

Freshwater Diatoms from Himalayan State Himachal Pradesh, India

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Abstract

Thirty one taxa of freshwater diatoms have been reported from the districts Mandi, Una, Hamirpur, Solan, Shimla, and Bilaspur of the state Himachal Pradesh. These taxa belong to genera *Cymbella* Agardh (4 spp. 1 var.), *Encyonema* Kützing (1 sp.), *Gomphonema* Ehrenberg (9 spp., 7 var. 2 forma), *Didymosphenia* M. Schmidt (1 sp.), *Pleurosigma* (Smith) Cleve (1 sp.), *Gyrosigma* Hassall (2 spp.), and, *Navicula* Bory (2 spp.). Out of these, *Encyonema subalpinum* (Hustedt) D. G. Mann and *Gomphonema towutense* Hustedt are the new records to the diatom flora of India.

Key words: New records/Diatoms/ Freshwater/ Himachal Pradesh/ India.

Introduction

Diatoms are the microscopic algae of wide distribution and their well-preserved glass-like walls make them ideal tools for a wide range of applications as both fossils and living organisms. They are used as environmental indicators in oil exploration and forensic examination. Currently major emphasis is on their use on analyzing ecological problems such as climate change, acidification and eutrophication (Round *et al.*, 1990, Stoermer and Smol 1999) Very little information is available on freshwater diatom flora of the ecologically sensitive Western Himalayan region. The countries that fall in Himalayan region are India (major part), China, Pakistan, Nepal and Bhutan. The Western Himalayan region that encompasses the States of Jammu and Kashmir and Himachal Pradesh is the source of rivers like Indus, Satluj, Ravi, Chenab, Byas, Ganges and Yamuna and many seasonal rivulets that form very important watershed areas for the India, China, Pakistan and Nepal.

Freshwater diatom studies have been done by Hustedt (1930, 1938, 1942) from Germany, Hendy (1964) from Britain, Patrick and Reimer (1966) from U.S.A., Khromov *et al.* (2002) and Lange-Bertalot *et al.* (2002) from Russia, Lee *et al.* (1997) from Korea, Cho and Kyung-Je (2001) from North Korea, Skvortzow (1935), Li *et al.* (1999) and Li *et al.* (2002, 2003a, b) from China, Rai (2006) from Nepal and Syed *et al.*, (2006) from Pakistan. From India, work on freshwater diatoms have been carried out by mainly by Gandhi (1955, 1956, 1958, 1959, 1960, 1970, 1999) from Central and West India, Suxena and Venkateswarlu (1970) from Uttarakhand, Prasad *et al.* (1984) from Ladakh, Nautiyal and Nautiyal (2002) from Ganga River Uttarakhand, Nautiyal *et al.* (2004) from the Himalaya of the state Uttarakhand, Nautiyal *et al.* (1996a, b) from the Alaknanda and Ganga River system in Himalayan stretch of Garhwal region. Kamat and Aggrawal (1975), Juettner and Cox (2001), Misra and Shukla (2006), Misra *et al.* (2005), Misra *et al.* (2007) have studied the diatom flora of the Kumaon region of Western Himalaya from the state Uttarakhand. Srivastava and Gupta (2004) have studied the diatom flora of the Pong dam wetland and Seth *et al.* (2005) have given the checklist of the algal flora of the Himachal Pradesh. So far, no work has been done on the diatom flora of the Indo-Western Himalayan region.

Materials and Method

Random sampling technique has been applied in the algal collection procedure. Samples were collected between Nov. 2003-Nov 2007 from the districts Una, Hamirpur, and Mandi of the state Himachal Pradesh. The planktonic forms were collected with the help of planktonic mesh net (pore size- 10 μ) while epiphytic forms were collected by squeezing the submerged plants. The algal samples were preserved in 3-4% Formalin solution and slides were prepared as per procedure of the Patrick and Reimer (1966) and mounted in DPX (Destyrene Pthalate Xylo). Detailed studies were made by examining specimens under the Nikon Labophot microscope E-400 with H-II photomicrographic attachment. All the measurements given in the plate are equal to the 10 μ .

Results and Discussion

The species identification has been done after Tiffany and Britton (1952), Prasad and Srivastava (1992), Hustedt (1942), Round *et al.* (1990).

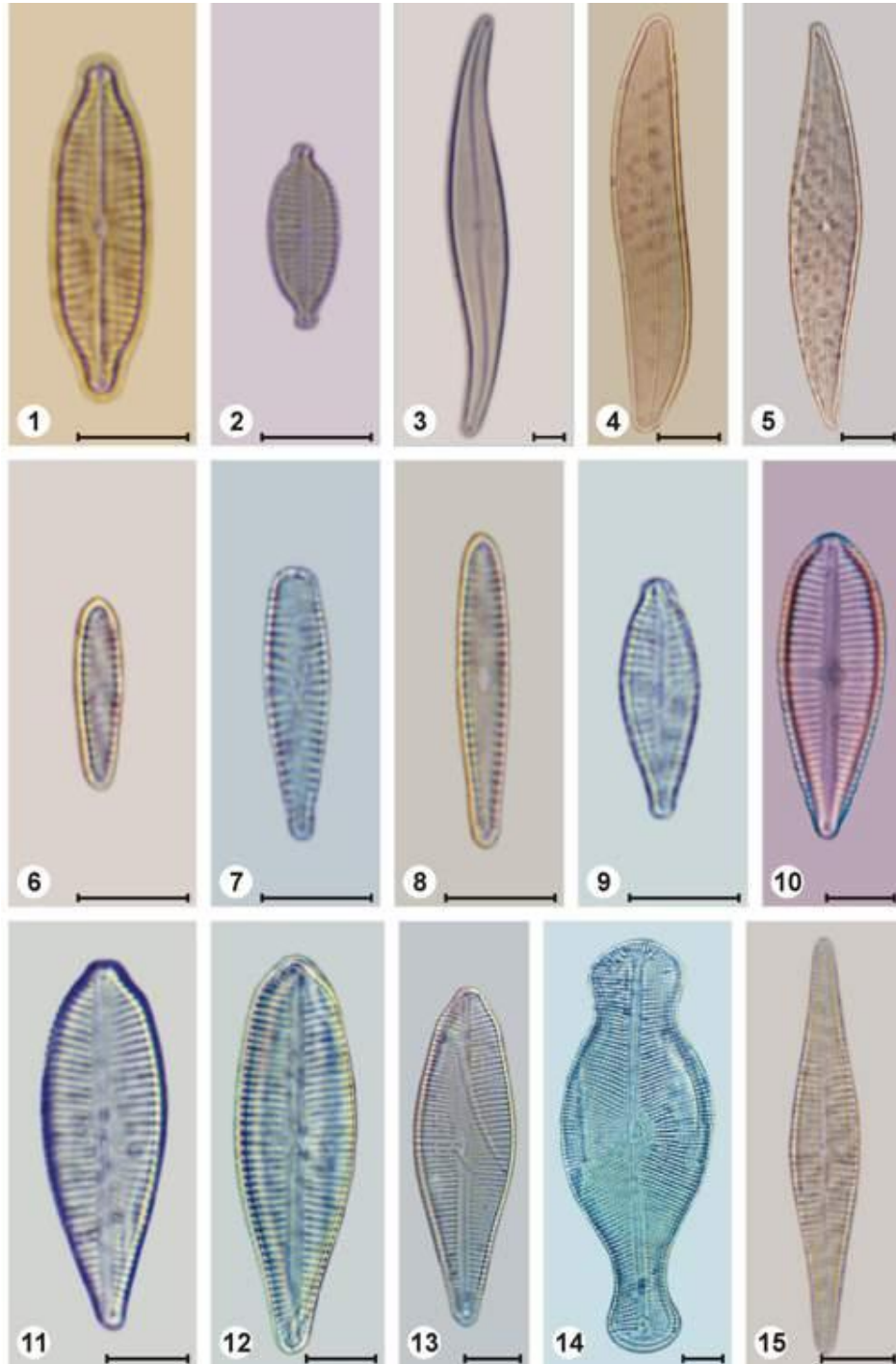


Plate – I. Legend. 1. *Gomphonema montanum* Schumann var. *subclavatum* Grunow. 2. *G. lanceolatum* Ehrenberg. 3. *G. constrictum* (Ehr.) var. *capitatum* (Ehr.) Grunow f. *turgidum* (Ehr.) Mayer. 4. *G. constrictum* (Ehr.) var. *capitatum* (Ehr.) Grunow. 5. *G. olivaceum* (Lyngbye) Kuetz. var. *calcareum* Cleve. 6. *G. clevei* Fricke. 7. *G. subtile* Ehr. var. *malayensis* Hustedt. 8. *G. sphaeroporum* Ehrenberg. 9. *G. acuminatum* var. *coronatum* (Ehr.) Rabenhorst. 10. *Cymbella tumida* (Breb.) Heurck. 11. *C. affinis* Kuetzing. 12. *C. reinhardti* Grunow. 13. *C. cymbiformis* (Kutz.) Heurck var. *unipuncta* Cleve. 14. *Encyonema subalpinum* (Hustedt) D. G. Mann. 15. *C. rupicola* Grunow

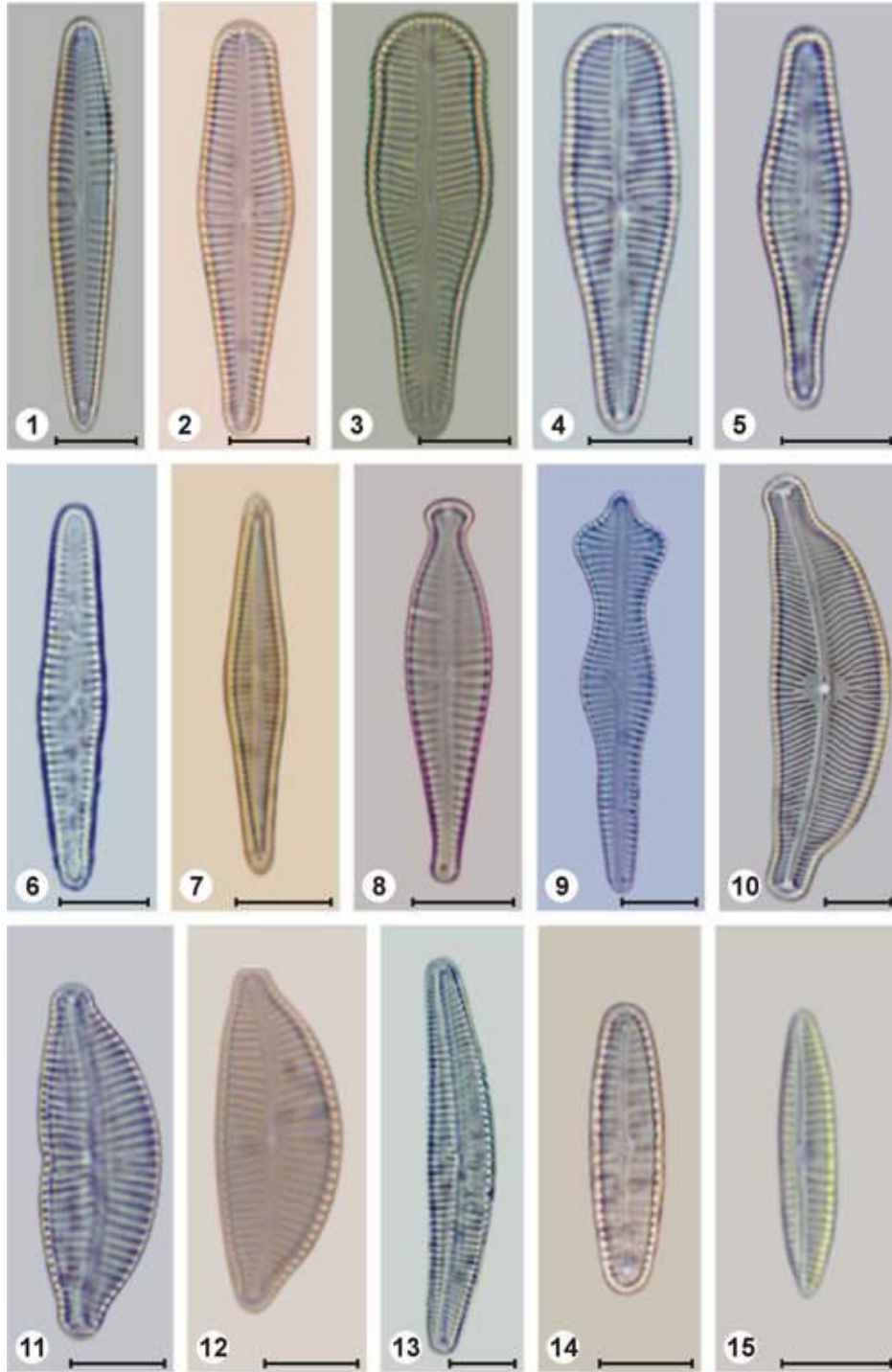


Plate – 2. Legend. 1. *Navicula exigua* (Gregory) Mueller. 2. *N. accomodata* Hustedt. 3. *Gyrosigma kuetzingii* (Grun.) Cleve. 4. *G. scalproides* (Rabenhorst) Cleve. 5. *Pleurosigma chandolensis* Gandhi. 6. *Gomphonema tenellum* Kuetzing. 7. *G. olivaceum* (Lyngbye) Kuetzing. 8. *G. towutense* Hustedt. 9. *G. parvulum* (Kuetz.) Grunow. 10. *G. lanceolatum* f. *turris* (Ehr.) Hustedt. 11. *G. lacus-rankala* Gandhi var. *chandolensis* Gandhi. 12. *G. subcapitatum* Fritsch & Rich. 13. *G. lacus-rankala* Gandhi. 14. *Didymosphenia geminata* (Lyngbye) M. Schmidt. 15. *G. gracile* Ehr. var. *dichotomum* (Kuetzing) Grunow

1. *Cymbella affinis* Kuetzing (Pl. 1, fig. 11)

Prasad, B.N. & Srivastava, M.N. (1992) (Pl. 34, fig. 5, Pg. 266)

Valves asymmetrical, semi-elliptical having dorsal margin convex, ventral margin slightly convex with constricted, very slightly produced rostrate ends; raphe thick, excentric curved with distinct central nodules, terminal fissures dorsally bent; axial area narrow, linear gradually widening towards centre; central area elliptical with a distinct puncta on the ventral side; striae coarse, radiate throughout the valve. Valves 38 µm long, 13 µm broad, Striae 10 in 10 µm.

Collection Number & Date: HP/SIR/4d, 21/6/2005

Locality: Giri River, Dadahu, Sirmaur

2. *C. cymbiformis* (Kuetz.) Heurck var. *unipuncta* Cleve (Pl. 1, fig. 13)

Gandhi (1956), (Fig. 17, Pg. 204)

Valves sickle-shaped more inflated in the middle on the ventral side with broadly rounded ends. Central area slightly enlarged with an isolated punctum on ventral side at the end of the central striae. Striae radial, strong and lineate. Raphe arcuate and thick. Valves 60 µm long, 10 µm broad, Striae 9 in 10 µm.

Collection Number & Date: HP/HAM/7c, 2/6/2005

Locality: River Gasoti Khad, Hamirpur.

3. *C. reinhardti* Grunow (Pl. 1, fig. 12)

Hustedt, F. (1938) (Pl. XXIV, fig. 28, Pg. 424)

Valves 45 µm long, 12 µm broad, Striae 9 in 10 µm.

Collection Number & Date: HP/MAN/2b, 19/5/2004

Locality: River Jarol Khad, Mandi

4. *C. rupicola* Grunow (Pl. 1, fig. 15)

Bock, W. (1970) (Pl. 3, fig. 51, Pg. 414)

Valves slightly asymmetrical, lanceolate with strongly convex dorsal and slightly convex ventral side; ends somewhat acute, constricted and produced. Raphe thin, very slightly excentric, arcuate with central pores ventrally bent. Axial area very narrow and slightly widened in the centre. Striae radial throughout, closely set at the ends and on the ventral side. Valves 26 µm long, 7 µm broad, Striae 12 in 10 µm.

Collection Number & Date: HP/MAN/7b, 21/5/2004

Locality: Gambar River, Mandi.

5. *C. tumida* (Breb.) Van Heurck (Pl. 1, fig. 10)

Hustedt, F. (1938) (Pl. XXVI, fig. 7)

Valves 63 µm long, 18 µm broad, Striae 9 in 10 µm.

Collection Number & Date: HP/MAN/7b, 21/5/2004

Locality: Gambar River, Mandi.

6. *Encyonema subalpinum* (Hustedt) D. G. Mann (Syn. *Cymbella subalpina* Hustedt 1942) (Pl. 1, fig. 14)

Round *et al.* (1990) (Pg. 667); Hustedt, F. (1942) (Fig. 182, Pg. 98)

Valves 30 µm long, 8 µm broad, Striae 8 in 10 µm.

Collection Number & Date: HP/SIR/4d, 21/6/2005

Locality: Giri River, Dadahu, Sirmaur.

7. *Gomphonema acuminatum* var. *coronatum* (Ehr.) Rabenhorst (Pl. 1, fig. 9)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 72, fig. 833, pg. 272)

Valves generally cuneate, with a broad flat apex medianly acutely topped and with a deep subapical constriction; central area large with an isolated dot; transverse striations somewhat radial. Valves 53 µm long, 13 µm broad, Striae 10 in 10 µm.

Collection Number & Date: HP/MAN/2b, 19/5/2004

Locality: Jarol Khad, Mandi.

8. *G. clevei* Fricke (Pl. 1, fig. 6)

Hustedt, F. (1938) (Tafel XXVII, Fig. 15-18, Pg. 441)

Valves 44 µm long, 8 µm broad, Striae 9 in 10 µm.

Collection Number & Date: HP/SIR/17b, 26/5/2004

Locality: Giri River, Yashwantnagar, Sirmaur.

9. *G. constrictum* (Ehr.) var. *capitatum* (Ehr.) Grunow (Pl. 1, fig. 4)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 72, fig. 840, Pg. 271)

Valves typically clavate, without transverse constriction, striations transverse, radial, evidently punctate, alternating long and short in the middle of the valves. Valves 39 µm long, 12 µm broad, Striae 11 in 10 µm.

Collection Number & Date: HP/SIR/4d, 21/6/2005

Locality: Giri River, Dadahu, Sirmaur.

10. *G. constrictum* (Ehr.) var. *capitatum* (Ehr.) Grunow f. *turgidum* (Ehr.) A. Mayer

(Pl. 1, fig. 3)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 72, fig. 841, Pg. 271)

Valves turgid. Valves 45 µm long, 13 µm broad, Striae 10 in 10 µm.

Collection Number & Date: HP/MAN/5b, 20/5/3004

Locality: Byas River, Mandi.

11. *G. gracile* Ehr. var. *dichotomum* (Kuetzing) Grunow (Pl. 2, fig. 15)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 72, fig. 848, Pg. 271)

Valves linear-clavate, expanded medianly, with broadly rounded apex and attenuated base; axial area wide; central area broad, one-sided, with isolated dot and median striations short, often lacking; transverse striations somewhat radial, evidently punctate. Valves 55µm long, 9 µm broad, Striae 11 in 10 µm.

Collection Number & Date: HP/SIR/4d, 21/6/2005

Locality: Giri River, Dadahu, Sirmaur.

12. *G. lacus-rankala* Gandhi (Pl. 2, fig. 13)

Gandhi (1999) (Pl. II, Fig. 47-50, Pg. 29)

Valves broadly lanceolate-clavate with constricted, broadly rostrate rounded apex and somewhat concave attenuated rounded base. Raphe thick with central portion unilaterally bent. Axial area narrowly lanceolate; central area slightly unilateral with a stigma in the opposite side. Valves 61 µm long, 19 µm broad, Striae 10 in 10 µm.

Collection Number & Date: HP/SIR/2d, 21/6/2005

Locality: Renuka Lake, Sirmaur.

13. *G. lacus-rankala* Gandhi var. *chandolensis* Gandhi (Pl. 2, fig. 11)

Gandhi (1999) (Pl. II, Fig. 51, Pg. 30)

Valves more broadly clavate-lanceolate with short but broadly rostrate-truncate apical end. Valves 45 µm long, 15 µm broad, Striae 10 in 10 µm.

Collection Number & Date: HP/HAM/7c, 2/6/2005

Locality: River Gasoti Khad, Hamirpur.

14. *G. lanceolatum* Ehr. f. *turris* (Ehr.) Hustedt (Pl. 2, fig. 10)

Hustedt, F. (1938) (Tafel 26, Fig. 8, Pg. 437)

Valves lanceolate-clavate with slightly constricted, broadly wedge-shaped apex and attenuated base. Raphe thin and straight. Axial area sublinear; central area quite large, unilaterally expanded with an isolated stigma on the opposite side. Striae clearly punctuate and radial. Valves 45 µm long, 16 µm broad, Striae 8 in 10 µm. Valves 45 µm long, 16 µm broad, Striae 8 in 10 µm.

Collection Number & Date: HP/UNA/4c, 1/6/2005

Locality: Swan River, Una.

15. *G. lanceolatum* Ehrenberg (Pl. 1, fig. 2)

Gandhi, H. P. (1958a) (Fig. 27, Pg. 501)

Valves lanceolate-clavate with distinctly rounded apex and base, base somewhat narrower. Raphe slightly thick and straight. Axial area narrow, linear; central area slightly unilateral with an isolated stigma on the opposite side. Striae radial and lineate.

Valves 52 µm long, 12 µm broad, Striae 10 in 10 µm.

Collection Number & Date: HP/MAN/2b, 19/5/2004

Locality: River Jarol Khad, Mandi.

16. *G. montanum* Schumann var. *subclavatum* Grunow (Pl. 1, fig. 1)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 73, fig. 851, Pg. 272)

Valves slightly clavate, poles rounded; axial area narrow; central area evident, sometimes one-sided, with isolated dot; transverse striations slightly radial. Valves 50 µm long, 9 µm broad, Striae 10 in 10 µm.

Collection Number & Date: HP/SIR/2d, 21/6/2005

Locality: Renuka Lake, Sirmaur.

17. *G. olivaceum* (Lyngbye) Kuetzing (Pl. 2, fig. 7)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 72, fig. 845, Pg. 270)

Valves ovoid-clavate, with broadly rounded apex and acutely rounded base; axial area narrow, linear; central area widened transversely without dots; raphe straight; transverse striations radial and indistinctly punctate. Valves 25 µm long, 6 µm broad, Striae 11 in 10 µm.

Collection Number & Date: HP/SIR/4d, 21/6/2005

Locality: Giri River, Dadahu, Sirmaur.

18. *G. olivaceum* (Lyngbye) Kuetz. var. *calcareum* Cleve (Pl. 1, fig. 5)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 72, fig. 846, Pg. 271)

Valves slender with evident median expansion, ovoid-clavate with broadly rounded apex and acutely rounded base; axial area narrow, linear; central area widened transversely; raphe straight; striations transverse, radial, indistinctly punctate.

Valves 34 µm long, 9 µm broad, Striae 12 in 10 µm.

Collection Number & Date: HP/SIR/4d, 21/6/2005

Locality: Giri River, Dadahu, Sirmaur.

19. *G. parvulum* (Kuetz.) Grunow (Pl. 2, fig. 9)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 72, fig. 838, Pg. 272)

Valves clavate-lanceolate, with shortly constricted poles; axial area very narrow; central area small, one-sided with isolated dot; transverse striations radial, indistinctly punctate.

Valves 22 µm long, 8 µm broad, Striae 13 in 10 µm.

Collection Number & Date: HP/SIR/4d, 21/6/2005

Locality: Giri River, Dadahu, Sirmaur.

20. *G. sphaeroporium* Ehrenberg (Pl. 1, fig. 8)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 72, fig. 847, Pg. 272)

Valves elliptic-clavate, sharply narrowing towards a rounded and slightly capitate basal poles and with a much wider knob-like apical pole; axial area narrow; linear; central area small, with a dot at the one side; striations transverse, more or less clearly punctate, slightly radial. Valves 39 µm long, 9 µm broad, striae 10 in 10 µm.

Collection Number & Date: HP/MAN/5b, 20/5/3004

Locality: Byas River, Mandi.

21. *G. subcapitatum* Fritsch & Rich (Pl. 2, fig. 12)

Gandhi (1999) (Pl. II, Fig. 57, Pg. 32)

Valves lanceolate-clavate, dilated in the middle, apex wedge-shaped, somewhat constricted and subapiculate, base narrowly rounded. Raphe thin and straight. Axial area narrow, linear; central area unilateral, fairly large with an isolated stigma on the opposite side. Striae radial, distinctly punctate and somewhat widely set in the middle. Valves 58 µm long, 18 µm broad, Striae 10 in 10 µm.

Collection Number & Date: HP/HAM/7c, 2/6/2005

Locality: River Gasoti Khad, Hamirpur.

22. *G. subtile* Ehr. var. *malayensis* Hustedt (Pl. 1, fig. 7)

Prasad, B.N. & Srivastava, M.N. (1992) (Pl. 33, fig. 14, Pg. 258)

Valves 40 µm long, 6 µm broad, Striae 16 in 10 µm.

Collection Number & Date: HP/UNA/4c, 1/6/2005

Locality: Swan River, Una.

23. *G. tenellum* Kuetzing (Pl. 2, fig. 6)

Gandhi (1999) (Pl. II, Fig. 78, Pg. 156)

Valves lanceolate-clavate, with broadly rounded ends. Raphe thin and straight. Axial area narrow, sublinear; central area fairly wide with a stigma on one side. Striae weakly radial.

Valves 18 µm long, 4 µm broad, Striae 12 in 10 µm.

Collection Number & Date: HP/SIR/17b, 26/5/2004

Locality: Giri River, Yashwantnagar, Sirmaur.

24. *G. towutense* Hustedt (Pl. 2, fig. 8)

Hustedt, F. (1942) (Fig. 243, Pg. 114)

Valves 29 µm long, 5 µm broad, Striae 12 in 10 µm.

Collection Number & Date: HP/MAN/14b , 25/5/2004

Locality: Satluj River, Tattapani, Mandi.

25. *Didymosphenia geminata* (Lyngbye) M. Schmidt (Pl. 2, fig. 14)

Round *et al.* (1990) (Fig. b, h, Pg. 496)

Valves robust, heteropolar, usually capitate at the poles. Valve face flat, sometimes with a marginal ridge at the junction with the mantles, which are deep; the ridges often end in spines at the head pole. Striae uniseriate, containing large poroids. Raphe central, straight. Raphe-sternum relatively narrow, pierced centrally by several stigmata. Valves 115 µm long, 40 µm broad, Striae 10 in 10 µm.

Collection Number & Date: HP/SIR/5d, 22/6/2005

Locality: Yamuna River, Ponta Sahib, Sirmaur.

26. *Pleurosigma chandolensis* Gandhi (Pl. 2, fig. 5)

Gandhi, H.P. (1999) (Pl III, Fig.92, Pg. 128)

Valves lanceolate sigmoid, in the middle slightly angular, ends acutely rounded, sometimes trifle rostrate. Raphe thin, sigmoid, in the middle central but at ends distinctly excentric. Valves 76µm long, 13 µm broad.

Collection Number & Date: HP/MAN/14b , 25/5/2004

Locality: Satluj River, Tattapani, Mandi.

27. *Gyrosigma kuetzingii* (Grun.) Cleve (Pl. 2, fig. 4)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 66, fig. 761, Pg. 269)

Valves sigmoid, lanceolate, tapering to narrowly rounded ends; transverse striations, radial in middle. Valve 110 µm long, 14 µm broad.

Collection Number & Date: HP/MAN/2b, 19/5/2004

Locality: River Jarol Khad, Mandi.

28. *G. scalproides* (Rabenhorst) Cleve (Pl. 2, fig. 4)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 66, fig. 762, Pg. 269)

Valves lanceolate, sigmoid gradually attenuated to rounded poles; transverse striations, usually perpendicular to the middle line, sometimes medianly radial. Valve 68 µm long, 11µm broad, striae 12 in 10 µm.

Collection Number & Date: HP/UNA/4c, 1/6/2005

Locality: Swan River, Una.

29. *Navicula accomodata* Hustedt (Pl. 2, fig. 2)

Hustedt, F. (1959) (Fig. 1208c, Pg.64)

Valve 17 µm long, 7 µm broad, striae 20 in 10 µm.

Collection Number & Date: HP/MAN/2b, 19/5/2004

Locality: River Jarol Khad, Mandi.

30. *N. exigua* (Gregory) Mueller (Pl. 2, fig. 1)

Tiffany, L.H. & Britton, M.E. (1952) (Pl. 67, fig. 770, Pg. 256)

Valve 30 µm long, 8 µm broad, Striae 12 in 10 µm.

Collection Number & Date: HP/UNA/4c, 1/6/2005

Locality: Swan River, Una.

In the present study 31 freshwater diatom taxa have been described from the different lotic and lentic water bodies from southern part of the state Himachal Pradesh, which is situated in the Indo-western Himalaya. Of these, *Encyonema subalpinum* (Hustedt) D. G. Mann and *Gomphonema towutense* Hustedt have been reported for the first time from the India while all the 31 taxa have been reported first time from the study area. A large part of the Indo-Western Himalaya is still unexplored regarding the algal floristic including the diatoms. The documentation of the diatom flora of the region, may act as the baseline data for the future studies and help the workers interested in algal taxonomy, geology, palaeoclimatology, palaeoclimatic reconstruction studies, and lacustrine ecology. According to Medvedeva (2001) algal taxonomy with diverse families is of great diagnostic value in floristic analysis as well as basic and applied aspect of research.

Acknowledgements

Authors are thankful to Ministry of Environment and Forest, New Delhi for financial assistance and to Head, Department of Botany, University of Lucknow, Lucknow for laboratory facilities. Rakesh Kumar Dwivedi and Rajveer Singh Chauhan S.R.F (C.S.I.R –N.E.T.) are thankful to C.S.I.R. New Delhi for financial assistance. Authors are thankful to Dr. A.K.S.K. Prasad, Florida State University, Florida USA for his valuable suggestions.

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