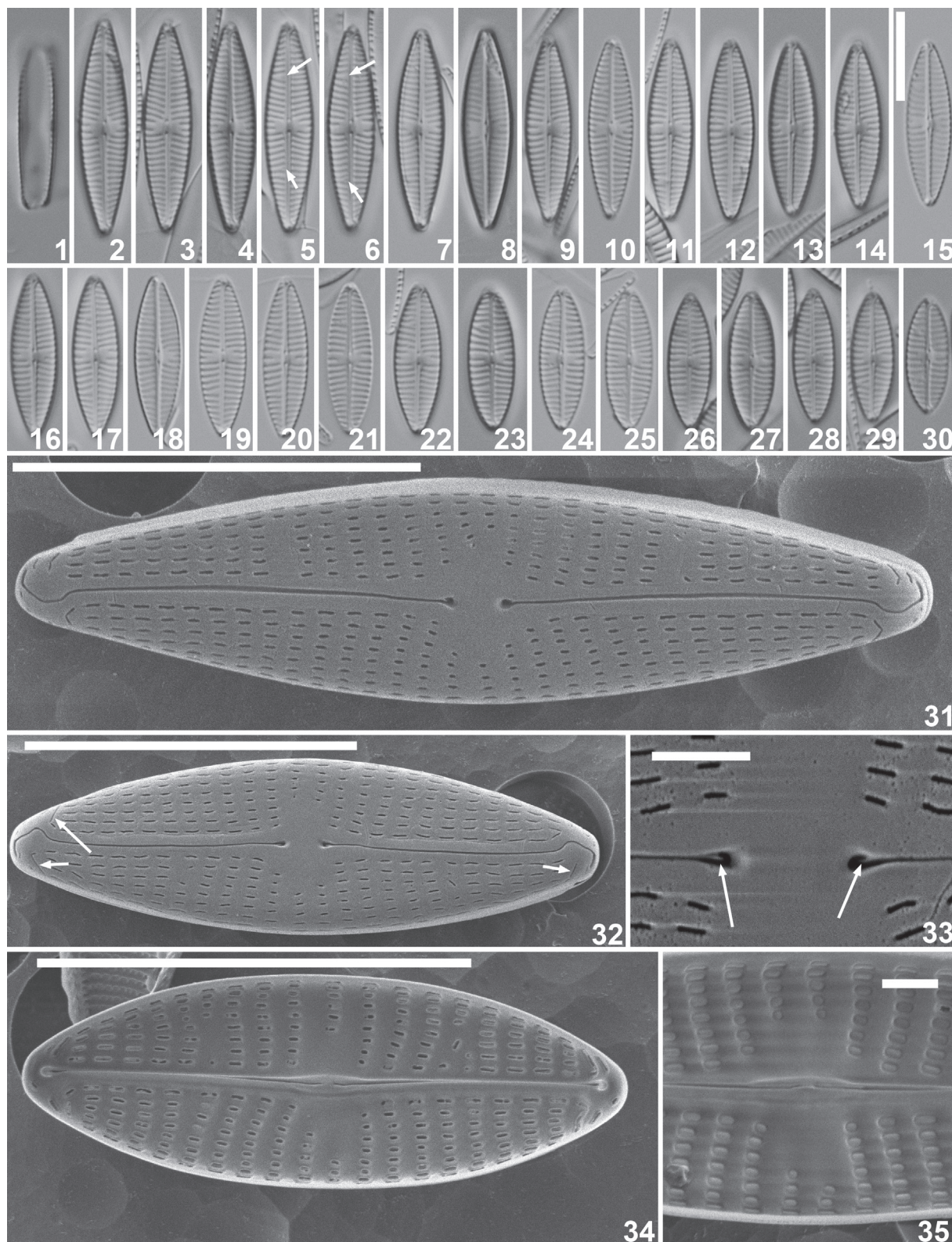
with elevated silica concentrations (18–81 $\text{mg}\cdot\text{L}^{-1}$), moderate to high total nitrogen (2–19 $\text{mg}\cdot\text{L}^{-1}$), and relatively high levels of total organic carbon (TOC, 1.6–5.6 $\text{mg}\cdot\text{L}^{-1}$).

DISCUSSION

Navicula teodoraе possesses a unique combination of morphological features (valve outline, size range, stria density, central area structure, and apical morphology) that distinguishes this new species from similar *Navicula* species (Table S1).

The most similar species is *Navicula cryptotenella* Lange-Bertalot, described in 1985 from a population in Brussels, Belgium (Krammer & Lange-Bertalot, 1985). Although valve dimensions and stria density overlap, the two species can be separated based on their valve outline and the shape and structure of the central area. *Navicula teodoraе* typically has convex valve margins that become slightly protracted near the apices, whereas *Navicula cryptotenella* has straight, not convex, non protracted margins at the apices (see for example Figures 119–132 representing the type of *N. cryptotenella* in Sagnet *et al.*, 2021). Moreover, *N. cryptotenella* has a central area bordered by several (often weakly shortened) radiating striae, while *N. teodoraе* has a small rectangular central area bordered on each side by usually 2 distinctly shortened striae. Similarly, *Navicula wildii* Lange-Bertalot and *N. similecataracta-rheni* Sagnet, Van de Vijver *et Tudesque* have a valve outline and central area structure more or less similar to *N. cryptotenella*, which are clearly different from those of *N. teodoraе* (Lange-Bertalot 2001; Sagnet *et al.*, 2022). *Navicula similecataracta-rheni* has wider valves (5.5–7 μm versus 5.0–5.5 μm in *N. teodoraе*) while its overall valve outline and central area structure are closer to those of *N. cryptotenella* than to the combination of characters observed in *N. teodoraе*. Another highly similar species is *Navicula veneta*, but it differs in its clearly protracted, rostrate apices, in contrast to the very weakly protracted apices of *N. teodoraе*. Although the stria density of *N. veneta* is generally somewhat lower, this character partly overlaps and is therefore less diagnostic than apical morphology. In the holotype sample, both species are present in almost equal numbers and can be clearly differentiated. *Navicula cadoi* Levkov *et* Krstic, described from Lake Prespa, also looks a bit similar but the name is now considered a heterotypic synonym of *N. veneta* (Z. Levkov, pers. comm.).

Other *Navicula* species with a similar central area combined with a lanceolate outline are rare. *Navicula breitenbuchii* Lange-Bertalot has larger (25–40 μm) and wider (6.5–7.5 μm) valves, a much lower stria density (10–11 striae in 10 μm), lineolae that are discernible in LM (though not very clearly), and almost parallel, straight (not convex) valve margins (Lange-Bertalot 2001,



Figures 1–35. *Navicula teodoraе* Milićević, Jakovljević, Popović *et* Van de Vijver, *sp. nov.* LM and SEM images taken from the holotype material (TM0005, Omoljica spring, Serbia). **(1)** LM image of a valve in girdle view. **(2–30)** LM images of the population arranged in decreasing length. **(31–32)** SEM external views of two entire valves. White arrows indicate transapical slits bordering the striae at the apices. **(33)** SEM external detail of the central area. White arrows indicate the small silica outgrowth inside the central raphe pores. **(34)** SEM internal view of an entire valve showing the sternum and the eccentric raphe branches. **(35)** SEM internal detail of the central area. Scale bars represent 10 µm (1–32, 34) and 1 µm (33, 35).

plate 37, figures 8–15). *Navicula vandamii* Schoeman et Archibald and its variety *mertensiae* Lange-Bertalot have very distinct lineolae, clearly visible in LM, somewhat narrower valves (4.5–5.0 μm) and protracted, rostrate apices (Lange-Bertalot, 2001, plate 37, figures 16–23). Another similar species, *N. vandeijveri* Reichardt, shows a comparable central area bordered by 2 shortened striae, but has more rostrate apices, areolae discernible in LM, and more radiate striae (Reichardt, 2018, plate 77, figures 40–49). *Navicula staffordiae* Bahls, has comparable valve dimensions (although with a slightly greater valve width, 4.5–6.5 μm), but differs in having a smaller, more rounded central area, clearly radiate striae in the middle part of the valve, and less convex margins, whereas in *N. teodora* the margins are distinctly convex and taper from the valve centre towards acutely rounded, very weakly protracted apices (Bahls, 2012). *Navicula leistikowii* Lange-Bertalot has more radiate striae, a lower stria density (12–13 striae in 10 μm), and more cuneate, slightly protracted apices (Lange-Bertalot, 2001, plate 16, figures 1–8). Finally, *Navicula erifuga* Lange-Bertalot has more broadly rounded apices, a rounded central area bordered by multiple shortened striae and broader valves (up to 7 μm) (Lange-Bertalot, 2001). *Navicula mariagraciellae* Metzeltin, Lange-Bertalot & García-Rodríguez is another relevant species for comparison (Metzeltin *et al.*, 2005). It resembles *N. teodora* in having a lanceolate outline and a more or less rectangular, almost symmetrical central area bordered by shortened striae. Nevertheless, *N. mariagraciellae* differs in its markedly larger (24–41 μm) and broader valves (6.6–8 μm), lower stria density (11–12 in 10 μm), non protracted cuneate apices, and in lacking the convergent distal striae characteristic of *N. teodora*. *Navicula tsetsemaae* Metzeltin is also relevant for comparison, but it is likewise clearly larger (30–36 μm) and broader than *N. teodora* (6.4–6.7 μm). In addition, it differs in having a rather large, almost symmetrical, mostly rhomboid central area, non protracted cuneate apices, and radial striae that become subparallel near the apices and are only barely convergent, with a lower stria density (13.5–14 in 10 μm) (Metzeltin *et al.*, 2009). *Navicula antonioides* Van de Vijver, Jarlman & Lange-Bertalot should also be considered, as it partly overlaps with *N. teodora* in valve dimensions, but differs in having lanceolate to elliptic-lanceolate valves with cuneately attenuated, non protracted apices, a smaller central area that is only weakly transapically widened, slightly lower stria density (14–15 vs 15–16 in 10 μm), and an externally raised raphe sternum around the central area (Van de Vijver *et al.*, 2010). Another relevant species is *Navicula tanakae* Fukushima, Kobayashi et Yoshitake, described from a hot spring outflow; although it partly overlaps with *N. teodora* in valve length and stria density, it differs in having narrower valves (3–5 μm) and more variable apices ranging from acute to rostrate (Fukushima *et al.*, 2002). The broad intraspecific variation documented in *N. tanakae*, especially in valve outline and degree of apical protrusion, indicates that

single characters should be interpreted with caution; however, the combination of valve width, central area architecture and stria pattern still supports the distinction of *N. teodora*.

The thermomineral springs studied in central Serbia are characterised by specific physico-chemical properties that apparently influence the composition of their phototrophic communities (Milićević *et al.*, 2025). *N. teodora* was mainly found in thermomineral springs with moderate to elevated temperatures (up to 25.1 $^{\circ}\text{C}$), slightly alkaline pH values (7.8–8.2), and high mineral content, as indicated by increased EC and TDS values, particularly in Omoljica and Ovčanska Spa. This habitat preference aligns with findings from other studies, which suggest that certain *Navicula* species, especially those inhabiting spring ecosystems such as *N. sanctamargaritae* and *N. veneta*, have an ecological optimum for alkaline, mineral-rich waters (Beauger *et al.*, 2023; Licursi *et al.*, 2010; Werum & Lange-Bertalot, 2004). The preference of *N. teodora* for habitats rich in silica (22–81 $\text{mg}\cdot\text{L}^{-1}$), moderate to high nitrogen (2–19 $\text{mg}\cdot\text{L}^{-1}$), and relatively elevated TOC (1.6–5.6 $\text{mg}\cdot\text{L}^{-1}$) indicates that this species is well adapted to nutrient-rich, organically influenced thermal waters. *N. tanakae* was also described from a thermal spring habitat, although from a hotter spring outflow (31 $^{\circ}\text{C}$, pH 7.6, NaCl 0.49%) (Fukushima *et al.*, 2002). Several *Navicula* species have previously been described from spring habitats. Van de Vijver & Cocquyt (2009) described four new diatom taxa from a Peruvian hot spring, including one new *Navicula* species (*N. cadei* Van de Vijver et Cocquyt). Beauger *et al.* (2015) reported the new species *N. sanctamargaritae* Beauger from a thermomineral spring in France with similar conditions, though with higher conductivity up to 8000 $\mu\text{S}\cdot\text{cm}^{-1}$. In contrast, *N. tsetsemaae* was described from the Shurguit River in Mongolia, where it was found on stones, mud and plants in cool, circumneutral, weakly mineralised waters - conductivity 100 $\mu\text{S}\cdot\text{cm}^{-1}$ and temperature 7.9 $^{\circ}\text{C}$ (Metzeltin *et al.*, 2009). *Navicula mariagraciellae*, on the other hand, is so far known only from river localities in Uruguay (Río Santa Lucía Chico and, based on a few specimens, Río Negro), whereas detailed physical and chemical data were not provided in the original description (Metzeltin *et al.*, 2005).

In conclusion, *Navicula teodora* is a morphologically distinct, subdominant species in the Omoljica thermomineral spring. Its differentiation from similar *Navicula* species highlights the importance of careful taxonomic study in spring ecosystems. This work expands the known diversity of the genus *Navicula* in thermomineral habitats and underscores the need for continued ecological and taxonomic investigations to accurately document these diatom assemblages.

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REFERENCES

- Bahls, L. L. (2012). Seven new species in *Navicula* sensu stricto from the Northern Great Plains and Northern Rocky Mountains. *Nova Hedwigia*, 141, 19–38.
- Beauger, A., Voldoire, O., Mertens, A., Le Cohu, R., & Van de Vijver, B. (2015). Two new *Navicula* species (Bacillariophyceae) from Western Europe. *Phytotaxa*, 230(2), 172–182. <https://doi.org/10.11646/phytotaxa.230.2.4>
- Beauger, A., Voldoire, O., Allain, E., Gosseaume, P., Blavignac, C., Baker, L.-A., & Wetzel, C. E. (2023). Biodiversity and environmental factors structuring diatom assemblages of mineral saline springs in the French Massif Central. *Diversity*, 15(2), Article 283. <https://doi.org/10.3390/d15020283>
- Cox, E. J. (1999). Studies on the diatom genus *Navicula* Bory. VIII. Variation in valve morphology in relation to the generic diagnosis based on *Navicula tripunctata* (O.F. Müller) Bory. *Diatom Research*, 14(2), 207–237. <https://doi.org/10.1080/0269249X.1999.9705467>
- Cox, E. J., & Ross, R. (1981). The striae of pennate diatoms. In R. Ross (Ed.), *Proceedings of the Sixth Symposium on Fossil and Recent Diatoms* (pp. 267–278). O. Koeltz.
- Fukushima, H., Ko-Bayashi, T., & Yoshitake, S. (2002). *Navicula tanakae* Fukush., Ts.Kobay. & Yoshit. nov. sp., new diatom taxon from hot spring. *Diatom*, 18, 13–21.
- Guiry, M. D., & Guiry, G. M. (2023). *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. <https://www.algaebase.org>
- Hustedt, F. (1962). Die Kieselalgen Deutschlands, Österreichs und der Schweiz unter Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete. In L. Rabenhorst (Ed.), *Kryptogamen-Flora von Deutschland, Österreich und der Schweiz* (Vol. 7, No. 3, pp. 161–348). Akademische Verlagsgesellschaft.
- Jüttner, I., Chudaev, D., & Kusber, W.-H. (2020). Re-examination of the type materials of *Navicula exilis* and *Navicula cryptocephala* (Naviculaceae, Bacillariophyceae). *Phytotaxa*, 472(2), 123–134. <https://doi.org/10.11646/phytotaxa.472.2.3>
- Kanavillil, N., Thorn, M., & Kurissery, S. (2012). Characterization of natural biofilms in temperate inland waters. *Journal of Great Lakes Research*, 38(3), 429–438. <https://doi.org/10.1016/j.jglr.2012.06.014>
- Krammer, K., & Lange-Bertalot, H. (1985). *Naviculaceae: Neue und wenig bekannte Taxa, neue Kombinationen und Synonyme sowie Bemerkungen zu einigen Gattungen* (Bibliotheca Diatomologica, Vol. 9). J. Cramer.
- Kulikovskiy, M. S., Thacker, M., Glushchenko, A. M., Kuznetsova, I. V., Iurmanov, A. A., Karthick, B., & Kociolek, J. P. (2023). *Gandhia* gen. nov.—A new diatom genus with unusual morphology split off from the genus *Navicula* Bory. *Plants*, 12(23), Article 3941. <https://doi.org/10.3390/plants12233941>
- Lange-Bertalot, H. (1980). Zur taxonomischen Revision einiger ökologisch wichtiger „Naviculaceae“ Cleve. Die Formenkreise um *Navicula lanceolata*, *N. viridula*, *N. cari*. *Cryptogamie, Algologie*, 1(1), 29–50.
- Lange-Bertalot, H. (1993). 85 Neue Taxa und über 100 weitere neu definierte Taxa ergänzend zur Süßwasserflora von Mitteleuropa Vol. 2/1–4 (Bibliotheca Diatomologica, Vol. 27). J. Cramer.
- Lange-Bertalot, H. (2001). *Navicula sensu stricto. 10 genera separated from Navicula sensu lato. Frustulia*. In H. Lange-Bertalot (Ed.), *Diatoms of Europe: Diatoms of the European Inland Waters and Comparable Habitats* (Vol. 2). A.R.G. Gantner Verlag K.G.
- Lange-Bertalot, H., Cavacini, P., Tagliaventi, N., & Alfinito, S. (2003). *Diatoms of Sardinia: Rare and 76 new species in rock pools and other ephemeral waters* (Iconographia Diatomologica, Vol. 12). A.R.G. Gantner Verlag K.G.
- Lange-Bertalot, H., Hofmann, G., Werum, M., & Cantonati, M. (2017). *Freshwater benthic diatoms of Central Europe: Over 800 common species used in ecological assessment*. Koeltz Botanical Books.
- Levkov, Z., Krstić, S., Metzeltin, D., & Nakov, T. (2007). *Diatoms of Lakes Prespa and Ohrid: About 500 taxa from ancient lake system* (Iconographia Diatomologica, Vol. 16). A.R.G. Gantner Verlag K.G.
- Licursi, M., Gómez, N., & Donadello, J. (2010). Ecological optima and tolerances of coastal benthic diatoms in the freshwater–mixohaline zone of the Río de la Plata estuary. *Marine Ecology Progress Series*, 418, 105–117. <https://doi.org/10.3354/meps08865>
- Mann, D. G., McDonald, S. M., Bayer, M. M., Droop, S. J. M., Chepurnov, V. A., Loke, R. E., Ciobanu, A., & Du Buf, J. H. (2004). The *Sellaphora pupula* species complex (Bacillariophyceae): Morphometric analysis, ultrastructure and mating data provide evidence for five new species. *Phycologia*, 43(4), 459–482. <https://doi.org/10.2216/i0031-8884-43-4-459.1>
- Metzeltin, D., Lange-Bertalot, H., & García-Rodríguez, F. (2005). *Diatoms of Uruguay: Compared with other taxa from South America and elsewhere* (Iconographia Diatomologica, Vol. 15). A.R.G. Gantner Verlag K.G.
- Metzeltin, D., Lange-Bertalot, H., & Soninkhishig, N. (2009). *Diatoms in Mongolia* (Iconographia Diatomologica, Vol. 20). A.R.G. Gantner Verlag K.G.
- Milićević, A., Popović, S., Milovanović, V., Karadžić, V., Savković, Ž., Bjelica, V., Krizmanić, J., Subakov-Simić, G., & Jakovljević, O. (2025). Phototrophs in unique habitats of thermomineral springs in Central Serbia. *Life*, 15(2), Article 169. <https://doi.org/10.3390/life15020169>
- Reichardt, E. (1918). *Die Diatomeen im Gebiet der Stadt Treuchtlingen*. Bayerische Botanische Gesellschaft.
- Ross, R., Cox, E. J., Karayeva, N. I., Mann, D. G., Paddock, T. B. B., Simonsen, R., & Sims, P. A. (1979). An amended terminology for the siliceous components of the diatom cell. *Nova Hedwigia, Beihefte*, 64, 513–533.
- Round, F. E., Crawford, R. M., & Mann, D. G. (1990). *The diatoms: Biology and morphology of the genera*. Cambridge University Press.
- Sagnet, D., Van de Vijver, B., & Tudesque, L. (2022). *Navicula similecataracta-rheni* sp. nov. and *N. aquitanoniponica* sp. nov. (Bacillariophyta), two new species from Nouvelle-Aquitaine, Southwestern France. *Fottea*, 22(2), 211–227. <https://doi.org/10.5507/fot.2022.007>
- Taylor, J. C., Harding, W. R., & Archibald, C. G. M. (2007). *A methods manual for the collection, preparation and analysis of diatom samples (Version 1.0)* (Water Research Commission Report TT 281/07). Water

- Research Commission.
- Turland, N. J., Wiersma, J. H., Barrie, F. R., Gandhi, K. N., Greuter, W., Hawksworth, D. L., Herendeen, P. S., Klopfer, R. R., Knapp, S., Kusber, W.-H., Li, D.-Z., May, T. W., Monro, A. M., Prado, J., Price, M. J., Smith, G. F., & Zamora Señoret, J. C. (Eds.). (2025). *International Code of Nomenclature for algae, fungi, and plants (Madrid Code)*. Koeltz Botanical Books.
- Van de Vijver, B., & Cocquyt, C. (2009). Four new diatom species from La Calera hot spring in the Peruvian Andes (Colca Canyon). *Diatom Research*, 24(1), 209–223. <https://doi.org/10.1080/0269249X.2009.9705792>
- Van de Vijver, B., Jarlman, A., & Lange-Bertalot, H. (2010). Four new *Navicula* (Bacillariophyta) species from Swedish rivers. *Cryptogamie, Algologie*, 31(3), 355–367.
- Van de Vijver, B., & Lange-Bertalot, H. (2009). New and interesting *Navicula* taxa from western and northern Europe. *Diatom Research*, 24(2), 415–429. <https://doi.org/10.1080/0269249X.2009.9705811>
- Van de Vijver, B., Zidarova, R., Sterken, M., Verleyen, E., de Haan, M., Vyverman, W., Hinz, F., & Sabbe, K. (2011). Revision of the genus *Navicula* s.s. (Bacillariophyceae) in inland waters of the Sub-Antarctic and Antarctic with the description of five new species. *Phycologia*, 50(3), 281–297. <https://doi.org/10.2216/10-49.1>
- Werum, M., & Lange-Bertalot, H. (2004). *Diatoms in springs from Central Europe and elsewhere under the influence of hydrogeology and anthropogenic impacts* (Iconographia Diatomologica, Vol. 13). A.R.G. Gantner Verlag K.G.
- Witkowski, A., Lange-Bertalot, H., & Metzeltin, D. (2000). *Diatom Flora of Marine Coasts I* (Iconographia Diatomologica, Vol. 7). A.R.G. Gantner Verlag K.G.