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Species Diversity of Pteridophytic Flora in Bhimkalipatan, Pokhara, Nepal

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ABSTRACT
The study of Pteridophytic flora of Bhimkalipatan, Pokhara was conducted from May 2018 to October 2018. The Pteridophytic plants were collected and then dried for herbarium specimen preparation. The prepared Herbarium voucher specimens were identified based on standard literatures and finally verified from KATH, Kathmandu. A total of 27 species under 19 genera belonging to 11 families were recorded. The family Polypodiaceae was the largest family with eight species under five genera. The family Pteridaceae stood second with six species under three genera. The family Dryopteridaceae was third largest family represented by three species under three genera. In the same way, the families Lygodiaceae and Thelypteridaceae were represented by two species each under two genera respectively. The remaining six families i.e. Davalliaceae, Equisetaceae, Lycopodiaceae, Nephrolepidaceae, Selaginellaceae and Woodsiaceae were represented by one species each. The largest genera were Pteris and Pyrossia representing three species each followed by Adiantum, Drynaria, Lygodium and Thelypteris with two species each respectively and the remaining 13 genera are monotypic genera. Habitat wise, the collected species were terrestrial represented by nine species followed by seven epiphytes, two climbers and one lithophyte. Likewise, three species were found as terrestrial, epiphytes and lithophytes; three species as epiphytes and lithophytes and two species as terrestrial and lithophytes.

KEYWORDS: Diversity, habitat, pteridophytes, species

INTRODUCTION

Pteridophytes also called Fern and Fern allies are spore bearing non-seeded vascular Cryptogamic plants having well developed root, stem and leaves (Kumar, 2014). They are the connecting link between non-vascular plants and higher group of seeded plants. The Pteridophytes are generally characterized by dominant sporophyte, reduced gametophyte, jacketed sex organs, requirement of water during fertilization; alternation of generations etc. (Pandey et al., 1977). The Fern and Fern allies generally thrive well in shady moist and humid tropical and temperate forests of different geographical regions. They show different ecological habit as epiphytes, lithophytes, terrestrial, climbers and hydrophytes. The Devonian and Carboniferous periods of Paleozoic era shows the origin and evolution of Pteridophytic flora (Pandey et al., 1977). There are around 4, 03,000 number of plant species worldwide including Phanerogams and Cryptogams (Chaudhary,

1998). A total of 13,271 living species of Pteridophytes are documented in a checklist of Ferns and Lycophytes of the world (Hassler, 2018), which forms nearly 3% of the world flora.

Several studies have been undertaken on the flora of Nepal by various researchers since the first Botanical exploration was made by F.B. Hamilton who collected around 50 species of ferns during his visit (1802-1803) to Kathmandu from Raxaul (Rajbhandary, 2016). Nepal occupies 0.1 percent of the global land area but harbors 3.2 percent of worlds known flora with 284 endemic species of Phanerogams (GON, Ministry of forest and soil conservation, 2014). Floral biodiversity of Nepal recorded 807 Algae, 2025 Fungi, 771 Lichens, 1150 Bryophytes, 534 Pteridophytes, 28 Gymnosperms and 6653 Angiosperms species (Kunwar, et al., 2010). The most recent data on Pteridophytic flora of Nepal is 580 identified taxa which is documented in 'Fern and Fern-allies of Nepal' volume I (Fraser-Jenkins et al., 2015). Some common Pteridophytic genera of Nepal are *Selaginella, Pteris, Asplenium, Thelypteris, Dryopteris, Lepisorus* etc. (Fraser-Jenkins et.al, 2015). The only research on Pteridophytic flora of Pokhara is limited to the research work on Fern and Fern allies (Bhattarai, 1997).

Ferns and its allies are considered economically important for their food value and ornamental decorative value as well as equally important with medicinal properties. The tender young leaves of *Tectaria coadunata* (Kalo niuro), *Diplazium esculentum* (Saune niuro) etc. are used locally as vegetables. Likewise, *Nephrolepis cordifolia, Drynaria coronans* etc. are used as decorative and ornamental plants in Nepal. Similarly, *Aleuritopteris bicolor, Adiantum capillus-veneris* etc. are medicinal Pteridophytes of Nepal (Annual progress report 2014-15, www.kath.gov.np). Some ferns play a great role in ecological succession, growing from the crevices of rocks and in open marshes before the advent of forest vegetation.

REVIEW OF LITERATURE

The research work on Pteridophytic flora of Nepal has been very much limited and only few works have been reported. The history of Nepal from collection and exploration point of view begins as early as 1802 (Hamilton, 1819) followed by N. Wallich in 1820-1821 (Don, 1825). The collection of Hamilton and Wallich were later worked by D.Don who published 'Prodromus Florae Nepalensis' in 1825 consisting of 87 species of ferns in Nepal (Don, 1825). Ferns collected from Nepal are published in a handbook entitled "Handbook to the Ferns of British India, Ceylon and Malay peninsula" (Beddome, 1883). Nine species of *Crypsinus* are enumerated in "An enumeration of the Ferns of Nepal' (Nakaike, 1987). Bhattarai (1997) reported 41 Pteridophytic species from Pokhara. A total of 293 species of Pteridophytes along Central Himalayan gradient are listed in journal of Biogeography (Bhattarai et al., 2004). The study conducted in winter of 1996 and 2000 reported 13 species of Pteridophytes in West Chitwan **(**Dangol, 2005). As many as 16 Pteridophytic species belonging to 14 genera and 10 families with ethnomedicinal importance are being used by Reang tribe of Tripura,India (Shil & Chaudhary, 2009). A survey carried out in East Nepal reported 35 species of Pteridophytes belonging to 23 families and 28 genera (Bhagat & Shrestha, 2010). Likewise, 10 species of Pteridophytes from Kolli Hills, Tamil Nadu, India with medicinal properties was reported (Perumal, 2010). Similarly, 15 Pteridophytic species have been reported during pre-monsoon season from Makalu Barun national park (Pathak et al., 2012). In the same way, 50 species of Pteridophytes were reported from Shivapuri National Park (Singh, 2014). A total of four Pteridophytic species were recorded as edible by Raji tribes of Mid-Western Nepal (Thapa et al., 2014). A total of 50 species of ferns and fern allies belonging to 31 genera and 18 families were reported

from Kamdev Hill region of Assam, India (Kalita, 2015). Likewise, 81 species of ferns under 27 genera and 11 families were documented from Shopian district of Kashmir valley, India (Mir et al., 2015). Similarly, 28 Pteridophytic species belonging to 13 families were collected from Rani Ban of Kaski, Nepal in June ,2015 which is reported in' An annual progress report' published by KATH (Annual progress report 2014-15, www.kath.gov.np). Altogether, 23 species of Pteridophytes were documented from Gujarat state of western India and out of which *Equisetum debile* and *Isoetes coromandelina* are in the state of extinction (Rajput et al., 2016). A total of 105 species of Pteridophytes under 19 families and 45 genera were recorded from Manaslu Conservation area **(**Bhattarai & Rajbhandary, 2017). Likewise, 22 Pteridophytic species belonging to 12 families and 17 genera have been reported as edible of the total 394 species of wild edible plants in Nepal (Dangol, 2017). Similarly, a total of 92 species of fern and fern allies belonging to 50 genera and 22 families were documented from Panchase region of Central Nepal (Thakur, 2018). In Lakhimpur area of Assam, 16 species of Pteridophytes were reported with food and medicinal value (Singh, 2018).

METHODOLOGY

a) Study Area

Nepal has a unique geography with great change in its elevation within short North-South span and associated with high variation in eco-climatic conditions resulted into 118 different ecosystems harboring rich floral diversity. The country position is at the crossroad of two major bio-geographic regions, the Indo-Malayan to the south and Paleoarctic to the north. Nepal lies between 26º 22' and 30 º27' N latitudes and 80º 04' and 88 º12' E longitudes. The annual precipitation ranges from 165 mm to 5500 mm in north of Himalaya to Pokhara respectively (GON, 2014)

The study area is Bhimkalipatan, Pokhara, Nepal encompassing an area of more than721 ropanis (366800 m^2) of land situated on the bank of Seti-Gandaki River to the north of Pokhara city. The study area is located within coordinates of $28^0$15'50"N and $83^0$58'20"E (Figure 1). The climate of Pokhara is warm and temperate with good rainfall during summers. The average annual rainfall and temperature is 3474 mm and 20.6^0c respectively. [*Source: http://en.climate-data.org]*

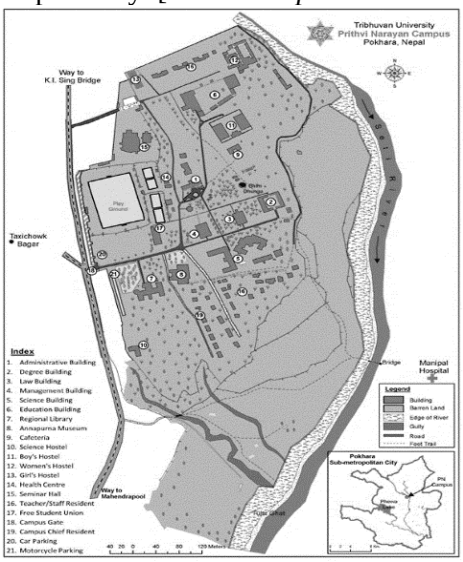

Figure 1: Map of Study Area, Bhimkalipatan
(*Source: www.pncampus.edu.np/campus_map.php*)

b) Materials and Equipments

Tools for plant collection and herbarium specimen preparation like Plant press, Polythene bags, Newspapers, Knife, Diggers, Iron hook, Scissors, Marker pen, Pen, Pencils, Field notebook, Herbarium sheet paper, Glue, Camphor, Cords, Camera, Tagging and labeling cards were gathered before field survey.

c) Field survey and data collection

The study area was surveyed thoroughly two times at an interval of three months with the first survey in the second week of May 2018 and second one at the last week of August 2018. The purposive sampling technique was adopted for the data collection and qualitative study of species diversity of fern and fern allies. The habitats were categorized as epiphytic, lifthophytic, terrestrial and climbing. The collected plant specimens were kept in polythene bags and each plant specimen was tagged with a sample number. Necessary information of each specimen was recorded in a field notebook in tabulated form. The collected specimens were brought in the laboratory of Department of Botany for herbarium specimen preparation. The herbarium preparation was conducted following herbarium technique and storage technique by Keshab R. Rajbhandari and Sangeeta Rajbhandary (DPR, 2015).

d) Identification

The collected specimens were identified by comparing with identified herbarium specimens and through standard literatures. The literatures used were *Fern and Fern-allies of Eastern Terai Nepal* (*Bhagat*, 2010), *Fern and Fern-allies of Nepal*, Vol-I, (Fraser-Jenkins et al., 2015) and *Fern and Fern- allies of Nepal*, (Rajbhandary, 2016). The identified specimens were finally verified by Pteridology section Cof National Herbarium and Plant Laboratories (KATH), Godavari, Lalitpur, Nepal. The classification of Pteridophytic flora of present work is based on classification of Kramer & Green (1990).

Table 1:
List of Pteridophytes of Bhimkalipatan, Pokhara, Nepal

S.N.	Scientific name	Family	Habitat
1	*Adiantum capillus-veneris* L.	Pteridaceae	Ter.
2	*Adiantum incisum* Forssk. Subsp. *incisum*	Pteridaceae	Ter., Epi. & Lit.
3	*Aleuritopteris bicolor* (Roxb.) Fraser-Jenk.	Pteridaceae	Ter., Epi. & Lit.
4	*Davallia bullata* Wall. *ex* Hook.	Davalliaceae	Epi. & Lit.
5	*Diplazium esculentum* (Retz.) Sw.	Woodsiaceae	Ter.
6	*Drynaria coronans* (Wall. *ex* Mett.) T. Moore	Polypodiaceae	Epi.
7	*Drynaria propinqua* (Wall. *ex* Mett.) J.Sm. *ex* Bedd.	Polypodiaceae	Epi.
8	*Dryopteris cochleata* (D. Don) C. Chr.	Dryopteridaceae	Ter. & Lit.
9	*Equisetum ramosissimum* Desf.	Equisetaceae	Ter.
10	*Huperzia squarrosa* (G. Forst.) Trevis	Lycopodiaceae	Epi.
11	*Hypodematium crenatum* (Forssk.) Kuhn.	Dryopteridaceae	Epi. & Lit.
12	*Lepisorus nudus* (Hook.) Ching	Polypodiaceae	Epi.
13	*Lygodium flexuosum* (L.) Sw.	Lygodiaceae	Clm.

14	*Lygodium japonicum* (Thunb.) Sw.	Lygodiaceae	Clm.
15	*Microsorum membranaceum* (D. Don) Ching	Polypodiaceae	Lit.
16	*Nephrolepis cordifolia* (L.) C. Presl	Nephrolepidaceae	Ter. & Lit.
17	*Phymatosorus cuspidatus* (D. Don) Pic.Serm.	Polypodiaceae	Epi. & Lit.
18	*Pteris biaurita* L.	Pteridaceae	Ter.
19	*Pteris subquinata* Wall. *ex* J. Agardh	Pteridaceae	Ter.
20	*Pteris vittata* L. subsp. *vittata*	Pteridaceae	Ter., Epi. & Lit.
21	*Pyrrosia costata* (C. Presl) Tagawa & K. Iwats	Polypodiaceae	Epi.
22	*Pyrrosia flocculosa* (D. Don) Ching	Polypodiaceae	Epi.
23	*Pyrrosia porosa* (C. Presl) Hovenkamp	Polypodiaceae	Epi.
24	*Selaginella varginata* Spring	Selaginellaceae	Ter.
25	*Tectaria coadunata* (J. Sm.) C.Chr.	Dryopteridaceae	Ter.
26	*Thelypteris arida* (D. Don) C.V. Morton	Thelypteridaceae	Ter.
27	*Thelypteris procera* (D. Don) Fraser-Jenk.	Thelypteridaceae	Ter.

*****Ter. =Terrestrial Epi. =Epiphytic lit.=Lithophytic Clm.=Climbing

Table 2:
List of Pteridophytic Families with Number of Genera and Number of Species in Bhimkalipatan, Pokhara, Nepal

S.N	**Family Name**	**Number of genera**	**Number of species**
1.	Davalliaceae	1	1
2.	Dryopteridaceae	3	3
3.	Equisetaceae	1	1
4.	Lycopodiaceae	1	1
5.	Lygodiaceae	1	2
6.	Nephrolepidaceae	1	1
7.	Polypodiaceae	5	8
8.	Pteridaceae	3	6
9	Selaginellaceae	1	1
10.	Thelypteridace	1	2
11.	Woodsiaceae	1	1

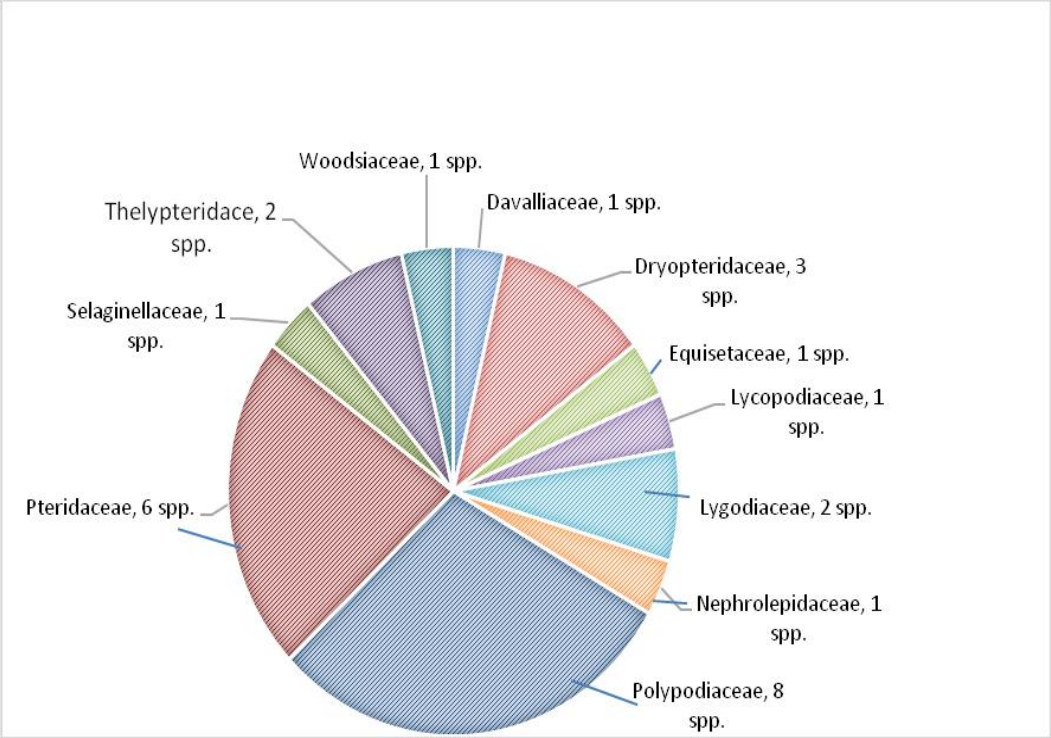

Figure 1: Family–Species wise richness of Pteridophytic species in Bhimkalipatan, Pokhara, Nepal

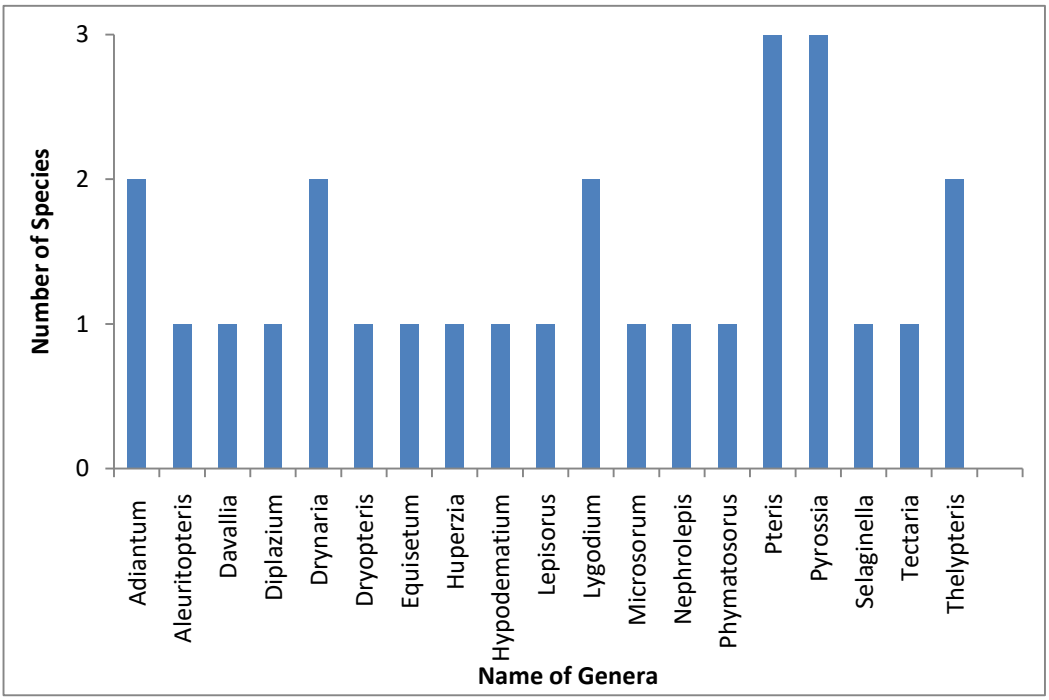

Figure 2: List of Pteridophytic Genera with Number of Species in Bhimkalipatan, Pokhara

Table 3:
Diversity of Pteridophytic Flora Based on Habitat in Bhimkalipatan, Pokhara Nepal

S. N	Habitat	Name of Species	No. of Species
1.	Terrestrial	*Adiantum capillus-veneris, Diplazium esculentum, Equisetum ramosissimum, Pteris biaurita, Pteris subquinata, Selaginella varginata, Tectaria coadunata, Thelypteris arida & Thelypteris procera*	9
2.	Epiphytic	*Drynaria coronans, Drynaria propinqua, Huperzia squarrosa, Pyrrosia costata, Pyrrosia flocculosa, Pyrrosia porosa & Lepisorus nudus*	7
3.	Climbing	*Lygodium flexuosum & Lygodium japonicum*	2
4.	Lithophytic	*Microsorum membranaceum*	1
5.	Epiphytic& Lithophytic	*Davallia bullata, Hypodematium crenatum & Phymatosorus cuspidatus*	3
6.	Terrestrial, Epiphytic& Lithophytic	*Adiantum incisum, Aleuritopteris bicolor & Pteris vittata*	3
7.	Terrestrial & Lithophytic	*Dryopteris cochleata & Nephrolepis cordifolia*	2

RESULT AND DISCUSSIONS

A total of 27 Pteridophytic species under 11 families and 19 genera were collected and identified (Table 1). The family with largest genera is Polypodiaceae represented by five genera followed by Dryopteridaceae and Pteridaceae with three genera each while the remaining eight families represented one genus each (Table 2). The Polypodiaceae and Pteridaceae with eight and six species respectively are the two largest family followed by Dryopivteridaceae with three species; the family Lygodiaceae and Thelypteridaceae encompasses two species each while the remaining six families are monotypic (Table 2). The largest genera are *Pteris* and *Pyrossia* representing three species each followed by *Adiantum, Drynaria, Lygodium* and *Thelypteris* with two species each and the remaining 13 genera are monotypic genera (Figure 2). Based on the habitat of the Pteridophytic flora, nine terreestrial species, seven Epiphytic species, two climbing species and one lithophytic species were recorded. Three species were found belonging to Epiphytic and lithophytic habitats Viz. *Davallia bullata, Hypodematium crenatum and Phymatosorus cuspidatus;* three species were found in Terrestrial, Epiphytic and Lithophytic habitats Viz. *Adiantum incisum, Aleuritopteris bicolor and Pteris vittata* and two species in terrestrial and lithophytic habitat viz. *Dryopteris cochleata and Nephrolepis cordifolia* (Table 3). Aquatic species were not reported as there was no aquatic habitat.

Likewise, Family–Species wise richness of Pteridophytic Flora is demonstrated in Figure 1 and Genera–Species wise richness of Pteridophytic Flora is illustrated in Figure 2.

Only one individual plant each of *Drynaria coronans* and *Huperzia squarrosa* was observed in the whole study area and care was taken to collect only a branch of each considering the ethical values. The number of species of Pteridophytic flora encountered in the present research work is near to the findings of K.R. Bhattarai who reported 41 species of Pteridophytes from Pokhara valley (Bhattarai, 1997). Likewise, the number of Pteridophytic species of Bhimkalipatan i.e. 27 species is on par with 28 Pteridophytic

species collected from Rani Ban area of Kaski district, Nepal by Department of Plant resources in June 2015. Species diversity of Pteridophytes in Bhimkalipatan was obtained very high in spite of short study period as compared with the 580 species richness of Nepal (Fraser-Jenkins et al., 2015). The richness in species diversity of Pteridophytic flora of the research area is due to good monsoon rainfall, humidity and presence of number of old trees with moist and shady places to flourish the Pteridophytes. However, due to habitat destruction on account of the establishment of various infrastructures in the study area, it leads to a decline in the Pteridophytic population. Due respect should be given in future for the conservation of Pteridophytes as these plants are ecologicaly, economically and academically important.

CONCLUSIONS AND RECOMMENDATIONS

The study on species diversity of Pteridophytic flora in Bhimkalipatan, Pokhara, Nepal was undertaken for a period of six months from May 2018 to October 2018. Altogether 27 Pteridophytic species representing 19 genera and 11 families were collected and identified. The herbarium specimen of each identified species was prepared. Aquatic species were not reported during the research period. Likewise, based on habitats, nine terrestrial, seven epiphytic, two climbing and one lithophytic Pteridophytic species are documented (Table 3). In spite of less climatic variation and limited time period for the present study, the study area was found to be rich in Pteridophytic flora. A good number of Pteridophytic species of the research area are found to be important from ecology, economic and academic point of view. The epiphytic species are the dominant species but the habitat destruction of epiphytes by cutting down trees in the name of infrastructure development is taking place.

Following measures are recommended for the promotion of Pteridophytic species of study area.

- Considering the high species richness of Pteridophytic flora in the study area, effective conservation methods should be adopted.
- The study did not cover annual diversity of Pteridophytic flora and so further exploration should be conducted in this area.
- A special attention is needed for the conservation of *Drynaria coronans* and *Huperzia squarrosa* which are represented by only one individual plant each in the whole study area.

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