

Research Article

Checklist of phytoplankton of the foot hill belt of Arunachal Himalayas

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ABSTRACT

Based on a yearlong random floristic survey on various locations, a checklist of the phytoplankton flora in the foot hill belt of Arunachal Himalayas was compiled. The current list contains 116 phytoplankton taxa representing 6 algal phyla, 35 families and 55 genera which were more than the results of all previous survey. With 34 taxa, Chlorophyta was the richest phylum followed by Charophyta (31), Bacillariophyta (27), Euglenozoa (14), Cyanobacteria (6) and Ochrophyta (4) respectively. Among the families, Desmidiaceae was the most species rich one with 19 species. *Closterium* and *Cosmarium* were the dominant genera with 11 species each. A total of 90 phytoplankton species were reported for the first time from foot hill belt of Arunachal Himalayas.

Key words: Floristic survey, algal diversity, Desmidiaceae, *Closterium*, *Cosmarium*

INTRODUCTION

Being a part of Himalaya biodiversity hotspot (Myers *et al.*, 2000), Arunachal Pradesh which is located at the trail of Eastern Himalaya is well known for its rich biological wealth. Continuous surveys have been undertaken throughout the state from lower Himalayan foothills up to alpine part (Das, 2016) to uncover the hidden biological wealth in different occasions by different researchers leading to discovery and rediscovery of a good number of taxa. Majority of these exploration works were to document the animalcules and in case of plants, these explorations were meant for higher group of plants (Borah *et al.*, 2020). The exploration on lower to higher cryptogamic flora was found to be scanty in the state (Das and Adhikary, 2012) which could be attributed to its difficult terrain position throughout the region. Phytoplankton is one such group on which a little information has so far been reported not only from Arunachal Himalaya (Reddy *et al.*, 1986; Singh *et al.*, 1997; Mikter *et al.*, 2006; Devi *et al.*, 2010; Oinam *et al.*, 2010; Das and Adhikary, 2012; Choudhary and Singh, 2013; Bhakta and Adhikary, 2014; Das, 2016; Ganie *et al.*, 2018; and Radhakrishnan *et al.*, 2020) but also from the entire stretch of eastern Himalaya (Prasad and Mishra, 1987; Kumar and Rai, 2005; Suseela and Toppo, 2006, 2007; Bhakta *et al.*, 2010; Das and Keshri, 2012; Das and Keshri, 2013 a, b, c; Das, 2015; Chettri and Thapa, 2016; Chettri *et al.*, 2020) which hence, needs intervention and fresh exploration in the entire Eastern Himalayas in general and Arunachal Himalayas in particular.

The land of Arunachal Pradesh could be categorized into three major climatic zones as hot and humid subtropical foothill belt, the cooler and microthermal region of lesser Himalayas and the cold Himadri type in upper region. The region is prominently characterized by uneven and undulating territory interspersed with a good number of lotic and lentic water bodies originated

due to varied geo-morphological features in the historical past. All these water bodies are the repository of typical biological wealth (Sinha and Tamang, 2015) which are yet to be fully explored. As the phytoplankton always play a proactive role in the maintenance of any aquatic ecosystem irrespective of its geographical locations throughout the globe (Vallinaa *et al.*, 2017), the present study was therefore aimed to prepare a checklist of the hitherto unknown phytoplankton flora growing in the lentic water bodies to fill up the existing knowledge gap in lower Himalayan foothill tracts of Eastern Himalaya with special reference to Arunachal Pradesh of India.

MATERIALS AND METHOD

Sample collection and identification:

Phytoplankton samples were collected randomly from different lentic water bodies (Figure 1) between March 2019 and February 2020. Samples were collected between 6 am to 10 am from each study site by filtering about 20 liters of water through the plankton net of mesh size 20 µm in clean plastic bottles and fixed with Lugol's iodine solution on the spot. The collected samples were transferred to Plant Ecology Laboratory of Department of Botany, Gauhati University and observed under Euromex (Delphi-X Observer series) compound microscope in different magnifications. Photographs were taken with the help of a digital camera (Euromex 20MP). The phytoplankton samples were identified by consulting the standard literatures and monographs of Desikachary (1959), Gonzalves (1981), Iyenger and Desikachary (1981), Prasad and Mishra (1992), Kargupta and Jha (2004), John *et al.*, 2005, Perumal and Anand (2009), Yamagishi (2010), Karthick *et al.*, 2013, Komarek (2013), Das and Adhikary (2014) and Das and Keshri (2016). The taxa were then authenticated with Algae Base (Guiry and Guiry, 2020) and arranged accordingly.

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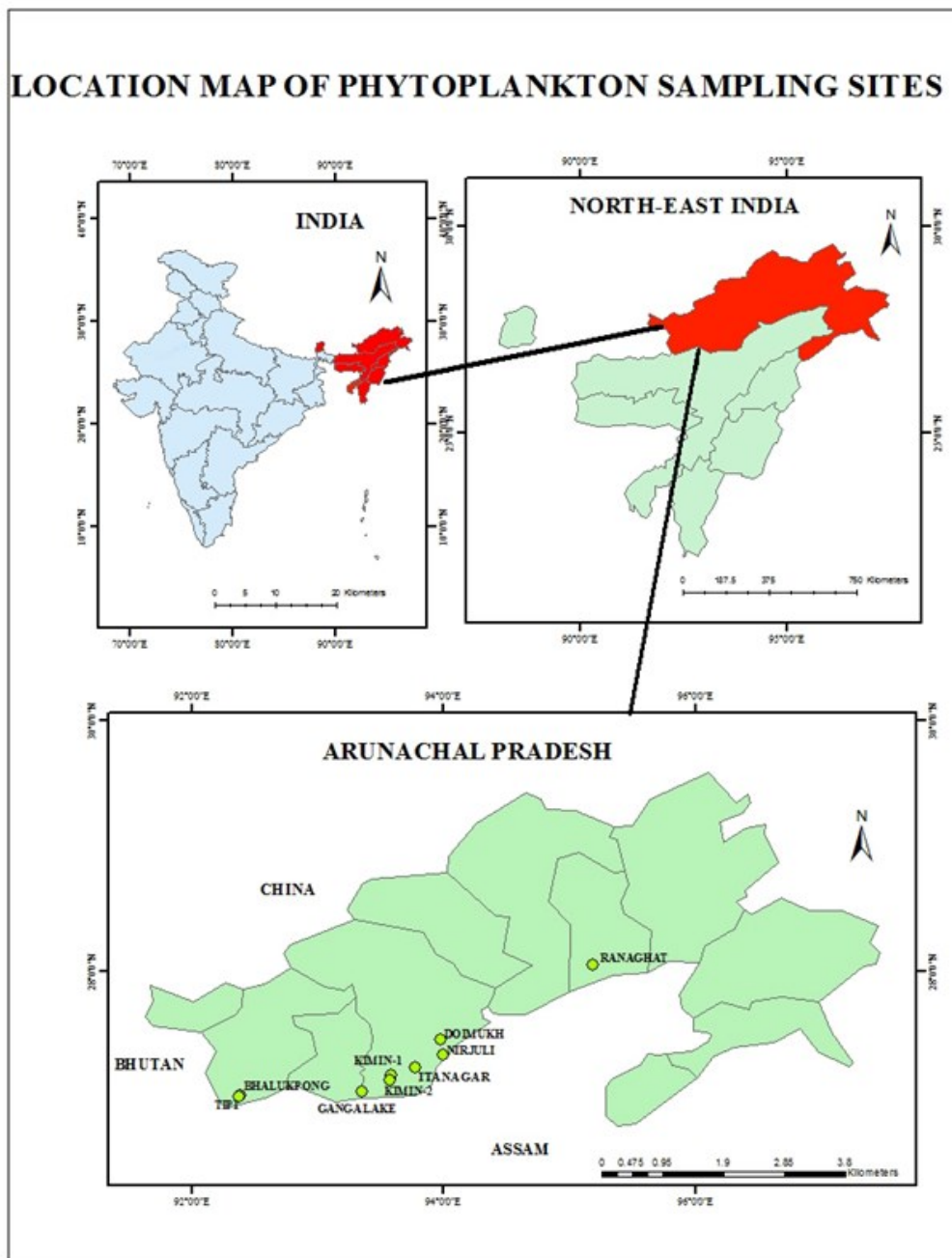


Figure 1. Map of Arunachal Himalaya showing phytoplankton sampling sites.

RESULTS

The current list contains one hundred and sixteen phytoplankton taxa belonging to six different algal phyla. With 34 taxa, Chlorophyta was the richest phylum followed by Charophyta (31), Bacillariophyta (27), Euglenozoa (14), Cyanobacteria (6) and Ochrophyta (4) respectively.

The top five species rich families of phytoplankton in this checklist were Desmidiaceae (19), Scenedesmaceae (13), Closteriaceae (11), Phacidae (9) and Hydrodictyaceae (7) respectively (Table 1). The top six species-rich genera were *Closterium*, *Cosmarium*, *Gomphonema*, *Pinnularia*, *Phacus* and *Trachelomonas* (Table 2).

Table 1. Top five species rich families of phytoplankton in foot hill belt of Arunachal Himalayas

Top 5 species-rich families		
Family	No. of Genera	No. of Species
Desmidiaceae	5	19
Scenedesmaceae	6	13
Closteriaceae	1	11
Phacidae	2	9
Hydrodictyaceae	6	7

Table 2. Top six species rich genera of phytoplankton in foot hill belt of Arunachal Himalayas

Top 6 species-rich Genera	
Genus	No. of Species
<i>Closterium</i>	11
<i>Cosmarium</i>	11
<i>Gomphonema</i>	5
<i>Pinnularia</i>	5
<i>Phacus</i>	5
<i>Trachelomonas</i>	5

Checklist:

The taxon names were systematically arranged for each record along with the information on place (s) of collection and previous report(s) from the region.

PHYLUM-BACILLARIOPHYTA**Family - Aulacoseiraceae**

1 Genus, 1 Species

Aulacoseira granulata (Ehrenberg) Simonsen 1979: 58 (Pl. 1, Fig. 1)

Previous report- Das and Adhikary (2012)

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)

Family - Bacillariaceae

1 Genus, 2 Species

Nitzschia reversa W.Smith 1853: 43, pl. 15: fig. 121 (Pl. 1, Fig. 2)

First record from Arunachal Pradesh

Place of Collection- Bhalukpong (27°01' 04" N 92°38' 17E), Doimukh (27°8' 52" N 93°45' 13" E)

Nitzschia umbonata (Ehrenberg) Lange-Bertalot 1978: 648, pls 1, 2, 4 (Pl. 1, Fig. 3)

First record from Arunachal Pradesh

Place of Collection- Ranaghat (28°5' 57" N 95°18' 24E)

Family - Catenulaceae

1 Genus, 1 Species

Amphora ovalis (Kützing) Kützing 1844: 107, pl. 5: figs 35, 39 (Pl. 1, Fig. 4)

First record from Arunachal Pradesh

Place of Collection- Tipi (27°01' 51" N 92°36' 59E), Doimukh (27°8' 52" N 93°45' 13" E)

Family - Cymbellaceae

1 Genus, 1 Species

Cymbella parva (W.Smith) Kirchner 1878: 118 (Pl. 1, Fig. 5)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)

Family - Diadesmidaceae

1 Genus, 1 Species

Diadesmis confervacea Kützing 1844: 109, pl. 30: fig. 8 (Pl. 1, Fig. 6)

Previous report- Das and Adhikary (2012), Das (2016)

Place of Collection- Itanagar (27°4' 52" N 93°35' 39" E), Ranaghat (28°5' 57" N 95°18' 24E)

Family - Eunotiaceae

1 Genus, 2 Species

Eunotia bilunaris (Ehrenberg) Schaarschmidt in Kanitz 1880: 159 (Pl. 1, Fig. 7)

First record from Arunachal Pradesh

Place of Collection- Tipi (27°01' 51" N 92°36' 59E)

Eunotia naegelii Migula 1905: 203 (Pl. 1, Fig. 8)

First record from Arunachal Pradesh

Place of Collection- Bhalukpong (27°01' 04" N 92°38' 17E), Doimukh (27°8' 52" N 93°45' 13" E)

Family - Fragilariaceae

1 Genus, 1 Species

Fragilaria tenera (W.Smith) Lange-Bertalot 1980: 746 (Pl. 1, Fig. 9)

Previous report- Das and Adhikary (2012)

Place of Collection- Ranaghat (28°5' 57" N 95°18' 24E)

Family - Gomphonemataceae

2 Genera, 6 Species

Gomphonema affine Kützing 1844: 86, pl. 30: fig. 54 (Pl. 1, Fig. 10)

Previous report- Das (2016)

Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)

Gomphonema hebridense W.Gregory 1854: 99, pl. 4: fig. 19 (Pl. 1, Fig. 11)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Itanagar (27°4' 52" N 93°35' 39" E)

Gomphonema lagenula Kützing 1844: 85, pl. 30: fig. 60 (Pl. 1, Fig. 12)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18' 4" N 93°58' 15" E), Ganga lake (27°4' 33" N 93°34' 8" E)

Gomphonema pseudoaugur Lange-Bertalot 1979: 202, figs 11-16 (Pl. 1, Fig. 13)

First record from Arunachal Pradesh

Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)

Gomphonema pseudosphaerophorum H.Kobayashi in Ueyama & H.Kobayashi 1988: 452, pl. 1: figs 1-10 (Pl. 1, Fig. 14)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18' 13" N 93°58' 6" E)

Placoneis molestissima Metzeltin, Lange-Bertalot & García-Rodríguez (Pl. 1, Fig. 15)

First record from Arunachal Pradesh

Place of Collection- Tipi (27°01' 51" N 92°36' 59E)

Family - Melosiraceae

1 Genus, 1 Species

Melosira aequalis C.Agardh 1832: 64, no fig. (Pl. 1, Fig. 16)

First record from Arunachal Pradesh

Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)

Family - Naviculaceae

1 Genus, 1 Species

Gyrosigma scalpoides (Rabenhorst) Cleve 1894: 118 (Pl. 1, Fig. 17)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18' 13" N 93°58' 6" E), Itanagar (27°4' 52" N 93°35' 39" E)

Family - Pinnulariaceae

1 Genus, 5 Species

Pinnularia acrosphaeria W.Smith 1853: 58, pl. XIX [19]: fig. 183 (Pl. 1, Fig. 18)

First record from Arunachal Pradesh

Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)

Pinnularia interrupta W.Smith 1853: 59, pl. 19: fig. 184 (Pl. 1, Fig. 19)

Previous report- Das and Adhikary (2012)

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)
Pinnularia latarea Krammer 2000: 110, 224, pl. 80: figs 1-6; pl. 84: figs 13-15 (Pl. 1, Fig. 20)
 First record from Arunachal Pradesh
 Place of Collection- Kimin (27°18' 13" N 93°58' 6" E)
Pinnularia subsimilis H.P.Gandhi (Pl. 1, Fig. 21)
 Previous report- Das and Adhikary (2012)
 Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)
Pinnularia viridis (Nitzsch) Ehrenberg 1843: 305, 315 (adnot.), 385 [pl. 1: fig. 7] (Pl. 1, Fig. 22)
 Previous report- Das and Adhikary (2012)
 Place of Collection- Bhalukpong (27°01' 04" N 92°38' 17E), Itanagar (27°4' 52" N 93°35' 39" E)

Family - Rhopalodiaceae

1 Genus, 1 Species

Epithemia gibba (Ehrenberg) Kützing 1844: 35, pl. 4, fig. 22 (Pl. 1, Fig. 23)
 First record from Arunachal Pradesh
 Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)

Family - Stephanodisceae

1 Genus, 1 Species

Discostella stelligera (Cleve & Grunow) Houk & Klee 2004: 208 (Pl. 1, Fig. 24)
 Previous report- Das and Adhikary (2012)
 Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)

Family - Ulnariaceae

1 Genus, 3 Species

Ulnaria amphirhynchus (Ehrenberg) Compère & Bukhtiyarova in Bukhtiyarova & Compère 2006: 280 (Pl. 1, Fig. 25)
 Previous report- Das and Adhikary (2012)
 Place of Collection- Ranaghat (28°5' 57" N 95°18' 24E)
Ulnaria delicatissima (W.Smith) Aboal & P.C.Silva 2004: 361 (Pl. 1, Fig. 26)
 Previous report- Das and Adhikary (2012)
 Place of Collection- Ranaghat (28°5' 57" N 95°18' 24E)
Ulnaria ulna (Nitzsch) Compère 2001: 100 (Pl. 1, Fig. 27)
 First record from Arunachal Pradesh
 Place of Collection- Bhalukpong (27°01' 04" N 92°38' 17E)

PHYLUM-CHAROPHYTA

Family - Closteriaceae

1 Genus, 11 Species

Closterium acerosum Ehrenberg ex Ralfs 1848: 164, pl. XXVII [27]: fig. 2 a, b, d-e (Pl. 1, Fig. 28)
 Previous report- Das (2016)
 Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)
Closterium bitangchoianum J.P.Keshri & D.Das in D.Das & J.P.Keshri 2016: 68, pl. XVIII [18]: figs 337, 338 (Pl. 1, Fig. 29)
 First record from Arunachal Pradesh
 Place of Collection- Kimin (27°18' 13" N 93°58' 6" E)
Closterium gracile Brébisson ex Ralfs 1848: 221, pl. XXI [21]: figs 8-12 (Pl. 1, Fig. 30)
 First record from Arunachal Pradesh
 Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)
Closterium incurvum Brébisson 1856: 150, pl. 2: fig. 47 (Pl. 1, Fig. 31)
 First record from Arunachal Pradesh
 Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)
Closterium kuetzingii Brébisson 1856: 156, pl. 2: fig. 40 (Pl. 1, Fig. 32)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18' 13" N 93°58' 6" E)
Closterium lunula Ehrenberg & Hemprich ex Ralfs 1848: 163, pl. XXVII [27]: fig. 1 (Pl. 1, Fig. 33)
 First record from Arunachal Pradesh
 Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E), Itanagar (27°4' 52" N 93°35' 39" E)
Closterium navicula (Brébisson) Lütkenmüller 1905: 337 (Pl. 1, Fig. 34)
 Previous report- Das (2016)
 Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)
Closterium pritchardianum f. *attenuatum* Irénée-Marie 1954: 38, pl. II [2]: fig. 5 (as '*attenuata*') (Pl. 1, Fig. 35)
 First record from Arunachal Pradesh
 Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)
Closterium pseudocynthia J.P.Keshri & D.Das in D.Das & J.P.Keshri 2016: 83, pl. XX [20]: figs 365, 366 (Pl. 1, Fig. 36)
 First record from Arunachal Pradesh
 Place of Collection- Kimin (27°18' 4" N 93°58' 15" E)
Closterium rostratum Ehrenberg ex Ralfs 1848: 175, pl. XXX [30]: fig. 3 (Pl. 1, Fig. 37)
 First record from Arunachal Pradesh
 Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E), Itanagar (27°4' 52" N 93°35' 39" E)
Closterium submoniliferum var. *malinvernianum* (De Notaris) Coesel in Coesel & Meesters 2007: 53, pl. 15: fig. 5 (Pl. 1, Fig. 38)
 First record from Arunachal Pradesh
 Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)

Family - Desmidiaceae

5 Genera, 19 Species
Cosmarium forceps Brühl & Biswas 1926: 286, pl. 15: fig. 86 (Pl. 1, Fig. 39)
 First record from Arunachal Pradesh
 Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Kimin (27°18' 4" N 93°58' 15" E), Itanagar (27°4' 52" N 93°35' 39" E)
Cosmarium lundellii Delponte 1877: 13, pl. 7: figs 62-64 (Pl. 1, Fig. 40)
 First record from Arunachal Pradesh
 Place of Collection- Kimin (27°18' 4" N 93°58' 15" E)
Cosmarium lundellii var. *ellipticum* West & G.S.West 1894: 5, pl. I [1]: fig. 11 (Pl. 2, Fig. 41)
 First record from Arunachal Pradesh
 Place of Collection- Kimin (27°18' 13" N 93°58' 6" E)
Cosmarium norimbergense Reinsch 1867: 117, pl. 22: figs A-IV: 1-11 (Pl. 2, Fig. 42)
 First record from Arunachal Pradesh
 Place of Collection- Bhalukpong (27°01' 04" N 92°38' 17E)
Cosmarium norimbergense var. *depressum* (West & G.S.West) Willi Krieger & Gerloff 1969: 292, pl. 48: fig. 1 (Pl. 2, Fig. 43)
 First record from Arunachal Pradesh
 Place of Collection- Tipi (27°01' 51" N 92°36' 59E)
Cosmarium porteanum f. *pseudoporteanum* J.P.Keshri & D.Das in D.Das & J.P.Keshri 2016: 116, pl. VI [6]: figs 187, 188 (Pl. 2, Fig. 44)
 First record from Arunachal Pradesh
 Place of Collection- Kimin (27°18' 13" N 93°58' 6" E)
Cosmarium pseudoretusum var. *inaequalipellucum* (West & G.S.West) Willi Krieger & Gerloff 1962: 97, pl. 20: fig. 20 (Pl. 2, Fig. 45)
 First record from Arunachal Pradesh
 Place of Collection- Kimin (27°18' 4" N 93°58' 15" E)
Cosmarium regnellii Wille 1884: 16, pl. I [1]: fig. 34 (Pl. 2, Fig. 46)

Previous report- Das (2016)

Place of Collection- Tipi (27°01' 51"N 92°36' 59"E), Ganga lake (27°4' 33"N 93°34' 8"E)

Cosmarium regnesi Reinsch 1866: 116, pl. XXII [22]: A; III [3] (Pl. 2, Fig. 47)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33"N 93°34' 8"E)

Cosmarium rosae Ruzicka 1949: 84, figs 1-9; pl. XV [15] (Pl. 2, Fig. 48)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18' 4"N 93°58' 15"E)

Cosmarium undulatum f. *reductum* Croasdale 1956: 59, pl. 3: fig. 9 (as '*var. alaskanum* f. *reductum*') (Pl. 2, Fig. 49).

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33"N 93°34' 8"E)

Euastrum denticulatum var. *quadrifarium* Willi Krieger 1937: 585, pl. 80: figs 20, 21 (Pl. 2, Fig. 50)



Photo plate 1. Fig. 1. *Aulacoseira granulata* 2. *Nitzschia revers* 3. *Nitzschia umbonata* 4. *Amphora ovalis* 5. *Cymbella parva* 6. *Diademesis confervacea* 7. *Eunotia bilunaris* 8. *Eunotia naegelii* 9. *Fragilaria tenera* 10. *Gomphonema affine* 11. *Gomphonema hebridense* 12. *Gomphonema lagenula* 13. *Gomphonema pseudoaugur* 14. *Gomphonema pseudosphaerophorum* 15. *Placoneis molestissima* 16. *Melosira aequalis* 17. *Gyrosigma scalproides* 18. *Pinnularia acrosphaeria* 19. *Pinnularia interrupta* 20. *Pinnularia latarea* 21. *Pinnularia subsimilis* 22. *Pinnularia viridis* 23. *Epithemia gibba* 24. *Discostella stelligera* 25. *Ulnaria amphirhynchus* 26. *Ulnaria delicatissima* 27. *Ulnaria ulna* 28. *Closterium acerosum* 29. *Closterium bitangchoianum* 30. *Closterium gracile* 31. *Closterium incurvum* 32. *Closterium kuetzingii* 33. *Closterium lunula* 34. *Closterium navicula* 35. *Closterium pritchardianum* f. *attenuatum* 36. *Closterium pseudocynthia* 37. *Closterium rostratum* 38. *Closterium submoniliferum* var. *malinvernianum* 39. *Cosmarium forceps* 40. *Cosmarium lundellii* (Scale bar = 10 μ m)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18' 13" N 93°58' 6" E)

Euastrum elegans Ralfs 1848: 89, pl. XIV [14]: figs 7b-d (Pl. 2, Fig. 51)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Itanagar (27°4' 52" N 93°35' 39" E)

Euastrum luetkemulleri F.Ducellier 1918: 134, fig. 123a (as '*lütkemüllerii*') (Pl. 2, Fig. 52)

First record from Arunachal Pradesh

Place of Collection- Bhalukpong (27°01' 04" N 92°38' 17" E)

Euastrum spinulosum var. *lindiae* Grönblad & A.M.Scott 1958: 17: pl. VII [7]: figs 84-88, photo 347 (Pl. 2, Fig. 53)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Kimin (27°18' 13" N 93°58' 6" E)

Micrasterias foliacea Bailey ex Ralfs 1848: 210, pl. XXXV [35]: fig. 3 (Pl. 2, Fig. 54)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Tipi (27°01' 51" N 92°36' 59" E)

Micrasterias pinnatifida Ralfs 1848: 77, pl. X [10]: fig. 3 (Pl. 2, Fig. 55)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Kimin (27°18' 4" N 93°58' 15" E)

Pleurotaenium ehrenbergii (Ralfs) De Bary 1858: index, 75 (Pl. 2, Fig. 56)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Kimin (27°18' 13" N 93°58' 6" E), Nirjuli (27°7' 56" N 93°44' 48" E)

Staurastrum margaritaceum Meneghini ex Ralfs 1848: 134, pl. XXI [21]: fig. 9 a-e (Pl. 2, Fig. 57)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)

Family - Zygnemataceae

1 Genus, 1 Species

Spirogyra parvula (Transeau) Czurda 1932: 170 (Pl. 2, Fig. 58)

Previous report- Das and Adhikary (2012), Bhakta and Adhikary (2014)

Place of Collection- Bhalukpong (27°01' 04" N 92°38' 17" E), Itanagar (27°4' 52" N 93°35' 39" E), Doimukh (27°8' 52" N 93°45' 13" E)

PHYLUM-CHLOROPHYTA

Family - Botryococcaceae

1 Genus, 1 Species

Botryococcus braunii Kützing 1849: 892 (Pl. 2, Fig. 59)

Previous report- Das and Adhikary (2012)

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Kimin (27°18' 4" N 93°58' 15" E)

Family - Chlorellaceae

2 Genera, 2 Species

Actinastrum hantzschii var. *subtile* Woloszynska 1911: 227, pl. III [3]: fig. 3 (Pl. 2, Fig. 60)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)

Dictyosphaerium granulatatum Hindák 1977: 39, pl. 11: figs 7-10 (Pl. 2, Fig. 61)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Kimin (27°18' 13" N 93°58' 6" E)

Family - Eremosphaeraceae

1 Genus, 1 Species

Neglectella solitaria (Wittrock) Stenclová & Kastovsky in Stenclová et al 2017: 1268 (Pl. 2, Fig. 62)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18' 4" N 93°58' 15" E)

Family - Hydrodictyaceae

6 Genera, 7 Species

Hydrodictyon reticulatum (Linnaeus) Bory 1824: 506 (Pl. 2, Fig. 63)

First record from Arunachal Pradesh

Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E)

Lacunastrum gracillimum (West & G.S.West) H.McManus in McManus & al. 2011: 128, 129, fig. 4 (Pl. 2, Fig. 64)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18' 4" N 93°58' 15" E), Ganga lake (27°4' 33" N 93°34' 8" E)

Pediastrum duplex Meyen 1829: 772, pl. XLIII [43]: figs 6-20 (Pl. 2, Fig. 65)

First record from Arunachal Pradesh

Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E), Ranaghat (28°5' 57" N 95°18' 24" E)

Sorastrum americanum (Bohlin) Schmidle 1899: 230 (Pl. 2, Fig. 66)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18' 4" N 93°58' 15" E), Kimin (27°18' 13" N 93°58' 6" E)

Stauridium tetras (Ehrenberg) E.Hegewald in Buchheim & al. 2005: 1051 (Pl. 2, Fig. 67)

Previous report- Das and Adhikary (2012)

Place of Collection- Itanagar (27°4' 52" N 93°35' 39" E)

Stauridium tetras var. *tetraodon* (Corda) J.D.Hall & Karol 2016: 153 (Pl. 2, Fig. 68)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)

Tetraëdron minimum (A.Braun) Hansgirg 1889: 133 (Pl. 2, Fig. 69)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Kimin (27°18' 4" N 93°58' 15" E)

Family - Scenedesmaceae

6 Genera, 13 Species

Coelastrum astroideum De Notaris 1867: 80, pl. IX [9]: fig. 93 (Pl. 2, Fig. 70)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Kimin (27°18' 4" N 93°58' 15" E)

Coelastrum microporum Nägeli in A.Braun 1855: 70, adnot. (Pl. 2, Fig. 71)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Doimukh (27°8' 52" N 93°45' 13" E)

Coelastrum pseudomicroporum Korshikov 1953: 347, fig. 318 (Pl. 2, Fig. 72)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E), Bhalukpong (27°01' 04" N 92°38' 17" E)

Desmodesmus abundans (Kirchner) E.H.Hegewald 2000: 1 (Pl. 2, Fig. 73)

Previous report- Das and Adhikary (2012)

Place of Collection- Ranaghat (28°5' 57" N 95°18' 24" E), Itanagar (27°4' 52" N 93°35' 39" E)

Desmodesmus armatus var. *longispina* (Chodat) E.Hegewald 2000: 5 (Pl. 2, Fig. 74)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)
Desmodesmus opoliensis var. *mononensis* (Chodat)
 E.Hegewald 2000: 15 (Pl. 2, Fig. 75)
 First record from Arunachal Pradesh
 Place of Collection- Ranaghat (28°5' 57" N 95°18' 24"E),
 Tipi (27°01' 51"N 92°36' 59"E)
Dimorphococcus cordatus Wolle 1887: 199, pl. CLX
 [160]: figs 30-38 (Pl. 2, Fig. 76)
 First record from Arunachal Pradesh
 Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E)

Scenedesmus pseudopoliensis Hortobágyi 1969: 48, 68,
 fi. 229, 230 (as '*pseudoopoliensis*') (Pl. 3, Fig. 77)
 Previous report- Das and Adhikary (2012), Bhakta and
 Adhikary (2014)
 Place of Collection- Nirjuli (27°7' 56" N 93°44' 48" E),
 Ganga lake (27°4' 33" N 93°34' 8" E)
Tetrademus dimorphus (Turpin) M.J.Wynne 2016: 84
 (Pl. 3, Fig. 78)
 First record from Arunachal Pradesh
 Place of Collection- Ganga lake (27°4' 33" N 93°34' 8" E),
 Itanagar (27°4' 52" N 93°35' 39" E)

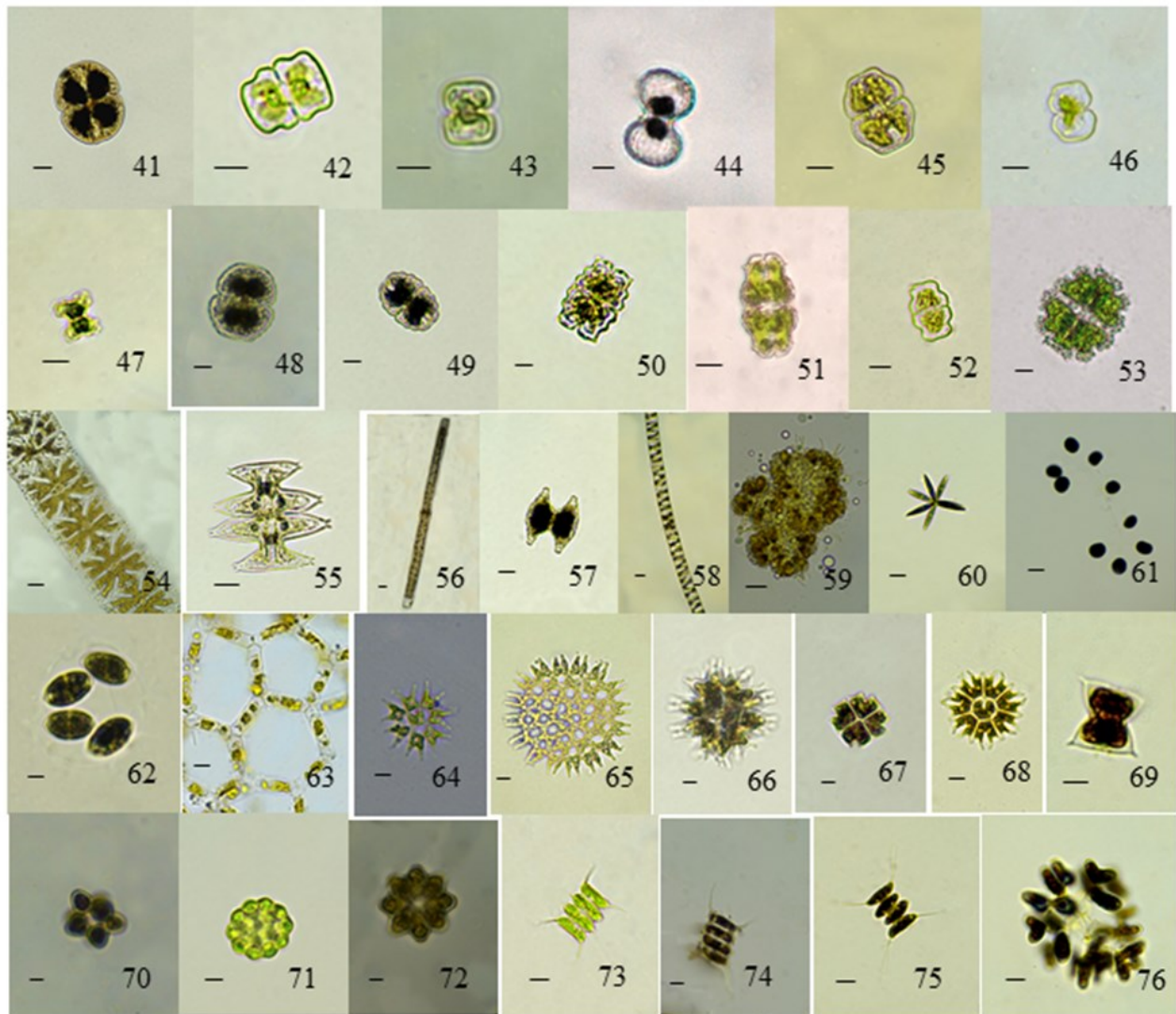


Photo plate 2. Fig. 41. *Cosmarium lundellii* var. *ellipticum* 42. *Cosmarium norimbergense* 43. *Cosmarium norimbergense* var. *depressum* 44. *Cosmarium porteanum* f. *pseudoporteanum* 45. *Cosmarium pseudoretusum* var. *inaequalipellicum* 46. *Cosmarium regnellii* 47. *Cosmarium regnesi* 48. *Cosmarium rosae* 49. *Cosmarium undulatum* f. *reductum* 50. *Euastrum denticulatum* var. *quadrifarium* 51. *Euastrum elegans* 52. *Euastrum luetkemulleri* 53. *Euastrum spinulosum* var. *lindiae* 54. *Micrasterias foliacea* 55. *Micrasterias pinnatifida* 56. *Pleurotaenium ehrenbergii* 57. *Staurastrum margaritaceum* 58. *Spirogyra parvula* 59. *Botryococcus braunii* 60. *Actinastrum hantzschii* var. *subtile* 61. *Dictyosphaerium granulatum* 62. *Neglectella solitaria* 63. *Hydrodictyon reticulatum* 64. *Lacunastrum gracillimum* 65. *Pediastrum duplex* 66. *Sorastrum americanum* 67. *Stauridium tetras* 68. *Stauridium tetras* var. *tetraodon* 69. *Tetraëdron minimum* 70. *Coelastrum astroideum* 71. *Coelastrum microporum* 72. *Coelastrum pseudomicroporum* 73. *Desmodesmus abundans* 74. *Desmodesmus armatus* var. *longispina* 75. *Desmodesmus opoliensis* var. *mononensis* 76. *Dimorphococcus cordatus* (Scale bar = 10 µm)

Tetradasmus lagerheimii M.J.Wynne & Guiry 2016: 1 (Pl. 3, Fig. 79)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18'4" N 93°58'15" E)

Tetradasmus obliquus (Turpin) M.J.Wynne 2016: 84 (Pl. 3, Fig. 80)

Previous report- Das and Adhikary (2012), Bhakta and Adhikary (2014)

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E), Ranaghat (28°5'57" N 95°18'24" E)

Tetrastrum elegans Playfair 1917: 832, pl. 57: fig. 6 (Pl. 3, Fig. 81)

First record from Arunachal Pradesh

Place of Collection- Itanagar (27°4'52" N 93°35'39" E)

Tetrastrum glabrum (Y.V.Roll) Ahlstrom & Tiffany 1934: 504 (Pl. 3, Fig. 82)

First record from Arunachal Pradesh

Place of Collection- Nirjuli (27°7'56" N 93°44'48" E)

Family - Selenastraceae

3 Genera, 6 Species

Ankistrodesmus densus Korshikov 1953: 300, fig. 262 a-c (Pl. 3, Fig. 83)

Previous report- Das and Adhikary (2012)

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E)

Ankistrodesmus falcatus (Corda) Ralfs 1848: 180, pl. XXXIV [34]: figs a-c (Pl. 3, Fig. 84)

Previous report- Das (2016)

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E), Kimin (27°18'13" N 93°58'6" E)

Kirchneriella diana (Bohlin) Comas 1980: 4 (Pl. 3, Fig. 85)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E)

Monoraphidium contortum (Thuret) Komárková-Legnerová in Fott 1969: 104, pl. 18: figs 1-5 (Pl. 3, Fig. 86)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E)

Monoraphidium indicum Hindák 1977: 105, pl. 44 (Pl. 3, Fig. 87)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18'13" N 93°58'6" E), Doimukh (27°8'52" N 93°45'13" E)

Monoraphidium tortile (West & G.S.West) Komárková-Legnerová 1969: 103, pl. 17: figs 1-6 (Pl. 3, Fig. 88)

First record from Arunachal Pradesh

Place of Collection- Bhalukpong (27°01'04" N 92°38'17" E)

Family - Oedogoniaceae

1 Genus, 3 Species

Oedogonium undulatum A.Braun ex Hirn 1900: 257, pl. XLV [45]: figs 272-275 (Pl. 3, Fig. 89)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18'4" N 93°58'15" E)

Oedogonium varians Wittrock & Lundell ex Hirn 1900: 84, pl. IV [4]: fig. 23 (Pl. 3, Fig. 90)

First record from Arunachal Pradesh

Place of Collection- Itanagar (27°4'52" N 93°35'39" E)

Oedogonium tiffanyi Ackley 1929: 304, pl. XXXVI: figs 15, 16 (as '*Tiffanii*') (Pl. 3, Fig. 91)

First record from Arunachal Pradesh

Place of Collection- Nirjuli (27°7'56" N 93°44'48" E), Doimukh (27°8'52" N 93°45'13" E)

Family - Treubariaceae

1 Genus, 1 Species

Treubaria setigera (W.Archer) G.M.Smith 1933: 439 (Pl. 3, Fig. 92)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E)

PHYLUM-CYANOBACTERIA

Family - Aphanizomenonaceae

1 Genus, 1 Species

Dolichospermum circinale (Rabenhorst ex Bornet & Flahault) P.Wacklin, L.Hoffmann & J.Komárek 2009: 61 (Pl. 3, Fig. 93)

First record from Arunachal Pradesh

Place of Collection- Itanagar (27°4'52" N 93°35'39" E), Doimukh (27°8'52" N 93°45'13" E)

Family - Merismopediaceae

1 Genus, 1 Species

Aphanocapsa parasitica (Kützing) Komárek & Anagnostidis 1995: 16 (Pl. 3, Fig. 94)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E)

Family - Microcystaceae

1 Genus, 1 Species

Microcystis wesenbergii (Komárek) Komárek ex Komárek in Joosen 2006: 209 (Pl. 3, Fig. 95)

Previous report- Das and Adhikary (2012)

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E)

Family - Nostocaceae

1 Genus, 1 Species

Anabaena oscillarioides Bory ex Bornet & Flahault 1886: 233 (Pl. 3, Fig. 96)

First record from Arunachal Pradesh

Place of Collection- Nirjuli (27°7'56" N 93°44'48" E), Itanagar (27°4'52" N 93°35'39" E)

Family - Oscillatoriaceae

2 Genera, 2 Species

Limnoraphis hieronymusii (Lemmermann) J.Komárek, E.Zapomelová, J.Smarda, J.Kopecký, E.Rejmánková, J.Woodhouse, B.A.Neilan & J.Komárková 2013: 45 (Pl. 3, Fig. 97)

First record from Arunachal Pradesh

Place of Collection- Kimin (27°18'13" N 93°58'6" E)

Oscillatoria anguina Bory ex Gomont 1892: 214, pl. VI/6: fig. 16 (Pl. 3, Fig. 98)

First record from Arunachal Pradesh

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E)

PHYLUM-EUGLENOZOA

Family - Euglenidae

1 Genus, 5 Species

Trachelomonas armata f. *punctata* (Svirenko) Deflandre (as '*var. steinii* f. *punctata*') (Pl. 3, Fig. 99)

Previous report- Das and Adhikary (2012)

Place of Collection- Ganga lake (27°4'33" N 93°34'8" E), Itanagar (27°4'52" N 93°35'39" E)

Trachelomonas dubia Svirenko [Svirenko] 1914: 638, pl. 19: fig. 20 (Pl. 3, Fig. 100)

First record from Arunachal Pradesh

Place of Collection- Nirjuli (27°7'56" N 93°44'48" E), Doimukh (27°8'52" N 93°45'13" E)

Trachelomonas hispida var. *granulata* Playfair 1915: 21, pl. III [3]: figs 11, 12 (Pl. 3, Fig. 101)
 Previous report- Das and Adhikary (2012)
 Place of Collection- Kimin (27°18'4"N 93°58'15"E), Ganga lake (27°4'33"N 93°34'8"E)
Trachelomonas volvocina (Ehrenberg) Ehrenberg 1834: 315 (Pl. 3, Fig. 102)
 Previous report- Das and Adhikary (2012)
 Place of Collection- Ranaghat (28°5'57"N 95°18'24"E), Itanagar (27°4'52"N 93°35'39"E), Ganga lake (27°4'33"N 93°34'8"E), Kimin (27°18'13"N 93°58'6"E)
Trachelomonas volvocina var. *punctata* Playfair 1915: 9, pl. I [1]: fig. 2 (Pl. 3, Fig. 103)

Previous report- Das and Adhikary (2012), Das (2016)
 Place of Collection- Kimin (27°18'13"N 93°58'6"E), Kimin (27°18'4"N 93°58'15"E)

Family - Phacidae

2 Genera, 9 Species

Lepocinclis elongata (Swirenko) W.Conrad 1934: 234 (Pl. 3, Fig. 104)

First record from Arunachal Pradesh

Place of Collection- Itanagar (27°4'52"N 93°35'39"E)

Lepocinclis hungpanchiaensis S.P.Chu 1936: 280, fig. 13 (Pl. 3, Fig. 105)

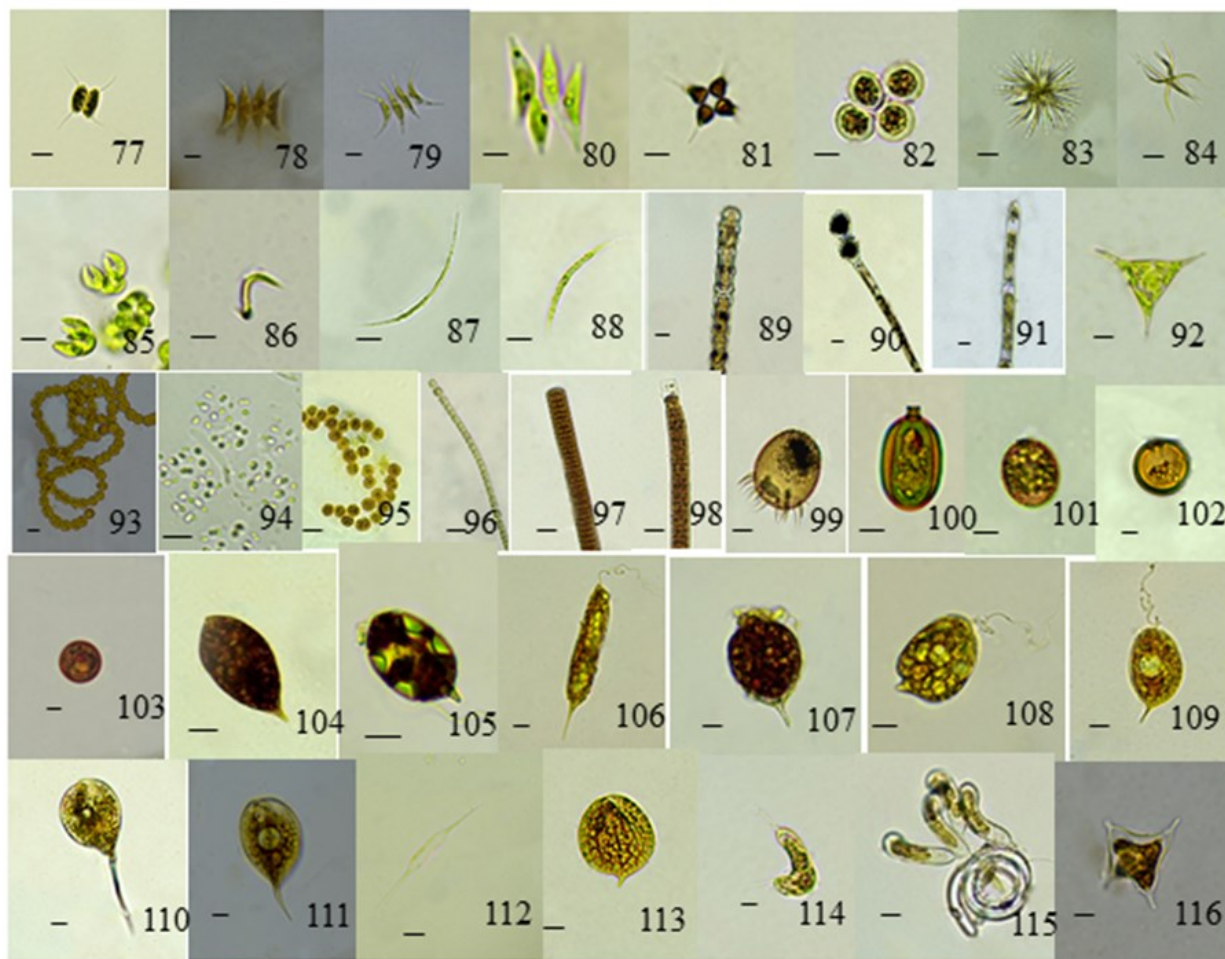


Photo plate 3. Fig. 77. *Scenedesmus pseudopoliensis* 78. *Tetradesmus dimorphus* 79. *Tetradesmus lagerheimii* 80. *Tetradesmus obliquus* 81. *Tetrastrum elegans* 82. *Tetrastrum glabrum* 83. *Ankistrodesmus densus* 84. *Ankistrodesmus falcatus* 85. *Kirchneriella diana* 86. *Monoraphidium contortum* 87. *Monoraphidium indicum* 88. *Monoraphidium tortile* 89. *Oedogonium undulatum* 90. *Oedogonium varians* 91. *Oedogonium tiffanyi* 92. *Treubaria setigera* 93. *Dolichospermum circinale* 94. *Aphanocapsa parasitica* 95. *Microcystis wesenbergii* 96. *Anabaena oscillarioides* 97. *Limnoraphis hieronymusii* 98. *Oscillatoria anguina* 99. *Trachelomonas armata* f. *punctata* 100. *Trachelomonas dubia* 101. *Trachelomonas hispida* var. *granulata* 102. *Trachelomonas volvocina* 103. *Trachelomonas volvocina* var. *punctata* 104. *Lepocinclis elongata* 105. *Lepocinclis hungpanchiaensis* 106. *Lepocinclis oxyuris* 107. *Lepocinclis wangi* 108. *Phacus acuminatus* 109. *Phacus elegans* 110. *Phacus longicauda* 111. *Phacus rotundus* 112. *Centrtractus belonophorus* 113. *Phacus triqueter* 114. *Ophiocytium capitatum* 115. *Ophiocytium cochleare* 116. *Tetraplektron laevis* (Scale bar = 10 µm)

First record from Arunachal Pradesh
Place of Collection- Kimin (27°18'13"N 93°58'6"E)
Lepocinclis oxyuris (Schmarda) B. Marin & Melkonian in B. Marin & al. 2003: 104 (Pl. 3, Fig. 106)
First record from Arunachal Pradesh
Place of Collection- Nirjuli (27°7'56"N 93°44'48"E)
Lepocinclis wangi Chu (Pl. 3, Fig. 107)
First record from Arunachal Pradesh
Place of Collection- Ganga lake (27°4'33"N 93°34'8"E)
Phacus acuminatus A. Stokes 1885: 183, fig. 1 (Pl. 3, Fig. 108)
First record from Arunachal Pradesh
Place of Collection- Ganga lake (27°4'33"N 93°34'8"E), Nirjuli (27°7'56"N 93°44'48"E)
Phacus elegans Pochmann 1942: 199, fig. 107 (Pl. 3, Fig. 109)
First record from Arunachal Pradesh
Place of Collection- Kimin (27°18'4"N 93°58'15"E), Doimukh (27°8'52"N 93°45'13"E)
Phacus longicauda (Ehrenberg) Dujardin 1841: 337, pl. 5 fig. 6 (Pl. 3, Fig. 110)
First record from Arunachal Pradesh
Place of Collection- Ganga lake (27°4'33"N 93°34'8"E), Nirjuli (27°7'56"N 93°44'48"E)
Phacus rotundus (Pochmann) Zakryš & M. Lukomska in Lukomska-Kowalczyk & al. 2015: 1153, nom. illeg. (Pl. 3, Fig. 111)
First record from Arunachal Pradesh
Place of Collection- Doimukh (27°8'52"N 93°45'13"E)
Phacus triquetra (Ehrenberg) Dujardin 1841: 338 (as '*triquetera*') (Pl. 3, Fig. 113)
First record from Arunachal Pradesh
Place of Collection- Doimukh (27°8'52"N 93°45'13"E), Ganga lake (27°4'33"N 93°34'8"E)

PHYLUM-OCHROPHYTA

Family - Centriactaceae

1 Genus, 1 Species

Centriactus belonophorus (Schmidle) Lemmermann 1900: 274 (as '*Centriactus belonophora*') (Pl. 3, Fig. 112)

First record from Arunachal Pradesh
Place of Collection- Kimin (27°18'4"N 93°58'15"E), Itanagar (27°4'52"N 93°35'39"E)

Family - Ophiocytaceae

1 Genus, 2 Species

Ophiocytium capitatum Wolle 1887: 176; pl. CLVIII [158]: figs 3-7 (Pl. 3, Fig. 114)

First record from Arunachal Pradesh
Place of Collection- Kimin (27°18'4"N 93°58'15"E)
Ophiocytium cochleare (Eichwald) A. Braun 1855: 54 (Pl. 3, Fig. 115)

First record from Arunachal Pradesh
Place of Collection- Kimin (27°18'13"N 93°58'6"E)

Family - Pleurochloridaceae

1 Genus, 1 Species

Tetraplektron laevis (Bourrelly) Ettl 1977: 561 (Pl. 3, Fig. 116)

First record from Arunachal Pradesh
Place of Collection- Ganga lake (27°4'33"N 93°34'8"E)

DISCUSSION

This present checklist provides a comprehensive account of phytoplankton flora in the lower foothills of Arunachal Himalaya. A total of 116 algal species were

documented from the study areas which were belonging to 55 genera of 35 families under 6 algal phyla. Desmidiaceae with 19 species was the dominant family in the region which was followed by Scenedesmaceae (13 species) and Closteriaceae (11 species) respectively. *Closterium* and *Cosmarium*, both belonging to phylum Charophyta were the dominant genera with 11 species each.

The number of phytoplankton species (116) documented during the present endeavour was much higher than that of any previous study made in Arunachal Himalayas (Das and Adhikary, 2012; Choudhary and Singh, 2013; Das, 2016; Ganie *et al.*, 2018; Das *et al.*, 2019; Radhakrishnan *et al.*, 2020). Das and Adhikary (2012) reported a total of 86 species from the entire Arunachal state from lower foot hills to alpine region and recorded around 39 species of Bacillariophyceae alone. Later, Das (2016) documented 66 species from the alpine lakes of Arunachal Himalaya, where also, the dominant class was the Bacillariophyceae with 36 species. During an exploration, Choudhary and Singh (2013) reported 35 Cyanobacterial species from the entire state. In contrast to Arunachal Himalayas, Sikkim Himalayan region was explored many times and more than 200 phytoplankton species have so far been recorded (Prasad and Mishra, 1987; Kumar and Rai, 2005; Suseela and Toppo 2006, 2007; Bhakta *et al.*, 2010; Das and Keshri, 2012; Das and Keshri, 2013 a, b, c; Das, 2015; Chettri and Thapa, 2016; Chettri *et al.*, 2020). It was also to be noted that in contrast to Sikkim Himalayas where no particular algal phylum was reported to be dominant, the water bodies of the lesser to upper Arunachal Himalayas were crowded with the members of Bacillariophyta. Interestingly the present study revealed that the chlorophycean members (34) were outnumbered in the water bodies of the foot hill belt of Arunachal Himalayas which was followed by Charophyta (31) and then only by Bacillariophyta (27). Chlorophycean dominance usually signifies the healthier nature of any water body (Descy, 1987). But little to moderate organic pollution in some occasions cannot be ruled out due to anthropogenic activities as reflected from the presence of few members of Euglenozoa (14 species) which were believed to be flourish in eutrophic environment (Das and Adhikary, 2012).

Out of 116 species recorded, a total of 90 phytoplankton species were reported for the first time from this region which signified that the foot hill tracts of Eastern Himalayas are very much unexplored in terms of algal research. So, the data generated by the present study on phytoplankton diversity of the region can serve as a baseline reference for identical upcoming studies.

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