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Diatom flora of Hasina pond, Morang, Nepal

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Abstract

Epiphytic diatoms of Hasina pond were studied during winter, summer, and monson seasons in 2014-2015. Samples were collected by squeezing submerged roots and leaves of hydrophytes and frustules were cleaned using nitric acid. A total 59 diatoms under 27 genera and 19 families were reported among which 33 diatoms were new to the country. *Epithemia adnata, Rhopalodia gibba, Gomphonema truncatum, Nitzschia palea, Ulnaria acus, U. ulna* and *Pinnularia amabilis* were dominant in the pond. Diatom species were found maximum in summer (40%) and minimum in monsoon (28%) seasons.

Keywords: Algae, *Bacillaria*, bacillariophyta, epiphytes, *Planothidium*

Introduction

Diatoms (Bacillariophyta) are beautiful microscopic algae found in almost all short of aquatic or moist environment. It is one of the largest and ecologically most significant groups of algae. They are planktonic, but some are benthic or epiphytic and are primary sources of food for zooplankton. They are mostly unicellular but some forms colonies and a few also exist in filaments. They show varied shapes ranging from oval, rounded, elongated, conical, rod shaped, disc shaped to triangular. Vegetative cells are uninucleate, diploid, without flagella. Cell wall composed of transparent silica, highly sculptured and symmetrically ornamented with two overlapping frustules. They are among the most beautiful of microscopic objects because of their wonderful sculpturing on cell walls (Prescott 1969). Chloroplast contain chlorophyll c and a toghther with fucoxanthin, diatoxanthin, and diadnoxanthin pigments. Reserved food is oil and chrysolainarin but never starch.

Due to their short life spans and rapid migration rate, they respond quickly to the changing environment and act as a good bioindicator (Prygiel *et al*. 1999). Their species richness, composition and abundance can also be used to assess human impacts on aquatic environments, and global changes in biodiversity (Stoermer & Smol 1999). The deposition of silica by diatoms can be used in nanotechnology (Bradbury 2004). Various shapes and sizes of their valves produced by their repeated division can be used to manufacture micro and nano scale structures which may be of use in a range of devices including optical systems such as semiconductor, nanolithography etc. Besides these, diatoms could also be used as a component of solar cells, by substituting photosensitive titanium dioxide for the silicon dioxide normally used in the creation of cell walls (Johnson 2009)**.** Diatom biofuel producing solar panels have also been proposed (Ramachandra *et al*. 2009). Diatoms can also be used in forensic researches especially in drawn cases. Diatoms are very common

and play an important role in global primary production. It is estimated that diatoms contribute to 25% of the atmospheric oxygen, and approximately 43% of the primary production of the ocean (Treguer *et al*. 1995)**.** Diatom frustules have accumulated over millions of years to form the fine, crumbly substance known as diatomaceous earth, which has a variety of uses (e.g., for filtration and insulation).

Diatom flora of Nepal has not been explored so far properly. Sporadic records were made by many foreign workers along their route for different expeditions to the Himalaya regions. Carter (1926) has reported *Navicula conferracea* from Makawanpur district which seems to be the first record of diatom from Nepal. Suxena and Venkateswarlu (1968) have reported 69 diatoms from Bhote koshi, a stream to Dudh pokhari (5250m), and small streams to Dudh koshi (2900-4200m) below Namche Bazaar. Hickel (1973) reported 4 species from Nagdaha and Taudaha (1350 m), Kathmandu. Subba *et al*. (1979**)** reported 3 species from Bhote koshi, a stream to Dudh pokhari (5250 m), small streams to Dudh koshi (2900-4200 m) below Namche Bazaar, Dudh Koshi river on the way from Dudh pokhari to Dole village (4790 m).

The Japanese workers made major contribution on the diatom flora of Nepal. The first major reports came from Hirano (1955, 1963, 1969, 1984) of Kyoto University who reported 182 diatoms from Phewa lake, Ankhu khola, Kaligandhaki, Trisuli river, Ranipokhari and many places of Central and Eastern Nepal. Nakanishi (1986) studied the limnology of Phewa, Begnas and Rupa lake and listed 12 diatom species. Watanabe (1995) has listed 2 diatoms from Rara Lake and its victinity (2970m). Rothfritz *et al.* (1997) have also studied the epiphytic and epilithic diatom from Nepalese Himalaya. Ormerod *et al.* (1994) and Ormerod and Jüttner (1998) have studied the altitudinal trend of diatoms occurrence in Nepalese river system and listed more than 36 taxa. Cantonati *et al.* (2001) have reported 182 diatoms from high mountain streams of Simikot-Rara lake area, Jumla-Dunai area, Makalu area and Kanchanjunga area (all above 3500 m).

Jüttner *et al*. (1996, 2000, 2003, 2010, 2011) have reported many diatoms from Kathmandu valley (38 diatoms), Likhu Khola (60 diatoms) and Arun valley (36 diatoms); Chubi Chu (La 16), Langtang National Park, tributaries of Tamur and Kabeli rivers from Taplejung, tributaries of Arun and Kasuwa river from Sankhuwasabha; streams of Kathmandu Valley and middle hills (Simikot–Rara lake area, Jumla–Dunai area Manasalu circuit, Makalu area and Kanchanjunga area above 3500m); Gokeyo valley, 4700 to 4800m, at inflow and lake margin of Gokeyo I, II and III (Dudh pokhari) lakes; streams of Nepal Himalya and listed the 36,4,168,5 and 8 diatoms species, respectively. Jüttner *et al.* (2010) also reported *Cymbella yakii* sp. nov. from Everest National Park, Nepal.

Maeda and Ichimura (2007) listed some diatoms from four subtropical mountain lakes in Pokhara valley. Hayashi (2011), Hayashi *et al.* (2012), and recently Hayashi and Tanimura (2015a, b) have studied the fossil diatoms from the core at Rabibhawan in the western central part of Kathmandu basin and reported more than 36 species including 5 new records.

Phycologists of Nepal have also made valuable contributions to the diatom flora of Nepal. Shrestha and Manandhar (1983) reported 4 species from Thankot, Swayambhu, Nagarjun,

Balaju, Dakshinkali, Taudaha, Kirtipur, Pashupati, and many place of Kathmandu valley. Pradhananga *et al.* (1988) listed 9 genera of diatoms from Narayani and Orahi River. Baral (1995) has listed 201 species of diatoms in his book "*Enumeration of the algae of Nepal"* during Biodiversity Profiles Project carried out jointly by Department of National Parks and Wildlife Conservation, Govt. of Nepal/Directorate General International Cooperation, Govt. of the Netherlands. Pokharel (1997) listed 4 diatom spices from Nandatal, Royal Chitwan National Park. Aryal and Locoul (1996) have identified total 19 bacillariophycean species from Punyamati Rivers, Panauti. Dahal and Jüttner (2004) have studied the water quality of middle hill springs using diatoms. Shrestha (2005) recorded 7 diatoms from Itahari and its adjoining area. Simkhada (2006) has studied the diatoms as the indicator of environmental change in lakes and ponds of low land, middle hills and high Himalaya of Nepal and concluded that the species richness was highest in Kathmandu (i.e., 213 species) in contrast to Koshi Tappu (i.e., 119 species) and high altitude lakes (i.e., 77 species). Simkhada and Jüttner (2006) have studied the diatoms of 12 ponds and 4 Lake of Kathmandu valley and ponds of Koshi Tappu, respectively including their relationship with hydro-chemicals and habit characters and reported 213 diatoms.

Prasad (2011) has also published a modern check list of algae of Nepal in which he listed 235 diatoms from Nepal. Ghimire *et al*. (2012) have studied diatoms from Sagarmatha National Park, Solukhumbu; Lukla to Everest Base Camp recorded 22 species of diatom. Shrestha *et al*. (2013) have studied the algal flora of Itahari and its adjoining area recorded 4 species.

This is the preliminary work for this pond as diatom flora of Hasina wetland has not been studied yet.

Materials and Methods

Study area

Hasina wetland (Simsar) is situated at Lat. $26^{0}41.515'$ N and Long. 87^{o} $18.860'$ E, and average elevation of 126 msl. It extends approximately 48 ha, is situated on the foothills of Churia hill in tropical zone. It occurs in Sandar Dulari Municipality, Morang district of Koshi zone. It is a natural wetland consists of swamp, marsh, pond and streams. The water body coverage area is 3.3 ha. The ponds feed by the ground originated 4-5 spring sources. The wetland type is lacustrine (lake/pond), palustrine (marsh/swamp) and riverine. The wetland is using for irrigation about 3200 ha land.

Diatom study was carried out only from a man-made pond situated at middle-eastern side of the Hasina wetland (Map 1). Its reserve water irrigates rice fields through south-east channel exit from here. The pond seems not long permanent as it has only a thin muddy dam on its south side which is not so strong. But this pond is rich in aquatic flora such as *Eichhornia crassipes, Pistia stratoites*, *Monochoria* sp, *Lemna minor*, *Vallisnaria natans*, etc (Siwakoti *et al*. 2012).

The topography and water parameters of 11 different collection sites of Hasina pond are as follows (Table 1)

Table 1. Diatom sampling sites and water parameters of Hasina pond (2014-15).

Sampling sites	Latitude (E)	Longitude (N)	Altitude (m)	Water pH	Water temperature (°C)		
					Winter	Summer	Monsoon
HS 1	$26^0$41.552'	$87^0$19.1o2'	120	6	18	28	23
HS 2	$26^0$41.589'	$87^0$19.112'	121	7	20	28	23
HS 3	$26^0$41.604'	$87^0$19.123'	119	6	20.5	29	24
HS 4	$26^0$41.615'	$87^0$19.1935'	120	6	20.5	30	24.5
HS 5	$26^0$41.660'	$87^0$19.142'	118	7	22	30	26
HS 6	$26^0$41.670'	$87^0$19.143'	120	7	23	31	26
HS 7	$26^0$41.662'	$87^0$19.149'	119	6	23	31	25
HS 8	$26^0$41.653'	$87^0$19.152'	119	7	21	30	26
HS 9	$26^0$41.633'	$87^0$19.157'	126	7	22	31	24
HS 10	$26^0$41.620'	$87^0$19.156'	120	7	23	29	22
HS 11	$26^0$41.600'	$87^0$19.137'	129	7	21	29	23

Map 1. Man-made pond in Hasina wetland where diatom was collected.

Sample collection

Diatom samples were collected during winter, summer and monsoon seasons, at 11AM to 2 PM, 2014-2015, from 11 peripheral sites of the pond. Only epiphytic diatoms were collected by squeezing the submerged roots and leaves of *Eichhornia*, *Pistia*, *Hydrilla*, *Potamogeton*, *Nhymphea* etc. Collections were also done from the middle area of the pond by using boat. They were preserved in 4% formaldehyde solution soon. Tagging and lebeling of samples were done properly. Geographical positions of each collection sites

were noted with the help of GPS Garmin e-Trex. Necessary photographs of the habitats were taken with the help of Canon Digital Camera. Water pH and temperature were measured using portable Hanna pH meter and alcohol thermometer, respectively.

Frustule cleaning and identification

Diatom frustules were cleaned using nitric acid method following PCER; ANSP (1988). For each sample, three permanent slides were made. Permanent slides were observed under light microscope in 40X objective. Number of diatom species present in the microscopic field was counted carefully for at leat 10 different fields per slide. Microphotographs were taken with the help of Olympus CH20i microscope attached with canon digital camera at 40X and 100X magnification. Algal dimension was measured using ocular micrometer.

Diatoms were identified follwoing literatures and monographs, *viz*., Tiffany and Britton (1952), Krammer and Lange-Bertalot (1988); Prasad and Srivastava (1992), Wojtal (2009), Bey and Ector (2013); Karthick *et al*. (2013), etc. All the collected materials and slides have been deposited in the repository of Phycological Research Lab, Department of Botany, Post Graduate Campus, Biratnagar.

Results and Discussion

A total 59 diatoms belonging to 27 genera, 19 families, 13 orders and 4 classes were reported from Hasina pond, Morang. There are 33 diatoms reported as new to Nepal.

Phylum: Bacillariophyta
Class: Coscinodiscophyceae
Order: Aulacoseirales
Family: Aulacoseiraceae
Genus: ***Aulacoseira*** Thwaites (1848)

1. ***Aulacoseira granulata*** var**.** ***angustissima*** (O. Müller) Simonsen (1979) (Figs. 1-2)
Karthick *et al.* 2013, Pl. 3
Valve diameter 13-30 µm, valve mantle depth 3-6 µm; Striae 8-12 in 10 µm
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: A ditch at Pitchara canal, Biratnagar, Morang (Rai & Rai, 2005); Phewa, Rupa and Begnas lakes, Pokhara, Kaski (Nakanishi, 1986); Punyamati River, 1500m, Kavrepalanchok (Aryal & Lacoul, 1996).

Class: Mediophyceae
Subclass: Thalassiosirophycidae
Order: Stephanodiscales
Family: Stephanodiscaceae
Genus: ***Cyclotella*** (Kützing) Brébisson (1838)

2. ***Cyclotella meneghiniana*** Kützing (1844) (Figs. 3-4)
Prasad & Srivastava 1992, P. 160, Pl. 24, Figs. 1-2; Karthick *et al.* 2013, Pl. 5; Agata 2009, P. 135, Pl. 1, Figs. 14-15.
Valve diameter 10-34.5 µm; Striae 6-8 in 10 µm.
Collection no. & date: HS. 5; 2070.11

Distribution in Nepal: Pond at Dillibazar, 1300m, Kathmandu (Hirano, 1963); Biratnagar, 72m, Morang, (Rai & Rai, 2005).

Class: Fragilariophyceae
Order: Fragilariales
Family: Fragilariaceae
Genus: ***Fragilaria*** Lyngbye (1819)

3. ***Fragilaria brevistriata*** Grunow (1885) [*Pseudostaurosira brevistriata* (Grunow) D.M. Williams et Round (1988)] (Fig. 5)
Lavoie *et al.* 2008, P. 231, Pl. 10; Bey & Ector 2013, P. 250, Figs. 1-20.
Valve 5-30 µm long, 3-7 µm broad; Striae 12-17 in 10 µm.
Collection no. & date: HS. 6; 2071.2.20
Distribution in Nepal: Not reprted earlier from Nepal.

4. ***Fragilaria capucina*** var. ***rumpens*** (Kützing) Lange-Bertalot ex Bukhtiyarova (1995) (Fig. 6)
Ivanov *et al*. 2006, P. 180, Pl. 2, Figs. 5-6.
Valve 10- ca 50 µm long, 4-5 µm broad; Striae 9-14 in 10 µm.
Collection no. & date: HS. 8; 2071.2.20
Distribution in Nepal: Punyamati River, 1500m, Kavrepalanchok (Aryal & Laucoul, 1996). River, Koshi reservoir, Sunsari 162m (Misra *et al*., 2009).

Order: Licmophorales
Family: Ulnariaceae
Genus ***Ulnaria*** (Kützing) Compère (2001)

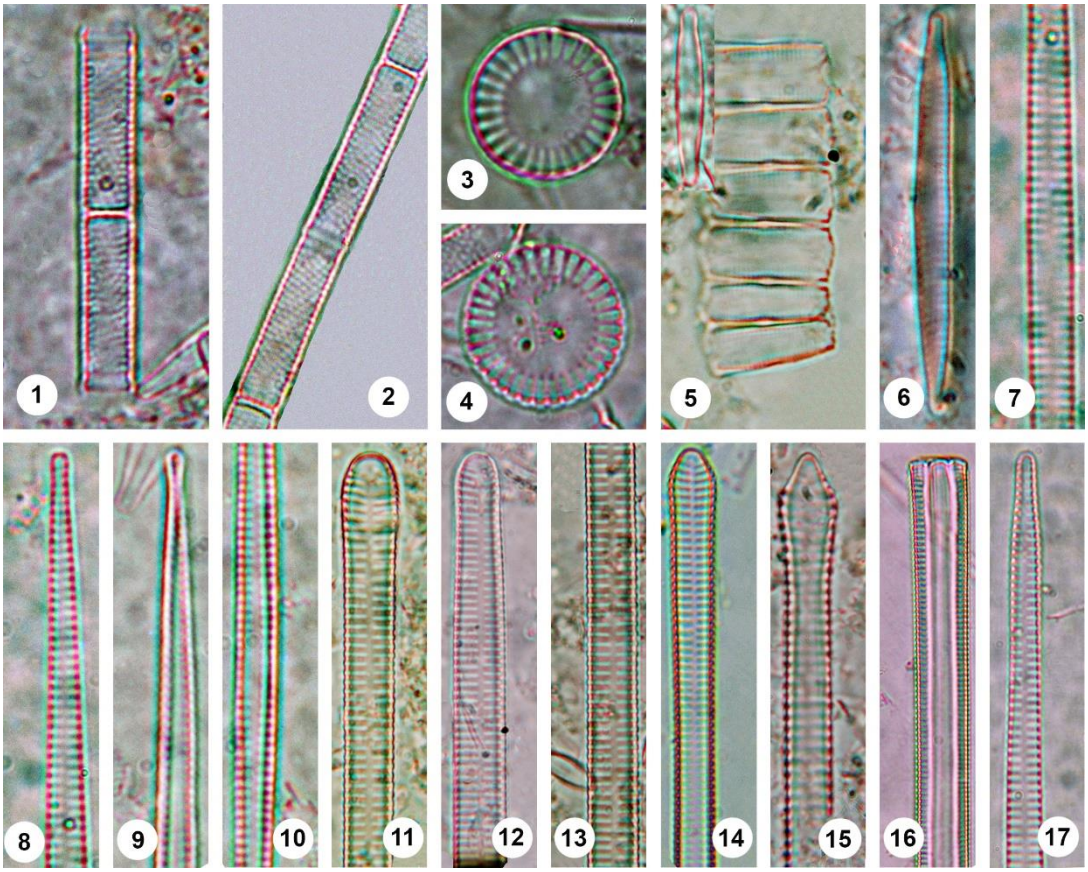
5. ***Ulnaria acus*** (Kützing) Aboal (2003) (Figs. 7-8)
Karthick *et al*. 2013, Pl. 17
Valve 90-166 µm long, 3-6 µm broad; Striae 13-14 in 10 µm.
Collection no. & date: HS. 10; 2070.11.3
Distribution in Nepal: Phewa, Rupa, and Begnas Lakes, 967m, Kaski (Nakanishi, 1986).

6. ***Ulnaria amphirhynchus*** (Ehrenberg) Compère et Bukhtiyarova (2006) (Figs. 9-10)
Prasad & Srivastava 1992, P. 171, Pl. 24, Fig. 10. (As *Synedra ulna* var. *amphirhynchus*)
Valve 228 µm long, 6 µm broad; Striae 9-10 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: As *Ulnaria ulna* var. *amphirhynchus* from Malaya roadside ditches, 72m, Biratnagar, Morang (Rai & Rai, 2005).

7. ***Ulnaria*** cf**. *biceps*** (Kützing) Compère (2001) (Figs. 11-13)
Karthick *et al*. 2013, Pl. 15 (As *Ulnaria ulna* var. *biceps*)
Valve 310 µm long, 6.5-7 µm broad; Striae 9-11 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: As *Ulnaria ulna* var. *biceps* from Ankhu, Tadi khola, 640m, Gorkha. Tukucha Moor, 2600m, Mustang. Thaple Himal, Bhot Base camp, 3500, Manang (Hirano, 1955)

8. ***Ulnaria capitata*** (Ehrenberg) Compère (2001) (Figs. 14-16)
Tiffany & Britton 1952, P. 236, Pl. 63, Fig. 722; Foged 1982, P. 357, Pl. 4, Fig. 12.
Valve 274 µm long, 8.5 µm broad; Striae 8-11 in 10 µm.
Collection no. & date: HS. 7; 2071.5.19
Distribution in Nepal: Not reported earlier from Nepal.

9. ***Ulnaria danica*** (Kützing) Compère et Bukhtiyarova (2006) (Fig. 17)
Bey & Ector 2013, P. 288, Figs. 1-6.
Valve 140-280 µm long, 4-6 µm broad; Striae 9-11 in 10 µm.
Collection no. & date: HS. 4; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.



Figures: 1-2. *Aulacoseira granulata* var. *angustissima* 3-4. *Cyclotella meneghiniana* 5. *Fragilaria brevistriata* 6. *Fragilaria capucina* var. *rumpens* 7-8. *Ulnaria acus* 9-10. *Ulnaria amphirhynchus* 11-13. *Ulnaria* cf. *biceps* 14-16. *Ulnaria capitate* 17. *Ulnaria Danica*

10. ***Ulnaria ulna*** (Nitzsch) Compère (2001) (Figs. 18-21)
Karthick *et al.* 2013, Pl. 18
Valve 90 µm long, 6.5 µm broad; Striae 10-11 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

11. ***Ulnaria ulna*** var. ***subaequalis*** (Grunow) Aboal (2003) (Figs. 22-23)
Karthick *et al*. 2013, Pl. 18
Valves 150 µm longe, 7 µm broad; Striae 10-11 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal**.**

Class: Bacillariophyceae
Subclass: Eunotiophycidae
Order: Eunotiales
Family: Eunotiaceae
Genus: ***Eunotia*** Ehrenberg (1837)

12. ***Eunotia bilunaris*** (Ehrenberg) Schaarschmidt (1880) (Figs. 24-25)
Bey & Ector 2013, P. 300, Figs 1-21; Karthick *et al*. 2013, Pl. 33.
Valve 66-86 µm long, 2-3 µm broad; Striae 19-20 in 10 µm.
Collection no. & date: HS. 9; 2071.5.19
Distribution in Nepal: Reported as *E. lunaris* from a branch stream of upper Langtang river, 3800m, Langtang, Rasuwa (Hirano 1969).

13. ***Eunotia tschirchiana*** O. Müller (1890) (Figs. 26-27)
Gandhi 1999, P. 26, Pl. 1, Fig. 37; P. 92, Pl. 1, Fig. 23; P. 153, Pl. 2, Fig. 61.
Valves 53-62.5 µm long, 8.5-10 µm broad; Striae 8-13 in 10 µm.
Collection no. & date: HS. 4; 2071.2.20
Distribution in Nepal: Stream at Mewa Khola, 4150m, Taplejung (Hirano, 1984); Ditches at Biratnagar, 72m, Morang (Rai & Rai, 2005).

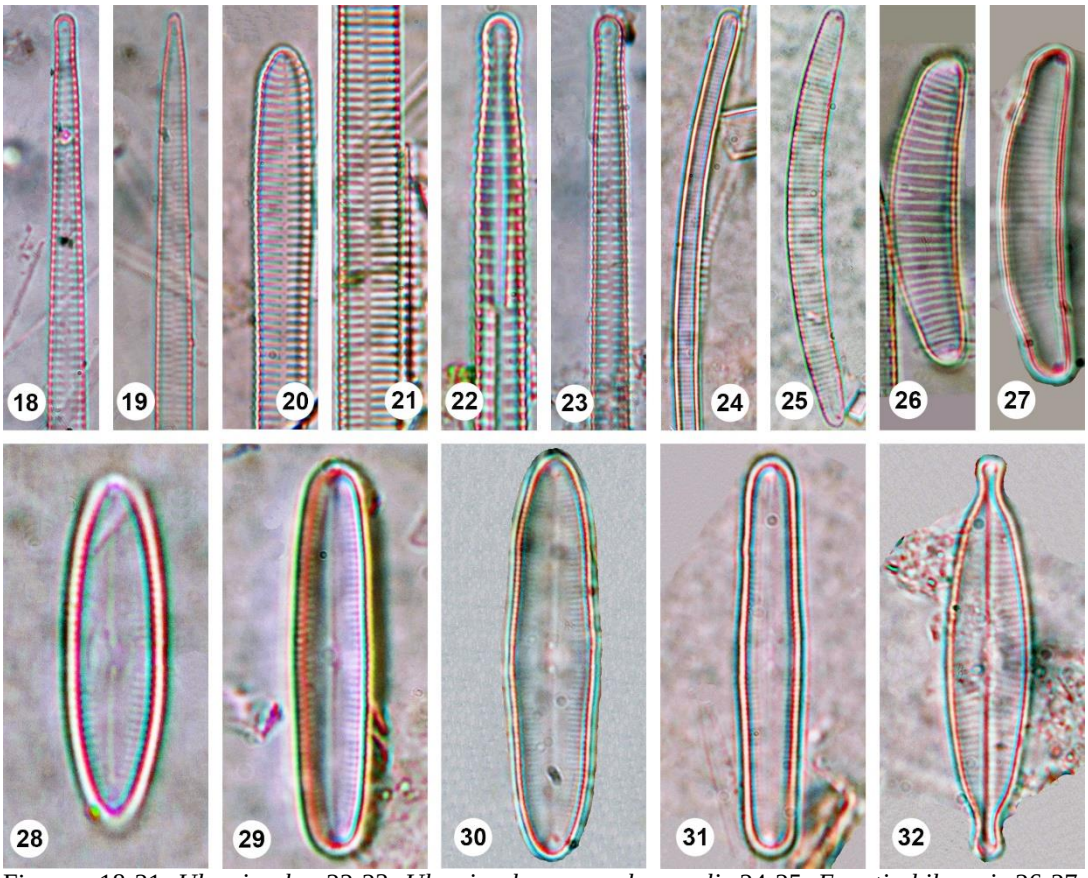
Subclass: Bacillariophycidae
Order: Naviculales
Suborder: Naviculineae
Family: Naviculaceae
Genus ***Caloneis*** Cleve (1894)

14. ***Caloneis bacillum*** (Grunow) Cleve (1894) (Figs. 28-31)
Karthick *et al.* 2013, Pl. 3.
Valve 16.5-33 µm long; 5-7 µm broad; Striae 20-24 in 10 µm.
Collection no. & date: HS. 11; 2070.11.3
Distribution in Nepal: Variety *fontinalis* was reported from watery places and small stream below Namchebazar at 2900-4200 m, Solukhumbu (Suxena & Venkateswarlu, 1968).

Genus ***Navicula*** Bory (1822)

15. ***Navicula americana*** Ehrenberg (Fig. 50) [*Sellaphora americana* (Ehr.) D.G. Mann 1989]
Krammer & Lange-Bertalot 1986, Fig. 67. 1.
Valve 59-90 µm long, 15-19 µm broad; Striae 16-18 in 10 µm.
Collection no. & date: H.S. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

16. ***Navicula capitatoradiata*** Germain ex Gasse (1986) (Fig. 32)
Bey & Ector 2013, P. 540, Figs 1-34.
Valve 24-45 µm long, 7 to 10 µm broad; Striae 11-14 in 10 µm.
Collection no. & date: HS. 9; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.



Figures: 18-21. *Ulnaria ulna* 22-23. *Ulnaria ulna* var. *subaequalis* 24-25. *Eunotia bilunaris* 26-27. *Eunotia tschirchiana* 28-31. *Caloneis bacillum* 32. *Navicula capitatoradiata*

17. ***Navicula notha*** Wallace (1960) (Figs. 33-34)
Karthick *et al.* 2013, Pl. 69
Valve 22.5-38 µm long, 3.5-6 µm broad; Striae 14-18 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

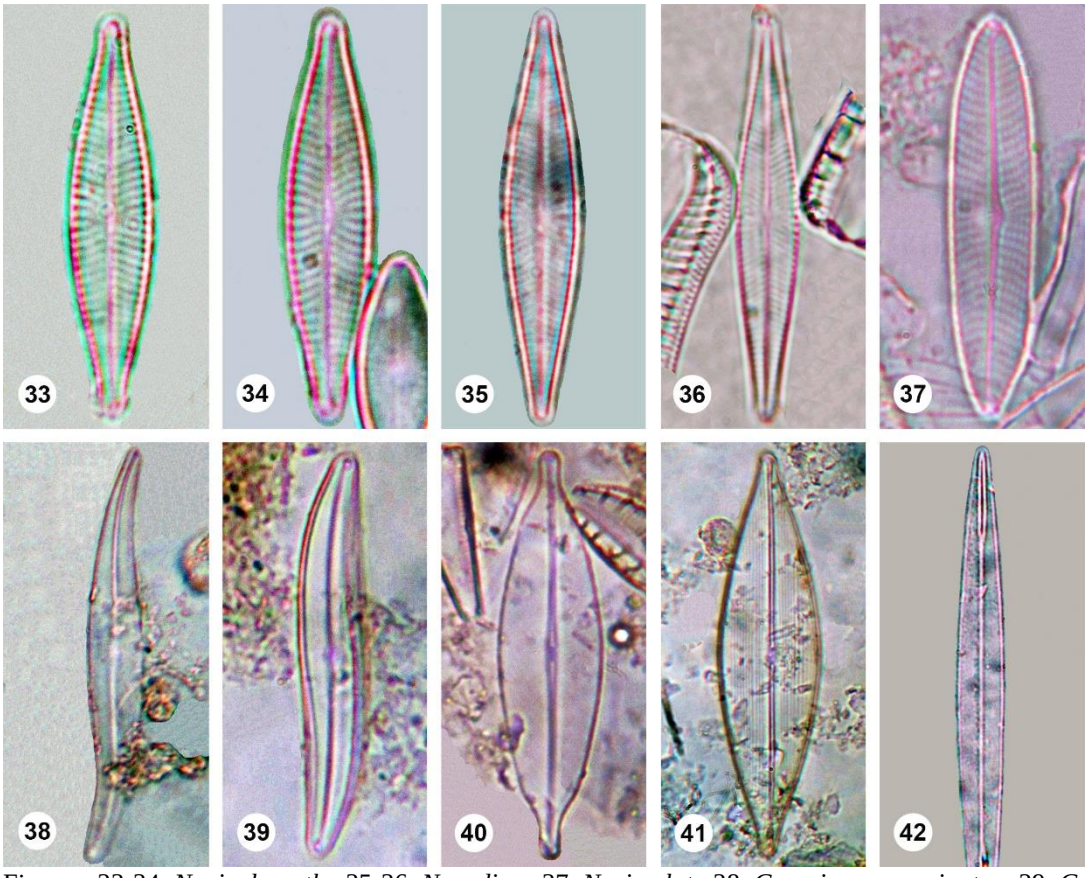
18. ***Navicula radiosa*** Kützing (1844) (Figs. 35-36)
Prasad & Srivastava 1992, P. 212, Pl. 28, Fig.4; Agata 2009, P. 175, Pl. 31, Fig. 14.
Valve 65 µm long, 12 µm broad; Striae 9-11 in 10 µm.
Collection no. & date: HS. 11; 2071.5.19
Distribution in Nepal: Luitel Bhanjyang, 770m, Gorkha; Kali Gandaki, 2600m, Mustang; Tukucha moor, 2640m, Mustang; Manang Bhot Base Camp, 3500m, Manang (Hirano,

1963); Phewa lake, 967m, Kaski (Nakanishi, 1986).

19. ***Navicula simulata*** Manguin (1942) (Fig. 37)
Bey & Ector 2013, P. 606, Figs. 1-18.
Valve 29-37 µm long, 6-7.5 µm broad; Striae 14-17 in 10 µm.
Collection no. & date: HS. 4; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.

Genus ***Gyrosigma*** Hassall (1845)

20. ***Gyrosigma acuminatum*** (Kützing) Rabenhorst (1853) (Fig. 38)
Wojtal 2009, P. 226, Pl. 87, Figs. 1-8; Pl. 88, Figs. 1-3.
Valve 70-180 µm long, 12-24 µm broad; longitudinal Striae 19-24 in 10 µm.
Collection no. & date: HS. 4; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.



Figures: 33-34. *Navicula notha* 35-36. *N. radiosa* 37. *N. simulata* 38. *Gyrosigma acuminatum* 39. *G. scalproides* 40. *Craticula ambigua* 41. *C. cuspidate* 42. *Amphipleura pellucida*

21. ***Gyrosigma scalproides*** (Rabenhorst) Cleve (1894) (Fig. 39)
Prasad & Srivastava 1992, P. 241, Pl. 31, Fig. 9; Agata 2009, P. 166, Pl. 24, Fig. 5

Valve 48 µm long, 12 µm broad.
Collection no. & date: HS. 4; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.

Family: Stauroneidaceae
Genus ***Craticula*** Grunow (1868)

22. ***Craticula ambigua*** (Ehrenberg) Mann (1990) (Fig. 40)
Bey & Ector 2013, P. 388, Figs. 1-5; Karthick *et al*. 2013, Pl. 46.
Valve 67.7-81.5 µm long, 18-21.5 µm broad; Striae 14-17 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

23. ***Craticula cuspidata*** (Kützing) Mann (1990) (Fig. 41)
Bey & Ector 2013, P. 392, Figs. 1-3; Karthick *et.al*. 2013, Pl. 45.
Valve 20-33 µm long, 4.5-8 µm broad; Striae 18-21 in 10 µm.
Collection no. & date: HS. 11; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.

Suborder: Neidiineae
Family: Amphipleuraceae
Genus ***Amphipleura*** Kützing (1844)

24. ***Amphipleura pellucida*** (Kützing) Kützing (1844) (Fig. 42)
Lavoie *et al*. 2008, P. 162-63, Pl. 49.
Valve 80-140 µm long, 7-9 µm broad; Striae extremely fine, 37-45 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal**.**

Suborder: Diploneidineae
Family: Diploneidaceae
Genus ***Diploneis*** Ehrenberg ex Cleve (1894)

25. ***Diploneis elliptica*** (Kützing) Cleve (1894) (Fig. 43)
Lange-Bertalot 1996, P. 204. Pl. 43, Fig. 6.
Valves 45 µm long, 30 µm broad; Striae 9-10 in 10 µm.
Collection no. & date: HS. 5; 2071.5.19
Distribution in Nepal: Riverbed of a branched stream of Langtang river at upper part of Sharvegan village, 2800m, Langtang, Rasuwa (Hirano 1969).

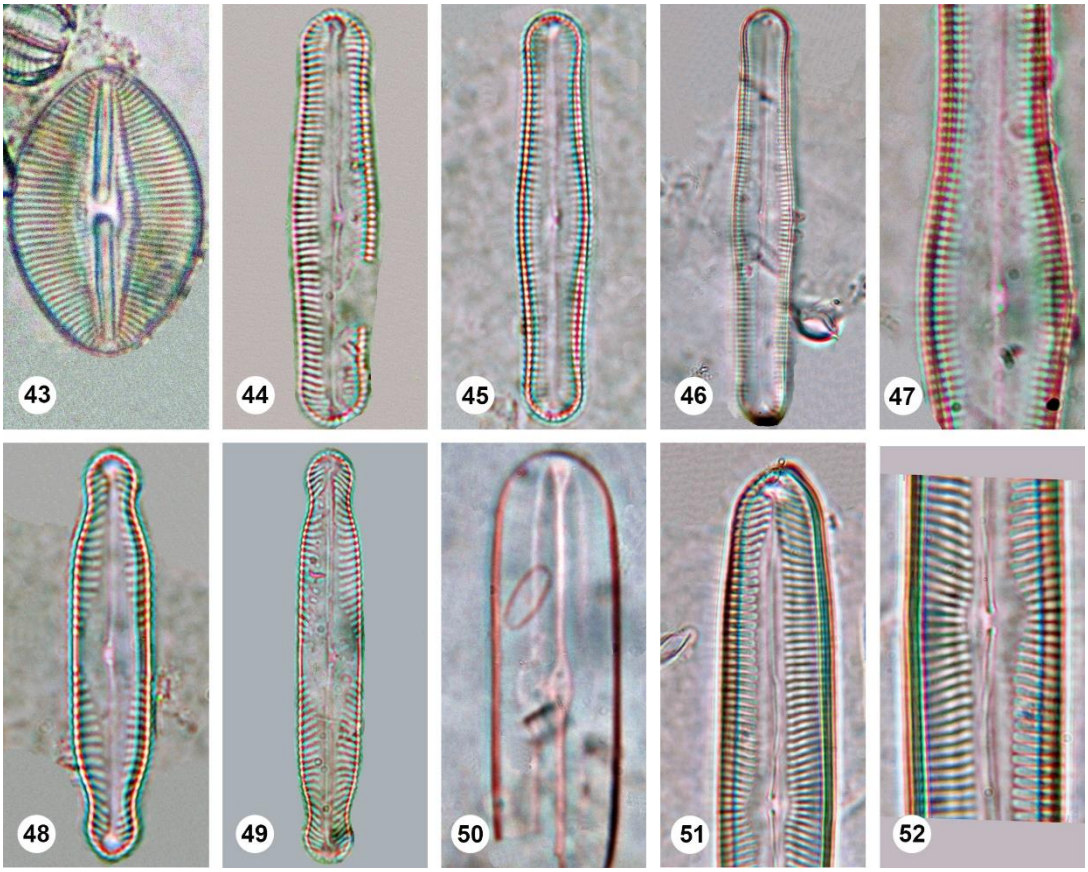
Suborder: Sellaphorineae
Family: Pinnulariaceae
Genus ***Pinnularia*** Ehrenberg (1843)

26. ***Pinnularia acrosphaeria*** Smith (1853) (Figs. 44-47)
Prasad & Srivastava 1992, P. 229, Pl. 30, Fig. 10; Gandhi 1999, P. 128, Pl. 3, Fig. 91; P. 224, Pl. 7, Fig. 285; Karthick *et al*. 2013, Pl. 74.
Valve 38-54 µm long, 8-12 µm broad; Striae 12-16 in 10 µm.
Collection no. & date: HS. 8; 2071.2.20

Distribution in Nepal: Variety *minor* was reported from a pond near Patan Dhoka, 1300m, Lalitpur (Hirano, 1963).

27. *Pinnularia amabilis* Krammer (2000) (Figs. 48-49)
Karthick *et al*. 2013, Pl. 73.
Valve 43-52.5 µm long, 7-8.5 µm broad; Striae 8-10 in 10 µm.
Collection no. & date: H.S. 11; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

28. *Pinnularia stidolphii* Krammer (2000) (Figs. 51-52)
Bey & Ector 2013, P. 668, Figs. 1-5.
Valve 100-170 µm long, 17-21 µm broad; Striae 7-9 in 10 µm.
Collection no. & date: HS. 4; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.



Figures: 43. *Diploneis elliptica* 44-47. *Pinnularia acrosphaeria* 48-49. *P. amabilis* 50. *Navicula. americana* 51-52. *P. stidolphii*

Order: Mastogloiales
Family: Achnanthaceae
Genus: ***Achnanthes*** Bory (1822)

29. ***Achnanthes exigua*** Grunow (1880) (Fig. 53)
Lavoie *et al*. 2008, P. 90-91, Pl. 13.
Valve 12-24 µm long, 4-7 µm broad; stria 17-24 in 10 µm.
Collection no. & date: HS. 4; 2071.5.19
Distribution in Nepal: Reported as var. *constricta* from riverbed of a branch stream of Langtang river at upper part of Sharvegan village, 2800m, Langtang, Rasuwa (Hirano, 1969)

30. ***Achnanthes inflata*** (Kützing) Grunow (1868) (Fig. 54)
Karthick *et al*. 2013, Pl. 23.
Valve 51.5-52 µm long, 12-12.5 µm broad; Striae 10-11 in 10 µm.
Collection no. & date: HS. 4; 2071.2.20
Distribution in Nepal: Riverbed of a branch stream of Langtang river at upper part of Sharvegan village, 2800m, Langtang, Rasuwa (Hirano 1969).

Order: Cocconeidales
Family: Achnanthidiaceae
Genus: ***Lemnicola*** Round et Basson (1997)

31. ***Lemnicola hungarica*** (Grunow) Round et Basson (1997) (Figs. 55-57)
Karthick *et al*. 2013, Pl. 25
Valve 22-38 µm long, 7.5-9.5 µm broad.
Collection no. & date: H.S. 11; 2070.11.3
Distribution in Nepal: Not repoted earlier from Nepal.

Genus ***Planothidium*** Round et Bukhtiyarova (1996)

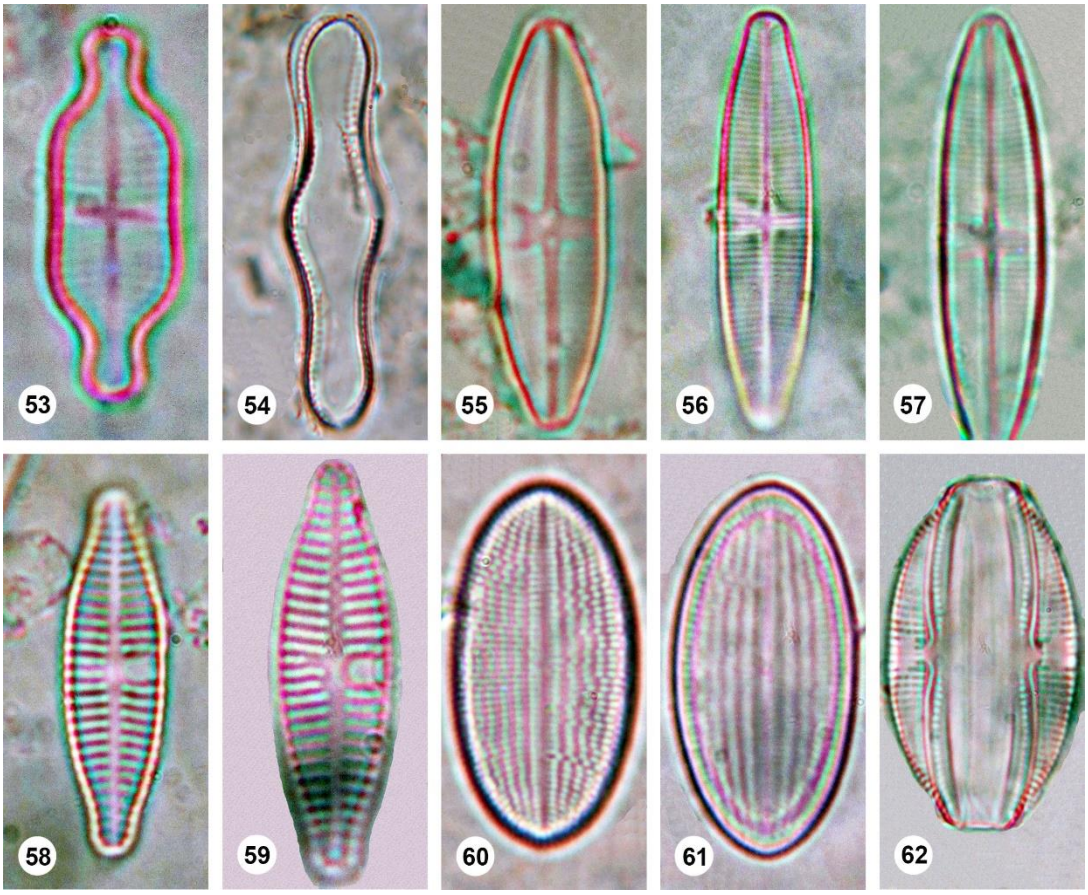
32. ***Planothidium biporomum*** Hohn et Hellerman ex Lange-Bertalo (1999) (Figs. 58-59)
Karthick *et al*. 2013, Pl. 24
Valve 15-24 µm long, 4-5.5 µm broad; Striae 11-13 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal**.**

Order: Cocconeidales
Family: Cocconeidaceae
Genus: ***Cocconeis*** Ehrenberg (1836)

33. ***Cocconeis placentula*** var. ***euglypta*** (Ehrenberg) Grunow (1884) (Figs. 60-61)
Tiffany & Britton 1952, P. 241, Pl. 64, Fig. 736; Prasad & Srivastava 1992, P. 199, Pl. 27, Fig 6; Agata 2009, P. 143, Pl. 7, Figs. 6-8.
Valve 11-70 µm long, 8-40 µm broad; Striae 23-25 in 10 µm.
Collection no. & date: HS. 10; 2071.2.20
Distribution in Nepal: Ponds at Kali Gandaki, 2500m, Mustang; Pisang, 3100m, and Manang Bhot Base Camp, 3500m, Manang (Hirano 1955; 1963).

Order: Thalassiophysales
Family: Catenulaceae
Genus: ***Amphora*** Ehrenberg ex Kützing (1844)

34. ***Amphora copulata*** (Kützing) Schoeman et Archibald (1986) (Fig. 62)
Karthick *et al.* 2013, Pl. 87
Valve 27-47.5 µm long, 6-22.5 µm broad; stria 12-15 in 10 µm.
Collection no. & date: HS. 1; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.



Figures: 53. *Achnanthes exigua* 54. *A. inflata* 55-57. *Lemnicola hungarica* 58-59. *Planothidium biporomum* 60-61. *Cocconeis placentula* var. *euglypta* 62. *Amphora copulata*

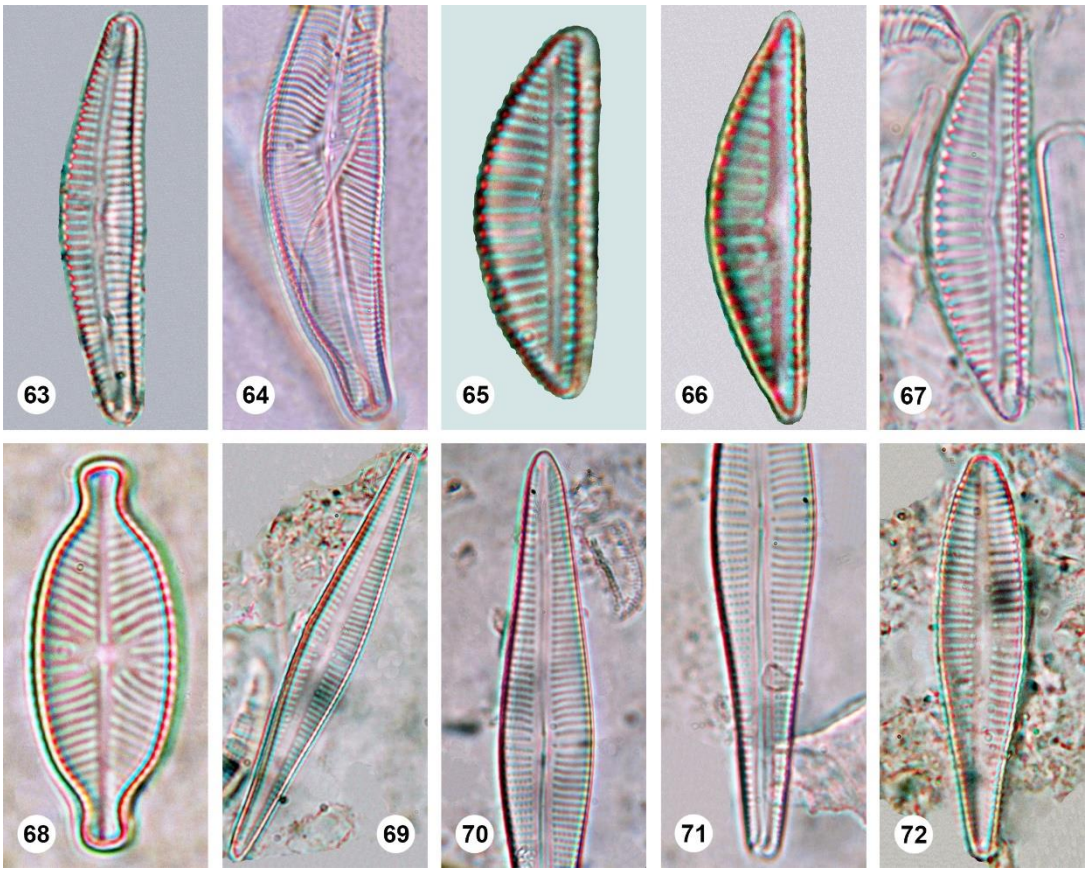
Order: Cymbellales
Family: Cymbellaceae
Genus: ***Cymbella*** Agardh (1830)

35. ***Cymbella parva*** (Smith) Kirchner (1878) (Fig. 63)
Karthick *et al*. 2013, Pl. 92
Valve 31-40 µm long, 7.5-11 µm broad; stria 9-11 in 10 µm.
Collection no. & date: HS. 2; 2070.11.3
Distribution in Nepal: Pond at Arughat Bazar, 710 m, Gorkha (Hirano, 1955); Pitchra ditch, Biratnagar, 72m, Morang (Rai, 2006); Stream at Gajurmukhi, Ilam (Rai *et al*., 2008).

36. ***Cymbella tumida*** (Brébisson) van Heurck (1880) (Fig. 64)
Tiffany & Britton 1952, P. 278, Pl. 74, Fig. 860; Karthick *et al.* 2013, Pl. 91.
Valve 40-105 µm long, 15-23 µm broad; Striae 8-10 in 10 µm.
Collection no. & date: HS. 3; 2070.11.3
Distribution in Nepal: Pond at Arughat Bazar, 710m, Gorkha (Hirano, 1955); Pitchhra ditch at Biratnagar, 72m, Morang (Rai, 2006).

Family: Gomphonemataceae
Genus: ***Encyonema*** Kützing (1834)

37. ***Encyonema silesiacum*** (Bleisch) Mann (1990) (Figs. 65-67)
Karthick *et al*. 2013, Pl.100.
Valve 37.5-68 µm long, 10-13.5 µm broad; Striae 7-11 in 10 µm.
Collection no. & date: HS. 8; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.



Figures: 63. *Cymbella parva* 64. *C. tumida* 65-67. *Encyonema silesiacum* 68. *Placoneis constans* var. *symmetrica* 69-71. *Gomphonema acidoclinatum* 72. *G. affine*

Genus: ***Placoneis*** Mereschkowsky (1903)
38. ***Placoneis constans*** var. ***symmetrica*** (Hustedt) Kobayasi (2002) [*Placoneis*

symmetrica (hustedt) Lange-Bertalot (2005)] (Fig. 68)
Mayama *et al*. 2002, P. 89.
Valve 23.5-30 µm long, 8-15 µm broad; stria 10-14 in 10 µm.
Collection no. & date: HS. 2; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.

Genus: ***Gomphonema*** Ehrenberg (1832)

39. ***Gomphonema acidoclinatum*** Lange-Bertalot et Reichardt (2004) (Figs. 69-71)
Bey & Ector 2013, P. 880-81, Figs. 1-18.
Valve 20-58 µm long, 6.6-8.5 µm broad; Striae 12-15 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

40. ***Gomphonema affine*** Kützing (1844) (Fig. 72)
Karthick *et al*. 2013, Pl. 77.
Valve 46-72 µm long, 8-9.5 µm borad; Striae 10-13 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

41. ***Gomphonema clavatum*** Ehrenberg (1832) (Figs. 73-74)
Bey & Ector 2013, P. 898-99, Figs 1-28.
Valve 30-70 µm long, 7-10 µm broad; Striae 9-11 in 10 µm.
Collection no. & date: HS. 10; 2071.5.19
Distribution in Nepal: Upper Mustang, 2888-4688m, Mustang (Subba *et al.*, 2009).

42. ***Gomphonema intricatum*** Kützing (1844) (Fig. 75)
Prasad & Srivastava 1992, P. 248., Pl. 33, Fig. 8.
Valve 33 µm long, 7 µm broad; Striae 17-20 in 10 µm.
Collection no. & date: HS. 5; 2071.5.19
Distribution in Nepal: A pond at Pisang, 3100 m, Manang (Hirano, 1955)

43. ***Gomphonema micropus*** Kützing (1844) (Fig. 76)
Ivanov *et al*. 2006, P. 173, 185, Pl. 7, Figs 19-20.
Valve 10-16 µm long, 5-13 µm broad; Striae 6-15 in 10 µm.
Collection no. & date: HS.2; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

44. ***Gomphonema parvulum*** (Kützing) Kützing (1849) (Fig. 77)
Karthick *et al*. 2013, Pl. 79.
Valve 14.5- 37.5 µm long, 6-12.5 µm broad; stria 7-15 in 10 µm.
Collection no. & date: HS. 1; 2070.11.3
Distribution in Nepal: A small stream on the slope of Mt. Salbachiome, 4200m, Langtang, Rasuwa (Hirano, 1969); var. *exillssima* was reported from a small pond near Kesalya river, Biratnagar, 72m, Morang (Rai & Rai, 2005)

45. ***Gomphonema pseudoaugur*** Lange-Bertalot (1979) (Fig. 78)
Karthick *et al*. 2013, Pl. 78.
Valve 41-60 µm long, 9.5-12 µm broad; stria 10-12 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

46. *Gomphonema sagitta* Schumann (1863) [*Gomphonema subtile* var. *sagitta* (Schumann) Grunow (1880)] (Figs. 79-80)
Lange-Bertalot 1996, P. 246, Pl. 64, Figs. 1-3.
Valve 28-50 µm long, 6-9 µm broad; Striae 8-17 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

47. *Gomphonema spiculoides* Gandhi (1960) (Fig. 81)
Karthick *et al*. 2013, Pl. 86.
Valve 57-68 µm, 8-9 µm broad; Striae 11-15 in 10 µm.
Collection no. & date: HS. 1; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

Figures: 73-74. *Gomphonema clavatum* 75. *G. intricatum* 76. *G. micropus* 77. *G. parvulum* 78. *G. pseudoaugur* 79-80. *G. sagitta* 81. *G. spiculoides* 82. *G. subclavatum*

48. *Gomphonema subclavatum* (Grunow) Grunow (1884) (Fig. 82)
Ivanov *et al.* 2006, P. 173, 185, Pl. 7, Figs. 17-18.
Valve 15-40 µm long, 4.5-9.5 µm broad; Striae 9-14 in 10 µm.
Collection no. & date: HS. 4; 2071.5.19
Distribution in Nepal: Not reported earlier from Nepal.

49. ***Gomphonema truncatum*** Ehrenberg (1832) (Figs. 83, 96)
Ivanov *et al.* 2006, P. 173, 185, Pl. 7, Figs 7-8.
Valve 25-70 µm long, 15-18 µm broad; Striae 5-12 in 10 µm.
Collection no. & date: HS. 4; 2070.11.3
Distribution in Nepal: Not reported earlier from Nepal.

Order: Rhopalodiales
Family: Rhopalodiaceae
Genus: ***Epithemia*** Kützing (1844)

50. ***Epithemia adnata*** (Kützing) Brébisson (1838) (Figs. 84-85)
Karthick *et al.* 2013, Pls. 102-103.
Valve 31.5-65.5 µm long, 7.5-11.5 µm broad; Striae 12-14 in 10 µm.
Collection no. & date: HS. 4; 2070.11.
Distribution in Nepal: Not reported earlier from Nepal.

Genus ***Rhopalodia*** Müller (1895)

51. ***Rhopalodia gibba*** (Ehrenberg) Müller (1895) (Figs. 86-87, 97)
Tiffany & Britton 1952, P. 282, Pl. 75, Fig. 884; Foged 1982, Pl. 3, Fig. 7; Karthick *et al*. 2013, Pl. 107.
Valve 42.0-96.5 µm long, 20-26 µm broad; Striae 8-10 in 10 µm; Fibula 6-8 in 10 µm.
Collection no. & date: HS. 3; 2070.11.3
Distribution in Nepal: A pond at Ankhu Khola, Gorkha, 630m; Pond at Pisang, Manang, 3100m; Stream at Tukucha Moor, Manang, 2600m (Hirano, 1955); Upper Mustang, 2888-4688m, Mustang (Subba *et al*., 2009).

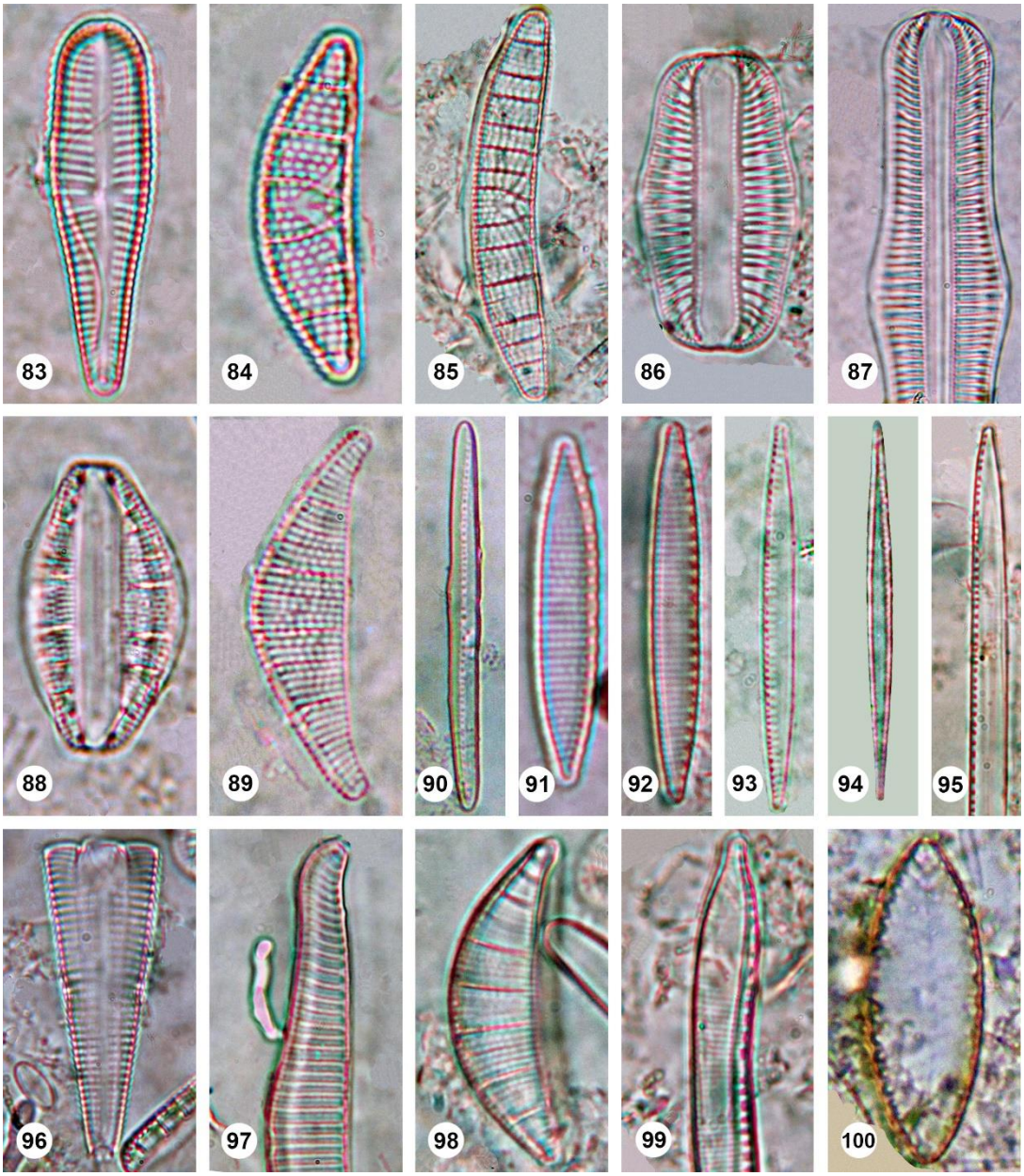
52. ***Rhopalodia musculus*** (Kützing) Müller (1900) (Figs. 88-89, 98)
Karthick *et al*. 2013, Pl. 78
Valve 22-32 µm long, 5-8 µm broad; costa 3-5 in 10 µm; Striae 2-4 between two costae.
Collection no. & date: HS. 2; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.

Order: Bacillariales
Family: Bacillariaceae
Genus: ***Bacillaria*** Gmelin (1791)

53. ***Bacillaria paradoxa*** Gmelin (1791) [*Bacillaria paxillifera* (Müller) Marsson (1901)] (Fig. 90)
Karthick *et al*. 2013, Pl. 109.
Valve 58-102 µm long, 5.0-6.5 µm broad; Fibula 5-9 in 10 µm; Striae 21-28 in 10 µm.
Collection no. & date: HS. 4; 2071.5.19
Distribution in Nepal: Not reported earlier from Nepal.

Genus: ***Nitzschia*** Hassall (1845)

54. ***Nitzschia palea*** (Kützing) Smith (1856) (Figs. 91-92)
Karthick *et al*. 2013, Pl. 118.



Figures: 83 & 96. *Gomphonema truncatum* 84-85. *Epithemia adnata* 86-87 & 97. *Rhopalodia gibba* 88-89 & 98. *R. musculus* 90. *Bacillaria paradoxa* 91-92. *Nitzschia palea* 93. *N. paleacea* 94. *N. pumila* 95. *N. recta* 99. *Hantzschia amphioxys* 100. *Surirella bifrons*

Valve 27.5-47.5 µm long, 3.5-5 µm broad; Stria more than 30 in 10 µm.
Collection no. & date: HS. 5; 2070.11.3
Distribution in Nepal: Pond at Arughat Bazar, 640m, Gorkha and a stream at Tukucha Moor, 2600m, Mustang (Hrano, 1955); Punyamati river, 1500m, Kavreplanchok (Aryal & Laucoul, 1996).

55. ***Nitzschia paleacea*** (Grunow) Grunow (1881) (Fig. 93)
Bey & Ector 2013, P. 1066, Figs. 1-58.
Valve 15.0-50.0 µm long, 1.5-4.0 µm broad; Fibula 14-18 in 10 µm.
Collection no. & date: HS. 3; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.

56. ***Nitzschia pumila*** Hustedt (1954) (Fig. 94)
Karthick *et al*. 2013, Pl. 127
Valve 56-60 µm long, 2.5-5.0 µm broad; Fibula 13-15 in 10 µm.
Collection no. & date: HS. 3; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.

57. ***Nitzschia recta*** Hantzsch ex Rabenhorst (1862) (Fig. 95)
Wojtal 2009, P. 272, Pl. 38, Figs. 6-8.
Valve 48-85 µm long, 4.7-7 µm broad; Fibulae 6-8 in 10 µm; Striae 39-50 in 10 µm.
Collection no. & date: HS. 7; 2070.11.3
Distribution in Nepal: Punyamati River, 1500m, Kavreplanchok (Aryal & Laucoul, 1996).

Genus: ***Hantzschia*** Grunow (1877)

58. ***Hantzschia amphioxys*** (Ehrenberg) Grunow (1880) (Fig. 99)
Karthick *et al*. 2013, Pl. 110.
Valve 34-52.5 µm long, 5-8 µm broad.
Collection no. & date: HS. 4; 2071.5.19
Distribution in Nepal: A gracier lake at Rarkya Pass, 4850m, Manang (Hirano, 1955); Ditches at Thimi, 1300m, Bhaktapur (Shrestha & Manandhar, 1983); var. *amphilepta* reported from a small stream on the slope of Mt. Salbachiome, 4200m, Langtang, Rasuwa (Hirano, 1969).

Order: Surirellales
Family: Surirellaceae
Genus: ***Surirella*** Turpin (1828)

59. ***Surirella bifrons*** (Ehrenberg) Ehrenberg (1843) (Fig. 100)
Krammer & Lange-Bertalot 1988, P. 520, Pl. 150, Figs. 4-6.
Valve 40- 60 µm long, 25-32 µm broad; Alar canal 30-50 in 100 µm.
Collection no. & date: HS. 4; 2071.2.20
Distribution in Nepal: Not reported earlier from Nepal.

Among the families, gomphonemataceae is the largest one (22%) followed by ulnariaceae and naviculaceae (12% each), bacillariaceae (10%) and pinnulariaceae (7%) (Fig. 101).

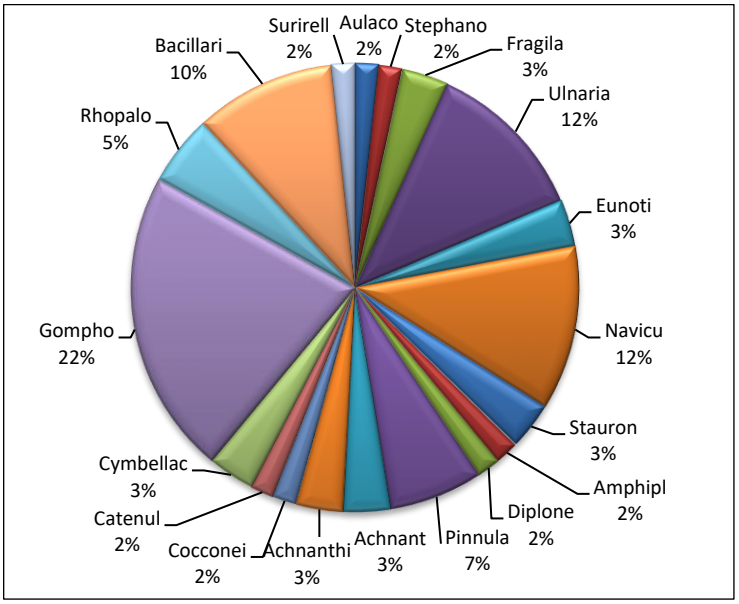


Figure 101. Classwise presentation of total diatoms reported from Hasina pond, Morang.

Among the genera, *Gomphonema* represents the highest number of taxa (11) followed by *Ulnaria* (7 taxa) and then *Navicula*, *Nitzschia* and *Pinnularia* (4 taxa each) (Fig. 102). Genera with single taxa were *Aulacoseira*, *Cyclotella*, *Caloneis*, *Amphipleura*, *Diploneis*, *Lemnicola*, *Planothidium*, *Cocconeis*, *Encyonema*, *Placoneis*, *Epithemia*, *Bacillaria*, *Hantzschia and Surirella*.

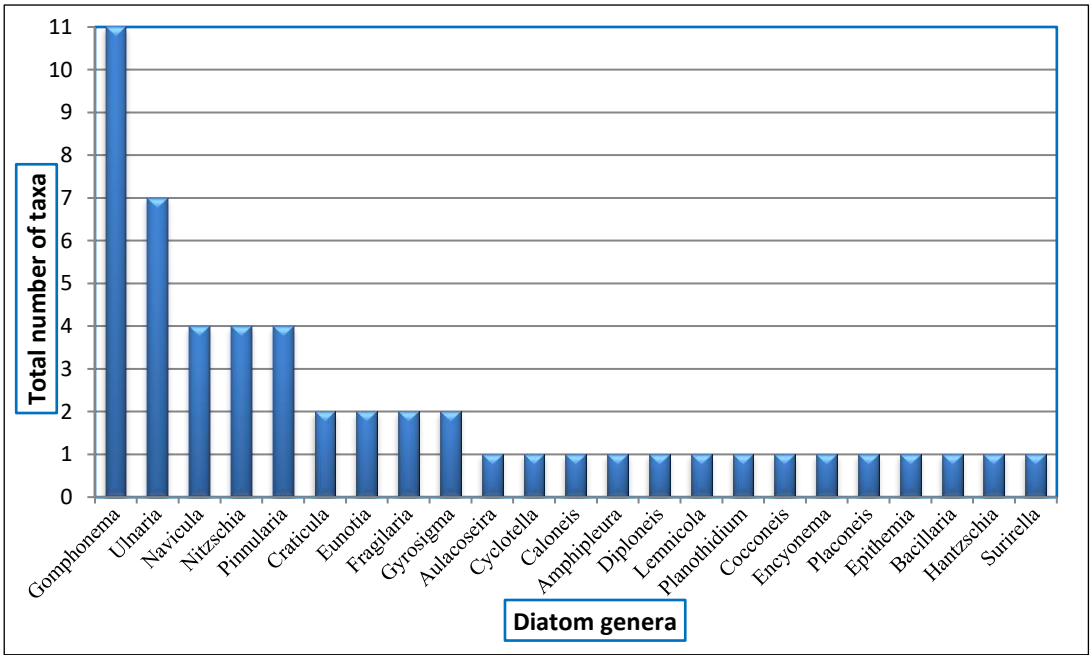


Figure 102. Diatom genera representing their number of taxa.

Seasonal occurence

Maximum diatoms were reported in summer (40%) and least in monsoon (28%) seasons (Fig. 103).

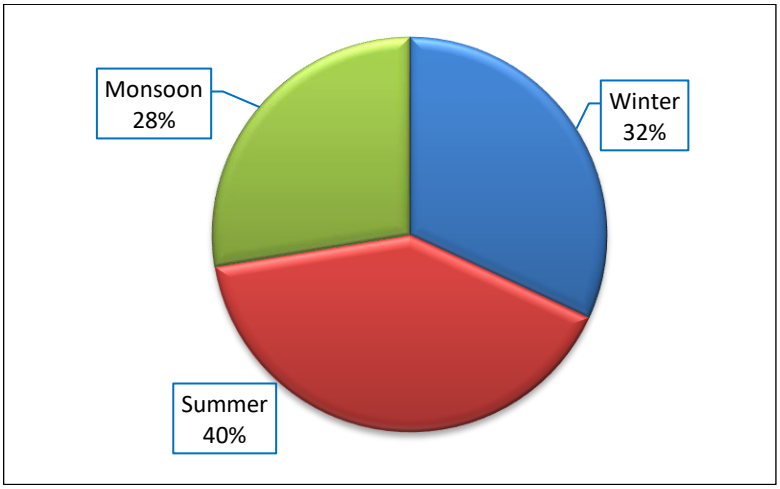


Figure 103. Seasonal occurrence of diatoms in Hasina pond, Morang.

Diatoms found in all three seasons were *Aulacoseira granulata* var. *angustissima, Fragilaria brevistriata, Ulnaria acus, U. capitata, U. ulna, Eunotia bilunaris, Navicula radiosa, Pinnularia amabilis, Lemnicola hungarica, Planothidium biporomum, Gomphonema affine, G. pseudoaugur, G. sagitta, G. truncatum, Epithemia adnata, Rhopalodia gibba,* and *Nitzschia palea* (Table 2). *Ulnaria amphirhynchus* and *Gomphonema micropus* were collected only in winter season where as *Navicula notha, Diploneis elliptica, Achnanthes exigua, Gomphonema intricatum, G. spiculoides* and *Bacillaria paradoxa* were collected only in monsoon season.

Table 2. Seasonal occurence of diatoms in Hasina pond, Morang.

Diatoms	Occurrence of diatoms in different seasons		
	Winter	**Summer**	**Monsoon**
1. *Aulacoseira granulata* var. *angustissima*	++	++	+
2. *Cyclotella meneghiniana*	+	+	-
3. *Fragilaria brevistriata*	++	+++	+
4. *F. capucina* var. *rumpens*	+	-	+
5. *Ulnaria acus*	+	++++	+++
6. *U. amphirhynchus*	+	-	-
7. *U.* cf. *biceps*	+	++	-
8. *U. capitata*	+	+++	++
9. *U. danica*	-	+	-
10. *U. ulna*	++++	++	++++
11. *U. ulna* var. *subaequalis*	-	+	-
12. *Eunotia bilunaris*	+	++	+
13. *E. tschirchiana*	-	+	-
14. *Caloneis bacillum*	+	++	-

15. *Navicula americana*	+	+	-
16. *N. capitatoradiata*	+	+	-
17. *N. notha*	-	-	+
18. *N. radiosa*	+++	++	+++
19. *N. simulata*	-	+	-
20. *Gyrosigma acuminatum*	-	+	-
21. *Gyrosigma scalproides*	-	+	+
22. *Craticula ambigua*	+	+	-
23. *C. cuspidata*	-	+	-
24. *Amphipleura pellucida*	+	++	-
25. *Diploneis elliptica*	-	-	+
26. *Pinnularia acrosphaeria*	-	++	+
27. *P. amabilis*	+++	++++	++
28. *P. stidolphii*	-	+	-
29. *Achnanthes exigua*	-	-	+
30. *A. inflata*	-	+	-
31. *Lemnicola hungarica*	+	+++	+++
32. *Planothidium biporomum*	++	++	+
33. *Cocconeis placentula* v. *euglypta*	+	+	-
34. *Amphora copulata*	-	+	+
35. *Cymbella parva*	+	++	-
36. *C. tumida*	++	-	+
37. *Encyonema silesiacum*	+	+	-
38. *Placoneis constans* var. *symmetrica*	-	+	-
39. *Gomphonema acidoclinatum*	+	+	-
40. *G. affine*	++	++	+
41. *G. clavatum*	+	-	+
42. *G. intricatum*	-	-	+
43. *G. micropus*	+	-	-
44. *G. parvulum*	+	+	-
45. *G. pseudoaugur*	+	+++	++
46. *G. sagitta*	++	+	+
47. *G. spiculoides*	-	-	+
48. *G. subclavatum*	+	-	+
49. *G. truncatum*	++	++++	+
50. *Epithemia adnata*	++++	++++	++
51. *Rhopalodia gibba*	++++	++++	++
52. *R. musculus*	+	++	-
53. *Bacillaria paradoxa*	-	-	+
54. *Nitzschia palea*	++	++++	++
55. *N. paleacea*	-	+	-
56. *N. pumila*	-	+	-
57. *N. recta*	+	++	-
58. *Hantzschia amphioxys*	-	+	+
59. *Surirella bifrons*	-	+	+
Total number of diatoms	**37**	**47**	**32**

(++++ Dominant, +++ Common, ++ Frequent, + Scarce, - Absent)

Diatoms collected only in summer season were *Ulnaria danica, U. ulna* var. *subaequalis, Eunotia tschirchiana, Navicula simulate, Gyrosigma acuminatum, Craticula cuspidata, Pinnularia stidolphii, Achnanthes inflata, Placoneis constans var. symmetrica, Nitzschia palea* and *N. pumila.*

The dominant diatoms reported from Hasina pond were *Epithemia adnata, Rhopalodia gibba, Gomphonema truncatum, Nitzschia palea, Ulnaria acus, U. ulna* and *Pinnularia amabilis* (Table 2).

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