

Pennate diatoms *Gomphonema* Ehrenberg from the Vindhya (Central Highland) and the Himalaya

Jyoti Verma and Prakash Nautiyal*

Department of Zoology, University of Allahabad, Allahabad-211001, India
*Department of Zoology, H.N.B. Garhwal University, Srinagar, 246174, Uttarakhand, India
E-mail address; diatombuster@gmail.com, lotic.biodiversity@gmail.com

Abstract

This paper presents the results of a floristic study focusing on the taxa representing the genus *Gomphonema* Ehrenberg in Vindhya and Himalayan Rivers of Indian subcontinent. The morphological and ecological characteristics of this taxon are little known in spite of the fact that it is generally considered to be widely distributed. In the present study, 19 diatom taxa belonging to the genus *Gomphonema* were identified. In the flora 15 species were recorded from the Vindhya region while 10 from the Himalaya. All of them were first records for the Vindhya. Five taxa were new records from the Himalayan region.

Key words: *Gomphonema*/Pennate/Diatom/Himalaya/Vindhya/India.

Introduction

Species of *Gomphonema* Ehrenberg are important components of the freshwater biota. *Gomphonema* are very frequently observed diatom taxa in the material in Indian Rivers (Sarode and Kamat, 1984; Gandhi 1999; Karthick *et al.*, 2011; 2015; Nautiyal *et al.*, 2004 a and b). According to Round *et al.* (1990), diatom taxa belonging to the genus *Gomphonema* Ehr. are characterized as follows; linear lanceolate heteropolar valves; wedge shaped girdle view, uniseriate (occasionally bisiratae) striae; pore fields present at the foot pole, straight raphae sternum; straight or slightly sinuous raphae fissures, unequal in length and usually one to a few stigma. Species belonging to *Gomphonema* Ehr. are relatively common to fresh water diatom communities. They often form branched mucilaginous stalks attached to solid substrata (Wojtal 2003).

The diatom genus *Gomphonema* in India has been documented for over 160 years. Until recently, there have been relatively few studies on the freshwater diatoms of the Asian continent. Classical works include those of Hustedt (1922) and Skvortzow (1930) as well as Meister (1932), Hirano (1967), Amossé (1969) and Gandhi (1999). More recent studies have been floristic in nature, compiling the distribution of known taxa that were mostly described from Europe (Zhu and Chen, 2000; Shi, 2004). Only recently, attempts were made to better characterize the diatom flora with the description of several new taxa, both at the genus and species levels (Metzeltin *et al.*, 2009; Li *et al.*, 2010). One group of diatoms from this region that has received significant attention is the genus *Gomphonema* Ehrenberg, resulting in the description of several new species from Nepal (Jüttner *et al.*, 2004), Russia (Lange-Bertalot and Genkal, 1999; Kulikovskiy *et al.*, 2012), China (Fan *et al.*, 2004; Li *et al.*, 2006, 2010; You *et al.*, 2013) and India (Karthick *et al.*, 2011; 2015). Many of the species described from the Himalayan region have a similar morphology suggesting that they may be closely related (e.g. Karthick *et al.*, 2011).

In the present report we have compiled a checklist of the genus *Gomphonema* previously reported and described from the Yamuna drainage in the Himalaya and Central Highlands, Vindhya rivers in particular, and some other locations on the Bhagirathi, Alaknanda and Ganga rivers and their tributaries.

Materials & Methods

The Vindhya rivers selected for the study were located between 23°30' to 26°N, 78°30' to 82°30'E while in the west Himalaya between 29°31' to 31°20'N latitude, 77°33' to 80°6'E longitude. The Vindhya rivers Ken, Paisuni and Tons flow north from low north of Narmada, around Tropic of Cancer to high latitude along southern fringe of the Indo-Gangetic Plains. The Ken and Tons were relatively larger drainage 300 to 350 km compared to the Paisuni 100 km having an average gradient of 0.91 m km⁻¹, 2.0 m km⁻¹ and 1.02 m km⁻¹, respectively. The land is primarily used for agriculture along the banks of the Ken and the Tons River. Patches of forest *Shorea robusta* occur in case of the Ken River. In case of the Paisuni river the headwaters is covered by forest and only lower stretch of the river is used for agriculture. Except for the mouth zone these rivers vary topographically.

The Himalaya streams Dharasu and Nagni Gad and rivers Supin-Tons, Yamuna, Bhagirathi and Alaknanda flow in southerly direction. The latter two are the parent Mountain Rivers forming the Ganga R. The Dharasu and

Nagni Gad are right bank tributaries of the Bhagirathi ca. 40 km upstream of Tehri and Ganga downstream of Devprayag. The Supin, a parent tributary of the Tons which along with the Giri R. forms the western limit of the Yamuna watershed and thus the Gangetic drainage. There was relatively more forest cover *Cedrus deodara*, *Quercus* spp. in the Yamuna system and Nagni Gad, than the Bhagirathi and Alaknanda Pine on hill tops where most of the slopes below 1100 -1500 m asl have scrub. The gradient ranges from 15 to 2.0 m km⁻¹.

Sampling: Diatom collections were obtained from 20 stations, 11 stations on 3 rivers in the Vindhya region and 9 stations on 3 rivers and 2 streams in the Himalaya. The samples were replicated at each station. Diatom samples were collected by scraping the cobble surface with a brush. The scrapings were transferred to storage vials and preserved in 4% formalin for further processing. The formalin preserved samples were first cleaned with double distilled water to remove traces of formaldehyde. Samples were given Hydrochloric acid- peroxide treatment, washed repeatedly and mounted in Naphrax. Two slides were prepared for each sample. Each slide was examined under bright field in a BX-40 Trinocular Olympus microscope with x100 oil immersion objective to identify the species. Images were obtained by NIKON Digital Imaging System and processed with ADOBE PHOTOSHOP software to prepare photographic plates of the flora at x1500. Identifications were made according to standard literature. The permanent mounts have been adequately stored at the Aquatic Biodiversity Unit, Department of Zoology, H. N. B. Garhwal University, Srinagar, Uttarakhand, India.

Results:

1. *Gomphonema angustum* Agardh 1831 (Figs. 164: 1-16). L 28-75, W 5-10, S 8-10, Linear-lanceolate, valves narrow, linear, club shaped, head pole bluntly wedge-shaped or bluntly rounded, central area relatively broad, extending on one side to the valve broader, one isolated stigma, separate from the middle point, axial and central area relatively wide (Plate 1, Figs. 1-2).
2. *G. angustatum* (Kützing) Rabenhorst 1864 (Figs. 155: 1-21). L 19-25, W 6-8, S 8-13, Lanceolate, apical pore slightly rostrate, axial area narrow, linear, central area small, elliptical, with unilateral isolated punctum, striae radiate (Plate 1, Fig. 3).
3. *G. augur* var. *sphaerophorum* (Ehrenberg) Grunow 1878 (Figs. 157: 9). L 42-50, W 10-12, S 12-13, Elliptical-club shaped, capitately rounded foot pole end strongly capitately rounded constricted head pole, axial area slender, linear, central area small (Plate 1, Fig. 4).
4. *G. brasiliense* var. *pacificum* Metzeltin and Lange-Bertalot. L 17-20, W 3.5-4.5, S 12-13, Lanceolate-club shaped, bluntly and sharply rounded apices, central area distinct, striae not reaching to centre (Plate 1, Fig. 5).
5. *G. clevei* Fricke 1902 (Figs. 164: 20, 21). L 23-33, W 5-5.5, S 12-13, Linear, club shaped, transapical striae short, standing on margins (Plate 1, Fig. 6).
6. *G. augur* var. *turris* (Ehr.) Lange- Bertalot, Hustedt 1937-1938, p. 439, pl. 28, Figs. 14-16. L 45-60, W 10-12, S 11-12, Linear-lanceolate, head end drawn out and rostrate with the widest breadth at the middle of the valve or just the tip of the valve suddenly narrows to a wedge shape, one isolated punctum present (Plate 1, Fig. 7).
7. *G. gracile* Ehrenberg 1838 (Figs. 156 1-11, Figs. 154 26, 27). L 25-70, W 4-11, S 9-17, Lanceolate-clavate, valves, strongly narrowed from the middle toward the ends and sharply rounded at the ends, often almost symmetrical to the transapical plane, axial area slender, linear, central area small, somewhat transversely widened, with an isolated stigma on one side. Transapical striae radial, indistinctly punctate (Plate 1, Fig. 8).
8. *G. gracile* var. *lanceolatum* Kützing, Schmidt 1902, Tafel. 237, Figs. 9-10. L 130, W 15, S 12, Lanceolate-clavate valves, strongly narrowed from the middle toward the ends and sharply rounded at the ends, axial area slender, linear, central area small, somewhat transversely widened, with an isolated stigma on one side. Transapical striae radial, distinctly punctate (Plate 1, Fig. 9).
9. *G. lagenula* Kützing Metzeltin et al. 2005, p. 145, Figs. 12-18. L 25-35, W 6-7.5, S 15-16, Clavate- lanceolate, valves with strongly drawn out, usually capitate apices, isolated stigma present, transapical striae dense, close to each other (Plate 1, Fig. 10).
10. *G. lanceolatum* Ehrenberg Schmidt 1902, Tafel. 237, Figs. 1-8. L 27-70, W 7-10, Clavate- lanceolate, valves with broad, bluntly rounded head pole and somewhat narrower foot pole, axial area moderately wide, sharply delimited, central area small, usually only unilateral, extending to on half-striae length, with isolated stigma, transapical striae robust, slightly radial, 12-13 in 10 µm coarsely punctate (Plate 1, Fig. 11).
11. *G. minutum* (Agardh) Agardh 1831 (Figs. 159: 5-10). L 14-20, W 4-6, S 10-13, Lanceolate, smaller forms, puncta in the striae practically indistinguishable, only one separate point for each striae at the valve mantle in girdle view (Plate 1, Fig. 12).

12. *G. parvulum* (Kützing) Kützing 1849 (Figs. 154: 1-25). L 15-30, W 4-7, S 14-16, Clavate-lanceolate, valves usually more or less oval-lanceolate, central area barely distinct, median density of the striae, valves with short drawn out ends, axial area very slender, central area unilateral, narrow, with an isolated punctum on the opposite side. Transapical striae radial, indistinctly punctate (Plate 1, Fig. 13).
13. *G. parvulum* var. *micropus* (Kützing) Cleve, Schmidt 1902, Tafel. 234, Figs. 16-17. L 10-14, W 3.5-4.4, S 11-14, Clavate - lanceolate, valve clavate-lanceolate with slightly constricted, produced, acutely rounded apex, axial area linear-lanceolate, central area broad, unilateral with an isolated puncta on opposite side (Plate 1, Fig. 14).
14. *G. parvulum* var. *subelliptica* Cleve, Hustedt 1985 (Figs. 713 b). L 12-14, W 4-5, S 13-15, Clavate-lanceolate, valves almost symmetrical-elliptical, barely drawn out at the apices, usually includes shorter forms, barely separable from var. *micropus* (Plate 1, Fig. 15).
15. *G. pumilum* var. *rigidum* Reichardt and Lange-Bertalot Metzeltin et al. 2005, p. 145, Figs. 37-44. L 12-20, W 3-4, S 8-9, Linear-elliptical, ends rounded, homopolar valves, one isolated punctum present, central area distinct, rectangular in shape (Plate 1, Figs. 16-17).
16. *G. sp. cf. apicatum* Ehr., Metzeltin et al. 2005, p. 138, Figs. 11-14. L 62, W 14, S 10, Linear-lanceolate, isolated punctum present, foot pole strongly narrowed, central area present due to shorting of the middle striae (Plate 1, Fig. 18).
17. *G. affine* Kützing var. *affine* Lange-Bertalot 1999, Figs. 7:1-9 p. 13-14, p. 138, Figs. 11-14. L 34, W 10, S 9, Linear-lanceolate, isolated punctum present, central area present due to shorting of the middle striae, striae punctate (Plate 1, Fig. 19).
18. *G. truncatum* Ehrenberg 1832 (Figs. 159: 11-18). L 28-35, W 13-15, S 10-12, Lanceolate, head end broadly rounded, constricted head end larger, middle striae alternately short and long (Plate 11, Fig. 20).
19. *Gomphonema* sp. 1. L 43, W 10, S 9-10, Linear-lanceolate, both of the ends of the valves narrowly rounded, axial area narrow, central area small, one isolated punctum, transapical striae radial, indistinctly punctate (Plate 1, Fig. 21).

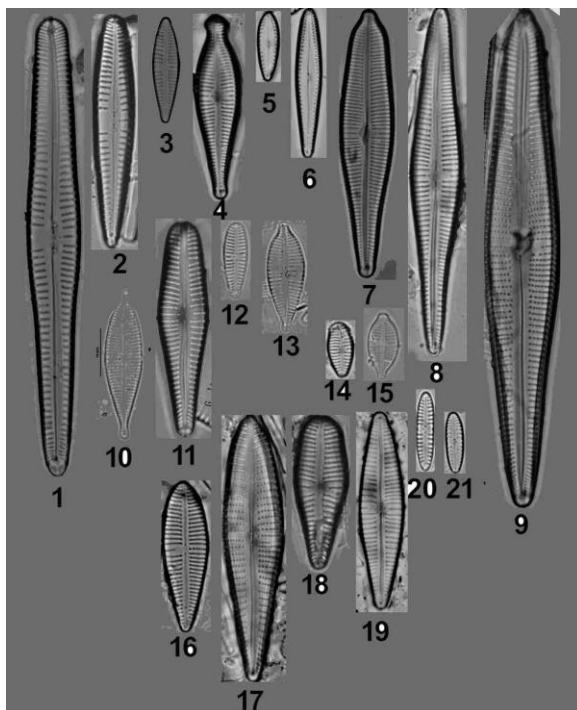


Plate 1. *Gomphonema*

Discussion

Nineteen diatom taxa belonging to the genus *Gomphonema* were recorded. Of these 15 taxa occurred in the Vindhya and 10 in the Himalaya. Five taxa; *Gomphonema brasiliense* var. *pacificum*, *G. clevei*, *G. lagenula*, *G. minutum*, *G. pumilum* var. *rigidum* were new records from the Himalayan region. Thirty three diatom taxa are known

from 46 six sites in the Himalaya (Nautiyal *et al.*, 2004 a and b). Now, the Himalayan region harbours 38 *Gomphonema* taxa 5 present + 33 earlier from 55 sites. The Vindhya region seems to be richer in *Gomphonema* as 15 taxa were obtained from 11 sites.

Taxonomic investigations on the diatom flora of India are still very limited especially in the central and northern Highlands of India (Nautiyal *et al.*, 2004 a and b; Jüttner *et al.*, 2004; Verma 2011; Karthick *et al.*, 2015). The establishment of a diatom database would be an essential contribution to the conservation of India's aquatic biodiversity. There are species that occur in single habitats, others limited to particular regions or restricted to either the Northern or Southern Hemisphere (Kociolek *et al.*, 2004). These current results underscore the pressing need to continue research into diatom taxonomy and ecology in least explored geographical zone on earth.

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