DIVERSITY OF PTERIDOPHYTES ALONG THE ALTITUDINAL GRADIENT IN PALPA DISTRICT, WESTERN NEPAL

A THESIS

SUBMITTED FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTER'S DEGREE IN BOTANY

BY

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DECLARATION

I, Kamana Acharya, hereby declare that the work enclosed here is entirely my own, except where states otherwise by reference or acknowledgement, and has not been published or submitted elsewhere, in whole or in part, for the requirement for any other degree or professional qualification. Any literature, data or works done by others and cited within this thesis has been given due acknowledgement and listed in the reference section.

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RECOMMENDATION

Date: 28 may 2023

This is to recommend that the proposed research work entitled **"Diversity of Pteridophytes Along the Altitudinal Gradient in Palpa District, Western Nepal"** is carried out by "Kamana Acharya" T. U. registration number "5-2-0049-0122-2015" under our supervision. The entire work is based on original scientific investigations and has not been submitted for any other degree in any institutions. We therefore; recommend this thesis work to be accepted for the partial fulfilment of M.Sc. Degree in Botany.

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LIST OF ABBREVIATION AND ACRONYMS

ANOVA	Analysis of Variance
cm	centimeter
°C	Degree Centigrade
D	Simpson's Diversity Index
GPS	Global Positioning System
GIS	Geographic Information System
H′	Shannon Wiener Diversity index
IVI	Importance Value Index
KATH	National Herbarium and Plant Laboratories, Godawari, Lalitpur
Mm	Millimeter
Masl	Meter above sea level
MDE	Mid Domain Effect
P	Level of significance
RF	Relative Frequency
RD	Relative Density
RC	Relative Coverage
SPSS	Statistical Package on Social Science

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ABSTRACT

The present study aims to study the diversity of pteridophytes along the altitudinal gradient in Northern and Southern aspects of Palpa district, Western Nepal. A total of 126 quadrats were laid, with 63 in a Southern and 63 in a Northern aspect and size of plot was 5m×5m for vegetation sampling. 7 plots were laid along horizontal transect at every 100m altitude, with a 20 m differences between each sample plots. Altogether 42 species of pteridophytes belonging to 12 families and 24 genera were recorded in the study area. Pteridaceae was found as largest family on the basis of number of species. Highest species richness was observed at an altitude of 800 m on both aspects. Species diversity was found maximum in the Northern aspect because of the moist habitat than in comparison to Southern aspect. Pteidophytes species like *Selaginella fulcrata, Thelypteris dentata, Selaginella pallida* were dominant in the Northern aspect, and *Selaginella fulcrata, Aleuritopteris bicolor, Dryopteris cochleata*, *Aleuritopteris dealbata* were dominant in southern aspect. The pteridophytes species richness pattern was decline with increase in elevation at both aspects in this study. The mean species richness across elevations in both aspects was also shown statistically significant ($p< 0.01$) based on one-way ANOVA. Furthermore, 15 species were commonly used by the locals for fodder, medicine, also as vegetables.

Keywords: *Pteridophytes, Northern and Southern aspect, species richness, Importance value index, Ethnobotany*

CHAPTER 1

INTRODUCTION

1.1 General Background

Pteridophytes (ferns and fern allies) are non-flowering prehistoric vascular plants that belong to the reptile group of plant life. They are found in wet and cold environments and exhibit a high level of variety in the tropics (Giri *et al*., 2021). In general, pteridophytes are distinguished by dominant sporophytes, reduced gametophytes, jacketed sex organs, water necessity during fertilization, and alternation of generation (Pandey *et al*., 1977). Pteridophytes are regarded as significant due to their evolutionary relevance, they are a notable ancient group of species with a significant number of relict and endemic ones (Patil *et al*., 2016). Pteridophytes are a beautiful part of the vegetation found in hills and fore (Gurung, 1991). In contrast to seeded plants, they can be found in ecosystems from the tropics to the poles and reproduce by means of tiny spores (Moran, 2004). After Linnaeus published "Species Plantarum" in 1753, with 140 genera and 182 species of pteridophytes, the history of study of pteridophytes began. Since the work of British botanists, the first plant exploration and taxonomic knowledge of Nepalese pteridophytes and other groups of plants have been known (Shrestha, 1999).

Pteridophytes are higher cryptogams with a well-developed vascular system, and there are around 13,271 live species listed in a global checklist of Ferns and Lycophytes (Hassler, 2018). They belong to two phylogenetically separate groups, the ferns (some 10,500 species), and the lycophytes (fewer than 1500 species) (PPG I, 2016). A total of 583 taxa of pteridophytes were reported in Nepal in the recent publication Ferns and Ferns allies, including 550 species and 33 subspecies (Fraser-Jenkins *et al*., 2015; Fraser-Jenkins and Kandel 2019; Kandel and Fraser-Jenkins 2020). Pteridophytes are found all over Nepal, from the low-lying terai to the high-altitude Himalayas and from east to west. The nation's greatest diversity of species is found in central Nepal, at an altitude of about 2000 meters (Bhattrai *et al*., 2004). The pteridophytic flora of Nepal is extremely diverse due to the country's significant altitudinal changes, which vary from humid tropical to mountain ranges, as well as the existence of a wide range of climatic conditions and soil types (Gurung, 1992). Pteridophytes can be found in many diverse habitats, including those that are terrestrial, lithophytic, climbers, aquatic, epiphytic, etc. and many ferns can also exist in several habitats (Thakur and Rajbhandary, 2018).

In general, species richness is the total number of species present in an ecological community (Colwell, 2009). The species richness is influenced by different factors such as, species elevation (Bhattrai and Vetaas, 2003; Baniya *et al*., 2010), aspect (Panthi *et al*., 2007), Land use types (Bhattrai and veetas, 2003). Based on a study of species richness along the elevation gradient, approximately 50% of the species show a hump-shaped trend, with the most of species present at the mid-elevation zone whereas 25% exhibit a monotonic reduction in species richness from low to high elevation (Rahbek, 1995). Several fern researcher has revealed that unimodal is a frequent trend of fern species against elevation (Kro¨mer *et al*., 2005; Grytnes and Beaman, 2006; Salazar *et al*., 2013; Nagalingum and Cantrill, 2015) however, monotonic decrease in species richness with increasing elevation is not uncommon (Stevens, 1992).

All types of living organisms, including pteridophytes, are impacted by climatic variable on species richness over elevation gradients (Körner, 1999; Whittaker *et al*., 2001). In any forest ecosystem, the distribution of species and their richness along the gradient can be influenced by a variety of climate factors, including temperature, potential evapotranspiration, growing season length, humidity, air pressure, nutrient availability, ultraviolet radiation, and rainfall (Funnell and Parish, 2001). Moisture is the most important climatic factor determining Pteridophyte diversity (Young and Leon, 1989; Kessler, 2001; Bhattari *et al*., 2004; Silva *et al*., 2018). The slope aspect is crucial for pteridophyte diversity because the facing of the terrain affects moisture availability (Panthi *et al*., 2007). Land use and geographic characteristics such as aspect and elevation, slope degree and fluctuations are regarded the key topographic elements that affect vegetation diversity and distribution pattern indirectly in Mountain areas (Sanders *et al*., 2007; Sanders and Rahbek, 2012). Plant species richness and composition are much higher on Northern than on Southern aspects (Panthi *et al*., 2007). According to Sagar *et al*., (2008), the woody plant canopy and different canopy types considerably maintain the amount of light that reaches the forest floor, which in turn regulates the pattern of herbaceous floral composition. Panthi *et al*., (2007) discovered a substantial relationship between moisture and canopy cover. Moreover, Veetas, (1997) discovered that the canopy served as the primary underlying environmental gradient for species richness and composition.

Pteridophytes have been utilized for food, medicine, ornamentation, and gardening since the prehistoric era (Gurung, 1988; Rajbhandary, 2010). Ferns were discovered to have a variety of ethnobotanical uses, including those for aesthetic, medicinal, and dietary purposes (Delos and Angeles, 2012). From ancient times, a variety of pteridophyte species, including *Pteridium aquilinum*, *Dryopteris filixas*, *Adiantum capillus*, *Adiantum Philippense*, and *Sellagenella moellendorfii*, have been used to treat both human and animal illnesses due to their therapeutic properties (Parihar and Parihar, 2006; Sen and Ghosh, 2011; Sathiyaraj *et al*., 2015; Zhao *et al.,* 2017). Numerous ferns, such as, *Tectaria coadunate*, *Drynaria propinqua*, *Angiopteris helferiana*, *Helminthostachys zeylanica*, *Polypodiodes amoena*, and many more were used as traditional medicines (Rajbhandary, 2015). *Diplazium esculentum*, *Diplazium maximum*, and *Tectaria coadunata* are the most popular Nepalese edible ferns and these were also sold for a profit in local markets (Fraser-Jenkins, 2008; Fraser-Jenkins and Kandel, 2019).

1.2 Justification of study

Pteridophytes have been a popular focus of research into species-elevation connections, with the greatest diversity found in tropical and subtropical highlands (Linder, 2001; Bhattrai *et al*., 2004). The diversity and species richness of the same altitudinal range at different Mountains within the same region differ. Pteridophyte diversity research may also become beneficial foundation to the country's income because they are useful in medicine, food, and ecological aspets. In Nepal, numerous studies on the usage and diversity of pteridophytes along the altitudinal gradient have been conducted (Bhattarai *et al.*, 2004; Panthi *et al.,* 2007; Rijal, 2009; Bhattarai and Rajbhandary, 2017; Shrestha, 2017; Nepali *et al.,* 2020) but comparatively study on the pteridophytes diversity in different aspect in Nepal is still insufficient. Although enumeration of Palpa district has been done in the past (Mahato, 2014; Naupane, 2023) but particularly in the Purbakhola Rural Municipality it has not been done. This research will attempt to enumerate and document the diversity and uses of pteridophytes of Purbakhola Rural Municipality. The result of this research work based on the exploration of ethno botanical study of pteridophytes and their diversity from a remote area of the country might be a useful database for the further research carried out in future.

1.3 Research questions

i. What is the diversity of pteridophytes in Purbakhola Rural Municipality Palpa?

ii. Is there any variation in the diversity of pteridophytes along elevation and in the Northern and Southern aspect?

iii. Do the local inhabitants have idea about the ethnobotanical uses of pteridophytes?

1.4 Objectives

A. General Objectives

The general objective of the study is to assess the diversity and uses, of pteridophytes of Purbakhola Rural Municipality and the specific objectives were:

B. Specific objectives

I. To enumerate the pteridophytes species in the studied area.

II. To find the pteridophytes diversity along the altitudinal gradient and aspects.

III. To document the traditional knowledge of pteridophytes in study area.

1.5 Limitations of the study

i. This study was unable to cover the full forest region because of the difficult topography

ii. Study was carried out in single season only.

CHAPTER 2

LITERATURE REVIEW

2.1 Pteridophytes diversity

The plant group that includes ferns (pterodphytes) is characterized by its spore and vascular bundles. There are no seeds generated by fern species. This group uses the discharge of spores to carry out sexual reproduction. Pteridophytes have a lengthy geological history and, unlike many seed plants, the majority of them are herbaceous perennials (a few are annuals or resemble trees) (Guo *et al.*, 2003). There are around 12,838 species worldwide, divided into 19 orders and 58 families (Hasselar and Swale, 2001). When researching the history of pteridophytes, Linnaeus (1753) was the pioneer in the documentation of pteridophytes after the publication of ‘'species Planarum’' who recorded 140 genera and 182 species.

Pteridophytes had been enumerated by several researchers from different regions of the world including Kalita (2015) identified 50 species of ferns and fern allies from the Kamdev Hill region of Assam, India, belonging to 31 genera and 18 families. Out of them, they found Polypodiaceae (6 genera) and Pteridaceae (11 species) were dominant families in terms of number of genera and species. In the same way, Karmrul Haque *et al.*, (2016) documented 52 species of pteridophytes from Rajkandi Reserve Forest of Moulvibazar district, Bangladesh, belonging to 30 genera of 20 families. Pteridaceae which is the largest family was determined to have nine species and species, genus *Pteris* having 6 species was found by them as the largest. Rahmad and Akomolafe (2018) recorded 23 fern species belonging to 14 families from Tropical University Campus, Malaysia. Among them, Thelypteridacea and Polypodiaceae had most dominant families on the basis of species.

In the same way, Sureshkumar *et al.*, (2020) recorded total 98 species of pteridophytes belonging to 58 genera and 32 families recorded from Kolli Hills of Eastern Ghats, India in which they documented with a maximum number of 29 species in the 1301-m to 1400-m elevation. Out of 98 recorded species Aspleniaceae was dominant family having 9 species. They discovered a positively significant correlation between the family, genus, and species richness with elevation. Most of the reported species displayed terrestrial environments, and the distribution of species richness in terms of life forms showed a hump. Deciduous and evergreen forests displayed monotonic distribution of species richness while scrub and semievergreen forests with elevation displayed humped distribution.

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) followed by N. Wallich in 1820- 1821 (Don, 1825). The Hamilton and Wallich collection was letter work by D. Don, who published 'Pandromous Florae Nepalensis' in 1825 consultings of 87 species of ferns in Nepal (Don, 1825). Several studies were conducted in various regions of Nepal like, Bhattrai *et al*., (2004) reported 293 species belonging to 95 genera and 35 families had been recorded from Central Himalayan elevational gradient, Nepal. Among them, the Athyriaceae and Dryopteridaceae were two of the most species-rich families. The largest species richness was found at 2000 meters, and there was a unimodal connection between species richness and elevation. Similarly, Siwakoti (2006) documented 23 pteridophyte species from Nepal's Tarai area wetlands. A total of 35 species of pteridophytes belonging to 23 family and 28 genera were reported from eastern Terai, Nepal. Among those species Polypodiaceae was dominant families including 5 species (Bagat and Shrestha, 2010). Total 100 species of ferns and fern allies were identified in the Makwanpur district by Phuyal *et al*., (2011). Likewise, Pathak *et al*. (2012) reported 140 species of ferns and fern-allies from Sankhuwasabha district, eastern Nepal, belonging to 59 genera and 26 families with notes on medicinal benefits.

Altogether 105 species of pteridophytes were identified from Nubri Valley, Manaslu Conservation Area, Central Nepal, belonging to 29 families and 45 genera. The largest family was polypodiaceae with 8 genera followed by Pteridaceae (6 genera), Woodsiaceae (6 genera), Dryopteridaceace (6 genera) and Dennstaedtiaceae (3 genera). The largest genus was *Dryopteris*. Among them, 65 species of pteridophytes were reported from terrestrial habitat, 28 species epiphytic, and 34 as lithophytes (Bhattrai, 2013). Total 25 pteridophytes species belonging to 8 families and 12 genera were collected from subtropical forests of Pyuthan District, Western Nepal. Among them, Pteridaceae was dominant family including 9 species followed by Dryopteridaceae (5 species), Polypodiaceae (3 species) and Adiantaceae (3 species). On the basis of habitat highest species were found from terrestrial habitat (9), and others are epiphyte (3), lithophytes (2) and climber (1) (Kandel and Pathak, 2013).

Total 85 pteridophytes species from Daman and surrounding areas, Makwanpur district, were collected, representing 24 families, 47 genera. Polypodiaceae was the largest family, followed by Pteridaceae, in terms of the number of species and genera. *Pteris*, which has 6 species, was the largest genus. Out of 85 pteridophyte species, 42 species (37%) were found in terrestrial habitat, 46 species (41%) as lithophytes, and 25 species (22%) as epiphytes (Prajapati, 2013). In the same way, Mahato, (2014) reported 37 species of pteridophytes belonging to 16 families and 19 genera from Palpa district, West Nepal. Among them, *Thelypteris* was dominant genus including 4 species. Altogether 105 species of pteridophytes discovered from the Manaslu Conservation area in Central Nepal, belonging to 20 families and 45 genera. The largest family was Polypodiaceae with 8 genera followed by Pteridaceae and Woodsiaceae each having 6 genera. *Dryopteris* was the largest of the 45 genera, with 12 species. Out of total, most of the species found from terrestrial habitat (65 species) followed by lithophytes (34), and epiphytic (28) (Bhattarai and Rajbhandary, 2017).

A total of 15 species of pteridophytes belongs to 10 families and 14 genera were reported from Chameli Community Forest, Bhaktapur, Nepal. Among them dominant genus was *Dryopteris* including 2 species and other species were single genus (Chaulagain and Shrestha-Malla, 2017). Likewise, total 92 species of ferns and fern allies recorded from the Panchase region of Central Nepal, belonging to 50 genera and 22 families. According to this study, Polypodiaceae, which contains 11 genera and 21 species, was the largest family. Out of total, largest genera was *Ledpisorus* having 7 species. Depending on habitat, terrestrial habitats (47 species) accounted for the largest portion of the species gathered, followed by epiphytic (28 species), and lithophytes (5 species). A few species, including 2 species that are both terrestrial and epiphytic and 7 species that are both lithophytes and terrestrial, were discovered in various habitats (Thakur and Rajbhandary, 2018).

Altogether 99 species of pteridophytes (ferns and ferns allies) belonging to 20 families and 48 genera documented from Besishahar to Lower Manang, Central Nepal. Among them, Pteridaceae and Polypodiaceae were the largest families with 9 genera and *Thelypteris* was the largest genus with 9 species 11 genera. The maximum diversity of pteridophytes was discovered between 2000 to 2600 meters above sea level. Out of 99 species of pteridophytes, highest number of species recorded from terrestrial habitat (55.21%) followed by epiphytic (23.96%) and lithophytes (20.83%) (Shrestha and Rajbhandary, 2019). Likewise, Upadhaya and Bastakoti, (2019) identified 27 pteridophytic species from Bhimkalipatan, Pokhara, Nepal, belonging to 11 families and 19 genera. Among them, the family with the largest genera (5) was Polypodiaceae followed by Dryopteridaceae and Pteridaceae, which each had 3 genera. *Pteris* and *Pyrossia,* which each had 3 species, were the largest genera, followed by *Adiantum*, *Drynaria*, *Lygodium,* and T*helypteris,* which each contained two species. Total 75 pteridophyte species had recorded from Arghakhanchi district, West Nepal, belonging to 18 families and 36 genera. The richest family was Pteridaceae, with 5 genera and 21 species, and the richest genus was *Thelypteris*, with 9 species. There were 39 species terrestrial, 12 lithophytes, and 11 epiphytes on the basis of habitat. The species richness of pteridophytes demonstrated statistical significance by unimodal relationship with altitude and temperature (Nepali *et al.*, 2020). Similarly, Chalise *et al.*, (2020) carried out by systematic investigation of floristic diversity of vascular plants from Daman and the adjoining areas of Makawanpur district, Central Nepal. In this study they reported 11 species of fern and fern allies. Pteridaceae was dominant family of fern in this study paper.

Altogether 50 species of ferns and fern allies representing 19 families and 32 genera were identified from Raja-Rani Wetland and adjoining forest, Eastern Nepal. Among them largest family (13 species) was Pteridaceae, followed by Polypodiaceae (6 species) and Thelypteridaceae (5 species). *Thelypteris*, with 5 species, was the largest genus, followed by *Pteris* and *Pyrrosia*, each with 4 species. The majority of the species (60%) were terrestrial, followed by those that were lithophytic (18%), epiphytic (10%), aquatic (6%) and climbers (6%) (Ojha and Niroula, 2021). Total of 30 species of pteridophytes belongs to 28 genera and 14 families were reported from Daman-Simbhanjyang area of Makwanpur district, Nepal. The largest family was Pteridaceae including 7 species which was followed by Polypodiaceae Dennstaedtiaceae (Magar and Chaudhary, 2022). Likewie, total 86 ferns and ferns allies reported from Palpa district, belonging to 20 families and 43 genera. Among them, Pteridaceae was largest families including 9 genera and 19 species. Similarly largest genus was *Thelypteris* with 10 species (Naupane, 2023).

2.2 Factors affecting Pteridophyte diversity

Land use and geographic variables, such as aspects and elevation, slope degree and fluctuations, are thought to be the primary topographic elements for the Mountain regions that indirectly affect the diversity and distribution of the flora (Sanders *et al.*, 2007; Sanders and Rahbek, 2012). According to Nahidan *et al.*, (2015), slope aspect can modify the rate of litter decomposition and the activity of soil microbes, which can have a substantial impact on the quantity of soil organic carbin, total nitrogen, and enzyme activity. In comparison to north facing slopes, south facing slopes typically receive higher temperatures, more intense light, and less rainfall (Warren, 2008). The Pteridophyte species richness was higher in the North facing slope than the South facing slope in the Himalayas because the Northern aspects are moisture than the Southern aspects (Panthi *et al.*, 2007). Similarly, terrestrial microhabitats alter as a result of point temperature, water availability, soil nutrients, soil moisture, and topographic characteristics over a distance of seventy-two meters, operating the pteridophytes distribution at largely diverse scales (Geiger *et al.*, 1995; Cicuzza *et al.*, 2013). The wide variety of epiphytes in the forest understory is caused by the many microhabitats. Comparatively more epiphytic ferns were observed on trees in dense, moist forests than in open, dry places (Rajbhandary, 2016). The high canopy's transparency enhanced light but decreased moisture, which in turn reduced the diversity of ground ferns (Zhang *et al*., 2015). Similarly, geography influences pteridophyte diversity, which is generally higher on slopes than on ridges (Kessler and Lehnert, 2009). According to Nettesheim *et al*., (2014), slopes only influence the species composition of ferns and lycophytes in Brazilian tropical forests, not their species richness.

2.3 Ethnobotany of Pteridophytes

Pteridophytes have also been used medicinally for over 2000 years (Parihar and Parihar, 2006). Altogether 15 species of pteridophytes reported from Chenchu tribes living in the Nallamalais in Andhra Pradesh, India, along with their botanical name, family name, vernacular name, habit, habitat, and ethnomedicinal usage. A few examples include *Actiniopteris radiate*, *Adiantum caudatum*, *Adiantum lunulatum*, *Ceratopteris thalictroides*, *Cyclosorus gongilodea*, *Cyclosorus parasiticus*, *Hemionitis arifolia*, *Lygodium flexuosum*, *Lygodium flexuosum*, *Nephrolepsis cordifolia*, *Selaginella indica* (Rao *et al*., 2007). Similarly, Sathiyaraj *et al*., (2015) conducted a survey on the pteridophytes in the Palani Hills of South India and offered details on 50 species, 35 genera, and 19 families, along with information on their botanical names, habitats, and medicinal preparations. In the same way, Verma and Kanwar (2020) identified 25 medicinal pteridophytes from Sarkaghat Tehsil in Mandi District, Himachal Pradesh, belonging to 14 genera and 10 families. They discovered that those pteridophytes were employed to cure 46 different human illnesses. In terms of plant parts, the majority of ailments were treated with the whole plant (40%) whereas the rhizome (23%) was the least used plant portion for human disease treatment.

In Nepal, huge numbers of ethnic tribes depend on natural resources for their daily requirements of food and medicine. However, only few researchers have recorded the ethnobotanical study of pteridophytes in Nepal. Manandhar (1996) reported 72 species of ferns with their local names, ethnobotanical use, habitat and distribution. Sapkota (2000) reported the use of 5 species of pteridophytes from Malika forest of Baglung district. Likewise, Shrestha and Shrestha (2005) found 35 pteridophytes species from Lantang National Park for ethnobotanical purposes. A total of 14 species of pteridophytes were reported for ethnobotanical uses from Central developmental region of Nepal (Joshi *et al*., 2008). Similarly, Joshi and Joshi (2008) found many uses of ferns, such as the juice of *Adiantum incisum* was used to cure scabies and

Adiantum capillus-veneris was utilized as a medicinal herb such as its leaf paste was used to cure headaches and chest pain; a plant decoction was used to treat whooping cough, throat, and bronchitis problems. Similarly young shoots of *Dryopteris cochleata* was used as vegetable in Makwanpur district, Central Nepal (Joshi *et al*., 2015).

According to Uprety *et al*., (2010), *Lepisorus mehrae* was used to cure digestive problems in the Rasuwa district. In the same way, several researchers found that *Drynaria propinqua* rhizome paste was utilized to treat backaches and dislocated bones (Malla *et al*., 2015, Tamang *et al*., 2017) as well as sprains and applied to the forehead to reduce headaches (Malla *et al*., 2015). Similarly, total 51 pteridophyte species from Panchase Forest were documented by Thakur and Rajbhandary (2018) for ethnobotanical purposes. Adhikari *et al*., (2019) were found that the juice of *Aleuritopteris bicolor* was utilized to cure diarrhoea, dysentery, and gastritis from the Kaski district. In the same way *Nephrolepis cordifolia* was used to cure skin conditions, bone fractures, boils, and jaundice (Pradhan *et al*., 2020). Similarly, Bista (2021) listed 10 species of pteridophytes as having ethnobotanical uses in East Rukum. According to survey conducted in Nepal, a total of 26 species of pteridophytes were used as food and 43 species of pteridophytes were used as traditional medicine, belonging to 20 families (Ojha and Devkota, 2021). Likewise, Naupane (2023) recently reported 21 pteridophytes species as ethnobotanical uses from the Palpa district.

Research on the relationships between species and elevation has frequently focused on pteridophytes, with the highest diversity seen in tropical and subtropical highlands (Linder, 2001; Bhattrai *et al*., 2004). Several studies of pteridophytes have already been conducted in various part of Nepal but comparative research on the diversity of pteridophytes in various aspects of Nepal is still insufficient. Few work done in Palpa district in the past are floristic research done by Mahato, (2014) and Shrestha *et al*., (2018), ethnobotanical work by (Singh *et al*., 2011; Gubajhu and Gaha, 2019 and Pangeni *et al*., 2020) , study on pteridophytes by (Mahato, 2014; Neupane, 2023) but in Purbakhola Rural Municipality have not been explored till date. The research work which was done previously was focused only in the enumeration of pteridophytes but the present study work was focused on the diversity of pteridophytes along the altitudinal gradient and as in different aspects as well as their ethnobotanical aspects.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study area

3.1.1 Physiographic location

The study area is located at Purbakhola Rural Municipality in Palpa district of province 5, Nepal. The total area of the Palpa district is around 1366 km^2. The elevation ranges from 300 to 1900 meters above sea level (Mahato, 2014). Palpa district is surrounded on the East by Nawalparasi and Tanahun district, on the West by Arghakhachi and Gulmi district, on the North by Syangja and Tanahun district, and on the South by Nawalparasi and Rupandehi district. Purbakhola Rural Municipality is located in the Eastern part of Palpa and is encircled by Rampur Municipality to the North, Rambha Rural Municipality to the West, and Mathagadi Rural Municipality to the South. Study area geographically situated between 27^0 46' to 27^0 50' N and 83^0 46' to 83^0 49' E. The altitude of this Rural Municipality ranges from about 770 to 1600 meters above sea level. Area occupied by 138 sq. km and total forest area covered by 72.5 sq km.

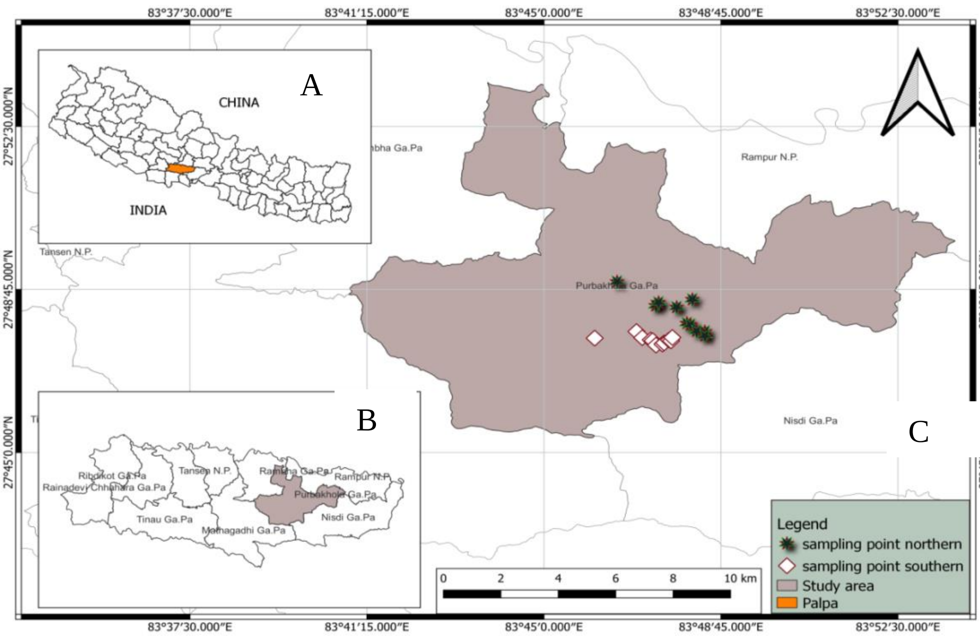

Figure 1. Map of study area; District Map of Nepal (A), Map of Palpa District showing Study area (B), Map of Purbakhola Rural Municipality Showing study Plots (C)

3.1.2 Climate

The study area lies in hilly region so the climate is sub-tropical type with wet summers and dry winters. Metrological data were collected from Department of Hydrology and Metrology, Katmandu Nepal of the Tansen station, Palpa. Data were obtained as monthly mean maximum and minimum temperatures and mean rainfall. The monthly average maximum temperature, minimum temperature, and precipitation were calculated using the obtained data. According to the climatic data of 2012-2022 of the Tansen station, Palpa (Lat./ Long. 27.86 N, 83.53 E Altitude: 1183masl.), the mean maximum temperature ranged from 19^0C to 30^0C and temperature was highest in the months of April and May and mean minimum temperature ranged from 6^0 C to 19^0 C and the least temperature was recorded in the months of January and December. The mean monthly highest precipitation was 520.19 mm in July and no precipitation was recorded in November (DHM, 2022) (Figure 2).

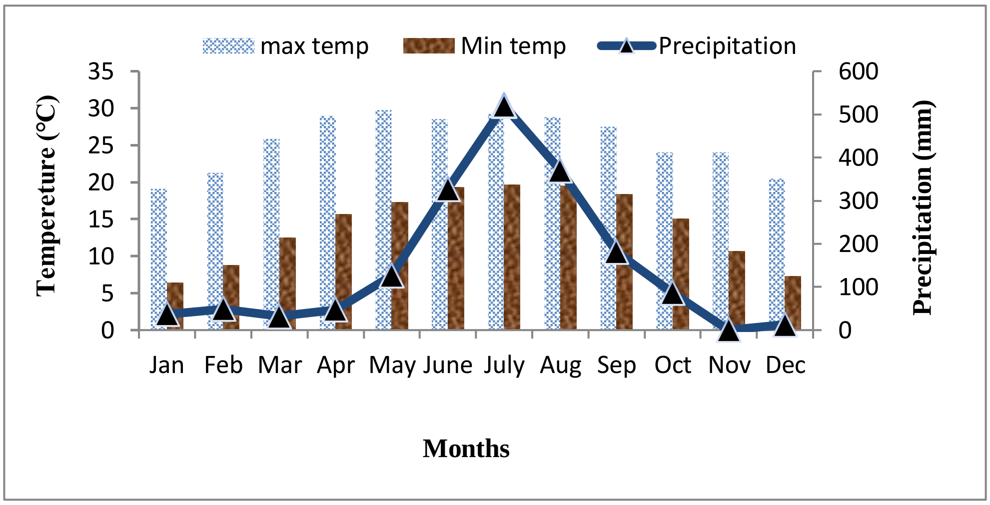

Figure 2. Ten years (2012-2022) average monthly maximum and minimum temperature and precipitation data of Tansen station, Palpa (source: Department of Hydrology and Metrology, Government of Nepal, Kathmandu, 2022)

3.1.3 Vegetation

Study area consist of of tropical and sub-tropical type vegetation inhabited by *Shorea robusta* forest at the lower altitudinal region (800-1000 m), *Pinus wallichiana* mixed forest in middle part (1000-1300 m) and *Quercus* mixed forest in the upper part (above 1400 m). Some major tree species in study area were *Shroea robusta*, *Pinus wallichina*, *Quercus glauca, Schima wallichi*, *Castonopsis indica*, *Syzizium cumini*, *Bauhinia variegate*, *Diploknema butyracea*, *Terminalia chebula*, *Terminalia alata*, *Phyllanthes emblica*, etc. Shrubs like *Justicia* *adhatoda*, *Urtica dioica*, *Bergenia ciliate*; *Bergenia ligulata*, *Crisium wallichii*, *Vitex negundo*, *Zanthoxylum armatum*, *Lyonia ovalifolia*, *Berberis aristata*, etc are found. *Ageratina adenophora*, *Bidense pilosa*. *Thysanolaena latifolia*, *Polygonum* sp, *Artemisia vulgaris*, *Cynodon dactylon*, *Fragaria* sp, *Hypericum* sp, etc, were found common herbs of research area. Climbers like *Smilex aspera*, *Cuscuta reflexa*, *Piper longum*, *Acrocephalus indicus*, *Periploca calophylla*, etc. were commonly found in the study area.

3.2 Pteridophytes sampling

The present study includes field visit, systematic sampling, formal interview and questionnaires. Before field sampling, the potentially rich area for species abundance and pteridophytes found in the area, identified after preliminary field visit. Preliminary field visit was done in May, 2022. The route of Ringneraha phat to Hattilake Mountain (Northern and Southern aspect) of Purbakhola Rural Municipality was selected for study. Extensive field visit and data collection was carried out for two times; between 20th October to 6 th November and 8th December to 10th December, 2022. Systematic sampling method was applied for data collection. At every 100m elevation a total 7 plots (5m×5m) were laid along horizontal transect and distance between each plot was at least 20 m. Same process was applied on both aspects (modified by Scheidegger *et al*., 2010) (Figure 3). In both aspects, sampling was carried out from elevation 800 masl. to 1600 masl. Altogether 126 quadrates were laid of which 63 quadrates in the Northern and 63 quadrates in the Southern aspects. GPS points were recorded with the help of GPS meter.

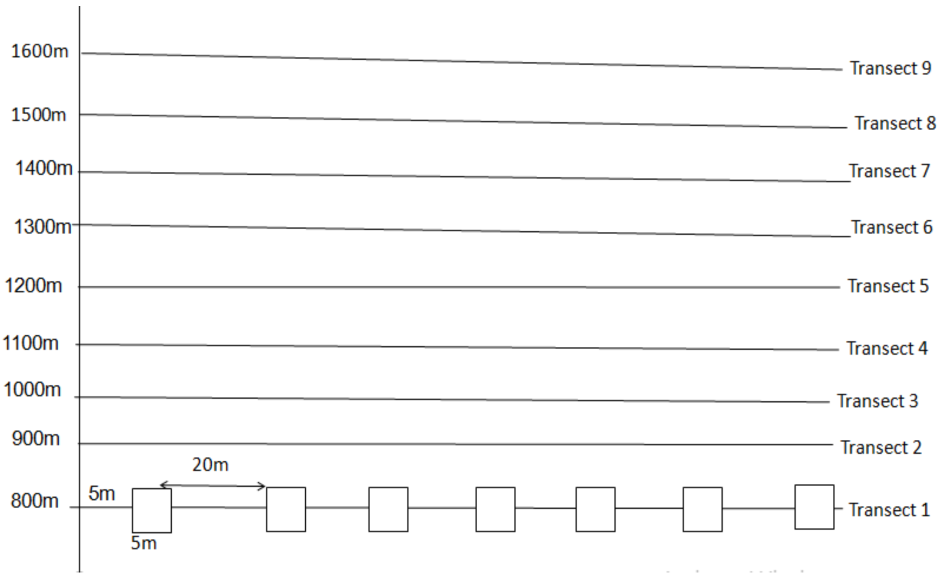

Figure 3. Schematic diagram of a survey site showing seven transect along 100m elevation (modified after Scheidegger *et al*., 2010)

Vegetation data such as, species richness, density, coverage, frequency and plot characteristics such as tree canopy, latitude, longitude, altitude, aspect etc. was collected from each sample plots. Each plot's enrooted pteridophyte species were counted and atleast one samples of each species were taken for identification and hebarium preparation. Each pteridophyte sample was photographed and ecological characteristics (habitat, associated species etc.) were also recorded. GPS was used to record the coordinates of each plot location. The species of pteridophyte that were present outside of the plots and along the path were also collected and their habitats and coordinates were recorded as an additional data. After drying the collected plants samples were preserved as herbarium for identification. Pteridophytes species were identified in the field by consulting flora books and literature (Fraser-Jenkins *et al*., 2015; Fraser- Jenkin and Kandel, 2019; Kandel and Fraser- Jenkin, 2020). Further conformation of the name of species was done with the help of herbarium at National Herbarium and Laboratory, Godawari (KATH). After identification, the altitudinal range of each species was given using the maximum and minimum altitudes of each species. All of those identified herbarium specimens were submitted to the Department of Botany, Amrit Campus.

3.3 Data analysis

3.3.1 Quantitative analysis

For vegetation analysis following parameters and formula were used Zobel *et al*., (1987).

$$\text{Density (D)} = \frac{\text{Total no.of individual species}}{\text{Total quadrate studied}}$$

$$\text{Relative Density (RD) (\%)} = \frac{\text{Density of species}}{\text{Density of all species}} \times 100$$

$$\text{Frequency (F) (\%)} = \frac{\text{No.of quadrat in which species occurred}}{\text{No.of quadrat in which species occurred}} \times 100$$

$$\text{Relativefrequency (RF) (\%)} = \frac{\text{Frequency of one species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Coverage (C)} = \frac{\text{Total coverage of species}}{\text{Total number of qudrate}}$$

$$\text{RC (\%)} = \frac{\text{Coverage of one species}}{\text{Total cover of all species}} \times 100$$

Importance value index = RF+RD+RC

Where,

IVI= Importance Value Index

RF= Relative Frequency (RF)

RD= Relative Density

RC= Relative Coverage

Diversity indices

Measures of diversity consider two aspects, namely: species richness and evenness. Species richness is the number of species present per sampling unit and evenness is the consistency of each species' population size in the area. Mostly, for vegetation analysis following two diversity indices was calculated i.e., Simpson's index and Shannon-wiener's index.

Simpson's Index

(SI) = $\frac{\Sigma n(n-1)}{N(N-1)}$

Where, n = number of individuals in the nth species, N = the total number of individuals of all the species,

Simpson's Diversity Index (D)

It is determined using 1-Simpson's Index. The value of diversity index (1-D) ranges from 0 to 1 where 1 represent infinite diversity and 0 no diversity (Magurran, 2004).

Shannon-Wiener Index (H): It was calculated by following equation (Mugurran, 2004)

Shanon-Wiener index (H') = $-\Sigma Pi \times (\ln Pi)$

Where,

(H')= Species diversity index

Pi = Proportion of individual species,

Pi = $\frac{ni}{N}$

Where, ni = number of individual species

N= total number of all species

3.3.2 Statistical analysis

Data management and basic calculations were done in Microsoft excel. Statistical Package for Social Science (IBM SPSS version 20) was used for the statistical analysis. The data were checked for normality using the Kolmogorov-Smirnov significant value ($p>0.05$). Parametric tests were performed for normal data. The number of plant species was used to determine the plant's species richness. The IVI of various species was calculated using the number of species, their coverage, and frequency. Shannon and Simpson diversity indices were used to calculate the species diversity between two aspects. To determine the level of significance and the relationship between altitude and species diversity, linear regression was carried out using SPSS. Linear regression was performed as a scatter plot between species richness and altitude, for this data sheet was made up of the number of species present in each quadrat as well as the respective altitude. Relationship between pteridophytes species richness and tree canopy cover was also assessed by linear Regression analysis. To examine the mean species richness at different altitudes, a one-way ANOVA was performed, followed by a Bonferroni post hoc test. Z-test was utilized to compare the mean difference between two aspects.

3.4 Ethnobotanical study

The information about local knowledge pteridophytes was collected following RRA (Rapid Rural appraisal) by interviewing the local people of different community. They were asked about abundance of pteridophytes and their uses. Some of the questions were predetermined (Appendix II) while others came up during the discussion.

3.4.1 Categorization of Mode of Use

The modes of medicine preparation by indigenous people observed during study period are as follows:

a. **Decoction**: A liquid medicinal preparation made by boiling the plant parts with water.
b. **Juice**: The plant part crushed in mortar and pestle and was squeezed or filtered through few layers of cloths to preapered an extract.
c. **Paste:** The fresh plant parts are crushed or grinded by motar and pestle made up of stone to prepared paste.
d. **Powder**: A product prepared from the plant parts which are dried in open sunlight and crushed using dry mortar and pestle or burnt to make ash.
e. **Raw**: The fresh plant parts that are taken in their natural form.

CHAPTER 4

RESULTS

4.1 Diversity of Pteridophytes

A total of 42 plant species (inside plot 39, outside plot 3) under 12 families and 24 genera were reported from the study area among which 38 species were found in the Northern aspect, and 29 species were found in the Southern (Figure 4, Appendix IV). Out of all collected species 25 species were found common to both aspects (Appendix V). Similarly, out of the total species, 13 species were found only in the Northern aspect, whereas 5 species were found only in the Southern aspect (Appendix IV). Out of 42 species of pteridophytes 7 species were epiphytic and others were lithophytes and terrestrial (Appendix VI).

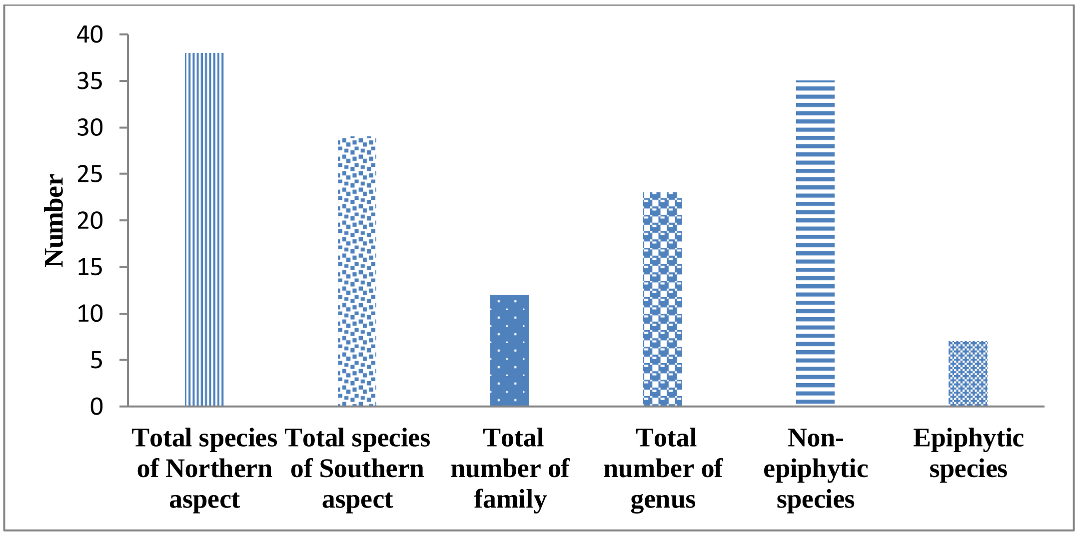

Figure 4. Diversity of Pterodophytes in study site

Pteridaceae was most dominant family having highest number of genera and species i.e., 5 and 15 respectively followed by Polypodiaceae which contains 5 genera and 6 species, Thelypteridaceae having 5 species belonging to 1 genus, Selaginellaceae 4 species 1 genus, Dryopteridaceae contains 3 genera and 3 species, Dennstaedtiaceae and Woodsiaceae both contains 2 genera and 2 species. Some families like Equisetaceae, Lindsaeceae, Lygodiaceae, Nephrolepidaceae, and Vittariaceae contained one genus and a species (Appendix VI, Figure 5).

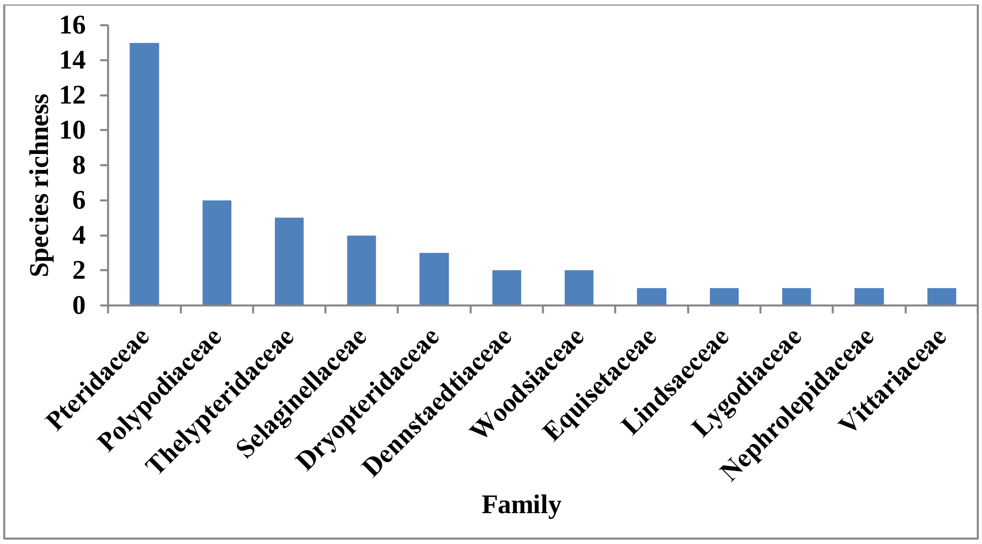

Figure 5. Species richness belonging to each family of the study area

The largest genus was *Pteris* having 6 species followed by *Thelypteris* (5), *Selaginella* (4), *Aleuritopteris* (3), *Adiantum* (3), *Pyrossia* (2), *Onychium* (2), *Dryopteris*, *Equisetum*, *Microsorum and Tectaria* (1 for each) (Appendix VI, Figure 6).

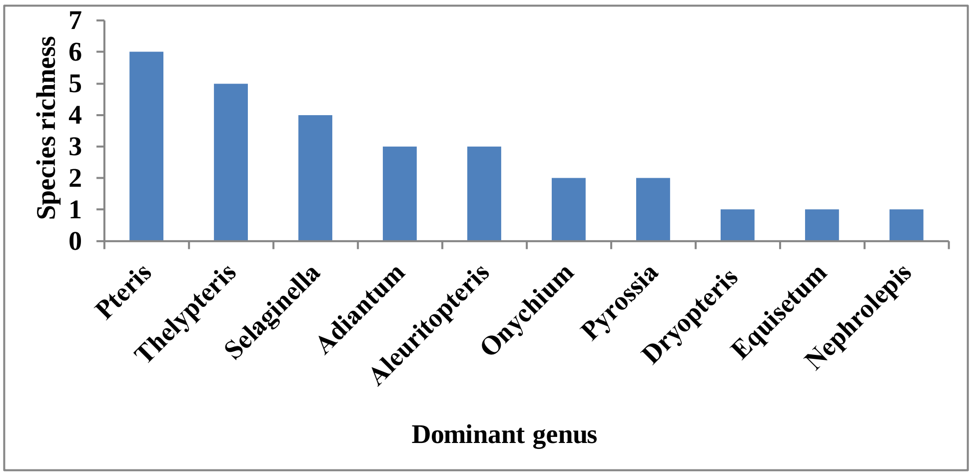

Figure 6. Most dominant genus of pteridophytes in the study area

4.2 Diversity indices

Simpson's diversity index and Shannon-Weiner index were both utilized to evaluate the overall state of pteridophytes diversity in the study site. The diversity index was examined between the Northern and Southern plots and at different altitudes. Overall, the highest Simpson's diversity index was found in Northern aspect i.e., 0.94 and slightly least in Southern aspect i.e, 0.92 due to moit habitat in Northern aspect. In the same way, Shannon-Weiner index was found highest (1.35) in Northern and lowest (1.20) in Southern aspect (Figure 7). In comparison to the altitudinal zone, the highest Simpson and Shannon Wiener index was found at 800m altitude while the lowest Simpson and Shannon Wiener index was found at 1600m. The range of Simpson's diversity index is from 0 to 1 and the high scores (close to 1) indicate high diversity. Thus it can be interpreted that there was high diversity found in Northern aspect of 800m and low in 1600m altitude (Table 1). The high value of Shannon Wiener index of the study reports indicates the high diversity species.

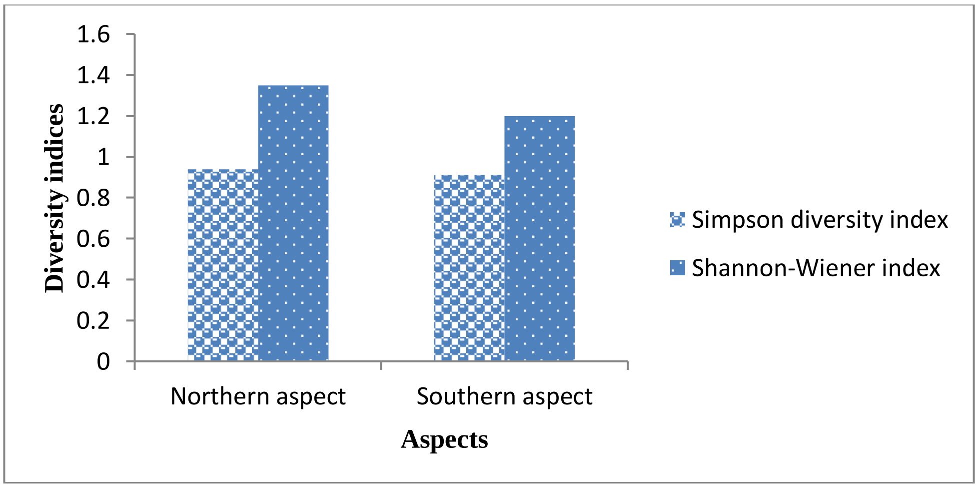

Figure 7. Simoson and Shannon-Wiener diversity index of Northern and Southern aspect

Table 1. Diversity indices of Pteridophytes species in different aspects of altitudinal zone

Atitudinal range	Northern aspect		Southern aspect	
	Simpson's diversity index (1-D)	**Shannon's Wiener diversity index**	**Simpson's diversity index(1-D)**	**Shannon's Wiener diversity index**
800 m	0.95	1.22	0.94	1.19
900m	0.92	1.06	0.91	1.00
1000m	0.89	1.83	0.88	0.92
1100m	0.90	1.00	0.88	0.90
1200m	0.94	1.13	0.90	1.00
1300m	0.91	0.95	0.81	0.72
1400m	0.90	0.98	0.88	0.95
1500m	0.93	1.07	0.80	0.69
1600m	0.79	0.65	0.79	0.63

4.3 Importance Value Index (IVI)

The importance value index measures a species' proportional contribution to the entire community. On the basis of IVI, *Selaginella fulcrata* was the most dominant species on both the Northern and Southern aspects, with IVI values of 36.90 and 79.51, respectively. In Northern aspect *Selaginella fulcrata* was followed by *Thelypteris dentata*, *Selaginella pallida*, *Dryopteris cochleata*, *Aleuritopteris bicolor*, *Selaginella chrysorrhizos*, *Pteris vitata*, *adiantum incisum*, *Aleuritopteris dealbata*, *Thelypteris penangiana* (Figure 8, Appendix VIII) while in Southern aspect, *Selaginella fulcrata* was followed by *Aleuritopteris bicolor*, *Dryopteris cochleata*, *Aleuritopteris dealbata*, *Selaginella chrysorrhizo*, *Adiantum incisum*, *Pteris vitata*, *Selaginella pallida*, *Hypodematium crenatum*, *Thelypteris procera* (Figure 9, Appendix IX). Out of total, *Pteris aspericaulis* had the least dominance in the Northern aspect, while *Microlepia speluncae* had the least dominance in the Southern aspect, with IVI values of 0.63 and 0.68, respectively (Appendix VIII and IX).

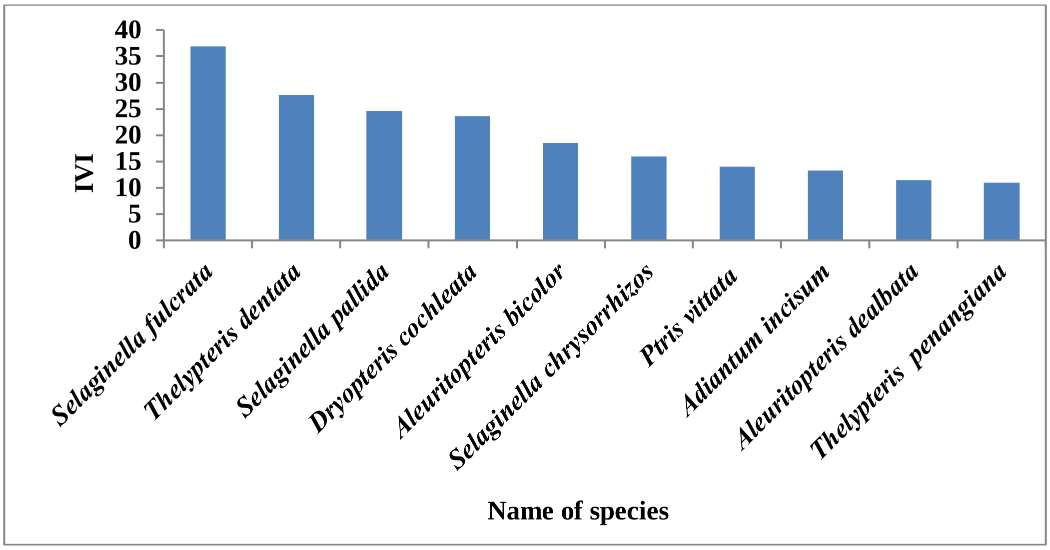

Figure 8. Dominant species of Northern aspect

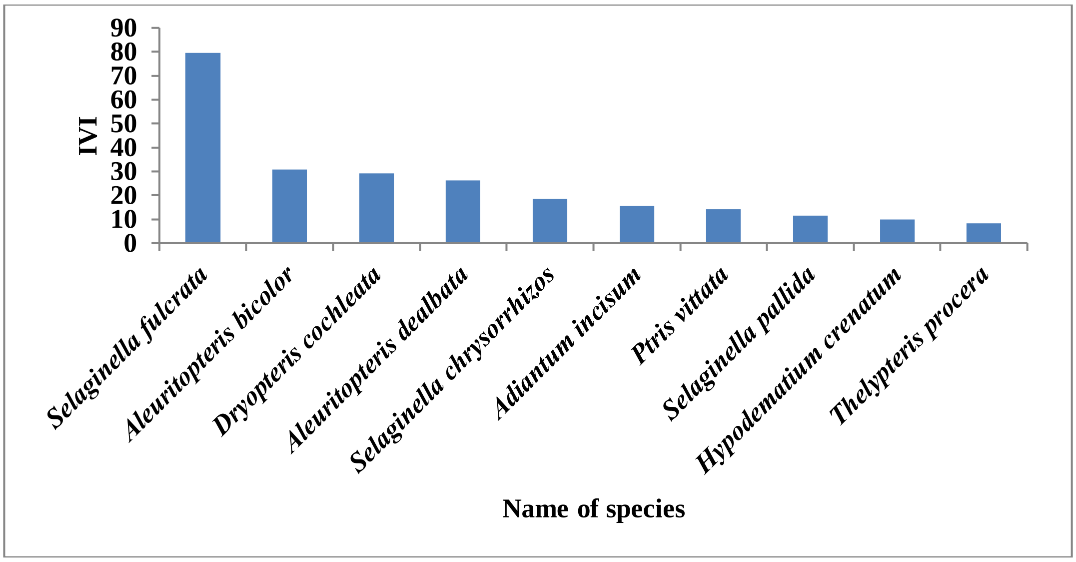

Figure 9. Dominant species of Southern aspect

4.4 Variation of Pterodophytes diversity

The mean difference between population of Northern and Southern aspects was found to be significant ($P<0.05$). Species richness decrease with increase in elevation in both Northern and Southern aspects ($p<0.01$) (Figure 10).

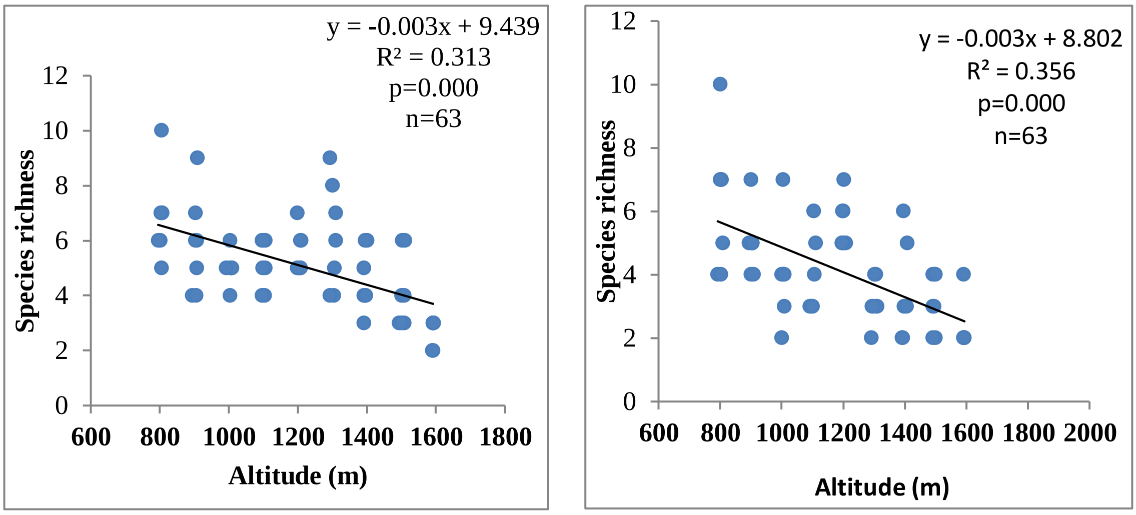

Figure 10. Linear regression between species richness and altitudinal gradient; Northern aspect (left), Southern aspect (right)

The relationship between the species richness and tree canopy cover was insignificant ($p>0.05$) in Northern aspect while significant ($p<0.05$) in Southern aspect. According to scatter plot and linear regression, the general species richness was greatest between 20-40% canopy cover (Figure 11).

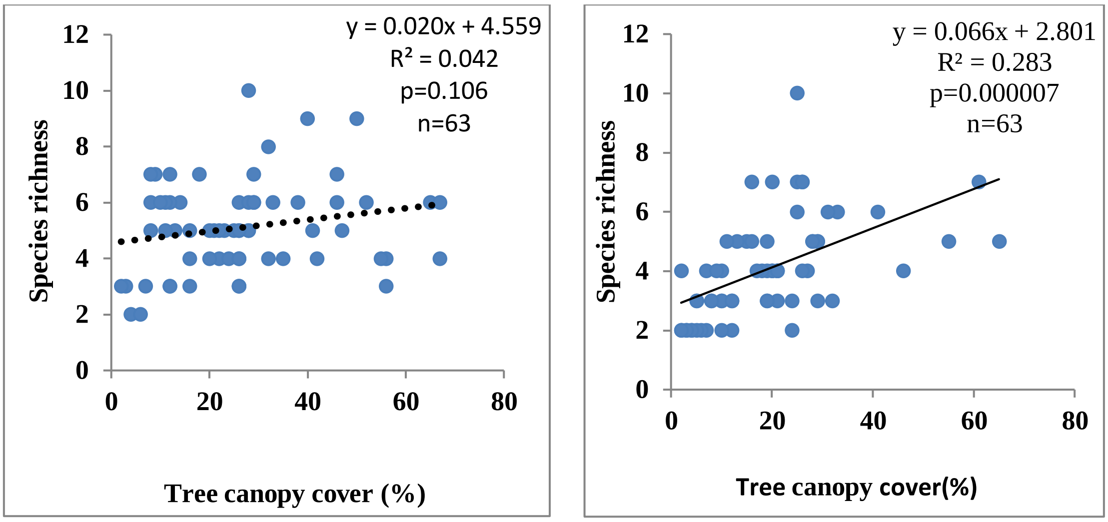

Figure 11. Relationship between the species richness and tree canopy cover; northern aspect (left), Southern aspect (right)

The mean species richness across elevations in both the aspects was statistically significant ($p < 0.01$) based on one way anova (Figure 12, 13). The mean species richness of the Northern and Southern aspects, along with the standard error, was presented as a descriptive statistic for different altitudes. The highest species richness was found at 800 m, followed by 1300m, 900m, 1200m, 1100m, 1000m, 1400m, 1500m, and 1600m in northern aspect (Table 2, Figure 11) Similarly at different altitude of Southern aspect, highest mean species richness was recorded from 800m followed by 1200m, 900m, 1000m, 1100m, 1400m, 1300m, 1500m, 1600m (Table 2, Figure 12).

Table 2. Mean species richness of Northern and Southern aspect values showed mean and standard error across different altitude.

Altitude	Aspects	
	Northern	Southern
	Speciesrichness (Mean±S.E.)	Speciesrichness (Mean±S.E.)
800m	6.85±0.594	6.28±0.808
900m	5.85±0.670	5.00±0.377
1000m	5.00±0.218	4.00±0.577
1100m	5.14±0.340	3.85±0.459
1200m	5.57±0.297	5.57±0.297
1300m	6.14±0.737	3.14±0.260
1400m	4.57±0.428	3.42±0.571
1500m	4.14±0.508	3.14±0.340
1600m	2.71±0.184	2.28±0.285

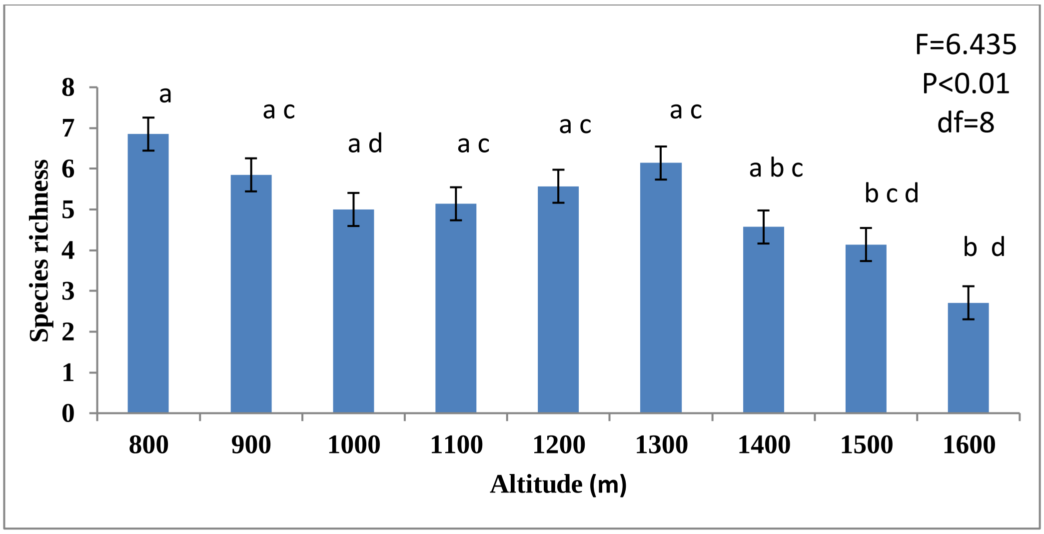

Figure 11. Test statistics (df, F and P) are based on one-way ANOVA and values sharing same letters are not significantly different in Northrn aspect

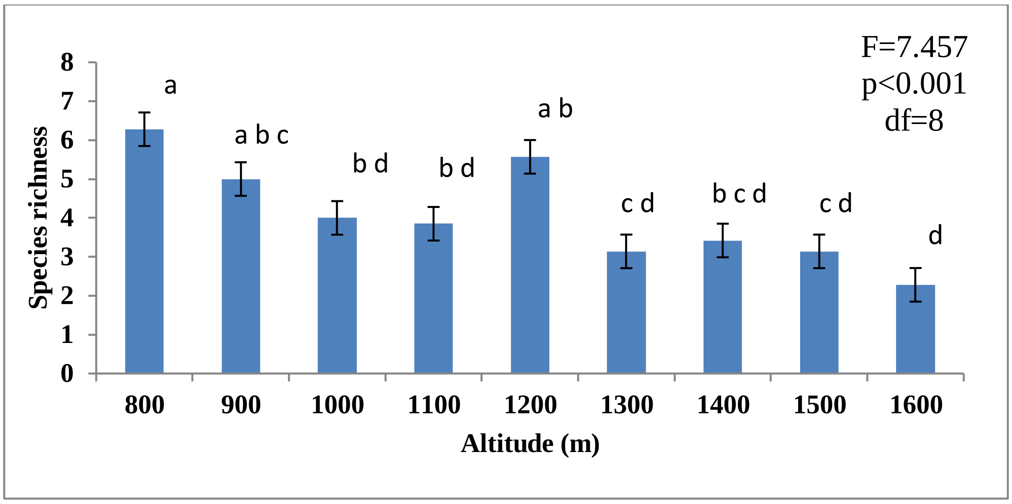

Figure 12. Test statistics (df, F and P) are based on one-way ANOVA and values sharing same letters are not significantly different in Southern aspect

4.5 Description of pteridopytes species

The distinguishing characteristics of each species of pteridophytes recorded from study area with several families, as well as their ecological characteristics, are listed below.

1. Dryopteridaceae

Dryopteris cochleata (D. Don) C. Chr.

Distinguishing characters: Plants is about 60-120 cm tall, rhizome short-creeping, scaly toward the base, scales yellowish or pale brown; stipe long, brown scales on the base, hair free upward; frond bipinnate, distinctly dimorphic; lamina ovate in outline, widest at the base, base ovate and apex pointed; sparse, brown scales on the rachis and costa; pinnate veins, unbranched, unclear adaxially, distinct abaxially; basal pinnae deltoid-lanceolate, margin incised-serrate, circular sori, yellowish–brown in two row, completely covering the entire lower side.

Ecology: In the partially dry area, tropical forest to mixed forest, mostly common in Northern.

Voucher specimen: **Alt.:** 800-1500 m, **Lat. /Long.:** 27°47′56.13″ N/83°48′06.28″ E. **Coll. Date:** 22/10/2022, **Locality:** Hattilake and Jamale site, Purbakhola, Palpa **Collector:** K. Acharya **Col. No.: 8 (Amrit Campus herbarium).**

Hypodematium crenatum (Forssk.) Kuhn subsp. Crenatum

Distinguishing characters: Rhizome shortly creeping or ascending, densely scaly together with stipe base; scales raddish brown color; stipe medium, straw color, base covered with scales, upwards with grayish white hairs; the lamina is pentagonal to elliptical, pinnate to pinnatified, and densely coated with long hairs on both surfaces, ponted apex; pinnae are moderately circular, with the lowest pair subopposite and the upper pair alternate; the basal pinnae are the largest, ranging from deltoid to elliptical; sori dorsal, 1-3 per segment, at middle of veinlets, orbiscular; indusial persistent, pale gray, reniform, large, membranous, densely covered with hairs; spores ellipsoid.

Ecology: Terrestrial, reported from dry places, attach with rocky surface, mixed forest.

Voucher specimen: **Alt.:** 800 -1400m, **Lat. /Long.:** 27°47′29.56 N/83°47′ 30.74″ E. **Coll. Date:** 29/10/2022, **Locality:** Khiluwatari, Siluwa, Purbakhola Western Palpa, **Collector:** K. Acharya, **Col. No.: 26 (Amrit Campus herbarium).**

Tectaria coadunata (J. sm.) C. chr.

Distinguishing characters: Tall plant, horizontal rhizome or sometime erect, stipe long bearing scattered darkish-brown scales, pale colored, glossy; lamina pinnatified to quadripinnatified, light green, deltoid, the basal pinnae are subopposite, while the middle pinnae are alternating and lobed; pinnules of the middle pinnae are stalked and oblong to lanceolate in shape, pinnules of the middle pinnae are stalked, oblong-subtraiangular, deeply lobed, and have acuminate apices; veins includesd free veinlets; small sori with subsidiary sori arranged at the tip; arranged in a single row on each side of the final lobes midrib, sori brown, or pale brown color.

Ecology: Terrestrial, moist places, sometimes tolerate dry habitat, in the mixed forest, tropical and subtropical region.

Voucher specimen: **Alt.:** 800-1500 m, **Lat. /Long.:** 28°32′15″ N/82°24′ 58″ E. **Coll. Date:** 20/10/2022, **Locality:** collected from Hattilake and Siluwa, Purbakhola, Palpa. **Collector:** K. Acharya **Col. No: 10 (Amrit Campus herbarium).**

2. Dennstaedtiaceae

Microlepia speluncae (C.) T. Moore

Distinguishing characters:

Species grow upto 2 m tall; the rhizome is thick and horizontal; the stipe is long and straight, and the fronds are tripinnate, distinctly deltate, broadest at the base, and narrowing as it near the apex; pinnae alternate, narrowly oblong to lanceolate; pinnules alternate, possessing small apical teeth; rachis thinly pubescent with minute hairs, eventually glabrous; sori on tip of the vein, clearly intramarginal, round-oblong; spores yellowish- light brown.

Specimen examined: Alt.: 800m. **Lat./Long.:** 27°48′22.67″N/ 83°47′22.14″ E.

Ecology: Terrestrial, plants grow on partially moist places, or rarely in dry habitat; under the shade condition, Sal forest, mixed forest.

Voucher specimen: **Alt.:** 800m. **Lat./Long.:** 27°48′22.67″N/ 83°47′22.14″ E. **Col. Date:** 02/11/2022, **Locality:** it was collected from Khiluwatari of Purbakhola and Jamale site of Siluwa, Purbakhola, Palpa. **Collector:** K. Acharya, **Col. No.: 30 (Amrit Campus herbarium).**

Pteridium revolutum (Blume) Nakai

Distinguishing characters: Pteridophyte which can grow upto 1 m tall, it has long creeping rhizome, fronds sub-leathery when dried, hard lamina margins often revolute, stipe straw-colored or brown, 35-50 cm, 5-8 mm in diameter at base, pinnules opposite or alternate, spreading, sessile, lanceolate, base truncate, not adnate to costule, deeply pinnate, apex shortly caudate-acuminate.

Ecology: Terrestrial, in the moist shady areas and open areas, mixed forest.

Voucher specimen: Alt.: 1300-1500m, **Lat./Long.:** 27°47′56.13″N/83°48′06.28″ E. **Col. Date:** 20/10/2079, **Locality:** on the way Hattilake Mountain, Sukhaura of Siluwa, Purbakhola, Palpa. **Collector**: K. Acharya, **Coll. No.: 1 (Amrit campus herbarium).**

3. Equisetaceae

Equisetum ramosissimum Desf.

Distinguishing characters: Plant small to medium size**,** rhizome subterranean, jointed, roots borne in whole at the noods; stem erect, larger stem with a very wide central space within, usually with fewer branches in less complete whorls, and with longer branchless bases and apex, the ribs of the stem are much more numerous and are hardly raised, the strobilus has a distinct darkened pointed umbo at its apex, very clear in younger, more compact cones.

Ecology: Terrestrial, in the moist shady area, near water resources, mixed forest.

Voucher specimen: Alt.: 800-900 m, **Lat./Long.:** 27°48′27.97″ N/83°47′26.25″ E. **Coll. Date:** 03/11/2022, **Locality:** collected from Khiluwatari, stream, on the way Dhakrebhangyang, Purbakhola, Palpa, **Collector:** K. Acharya, **Col. No.: 34 (Amrit campus herbarium).**

4. Lindsaeceae

Odontosoria chinensis (L.) J. Sm.

Distinguishing characters: An average-sized fern; rhizome short creeping, the stipe is glabrous, slender, and straw-colored; lamina is tripinnate to quadripinnatifid and lanceolate; pinnae alternate, margin denticulate to erose, apex acuminate; veins visible on abaxial surface, sori terminal on uniting 2 or 3 vein ends, black colored sori when mature.

Ecology: Terrestrial, under the canopy cover, found in mixed forest.

Voucher specimen: Alt.: 1500 m. **Lat. /Long.:** 27°47′47.42″ N/83°48′14.08″E. **Coll. Date:** 20/10/2022, **Locality:** Hattilake, Purbakhola, Palpa **Collector:** K. Acharya, **Coll. No.: 2 (Amrit Campus herbarium)**

5. Lygodiaceae

Lygodium japonicum (Thunb.) Sw.

Distingushing characters: Rhizome that is broadly creeping and dichotomously branching; stipes are spaced to 1 cm apart on the rhizome; stem remain under-ground, juvenile frond erect; Pinnae on frondlets range from triangular to deltoid in form, with short stalks, double-serrated pinna margins; fertile leaflets are contracted in shape, Spores with conspicuous laesurae and fine, modest tuberculation.

Ecology: Climbing with shrubs and tree, partially dry places, found in mixed forest of *Pinus*, *Bauhinia* and *Shorea*, Sal forest.

Voucher specimen: **Alt.:** 800m-1000m **Lat. /Long.:** 27°47′37.33″ N/83°47′02.94″ E **Coll. Date:** 01/11/2022, **Locality:** Hattilake forest, Dakre Bhangyang site, Jamale Site, Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya, **Coll. No.: 28 (Amrit Campus herbarium).**

6. Nephrolepidaceae

Nephrolepis cordifolia (L.) C. Presl.

Distinguishing characters: Rhizomes erect, producing long-creeping runners with adventitious buds and tubers; rhizome covered with densely pale brown scales; stipe usually short, to 15 cm long; central pinnae oblong to lanceolate-oblong, straight to slightly falcate, base auriculate- cordate; achis with acroscopic overlap, margins entire to serrulate to smoothly crenate, apex acute to bluntly rounded; indusial reniform to runate or deltate-rounded; Sori in two rows along the vines.

Ecology: Terrestrial or epiphytic, reported from moist paces, grow in shady places, near water resources, sometime found on tree, found in mixed forest.

Voucher specimen: Alt.: 800m–900m. **Lat. /Long.:** 27°48′27.97″ N/83°47′26.25″ E. **Coll. Date:** 05/11/2022, **Locality:** Khiluwatari khola, on the way of Dhakrebhangyang site, Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 29 (Amrit Campus herbarium).**

7. Polypodiaceae

Drynaria propinqua Wall. ex Mett.) Bedd.

Distingushing characters: It is an epiphytic species; rhizome long, upto 1 cm diameter, creeping, very densely scaly, scales brown; dimorphic, glaborous fronds; The orbicular or oval basal fronds have an irregularly dentate margin; foliar fronds are stalked, stipe medium length straw colors, somewhat winged; the lamina is a little pinnatified, the margin is dentate, and the apex is pointed; sori round, yellowish brown in single row between costa and margin.

Ecology: Epiphytic plant, partially dry places, mostly found in moss cover tree trunk, found in mixed forest.

Voucher specimen: Alt.: 1200-1400m **Lat./Long.:** 27°47′56.13″N/83°48′06.28″ E **Coll. Date:** 22/10/2022, **Locality:** On the way of Hattilake Mountain, Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 23 (Amrit campus herbarium)**.

Lepisorus nudus (Hook.) Ching

Distingushing characters: Epiphytic species having long creeping rhizome, branched, scales pale brown- dark brown; stipes are scattered and short, grey brown to dark brown in color; lamina simple, glaborous, largest just below midpoint, gradually tapering towards both ends, apex acuminate, base decurrent, margin entire, lamina dark green above, pale green below; midrib raised rather above and below; sori superficial, grouped in two rows between the margin and midrib on the distal half of the frond; sori orange to dark brown.

Ecology: Epiphyte on *Schima*, *Quercus glauca*, found moss cover tree trunk; mixed forest.

Voucher specimen: Alt.: 800m -1600m **Lat. /Long.:** 27°47′46.79″ N/83°48′24.68″ E. **Col. Date:** 20/10/2022, **Locality:** on the way Hattilake Mountain forest, Dhakrebhangyang site, Sukhaura, Jamale site, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 12 (Amrit campus herbarium).**

Microsorum cuspidatum D. Don) Tagawa sub sp. Cuspidatum

Distingushing characters: Rhizome thick, creeping, light green color, lightly scaly, roots densely; stipe long, brown or light shiny blacky color, lamina green, margin entire; veins unclear or absent; sori separate, round, one sori per primary costal areole, in one row on each side of costa, yellow- orange color.

Ecology: Epiphytic, under the canopy cover, epiphyte on tree or sometime attach with stone, partially dry places, it was found in tropical region.

Voucher specimen: Alt.: 800m – 900m **Lat. /Long.:** 27°48′22.12″ N/83°47′15.58″E. **Coll. Date:** 03/11/2022, **Locality:** Khiluwatar khola, on the way of Dhakrebhangyang, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 35 (Amrit campus herbarium).**

Polypodiodes lachnopus (Wall. ex Hook.) Ching

Distingushing characters: Rhizome creeping, scaly or hairy, black colored hair; stipe brown or straw color, brown color scales prest on stipe; lamina light green, margin slightly serrate; sori separate, round, single row between midrip and margin, orange color.

Ecology: Epiphytic**,** moist humid places, found in *Quercus* mixed upper sub-tropical forest.

Voucher specimen: Alt.: 1343 m, **Lat./Long.:** 27°47′49.5″ N/83°48′11.84″ E. **Coll. Date:** 21/10/2022, **Locality:** on the way of Hattilake Mountain forest **Collector:** K. Acharya, **Col. No.: 19 (Amrit campus herbarium).**

Pyrossia costata (C. Presl) Tagawa & K.I Wats

Distinguishing characters: Fern plants with 20-80 cm tall, rhizome short, up to 5 mm in diam., fronds monomorphic, sub stipitate or stipitate; stipe 1-5 cm; Lamina wide in the middle, gradually narrowing to the base, sharp pointed apex; sori thick, brown in color, superficial, and lacking a central bundle of paraphyses.

Ecology: Epiphytic, under the canopy cover, attach with stone and tree trunk; it was found in tropical region, mixed forest.

Voucher specimen: **Alt.:** 800 m **Lat. /Long.:** 27°48′22.12″ N/83°47′15.58″ E. **Coll. Date:** 03/11/2022, **Locality:** Khiluwatari khola, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 36 (Amrit campus herbarium).**

Pyrossia stenophylla (Bedd.) Ching

Distinguishing characters: Plants small- medium size (upto 15-30 cm tall); rhizome shortly extended; stipe very short or almost absent; lamina widest above the middle, base gradually narrow, apex acute to acuminate; indusial brown or lower layer whitish.

Ecology: Epiphyte on *Schima*, *Quercus glauca*, sometimes found on rocks; found in sal forest, mixed forest, sub-tropical region.

Voucher specimen: Alt.: 800 m- 1600m **Lat. /Long.:** 27°47′46.79″ N/83°48′24.68″ E. **Col. Date:** 20/10/2022, **Locality:** Hattilake forest, Jamale site, Khiluwatari, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 14 (Amrit campus herbarium).**

8. Pteridaceae

Adiantum capillus-veneris L.

Distinguishing Characters: Plant height ranges from 15 to 30 cm, forms extensive colony, its fronds arising in clusters from creeping rhizomes; stipe glossy black, frond tripinnate, pinnae compound with small rounded segments narrowing symmetrically to connate bases, apical margin of pinnae deeply lobed into rounded rectangular lobe; sori present in both small and large fronds, sori are present at the top of lobe of the pinnae, sori white to brown color.

Ecology: Terrestrial, moist places, attached with stone, near streams, found in the mixed forest, tropical zone.

Voucher specimen: **Alt.** 800-900 m, **Lat./Long.:** 27°48′27.97″ N/83°47′26.25″ E. **Coll. Date:** 03/11/2022, **Locality:**, Khiluwatari khola, on the way Dhakrebhangyang, Purbakhola, Palpa. **Collector:** K. Acharya, **Col. No.: 32 (Amrit campus herbarium).**

Adiantum incisum forssk.

Distinguishing characters: Rhizome erect, densely scaly, raddish-brown color; stipes numerous, tufted, raddish-brown to dark brown, silky, thinly covered by pale brown hair; lamina is oblong-lanceolate, slender, simply pinnate, lowest pinna usually slightly largest and semicircular slightly downward directed, rather fan-like, basal pinnae sub-opposite, rest of the pinnae alternate, pinnae pale green; sori marginal, oblong and reniform, indusial dark brown.

Ecology: partially dry places, found in rocky surface, found in mixed forest, pine forest, Sal forest.

Voucher specimen: Alt.: 800 -1400m **Lat. /Long.:** 27°47′57.94″ N/83°48′03.3″ E **Coll. Date:** 22/10/2022, **Locality:** Hattilake forest, Dhakrebhangyang site, Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 25 (Amrit Campus herbarium)**.

Adiantum philippense L. subsp. *philippense*

Distinguishing Characters: This species is also known as walking maidenhair fern or black maidenhair. Rhizome erect, short, scales dark brown; stipe thin, glossy black, glabrous, rachis blackish, lamina alternate, semicircular pinnae lamina alternate, semicircular pinnae with shallow lobe; sori 2-6 per pinna, sori elongated around the distal end of pinnae.

Ecology: partially dry places, sometime found under rocky surfaces, mixed forest of *Bauhinia*, *Terminalia*, *pinus*.

Voucher specimen: **Alt.:** 800m -1500 m **Lat./Long.:** 27°47′46.74″ N/83°48′24.64″ E. **Coll. Date:** 21/10/2022, **Locality:** on the way Hattilake Mountain, Sukhaura, Siluwa, Purbakhola, Western Palpa, **Collector:** K. Acharya, **Col. No.: 13 (Amrit campus herbarium).**

Aleuritopteris bicolor (Roxb) Fraser-Jenk.

Distinguishing characters: It is also known as the main silver fern Rani Sinka, the stipe is long, slender, dark purplish-brown, the bicolor scales are limited to the narrow base of the stipe and are absent from the upper stipe, rachis, and costae; the lamina is noticeably deltate and pentagonal, with the lowest pinnae being the longest, Pinnules with unusually lengthy basal basiscopic bases, somewhat finely dissected or lobed, pale, frequently yellowish green, white ferinosa below, although not as heavily or smoothly.

Ecology: partially dry places, above and under rocky surfaces, mixed forest of *Quercus*, sal forest.

Voucher specimen: **Alt.:**, 900-1600, **Lat. /Long.:** 27°47′46.79″ N/83°48′24.68″ E. **Coll. Date:** 20/10/2022, **Locality:** Hattilake, Siluwa forest Purbakhola, Palpa, **Collector:** K. Acharya **Col. No.: 9 (Amrit campus herbarium).**

Aleuritopteris dealbata (C. Presl) Fee

Distinguishing characters: A large frond; rhizome erect, short; the stipe is glossy-black and thick, scales are yellowish-brown in color and do not extend onto the rachis; lamina is quite long and slender, with narrow triangular lanceolate leaves that are usually dark green; the rachis and costae are the same color as the stipe; wide segments on the pinnae with the middle and upper ones practically being unlobed, typically with narrow, round apices, and shining white farinose underneath; sori are typically divided into tiny lobes that contain many sporangia and confluent when mature; false indusial is underdeveloped, extremely thin and unclear.

Ecology: found in usually moist places, usually near water resources, sometimes dry places, above and under rocky surfaces, mixed forest.

Voucher specimen: Alt.:, 800-1500m, **Lat./Long.:** 27°47′46.79″ N/83°48′24.68″ E. **Coll. Date:** 02/11/2022, **Locality:** collected from on the way Hattilake Mountain, Siluwa forest Purbakhola, Palpa, **Collector:** K. Acharya **Col. No.: 40 (Amrit campus herbarium).**

Aleuritopteris rufa (D. Don) Ching

Distinguishing characters: Rhizome erect, short; scales bicolorous, black with narrow brown margins; frond clustered; the stipe, rachis, and costae are densely covered in reddish brown woolly, hair like fibrils, lowest with dark centres, combined with a few little scales on the stipe; stipe usually short; frond narrowly lanceolate, widest slightly above the base, bipinnatified, with short, pinnatified pinnae, broaden their bases, lamina heavily fibrillose above, having a faintly visible white or cream-colored farina underneath; sori consisting of several sporangia, confluent at maturity; false indusial with fimbriate edges that is disrupted.

Ecology: found on rocky surface, mixed forest, pine forest temperate region.

Voucher specimen: Alt.: 1000m–1500m, **Lat./Long.:** 27°47′58.21″ N/83°48′1.9″ E. **Coll. Date:** 23/10/2022, **Locality:** Hattilake forest, Siluwa site forest Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 15 (Amrit campus herbarium).**

Coniogramme fraxinea (D. Don) Fee

Distinguishing characters: Large species that can grow to be 1 to 1.5 m tall**;** rhizome strong, shortly creeping**;** scales dark brown; fronds scattered; stipe straw colored; the bases of pinnae and pinnules can be cuneate, broadly rounded, or occasionally slightly cordate, when they are fully grown, they typically bear few pinnules toward their base; lamina usually dark green and smooth, narrowly ovate or ovate oblong; margin entire or rarely undulate with thin, apex abruptly caudate, young plants may have cordate bases and broad wide, simple pinnae; veins distinct on both surface, not extending to lamina margin; sori along vein, brown to dark brown colors.

Ecology: moist humid places, found in *Quercus* mixed upper sub-tropical forest.

Voucher specimen: Alt.: 1343 m, **Lat./Long.:** 27°47′49.5″ N/83°48′11.84″ E. **Coll. Date:** 21/10/2022, **Locality:** collected from on the way of Hattilake Mountain. **Collector:** K. Acharya, **Col. No.: 17 (Amrit campus herbarium).**

Onychium lucidum (D. Don) Spreng

Distinguishing Characters: plants 45-80 cm tall or more, subterranean and long creeping rhizomes; fronds developed separately, branched; the stipe is frequently brown to chestnut-brown color, strong and erect to spreading; fronds ascending to partially erect, lamina 3-4 pinnate, infertile fronds that have been sharply dissected and serrated; pseudoindusia is long, entire, and not very wide open when ripe, which typically extends to the fertile section's tip; sori covers almost whole part of pinnules.

Ecology: partially humid area, found in mixed forest of *Pinus* and *Quercus*.

Voucher specimen: Alt.: 1200m, **Lat. /Long.:** 27°47′52.25″ N/83°48′10.83.28″ E **Coll. Date:** 23/10/2022, **Locality:** Hattilake forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 24 (Amrit campus herbarium).**

Onychium siliculosum (Decv.) C. Chr.

Distinguishing Characters: Rhizome erect or ascending, having numerous branching and side-lobed roots, more densely packed leaves than other species; stipe long, rigid, partially green to dark blackish brown color; the majority of fertile fronds are tripinnate, pinnatified, and have rather well-separated, lengthy segments, ovate-deltoid lamina of sterile fronds; false indusial linear with full edges that nearly reaches the midvein; rapidely, sporangia with distinctive and diagnosable sulfur yellow coloring.

Ecology: found in partial dry area forest.

Voucher specimen: Alt.: 800m, **Lat. /Long.:** 27°48′24.41″N/83°47′13.44″ E. **Coll. Date:** 03/11/2022, **Locality:** Pandanda, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 37 (Amrit campus herbarium).**

Pteris aspericaulis wall ex J. Agard

Distinguishing characters: It is terrestrial herb, it is compound *Pteris*, erect rhizome, stipe and rachis varies in color, lamina long, lower lamina with 2-3 pairs of pinnae with single or sometimes with accessory pinnules, sori on the lobe arch of pinnules, spores dark brown.

Ecology: partially moist areas, it was found in tropical region.

Voucher specimen: Alt.: 800 m, **Lat. /Long.:** 27°48′22.12″ N/83°47′15.58″ E**. Coll. Date:** 03/11/2022, **Locality:** Khiluwatari, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 39 (Amrit Campus herbarium).**

Pteris biaurita L.

Distingushing characters: Rhizome erect, apex densely covered with brown scales; green stipe, but when dred turns straw color; lamina broad, pale green color, oblong-ovate shape; pinnaa-lobes are not as extensively cut down towards the costa as in other *Pteris* species, a typical U-shaped space exists between the adjacent pinna lobes, rounded pinna-lobed apices; indusial light brown, entire, and persistent.

Ecology: partially moist places, found in mixed forest, Sal forest.
Voucher specimen: Alt.: 804. **Lat. /Long.:** 27°47′39.99″ N/83°46′57.67″E. **Coll. Date:** 02/11/2022, **Locality:** Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: (Amrit Campus herbarium).**

Pteris cretica L. subsp. *cretica*

Distinguishing characters: Rhizome erect, covered by ovate-lanceolate scales at the apex; stipe long, trufted, abaxially rounded, adaxially grooved, glabrous and glossy; sterile-fertile dimorphic frond, the sterile frond is smaller and more widely spaced, has broader segments and margin bearing teeth, and fertile frond with longer, narrower segments and tiny teeth only at the sterile apices, with the majority of the segments having long; the lamina with 2-5 pairs of pinnae, pinnae dark green, long and lanceolate, except for the base and distal half of the pinnae; the sori is linear all along the margin; spores dark brown.

Ecology: under canopy, shady places, mixed forest.

Voucher specimen: **Alt.:** 1400-1500m, **Lat./Long.:**. 27°47′49.42″ N/83°48′12.6″ E. **Coll. Date:** 20/10/2022, **Locality:** Hattilake, Purbakhola, Palpa, **Collector:** K. Acharya **Col. No.: 5 (Amrit Campus herbarium).**

Pteris stenophylla Wall. Ex Hook and Grev.

Distinguishing characters:

A medium sized frond (about 50 cm tall); rhizome ascending; stipe teeming, thin, stipe straw colored, glaborous; lamina digitate with 3-5 segments, Both sterile and fertile fronds have entire margins, narrowed to entire, acuminate point apically; fertile fronds typically have taller, thinner blades; the pseudoindusium was continuous and long, although it didn't reach the apex; sori brown – black colours.

Ecology: under canopy or open forest, shady places or partially dry places, mixed forest.

Voucher specimen: **Alt.:** 1502m, **Lat./Long.:**. 27°47′49.42″ N/83°48′12.6″ E. **Coll. Date:** 20/10/2022, **Locality:** on the way Hattilake Mountain, Dhakrebhangyang site, jamale site of Siluwa, Purbakhola, Palpa, **Collector:** K. Acharya **Col. No.: 3 (Amrit Campus herbarium).**

Pteris subquinata Wall. ex. J. Agardh

Distinguishing characters:

Plants small to medium size, rhizome erect; stipe straw colored, glaborous, grooved adaxially; lamina Short, equally wide as long, typically with one or two, occasionally three pairs of noticeably opposing pinna, and with an imparripinnate frond-apex that is similar; ultimate segments are slender and long, cut almost to the costa, and rounded at the apex; sori brown color, lengthy marginal pseudoindusia that don't reach the apex.

Ecology: moist humid places, mostly partially dry paces, sometimes near rocky surfaces; found in tropical forest to *Quercus* mixed upper sub-tropical forest.

Voucher specimen: Alt.: 800-1400m, **Lat./Long.:** 27°47′49.5″ N/83°48′11.84″E. **Coll. Date:** 21/10/2022, **Locality:** Hattilake forest, Siluwa forest, Purbakhola, Palpa. **Collector:** K. Acharya, **Col. No.: 16(Amrit Campus herbarium).**

Pteris vittata L.

Distinguishing characters: Family is commonly known Chinese ladder brake, or short blakish rhizome with branched roots; scales pale brown; frond erect to arching, stipe short, covered with dense pale scales, alternate pinnae; imparripinnate frond apex that abruptly shrinks to a longer, drooping terminal section; sori dark brown, deposed on both sides of the pinna in a sub-marginal line, from near the base to near the tip.

Ecology: with other herbs, moist places, dry areas, near rocky surface, mixed forest, tropical to temperate forest.

Voucher specimen: Alt.: 800-1300m, **Lat./Long.:** 27°47′51.45″ N/83°48′7.08 ″E. **Coll. Date:** 22/10/2022, **Locality:** Khiluwatari, Hattilake forest and Sukhaura, Jamale ghat, Siluwa, Purbakhola, Palpa. **Collector:** K. Acharya, **Col. No.: 21 (Amrit Campus herbarium).**

9. Selaginellaceae

Selaginella chrysorrhizos Spring

Distinguishing characters: Small plants, rhizophores restricted to base of stem; stem, erect glaborous, glossy yellow; leaves small, pale green; leaves with a forked shape and one or two pinnate branches; axillary leaves are ovate-oblong, margin denticulate, and have an acute tip; Ventral leaves are ovate-oblong, ascending, with a denticulate margin, a basiscopic base, entire, except the apices, and an obtuse apex; the dorsal leaves are subfalcate and oval, apex is short and cuspidate, with a denticulate margin; strobili broader, at the terminals of branches, sometimes lengthy in older plants; sporophylls diamorphic; megasporophyll is dark brown, while microsporophyll is pale brown.

Ecology: growing on rock and path sided, partially dry paces, sometimes near water resources; found in tropical forest to sub-tropical forest.

Voucher specimen: Alt.: 800m-1500m, **Lat./Long.:** 27°47′51.45″ N/83°48′7.08″ E. **Coll. Date:** 22/10/2022, **Locality:** Hattilake forest and Siluwa site, Purbakhola, Palpa. **Collector:** K. Acharya, **Col. No.: 20 (Amrit Campus herbarium)**.

Selaginella fulcrata *(Buch.-Ham. ex D. Don) spring*

Distinguishing characters: Large species up to 50-110 cm tall; stem glaborous, erect; main stem simple at the base, branching from the center of the stem; bipinnate-tripinnate side branches, broad triangular-ovate in shape, delicate, with a loose lather, obtuse-apex, pale yellowish- green, thin lateral leaves, and obtuse median leaves, leaves with a fan of prominent long; stiff cilia that protrude from the axial and have stems with a light color at their bases, only older leaves ciliate at the base, the remainder are entire, while younger leaves are complete throughout.; strobili solitary, terminal, compact, sporophyll isomorphic, ovate, cordate at base, apex abruptly acute; spore raddish-brown.

Ecology: under the canopy cover, partially dry places and sometime grow on bare land, it was found in tropical to upper subtropical region.

Voucher specimen: Alt.: 800 m-1600m **Lat. /Long.:** 28032′15″ N/82024′58″ E. **Coll. Date:** 23/10/2022, **Locality:** on the way Hattilake, Jamale site, Khiluwatar khola, Siluwa Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 11 (Amrit Campus herbarium).**

Selaginella pallida (Hook. & Grev.) Spring

Distinguishing characters: A plant that is tiny to medium in size; creeping stem, rhizospores are found at intervals throughout the length of the main stem, borne on the ventral side at the axil of branches; the primary stem is branched all the way through and is pinnately branched; leaves dark green, lateral leaves are denticulate, symmentrical at their axes, and not sloping, the median leaves are oval and have a long arista; spikes are narrow, four-sided spikes, sporophylls are isomorphic; spores light yellow- red.

Ecology: moist places or also found in dry places; found in mixed forest.

Voucher specimen: Alt: 900-1600m, **Lat. /Long.:** 27°47′37.8″ N/83°47′04.58″ E. **Coll. Date:** 20/10/2022, **Locality:** Hattilake forest, Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 4 (Amrit Campus herbarium).**

Selaginella subdiaphana (Wall ex Hook. & arev. Spring)

Distinguishing characters: Rhizome creeping or suberect; rhizosportes only occurs in the bottom portion of the main stem; stem slender; possess lateral leaves sloping, their acroscopic bases broadly articulate, lower leaves on the bases become more teeming, smaller, narrower; sporophyll diamorphic, ventral sporophyll oval, border ciliolate, apex acute; dorsal sporophyll ovate, marginal denticulate; spores orange-red.

Ecology: partially moist places, found in mixed forest, Sal forest.

Voucher specimen: Alt.: 800m. **Lat. /Long.:** 27°47′39.99″ N/83°46′57.67″ E **Coll. Date:** 02/11/2022, **Locality:** Siluwa site, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No. 41 (Amrit Campus herbarium).**

10. Thelypteridaceae

Thelypteris arida (D. Don) Fraser-Jenk.

Distinguishing characters: Rhizome creeping; except in sheltered sterile fronds, the lamina is rigid with a dryish texture; reduced and short lower three to four pairs of pinnae; Pinnae have lightly lobed at their margin, prominent mucro is visible at the end of each lobe, typically have a highly glandular-pubescent underside; veins rising beneath, linking the sinus membrane in three to four pairs; spores brown-dark brown.

Ecology: partially moist places, found in mixed forest, Sal forest.

Voucher specimen: Alt.: 804. **Lat. /Long.:** 27°47′39.99″ N/83°46′57.67″ E. **Coll. Date:** 02/11/2022, **Locality:** Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.:31 (Amrit Campus herbarium).**

Thelypteris dentata (Forrsk.) E. P. st. John

Distinguishing characters: Rhizome thick, creeping; lamina varying from tapering below to more typically slightly shorter at its base; fertile leaves with longer petiole and more contracted pinnae, pinnae lobed to about their half depth; petiole often purplish brown, at base with brown hairy, linear-lanceolate, hairy scales; veins adaxially with stouter hairs; sori round brown color, linearly placed on the surface of pinnae.

Ecology: partially humid area, under the canopy cover, found in mixed forest of Schima, pinus.

Voucher specimen: Alt.: 800m-1500m **Lat. /Long.:** 27°47′49.42″ N/83°48′12.6″E. **Coll. Date:** 20/10/2022, **Locality:** Hattilake forest, Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.:7 (Amrit Campus herbarium).**

Thelypteris penangiana (Hook) C. F. Reed

Distinguishing characters: Long plants, rhizome a little broad, creeping, thin dark brown scales; stipe typically slender, light brown to dark brown color; lamina rough and chartaceous in texture, shortly stiff hairy to nearly glaborous beneath; pinnae are quite small, ranging from very shallowly pointed-lobed at the margins to just sharply serrated; a common excurrent vein is joined by numerous pairs of veinlets that anastomose from loops, veins clearly shows straw color, sori round brown-black color.

Ecology: moist places, mostly found in near streams, in the mixed forest of *Quercus*, *Schima*, *Pinus*.

Voucher specimen: **Alt.:** 800m- 1300m, **Lat./Long.:** 27°48′55.57″ N/83°46′33.04″ E. **Coll. Date:** 22/10/2022, **Locality:**, Khiluwatari khola, Hattilake forest, Siluwa site forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 22 (Amrit campus herbarium).**

Thelypteris procera *(D. Don) Fraser. Jenk.*

Distinguishing characters: Rhizome long creeping; stipe short to medium, hairy; lamina is lanceolate, somewhat narrowing in the lowest two pinnae, pinnae are yellowish-green, typically narrowly rounded-acute segments, long, white, somewhat curled hairs are abundant in the veins and costae below, as well as in the lamina margin; sori slightly small.

Ecology: moist places, near water resources, found in mixed forest.

Voucher specimen: **Alt:** 800m-900m. **Lat. /Long.:** 27°47′37.8″ N/83°47′04.58″ E**. Coll. Date:** 01/11/2022, **Locality:** Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 27 (Amrit campus herbarium).**

Thelypteris sp

Distingushing characters: Rhizome short creeping; stipe long; lamina dark green; midrip clear; sori near to the vein.

Ecology: reported from moist paces, near water resources, found in mixed forest of *Cinnamomum*, *Pinus*.

Voucher specimen: **Alt.:** 900m **Lat. /Long.:** 27°48′27.97″ N/83°47′26.25″ E **Coll. Date:** 05/11/2022, **Locality:** on the way Dhakrebhangyang, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 38 (Amrit campus herbarium).**

11. Vittariaceae

Antrophylum reticulatum (G. Forst.) Kaulf

Distinguishing characters: Plants small size up to 15-30 cm, rhizome short, erect; stipe is very short or more or less absent; lamina with a range of straight to slightly falcate-curved surfaces; narrow decurrent below, widest above or just above the middle, then narrows gradually and abruptly above to a pointed apex, midrib unclear to missing, there are visible raised veins when partially drying; sori in reticulate pattern of lines in upper half of lamina, following vainlets, indusial absent, sporangia among a number of long, slender, ribbon-shaped paraphyses that are brown in color.

Ecology: Epiphytic plants, sometime found attached with rocky surface, found the partially moist area, and mixed forest.

Voucher specimen: Coll. Date: Alt.: 915 m, **Lat. /Long.:** 27°47′36.55″ N/83°47′05.66″ E. 08/12/2022, **Locality:** Siluwa forest, Purbakhola, Palpa **Collector:** K. Acharya **Col. No.: (Amrit campus herbarium).**

12. Woodsiaceae

Athyrium cuspidatum (Bedd.) M. Kato

Distinguishing characters: Rhizome shortly creeping, woody, densely covered with brown color scales at apex; upper stipe pale purple or brownish, thinly scaley; the lamina is dark green, imparipinnate, oblong-lanceolate, with a rounded-cuneate base and an acuminate apex.; the lateral pinnae are alternating, severely serrated, with beak-like points at the margin, and long acuminate at the apex; terminal pinnae somewhat larger; veins free, visible on surfaces, lateral vein pinnate; sori are dense, tiny orbicular, abaxial near the base or in proximal, rarely medial vein palaces, cinnamon-colored sori; indusial brown.

Ecology: partially humid area, under the canopy cover, found in mixed forest of *Schima*, *Quercus*.

Voucher specimen: Alt.: 1300-1500m**.** **Lat. /Long.:** 27°47′49.42″ N/83°48′12.6″ E. **Coll. Date:** 20/10/2022, **Locality:** Hattilake forest, Purbakhola, Palpa **Collector:** K. Acharya, **Col. No.: 6 (Amrit campus herbarium).**

Diplazium spectabile (wall. ex Mett.) Ching

Distinguishing characters: Rhizome creeping; fern large, tripinnate quadripinnatified fronds; stipe long, stiff, scales black; lamina widest at the base, finely divide/lobed; pinnae overlapping; pinnules with deeply lobed pinnulets with short, narrowish, pointed side lobes, reaching almost pinnate again in large fronds; sori short, medial or slightly closer to the segment-midrib.

Ecology: moist humid places, found in *Quercus* mixed upper sub-tropical forest.

Voucher specimen: Alt.: 1343 m, **Lat./Long.:** 27°47′49.5″ N/83°48′11.84″ E. **Coll. Date:** 21/10/2022, **Locality:** on the way of Hattilake Mountain. **Collector:** K. Acharya, **Col. No.: 18 (Amrit campus herbarium).**

4.7 Ethnobotanical study

A study on ethnobotany was conducted in major two communities (Brahman and Magar) of 30 households. Most of the people were not aware about the importance and usage of pteridophytes. The majority of adults infrequently use ferns for food, medication, and other incidental needs. There were only 15 species reported for ethnobotanical use, out of 42 species reported in this study. Pteridophytes were used chiefly for medicine (6 species), food (2 species) and veterinary uses (2 species), fodder (8 species), others (1 species). This study demonstrated that pteridophytes are mostly used for medical purposes and as animal feed. The plants were more used as juice, decoction, raw, power for various purposes. Out of 15 species, *Tectaria coadunate* is frequently consumed as food and medicine (Table 3.1).

Table 3.1. Ethnobotanical important pteridophyte species found in the study area and their uses

S.N	Scientific name	Local name	Uses/purpose	Traditional uses
1	*Aleuritopteris bicolor*	Kali sinki	Medicine	The juice (as a decoction) is used for treatment of diarrhoea, stomach pain, fever, and typhoid.
2	*Aleuritopteris dealbata*	Kali sinka/rani sinka	Medicine/ others	Juice of rhizome is used to treat diarrhoea and stem part used after ear piercing for some times.
3	*Dryopteris cochleata*	Seto niuro or kuthurke	Vegetable/ fodder	The young leaves are used as vegetable in monsoon.
4	*Equisetum ramosissimum*	Suiro	Fodder or medicine	Juice was used to treat cattle red urination (Dhatu) and also used as a fodder.
5	*Lygodium japonicum*	Janai laharo	Medicine	Paste or juice of stem used to treat wound, harpes zoster (janai khatira).
6	*Microsorum cuspidatum*	Kammare laharo	Medicine	The powder of rhizome is used for back pain or body part pain.
7	*Nephrolepis cordifolia*	Pani amala	Medicine	Tubers are used to treat jaundice, and reduce body temperature.
8	*Pteris vittata*	Unayo	Fodder	Young plants are used as fodder for cattle.
9	*Selaginella subdiaphana*	Sindure jhar	Others	Married women used the sori portion as vermilion (sindoor).
10	*Selaginella fulcrata*		Fodder	The plant without the rhizome was utilized as cattle feed.
11	*Tectaria coadunata*	Kali niuro	Medicine vegetable,	The young leaves are used as vegetable. Root juice (Decoction or fresh juice) is

			fodder	used for treatment of diarrhoea, stomach pain and dysentery.
12	*Thelypteris arida*	Kalo unayo	Fodder	The plant without the rhizome was used as cattle feed.
13	*Thelypteris dentata*	Unayo	Fodder/bedding	Arial parts are used as fodder and beeding for cattle in rainy season.
14	*Thelypteris procera*	Jhuse unayo	Bedding/ medicine	Whole plants are used as bedding sit for pigs for treat scabies disease.
15	*Thelypteris penangiana*	Unayo	fodder	Arial parts of the plant are used as livestock fodder.

CHAPTER 5

DISCUSSION

5.1 Species diversity

Pteridophytes composition has been studied to enumerate species and determine how species richness varies in retation to elevation gradient and aspects in Purbakhola Rural Municipality, Palpa. The diversity of flora was facilitated by the variation in elevational range and climatic conditions. Plant diversity was directly influenced by various the environmental factors (biotic, and abiotic). Altogether 42 species belonging to 14 families and 24 genera were recorded from study site (Appendix IV). This study reported less number of pteridophytes than studies reported by Thakur and Rajbhandary, (2018) who reported 92 species from the Panchase protected forest Central Nepal. Similarly, 75 species of pteridophytes were reported by Nepali *et al*., 2020 in Arghakhanchi district West Nepal. However, the number of pteridophytes species in this study is significantly higher than the 11 fern and fern-allies species reported from Daman and surrounding areas of Makwanpur district, Central Nepal (Chalise *et al*., 2020), and the 15 pteridophytes species were reported from Chameli Community forest, Bhaktapur, Nepal (Chaulagain and Shrestha-Malla, 2017). In comparison to the study of Thakur and Rajbhandary, (2018) the number of species recorded in this study was less; this might be due to the sample being taken in a single season only, post-monsoon and the altitudinal range being lower than those study areas. The study of Thakur and Rajbhandary (2018) was done in two seasons and Nepali *et al*., (2020) was done for two years in post monsoon seasons. It might be the reason for getting lesser number of pteridophytes in this study.

Among the 42 species, *Polypodiodes lachnopus*, *Antrophylum reticulatum*, and *Diplazium spectabile* were found beyond the plots and between distinct altitudinal zones. There was a wide variety of pteridophytes species on both aspects but in comaprision to Southern aspect, Northern aspect had higher species diversity (Appendix IV). The current study was similar to those of Panthi *et al*., (2007) who indicated that in the Himalayas, Northern aspects were considerably moist than Southern aspects, leading to higher species richness in North-facing slopes than South-facing slopes. According to Parker (1991), the direction of the landscape controls the amount and duration of many abiotic components, such as soil moisture, temperature, and rainfall, which has an impact on species diversity. South facing slopes often receive higher temperatures, more intense light, and less rainfall than North facing slopes (Warren, 2008). Similarly, Lindsey (2016) also supported areas with low light intensity having good fern growth and diversity. Among the total plant species reported, large number of plant species were represented by family Pteridaceae with 5 genera and 15 species, followed by 6 species with 5 genera in the family Polypodiaceae and only single species and single genus was found from the family Equisetaceae, Lindsaeceae, Lygodiaceae, Nephrolepidaceae, and Vittariaceae. The largest genus was *Pteris* which includes 6 species followed by *Thelypteris, Selaginella, Aleuritopteris, Adiantum, Pyrossia, Onychium, Dryopteris, Equisetum, Microsorum and Tectaria* (Appendix VI). This study is similar to previous studies such as, Fraser-Jenkins *et al.,* (2015) in their book "Fern and Fern Allies Volume-1", reported high number of species from family Pteridaceae from Nepal. Similarly, Kandel and Pathak (2013) also reported highest family pteridaceae and common genus *Pteris* from subtropical forest of Pyuthan district, Western Nepal. However, present study is different than Mahato, (2014) who reported *Thelypteris* as a dominant genus from Palpa, district. Single species reported in the family Equisetaceae in present study might be because of its small family size. Only three sub-species from this family have been reported by Fraser-Jenkins *et al*., (2015) in Nepal. The reason behind the finding of single species in other pteridophyte groups may be because of various factors like; less moisture at higher altitudes, disturbances, and exposure to direct solar radiation at the study area.

In different regions of Nepal, Rajbhandary (2013) and Rajbhandary (2016) identified three essential habitats (Terrestrial, epiphytic, and lithophytes) for ferns and ferns allies. In present study, out of total 42 species, 7 species were epiphytic, and others were non epiphytic (lithophytes and terrestrial) and some species were also found in multiple separate habitats (Appendix VII). Bhattrai and Rajbhandary (2017) also reported one species from a different habitat. The fact that there are more terrestrial species here suggests that the conditions on land are suitable for fern diversity in this region (Nepali *et al*., 2020). Some epiphytic species *Pyrossia stenophylla*, *Lepisorus nudus,* and *Drynaria propinqua* were more common on the trunks of *Schima wallichii* and *Quercus* trees, which may provide a good substrate for growth. Thakur and Rajbhandary (2018) found 47 and 28 species of terrestrial and epiphytic pteridophytes respectively from Panchase Protected forest, central Nepal. Nepali *et al*., (2020) found 39 terrestrial species, 12 lithophytes, and 11 epiphytic species from the Arghakhanchi district, western Nepal. *Cinnamomum tamala, Syzgium cumini, Shorea robusta, Pinus roxburghii, Bauhinia vahlii, Terminalia alata, Quercus glauca, Phyllanthus emblica, Diploknema butyracea were* dominant species in study site. The majority of the pteridophytes species were found in mixed forest in study site which might support favourable environmental conditions (Shrestha and Rajbhandary, 2019).

The IVI of several pteridophytes species in various aspects revealed a significant sharing of the value of number of species. On the basis of IVI, *Selaginella fulcrata* was found as the dominant species on both the Northern and Southern aspects, with IVI values of 39.56 and 77.86, respectively (Appendix VIII and IX). The species dominance was also different along different altitude. The least dominant species in this study were *Pteris aspericaulis* (0.66) and *Microlepia speluncae* (0.67), for the Northern and Southern aspects, respectively (Appendix VII and IX). According to this study, *Selaginella fulcrata* was predominantly found in that location in comparision to other species. This might be due to the species' potential ability to tolerate both moisten and dry environments as well as well adapted to the environmental condition of the study area. The dominance of *Selaginella fulcrata* on both aspects suggests that the species may have wider ecological amplitude compared to other species in the study area. Salazar *et al*., (2013) and Nettesheim *et al*., (2014) revealed that different growth factors, moisture, light incidence, slope orientation and nutrients cause variance in species diversity and dominance.

Simpson's and Shannon-Wiener diversity Index in Northern aspect indicated highest species diversity (i.e. D =0.952, H = 1.227) at 800m altitude as area faced shady surfaces and fewer species diversity (i.e. D=0.795, H= 0.650) at 1600m altitude because it was very dry area (Table 2). The lower species diversity in the higher altitudes was caused by the absence of watery surfaces and moisture in these regions also supported by Bhattarai *et al*., (2004) and Kluge *et al*., (2006). In the southern aspect, less species diversity was also seen in upper altitude and species diversity was maximum (D = 0.86, H = 2.35) in the lower altitude which was due to shady surfaces, water availability, as supported by Salazar *et al*., (2015). Present study also shows highest diversity (Simpson and Shannon-wiener index) in lower elevation may be due to more favorable climate conditions, tree canopy cover, highest nutrient availability and greater habitat complexity. In contrast, higher elevations may have harser environmental conditions, like low humidity, less water availability, less tree canopy cover, and edaphic factor like less nutrient and rocky surfaces, which can limit the diversity of plant species. In addition to declining tree species, epiphytic species were also in declining phase (Bhattarai *et al*., 2004; Etisa, 2010) so, it may effect on the pteridophytes diversity.

5.2 Variation of Pteridophytes diversity

The findings of the regression analysis revealed that the species richness of pteridophyte decreases with increase in elevation ($P<0.01$) at both Northern and Southern aspect (Figure 10). Pteridophyte species richness was found to be highest at 800 meters and least at 1600 meters in both aspects. Hortal *et al*., (2013) have reported that species richness can decrease with altitude, similarly Bhattarai and Vetaas (2003) reported there is no significant trend of increasing species richness with increase in altitude but Dorji *et al.*, (2018) reported that species richness increases by elevation and affected by environmental factors. Hence, the number of species was not always significantly related with altitude and may change due to environmental conditions.

On the other hands, the relationship between the species richness and tree canopy cover was not significant ($p=0.106$, $p>0.05$) in Northern aspect but significant ($p=0.000$, $p<0.05$) in the Southern aspect (Figure 11). This could be due to the fact that the Northern slope was already moist due to low light intensity whereas the Southern slope is dry in comparison to the Northern slope due to comparatively high light intensity, and so canopy cover may have a substantial relationship with canopy cover on the Southern side. The general species richness was greatest between 20-40% canopy cover, according to scatter plot and linear regression. Some previous research has found a relationship between canopy cover and ground vegetation. Panthi *et al*., (2007) discovered a substantial association between moisture and canopy cover and concluded that canopy is the primary underlying environmental gradient for species richness and composition (Vettas,1997). The forest canopy is the key factor affecting plant survival, growth, and vegetation type (Jennings, 1999). The forest canopy alters the amount of understory resources including light, water, and soil nutrients that are available (García *et al*., 2006). The pattern of herbaceous floral composition is controlled by the amount of light that reaches the forest floor, which is significantly maintained by the woody plant canopy and various canopy types (Sagar *et al*., 2008).

In both aspects, species richness was greatest at 800 m height it was because the location had a lot of moisture, was close to water sources and more area available for species. Salazar *et al.,* (2015) supported that shady and moist habitat help in well diversity of ferns. The majority of elevation gradient studies on plants, particularly fern species, revealed a hump-shaped pattern by several researchers from throughout the world (Bhattrai *et al*., 2004; Kro¨mer *et al*., 2005; Grytnes and Beaman, 2006; Kluge *et al*., 2006; Salazar *et al*., 2013; Nagalingum and Cantrill, 2015; Nepali *et al*., 2020) while some studies found asymmetric hump-shaped pattern (Tanaka and Sato, 2014; Jeyalatchagan *et al*., 2020). This study found decreasing pattern of species richness along the elevational gradient this might be due to study was conducted over a short range of elevation, so species richness decline to the first elevation band which was also supported by the study of Tamang, (2013). The absence of wet surfaces, water availability and moisture in these areas might be the cause of the lower species richness in the higher elevation also supported by (Bhattarai *et al*., 2004; Kluge *et al*., 2006). Decreasing pattern with increase elevation of plant species richness was also found by several reasearcher (Bhuju and Rana, 2000; Wang *et al.*, 2006; Paudel *et al*., 2010; Shimono *et al*., 2010; Bhattarai *et al.*, 2014).

Overall, present research shows that species richness decrease with increase in elevation. This might be due to the area differences in different ranges of elevation. The number of species tends to increase as the area increases as supported by previous recherchers (Rahbek, 1997; Mccoy, 2002; Rahbek, 2005). However, because of the complex terrain of the Himalayan region along the altitudinal gradient, the several 100m bands do not have equal areas (Bhattrai *et al*., 2004). Different factors like moisture availability, topography, soil characteristics, canopy cover, vegetation and microclimate may also play significant role in determining species richness in study area. Shah *et al*., (2011) had argued that the topography, soil, climate, and geographic position should be used to characterize the herterogeneity in vegetation and species distribution in the Himalayas. The presence of moisture is the most influencing factor for pteridophytes diversity as supported by previous researchers (Kessler, 2001; Bhattari *et al*., 2004; Salazar *et al*., 2015; Silva *et al*., 2018) so changes in moisture availability might be one of the primary causes of fluctuations in pteridophytes species richness across different elevation in this study site. Many interrelated biological, environmental, and historical factors also control how species richness is distributed along elevation gradients (Colwell and Lees, 2000). Thus, this study shows that altitude was not only factors that affect species richness patterns in the study site, other factors can also have a significant impact on species richness patterns as suggested by McCain and Grytnes, (2010).

5.3 Ethnobotany of Pteridophytes

Among the documented species, only 15 species were recorded for ethnobotanical use in this study (Table 3). This indicates that local people have not enough knowledge about various types of use of pteridophytes species. However numerous studies had reported the ethnobotnical value of ferns in the different regions of the world such as Shrivastav (2007) who reported 12 species of fern having medicinal value emphasizing their traditional uses. Sathiyaraj *et al.*, (2015) reported 50 ethnomedicinal species of pteridophytes by Paliyar tribes on Palani Hills of the Western Ghats in South. Verma and Kanwar, (2020) identified 25 medicinal pteridophytes from Sarkaghat Tehsil in Mandi District, Himachal Pradesh, belonging to 14 genera and 10 families.

Pteridophytes species used for various ethnobotanical purposes in Nepal such as Joshi *et al.*, (2015) were reported young shoots of *Dryopteris cochleata* used as vegetable in Makwanpur which is similar to present study. Similarly, Adhikari *et al*., (2019) reported that the juice of *Aleuritopteris bicolor* was used to treat diarrhoea, dysentery, and gastritis in Kaski district. Young leaves of *Tectaria coadunate* were used as vegetables (Luni *et al*., 2011; Joshi *et al*., 2015). Similarly, *Nephrolepis cordifolia* was used to treat jaundice, boils, bone fracture and skin problems (Pradhan *et al*., 2020). The Juice of the *Lygodium japonicum* was applied in wound, boils and scabies, and the paste of the plant was applied to treat joints pain (Malla *et al*., 2015). Uses of above pteridophytes species are almost similar to the use pattern of this study except *Equisetum ramosissimum.* In this study the juice of this plant was used to cure cattle red urination but other researchers reported the different uses of this species, such as a paste made from pounded dried plant being used to cure bone fractures (Joshi *et al*., 2011) and ash from the entire plant to treat scabies and burns (Joshi, 2014).

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

A total of 42 species belonging to 12 families, and 24 genera were collected. Pteridaceae was most dominant family having highest number of genera (5) and species (15). The majority of the gathered species were found to be growing across the terrestrial habitat. In general, speies diversity was found highest in Northen aspect than Southern aspect. Aspect also plays the significant role for changing the species composition due to change in sunlight and moisture. In comparision to different altitude, species diversity was highest at 800 meters at both the Northern and Southern aspect, and it was lowest at 1600 meters. On the basis of IVI, *Selaginella fulcrata* was identified as the dominant species on both the Northern and Southern aspects. The mean species richness across elevations in both aspects was statistically significant ($p< 0.01$) based on one way anova and the population mean between northen and southern aspect was also statistically significant ($p<0.01$) based on Z-test. The species richness pattern decrease with increase in elevation. Locals have little awareness of the applications of pteridophytes species.

Overall, it has been concluded that species diversity varies with aspect and altitude because of climatic conditions, environmental as well as biotic and abiotic factors. The pattern of species richness tends to vary with altitude and others factors can influence it, so it is important to consider all of other factors while studying the patterns of species richness. Some species of pteridophytes have been used by local peoples for various purposes.

6.2 Recommendations

On the basis of the findings of this investigation, the following recommendations have been made:

i. This study was only focused on the Northern and Southern aspects of Purbakhla Rural Municipality, Hattilake forest; other forest should also be studied to generalize the distribution pattern along the altitude and aspects.

ii. While studying the patterns of species richness, it is critical to consider other parameters such as moisture, temperature, topography and soil characteristics as they greatly affects the species richness.

REFERENCES

Adhikari, M., Thapa, R., Kunwar, R.M., Devkota, H.P., & Poudel, P. (2019). Ethnomedicinal Uses of Plant Resources in the Machhapuchchhre RuralMunicipality of Kaski District, Nepal. *Medicines*, ***6***(2), 69.

Baniya, C. B., Solhøy, T., Gauslaa, Y., & Palmer, M. (2010). The elevation gradient of lichen species richness in Nepal. *Lichenologist*, ***42***(1), 83–96.

Bhagat, I.M., & Shrestha, S. (2010). Ferns and Fern-Allies of Eastern Tarai, Nepal. *Our Nature* ***8***, 359-362.

Bhattrai, K.R., & Vetaas, O.R. (2003). Variation in plant species richness of different life forms along a subtropical elevation gradient in the Himalayas, east Nepal. *Global Ecology and Biogeography*, ***12***(4), 327-340.

Bhattarai, K.R., Vetaas, O.R., & Grytnes, J.A. (2004). Fern species richness along a central Himalayan elevational gradient. *Journal of Biogeography*, ***31***(3), 389-400.

Bhattarai, S. (2013). Pteridophytes of Nubri Valley, Manaslu Conservation Area, Central Nepal. M.Sc. Thesis submitted to Central Department of Botany, TU.

Bhattarai, S., & Rajbhandary, S. (2017). Pteridophyte flora of Manaslu conservation area, Central Nepal. *American Journal of Plant Sciences*, ***8***(4), 680-687.

Bhuju, D.R., & Rana, P. (2000). An appraisal of human impact on vegetation in high altitudes (Khumbu region) of Nepal. *Nepal Journal of science and Technology*, ***2***, 110-105.

Bista, M.S., Adhikari, M.K., & Rajbhandary, K.R. (2002). *Pteridophytes of Nepal*. Bull. Dept. Plant Resources No. 19 (pp.175). Kathmandu, Nepal: Department of Plant Resources.

Bista, C.B. (2021). *Diversity of Pteridophytes along the altitudinal gradient in the forest of Chuwang, Eastern Rukum*. Amrit Campus Department of Botany, TU, Kathmandu, Nepal.

Chalise, P., Paneru, Y.R., Dhakal, S., & Tharu, L.R. (2020). Floristic Diversity of Vascular Plants in Daman and Adjoining Area, Makawanpur District, Central Nepal. *Journal of Plant Resources*, ***18*(**1), 116-123.

Chaulagain, S., & Shrestha-Malla, A. M. (2017). Study on Plant Distribution Pattern of Chameli Community Forest, Bhaktapur, Nepal. I*nternational Journal of Applied Science and Biotechnology, **3***(4), 82-88.

Cicuzza, D., Krör Mer, T., Poulsen, A.D., Abrahmczyk, S., Delhotal, T., Piedra, H.M., & Kessler, M. (2013). A transcontinental comparision of the diversity and composition of tropical forest understory herb assemblage. *Biodiversity and Conservation*, ***22***, 755-772.

Colwell, R.K., & Lees, D.C. (2000). The mid-domain Effect: geometric constraints on the geography of species richness. *Trends in Species richness and Evolution, **15***(2)-70-72.

Colwell, R.K. (2009). Biodiversity: Concepts, Patterns , and Measurement. In: Simon A. Levin. The Princeton Guide to Ecology). *Princeton University Press*, 257-263.

Delos Angeles, M., & Buot, I. (2012). Orders and Families of Philippine Pteridophytes. *Journal of Nature Studies, **11***(1 & 2), 19-33.

DHM (2022). Meteorological Data. Kathmandu: Department of Hydrology and Meteorology.

Don, D. (1825). *Prodromus Florae Nepalensis*: 1-256. Londinium. Reprinted 1976. Dehra Dun, Delhi.

Dorji, T., Moe, S.R., Klein, J. A., & Totland, O. (2018). Plant species, richness, evenness and composition along environmental gradients in an alpine meadow grazing ecosystem in central, Tiebet, China. *Artic, Antartic, and Alpine Research*, ***46*** (2), 308-126.

Dudani, S.N., Mahesh, M.K. Subash Chandran, M.D., & Ramachandra, T.V. (2014). Pteridophyte dversity in wet evergreen forests of Sakleshpur in Central Western Ghats. *Indian Journalof Plant Sciences, **3***(1), 28-39.

Etisa A.T. (2010). *Diversity of vascular epiphytes along disturbance gradient in Yayu*

Forest, Southwest Oromia, Ethiopia. M.Sc. Thesis. School of Graduate Studies of Addis Ababa University, Ethiopia.

Fraser-Jenkins, C.R., Kandel, D.R., & Pariyar, S. (2015). *Ferns and Fern-allies of Nepal- **1*** pp. 492. National Herbarium and Plant Laboratories, Department of Plant Resources, Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

Fraser-Jenkins, C.R., & Kandel, D.R. (2019). Ferns and Fern-allies of Nepal-***2*** pp. 446. Department of Plant Resources, Ministry of Forests and Environment, Kathmandu, Nepal

Funnell, D., & Parish, R. (2001). *Mountain Environment and Communities*. London and New York: Routledge Physical Environment Series.

García L. V. García, Maltez-Mouro, S. Pérez-Ramos, I. M., Freitas, H., & Marañón, T. (2006). Counteracting gradients of light and soil nutrients in the understorey of Mediterranean oak forests. – *Web Ecol*, ***6***(1), 67–74.

Geiger, R., Aron, R. H. & Todhunter, P. (1995). The Climate Near the Ground, Friedr. *Vieweg & Sohn Verlagsgesellschaft, Braunschweig*, 327-406.

Giri, P., Kumari, P., Sharma, P., & Uniyal, P. L. (2021). Ethnomedicinal uses of Pteridophytes for treating various human ailments in India. *New vistas in Indian flora, 1st Edn. M/s Bishen Singh Mahendra Pal Singh, Dehradun, India. ISBN*, 978-81.

Grytnes, J. A., & Beaman, J.H. (2006). Elevational species richness patterns for vascular plants on Mount Kinabalu, Borneo. Journal of Biogeography ***33***, 1838–1849.

Gubajhu, M.R., & Gaha, Y. (2019). Ethnomedicinal Uses of Plants in Mityal, Palpa, Nepal. *Journal of Plant Resources*, ***17***(1), 155-162.

Guo, Q., Kato, M., & Ricklefs, R. E. (2003). Life history, diversity and distribution: a study of Japanese pteridophytes. *Ecography*, ***26***(2), 129-138.

Gurung, V.L. (1988). Useful Pteridophytes of Nepal Himalaya. *Ad. Plant Science*, ***1***(1), 67-76.

Gurung, V.L. (1991). Ferns the Beauty of Nepalese Flora. Sahayogi Press, Kathmandu.

Gurung V.L. (1992). The Study of Usefulness of Nepalese *Pteridium aquilinum* (L.) Kuhn In: The proceedings of the First National Botanical conference of Kathmandu, pp 72-76.

Hamilton, F.B. (1819). *An account of the Kingdom of Nepal and of the Territories Annexed to this Dominion by the House of Gorkha*. Bibliotheca Himalayica, Series 1, 10, Rep.ed. 1971. Manjushri Publishing House, New Delhi, India.

Hassler, M., & Swale, B. (2001). Checklist of Ferns and Fern Allies. IUCN Red List Categories and Criteria: Version 3.1 IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

Hassler, M. (2018). Checklist of ferns and lycophytes of the world version 7.4.

Ho, R., Teai, T., Bianchini, J. P., Lafont, R., & Raharivelomanana, P. (2010). Ferns: from traditional uses to pharmaceutical development, chemical identification of active principles. *Working with ferns: issues and applications*, 321-346.

Hortal, J., Carrascal, L.M., Triantis, K.A., & Meiri, S. (2013). Species richness can decrease with altitude but not with habitat diversity. *Proceedings of the national academy of sciences*, ***110*** (24), 2149-2150.

Jennings, S. (1999). Assessing forest canopies and understorey illumination: Canopy closure, Canopy cover and other measures. *Forestry*, ***72***(1), 59-74.

Jeyalatchagan, S.K., Ayyanar, M., & Silambarasan, R. (2020). Pteridophyte species richness along elevation gradients in Kolli Hills of the Eastern Ghats, India. *Journal of Asia Pacific Biodiversity*, ***13***(1), 92-106.

Joshi, K., & Joshi A.R. (2008). Ethnobotanical Studies on Some Lower Plants of the Central Development Region, Nepal. *Ethnobotanical Leaflets* ***12***, 832-40.

Joshi, K., Joshi, R., Joshi, AR. (2011). Indigenous knowledge and uses of medicinal plants in Macchegaun, Nepal. *Indian Journal of Traditional Knowledge*, ***10***(2): 281-286.

Joshi N.P. (2014). Utilization opattern and conservation status of plant resources of Makawanpu district, Nepal. Phd Dissertation, TribhuvanUniversity

Joshi, N., Siwakoti, M., & Kehlenbeck, K. (2015). Wild vegetables pecies in Makawanpur district, central Nepal: Developing apriority setting approach for domestication to improve food security. *Economic Botany,* ***69***(2), 161-170.

Kalita, P.C. (2015). Survey for Pteridophytic Diversity in Madan Kamdev Hill Region of Assam, India. P*leione*, ***9***(2), 376-400.

Kandel D.R. and Pathak M. (2013). Documentation of Ferns From Subtropical Forests of Pyuthan District, Western Nepal. *Jour. Dep. Pl. Res,* ***35****,* 46-49.

Kandel, D.R., & Fraser-Jenkins, C.R. (2020). Ferns and Fern-allies of Nepal- vol **3**. National Herbarium and Plant Laboratories, Department of Plant Resources, Ministry of Forests and Environment, Kathmandu, Nepal. [in press].

Karmurl Haque, M., Rahman, M.M., Islam, M.T., & Hasan, M.A. (2016). Ethnobotanical study of Pteridophytes in Rajkandi Reserve Forest of Moulvibazar district, Bangladesh. *Journal of Medicinal Plants Studies,* ***4***(1), 50-55.

Kessler, M. (2001). Pteridophyte species richness in Andean forest in Bolivia. *Biodiversity and Conservation,* ***10***(9), 1473-1495.

Kessler, M., & Lehnert, M. (2009). Do ridge habitats contribute to pteridophyte diversity in tropical montane forests? A case study from southeastern Ecuador. *Journal of Plant Research*, ***122***(4), 421-428.

Kluge, J., Kessler, M., & Dunn, R. R. (2006). What drives elevational patterns of diversity? A test of geometric constraints, climate and species pool effects for pteridophytes on an elevational gradient in Costa Rica. *Global ecology and biogeography*, ***15***(4), 358-371.

Körner, C., & Kèorner, C. (1999). Alpine plant life: functional plant ecology of high mountain ecosystems.

Kro¨ Mer, T., Kessler, M., Gradstein, S.R., & Acebey, A. (2005). Diversity patterns of vascular epiphytes along an elevational gradient in the Andes. *Journal of Biogeography*, ***32***, 1799–1809.

Krömer, T., Kessler, M., & Gradstein, S. R. (2007). Vertical stratification of vascular epiphytes in submontane and montane forest of the Bolivian Andes: the importance of the understory. *Plant Ecology*, ***189***, 261-278.

Linder, H. P. (2001). Plant diversity and endemism in Sub-Saharan tropical Africa. *Journal of Biogeography*, ***28***(2), 169-182.

Lindsey P. (2016). *Environmental and Evolutionary Influences of Light on Fern Leaf Morphology in California. Nature.berkely.education.*, retrieved on August, 2020.

Luni, P., Maharjan, K., & Joshi, N. (2011). Forest and Food Security of Indigenous People: A Case of Chepangs in Nepal. *Journal of International Development and Cooperation*, ***17***(1), 113-135.

Magar, G.T., & Chaudhary, S. (2022). Wild Floristic Diversity of Daman-Simbhanjyang Area, Makwanpur District, Central Nepal. *International Journal Applied sciences and Biotechnology*, ***10***(2), 112-123.

Magurran, A.E. (2004). Measuring Biological Diversity. Hoboken, NJ, USA: John Wiley and Sons.

Mahato, R.B. (2014). Floristic composition of Palpa district, west Nepal. *Nepalese Journal of Biosciences*, ***4***(1), 16-21.

Malla, B., Gauchan, D.P, & Chhetri, R.B. (2015). An ethnobotanical study of medicinal plants used by ethnic people in Parbat district of Western Nepal. *Journal of Ethnopharmacology*, ***165***, 103-117.

Manandhar, N P. (1995).A survey of medicinal plants of Jajarkot district, Nepal. *Journal of Ethnopharmacology*, ***48***(1), 1-6.

Manandhar, N.P. (1996). Ethnobotanical observation of ferns and ferns allies of Nepal. *Journal of Economics and Taxomic Botany*, ***12***. 414-422.

Manandhar, NP. (1986). Ethnobotany of Jumla District, Nepal. *International Journal of Crude Drug Research*, ***24***(2), 81- 89.

McCain, C.M., & Grytnes, J.A. (2010). Elevational Gradients in Species Richness, *Encyclopedia of Life Sciences*. p 1-10, USA: John Wiley & Sons, Ltd.https://sci-hub.tw/https.

McCoy, E. D. (2002). The veiled gradients problem in ecology. *Oikos* ***99,*** 189-192.

Miehe, G. (1987). An annotated list of vascular plants collected in the valleys south of Mt Everest. *Bulletin of the British Museum. Natural History. Botany*, ***16***(3), 225-268.

Moran, R.C. (2004). A natural history of ferns. 301 pp. Portland, Oregon: Timber Press Nagalingum, N.S. & Cantrill, D.J. (2015). The Albian fern flora of Alexander Island, Antarctica. *Cretaceous Research*, ***55***, 303-330.

Nagalingum, N., & Cantrill, D.J. (2015). The Albian fern flora of Alexander Island, Antarctica. *Cretaceous Research*, ***55***, 303-330.

Nahidan, S., Nourbakhsh, F., & Mosaddeghi, M.R. (2015). Variation of soil microbial biomass C and hydrolytic enzyme activities in a rangeland ecosystem: are slope aspect and position effective? *Archives of Agronomy and Soil Science*, ***61***(6), 797-811.

Naupane, S. (2023). *Ferns and Ferns allies of Palpa District, Central Nepal*. M.Sc.Thesis, submitted to the Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Nepali, B.R., Skartveit, J., & Baniya, C.B. (2020). Altitudinal Pattern of Pteridophyte in Arghakhanchi district, West Nepal. *Journal of Plant Resources*, ***18***(1), 173-182.

Nettesheim, F. C., Damasceno, E. R., & Sylvestre, L. S. (2014). Different slopes of a mountain can determine the structure of ferns and lycophytes communities in tropical forest of Brazil. *An. Acad. Bras. Cienc*, ***86***(1), 199–210.

Ojha, R., & Devekota, H.P. (2021) Edible and Medicinal Pteridophytes of Nepal: A Review. *Ethnobotany research and Applications*, ***22***(16), 1-16.

Ojha, R., & Niroula, B. (2021). Inventory of Ferns and Fern Allies of Raja-Rani Wetland and Adjoining Forest, Eastern Nepal. *Journal of Plant Resources*, ***19***, 55-61.

Pandey, S.N., Trivedi, P. S., & Mishra, S.P. (1977). *A textbook of Botany*. ***2***, Vikas Publishing House Pvt. Ltd, New Delhi, India.

Pangeni, B., Bhattarai, S., Paudyal, H., & Chaudhary, R. P. (2020). Ethnobotanical Study of Magar Ethnic Community of Palpa District of Nepal. *Ethnobotany Research and Applications*, ***20***, 1–17.

Panthi, M.P., Chaudhary, R.P., & Vetaas, O.R. (2007). Plant species richness and composition in a trans-Himalayan inner valley of Manang district, central Nepal. *Himalayan Journal of Sciences*, ***4***(6), 57-64.

Pathak, M., Phuyal, N., & Tharu, L.R. (2012). Inventory of the Pteridophytic flora of Sankhuwasabha district, eastern Nepal with notes on medicinal values. *Bull. Dept. Pl. Res*, ***34***, 47-55.

Parihar, P., & Parihar, L. (2006). Some Pteridophytes of Medicinal Importance from Rajsthan. *Natural Product Radiance*, ***5***(4), 297-301.

Parker, K. (1991). Topography, substrate and vegetation patterns in the northern Sonoron desert. *Journal of Biogeography*, ***18***(2), 151- 163.

Patil, S., Lavate, R., Rawat, V., & Dongare, M. (2016). Diversity and distribution of pteridophytes from Satara District, Maharashtra (India). *Plant Science Today*, ***3***(2), 149-156.

Paudel, E.N., Shrestha, K.K., & Bhuju, D.R. (2010). *Enumeration of herbaceous flora of Imja Valley, Sagarmatha National Park, Nepal*. In: P.K.Jha and I.P. Khanal (eds.) Contemporary Research in Sagarmatha (Mt. Everest) Region, Nepal. 173-188.

Phuyal, N., Bhatta, G.D., Maharjan, S., & Pokhrel, K.K. (2011). A contribution to the pteridophytic flora of Makwanpur district, Central Nepal. *Bull. Dep. Pl. Res*. ***33***, 45-59

PPG I. (2016). A community-derived classification for extant lycophytes and ferns. *Journal of Systematics and Evolution*, ***54***(6), 563-603.

Pradhan, S. P., Chaudhary, R. P., Sigdel, S., & Pandey, B.P. (2020). Ethnobotanical knowledge of Khandadevi and Gokulganga Rural Municipality of Ramechhap District of Nepal. *Ethnobotany Research and Applications*, ***20***, 1-32.

Prajapati, S. (2013). Pteridophytes of Daman and Adjoining Areas, Makwanpur District, Central Nepal. M.Sc.Thesis, submitted to the Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Rajbhandary, S. (2013). Inventory of *Pteridophytes of Daman VDC, Makawanpur District, Central Nepal with Application of GIS*. A report Submitted to Universiry Grants Commission (UGC), Nepal (2012-2013) for faculty Research Grant.

Rajbhandary, S. (2016). Fern and Fern Allies of Nepal. In Jha, P.K., Siwakoti, M. and Rajbhandary, S.(E D.). Frontiers of Botany (pp. 124-150). Kathmandu, Nepal: Central Department of Botany, Tribhuvan University.

Rahbek, C. (1995). The elevation gradient of species richness: a uniform pattern? *Ecography*, ***18***(2), 200-205.

Rahbek, C. (2005). The role of spatial scale and the perception of large-scale species-richness patterns. *Ecol. Lett*, ***8***, 224-239.

Rahmad, Z.B.A., & Akomolafe, G.F. (2018). Distribution, Diversity and Aboundance of Ferns in A Tropical University Campus, Malaysia. *Journal of Tropical Agricultural Science, **41***(4), 1875-1887.

Rao, K. T., Reddy, K.N., Pattanaik, C., & Reddy, C. S. (2007). Ethnomedicinal Importance of Pteridophytes used by Chenchus of Nallamalais, Andhra Pradesh, India. *Ethnobotanical Leaflets, **11**, 6-10.*

Rijal, D. P. (2009). Species richness and elevation: searching for patterns at a local scale (Langtang National Park), Central Nepal. M.Sc. Thesis, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Rout S. D., Panda, T., & Mishra, N. (2009). Ethnomedicinal studies on some Pteridophytes of Similipal Biosphere Reserve, Orissa, India**.** *International Journal of Medicine and Medical Sciences, **1***(5), 192-197.

Sagar, R., Raghubanshi, A.S., & Singh, J. S. (2008). Comparison of community Composition and species diversity of understorey and overstorey tree species in a dry tropical forest of northern India. *Journal of Environmental Management*, ***88***(4), 1037-1046.

Salazar, L., Homier, J., Kessler, M., Abrahamczyk, S., Stefan, A., Lehnert, M., Krömer, T., & Kluge, J. (2013). Diversity Patterns of ferns along elevation in Andean tropic forests. *Plant Ecology and Diversity, **8***(1), 13-24.

Salazar, L., Homeier, J., Kessler, M., Abrahamczyk, S., Lehnert, M., Krömer, T., & Kluge, J. (2015). Diversity patterns of ferns along elevational gradients in Andean tropical forests. *Plant Ecology and Diversity*, ***8***(1), 13-24.

Sanders, N.J., Lessard, J.P., Fitzpatrict, M.C., & Dunn, R.R. (2007). Temperature, but not Productivity or geometry, predicts elevational diversity gradient in ants across spatial grains. *Global Ecology and Biogeography*, ***16***(5), 640-649.

Sanders, N. J., & Rahbek, C. (2012). The patterns and causes of elevational diversity gradients. *Ecography*, ***35***(1), 1.

Sapkota, P.P. (2000). *An Ecological Study and Medicinal Uses of Plants of Malica Forest, Baglung, Western Nepal*. M.sc. Thesis Submitted to Central Department of Botany, Tribhuvan University.

Sathiyaraj, G., Muthukumar, T., & Ravindra, K. C. (2015). Ethnomedicinal importance of fern and fern allies traditionally used by tribal people of Palani Hills (Kodaikanal), Western Ghats, South India. *Journal of Medicinal Herbs and Ethno medicine*, ***1***(1), 4-9.

Scheidegger, C., Nobis, M., & Shrestha, K.K. (2010). Biodiversity and Livelihood in Land-use Gradient in an Era of Climate change-Outline of Nepal-Swiss Research project. Botanica Orintalis. *Journal of Plant science*, ***7***, 7-14.

Sen, A., & Ghosh, P.D. (2011). A note on the ethno-botanical studies of some Pteridophytes in Asam. *Indian Journal of traditional knowledge*, ***10*** (2), 292-295.

Shah, S., Tewari, A., & Srivastava, A.K. (2011). Influence of aspect and location of stands on biodiversity in Sal mixed broadleaved forest in Kumaun central Himalaya. *Russian Journal of Ecology*, ***42***(3) 211-125.

Shimono, A., Zhou, H., Shen, H., Hirota, M., Ohtsuka, T., & Tang, Y. (2010). Patterns of plant diversity at high altitudes on the Qinghai-Tibetan Plateau. *Journal of Plant Ecology*, ***3***(1), 1-7.

Shrestha, T.B. (1999). Nepal Country Report on Biological Diversity IUCN-The Conservation Union.

Shrestha, H. S. (2017). Floristic Studies on Fern and fern Allies along altitudinal gradient from Besishahar to lower Manang, central Nepal. M. Sc. Thesis, Central Department of Botany, Tribhuvan University, Kathmandu, Nepal.

Shrestha, P., Chaudhary. R.P., Shrestha, K.K., & Dangol., D.R. (2018). Flora of community managed forests of Palpa district, western Nepal. *Journal of Natural History Museum*, ***30***, 102-120.

Shrestha, I., & Shrestha, K. (2005). Ethnobotanical Notes on Some Ferns and Ferns allies of Langtang National Park, Central Nepal. *Nepal Journal of Plant Sciences*, ***1***, 124-128.

Shrestha H. S., & Rajbhandary, S. (2019) Floristic Study of Fern and Fern Allies along Altitudinal Gradient from Besishahar to Lower Manang, Central Nepal. *Journal of Plant Resources*, ***17***, 29-34.

Silva, V. L., Mehltreter, K., & Schmitt, J. L. (2018). Ferns as potential ecological indicators of edge effects in two types of Mexican forests. *Ecological indicators*, ***93***, 669-676.

Singh, A.G., Gautam, L.P., & Tiwari, D.D. (2011). Folk Uses if some Medicinal Plant of Dovan VDC of Palpa District, Western Nepal. Journal of Phytology, ***3***(8), 62-67.

Siwakoti, M. (2006). An overview of floral diversify in wetlands of Terai region of Nepal. *Our Nature*, **4**, 83-90.

Srivastav, K. (2007). Ethno-botanical Studies of Some Important Ferns. *Ethnobotanical Leaflets*. ***11***, 164-172.

Stevens, G.C. (1992). The elevational gradient in altitudinal range, an extension of Rapopor's latitudinal rule to altitude. *American Naturalist*, ***140***(6), 893-911.

Sureshkumar, J. Ayyanar, M., & Silambarasa, R. (2020). Pteridophyte Species Richness along Elevation Gradient in Kolli Hills of Eastern Ghats. *Journal of Asia-Pacific Biodiversity*, ***13***(1), 92-106.

Tamang, R. (2013). *Vascular Plant Diversity in Ghunsa Valley of Kanchenjunga Conservation Area, Eastern Nepal*. M.sc. Thesis of Plant Systematics and Biodiversity Unit. Central Department of Botany Tribhuvan University Kirtipur, Kathmandu, Nepal.

Tamang, R., Thakur, C., Koirala, D., & Chapagain, N. (2017). Ethno medicinal Plants Used by Chepang Community in Nepal. *Journal of Plant Resources*,***15***(1):21-30.

Tanaka, T., & Sato, T. (2014). Species richness of seed plants and fern along the tempereate elevation gradient in Central Japan. *Plant Ecology,* ***215***, 1299-1311.

Thakur, C., & Rajbhandary, S. (2018). Ferns and Ferns Allies of Panchase Protected Forest, Central Nepal. *Journal of Plant Resources*, ***16***(1), 39-45.

Upadhaya, H., & Baskoti, N. (2019). Species diversity of pteridophytic flora in Bhimkalipatan, Pokhara, Nepal. *Prithvi journal of research and innovation*, ***1***, 581-661.

Uprety, Y. ,Asselin, H., Boon, E, Yadav, S., & Shrestha, K. (2010). Indigenous use and bio-efficacy of Rasuwa district, central Nepal. *Journal of Ethnobiology and Ethnomedicine* ***6***(3), 1-10.

Vasistha P.C., Sinha, A.K., & Kumar, A. (2015). *Botany for degree students Pteridophyta (vascular cryptogams*). S Chand Publishing. A division of S. Chand and Company Pvt. Ltd, New Delhi, India.

Veetas, O.R. (1997). The effect of canopy disturbance on species richness in a central Himalayan Oak forest. *Plant Ecology,* ***132***, 29-38.

Verma, S.K., & Kanwar, S. (2020). Medicinal Pteridophytes Used in the Treatment of Various Diseases by the Inhabitants of Sarkaghat Tehsil, Mandi District, Himachal Pradesh. *Journal of Pharmacutical Sciences and Research*, ***12***(3), 360-364.

Wang, W., Wang, Q., Li, S., & Wang, G. (2006). Distribution and species diversity of plant communities along transect on the northeastern Tibetan Plateau. *Biodiversity and Conservation,* ***15***, 1811-1828

Warren, R. J. (2008). Mechanisms driving understory evergreen herb distributions across slope aspects: As derived from landscape position. *Plant Ecology*, **198**(2), 297–308.

Whittaker, R. J., Wills, K. J., & Field, R. (2001). Scale and species richness: towards a general, hierarchical theory of species diversity. *Journal of biogeography*. ***28***(4), 453-470.

Young, K.R., & León, B. (1989). Pteridophyte species diversity in the central Peruvian Amazon: importance of edaphic specialization. *Brittonia*, ***41***(4), 388-395.

Zhang, S., Chen, W., & Huang, J. (2015). Orchid species richness along elevational and environmental gradients in Yunnan, China. *PLoS ONE*, ***10***(10), 371.

Zhao, P., Chen, K. L., Zhang, G. L., Deng, G. R., & Li, J. (2017). Pharmacological basis for use of *Selaginella moellendorffii* in gouty arthritis: antihyperuricemic, anti-inflammatory, and xanthine oxidase inhibition. *Evidence-based complementary and alternative medicine*.

Zobel, D. B., Jha, P. K., Behan, M. J., & Yadav, U. K. R. (1987). A practical manual for ecology. *Ratna Book Distributors, Kathmandu, Nepal*, ***149***.

APPENDICES

Appendix I. Data Sheet used in field sampling

Investigators'Name:………………………Phone:………………Campus: Amrit Campus

Email:…………………Date:……………Locality:…………..District:……………

Gaupalika/Nagarpalika:……..……………..Slope....................... Aspect:…………

Land use type:……………………......Altitude (m):…..........Latitude(N):……………

Longitude (E):……………………Disturbance level (1, 2, & 3):………………

Forest type:………………………..Distance from road:…………. Distance from settlement:…………..Ethnicity of locals:……………………………..Litter depth (cm):…………..Canopy cover (%):…………… Soil color:………… Soil type:……………Transect:………… Plot no:………Size of Plot:…………

For Pteridophytes

Transect no:………..Plot no…………..Size of Plot: ……………..

Species	**Number**	**Cover (%)**	**Remarks** (Any observable characters)

Appendix II. Questionnaire used for Ethnobotanical study

A: For general information

Occupation							
Agriculture	**Job**			**Business**		**Others**	
Name of plants	**Uses**						
	Medicinal	**Fodder**	**Food**	**Firewood**	**Religious**	**Bedding**	**Others**

B: For medicinal uses

Name of plants	**Local name**	**What purpose** **a.** **b.** **c.**	**Which part** **a.** **b.** **c.**	**Mode of preparation of medicine**	**Mode of application of medicine**

Appendix III. Plot Characteristics of study site:

Transect /plot	Aspect	Plots	Num. of sp	Date	Locality	Lat(N)	long(E)	Alt (m)	Land use types	Dominant tree species	Slope (in degree)	Forest Canopy cover (%)
T1P1	North	1	7	17/07/079	Khiluwatari, Purbakhola	27.80629444	83.78950556	806	Stream bank	*Cinnamomum tamala*	8°	12%
	North									*Ficus carica*		
	North									*Garuga pinnata*		
T1P2	North	2	7		Khiluwatari	27.80629722	83.78948333	804	Stream bank	*Ficus semicordata*	8.02°	9%
	North									*Cinnamomun tamala*		
	North									*Syzgium cumini*		
T1P3	North	3	5		Khiluwatari	27.80629722	83.78948333	804	Stream bank	*Garuga pinnata*	11.08°	13%
	North									*Cinnamomum tamala*		
	North									*Ficus carica*		
T1P4	North	4	7		Khiluwatari	27.80629722	83.78948333	803	Forest	*Cinnamomum tamala*	20°	18%
T1P5	North	5	10		Khiluwatari	27.80614444	83.78777222	805	Forest	*Zizyphus incurva*	25°	28%
T1P6	North	6	6		Khiluwatari	27.80636667	83.78771389	801	Forest	*Shorea robusta*	8.06°	8%
T1P7	North	7	6		Pandanda	27.80678056	83.78706667	795	Forest	*Shorea robusta*	22°	14%
T2P1	North	8	9	19/07/2079	Achidanda	27.80776944	83.790625	908	Forest	*Cinnamomum tamala*	15.02°	40%
	North									*Terminalia alata*		
T2P2	North	9	5		Achindanda	27.80776944	83.790625	907	Stram bank	*pinus roxburghii*	13.08°	41%
	North									*Syzizium cumini*		
	North									*Cinnamomum tamala*		
T2P3	North	10	7			27.80776944	83.790625	902m	Forest	*Bauhinia vahlii*	21°	46%
	North									*Cinnamomum tamala*		
T2P4	North	11	6			27.80776944	83.790625	907m	Forest	*Zizyphus incurva*	18°	33%

	North									*Terminalia alata*		
	North									*Bauhinia vahlii*		
T2P5	North	12	6			27.80724167	83.79018889		Forest	*Cinnamomum tamala*	19°	12%
	North									*Ficus semicordata*		
T2P6	North	13	4			27.80745556	83.79049722	894	Forest	*Terminalia alata*	24.08°	56%
	North											
T2P7	North	14	4			27.80745556	83.79049722	905		*Terminalia alata*	21.02°	56%
T3P1	North	15	5	18/07/2079	Dhakre-bhangyang	27.80615833	83.79625	1009	Forest	*Shorea robusta*	22°	28%
	North									*Pinus roxburghii*		
	North									*Terminalia alata*		
T3P2	North	16	4			27.80605	83.79616667	1003	Forest	*Pinus roxburghii*	21.07°	22%
	North									*Terminalia alata*		
T3P3	North	17	6			27.806075	83.79616667	1003	Forest	*Pinus roxburghii*	20.06°	38%
	North									*Shorea robusta*		
	North									*Terminalia alata*		
	North									*Bauhinia vahlii*		
T3P4	North	18	5			27.80593056	83.79678889	1006	Forest	*Shorea robusta*	23°	23%
	North									*Terminalia alata*		
	North									*Pinus roxburghii*		
T3P5	North	19	5			27.80605	83.79616667	1003	Forest	*Pinus roxburghii*	18.06°	26%
	North									*Terminalia alata*		
T3P6	North	20	5			27.80565	83.79688611	1007	Forest	*Shorea robusta*	20°	25%
	North									*Bauhinia vahlii*		
T3P7	North	21	5			27.80563333	83.79683889	992	Forest	*Shorea robusta*	16°	28%
	North									*Pinus roxburghii*		
	North									*Bauhinia purpuria*		
	North									*Terminalia alata*		
T4P1	North	22	5	6/7/2079	Hattilake forest	27.79950278	83.80052778	1104	Forest	*Pinus roxburghii*	24.5°	21%
	North											

	North									*Bauhinia purpuria*		
T4P2	North	23	4			27.79950278	83.80052778	1102	Forest	*Pinus roxburghii*	13.8°	24%
	North									*Aesandra butyraceae*		
T4P3	North	24	6			27.79950278	83.80052778	1105	Forest	*Pinus roxburghii*	21.05°	26%
	North									*Diploknema butyracea*		
	North									*Bauhinia variegata*		
	North									*Lyonia ovalifolia*		
T4P4	North	25	5			27.79950278	83.80052778	1098	Forest	*Terminalia chebula*	23°	20%
	North									*Bauhinia vahlii*		
	North											
T4P5	North	26	4		Hattilake forest	27.80307222	83.79975833	1096	Forest	*Diploknema butyracea*	25°	16%
	North									*Pinus roxburghii*		
	North											
T4P6	North	27	6			27.81542778	83.79975833	1096	Forest	*Diploknema butyracea*	26°	11%
	North									*Pinus roxburghii*		
T4P7	North	28	6			27.80462222	83.79845	1100	Forest	*Pinus roxburghii*	28.02°	10%
T5P1	North	29	6	5/6/2079	Hattilake forest	27.79784722	83.80074722	1208	Forest	*Pinus roxburghii*	19°	46%
	North									*Quercus glauca*		
T5P2	North	30	6			27.79876944	83.77584444	1207	Forest	*Quercus glauca*	13.9°	52%
	North									*Pinus roxburghii*		
T5P3	North	31	5			27.798925	83.80174444	1206	Forest	*Pinus roxburghii*	12°	11%
	North											
T5P4	North	32	5			27.79942778	83.80091667	1202	Forest	*Ficus carica*	13°	9%
	North									*Pinus roxburghii*		
T5P5	North	33	5			27.79950556	83.80074722	1207	Forest	*Pinus roxburghii*	9.8°	

T5P6	North	34	7			27.79950556	83.80074722	1197	Forest		12°	8%
	North									*Pinus roxburghii*		
T5P7	North	35	5			27.79950278	83.80052778	1198	Forest	*Schima wallichi*	17°	22%
	North									*Pinus roxburghii*		
T6P1	North	36	5	4/7/2079	Hattilake forest	27.797625	83.80196667	1306	Forest	*Pinus roxburghii*	19°	16%
	North									*Diploknema butyracea*		
T6P2	North	37	7			27.81542778	83.77584444	1308	Forest	*Schima wallichi*	21°	29%
	North									*Pinus roxburghii*		
	North									*Quercus glauka*		
T6P3	North	38	6			27.79780833	83.80243889	1309	Forest	*Bauhinia* sp.	21.08°	28%
	North									*Quercus glauca*		
T6P4	North	39	4			27.80887778	83.80243889	1304	Forest	*Pinus roxburghii*	22°	42%
	North									*Bauhinia* sp.		
T6P5	North	40	4			27.79799444	83.80249722	1293	Forest	*Pinus roxburghii*	22.07°	55%
	North											
T6P6	North	41	9			27.79799444	83.80249722	1293	Forest	*Diploknema butyracea*	20°	50%
	North											
T6P7	North	42	8			27.79784722	83.80300833	1299	Forest		23°	32%
	North											
T7P1	North	43	6	4/7/2079	Hattiklake forest	27.79631667	83.80684444	1400	Forest	*Quercus glauca*	18.9°	29%
	North									*Diploknema butyracea*		
	North									*Zizyphus incurva*		
	North											
T7P2	North	44	6			27.79663333	83.804025	1395	Forest	*Quercus gluca*	21.04°	65%
	North									*Pinus roxburghii*		
T7P3	North	45	5			27.7965	83.80103611	1391	Forest	*Pinus roxburghii*	22°	47%
	North									*Quercus glauca*		

T7P4	North	46	4			27.79664167	83.80403333	1391	Forest	*Zizyphus incurva*	16°	32%
T7P5	North	47	4			27.79663333	83.804025	1395	Forest	*Bauhinia purpurea*	15°	26%
	North									*Debregeasia salicifolia*		
T7P6	North	48	4			27.79663333	83.804025	1396	Forest	*Pinus wallichiana*	24.07°	20%
	North											
	North											
T7P7	North	49	3			27.79664167	83.80402778	1391	Forest	*Quercus glauca*	19°	56%
	North									*Debregeasia salicifolia*		
T8P1	North	50	4	3/7/2079	Hattilake forest	27.79650556	83.80391111	1500	Forest	*Debregeasia* sp.	25.4°	35%
T8P2	North	51	6			27.79708889	83.80335	1502	Forest	*Schima wallichi*	23.07°	67%
T8P3	North	52	3			27.79629722	83.80681111	1507	Forest		16.94°	26%
T8P4	North	53	3			27.79593056	83.80590278	1493	Forest	*Quercus glauca*	21°	16%
	North									*Bauhinia* sp.		
T8P5	North	54	3			27.79650556	83.80391111	1500	Forest	*Zizyphus incurva*	18.03°	12%
T8P6	North	55	4			27.79631667	83.80129167	1508	Forest	*Sapium insigne*	14.06°	26%
	North									*Zizyphus incurva*		
T8P7	North	56	6			27.79633056	83.80685556	1509	Forest	*Bauhinia* sp.	12°	29%
	North											
T9P1	North	57	2	3/7/2079	Hattilake danda	27.79473611	83.80685	1590	Gressland	*Phyllanthus emblica*	2.09°	4%
	North									*Schima wallichi*		
T9P2	North	58	3			27.79484722	83.80685	1591	Grassland	*Quercus glauca*	9.8°	3%
	North									*Bauhinia purpurea*		
T9P3	North	59	3			27.79484722	83.80685	1590	Forest	*Quercus glauca*	13°	26%
T9P4	North	60	2			27.79486944	83.80685	1589	Grassland	*Castonopsis indica*	3°	6%
T9P5	North	61	3			27.79445833	83.80685	1591	Grassland	*Quercus glauca*	2°	12%
	North									*Phyllanthus emblica*		
T9P6	North	62	3			27.79484722	83.80685	1590	Grassland	*Phyllanthus emblica*	5.6°	2%
T9P7	North	63	3			27.79473611	83.80685	1592	Grassland	*Quercus glauca*		

T1P1	South	64	10	16/7/2079	Jamale site,Siluwa	27.79635556	83.78268889	800m	Forest	*Shorea robusta*	18.06°	25%
T1P2	South	65	7			27.79444167	83.78129722	804	Forest	*Shorea robusta*	19°	26%
	South											
T1P3	South	66	7			27.79444167	83.78129722	803	Forest	*Shorea robusta*	8.02°	61%
	South									*Syzgium cumini*		
T1P4	South	67	4			27.79664444	83.78285556	782	Forest	*Bauhinia* sp.	18°	10%
	South									*Terminalia alata*		
	South									*Shorea robusta*		
T1P5	South	68	4		Siluwa area	27.79691111	83.78257778	803	Forest	*Shorea robusta*	24°	20%
	South											
T1P6	South	69	5			27.79698333	83.78270278	809	Forest	*Shorea robusta*	22.07°	19%
	South									*Pinus roxburghii*		
T1P7	South	70	7			27.79698333	83.78270278	800	River bank	*Diploknema butyracea*	12°	25%
	South									*Shorea robusta*		
	South									*Syzgium cumini*		
	South									*Cinnamomum*		
T2P1	South	71	7	14/7/2079	Siluwa forest	27.79383333	83.76793889	900m	Riverbank	*Shorea robusta*	17°	26%
T2P2	South	72	5			27.79383333	83.76798611	895	Forest	*Syzgium cumini*	27.07°	29%
	South									*Shorea robusta*		
T2P3	South	73	4			27.79372222	83.7677	901	Forest		21°	21%
	South									*Castonopsis indica*		
T2P4	South	74	5			27.79315	83.7677	905	Forest	*Shorea robusta*	21°	28%
T2P5	South	75	5			27.79375278	83.78436667	905	Forest		21°	29%
T2P6	South	76	4			27.79370278	83.78415	908	Forest	*Shorea robusta*	16.06°	19%
	South									*Castonopsis indica*		
T2P7	South	77	5			27.79401111	83.78474167	905	Forest	*Diploknema butyracea*	21.04°	15%
	South									*Shorea robusta*		
T3P1	South	78	2		Siluwa forest	27.79329444	83.78729722	1000	Forest	*Pinus roxburghii*	21°	12%

	South									*Shorea robusta*		
	South									*Terminalia alata*		
T3P2	South	79	7			27.79330278	83.78764444	1005	Forest	*Bauhinia vahlii*	23°	16%
	South									*Shorea robusta*		
T3P3	South	80	3			27.79315	83.78771667	1008	Forest	*Diploknema butyracea*	14°	10%
	South									*Shorea robusta*		
T3P4	South	81	4			27.79315	83.78771667	1005	Forest	*Bauhinia vahlii*	21.07°	46%
	South									*Terminalia alata*		
T3P5	South	82	4			27.79315	83.78771667	1001	Forest	*Pinus roxburghii*	20.8°	27%
	South									*Bauhinia vahlii*		
	South									*Terminalia alata*		
T3P6	South	83	4			27.79315	83.78771667	1006	Forest	*Terminalia alata*	21°	21%
	South											
T3P7	South	84	4			27.79340833	83.78710556	1008	Forest	*Shorea robusta*	17°	20%
	South									*Pinusroxburghii*		
T4P1	South	85	3	13/7/2079	Siluwa forest	27.79196667	83.78855833	1100m	Forest	*Bauhinia vahlii*	16°	29%
	South									*Pinusroxburghii*		
	South									*Terminalia alata*		
	South									*Schima wallichi*		
T4P2	South	86	3			27.79308889	83.78855833	1092	Forest	*Terminalia alata*	18°	32%
	South									*Bauhinia vahlii*		
	South									*Pinus roxburghii*		
T4P3	South	87	3			27.79274722	83.78851944	1094	Forest	*Pinus roxburghii*	18°	21%
	South									*Bauhinia vahlii*		
T4P4	South	88	4			27.79285278	83.78838611	1107	Forest	*Bauhinia vahlii*	20°	26%
	South									*Terminalia alata*		
T4P5	South	89	6			27.7924	83.78840278	1105	Forest	*Bauhinia purpuria*	25°	33%
	South									*Terminalia alata*		

	South									*Bauhinia vahlii*		
T4P6	South	90	3			27.79285278	83.78866389	1101	Forest	*Bauhinia vahlii*	19.04°	19%
	South									*Bauhinia purpuria*		
T4P7	South	91	5			27.79256389	83.788575	1110	Forest	*Bauhinia purpuria* i	26°	28%
	South									*Terminalia alata*		
T5P1	South	92	6	13/7/2079	Sukhaura,Siluwa	27.79196667	83.78991667	1200m	Forest	*Shorea robusta*		
	South									*Bauhinia vahlii*		
	South									*Terminalia alata*		
T5P2	South	93	6			27.79196667	83.78991667	1198	Forest	*Bauhinia variegata*	23°	31%
	South									*Pinus roxburghii*		
T5P3	South	94	5			27.79196667	83.78991667	1209	Forest	*Pinus roxburghii*	23°	13%
	South									*Bauhinia variegata*		
T5P4	South	95	5			27.79116944	83.78958889	1196	Forest	*Shorea robusta*	24°	11%
	South									*Pinus roxburghii*		
T5P5	South	96	5			27.79116944	83.78958889	1204	Forest	*Shorea robusta*	17.8°	65%
	South									*Terminalia alata*		
	South									*Bauhinia vahlii*		
T5P6	South	97	7			27.79116944	83.78958889	1203	Forest	*Bauhinia vahlii*	19°	20%
	South											
T5P7	South	98	5			27.79116944	83.78958889	1198	Forest	*Phyllanthus emblica*	14°	55%
	South									*Ficus religiosa*		
	South									*Terminalia alata*		
	South											
T6P1	South	99	2	12/7/2079	Siluwa forest	27.79176111	83.79161111	1291	Forest	*Shorea robusta*	16°	10%
	South									*Bauhinia vahlii*		
	South									*Pinus roxburghii*		
	South									*Terminalia alata*		
T6P2	South	100	3			27.79176111	83.79161111	1294	Forest	*Shorea robusta*	16.9°	12%
	South									*Phyllanthus emblica*		

	South									*Ficus carica*		
T6P3	South	101	3			27.79154444	83.79188333	1310	Forest	*Terminalia alata*	19°	5%
	South									*Bauhinia purpuria*		
T6P4	South	102	4			27.79154444	83.79188333	1307	Forest	*Bauhinia vahlii*	24°	18%
	South									*Pinus*		
	South									*Bauhinia variegata*		
T6P5	South	103	3			27.79090278	83.79152778	1309	Forest	*Shorea robusta*	13°	24%
	South									*Terminalia alata*		
	South									*Lyonia* sp.		
	South									*Phyllanthus emblica*		
T6P6	South	104	3			27.79068056	83.79159444	1292	Forest	Phyllanthus emblica	10.8°	19%
	South									*Terminalia alata*		
T6P7	South	105	4			27.79154444	83.79187222	1301	Forest	*Shorea robusta*	19°	17%
	South									*Bauhinia vahlii*		
T7P1	South	106	6	12/7/2079	Siluwa forest	27.79134444	83.79293056	1396	Forest	*Bauhinia vahlii*	26°	25%
	South									*Diploknema butyracea*		
	South									*Terminalia alata*		
	South									*Euphorbia royleana*		
T7P2	South	107	3			27.79134444	83.79293056	1400m	Forest	*Bauhinia variegata*	25°	10%
	South											
T7P3	South	108	5			27.79148611	83.79306944	1408	Forest	*Bauhinia vahlii*	26°	16%
T7P4	South	109	3			27.7914	83.792525	1398	Forest	*Shorea robusta*	20.02°	12%
	South									*Bauhinia vahlii*		
T7P5	South	110	2			27.7914	83.792525	1391	Grassland	*Terminalia alata*	24°	7%

T7P6	South	111	3			27.79200278	83.79246111	1405	Forest	*Euphorbia royleana*	25°	8%
	South									*Ficus religiosa*		
T7P7	South	112	2			27.79143889	83.79325833	1394	Forest	*Bauhinia purpuria*	24.08°	24%
	South									*Ficus religiosa*		
T8P1	South	113	3	11/7/2079	Siluwa forest	27.79227222	83.792425	1492	Forest	*Bauhinia variegata*	18°	8%
T8P2	South	114	2			27.79263333	83.79384722	1500m	Forest	*Bauhinia variegata*	19°	6%
T8P3	South	115	4			27.79309722	83.79418056	1497	Forest		24°	7%
T8P4	South	116	2			27.79309722	83.79418056	1491	Grassland		18.02°	5%
T8P5	South	117	4			27.79269444	83.79476944	1492	Forest	*Euphorbia royleana*	27°	9%
T8P6	South	118	3			27.79278889	83.79488889	1495	Forest		27.07°	5%
T8P7	South	119	4			27.79279444	83.79488889	1500m	Forest	*Euphorbia royleana*	21°	21%
	South									*Terminalia alata*		
	South									*Bauhinia purpuria*		
T9P1	South	120	2	11/7/2079	Hattilake forest	27.79405278	83.79535278	1593	Grassland		7°	4%
T9P2	South	121	2			27.79405278	83.79535278	1593	Grassland	*Euphorbia royleana*	2°	4%
T9P3	South	122	2			27.79405278	83.79535278	1592			2°	3%
	South											
T9P4	South	123	2			27.79405278	83.79535278	1591	Grassland		3°	4%
	South											
T9P5	South	124	4			27.79349167	83.79526389	1592	Grassland		2.5°	2%
	South											
T9P6	South	125	2			27.79349167	83.79526389	1593	Grassland	*Euphorbia royleana*	1.6°	3%
	South											
T9P7	South	126	2			27.79408056	83.79535833	1594	Grassland		2°	2%

Appendix IV. List of Ptridophytes species found in Purbakhola Rural Municipality, Palpa

S.N.	Name of species	Family	Northern aspect	Southern aspect
1	*Dryopteris cochleata* (D, Don) C. Chr.	Dryopteridaceae	+	+
2	*Hypodematium crenatum* (Forssk.) Kuhn subsp. Crenatum	Dryopteridaceae	+	+
3	*Tectaria coadunata* (J. sm.) C. Chr.	Dryopteridaceae	+	+
4	*Microlepia speluncae* (C.) T. Moore	Dennstaedtiaceae	+	+
5	*Pteridium revolutum* (Blume) Nakai	Dennstaedtiaceae	+	+
6	*Equisetum ramosissimum* Desf.	Equisetaceae	+	
7	*Odontosoria chinensis* (L.)J. Sm.	Lindsaeceae	+	
8	*Lygodium japonicum* (Thunb.) Sw.	Lygodiaceae	+	+
9	*Nephrolepis cordifolia* (L.) C. Presl	Nephrolepidaceae	+	+
10	*Drynaria propinqua* Wall. ex Mett.) Bedd.	Polypodiaceae	+	+
11	*Lepisorus nudus* (Hook.) Ching	Polypodiaceae	+	+
12	*Microsorum cuspidatum* D. Don) Tagawa sub sp.	Polypodiaceae	+	
13	*Polypodiodes lachnopus* (Wall. ex Hook.) Ching	Polypodiaceae	+	
14	*Pyrossia costata* (C. Presl) Tagawa & K.I wats	Polypodiaceae	+	
15	*Pyrossia stenophylla* (Bedd.) Ching	Polypodiaceae	+	+
16	*Adiantum capillus- veneris* L.	Pteridaceae	+	+
17	*Adiantum incium* forssk.	Pteridaceae	+	+
18	*Adiantum philippense* L. Subsp. philippense	Pteridaceae	+	+
19	*Aleuritopteris bicolor* (Roxb) Fraser-Jenk.	Pteridaceae	+	+
20	*Aleuritopteris dealbata* (C. Presl) Fee	Pteridaceae	+	+
21	*Aleuritopteris rufa* (D. Don) Ching	Pteridaceae	+	+
22	*Coniogramme fraxinea* (D. Don) Fee	Pteridaceae	+	

23	*Onychium lucidum* (D. Don) Spreng	Pteridaceae	+	
24	*Onychium siliculosum* (Decv.) C. Chr.	Pteridaceae	+	
25	*Pteris aspericaulis* wall ex J. Agard	Pteridaceae	+	
26	*Pteris biaurita* L.	Pteridaceae		+
27	*Pteris cretica* L.	Pteridaceae	+	
28	*Ptris vittata* L.	Pteridaceae	+	+
29	*Pteris stenophylla* Wall. Ex Hook and Grev.	Pteridaceae	+	+
30	*Pteris subquinata* Wall. ex. J. Agardh	Pteridaceae	+	+
31	*Selaginella chrysorrhizos* Spring	Selaginellaceae	+	+
32	*Selaginella fulcrata (Buch.-Ham. ex D. Don) Spring*	Selaginellaceae	+	+
33	*Selaginella pallida* (Hook. & Grev.) Spring	Selaginellaceae	+	+
34	*Selaginella subdiaphana* (Wall ex Hook. & arev. Spring)	Selaginellaceae		+
35	*Thelypteris arida* (D. Don) Fraser-Jenk.	Thelypteridaceae		+
36	*Thelypteris dentata* (Forssk.) Kuhn	Thelypteridaceae	+	+
37	*Thelypteris penangiana* (Hook) C. F. Reed	Thelypteridaceae	+	+
38	*Thelypteris procera (D. Don) Fraser. Jenk.*	Thelypteridaceae	+	+
39	*Thelypteris* sp	Thelypteridaceae	+	
40	*Antrophylum reticulatum* (G. Forst.) Kaulf	Vittariaceae		+
41	*Athyrium cuspidatum* (Bedd.) M. Kato	Woodsiaceae	+	
42	*Diplazium spectabile* (wall. ex Mett.) Ching	Woodsiaceae	+	

Note: '+' indicates recorded Pteridophytes species in different aspects

Appendix V. List of common species found in both Northern and Southern aspects

S.N	**Name of species**	**Family**
1	*Dryopteris cochleata* (D, Don) C. Chr.	Dryopteridaceae
2	*Hypodematium crenatum* (Forssk.) Kuhn subsp. Crenatum	Dryopteridaceae
3	*Tectaria coadunata* (J. sm.) C. Chr.	Dryopteridaceae
4	*Microlepia speluncae* (C.) T. Moore	Dennstaedtiaceae
5	*Pteridium revolutum* (Blume) Nakai	Dennstaedtiaceae
6	*Lygodium japonicum* (Thunb.) Sw.	Lygodiaceae
7	*Nephrolepis cordifolia* (L.) C. Presl	Nephrolepidaceae
8	*Drynaria propinqua* Wall. ex Mett.) Bedd.	Polypodiaceae
9	*Lepisorus nudus* (Hook.) Ching	Polypodiaceae
10	*Pyrossia stenophylla* (Bedd.) Ching	Polypodiaceae
11	*Adiantum capillus- veneris* L.	Pteridaceae
12	*Adiantum incium* forssk.	Pteridaceae
13	*Adiantum philippense* L. Subsp. philippense	Pteridaceae
14	*Aleuritopteris bicolor* (Roxb) Fraser-Jenk.	Pteridaceae
15	*Aleuritopteris dealbata* (C. Presl) Fee	Pteridaceae
16	*Aleuritopteris rufa* (D. Don) Ching	Pteridaceae
17	*Ptris vittata* L.	Pteridaceae
18	*Pteris stenophylla* Wall. Ex Hook and Grev.	Pteridaceae
19	*Pteris subquinata* Wall. ex. J. Agardh	Pteridaceae
20	*Selaginella chrysorrhizos* Spring	Selaginellaceae
21	*Selaginella fulcrata (Buch.-Ham. ex D. Don) Spring*	Selaginellaceae
22	*Selaginella pallida* (Hook. & Grev.) Spring	Selaginellaceae
23	*Thelypteris dentata* (Forssk.) Kuhn	Thelypteridaceae
24	*Thelypteris penangiana* (Hook) C. F. Reed	Thelypteridaceae
25	*Thelypteris procera* (D. Don) Fraser. Jenk.	Thelypteridaceae

Appendix VI. Family, genera and species composition of Pteridophytes in Purbakhola Rural Municipality

S.N.	**Family**	**Genera**	**No. of species**
1.	Dryopteridaceae	*Dryopteris*	1
		Hypodematium	1
		Tectaria	1
2.	Dennstaedtiaceae	*Microlepia*	1
		Pteridium	1
3.	Equisetaceae	*Equisetum*	1
4.	Lindsaeceae	*Odontosoria*	1
5.	Lygodiaceae	*Lygodium*	1
6.	Nephrolepidaceae	*Nephrolepis*	1
7.	Polypodiaceae	*Drynaria*	1
		Lepisorus	1
		Polypodiodes	1
		Pyrossia	2
		Microsorum	1
8.	Pteridaceae	*Adiantum*	3
		Aleuritopteris	4
		Coniogramme	1
		Onychium	2
		Pteris	6
9	Selaginellaceae	*Selaginella*	3
10	Thelypteridaceae	*Thelypteris*	5
11	Vittariaceae	*Antrophylum*	1
12.	Woodsiaceae	*Athyrium*	1
		Diplazium	1
	Total family= 12	Total genus= 24	Species =42

Appendix VII. Habitat of Pteridophytes species

S.N.	**Name of species**	**Family**	**Habitat**
1	*Dryopteris cochleata* (D, Don) C. Chr.	Dryopteridaceae	Terrestrial
2	*Hypodematium crenatum* (Forssk.) Kuhn subsp. Crenatum	Dryopteridaceae	Terrestrial
3	*Tectaria coadunata* (J. sm.) C. Chr.	Dryopteridaceae	Terrestrial
4	*Microlepia speluncae* (C.) T. Moore	Dennstaedtiaceae	Terrestrial
5	*Pteridium revolutum* (Blume) Nakai	Dennstaedtiaceae	Terrestrial
6	*Equisetum ramosissimum* Desf.	Equisetaceae	Terrestrial
7	*Odontosoria chinensis* (L.)J. Sm.	Lindsaeceae	Terrestrial
8	*Lygodium japonicum* (Thunb.) Sw.	Lygodiaceae	Climber/Terrestrial
9	*Nephrolepis cordifolia* (L.) C. Presl	Nephrolepidaceae	Terrestrial
10	*Drynaria propinqua* Wall. ex Mett.) Bedd.	Polypodiaceae	Epiphytic
11	*Lepisorus nudus* (Hook.) Ching	Polypodiaceae	Epiphytic
12	*Polypodiodes lachnopus* (Wall. ex Hook.) Ching	Polypodiaceae	Epiphytic
13	*Pyrossia costata* (C. Presl) Tagawa & K.I wats	Polypodiaceae	Epiphytic/Lithophytes
14	*Pyrossia stenophylla* (Bedd.) Ching	Polypodiaceae	Epiphytic/Lithophytes
15	*Microsorum cuspidatum* (D. Don) Tagawa sub sp. Cuspidatum	Polypodiaceae	Epiphytic/ Lithophytes
15	*Adiantum capillus- veneris* L.	Pteridaceae	Terrestrial/ Lithophytes
16	*Adiantum incium* forssk.	Pteridaceae	Terrestrial/ Lithophytes
17	*Adiantum philippense* L. Subsp. philippense	Pteridaceae	Terrestrial/ Lithophytes
18	*Aleuritopteris bicolor* (Roxb) Fraser-Jenk.	Pteridaceae	Terrestrial
19	*Aleuritopteris dealbata* (C. Presl) Fee	Pteridaceae	Terrestrial
20	*Aleuritopteris formosana* (Hayata) Tagawa	Pteridaceae	Terrestrial
21	*Aleuritopteris rufa* (D. Don) Ching	Pteridaceae	Lithophytes
22	*Coniogramme fraxinea* (D. Don) Fee	Pteridaceae	Terrestrial
23	*Onychium lucidum* (D. Don) Spreng	Pteridaceae	Terrestrial
24	*Onychium siliculosum* (Decv.) C. Chr.	Pteridaceae	Terrestrial
25	Pteris aspericaulis wall ex J. Agard	Pteridaceae	Terrestrial
26	*Pteris biaurita* L.	Pteridaceae	Terrestrial
27	*Pteris cretica* L.	Pteridaceae	Terrestrial
28	*Ptris vittata* L.	Pteridaceae	Terrestrial

29	*Pteris stenophylla* Wall. Ex Hook and Grev.	Pteridaceae	Terrestrial
30	*Pteris subquinata* Wall. ex. J. Agardh	Pteridaceae	Terrestrial
31	*Selaginella chrysorrhizos* Spring	Selaginellaceae	Terrestrial/ Lithophytes
32	*Selaginella fulcrata (Buch.-Ham. ex D. Don) Spring*	Selaginellaceae	Terrestrial
33	*Selaginella pallida* (Hook. & Grev.) Spring	Selaginellaceae	Terrestrial
34	*Selaginella subdiaphana* (Wall ex Hook. & arev. Spring)	Selaginellaceae	Terrestrial / Lithophytes
35	*Thelypteris arida* (D. Don) Fraser-Jenk.	Thelypteridaceae	Terrestrial
36	*Thelypteris dentata* (Forssk.) Kuhn	Thelypteridaceae	Terrestrial
37	*Thelypteris penangiana* (Hook) C. F. Reed	Thelypteridaceae	Terrestrial
38	*Thelypteris procera (D. Don) Fraser. Jenk.*	Thelypteridaceae	Terrestrial
39	*Thelypteris* sp	Thelypteridaceae	Terrestrial
40	*Antrophylum reticulatum* (G. Forst.) Kaulf	Vittariaceae	Epiphytic
41	*Athyrium cuspidatum* (Bedd.) M. Kato	Woodsiaceae	Terrestrial
42	*Diplazium spectabile* (wall. ex Mett.) Ching	Woodsiaceae	Terrestrial

Appendix VIII. Shows Frequency(F), Relative frequency(RF), Density(D), Relative Density(RD), Coverage(C), Relative Coverage(RC) and Importance value index of Pteridophytes species in Northern aspect

S.N.	**Name of species**	**Density (D)**	**R.D**	**Frequency (F)**	**R. F.**	**Coverage (C)**	**R.C.**	**IVI**
1	*Pteridium revolutum*	1.49	2.18	9.52	1.86	0.88	2.61	6.65
2	*Pteris stenophylla*	1.07	1.57	15.87	3.10	0.44	1.30	5.99
3	*Selaginella pallida*	6.98	10.20	41.26	8.07	2.15	6.34	24.63
4	*Pteris cretica*	0.39	0.58	4.76	0.93	0.19	0.56	2.07
5	*Athyrium cuspidatum*	0.11	0.16	1.58	0.31	6.34	18.67	19.14
6	*Thelypteris dentata*	5.98	8.74	30.15	5.90	4.39	12.93	27.57
7	*Dryopteris cochleata*	5.507	8.05	41.26	8.07	2.53	7.46	23.59
8	*Aleuritopteris bicolor*	4.49	6.56	39.68	7.76	1.41	4.15	18.48
9	*Tectaria coadunata*	0.809	1.18	33.33	6.52	0.33	0.98	8.68
10	*Selaginella fulcrata*	9.79	14.31	55.55	10.86	3.98	11.71	36.90
11	*Lepisorus nudus*	0.85	1.25	14.28	2.79	0.23	0.70	4.74

12	*Adiantum philippense*	2.190	3.20	22.22	4.34	0.57	1.68	9.23
13	*Pyrossia stenophylla*	2	2.92	14.28	2.79	0.39	1.16	6.88
14	*Aleuritopteris rufa*	0.19	0.27	3.17	0.62	0.079	0.23	1.13
15	*Pteris Subquinata*	1.88	2.76	17.46	3.41	0.66	1.96	8.13
16	*Coniogramme fraxinea*	0.206	0.30	1.58	0.31	0.095	0.28	0.89
17	*Selaginella chrysorrhizos*	5.01	7.33	20.63	4.03	1.57	4.62	15.99
18	*Ptris vittata*	2.98	4.36	28.57	5.59	1.39	4.10	14.06
19	*Thelypteris penangiana*	2.49	3.64	15.87	3.105	1.44	4.24	10.99
20	*Drynaria propinqua*	0.33	0.48	3.17	0.62	0.15	0.46	1.57
21	*Onychium lucidum*	0.22	0.32	1.58	0.31	0.095	0.28	0.91
22	*Adiantum incisum*	4.06	5.93	20.63	4.03	1.12	3.31	13.29
23	*Hypodematium crenatum*	0.55	0.81	6.34	1.24	0.15	0.46	2.52
24	*Thelypteris procera*	0.301	0.44	4.76	0.93	0.11	0.32	1.69
25	*Lygodium japonicum*	0.11	0.16	3.17	0.62	0.079	0.23	1.01
26	*Nephrolepis cordifolia*	0.873	1.27	3.17	0.62	0.42	1.26	3.15
27	*Microlepia speluncae*	0.44	0.64	3.17	0.62	0.15	0.46	1.73
28	*Aleuritopteris dealbata*	2.904	4.24	23.80	4.65	0.87	2.56	11.47
29	*Adiantum capillus-veneris*	1.61	2.36	9.52	1.86	0.53	1.58	5.81
30	*Equisetum ramosissimum*	1.06	1.55	4.76	0.93	0.507	1.49	3.98
31	*Microsorum cuspidatum*	0.34	0.51	3.17	0.62	0.14	0.42	1.55
32	*Pyrossia costata*	0.22	0.32	1.58	0.31	0.09	0.28	0.91
33	*Onychium siliculosum*	0.14	0.20	1.58	0.31	0.06	0.18	0.706
34	*Thelypteris* sp	0.444	0.64	4.76	0.93	0.19	0.56	2.14
35	*Pteris aspericaulis*	0.12	0.18	1.58	0.31	0.047	0.14	0.63
36	*Odontosoria chinensis*	0.15	0.23	3.17	0.62	0.06	0.18	1.03
	Total	68.41	100	511.11	100	34	100	300

Appendix IX. Shows Frequency (F), Relative frequency (RF), Density (D), Relative Density (RD), Coverage(C), Relative Coverage (RC) and Importance value index of pteridophytes speciesin in Southern aspect

S.N.	**Name of species**	**Density**	**R.D.**	**Frequency (F)**	**R. F.**	**A.C.**	**R.C.**	**IVI**
1	*Pteridium revolutum*	0.61	1.19	3.17	0.78	0.26	1.48	3.46
2	*Pteris biaurita*	0.46	0.89	4.76	1.17	0.20	1.13	3.203
3	*Pteris stenophylla*	0.095	0.18	1.58	0.39	0.03	0.17	0.75
4	*Selaginella pallida*	2.01	3.904	17.46	4.31	0.58	3.23	11.44
5	*Adiantum capillus- veneris*	0.28	0.55	1.58	0.39	0.079	0.43	1.38
6	*Aleuritopteris dealbata*	4.76	9.22	38.09	9.41	1.39	7.68	26.31
7	*Thelypteris dentata*	0.31	0.61	4.76	1.17	0.14	0.78	2.57
8	*Dryopteris cochleata*	4.31	8.36	49.20	12.15	1.57	8.64	29.16
9	*Aleuritopteris bicolor*	5.85	11.34	47.61	11.76	1.38	7.59	30.70
10	*Tectaria coadunata*	0.19	0.36	4.76	1.17	0.07	0.43	1.98
11	*Selaginella fulcrata*	14.58	28.25	77.77	19.21	5.82	32.05	79.51
12	*Lepisorus nudus*	0.30	0.58	4.76	1.17	0.09	0.52	2.28
13	*Adiantum philippense*	0.74	1.44	9.52	2.35	0.20	1.13	4.93
14	*Pyrossia stenophylla*	0.84	1.62	7.93	1.96	0.26	1.48	5.07
15	*Aleuritopteris rufa*	1	1.93	15.87	3.92	0.38	2.09	7.95
16	*Pteris Subquinata*	0.52	1.01	6.34	1.56	0.23	1.31	3.89
17	*Selaginella subdiaphana*	0.66	1.29	3.17	0.78	0.20	1.13	3.21
18	*Selaginella chrysorrhizos*	3.68	7.13	22.22	5.49	1.06	5.85	18.47
19	*Ptris vittata*	2.17	4.21	19.04	4.70	0.93	5.15	14.07
20	*Thelypteris penangiana*	0.74	1.44	4.76	1.17	0.26	1.48	4.10
21	*Drynaria propinqua*	0.85	1.66	4.76	1.17	0.38	2.09	4.93
22	*Thelypteris arida*	0.301	0.58	1.58	0.39	0.12	0.69	1.67
23	*Adiantum incisum*	2.98	5.77	19.04	4.705	0.92	5.06	15.55
24	*Hypodematium crenatum*	1.39	2.705	17.46	4.31	0.52	2.88	9.90
25	*Thelypteris procera.*	1.301	2.52	7.93	1.96	0.71	3.93	8.41
26	*Lygodium japonicum*	0.301	0.58	4.76	1.17	0.14	0.78	2.54
27	*Nephrolepis cordifolia*	0.23	0.46	3.17	0.78	0.09	0.52	1.76
28	*Microlepia speluncae*	0.06	0.12	1.58	0.39	0.03	0.17	0.68
Total		51.63	100	404.76	100	18.17	100	300

Appendix X. Bonferroni Post Hoc test of Pteridophytes species richness of Northern aspect

(I) Altitude	(J) Altitude	Mean Difference (I-J)	Std. Error	P-value
1.00	2.00	1.00	.679	1.00
	3.00	1.85	.679	.30
	4.00	1.71	.679	.524
	5.00	1.28	.679	1.00
	6.00	.71	.679	1.00
	7.00	2.28	.679	.051
	8.00	2.71*	.679	.007
	9.00	4.14*	.679	.00
2.00	1.00	-1.00	.679	1.00
	3.00	.857	.679	1.00
	4.00	.714	.679	1.00
	5.00	.285	.679	1.00
	6.00	-.285	.679	1.00
	7.00	1.28	.679	1.00
	8.00	1.71	.679	.524
	9.00	3.14*	.679	.001
3.00	1.00	-1.85	.679	.303
	2.00	-.857	.679	1.00
	4.00	-.142	.679	1.00
	5.00	-.57	.679	1.00
	6.00	-1.14	.679	1.00
	7.00	.428	.679	1.00
	8.00	.857	.679	1.00
	9.00	2.28	.679	.051
4.00	1.00	-1.71	.679	.524
	2.00	-.714	.679	1.00
	3.00	.142	.679	1.00
	5.00	-.428	.679	1.00
	6.00	-1.00	.679	1.00
	7.00	.571	.679	1.00
	8.00	1.00	.679	1.00
	9.00	2.42*	.679	.027
5.00	1.00	-1.28	.679	1.00

	2.00	-.28	.679	1.00
	3.00	.571	.679	1.00
	4.00	.428	.679	1.00
	6.00	-.571	.679	1.00
	7.00	1.00	.679	1.00
	8.00	1.42	.679	1.00
	9.00	2.85*	.679	.004
6.00	1.00	-.71	.679	1.00
	2.00	.285	.679	1.00
	3.00	1.14	.679	1.00
	4.00	1.00	.679	1.00
	5.00	.57	.679	1.00
	7.00	1.57	.679	.882
	8.00	2.00	.679	.171
	9.00	3.42*	.679	.00
7.00	1.00	-2.28	.679	.051
	2.00	-1.28	.679	1.00
	3.00	-.428	.679	1.00
	4.00	-.571	.67	1.00
	5.00	-1.00	.679	1.00
	6.00	-1.57	.679	.882
	8.00	.428	.679	1.00
	9.00	1.85	.679	.303
8.00	1.00	-2.71*	.679	.007
	2.00	-1.71	.679	.524
	3.00	-.85	.679	1.00
	4.00	-1.00	.679	1.00
	5.00	-1.42	.679	1.00
	6.00	-2.00	.679	.171
	7.00	-.42	.679	1.00
	9.00	1.42	.679	1.00
9.00	1.00	-4.14*	.679	.000
	2.00	-3.14*	.679	.001
	3.00	-2.28	.679	.051
	4.00	-2.42*	.679	.027
	5.00	-2.85*	.679	.004
	6.00	-3.42*	.679	.000

	7.00	-1.85	.679	.303
	8.00	-1.42	.679	1.00

*. The mean difference is significant at the 0.05 level. (Where 1=800m, 2=900m, 3=1000m,4=1100m, 5=1200m, 6=1300m, 7=1400m, 8=1500m, 9=1600m)

Appendix XI. Bonferroni Post Hoc test of Pteridophytes species richness of southern aspect

(I) altitude	(J) altitude	Mean Difference (I-J)	Std. Error	P-value
1.00	2.00	1.28	.670	1.00
	3.00	2.28*	.670	.044
	4.00	2.42*	.670	.023
	5.00	.714	.670	1.00
	6.00	3.14*	.670	.001
	7.00	2.87*	.670	.003
	8.00	3.14*	.670	.001
	9.00	4.00*	.670	.000
2.00	1.00	-1.28	.670	1.00
	3.00	1.00	.670	1.00
	4.00	1.14	.670	1.00
	5.00	-.57	.670	1.00
	6.00	1.85	.670	.275
	7.00	1.57	.670	.818
	8.00	1.85	.670	.275
	9.00	2.71*	.670	.006
3.00	1.00	-2.28*	.670	.044
	2.00	-1.00	.670	1.00
	4.00	.142	.670	1.00
	5.00	-1.57	.670	.818
	6.00	.857	.670	1.00
	7.00	.571	.670	1.00
	8.00	.857	.670	1.00

	9.00	1.71	.670	.481
4.00	1.00	-2.42*	.670	.023
	2.00	-1.14	.670	1.00
	3.00	-.142	.670	1.00
	5.00	-1.71	.670	.481
	6.00	.714	.670	1.00
	7.00	.428	.670	1.00
	8.00	.714	.670	1.00
	9.00	1.57	.670	.818
5.00	1.00	-.71	.670	1.00
	2.00	.571	.670	1.00
	3.00	1.57	.670	.818
	4.00	1.71	.670	.481
	6.00	2.42*	.670	.023
	7.00	2.14	.670	.083
	8.00	2.42*	.670	.023
	9.00	3.28*	.670	.00
6.00	1.00	-3.14*	.670	.001
	2.00	-1.85	.670	.275
	3.00	-.86	.670	1.00
	4.00	-.714	.670	1.00
	5.00	-2.43*	.670	.023
	7.00	-.28	.670	1.00
	8.00	.00	.6700	1.00
	9.00	.857	.670	1.00
7.00	1.00	-2.86*	.670	.003
	2.00	-1.57	.670	.818
	3.00	-.57	.670	1.00
	4.00	-.428	.670	1.00
	5.00	-2.14	.670	.083
	6.00	.286	.670	1.00
	8.00	.286	.670	1.00
	9.00	1.14	.670	1.00
8.00	1.00	-3.14*	.670	.001
	2.00	-1.86	.670	.275
	3.00	-.857	.670	1.00
	4.00	-.714	.670	1.00

	5.00	-2.42*	.670	.023
	6.00	.000	.670	1.00
	7.00	-.28	.670	1.00
	9.00	.857	.670	1.00
9.00	1.00	-4.00*	.670	.00
	2.00	-2.71*	.670	.00
	3.00	-1.71	.670	.48
	4.00	-1.57	.670	.81
	5.00	-3.28*	.670	.00
	6.00	-.85	.670	1.00
	7.00	-1.14	.670	1.00
	8.00	-.857	.670	1.00

* The mean difference is significant at the 0.05 level (Where 1=800m, 2=900m, 3=1000m,4=1100m, 5=1200m, 6=1300m, 7=1400m, 8=1500m, 9=1600m.

PHOTOPLATES

Microsorum cuspidatum

Aleuritopteris dealbata

Onychium lucidum

Lygodium japonicum

Coniogramme fraxinea

Pteris subquinata

Selaginella fulcrata

Selaginella subdiaphana

Adiantum incisum

Hypodematium crenatum

Equisetum ramosissimum

Antrophylum reticulatum

Pteris cretica

Odontosoria chinensis

Drynaria propinqua

Lepisorus nudus

Thelypteris penangiana

Pteridium revolutum

Dryopteris cochleata

Thelypteris arida

Athyrium cuspidatum

Tectaria coadunata

Pteridophytes collection

Interviewing with local peoples