

Taxonomy and Diversity of Genus *Pediastrum* Meyen (Chlorophyceae, Algae) in East Nepal

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Abstract

Pediastrum Meyen is a green algae occurs frequently in lentic environment like pond, puddles, lakes etc. mostly in warm and humid terai region. Twenty taxa of *Pediastrum* have been reported from Nepal, mostly from central and western part of the country, hitherto. Among them, in the present study, ten taxa of *Pediastrum* are enumerated also from east Nepal. Taxonomy and diversity of each taxa have been described with photomicrography.

Key words: Algae, Chlorophyceae, *Pediastrum*, Taxonomy, Nepal

Introduction

Green algae are aquatic plants and act as the pioneer photosynthetic organism or producer in the World of ecosystem. The genus *Pediastrum* Mayen (Chlorophyceae, Sphaeropleales) is a free floating, coenobial, green algae occurs commonly in natural freshwater lentic environments like ponds, lakes, reservoirs etc. Their occurrence in brackish and salty waters is rare (Parra, 1979). At present, only 24 species of *Pediastrum* have been described from the World and among them four species (*P. boryanum*, *P. duplex*, *P. simplex* and *P. tetras*) are Worldwide in distribution and occur generally in eutrophic waters (Komárek and Jankovská, 2001). Out of these four, rest other taxa belong to the various different ecological and geographical ranges (Komárek and Jankovská, 2001). Most of the species of *Pediastrum* are restricted in particular geographical areas or recorded from distant localities (Kowalska and Wolowski, 2010).

The outer layer of cell wall of *Pediastrum* is composed of sporopollenin

combined with silicon oxide which makes them high resistance to decay. Therefore, they remain preserved well in lake sediments as fossil record for palynological studies (Komárek and Jankovská, 2001). Thus, the knowledge of *Pediastrum* can be useful for the determination of trophicity or salinity of water at present and past (Paształeniec and Poniewozik, 2004).

Study on algal flora of Nepal is incomplete and sporadic. The maximum areas of the country still untouched and have to explore extensively. The genus *Pediastrum* has been little studied in Nepalese water body. Baral (1999) and Prasad (2011) have noted only 11 taxa of *Pediastrum* from Nepal. At present, including this, the total *Pediastrum* reported from the country reached to 20 taxa (Tab. 1).

The aim of this study was to determine the flora of *Pediastrum* with its taxonomy and diversity in Nepal. This study will contribute to the National Algal Database of Nepal.

Table 1. Total *Pediastrum* taxa reported from Nepal.

S.N.	<i>Pediastrum</i> taxa	Distribution
1	<i>P. angulosum</i> (Ehr.) Menegh. var. <i>rugosum</i> Racib.	A pond at Pisang, 3100 m, Manang (Hirano, 1955; Hickel, 1973)
2	<i>P. biradiatum</i> Meyen	Fish pond at Hetauda, Makawanpur (Sahay <i>et al.</i> , 1992)
3	<i>P. boryanum</i> (Turp.) Menegh.	A pool above the bridge of Charang, 770 m, Gorkha (Hirano, 1963)
4	<i>P. boryanum</i> var. <i>longicorne</i> Reinsch	Described in above text.
5	<i>P. duplex</i> Meyen	Described in above text.
6	<i>P. duplex</i> var. <i>brachilobum</i> A. Br.	A ditch at Gaidakot, Nawalparasi (Das and Verma, 1996).
7	<i>P. duplex</i> var. <i>clathratum</i> A. Br. Ex. Lagerh.	A shallow pool near Phewa lake, 967 m, Kaski (Hirano, 1955); Fish pond at Hetauda, Makawanpur (Sahay <i>et al.</i> , 1992); A ditch at Gaidakot, Nawalparasi and Manahari river at Manhari, Chitwan (Das and Verma, 1996).
8	<i>P. duplex</i> var. <i>gracillium</i> West et G.S. West	Described in above text.
9	<i>P. duplex</i> var. <i>subgranulatum</i> Racib.	Described in above text.
10	<i>P. duplex</i> var. <i>reticulatum</i> Lagerh.	Karra river at Hetauda, Makawanpur (Sahay <i>et al.</i> , 1992); Rapti river and its tributaries at Tandi, Chitawan (Das and Verma, 1996)
11	<i>P. duplex</i> var. <i>rugulosum</i> Racib.	A pond at Pisang, 3100 m, Manang (Hirano, 1955)
12	<i>P. integrum</i> Näg. f. <i>glabra</i> Racib.	A pond at Pokhara, 967 m, Kaski and a stream at Tukucha Moor, 2600 m, Mustang (Hirano, 1955).
13	<i>P. obtusum</i> Lucks	Bakaya river bank and fish pond at Hetauda, Makawanpur (Sahay <i>et al.</i> , 1992).
14	<i>P. ovatum</i> (Ehr.) A.Br.	Fish pond at Hetauda, Makawanpur (Sahay <i>et al.</i> , 1992)
15	<i>P. simplex</i> Meyen	Described in above text.
16	<i>P. simplex</i> var. <i>duodenarium</i> (Bailey) Rabenh.	Described in above text.
17	<i>P. tetras</i> (Ehr.) Ralfs	Described in above text.
18	<i>P. tetras</i> var. <i>apiculatum</i> Fritsch	Described in above text.
19	<i>P. tetras</i> var. <i>excisum</i> (Rabenh.) Hansg.	Described in above text.
20	<i>P. tetras</i> var. <i>tetraodon</i> Rabenh.	Described in above text.

Materials and methods

Algal samples were collected with the help of plankton-net (mesh size 10 µm) as well as by squeezing the macrophytes from different lotic and lentic habitats of east Nepal (Map 1). The collections were preserved in 4% formaldehyde solution and then brought to the Algal Research Lab, Department of Botany, P.G. Campus, Biratnagar for further investigation. Temporary glycerin mount slides of each collection were made and studied under light microscope. Microphotographs of each *Pediastrum* taxa were taken using Nikon E-

400 microscope with H-III photomicrographic attachment. Their taxonomy and identification were confirmed on the basis of Prescott (1951), Tiffany and Britton (1952), Philipose (1967), Wendy (2012) and online available databases *viz.* WoRMS, ITIS and Algaebase. The taxonomy of the *Pediastrum* algae were determined by studying their morphological features such as number of cells in the coenobia, outline and shape of the cells, number of lobes/processi, depth of incisions of marginal cells, sculpture of cell wall, dimensions of colony and cells, length of

lobes/processi etc. Stage and ocular micrometers were used for the measurement of algal dimensions. Necessary Camera-lucida pictures were also drawn to compare and confirm their morphotaxonomic features.

L = Locality and D = Distribution in Nepal and Asia.

Results

Genus: *Pediastrum* Meyen 1829

A. Systematic position:

- Phylum: Chlorophyta
- Subphylum: Tetrphytina
- Class: Chlorophyceae
- Order: Sphaeropleales
- Family: Hydrodictyaceae

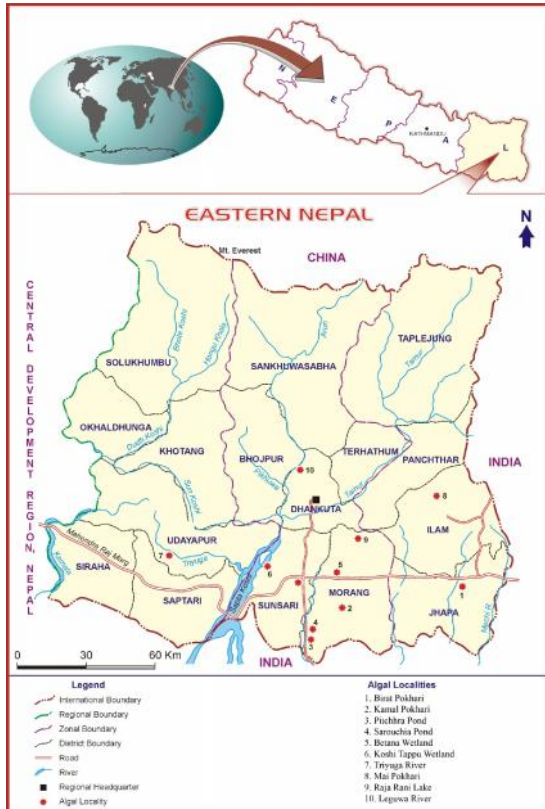
Genus: *Pediastrum* Meyen 1829

B. Generic characters: Colonies free floating, disc-shaped to stellate, flat, monostromatic with 4-8-16-32-64 or more polygonal cells, compact or perforate; cells coenocytic, smooth or rough walls, marginal cells with or without process and usually differently shaped than interior cells; chloroplast parietal, disc shaped, in later stages filling entire cell, with 1-4 pyrenoids; reproduction by formation of zoospores, aplanospores, isogametes and zygotes.

C. Key to the species

- i. Marginal cells with single projection.....
P. simplex
- i. Marginal cells with 2 or more projections, or bilobed. ii
 - ii. Projections simple. iii
 - ii. Projections emarginated or bidentate.....*P. tetras*
- iii. Coenobium perforate*P. duplex*
- iii. Coenobium entire, projections end into linear teeth..... *P. boryanum*

D. Taxonomic description: A total ten *Pediastrum* taxa reported from east Nepal are described below.



Map 1. Eastern Nepal showing *Pediastrum* distribution localities

All the samples and slides have been deposited in the algal repository of Department of Botany, P.G. Campus, Biratnagar. Accession numbers of these collections are same as those of the collection numbers. Abbreviations and symbols used in the text are as CN = Collection number, DC = Date of collection,

1. *Pediastrum boryanum* (Turpin) Meneghini var *longicorne* Reinsch (Fig. 7)
Prescott, G.W. 1951, P. 222, Pl. 47, Fig. 10;
Tiffany, L.H. and M.E. Britton 1952, P. 112, Pl. 30, Figs. 295, 296; Philipose, M.T. 1967, P. 119, Fig. 40b.

Colonies circular to oval, usually 16-32 celled, up to 256 celled; cells arranged in concentric rings without intercellular space; inner cells polygonal with straight sides, outer face of peripheral cells emarginated and extended into two longer processes ending into swollen stumpy spines; cell wall usually granulated or smooth; cells up to 40 μm in diameter, processes 10-30 μm long.

L: Epiphytic on the roots of *Eichhornia crassipes* (Mart.) Solms at Koshi Tappu wetland, 206 m, Kusaha, Sunsari.

CN : SK 57, DC : 20-06-2011.

D : Nepal - a pool above the bridge of Charang, 770 m, Gorkha (Hirano, 1963); India (Philipose, 1967), Taiwan (Anon., 2012).

2. *Pediastrum duplex* Meyen (Figs. 8, 9)
Prescott, G.W. 1951, P. 223, Pl. 48, Fig. 4;
Tiffany, L.H. and M.E. Britton 1952, P. 112, Pl. 30, Fig. 300; Philipose, M.T. 1967, P. 121, Fig. 43b.

Colonies usually of 16-32 celled, sometimes 4, 8, 64 or 128 celled with small lens shaped perforations between cells; inner cells quadrate to angular in shape, inner side of marginal cells concave, outer side produced into two short truncate processes; colonies 38-90 μm in diameter; marginal cells 13 μm long, 9-11.5 μm broad; inner cells 11 μm long, 8-9 μm broad.

L : Epiphytic on the roots of *Pistia stratiotes* L. at Pitchhra pond, 72 m, Biratnagar, Morang.

CN : SK 44, DC : 11-06-2011.

D : Nepal - Rupa, Phewa, Begnas, and Khaste lakes, 900 m, Pokhara, Kaski (Hickel, 1973); Fish pond at Hetauda, Makawanpur (Sahay *et al.*, 1992); Municipal drain near Bus Stand, Narayanghat, Chitwan (Das and Verma, 1996); China (Cao *et al.*, 2005; Hu and Wei, 2006), India (Arulmurugan *et al.*, 2010), Singapore (Pham *et al.*, 2011), Taiwan (Yamamoto and Shiah, 2012).

3. *Pediastrum duplex* Meyen var. *gracillium* West et G.S. West [Current accepted name: *Lacunastrum gracillium* (West et G.S. West) H. McManus] (Fig. 6)

Biswas, K. 1949, P. 67, Pl. 3, Fig. 28;
Prescott, G.W. 1951, P. 224, Pl. 48, Fig. 12;
Philipose, M.T. 1967, P. 124, Figs. 43 h-i.

Colonies with large intercellular spaces; cells narrow, as broad or narrower than the processes; marginal cells curved outwards and with two long processes with emarginated apex; inner cells also similar to marginal cells but with shorter processes; colonies 50-52 μm in diameter; marginal cells 13-16.5 μm long, 8-10 μm broad; inner cells 12.5-14.5 μm long, 9.5-13.5 μm broad.

L : Planktonic in the stagnant water at Kamal Pokhari, 73 m, Sukrabare, Kechana, Morang.

CN : SK 79, DC : 05-07-2011.

Distribution: Nepal - Fish pond at Hetauda, Makawanpur (Sahay *et al.*, 1992); Pond

near Mahendranagar Bazar, Kanchanpur (Chaturvedi and Habib, 1996); China (Hu and Wei, 2006), India (Biswas, 1949), Singapore (Pham *et al.*, 2011), Taiwan (Anon., 2012).

4. *Pediastrum duplex* var. *subgranulatum* Raciborski (Fig. 11)

Bruehl, P. and K. Biswas 1926, P. 269, Pl. 6, Figs. 43 a-b; Philipose, M.T. 1967, P. 125, Fig. 43j; Komarek, J. 1983, P. 82, Figs. 7 a-d.

Colonies 16-64 celled; cells and intercellular spaces similar as in *P. duplex*; cell wall granulate; colonies 108-118 μm in diameter; marginal cells 18.5 μm long, 18-19 μm broad; inner cells 20 μm long, 16 μm broad.

L : Epiphytic on the roots of *Eichhornia crassipes* (Mart.) Solms at Birat Pokhari, 135 m, Anarmani, Jhapa.

CN : SK 97, DC : 28-07-2011.

D : Nepal - Phewa lake, 967 m, Pokhara, Kaski (Hickel, 1973); India (Philipose, 1967).

5. *Pediastrum simplex* Meyen [Current accepted name: *Monactinus simplex* (Meyen) Corda] (Figs. 5, 12)

Prescott, G.W. 1951, P. 227, Pl. 50, Fig. 2; Tiffany, L.H. and M.E. Britton 1952, P. 110, Pl. 30, Figs. 290-291; Philipose, M.T. 1967, P. 113.

Colonies circular to oval, 5-8-16-32 celled; inner side of marginal cells more or less straight, outer side produced into a gradually tapering process, sides concave; inner cells polygonal; intercellular space

usually absent but if present they are small and few in number; cell wall smooth or punctate to granulate; colonies 70-100 μm in diameter; cells 19-26 μm long, 8-13 μm broad.

L : Planktonic in the stagnant water at Mai Pokhari, 2150 m, Ilam.

CN : SK 85, DC : 10-07-2011.

D : Nepal - Phewa lake, 967 m, Kaski (Hickel, 1973); Pakistan (Mehwish and Aliya, 2005), China (Cao *et al.*, 2005), India (Philipose, 1967), Singapore (Pham *et al.*, 2011), Taiwan (Anon., 2012).

6. *Pediastrum simplex* var. *duodenarium* (J.W. Bailey) Rabenhorst (Current accepted name *P. simplex* Meyen) (Fig. 10)

Prescott, G.W. 1951, P. 227, Pl. 50, Figs. 4-5; Tiffany, L.H. and M.E. Britton 1952, P. 110, Pl. 30, Fig. 292; Philipose, M.T. 1967, P. 115, Figs. 36 d-h.

Colonies usually 8-16-32 celled; it differs from *P. simplex* having large intercellular spaces; inner side of marginal cells concave, outer side produced a single delicately tapering process; inner cells similar to marginal cells but with shorter processes; cell wall smooth or finely punctate; colonies 63-97 μm in diameter; marginal cells 18-29 μm long, 9-15 μm broad; inner cells 10-15 μm long, 9-14 μm broad.

L : Epiphytic on the leaf of *Blyxa japonica* (Miq.) Maxin. Ex Aschers and Gurke at Betana pond, 123 m, Belbari, Morang.

CN : EN 39, DC : 04-06-2011.

D: Nepal - Fish pond, Hetauda, Makawanpur (Sahay *et al.*, 1992); China

(Hu and Wei, 2006), India (Arulmurugan *et al.*, 2010).

7. *Pediastrum tetras* (Ehrenberg) Ralfs [Current accepted name *Stauridium tetras* (Ehrenberg) E. Hegewald] (Fig. 2)

Tiffany, L.H. and M.E. Britton 1952, P. 110, Pl. 30, Fig. 293; Philipose, M.T. 1967, P. 128, Figs. 45a-c; Komarek, J. 1983, P. 83, Pl. 4, Fig. 11; Prasad, B.N. and P.K. Misra 1992, P. 11, Pl. 1, Fig. 9.

Colonies rectangular, oval or circular, of 4-8-16 celled, without intercellular spaces; marginal cells divided into two lobes by a deep linear to cuneate incision on the outer side reaching to the middle of the cell; each lobe truncate, slightly emarginated or further divided into two lobes; inner cells 4-6 sided with a single linear incision; colonies 12-16 μm in diameter; cells 5-15 μm in diameter.

L : Planktonic in the small puddle at the bank of Leguwa river near Arun Khola, 475 m, Dhankuta.

CN : SK 112, DC : 18-08-2011.

D : Nepal - A pond at Ankhu Khola, 640 m, and Luitel Bhanjyang, 770 m, Gorkha (Hirano, 1955; Nakanishi, 1986); Stream at Khumbu, 2000 m (Kusel-Fetzmann, 1969) and Sanegang, 2500 m (Hirano, 1983), Solukhumbu; Small pond south of Rara lake, 3030 m, Mugu (Watanabe, 1995); China (Hu and Wei, 2006), India (Mahendraperumal and Anand, 2008; Arulmurugan *et al.*, 2010), Iran (Afsharzadeh *et al.*, 2003), Taiwan (Anon., 2012), Turkey (Soylu and Gönülol, 2006).

8. *Pediastrum tetras* var. *apiculatum* Playfair (Fig. 3)

Fritsch, F.E. and Stephens 1921, P. 10, Figs. 2 A-D; Prescott, G.W. 1951, P. 227, Pl. 50, Fig. 7 (as *P. tetras* var. *tetraodon*); Philipose, M.T. 1967, P. 130, Fig. 45h.

It has similar characters with *P. tetras* except its processes with apical nodular thickening; Colonies 25 μm in diameter; cells 14.5 μm long, 17.5 μm broad.

L : Epiphytic on the root of *Eichhornia crassipes* (Mart.) Solms at Raja Rani lake, 700 m, Bhogateni, Morang.

CN : SK 50, DC : 17-06-1011.

D: Nepal - Fish pond, Hetauda, Makawanpur (Sahay *et al.*, 1992); India (Philipose, 1967).

9. *Pediastrum tetras* var. *excisum* (Rabenh.) Hansg. [Current accepted name *P. tetras* (Ehr.) Ralfs] (Fig. 1)

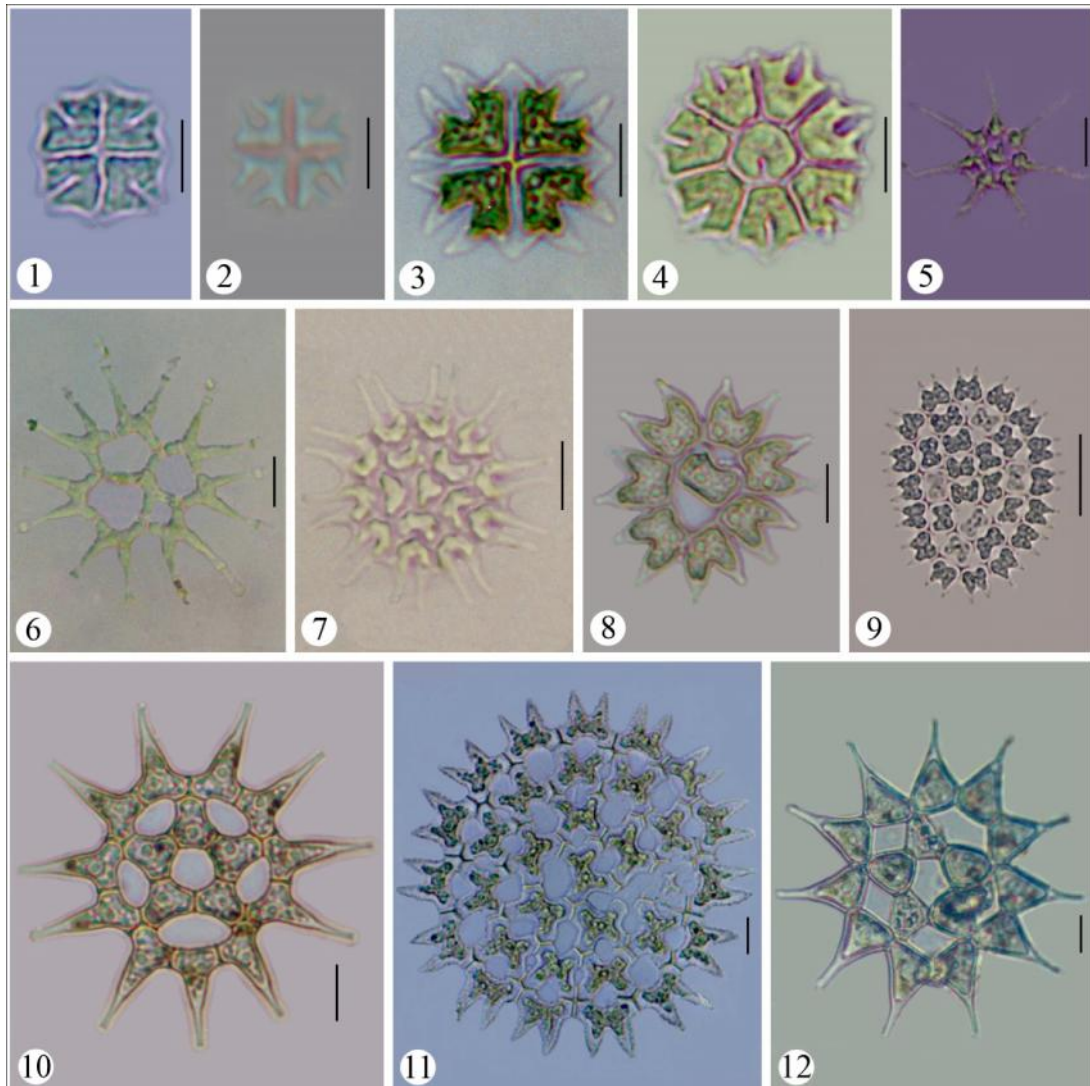
Philipose, M.T., 1967, P. 129, Fig. 45f; Prasad, B.N. and P.K. Misra 1992, P. 12, Pl. 1, Fig. 12.

Marginal cells with more or less deeply concave lobes, rest are similar as in *P. tetras*; colonies 18.5 μm in diameter; cells 10.5 μm long, 12 μm broad.

L : Benthic on the pebbles at Triyuga river, 152 m, Gaighat, Udayapur.

CN : SK 61, DC : 26-06-2011.

D : Nepal - Bakeya river (Sahay *et al.*, 1992); India (Arulmurugan *et al.*, 2010).



Figures: 1. *Pediastrum tetras* var. *excisum*, 2. *P. tetras*, 3. *P. tetras* var. *apiculatum*, 4. *P. tetras* var. *tetraodon*, 5. *P. simplex*, 6. *P. duplex* var. *gracillium*, 7. *P. boryanum* var. *longicorne*, 8-9. *P. duplex*, 10. *P. simplex* var. *duodenarium*, 11. *P. duplex* var. *subgranulatum*, 12. *P. simplex*. (Scale bars measure 10 μ m)

10. *Pediastrum tetras* var. *tetraodon* (Corda) Hansgirg (Fig. 4)

Tiffany, L.H. and M.E. Britton 1952, P. 112, Pl. 30, Fig. 294; Philipose, M.T. 1967, P. 129, Fig. 45g; Prasad, B.N. and P.K. Misra 1992, P. 12, Pl. 1, Figs. 7, 10.

Colonies 4-8-16 celled; incision of cells deep with the lobes adjacent to the incision of the marginal cell; colonies 30 μ m in diameter; marginal cells 10 μ m long, 9-10 μ m broad; inner cells 8.5 μ m long, 9.5 μ m broad.

L : Epiphytic on the root of *Pistia stratiotes* L. at Sarouchia pond, 72 m, Biratnagar, Morang.

CN : SK 46, DC : 13-06-2011.

D : Nepal - A pond at Ankhu Kholra, 640 m, Gorkha (Hirano, 1955); Small pond at Gadda Chauki, Mahendranagar, Kanchanpur (Chaturvedi and Habib, 1996); China (Hu and Wei, 2006), India (Arulmurugan *et al.*, 2010), Iran (Ramazannejad Ghadi, 2008).

The study revealed that the genus *Pediastrum* is not restricted at the centre and west but also distributed towards the eastern part of Nepal mainly at the hot and humid Terai plain where lentic habitats are common. A total 20 taxa of *Pediastrum* belonging to its 9 species are recorded from Nepal including the present 10 taxa (Tab. 1).

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