Journal of Plant Resources (2024) **22**(1), 14-22
https://doi.org/10.3126/bdpr.v22i1.68288

Algal Flora of Gunde Lake, Lekhnath Municipality, Kaski District, Gandaki Province, Nepal

Sajita Dhakal[1]*, Pratikshya Chalise[1] & Sangita Thapa[2]
[1]National Herbarium and Plant Laboratories (KATH), Godawari, Lalitpur, Nepal
[2]Budhanilkantha School, Budhanilkantha-5, Kathmandu, Nepal
***Email:** dhakalsajita0@gmail.com

Abstract

Algae play a crucial role in maintaining life on earth, are beneficial to aquatic ecosystems and serve as excellent indicators of water pollution. The current study was carried out to identify algal species from Gunde Lake, Lekhnath, Central Nepal. Microscopic images were taken and studied to identify algal species. A total of 50 species were recorded that belong to 13 orders, 16 families and 29 genera including new records of three taxa for Nepal viz. *Cosmarium capense* var. *nyassae/schmidle*, *Staurastrum forficulatum* P. Lundell and *Staurastrum polytrichum* (Prety) Rabenhorst. Among identified taxa, *Closterium* was the most common genus with 10 species accounting for 20% of the total number of species. The second most common genus was *Staurastrum* with six species, contributing 12% of the total number of species. Hence, the current study reveals that Gunde Lake is rich in algal flora.

Keywords: Algae*, Cosmarium capense* var. *nyassae,* Freshwater algae*, Staurastrum forficulatum, Staurastrum polytrichum*

Introduction

Algae are a large and diverse group of simple plants ranging from unicellular to multicellular forms. Unlike the higher plants, they lack leaves, roots and other organs. These organisms are widely distributed and may be found in about every type of habitat, including freshwater and marine environments, dry sands, hot springs and snow (Lone et al., 2021). These aquatic photosynthetic organisms are varied, favoring a range of environments and exhibiting variances in cell morphologies, life cycles and growth patterns (Alam et al., 2019). Algae are widely used for food, biofuel, fertilizer and pollution indicators. Microalgae represent an interesting possibility to supply the growing need for protein demand as well as a source of bioactive compound (Matos, 2017).

Algal flora of different lakes of Nepal has been studied by various workers such as Hirano, 1955; Hirano, 1963; Watanabe, 1995; Rajopadhya et al., 2018; Shrestha & Rai, 2017; Rai & Paudel, 2019; Pokhrel et al., 2021; Rai et al., 2022; Roka et al., 2022 etc. Gunde Lake is the smallest and most neglected among the nine lakes within the Ramsar site known as the Lake Cluster of Pokhara Valley. The algal flora of Gunde Lake has not been studied till date. The present study, therefore, aims at exploring the algae thriving naturally in the Gunde Lake. The identified species were further assessed for their occurrence at global, regional and local levels.

Materials and Methods

Study area

Gunde Lake is located between latitude 28.1889°N to 28.2001°N and longitude 84.0392°E to 84.0476°E, elevation 741 to 948 m above sea level in Lekhnath Municipality within Pokhara Valley, Kaski District, Gandaki Province, Nepal. It is situated on the northeast side of Budhibazar of Pokhara Valley. Its total catchment area is 0.61 sq km while total water body coverage area is 0.08 sq km (Ministry of Forests and Environment [MoFE], 2018) (Figure 1).

In Nepal, wetlands cover about 5% of the landmass with tremendous water storage capacity and support large numbers of migratory birds such as waterfowl (MoFE, 2018). Wetlands in ten locations in Nepal are designated as Ramsar sites, which are of international importance. Of these, the Lake Cluster

of Pokhara Valley (LCPV), comprising nine lakes, is the largest and is important both ecologically and to the local community. The valley attracts millions of visitors annually, mainly because of the majestic views of the Annapurna Mountain Range and LCPV. The LCPV includes Phewa, Begnas, Rupa, Dipang, Maidi, Khaste, Neureni, Gunde and Kamalpokhari lakes. The climate of Pokhara Valley is subtropical monsoon type. The mean annual temperature is 24°C, with a maximum temperature of 36°C in June/July and a minimum of 5°C in January/February (Pathak et al., 2021).

Gunde Lake does not have perennial river input but some from Soto Khola during monsoon season (MoFE, 2018). The name Gunde Lake is derived from the local name 'Gund' which is locally used to make mats, called Gundri (M. Gurung, personal communication, September 12, 2023). The scientific name of this gund plant is *Machaerina rubiginosa* (Biehler) T.Koyama, a member of the family Cyperaceae (Bhandari et al., 2021). Gund is locally used in making mats, called as "Gundri". The lake is a rich habitat for several aquatic macrophytes such as *Blyxa echinosperma* (C.B.Clarke) Hook.f., *Nechamandra alternifolia* (Roxb. ex Wight) Thwaites, *Eleocharis dulcis* (Burm.f.) Trin. ex Hensch., *Lemna minor* L. etc. (http://plantdatabase.kath.gov.np/).

Samples collection and identification

A total of 21 samples were collected from peripheral sites of Gunde Lake during September, 2023. Phytoplanktons were collected directly by hand picking, epiphytic algae were collected by squeezing of submerged hydrophytes and diatoms were collected by brushing surface of submerged stones. All algal samples were collected in liquid form and preserved in 4% formaldehyde solution in airtight bottles and brought to the laboratory of National Herbarium and Plant Laboratories, Godawari. Samples were screened, then; photomicrography was done for each specimen under 10X and 40X objectives using a HumaScope Premium LED microscope fitted with a digital camera. Identification of the observed taxa was done with the help of Prescott (1951), Scott & Prescott (1961), Legnerova (1965) and other literatures on algae. Nomenclature, as well as classification, follows AlgaeBase (https://www.algaebase.org).

Results and Discussion

In the present study, 50 different species of algae belonging to 4 phyla, 6 classes, 13 orders, 16 families and 32 genera were identified. Class Zygnematophyceae represents highest number of taxa i.e. 31 (62%). The most common genera were *Closterium* (40 %) followed by *Staurastrum* (12%), *Cosmarium* (10%) and *Euastrum* (6%). The rest of

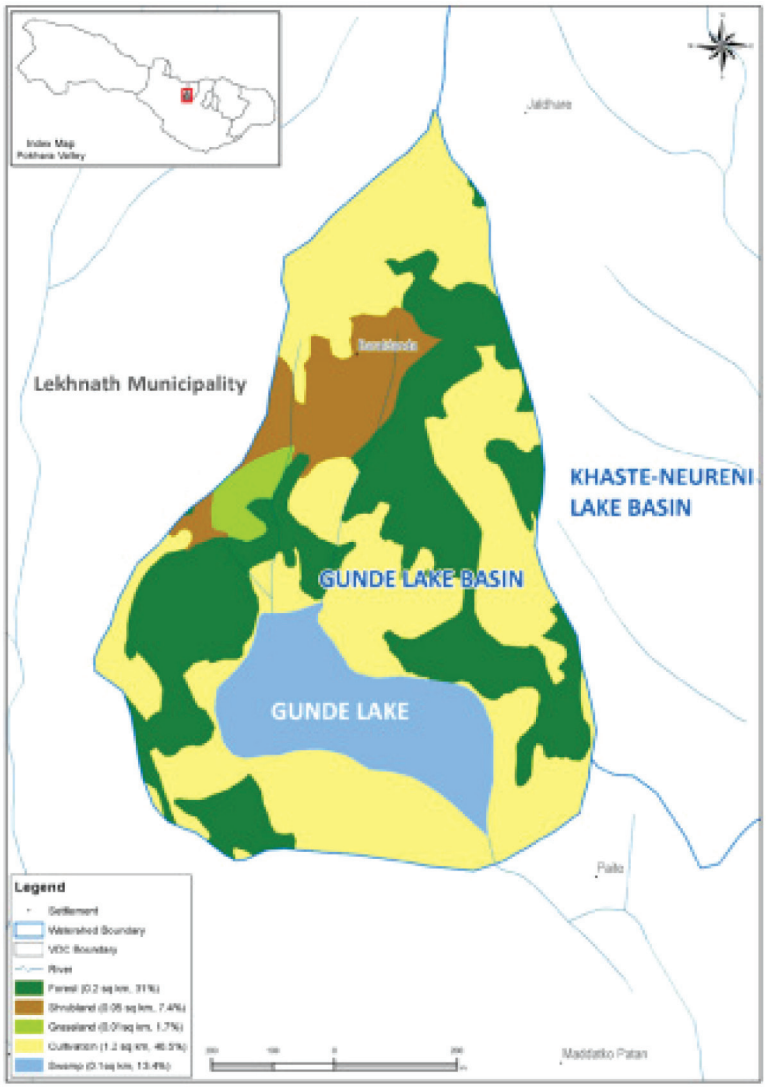

Figure 1: Map of Gunde Lake, Pokhara Valley (Source: MoFE, 2018).

genera were represented by one (2%) species each (Table 1).

In the present study, one species of *Cosmarium* (*Cosmarium capense* var. *nyassae* Schmidle) and two species of *Staurastrum* [*Staurastrum forficulatum* P. Lundell and *Staurastrum polytrichum* (Perty) Rabenhorst] were reported for the first time from Nepal. They are marked with an asterisk (*) in Table 1 and described below.

Table 1: List of algae reported from Gunde Lake

Phylum	Class	Order	Family	Algae
Cyanobacteria	Cyanophyceae	Croococcales	Microcystaceae	1. *Microcystis* sp.
Chlorophyta	Chlorophyceae	Sphaeropleales	Hydrodictyaceae	2. *Pediastrum angulosum* Ehrenberg ex Meneghini
				3. *Stauridium tetras* (Ehrenberg) E. Hegewald
			Selenastraceae	4. *Ankistrodesmus falcatus* (Corda) Ralfs
				5. *Kirchneriella obesa* (West) West & G.S. West
				6. *Messastrum gracile* (Reinsch) T.S. Garcia
			Scenedesmaceae	7. *Coelastrum cambricum* W. Archer
				8. *Hariotina reticulate* P.A. Dangeard
				9. *Desmodesmus tropicus* (W.B. Crow) E. Hegewald
				10. *Tetradesmus lagerheimii* M.J. Wynne & Guiry
	Trebouxiophyceae	Chlorellales	Chlorellaceae	11. *Dictyosphaerium ehrenbergianum* Nageli
Charophyta	Zygnematophyceae	Desmidiales	Closteriaceae	12. *Closterium abruptum* West
				13. *Closterium acerosum* Ehrenberg ex Ralfs
				14. *Closterium dianae* Ehrenberg ex Ralfs
				15. *Closterium ehrenbergii* Meneghini ex Ralfs
				16. *Closterium gracile* Brebisson ex Ralfs
				17. *Closterium incurvum* Brebisson
				18. *Closterium kuetzingii* Brebisson
				19. *Closterium navicula* (Brebisson) Lutkemuller
				20. *Closterium ralfsii* var. *hybridum* Rabenhorst
				21. *Closterium rostratum* Ehrenberg ex Ralfs
			Desmidiaceae	22. **Cosmarium capense* var. *nyassae* Schmidle
				23. *Cosmarium connatum* Brebisson ex Ralfs
				24. *Cosmarium decoratum* West & West
				25. *Cosmarium javanicum* Nordstedt
				26. *Cosmarium* cf. *quadratum* Ralfs ex Ralfs
				27. *Euastrum ansatum var. rhomboidale* Ducellier
				28. *Euastrum spinulosum* Delponte
				29. *Euastrum* sp.
				30. *Micrasterias pinnatifida* Ralfs

Phylum	Class	Order	Family	Algae
				31. *Pleurotaenium nodosum* (Bailey ex Ralfs)
				32. *Pleurotaenium trabecula* Nageli
				33. *Staurastrum bifidum* Brebisson ex Ralfs
				34. **Staurastrum forficulatum* P. Lundell
				35. *Staurastrum leptocladum* var. *cornutum* Wille
				36. *Staurastrum* cf. *levanderi* Gronblad
				37. **Staurastrum polytrichum* (Perty) Rabenhorst
				38. *Staurastrum* sp.
				39. *Teilingia granulata* (J.Roy & Bisset) Bourrelly
		Spirogyrales	Spirogyraceae	40. *Spirogyra* sp.
		Zygnematales	Zygnemataceae	41. *Netrium digitus* (Brebisson ex Ralfs) Itzigsohn & Rothe
				42. *Mougeotia* sp.
Ochrophyta	Xanthophyceae	Tribonematales	Tribonemataceae	43. *Tribonema minus* (Wille) Hazen
Heterokontophyta	Bacillariophyceae	Cymbellales	Cymbellaceae	44. *Cymbella* sp.
		Fragilariales	Fragilariaceae	45. *Fragilaria* sp.
		Naviculales	Pinnulariaceae	46. *Pinnularia viridis* (Nitzsch) Ehrenberg
				47. *Neidium* sp.
		Rhabdonematales	Tabellariaceae	48. *Tabellaria* sp.
		Surirellales	Surirellaceae	49. *Surirella* sp.
		Licmophorales	Ulnariaceae	50. *Ulnaria ulna* (Nitzsch) Compere

*** *Cosmarium capense* var. *nyassae*** Schmidle (Figure 28)

References: Gronblad & Croasdole, 1971, Fig. 61; Schmidle, 1902, p.66.

Rounded semi-cells and very straight apical depression; many pyrenoides. Cells 64.67 µm long, 38-44 µm broad; isthmus 19.80 µm wide; apices 6.63 µm broad.

*** *Staurastrum forficulatum*** P.Lundell (Figure 43)

References: Palamar-Mordvintseva, 1982, p. 265, Fig 1-7; Ling & Tyler, 1986, p. 40, Plate 39:36-46.

Cells are hexagonal, semi-cells are rounded-trapezoidal or almost trapezoidal, with a slightly convex or truncated apex with numerous processes that are buried two thick spines and convex sides; lateral angles slightly elongated, ending in two strong diverging spines. Cells 46.05-56.77 µm long, 39.40-39.96 µm broad; isthmus 13.03 µm wide.

*** *Staurastrum polytrichum*** (Perty) Rabenhorst (Figure. 46)

Reference: Nath & Baruah, 2024, p. 214.

Cells medium-sized, slightly longer than broad, median constriction deep, sinus acute and open, semicells elliptcal, margins broadly oval and furnished with moderately long, acute spines arranged in concentric circles around the angles and gradually becoming shorter towards the apex, cells triangular in vertical view with slightly concave lateral sides, cell wall punctuate; cells 52.34 55.40 µm long, 44.55 46.31 µm broad and isthmus 13.33 µm broad.

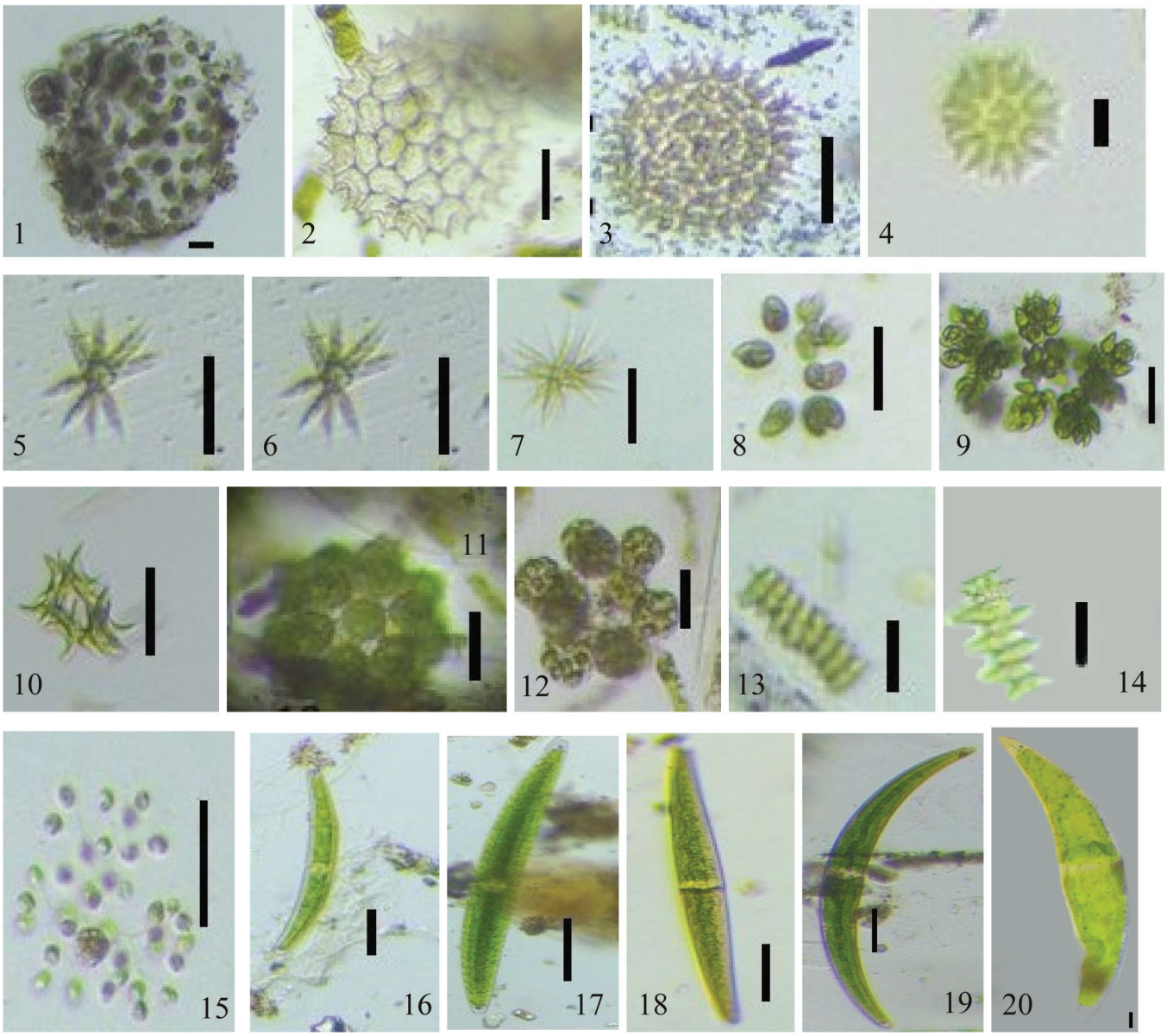

Figure 2A: 1. *Microcystis* sp., **2-3.** *Pediastrum angulosum*, **4.** *Stauridium tetras*, **5-7.** *Ankistrodesmus falcatus*, **8-9.** *Kirchneriella obese*, **10.** *Messastrum gracile*, **11.** *Coelastrum cambricum*, **12.** *Hariotina reticulate*, **13.** *Desmodesmus tropicus,* **14.** *Tetradesmus lagerheimi*, **15.** *Dictyosphaerium ehrenbergianum*, **16.** *Closterium abruptum*, **17-18.** *Closterium acerosum*, **19.** *Closterium dianae*, **20.** *Closterium ehrenbergii* (Scale bar represent: 1, 4, 11,12, 13, 14 & 20; 10 µm; 2,3, 5,6,7,8,9,10,15,16,17,18,19; 30 µm).

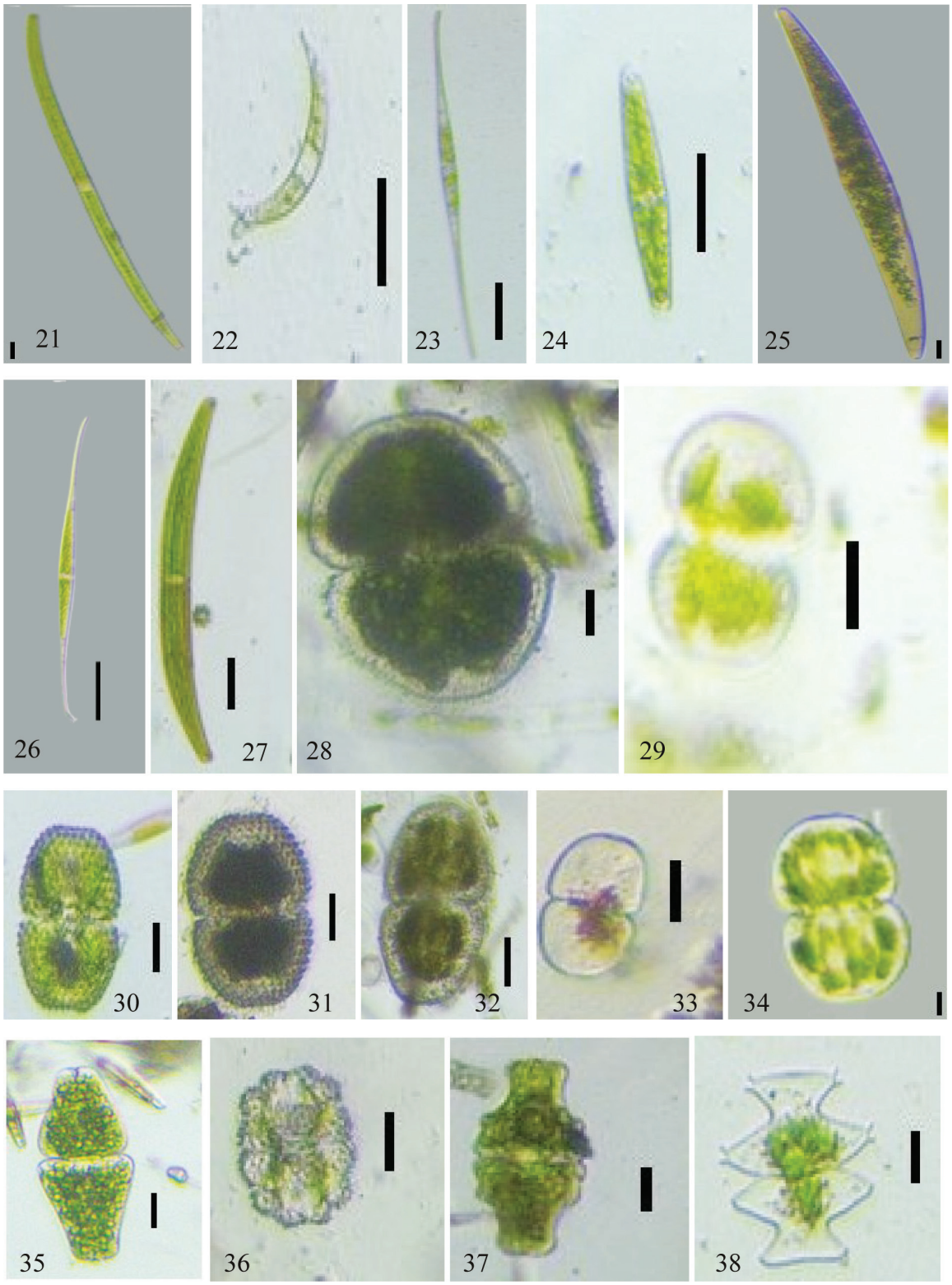

Figure 2B: 21. *Closterium ehrenbergii*, **22.** *Closterium incurvum*, **23.** *Closterium kuetzingii*, **24.** *Closterium navicula*, **25.** *Closterium ralfsii var. hybridum*, **26.** *Closterium rostratum*, **27.** *Closterium striolatum*, **28.** *Cosmarium capense* var. nyassae, **29.** *Cosmarium connatum*, **30-31.** *Cosmarium decoratum*, **32.** *Cosmarium javanicum*, **33-34.** *Cosmarium* cf. *quadratum*, **35.** *Euastrum ansatum* var. *rhomboidale*, **36.** *Euastrum spinulosum*, **37.** *Euastrum* sp., **38.** *Micrasterias pinnatifida* (Scale bar represent: 21, 25 to 38; 10 µm; 22, 23 & 24; 30 µm).

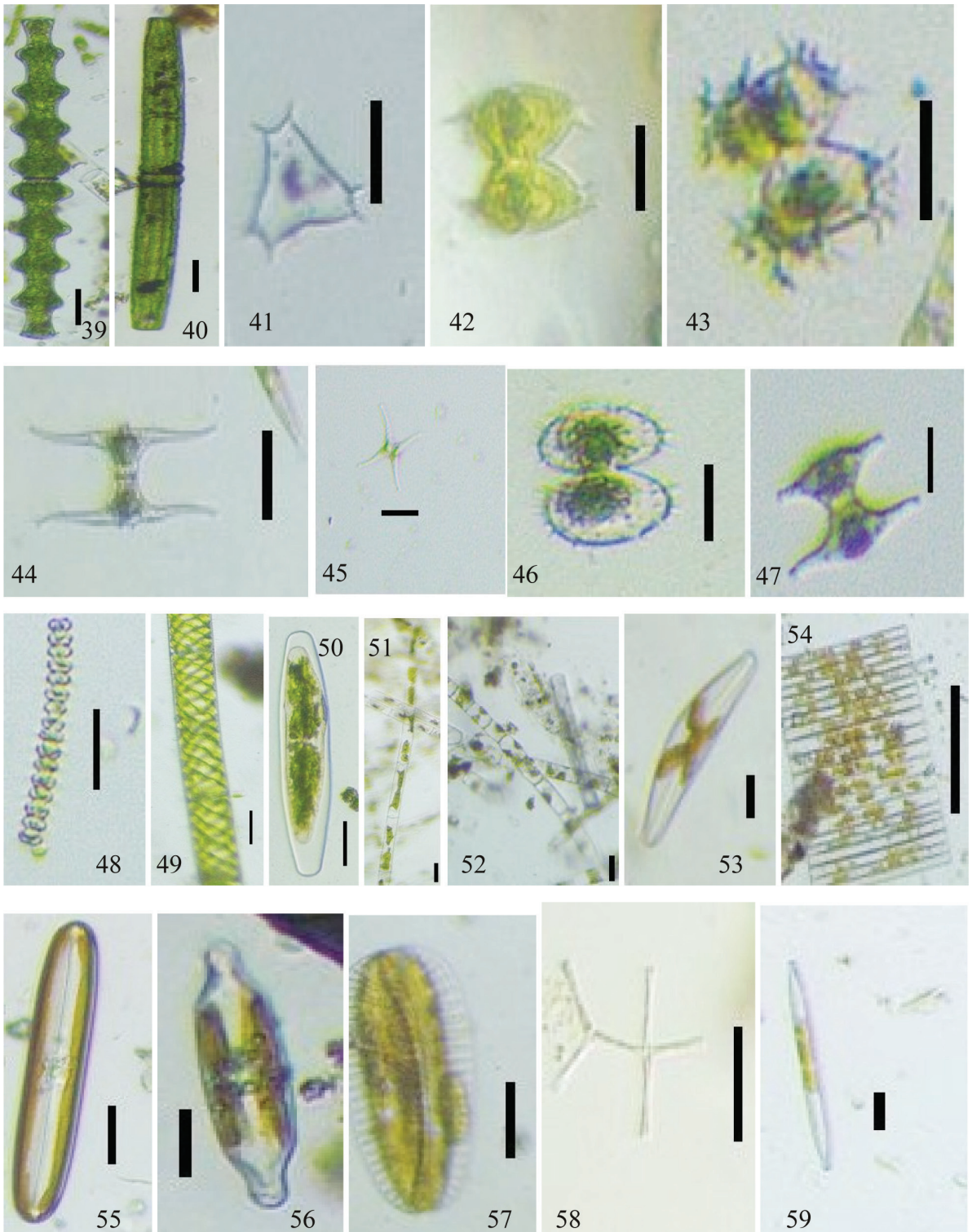

Figure 2C: 39. *Pleurotaenium nodosum*, **40.** *Pleurotaenium trabecula*, **41-42.** *Staurastrum bifidum,* **43.** *Staurastrum forficulatum*; **44.** *Staurastrum leptocladum* var. *cornutum*, **45.** *Staurastrum* cf. *levanderi*, **46.** *Staurastrum polytrichum*, **47.** *Staurastrum* sp., **48.** *Teilingia granulate*, **49.** *Spirogyra* sp., **50.** *Netrium digitus*, **51.** *Tribonema minus*, **52.** *Mougeotia* sp., **53.** *Cymbella* sp., **54.** *Fragilaria* sp., **55.** *Pinnularia viridis*, **56.** *Neidium* sp., **57.** *Surirella* sp., **58.** *Tabellaria* sp., **59.** *Ulnaria ulna* (Scale bar represent: 39, 40, 45, 51, 52, 53, 55 & 59; 10 µm; 41, 42, 43, 44, 46, 47, 48, 49, 50, 54, 56, 57& 58 ; 30 µm).

The previous studies in Beeshazari Lake (Roka et al., 2022) and in Kingfisher Lake (Dhakal et al., 2022) showed that the common species found are of the genus *Closterium*, which also supports this work. Family Desmidiaceae consists of phytoplanktons that are very sensitive to environmental changes and their growth is restricted by the eutrophic condition of water (Gayathri et al., 2011).

Conclusion

This study explored the algae of Gunde Lake. Fifty species of algae were observed including one species of *Cosmarium* (*C. capense* var. *nyassae*) and two species of *Staurastrum* (*S. forficulatum* and *S. polytrichum*) that were recorded as the new additions to the algal flora of Nepal. This preliminary investigation of algal samples of only one season showed that the lake is rich in algae. Thus further study of algae in different seasons compared with water parameters is highly recommended.

Author Contributions

The first author conceptualized investigations, methodology, data curation and writing an original draft. The second author was involved in investigations, visualization, review and editing and the third author helped in language editing.

Acknowledgements

We are thankful to Mr. Subhash Khatri, Chief of National Herbarium and Plant Laboratories, Godawari, Lalitpur for providing the necessary facilities during the study. We are also grateful to Mr. Binod Silwal, Mrs. Maiya Pandey and Mr. Narayan Bhattarai for the field assistance during sample collection.

References

Alam, M. M., Mumtaz, A. S., Hallenbeck, P. C., Shah, S. A., Abidin, S. Z. U., & Inam, F. (2019). Morphological characterization, growth appraisal and probing biofuels potential of newly isolated *Scenedesmus* sp. from desert Cholistan. *Microscopy Research and Technique*, *82*(12), 2079-2088. http://dx.doi.org/10.1002/jemt.23380

Bhandari, P., Chaudhary, S., Neupane, A., Zhou, S., & Zhang, S. (2021). Taxonomic notes on Cyperaceae of Nepal: New records of a genus, six species and other noteworthy species. *Phytokeys*, *180*, 141-156. http://dx.doi.org/10.3897/phytokeys.180.67634

Dhakal, S., Ghimire, N. P., Rai, S. K., & Dhakal, S. (2022). Seasonal variations of algae in relation to the water quality at Kingfisher Lake, central Nepal. *Journal of Plant Resources Special Issue*, *20*(2), 1-11. https://doi.org/10.3126/bdpr.v20i2.56773

Gayathri, N., Rajashekhar, M., Fatima, K.,Vijaykumar, K., Ratandeep, & Baburrao, M. (2011). Hydrochemistry and plankton diversity of Tungabhadra reservoir Bellary District, Karnataka. *International Journal of Zoological Research*, *1*(1), 01-07.

Grönblad, R., & Croasdale, H. T. (1971). Desmids from Namibia (SW Africa). *Acta Botanica Fennica*, *93*, 1-40.

Hirano, M. (1955). Fresh water algae. In H. Kihara (Ed.), *Fauna and flora of Nepal Himalaya*, (pp. 5-42). Fauna and Flora Research Society; Kyoto University.

Hirano, M. (1963). Fresh water algae from the Nepal Himalaya, collected by a memberof the Japanese Climbing Expedition. *Contributions from Biological Laboratory Kyoto University, 16*, 1-23.

Legnerova, J. (1965). The genera *Ankislrodesmus* Corda and *Raphidium* Ktitzing and their position in the family Ankislrodesmaceae. *Preslia*, *37*, 1-8.

Ling, H. U., & Tyler, P. A. (1986). *A limnological survey of the Alligator Rivers Region: Freshwater algae, exclusive of diatoms* (Research Report 2). Australian Government Publishing Service.

Lone, J. A., Lone, F. A. & Toppo, K. (2021). *Fresh water algae of Dal Lake, Kashmir, India*. Cambridge Scholars Publishing.

Matos, A. P. (2017). The impact of microalgae in food science and technology. *Journal of the American Oil Chemist's Society, 94*, 1333-1350. http://dx.doi.org/ 10.1007/s11746-017-3050-7

Ministry of Forests and Environment. (2018). *Integrated lake basin management plan of Lake Cluster of Pokhara Valley, Nepal (2018-2023)*.

Nath, S., & Baruah, P. P. (2024). Desmids of Brahmaputra valley, a major southern Asian river basin. *Journal of Threatened Taxa*, *16*(2), 24658-24693. https://doi.org/10.11609/jott.8347.16.2.24658-24693

Palamar-Mordvintseva, G.M. (1982). *Opredelitel' presnovodnykh vodorosley SSSR. Zelenyye vodorosli. Klass Kon'yugaty. Poryadok Desmidiyevyye* [Manual for identification of the freshwater algae of the USSR. Desmidiales] (Vol. 11(2)). Nauka Leningradskoe Otdelenie.

Pathak, H., Bhuju, D., Shrestha, B. B., & Ranjitkar, S. (2021). Impacts of invasive alien plants on ecosystem services of Ramsar lake cluster in middle mountain Nepal. *Global Ecology and Conservation*, *27*, e01597. https://doi.org/10.1016/j.gecco.2021.e01597

Pokhrel, S., Ghimire, N. P., & Rai, S. K. (2021). Seasonal variation of algal diversity with reference to water quality in Jagadishpur Reservoir, Nepal. *Limnological Review*, *21*(4), 189-199. https://doi.org/10.2478/limre-2021-0018

Prescott, G. W. (1951). *Algae of the Western Great Lakes area*. Wm. C. Brown Publishers.

Rai, S. K., & Paudel, S. (2019). Algal flora of Jagadishpur Tal, Kapilvastu, Nepal. *Journal of Plant Resources*, *17*(1), 6-20.

Rai, S. K., Chaudhary, L., Ghimire, N. P., & Dhakal, S. (2022). Algal flora of Barju (Chimdi) taal, Sunsari District, Province 1, Nepal. *Journal of Plant Resources*, *20*(1), 20-46. https://doi.org/10.3126/bdpr.v20i01.56551

Rajopadhyaya, R. & Rai, S. K. (2018). Some freshwater algae from Bagh-Jhoda wetland, Morang: New for Nepal. *Journal of Natural History Museum*, *30*, 15-27.

Roka, D., Rai, S. K., & Ghimire, N. P. (2022). Seasonal variations of algal diversity in response to water quality at Beeshazari Lake, tropical lowland, Nepal. *Pakistan Journal* of Botany, 54(4), 1445-1452. http://dx.doi.org/10.30848/PJB2022-4(19)

Schmidle, W. (1902). Beiträge zur Algenflora Afrikas. *Botanische Jahrbücher für Systematik Pflanzengeschichte und Pflanzengeographie*, *30*, 58-68.

Scott, A. M., & Prescott, G. W. (1961). Indonesian desmids. *Hydrobiologia*, *17*(1-2), 1-132.

Shrestha, G., & Rai, S. K. (2017). Algal flora of Rajarani Lake, Dhankuta and their seasonal distribution. *Our Nature*, *15*(1-2), 44-54. http://dx.doi.org/10.3126/on.v15i1-2.18793

Watanabe, M. (1995). Algae from Lake Rara and its vicinities, Nepal Himalayas. In M. Watanabe, & H. Hagiwara (Eds.), *Cryptogams of the Himalayas: Nepal and Pakistan* (Vol. 3). (pp. 1-17). National Science Museum.