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# A new freshwater *Gomphonema* Ehrenberg (Bacillariophyta) species from Eastern Himalayas, India

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**Abstract:** A new freshwater diatom species, *Gomphonema adhikarii* sp. nov., is described from a small road–side pool from the alpine region of Arunachal Pradesh, Eastern Himalayas, India. Detailed valve morphological features, based on both light and scanning electron microscopy, is presented and this taxon is compared with similar species. *Gomphonema adhikarii* has a distinct asymmetry about the apical axis and slightly bent foot pole area. The outline of the valve is slightly undulate, the valve centre is swollen and both apices are broadly rounded. This new species described from the Eastern Himalayas supports the idea of the area being rich in biodiversity, even with respect to the freshwater diatom flora.

**Key words:** *Gomphonema*, Arunachal Pradesh, Tawang, *Gomphonema adhikarii* sp. nov.

## Introduction

The Eastern Himalayas are rich in biodiversity, positioned within two major biodiversity hotspots, i.e. Indo–Burma and the Himalaya Hotspots (CEPF 2005). This region extends geographically from Nepal to Tibet and Yunnan of China including the north–eastern states of India. A unique geo–climatic complexity in this region supports a wide range of species diversity. This region alone houses more than 1500 endemic plant species (Myers et al. 2000). Studies on the diatom flora of the Himalayan region have been confined to Nepal (Jüttner et al. 2000, 2004, 2010a, 2010b, 2011, 2017, 2018; Van de Vijver et al. 2011; Krstić et al. 2013), Tibet and China (Mereschkowsky 1906; Kociolek 1992; Huizhong & Jiayou 2000; Li et al. 2010a, 2010b; Gong & Li 2011; Hu et al. 2013; Gong et al. 2015; Jiang et al. 2018; Liao & Li 2018). Studies on the freshwater diatoms from the Indian Territory of the region are limited to a few recent records (Das et al. 2018; Wadmare et al. 2019). Beyond floristic and biodiversity discovery studies, several efforts have also been made for ecological assessment of streams, rivers and lakes through diatom studies in the adjoining Nepalese Himalayas (Ormerod et al. 1994; Jüttner et al. 1996, 2003; Simkhada & Jüttner 2006; Simkhada et al. 2006; Sharma et al. 2012; Gurung et al. 2018).

*Gomphonema* Ehrenberg is one of the most taxon–rich diatom genera comprised of more than 940 taxa so far (Kociolek et al. 2020). Members of the genus are identified by linear–lanceolate heteropolar valves with (usually) a single stigma present in the central area (Round et al. 1990). More than 130 *Gomphonema* taxa have been documented so far from various freshwater and terrestrial habitats of India, since the first record by Ehrenberg (1845). About 30% of these taxa are endemic (Karthick et al. 2011). Some *Gomphonema* species from high elevations of the Eastern Himalayas showed higher endemism (Jüttner et al. 2004). The higher endemism in the Himalayas can be inferred from the oligotrophic conditions of the freshwaters there (Moser et al. 1998; Jüttner et al. 2004). We have begun an initial survey of biodiversity discovery and floristics in Northeastern India. Das et al. (2018) described three new *Gomphonema* species from a river in Western Arunachal Pradesh including *Gomphonema mayamae* Sudipta K. Das, C. Radhakrishnan, Kociolek et B. Karthick (Das et al. 2018), which had a fimbriate structure in the girdle band near the head pole. This morphological feature is

unique among the freshwater *Gomphonema* species. In the present study, we further our work by describing one new *Gomphonema* species from a small road–side pool in the Tawang region of Arunachal Pradesh state of India.

## Materials and Methods

**Study area.** Material was collected from epilithic habitats on submerged stones in a small road–side pool near Nagula Lake, on the way to Bumla (Indo–China border) in the Tawang district of Arunachal Pradesh (27°39'49.7"N, 91°51'32.6"E; elevation 4173 m a.s.l) (Fig. 1). The sampling site and the adjacent area are part of the Nagula High Altitude Wetland (HAW) Complex, one of the two ecologically crucial HAW complexes located in the Tawang district at an elevation of more than 3700 m (PANIGRAHY et al. 2012). Both Nagula and Bhagajang HAW complexes have alpine to tundra climatic conditions, encompassing more than 360 lakes, along with their feeding and outflow streams. Apart from the lakes, there are also small pools, which generally turn to small swamps during the summer months. All of the lentic freshwater bodies in this locality are treated as sacred by local religious communities, thus they are mostly pristine.

**Diatom collection and treatment.** Brown coloured slimy films from small stones were scraped for diatoms using a toothbrush along with the pool water. The resulting brown suspension was transferred to the laboratory in a plastic container. The suspension was cleaned by boiling in concentrated Nitric acid ($HNO_3$) to oxidize organic matter. Subsequently, the resulting material was alternately centrifuged and rinsed with distilled water several times until the sample attained a neutral pH. The cleaned suspension was air–dried onto coverslips and mounted with Napharax® mounting medium. Light microscopy (LM) observations were made with an Olympus BX 53 (Tokyo, Japan), equipped with Differential Interference Contrast optics and images were captured with an Olympus DP 73 digital


Fig. 1. Location map of the study site in Tawang, Arunachal Pradesh.

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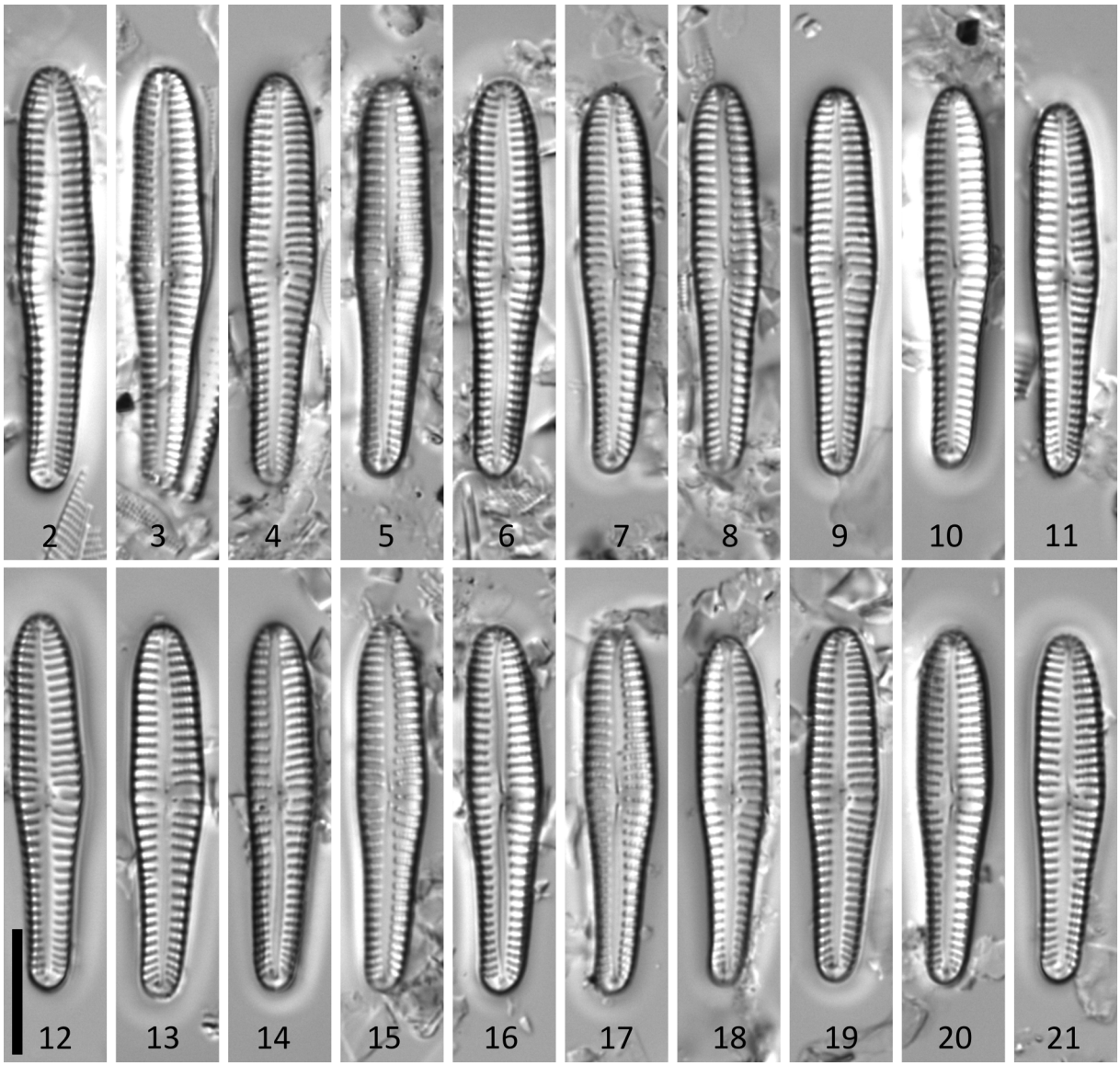
camera. The clean material was used for SEM observations. The diatom materials were dried onto glass coverslips and affixed to aluminum stubs with double–sided carbon tape. Stubs with the cleaned material were sputter–coated with gold–palladium with an Emitech K575X sputter coater. SEM observations were performed with an EVO MA15, Carl Zeiss microscope with LaB6 filament. LM and SEM images were processed in GIMP (version 2.8.14) and plates were compiled with Inkscape (version 0.91). Cleaned material and slides are archived at the Diatom Collection at Agharkar Research Institute Herbarium (AHMA).

## Results

***Gomphonema adhikarii* C.Radhakrishnan, Sudipta K.Das, Kociolek et B.Karthick sp. nov. (Figs 2–35)**
**LM Description (Figs 2–21)**: Valves distinctly clavate, clearly asymmetrical about the apical axis, apices broadly rounded at the head pole, narrowly rounded foot pole. Length (28–34 μm) and breadth (5–6 μm) (n=72). Axial area narrow, linear–lanceolate in shape. Raphe lateral, proximal raphe endings slightly undulate and curved distal raphe fissures visible. Isolated round stigma present in the central area. Striae uniseriate, slightly radiate at centre, becoming parallel to radiate near the foot pole (12–14 in 10 μm). The broad central area has one shortened stria on each side. Apical pore field (APF) present at the foot pole.
**SEM Description (Figs 22–35)**: In the SEM, externally, striae are uniseriate, mostly occluded with volae to give "reverse C– or 3–" shaped areolae, which extend to the mantle (Figs 24–26). Raphe undulate, proximal raphe endings deflected to the stigma side (Fig. 26), distal raphe ending curved onto the mantle, in the direction opposite the stigma (Fig. 25). Central area small, an isolated round stigma opening is present (arrow in Fig. 26). The apical pore field is composed of round porelli. Porelli



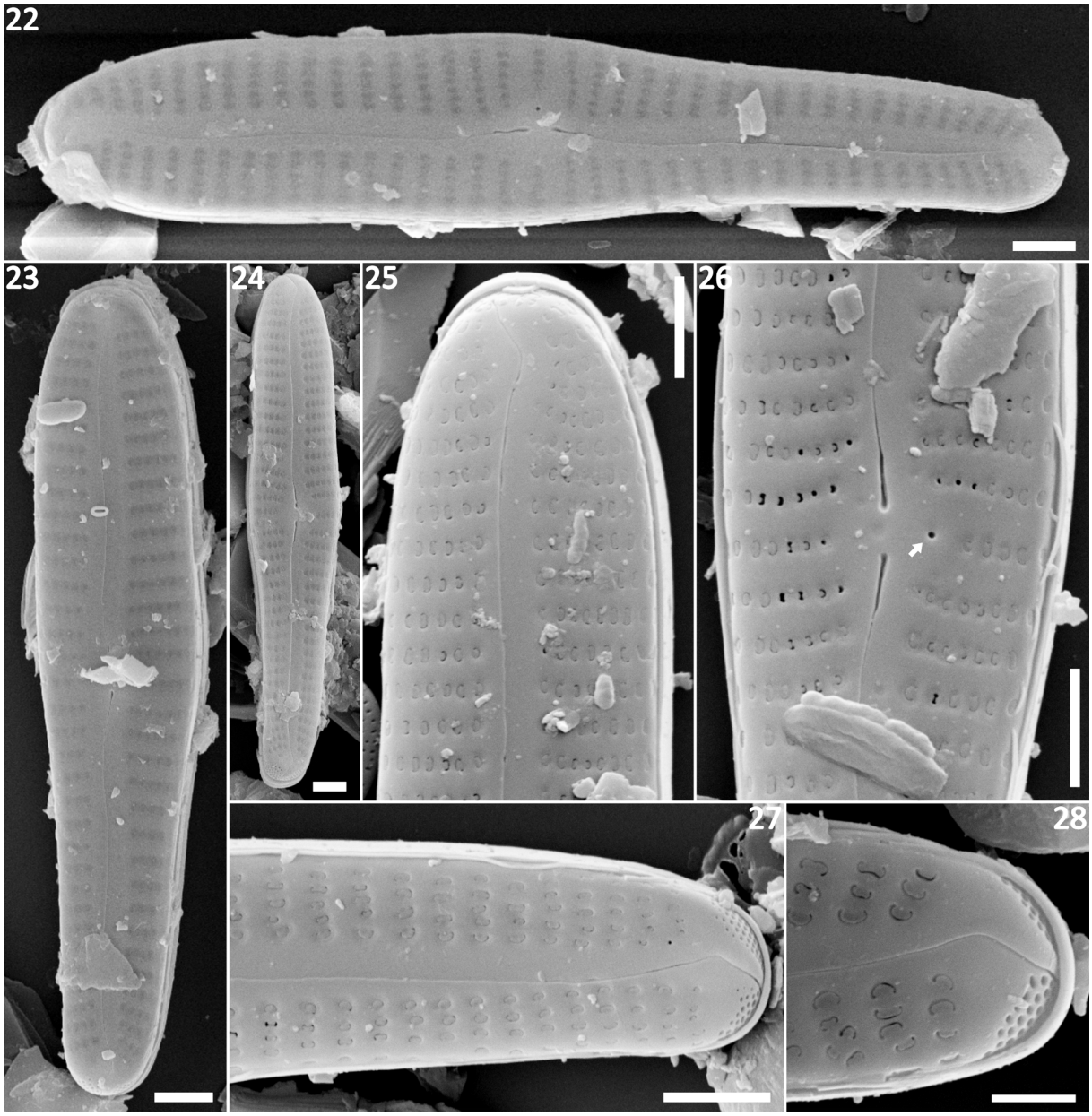

Figs 2–21. Light microscope images of *Gomphonema adhikarii* sp. nov. Valve view showing size diminution series. Scale bar 10 μm.

number 56–58/10 µm (measured perpendicular to raphe) (Fig. 28). The pore field is distinctly separate from the areolae, that is it is both morphologically different and physically separated from the areolae (Figs 24, 27–28). Internally, striae are parallel, slightly radiate at the foot pole (Figs 29–31). Raphe almost straight and a prominent helictoglossa is present at the raphe ends (marked as 'H' in Figs 32, 34–35). There is a small–sized pseudoseptum present at the headpole and footpole (Fig 32, 34). Internal areolae openings are C– or 3–shaped and present in deep grooves (Figs 32–35). The central nodule is slightly large and elliptical (Fig. 33). Proximal raphe ends are curved. A small elliptical stigma opening is present at one side of the central nodule (Figs 29, 33) (arrow in Fig. 33). Apical pore fields are covered internally by the pseudoseptum (Figs 34–35).

**Holotype**: Slide #49–065; Sample Accession #2433; deposited at the Diatom Collection, Agharkar Research Institute Herbarium (AHMA), Pune, India.

**Type locality**: INDIA, Arunachal Pradesh, A pool located at the roadside, On the way to Bumla, Tawang district (27°39'49.7"N, 91°51'32.6"E; elevation 4173 m a.s.l.) (holotype: Agharkar Research Institute Herbarium (AHMA). Collected from an epilithic habitat.

**Etymology**: Named in the honour of the Indian algologist Prof. Siba Prasad Adhikary, Visva–Bharati, Siksha Bhavana Santiniketan for his phycological contributions in north–eastern India.




Figs 22–28. External view of the scanning electron micrographs of *Gomphonema adhikarii* sp. nov.: (22–24) External view of whole valve showing slightly cymbelloid valves; (25) Rounded head pole showing distal raphe end; (26) Central area of the valve showing stigma (pointed by an arrow) and proximal raphe ending; (27–28) Foot pole showing 'c' or rarely '3' shaped areolae and apical pore field. Scale bars 2 µm (22–24), 1 µm (25–28).

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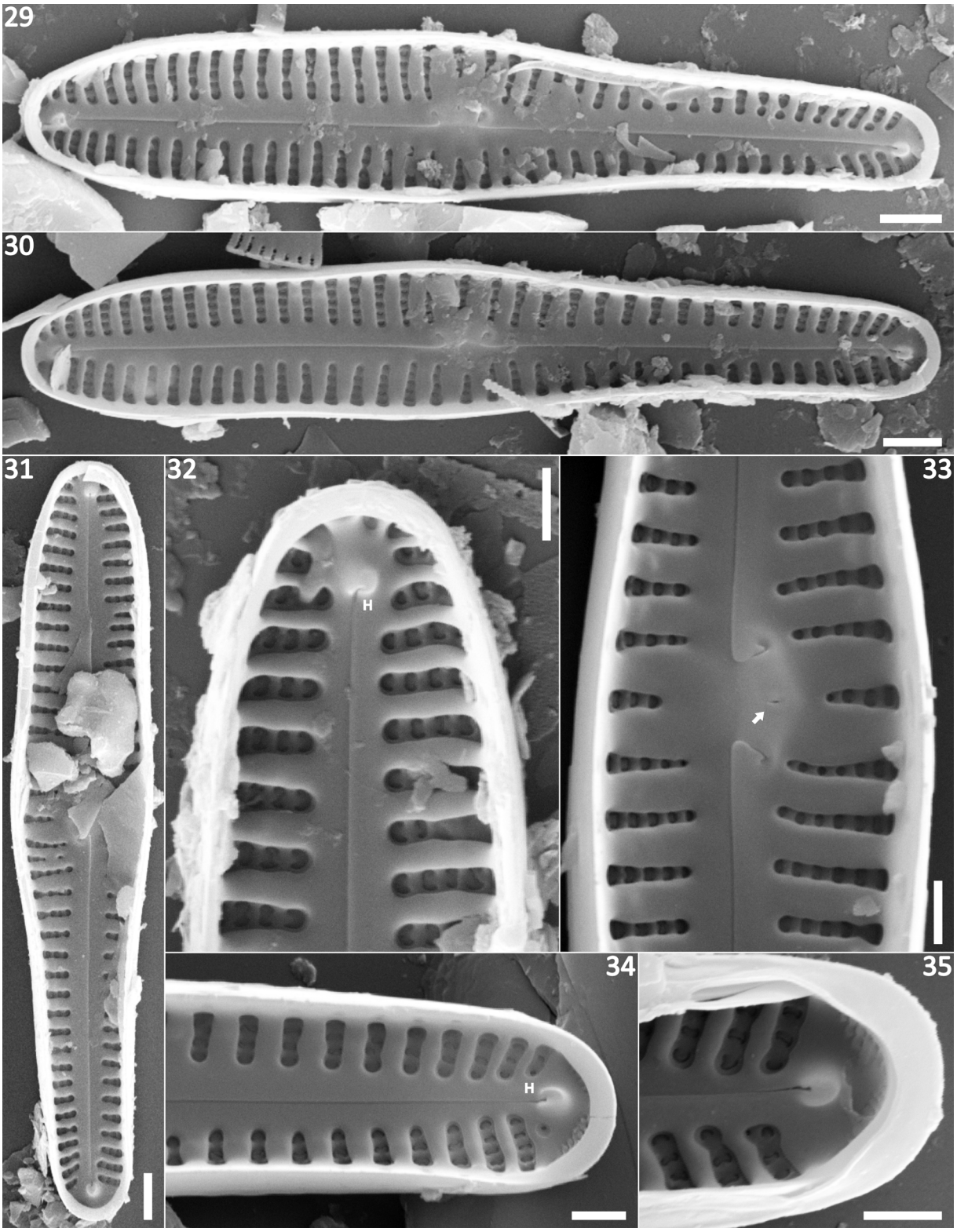


Figs 29–35. Internal view of the scanning electron micrographs of *Gomphonema adhikarii* sp. nov.: (29–31) Internal view of the whole valve showing helictoglossae and parallel to radiate striae; (32) Rounded head pole showing helictoglossae (pointed by 'H') and pseudoseptum; (33) Valve centre showing proximal raphe ends and stigma opening (pointed by an arrow); (34–35) Foot pole showing helictoglossae (pointed by 'H') and pseudoseptum. Scale bars 2 μm (29–31), 1 μm (32–35).

Table.1 Comparison of morphologically similar species of *Gomphonema adhikarii* sp. nov.

| Characters | *Gomphonema adhikarii sp.nov* | *G. mayamae* | *G. scardicum* | *G. angusticephalum* | *G. heilongtanensis* | *G. jergackianum* |
|---|---|---|---|---|---|---|
| **Length (µm)** | 28–34 | 22.5–36.7 | 36–63 | 19.5–49 | 21–37 | 20–37 |
| **Width at centre (µm)** | 5–6 | 5.6–6.9 | 7.5–9.5 | 4–6.4 | 5.1–6.5 | 5–5.7 |
| **Striae (in 10 µm)** | 12–14 | 11–13 | 9–12 | 10–14 | 11–14 | 12 |
| **Valve shape** | Linear, clavate, undulated margin, slightly cymbelloid due to convex margin on one side near foot pole | Clavate, slightly asymmetrical to apical axis | Linear–lanceolate, largest valve width near mid–valve | Clavate, margin rarely undulate | Clavate, linear | Clavate, lanceolate, slightly cymbelloid |
| **Constriction between head pole and mid–valve** | No constriction | No constriction | Weak in larger valves and indistinct in smaller valves | Indistinct to weak | No constriction | No constriction |
| **Head pole** | Rounded | Broadly rounded, girdle band with a fimbriate margin | Narrowly rounded to cuneate | Acutely rounded, wider than central area | Wedge shaped acutely rounded | Obtuse, more broadly rounded |
| **Foot pole** | Narrowly rounded | Narrowly rounded | Acutely rounded | Acutely round | Narrowly rounded | Narrowly rounded |
| **Raphe** | Lateral, proximal endings slightly undulated | Lateral, undulated near proximal end | Lateral, weakly undulated | Lateral, undulated | Lateral, external raphe fissure slightly to moderately undulated | Lateral, slightly undulate |
| **Striae** | Uniseriate, parallel to radiate towards foot pole | Uniseriate, slightly radiate at the centre | Uniseriate | Uniseriate, mostly parallel, radiate towards the poles | Uniseriate, parallel in center, with slightly radiate towards apices | Uniseriate, moderately radiate, sometimes almost parallel at the head pole |
| **Areolae** | c– or rarely 3– shaped | c– or 3– shaped | c–shaped | c–shaped | c–shaped | c– or weakly 3–shaped |
| **Central area** | Broad but small, had one shortened striae on each side | Small with one shortened striae on each side | Small, formed by shortening of single central stria on both valve sides | Small, with single central stria on both valve sides | Small, rounded, with two slightly shortened median striae | Widely roundish, occupying half the width of the valve |
| **Stigmata** | Stigma opening round, situated at the end of central striae | Stigma opening round, situated at end of central striae | Stigma opening round, situated at end of central striae | Stigma opening round, in the central area | Stigma clearly separated from striae, close to the central nodule, stigma opening round | Stigma opening round in external valve. Small and slit–like in internal valve |
| **Axial area** | Narrow, linear–lanceolate | Narrow the entire length of the valve | Narrow, linear–lanceolate | Narrowly linear | Narrow at apices, slightly expanded towards the valve centre | Lanceolate, widening towards central area |
| **Reference** | Present study | DAS et al. 2018 | MITIĆ–KOPANJA et al. 2014 | REICHARDT 1999 KULIKOVSKIY et al. 2015 | LI et al. 2010b | REICHARDT 2009 |

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## Discussion

The newly–described *Gomphonema* species has several morphological features such as asymmetrical to apical axis, swollen valve centre, and rounded apices which differentiate it from all other known species, in particular, the species described from the Himalayan region (Jüttner et al. 2004, 2018; Karthick et al. 2015; Das et al. 2018). A comparative account of the morphology of *Gomphonema adhikarii* and taxa that appear morphologically similar are presented in the Table. 1.

Our new species is most similar under the LM to *G. mayamae* (fig 1–21 in Das et al. 2018), a species that is also asymmetric to both the apical and transapical axes and described from the Eastern Himalayan region of India (Das et al. 2018). The two species differ in valve shape (*G. adhikarii* sp. nov. has a more undulate valve outline, the headpole is less quadrate and the footpole is more broadly rounded than in *G. mayamae*). The two species also differ in that under the electron microscope *G. mayamae* was described to have a fimbriate girdle band structure not described elsewhere amongst the freshwater gomphonemoid diatoms (Das et al. 2018). This type of girdle band structure is apparently missing in *G. adhikarii* sp. nov.

The newly described species bears some resemblance with *G. heilongtanensis* Li, Kociolek et Metzeltin (fig 35–70 in Li et al. 2010b), described from Tibet. Though the valve shape and dimensions match one another, the distinctly cuneate headpole in *G. adhikarii* differentiates it from the species described from China.

It is common to separate the Cymbellales into those taxa that possess asymmetry about the apical axis ('cymbelloid' diatoms) from those with asymmetry about the transapical axis ('gomphonemoid' diatoms). In fact, in both groups, there are species that possess both symmetry types. In the cymbelloids, both *Gomphocymbellopsis* Krammer and *Didymosphenia* M. Schmidt (e.g. *D. curvirostrum* (Tempère et Brun in Brun et Tempère) M. Schmidt; see Kociolek & Stoermer 1988) have species with asymmetry about the transapical axis. And in the gomphonemoid lineage, *Afrocymbella* Krammer, a genus endemic to East African Rift Valley lakes that is more closely related to gomphonemoid diatoms than its name suggests (Kociolek & Stoermer 1988) is diagnosed by having species with both cymbelloid and gomphonemoid symmetry. Within *Gomphonema*, species with asymmetry about the apical axis have been named but considered as possible teratologies by Mayer (1917, 1919) and named by Fricke (1902). These taxa are known from Europe, Asia and North America (Mayer 1919; Fricke 1902; Das et al. 2018). It seems likely that this feature of asymmetry about both the apical and transapical axes in members of the Cymbellales has been achieved independently many times, rather than a feature that is diagnostic for a natural group of taxa.

Recently many novel taxa representing multiple lineages of diatoms were described from Asia, in particular, tropical Asia (Glushchenko et al. 2019a, b; Thacker et al. 2019; Liu et al. 2019; Roy et al. 2019; Kulikovskiy et al. 2020). These discoveries confirm that Asia is the hotspot of diatom diversification as proposed by Kociolek (2019) and the same finding need to be strengthened using molecular phylogenetic tools.

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## References

CEPF (2005): Ecosystem Profile: Eastern Himalayas Region. Critical Ecosystem Partnership Fund. – Available at: http://www.cepf.net/Documents/final.ehimalayas.ep.pdf.

Das, S.K.; Radhakrishnan, C.; Kociolek, J.P. & Karthick, B. (2018): Three new species of *Gomphonema* Ehrenberg (Bacillariophyta), from Eastern Himalayas, with a note on the unique girdle band structure. – Nova Hedwigia 147: 359–371. http://doi.org/10.1127/nova–suppl/2018/025

Ehrenberg, C.G. (1845): Neue Untersuchungen über das kleinste Leben als geologisches Moment. – Bericht über die zur Bekanntmachung geeigneten Verhandlungen der Königlich–Preussischen Akademie der Wissenschaften zu Berlin 1845: 53–87.

Fricke, F. (1902): Verzeichniss der in A. Schmidt's Atlas der Diatomaceenkunde. – Tafel 1–240 (series I.–V.), abgebildeten und benannten Formen. Herausgegeben von Dr. phil. Friedr. Fricke.

Glushchenko, A.; Kociolek, J.P.; Kuznetsova, I.; Kezlya, E. & Kulikovskiy, M. (2019a): *Neidiomorpha gusevii* – a new diatom species (Bacillariophyceae: Neidiaceae) from Southeast Asia. – Phytotaxa 415: 279–285. http://dx.doi.org/10.11646/phytotaxa.415.5.4

Glushchenko, A.; Kuznetsova, I.; Kociolek, J.P. & Kulikovskiy, M.S. (2019b): *Karthickia verestigmata* gen. et sp. nov. – an interesting diatom with frustular morphology similar to several different cymbelloid diatom genera. – Phycologia 58: 605–613. https://doi.org/10.1080/00318884.2019.1626605

Gong, Z.J. & Li, Y.L. (2011): *Cymbella fluxianensis* Li & Gong sp. nov. (Bacillariophyta) from Yunnan Plateau, China. – Nova Hedwigia 92: 551–556. https://doi.org/10.1127/0029–5035/2011/0092–0551

Gong, Z.J.; Metzeltin, D.; Li, Y.L. & Edlund, M. (2015): Three new species of *Navicula* (Bacillariophyta) from lakes in Yunnan Plateau (China). – Phytotaxa 208: 135–146. http://dx.doi.org/10.11646/phytotaxa.208.2.2

Gurung, S.; Gurung, A.; Sharma, C.M.; Jüttner, I.; Tripathee, L.; Bajracharya, R.M.; Raut, N. et al. (2018): Hydrochemistry of Lake Rara: A high mountain lake in western Nepal. – Lakes and Reservoirs 23: 87–97. https://doi.org/10.1111/lre.12218

Hu, Z.J.; Li, Y.L. & Metzeltin, D. (2013): Three new species of *Cymbella* (Bacillariophyta) from high altitude lakes, China. – Acta Botanica Croatica 72: 359–374.

Huizhong, Z. & Jiayou, C. (2000): Bacillariophyta of the

Xizang Plateau. – 353 pp., Science Press, Beijing, China.

Jiang, Z.; Liu, Y.; Kociolek, J.P. & Fan, Y. (2018): One new *Gomphonema* (Bacillariophyta) species from Yunnan Province, China. – Phytotaxa 349: 257–264. http://dx.doi.org/10.11646/phytotaxa.361.1.11

Jüttner, I.; Williams, D.M.; Gurung, S.; Van de Vijver, B.; Levkov, Z.; Sharma, C.M.; Sharma, S. & Cox, E.J. (2017): The genus *Odontidium* (Bacillariophyta) in the Himalaya – a preliminary account of some taxa and their distribution. – Phytotaxa 332: 01–21. http://dx.doi.org/10.11646/phytotaxa.332.1.1

Jüttner, I.; Cox, E.J. & Ormerod, S.J. (2000): New and poorly known diatoms from Himalayan streams. – Diatom Research 15: 237–262. https://doi.org/10.1080/0269249X.2000.9705498

Jüttner, I.; Reichardt, E. & Cox, E.J. (2004): Taxonomy and ecology of some new *Gomphonema* species common in Himalayan streams. – Diatom Research 19: 235–264. https://doi.org/10.1080/0269249X.2004.9705873

Jüttner, I.; Rothfritz, H. & Ormerod, S.J. (1996): Diatoms as indicators of river quality in the Nepalese Middle Hills with consideration of the effects of habitat specific sampling. – Freshwater Biology 36: 475–486. https://doi.org/10.1046/j.1365–2427.1996.00101.x

Jüttner, I.; Chimonides, J. & Cox, E.J. (2011): Morphology, ecology and biogeography of diatom species related to *Achnathidium pyrenaicum* (Hustedt) Kobayasi (Bacillariophyceae) in streams of the Indian and Nepalese Himalaya. – Algological Studies 136/137: 45–76. https://doi.org/10.1127/1864–1318/2011/0136–0045

Jüttner, I.; Kociolek, J.P.; Gurung, S.; Gurung, A.; Sharma, C.M.; Levkov, Z.; Williams, D.M. & Ector, L. (2018): The genus *Gomphonema* (Bacillariophyta) in Rara lake, Nepal: taxonomy, morphology, habitat distribution, and description of five new species, and a new record for *Gomphoneis qii*. – Diatom Research 33: 283–320. https://doi.org/10.1080/0269249X.2018.1528182

Jüttner, I.; Krammer, K.; Van de Vijver, B.; Tuji, A.; Simkhada, B.; Gurung, S.; Sharma, S.; Sharma, C. & Cox, E.J. (2010a): *Oricymba* (Cymbellales, Bacillariophyceae), a new cymbelloid genus and three new species from the Nepalese Himalaya. – Phycologia 49: 407–423. https://doi.org/10.2216/09–77.1

Jüttner, I.; Gurung, S.; Sharma, C.; Sharma, S.; De Haan, M. & Van de Vijver, B. (2010b): Morphology of new taxa in the *Cymbella aspera* and *Cymbella neocistula* groups, *Cymbella yakii* sp. nov. and *Cymbella cf. hantzschiana* from Everest National Park, Nepal. – Polish Botanical Journal 55: 73–92.

Jüttner, I.; Sharma, S.; Dahal, B.M.; Ormerod, S.J.; Chimonides, P.J. & Cox, E.J. (2003): Diatoms as indicators of stream quality in the Kathmandu Valley and Middle Hills of Nepal and India. – Freshwater Biology 48: 2065–2084. https://doi.org/10.1046/j.1365–2427.2003.01138.x

Karthick, B.; Kociolek, J.P.; Mahesh, M.K. & Ramachandra, T.V. (2011): The diatom genus *Gomphonema* Ehrenberg in India: Checklist and description of three new species. – Nova Hedwigia 93: 211–236. https://doi.org/10.1127/0029–5035/2011/0093–0211

Karthick, B.; Nautiyal, R.; Kociolek, J.P. & Ramachandra, T.V. (2015): Two new species of Gomphonema (Bacillariophyceae) from Doon Valley, Uttarakhand, India. – Nova Hedwigia Beiheft, 144: 165–174.

Kociolek, J.P. (1992): Valve ultrastructure and systematic position of *Gomphonema kaznakowi* Mereschkowsky. – Diatom Research 7: 259–265. https://doi.org/10.1080/0269249X.1992.9705218

Kociolek, J.P. (2019): A worldwide listing and biogeography of freshwater diatom genera: a phylogenetic perspective. – Diatom Research 33: 509–534. https://doi.org/10.1080/0269249X.2019.1574243

Kociolek, J.P. & Stoermer, E.F. (1988): Taxonomy, ultrastructure and distribution of *Gomphoneis herculeana*, *G. eriense*, and closely related species. – Proceedings of the Academy of Natural Sciences of Philadelphia 140: 24–97.

Kociolek, J.P.; Karthick, B.; Blanco, S.; Coste, M. et al. (2020): *Diatombase*. Accessed at http://www.diatombase.org, on 2020–02–24.

Krstić, S.S.; Pavlov, A.; Levkov, Z. & Jüttner, I. (2013): New *Eunotia* taxa in core samples from Lake Panch Pokhari in the Nepalese Himalaya. – Diatom Research 28: 203–217. https://doi.org/10.1080/0269249X.2013.782343

Kulikovskiy, M.S.; Chudaev, D.; Glushchenko, A.; Kuznetsova, I.; Krivova, Z. & Kociolek, J.P. (2020): *Navicula gogorevii* – a new large–celled diatom species from Vietnam (Southeast Asia). – Phytotaxa 428: 60–66. http://dx.doi.org/10.11646/phytotaxa.428.1.6

Kulikovskiy, M.S.; Kociolek, J.P.; Solak, C.N. & Kuznetsova, I. (2015): The diatom genus *Gomphonema* Ehrenberg in Lake Baikal. II. Revision of taxa from *Gomphonema acuminatum* and *Gomphonema truncatum–capitatum* complexes. – Phytotaxa 233: 251–272. http://dx.doi.org/10.11646/phytotaxa.233.3.3

Li, Y.; Williams, D.M.; Metzeltin, D.; Kociolek, J.P. & Gong, Z. (2010a): *Tibetiella pulchra* gen. nov. et sp. nov., a new freshwater epilithic diatom (Bacillariophyta) from river Nujiang in Tibet, China. – Journal of Phycology 46: 325–330. https://doi.org/10.1111/j.1529–8817.2009.00776.x

Li, Y.L.; Kociolek, J.P. & Metzeltin, D. (2010b): *Gomphonema sichuanensis* Li & Kociolek sp. nov. and *Gomphonema heilongtanensis* Li, Kociolek & Metzeltin sp. nov. from two high mountain lakes, China. – Diatom Research 25: 87–98. https://doi.org/10.1080/0269249X.2010.9705831

Liao, M.N. & Li, Y.L. (2018): One new *Gomphonema* Ehrenberg (Bacillariophyta) species from a high mountain lake in Yunnan Province, China. – Phytotaxa 361: 123–130. http://dx.doi.org/10.11646/phytotaxa.361.1.11

Liu, Q.; Li, J.; Nan, F.; Feng, J.; Lv, J.; Xie, S. & Kociolek, J.P. (2019): New and interesting diatoms from Tibet: I. Description of a new species of *Clipeoparvus* Woodbridge et al. – Diatom Research 34: 33–38. https://doi.org/10.1080/0269249X.2019.1578697

Mayer, A. (1917): Beiträge zur Diatomeenflora Bayerns. Part III, A. Bacillariales aus einem Weiher bei Kondrau, B. Regensburger Bacillarien. – Denkschriften der Koniglich–Baierischen Botanischen Gesellschaft in Regensburg 13: 127–151.

Mayer, A. (1919): Bacillariales von Reichenhall und Umgebung. – Kryptogamische Forschungen herausgegeben von der Kryptogamenkommission der Bayerischen Botanischen Gesellschaft zur Erforschung der heimischen Flora 1: 191–216.

Mereschkowsky, C. (1906): Diatomovyia vodorosil Tibeta. – Trudy ékspeditsii Imperatorskago russkago geograficheskago obshcheskago obshchestva, sovershennoï v 1899–1901 gg. pod rukovodstvom P.K. Kozlova. Izdanïe Imperatorskago russkago geograficheskago obshchest 8: 1–39.

Mitić–Kopanja, D.; Wetzel, C.E.; Ector, L. & Levkov, Z. (2014):

*Fottea, Olomouc, 20(2): 128–136, 2020*
*DOI: 10.5507/fot.2020.003*

Two new *Gomphonema* Ehrenberg (Bacillariophyceae) species from Macedonia and comparison with type material of *G. brebissonii* Kützing. – Fottea 14: 149–160. https://doi.org/10.5507/fot.2014.012

Moser, G.; Lange–Bertalot, H. & Metzeltin, D. (1998): Insel der Endemiten. Geobotanisches. Phänomen Neukaledonien. – Bibliotheca Diatomologica 38, J. Cramer, Berlin.

Myers, N.; Mittermeier, R.A.; Mittermeier, C.G.; Da Fonseca, G.A. & Kent, J. (2000): Biodiversity hotspots for conservation priorities. – Nature 403: 853–858. https://doi.org/10.1038/35002501

Ormerod, S.J.; Rundle, S.D.; Wilkinson, S.M.; Daly, G.P.; Dale, K.M. & Jüttner, I. (1994): Altitudinal trends in the diatoms, bryophytes, macroinvertebrates and fish of a Nepalese river system. – Freshwater Biology 32: 309–322. https://doi.org/10.1111/j.1365–2427.1994.tb01128.x

Panigrahy, S; Patel, J.G. & Parihar, J.S. (Eds.) (2012): National Wetland Atlas: High altitude lakes of India – 108 pp., Space Applications Centre, ISRO, Ahmedabad, India.

Reichardt, E. (1999): Zur Revision der Gattung *Gomphonema*. Die Arten um *G. affine*/*insigne*, *G. angustatum*/*micropus*, *G. acuminatum* sowie gomphonemoide Diatomeen aus dem Oberoligozän in Böhmen. – In: Lange–Bertalot, H. (ed.): Iconographia Diatomologica. Annotated diatom monographs, Vol. 8. Taxonomy. – 203 pp., A.R.G. Gantner, Ruggell, Liechtenstein.

Reichardt, E. (2009): New and recently described *Gomphonema* species (Bacillariophyceae) from Siberia. – Fottea 9: 289–297. https://doi.org/10.5507/fot.2009.028

Round, F.E.; Crawford, R.M. & Mann, D.G. (1990): The Diatoms. Biology and morphology of the Genera. – 747 pp., Cambridge University Press, Cambridge.

Roy, S.; Liu, Y.; Kociolek, J.P.; Lowe, R.L. & Karthick, B. (2019): *Kulikovskiyia* gen. nov. (Bacillariophyceae) from the lateritic rock pools of the Western Ghats, India and from Hainan Province, China. – Phycological Research. https://doi.org/10.1111/pre.12400

Sharma, C.M.; Sharma, S.; Bajracharya, R.M.; Gurung, S.; Jüttner, I.; Kang, S.; Zhang, Q. & Li, Q. (2012): First results on bathymetry and limnology of high altitude lakes in the Gokyo Valley, Sagarmatha (Everest) National Park, Nepal. – Limnology 13: 181–192. https://doi.org/10.1007/s10201–011–0366–0

Simkhada, B. & Jüttner, I. (2006): Diatoms in ponds and small lakes of the Kathmandu Valley, Nepal – relationships with chemical and habitat characteristics. – Archiv für Hydrobiologie 166: 41–65. https://doi.org/10.1127/0003–9136/2006/0166–0041

Simkhada, B.; Jüttner, I. & Chimonides, P.J. (2006): Diatoms in lowland ponds of Koshi Tappu, Eastern Nepal – relationships with chemical and habitat characteristics. – International Review of Hydrobiology 91: 574–593. https://doi.org/10.1002/iroh.200610852

Thacker, M.; Roy, S.; Kociolek, J.P.; Lowe, R.L. & Karthick, B. (2019): A new species of *Germainiella* (Bacillariophyta) from the *Myristica* swamps of the Western Ghats, India. – Diatom Research 34: 181–191. https://doi.org/10.1080/0269249X.2019.1671236

Van de Vijver, B.; Jüttner, I.; Gurung, S.; Sharma, C.; Sharma, S.; De Haan, M. & Cox, E.J. (2011): The genus *Cymbopleura* (Cymbellales, Bacillariophyta) from high altitude freshwater habitats, Everest National Park, Nepal, with the description of two new species. – Fottea 11: 245–269. https://doi.org/10.5507/fot.2011.025

Wadmare, N.; Roy, S.; Kociolek, J.P. & Karthick, B. (2019): Two new aerophilic species of *Stauroneis* Ehrenberg (Bacillariophyta) from the Eastern Himalayas. – Botany Letters 166: 234–245. https://doi.org/10.1080/23818107.2019.1602786


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