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Altitudinal Pattern of Pteridophyte in Arghakhanchi district, West Nepal

Babu Ram Nepali[1,2 *], John Skartveit[3] and Chitra Bahadur Baniya[1]
[1] Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal
[2]Butwal Multiple Campus, Tribhuvan University, Butwal, Nepal
[3]University College, NLA, Bergen, Norway
[*]Email: *nepalibaburam7@gmail.com*

Abstract

Pteridophyte species richness pattern was carried out in Arghakhanchi district, West Nepal during October-November, 2018 and 2019. Main objectives of this study were to document the floristic composition of pteridophyte and to access the species richness pattern along altitude, temperature, rainfall and area per 100 m contour elevation. The pteridophyte species were recorded and collected after utilizing systematic random sampling strategies in each forest types into 10 x 10 m^2 area each 100 m altitudinal band from the bottom to the top of the mountain (240-2300 m asl). Herbarium of each collected pteridophyte sample present inside plots and along the track was identified with the help of the published literature and deposited in the TUTH. The pteridophyte species richness was plotted against altitude, interpolated temperature, rainfall and area per 100 m contour elevation through application of the Generalized Linear Model (GLM). The species environment relation was observed by application of CCA. A total of 75 pteridophyte species belonging to 18 families and 36 genera were reported among which Pteridaceae with 5 genera and 21 species was the richest family and *Thelypteris* with 9 species was the richest genera. Among those species 39 species were terrestrial followed by 12 species of lithophytes and 11 epiphytes. The pteridophyte richness showed statistically significant unimodal relationship with altitude and temperature (R^2 = 0.95 and $p < 0.001$).Most of the fern species were present at moist places of *Schima-Castonopsis-Quercus* forest above than 1500 m.

Keywords: Contour, Elevation, Habitat, Pteridaceae, Species richness,Unimodal

Introduction

Pteridophyte is a beautiful gift of nature which provides magnificent beauties without flowers. They form an attractive component of the vegetation of hills and forests (Gurung, 1991). They live in habitats from the tropics to polar latitudes unlike seeded plants; they reproduce by minute spores (Moran, 2004). The popular Nepalese local slogan "Unyu phulnu ra dhunga rasaunu ekai ho" says that ferns have neither seeds nor flowers but can reproduce offspring. They complete their life-cycle in two generations: sporophyte and gametophyte. Pteridophyte is a unique group of plant with two phases independent life cycle: gametophyte and sporophyte.

Pteridophytes are the earliest vascular plants originated during the Silurian period (400 million years ago) of Paleozoic Era and formed the dominant during Devonian to Permian period (Khare, 1996). They are the most diverse group and the oldest lineage of vascular plant and the second most species after angiosperms with an estimate of 12,000 species in the world (Vidyashree, 2018). Most of them are abundantly found in humid and shady forests area. Nowadays, pteridophyte found grows in different ecological habits thus classified as epiphyte, lithophytes, terrestrial, tree ferns, climbers and hydrophytes (Gurung 1984; Gurung, 1991; Moran, 2004), but some species occur in more than one habitat. Most of them are annual and some are perennial, but some are climbers, creepers and small tree (*Cyathea spinulosa*). They rarely form pure vegetation but form understory inside the forest. Pteridophyte foliage is highly considered as economically valuable in decoration, food, medicine, biofertilizer, ornamental and reclamation of contaminated soil (Vidyashree, 2018). Being very sensitive to direct sunlight, epiphytic ferns could be used as indicators of forest disturbances (Edward et al., 2003) andhave wide range of habitat preferences (Nagalingum & Cantrill, 2015).

Nepal has a rich and diversified bioresources due to varied topographical and climatic regions. The studies on species richness patterns of Medicinal plants (Acharya et al., 2010), orchids (Acharya et al., 2011), higher plants (Bhattarai & Vetaas, 2003), ferns (Bhattarai et al., 2004), bryophytes (Grau et al., 2007) in Nepal's mountains show unimodal pattern with variation in peak. Many studies in ferns (Bhattarai & Vetaas, 2003; Watkie et al., 2006; Nagalingum & Cantrill , 2015; Jeyalatchayan et al., 2020) showed that unimodal is common pattern of fern species against altitude. In many cases, area accounts the large percentage of variation than altitude (Xiang et al., 2017). The environmental gradient drives pattern of fern species richness on the spatial scale (Watkin et al., 2006). Climate is one of the strongest predictors for diversity of species and their richness, especially for epiphytic species (Zhang et al., 2015).

The Department of Plant Resources (DPR), Nepal (2002) reported 534 species of pteridophyte species in Nepal. Fraser-Jenkins et al. (2015) reported 580 species of pteridophyte in Nepal. These reports only generalized the number of pteridophyte species present in the whole country after enumeration. No direct ecological study has been taken yet so far focusing on the definite landscape. Arghakhanchi, one of the middle mountains in Nepal, lies in the borderline between tropical and subtropical ecological zones as well as beginning of west Nepal has been considered as important place to this study. The main objectives of this paper were documentation of pteridophyte species present in Arghakhanchi district and find out the pteridophyte species richness pattern along altitude temperature, rainfall and area per 100 m contour elevation.

Materials and Methods

Physiography and vegetation of the study area

Arghakhanchi, one of beautiful hilly districts, is located in providence no. 5, West Nepal. Arghakhanchi occupies an area of 1193 km^2 and extended between 27º45' to 28º06' N and 80º45' to 83º23' E (Figure 1). The population of this district was 197,632 (Central Bureau of Statistics [CBS], 2012). Other neighboring districts are Palpa in the east, Gulmi in the north, Kapilbastu and Rupandehi in the south and Pyuthan and Dang are in the west. About 68% land of this whole district lies within the Mahabharata range and remaining are in the Siwalik Hills. The elevation of this district ranges from 240 to 2515 masl (Alternative energy promotion center, [AEPC], 2016).

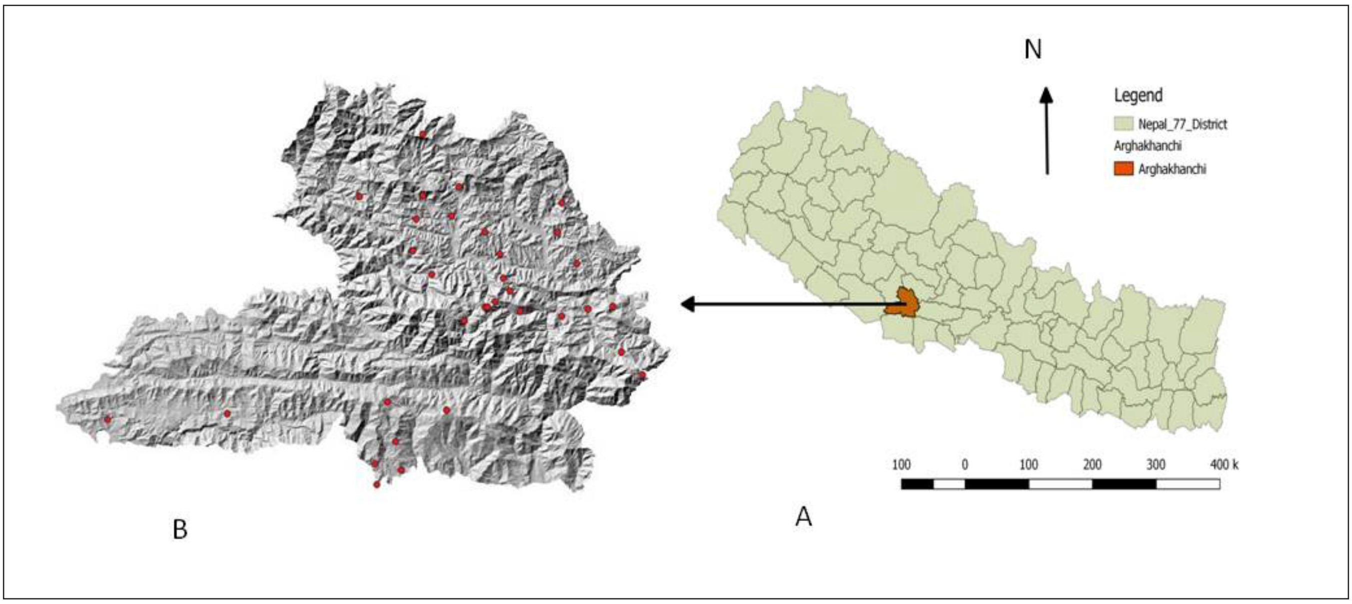

Figure 1: A. Arghakhanchi district in Nepal, B. Botanically explored sites (Drawn by using QGIS)

Physiographically, this district has four zones: lower tropical (less than 300 m asl) which covers 0.2%, upper tropical (300-1000 m asl) coves 51%, subtropical (1000-2000 m asl) which covers 49% and temperate zone (2000-3000 m asl) of 0.2% (CBS, 2012).The maximum and minimum average mean temperatures ranged between 25-27°C and 5-7°C respectively between May-July and January (Department of Hydrology and Meteorology [DHM, 2017). The average annual rainfall of this district remains around 1750 mm (CBS, 2012). Arghakhanchi district lies in the moderate temperate climatic zone of the country.

In Arghakhanchi, about 40 % of the total land is covered by the forest. Lowland (below 500 m asl) towards south consists of lower tropical *Shorea robusta* forest. Churia Sal forest lies between 500-1000 m asl and Inner hill Sal forest (up to 900 m). Northern slope of this district lies in the Mahabharat range (1000-1500 m) with the broad leaved forest intermixed with *Pinus* species. Between 1500-2000 masl, *Rhododendron arboreum, Schima wallichii, Pinus roxburghii, Myrica esculenta,* containing forest are present. The uppermost region (above 2000 m) in this district bear *Rhododendron-Quercus-Maesa* mixed forest with bushes (Panthi & Chaudhary, 2002).

Sampling design and primary data collection

The Arghakhanchi district is mainly occupied by two landscapes(Narapani-Masina landscape, 200-2200 m and Malarani-Gokhunga landscape, 700-2300 m) which are extended from East to West. The overall altitude range of this district was divided equally by 100 elevation band. The field was visited and sampled twice in the post-monsoon (October and November) of 2018 and 2019. 3-4 Sampling plot of 10 x 10 m^2 was placed at each altitudinal band of both aspects (north and south) focusing at the forest type. The distance between two sample plots varied from 100 to 150 m distance.

All pteridophyte species enrooted inside each plot was recorded and one sample of each species was collected. Photograph of each pteridophyte sample was taken. The coordinate of each plot location was also measured through GPS (*eTrex*). The pteridophyte species present outside the plots and along the track were also collected and their habitats and coordinate were also noted.

Herbarium of each properly dried and specimens were prepared in the laboratory. GPS data and other micro-ecological characters were also recorded to each herbarium specimen. All herbarium specimens were identified with the help of relevant taxonomic literature such as Gurung, 1984 & 1991; Fraser-Jenkins et al., 2015; Rajbhandary, 2016; Fraser-Jenkins & Kandel, 2019. Some species were also identified with the help of consulting experts and comparing with specimens deposited at National Herbarium and Plant Laboratories (KATH) and Tribhuvan University Central Herbarium (TUCH). All these identified herbarium were submitted in the TUCH. After identification, the altitudinal range of each species was determined on the basis of their maximum and minimum altitude.

Altitudinal area and climatic variables calculation

Species numbers tend to increase as the area increase (Rahbek, 1997), but area per 100 contour elevation does not contain equal areas due to complex pyramidal and topography of Himalayas along the elevational gradient. So, the area occupied per 100 m contour elevation of Arghakhanchi district was calculated by using Digital Elevational Model (DEM) in QGIS. Similarly, physiographic and climatic information obtained from the Department of Hydrology and Meteorology and their periodical publications such as Ministry of Agriculture and Co-operatives [MoAC], (2011),DHM (2017).The climatic variables used in this study are mean annual average temperature (AMT) and mean annual Total rainfall (MAR). The climatic records 20 years (1994-2013) of 11 stations of Arghakhanchi and surrounding districts were collected. The temperature was interpolated in 100 m counter elevation by linear regression ($r^2 = 0.99$; $p \leq 0.001$) at lapse rate of 0.5°C/100 m for mean annual temperature (AMT). Rainfall is not a simple linear function of elevation, and therefore a cubic smooth spline in Generalized Additive Model (Hastie & Tibshirami, 1990) was used with 4 degrees of freedom to estimate total annual rainfall in each 100 m counter elevation.

Statistical analysis

The patterns related to pteridophyte species as response and their altitudes, area per 100 m contour elevation, temperature and rainfall as predictor variables were analyzed after underlying the principal of Generalized Linear Model (GLM) in R 3.6.2 (R Core Team, 2019). The quasi-poisson family of error distribution was applied to remove over dispersion as Baniya et al. (2010). The assumption of normal distribution of error was conformed after Q-Q diagnostic plots plotted against residuals. The change in deviance follows the F-distribution. Canonical Correspondence Analysis (CCA) used to analyze species environmental composition (Kent & Carmel, 2011).

Results and Discussion

Pteridophyte diversity in Arghakhanchi district

A total of 75 species of pteridophytes belonging to 18 families and 36 genera were found in Arghakhanchi district. The largest families were: Pteridaceae (6 genera with 22 species), Polypodiaceae (8 genera with 11 species) (Figure 2).

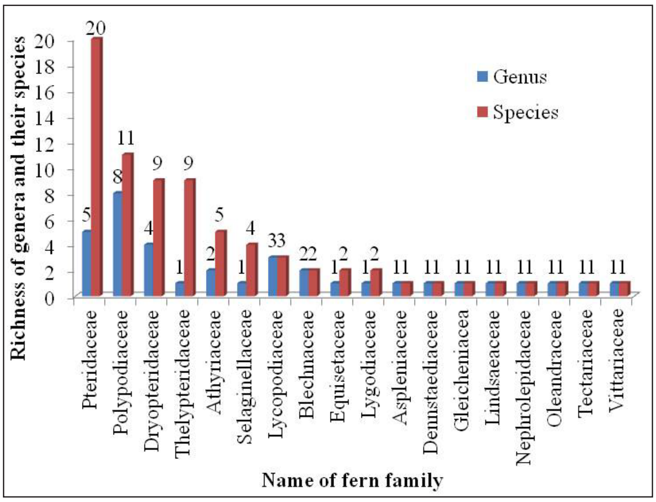

Figure 2: Richness of family wise genera and species of fern

There were 8 monogeneric (having single genus and single species) families: Aspleniaceae (*Asplenium ensiforme,)* Dennstaediaceae (*Pteridium revolutum*), Gleicheniaceae (*Dicranopteris lanigera)*, Lindsaeaceae (*Odontosoria chinensis*), Nephrolepidaceae (*Nephrolepis cordifolia*), Oleandraceae (*Oleandra wallichii*), Tectariaceae (*Tectaria gemmifera*), Vittariaceae (*Vittaria linearifolia* Ching) (Table 1). The largest species bearing genera were: *Thelypteris* (9 species), *Aleuritopteris* (6 species) and *Pteris* (5 species) (Table 1).

Pteridophyte distribution according to habitats

Pteridophyte of Arghakhanchi was found distributed into three broad habitats: terrestrial, epiphytes and lithophytes. This study found 39 terrestrial species followed 12 species of lithophytes and 11 species of epiphytes (Figure 3). The epiphytic species *Asplenium ensiforme*, *Lepisorus loriformis*, *Pyrrosia flocculosa*, *Pyrrosia porosa* were found above than 1500 m asl. The species of *Adiantum*, *Aleuritopteris Pteris, Thelypteris* were distributed at all types of forest from low to high altitude (Table 1). 47 species (63%) were present in moist places of *Schima-Castonopsis-Quercus* forests.

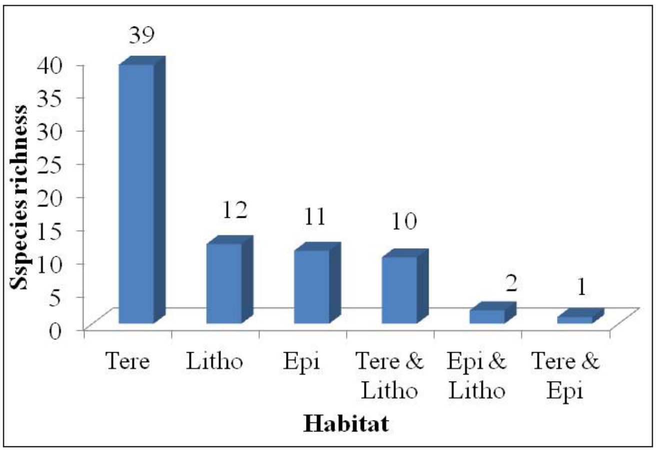

Figure 3: Pteridophyte species richness on the basis of habitat (Tere-Terestrial, Litho-Lithophyte & Epi-Epiphytes)

Species richness pattern and species environment relation

The pteridophyte species richness showed statistically highly significant unimodal richness pattern against both altitude and area per 100 m contour elevation in Arghakhanchi district (Figure 4 A and B). The pteridophyte species richness was found maximum spp. 66 at 1300 m asl and then declining ($R^2 = 0.95$ & $p < 0.001$, Figure 4A). Similarly, species richness was found statistically unimodal pattern with area per 100 m asl contour elevation with the peak at 800 m (maximum species = 46&$R^2 = 0.28$; Figure 3B). The species richness also showed the unimodal structure against temperature ($R = 0.95$, $p < 0.001$) and rainfall ($R^2 = 0.42$; $p < 0.001$).

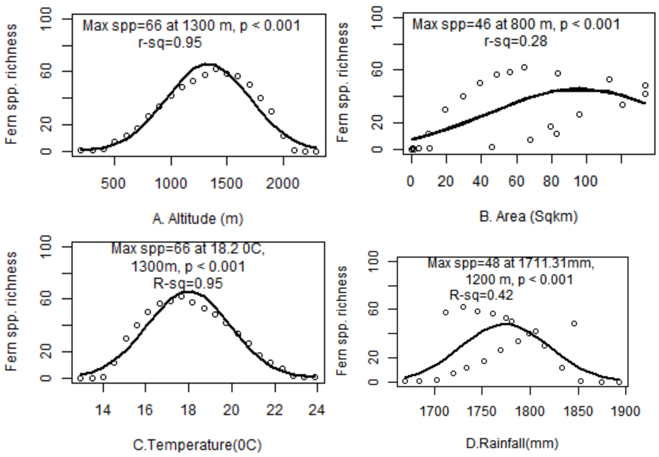

Figure 4: Scatter plots of the relationships between Pteridophyte species richness and (A) altitude & (B) area per 100 m contour elevation and (C) temperature & (D) rainfall which shows the second order polynomial fitting curves generated using *GLM* model.

The temperature and area showed the negative relation with altitude (Figure 4), but rainfall did not show any particular relation. The *Dicranopteris lanigera*, *Thelypteris glanduligera*, *Athyrium pectinatum*, *Polystichum discretum*, *Equisetum ramosissimum*, *Selaginella subdiaphana*, *Adiantum philippense*, *Lygodium japonicum* etc. were present dominant condition in Sal forest at low elevation. The species *Adiantum venustum*, *Asplenium ensiforme*, *Dryopteris chrysocoma*, *Lepisorus loriformis*, *Lepisorus scolopendrium*, *Polypodiodes lachnopus*, *Onychium lucidum*, *Pteris wallichiana*, *Vittaria linearifolia*, *Pyrrosia flocculosa*, *Woodwardia unigemmata* etc were present at moist places of *Schima-Castonopsi*, *Schima-Querscus*and *Schima-Diploknema* forests at high altitude (Figure 5 & Table 1).

The result shows that Arghakhanchi is rich in pteridophyte diversity due to presence of about 13% of total pteridophyte species of Nepal. Pteridaceae

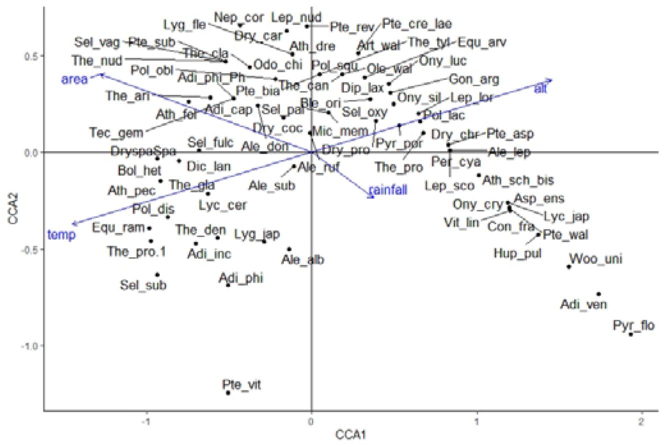

Figure 5: CCA biplot showing relationship among species and environment variables

is the richest family and Polypodiceae lies in second position. Polypodiaceae (polypod ferns) with 4,080 species is the largest family of ferns in world (State of the World Plant [SOTWP], 2017). There are of 8 monogeneric families and 23 genera consist of single species. This fact also indicates the variation in fern diversity.

Most of the fern species are terrestrial which are followed by lithophytes and epiphytes. The Presence of more terrestrial species indicates the favorable condition on land for fern diversity in this area. The species *Oleandra wallichii*, *Drynaria propinqua*, *Lepisorus loriformis*, *Lepisorus nudus* etc. are inhabiting on the bark of perennial trees as *Schima-Castanopsis*, *Castonopsis-Quercus forest of* areas above than 1500 m asl. The presence of more epiphytic specieson higher altitude possibly occurs due to increasing environmental humidity (Acebey et al., 2017). Shrestha & Rajbhandary (2019) also found the most of the epiphytic species on barks of *Quercus*, *Acer* & *Betula* species. The epiphytic ferns cannot survive as the forest become more and more open (Edward et al., 2003), or they lie mainly on ecologically undisturbed forest. Presence of epiphytic fern indicates that some forest of this area provides suitable place for epiphytic ferns.

The fern species shows dome shaped pattern against altitude, area and interpolated temperature and rainfall. Lili et al. (2014) found the hump shaped pattern of fern against altitude, area, mean annual temperature and mean annual precipitation. Bhattarai et al. (2004) also reported unimodal pattern of fern species against altitude in central Nepal with maximum species at 2000 m. The richness of terrestrial fern species exposes the mid elevation maximum (Watkin et al., 2006).The species richness plotted the peak value at 1300 m against altitudeand sharply decreased onwards in this study. This decreased altitude of highest modeled species richness than Bhattarai et al. (2004) may be the matter of scale and hard boundary effect due to low altitudinal range of species or narrow distribution. The random placement of range of species increases the overlap of species towards middle of geographical domain and results hump shaped (Colwell & Lees, 2000). This shows that species richness generally increases with increase of elevation and decrease of temperature and fitness of unimodal pattern of fern species looks stronger with altitude and temperature ($R^2 = 0.95$) than area and rainfall.

Rainfall does not show clear relation with temperature and altitude, but temperature showed opposite relation with altitude. However, these parameters showed effect in distribution pattern of species. No single variables can explain for distribution of plants (McCain & Grytnes, 2010). Altitude determines the climatic condition of any place and is main controlling factor of altitudinal species richness than others Li & Feng, 2015.The actual mechanism controlling the patterns lies in a combination of factors related to biology, the environment and geometric constrains on geographical range (Watkins et al., 2006).The area size can also significantly affect relationship between species richness and elevation and covers the effects of other predictors (Xiang & Hua-yong, 2017). Generally, area decreases with the increase of altitude in the Himalaya region.The increasing area per elevation band up to mid altitudinal range may be played main role to develop the unimodal pattern of species richness.

According to Acebey et al. (2017) the understory is a very important habitat for epiphytic ferns and others depending on the elevational zone. The different microhabitats in the forest understory determine the high diversity of epiphytes (Kromeret al., 2007).The number of epiphytes found in dense and moist forests is comparatively higher than those found on trees in open and dry areas (Rajbhandary, 2016). The species like *Adiantum venustum, Asplenium ensiforme, Dryopteris chrysocoma, Lepisorus loriformis, Lepisorus scolopendrium, Polypodiodes lachnopus, Onychium lucidum, Woodwardia unigemmata* etc. are restricted at Schima-Castonopsis- Quercus forest above than 1500m which covers about 25% of total species.

The study shows that most of the fern species are moist loving and present at north aspect of hills.

Conclusion

On the floristic study of Pteridophyte, 75 species belonging to 18 families and 36 genera were found in Arghakhanchi**.** Peridaceae consisting of 5 genera and 21 species was found the richest family. Most of the species (39) were located as terrestrial. The species richness showed the statistically significant unimodal pattern against altitude and temperature. Most of the fern species were present at moist places of *Schima-Castonopsis-Quercus* forest above than 1500 m. The further detail systematic study of plants including pteridophyte and their ecological status in this district is necessary.

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Table 1: Name list of Pteridophyte found in Arghakhanchi district

S.N.	Family	Name of species	Habitat	Altitude Range	*Location (® Type of Forest, Altitude)
1	Aspleniaceae	*Asplenium ensiforme* Wall. ex Hook. & Grev.	Epi	1600-1900	Ml(SQ.1610),Go(CS,1890)
2	Athyriaceae	*Athyrium drepanopterum* (Kunze) A. Braun ex Milde	Tere	1000-1700	Bh(SP,1520), Da(PS,1010), Ka(SC,1680)
3	Athyriaceae	*Athyrium foliolosum* T.Moore ex R.Sim	Tere	800-1400	Bh(SP,820),Sa(SP,1400)
4	Athyriaceae	*Athyrium pectinatum* (Wall ex Mett.) T. Moore	Tere	600-1300	Ba(S,620),Th(S,1320);Ra(S,1100)
5	Athyriaceae	*Athyrium schimperi* Moug.ex Fee subsp biserrulatum (Christ)	Tere	1500-1900	Se(SC,1915), Dh(SC,1510)
6	Athyriaceae	*Diplazium laxifrons* Rosenst.	Tere	1100-1900	Ml(SQ,1880); Ro(CS,1090)
7	Blechnaceae	*Blechnum orientale* L.	Tere	1100-1700	Dn(SC,1110), Se(SC,1685)
8	Blechnaceae	*Woodwardia unigemmata* (Makino) Nakai	Tere	1700-2000	Ml(SQ,1730;1990)
9	Dennstaediaceae	*Pteridium revolutum* (Blume) Nakai	Tere	1200-1600	Ml(SQ,1610),Sa(CS,1220)
10	Dryopteridaceae	*Bolbitis heteroclita* (C. Presl) Ching	Tere&Litho	800-1200	Hi(S,820), Ra(S,1190)
11	Dryopteridaceae	*Dryopteris carolihopei* Frasser-Jenk	Tere	1100-1600	La(CS,1080), Gl(CS,1380), Dn(SC,1580)
12	Dryopteridaceae	*Dryopteris chrysocoma* (Christ) C. Chr.	Tere	1300-2000	Se(SC,1985),Sa(CS,1310)
13	Dryopteridaceae	*Dryopteris cochleata* (D. Don) C. Chr.	Tere&Litho	800-1800	Ny(S,820), Ka(SC,1770)
14	Dryopteridaceae	*Dryopteris sparsa* (D.Don) Kuntze subsp. Sparsa	Tere	700-1400	Sa(SC,1410), Bh(SP,1120),Ra(S,710)
15	Dryopteridaceae	*Peranema cyatheoides* D.Don	Tere	1400-1900	Poudi khola(PS,1425), Ga(SQ,1910)
16	Dryopteridaceae	*Polystichum discretum* (D.Don) Sm	Tere	600-1400	Gl(CS,1390),Do(S,610),
17	Dryopteridaceae	*Polystichum obliquum* (D. Don) T. Moore	Tere	900-1700	Ro(CS,910),Ha(CS,1120), Kh(RS,1690)
18	Dryopteridaceae	*Polystichum squarrosum* (D. Don) Fée	Tere&Litho	1000-1800	Kh(RS,1780),Sa(SC,1340),Bh(SP,1020)
19	Equisetaceae	*Equisetum arvense* L.	Tere	1200-1800	Na(SQ,1810), Po(PS,1225)
20	Equisetaceae	*Equisetum ramosissimum* Desf.	Tere	700-1200	Kc(W,885), Bh(SP,1120), Du(W,720)
21	Gleicheniacea	*Dicranopteris lanigera* Fraser-Jenk.	Tere	700-1400	Th(S,1380), Pk(810),Si(690)
22	Lindsaeaceae	*Odontosoria chinensis* (L.) J. Sm.	Tere	900-1600	Bh(SP,930),Da(SP,1595)
23	Lycopodiaceae	*Huperzia pulcherrima* (Wall. ex Hook. & Grev.) T. Sen & U. Sen	Epi	1600-2000	Kh(RS,1630), Ms(SC,2020)
24	Lycopodiaceae	*Lycopodiella cernua* (L.) Pic. Serm.	Tere& Lit	600-1600	Si(SC,625), Na(PS,1582)
25	Lycopodiaceae	*Lycopodium japonicum* Thunb.	Tere	1600-1850	Ka(SC,1590; 1780)
26	Lygodiaceae	*Lygodium flexuosum* (L.) Sw.	Tere	1000-1700	Am(S,960),Bh(SP,1650)
27	Lygodiaceae	*Lygodium japonicum* (Thunb.) Sw.	Tere& Lit	500-1900	Do(S,520), Am(S,950),Wa(S,1340),Ag(PS,1890)
28	Nephrolepidaceae	*Nephrolepis cordifolia* (L.) C. Presl	Tere	1000-1500	Ny(SC,1115), Ma(SC,M,1300),Gl(CS,1480)
29	Oleandraceae	*Oleandra wallichii* (Hook.) C. Presl	Epi	1100-1800	Se(SC,1785), Gl(CS,1120), Ml(SQ,1685)
30	Polypodiaceae	*Arthromeris wallichiana* (Spreng.)Ching	Epi	1300-1700	Ma(SS,1310), Ka(SC,1680)
31	Polypodiaceae	*Drynaria propinqua* (Wall. ex Mett.) Bedd.	Epi	1000-2000	Se(SC,1985), De(SC,1550), Dd(CS,1020)
32	Polypodiaceae	*Goniophlebium argutum* (Wall. ex Hook.) J. Sm. ex Hook.	Epi	1400-1700	Ja(P,1420), Ml(SQ,1710)
33	Polypodiaceae	*Lepisorus loriformis* (Wall. ex Mett.) Ching	Epi	1300-1900	Bh(SP,1290), Al(SC,1520),Na(SC,1880)
34	Polypodiaceae	*Lepisorus nudus* (Hook.) Ching	Epi & Lit	1200-1600	Dn(SC,1800), Dh(SC,1620),Da(SP,1220)
35	Polypodiaceae	*Lepisorus scolopendrium* Mehra& Bir	Epi	1400-1900	Bh(SP,1380),Se(SC,1910)
36	Polypodiaceae	*Microsorum membranaceum* (D. Don) Ching	Tere& Epi	900-1900	Rosa(CS,910),Se(SC,1890), Gl(CS,1498)
38	Polypodiaceae	*Pyrrosia flocculosa* (D. Don) Ching	Epi	1600-2000	Ml(SQ,1610; 2010)
39	Polypodiaceae	*Pyrrosia porosa* (C. Presl) Hovenkamp	Epi	1100-1900	Ka(SC,1780), Dd(CS,1120)
40	Polypodiaceae	*Selliguea oxyloba* (Wall. ex Kunze) Fraser-Jenk.	Epi	1000-2000	Ms(B,1950); Na(PS,1620); Da(CS,980)
41	Pteridaceae	*Adiantum capillus* veneris L.	Lit	800-1700	Bh(SP,780), Da(SC,1680)

42	Pteridaceae	*Adiantum incisum* Forssk.	Lit	500-1600	Am(S,1050), Ra(S,520), Na(SC,1610)
43	Pteridaceae	*Adiantum philippense* L.	Lit	400-1800	Do(S,390),Am(S,990),Na(SQ,1790), Ha(CS,1220)
44	Pteridaceae	*Adiantum philippense* L.subsp. philippense	Lit	800-1600	Bh(SP,810), Na(SC,1580)
45	Pteridaceae	*Adiantum venustum* D.Don	Lit	1700-2100	Ml(SQ,1710;2080)
46	Pteridaceae	*Aleuritopteris albomarginata* C.B. Clarke	Lit	500-2000	Do(S,480);Ar(PS,1770), Gl(CS,1190),Go(SQ,1970)
47	Pteridaceae	*Aleuritopteris doniana* S.K. Wu	Lit	800-1700	La(CS,815), Sa(SC,1450),Di(PS,1705)
48	Pteridaceae	*Aleuritopteris leptolepis* (Fraser-Jenk.) Fraser-Jenk.	Lit	1400-1900	Se(SC,1880), Gl(CS,1415)
49	Pteridaceae	*Aleuritopteris rufa* (D. Don) Ching	Lit	800-1900	Se(SC,1880), Ar(PS,1710),La(CS,790)
50	Pteridaceae	*Aleuritopteris subdimorpha* (C.B. Clarke & Baker) Fraser-Jenk.	Lit	700-1900	Se(SC,1890), Gl(CS,1415), Ha(CS,900),Ba(S,710)
51	Pteridaceae	*Coniogramme fraxinea* (D.Don) Fee ex Diels	Tere	1700-1900	Ml(SQ,1690;1910)
52	Pteridaceae	*Onychium cryptogrammoides* Christ	Tere	1500-2000	Se(SQ,1920), Da(PS,1520)
53	Pteridaceae	*Onychium lucidum* (D. Don) Spreng.	Tere	1300-1800	Se(SC,1780),De(SC,1305)
54	Pteridaceae	*Onychium siliculosum* (Desv.) C. Chr.	Tere& Lit	1200-1900	Bh(S,885), Ml(SQ,1780), Se(SC,1880)
55	Pteridaceae	*Pteris aspericaulis* Wall. ex J. Agardh	Tere	1300-2000	Ms(B,2020), Na(SC,1710) , Bh(SP,1320)
56	Pteridaceae	*Pteris biaurita* L.	Tere& Lit	1000-1800	Se(SC,1780),Am(S,980)
57	Pteridaceae	*Pteris cretica* var. laeta (Wall. ex Ettingsh.) C. Chr. & Tardieu	Tere	1300-1700	Bh(SP,1320),Na(SC,1680)
58	Pteridaceae	*Pteris subquinata* Wall. ex J. Agardh	Tere	900-1500	Th(S,1240), Pk(CS,840), Sa(SC,1480)
59	Pteridaceae	*Pteris vittata* L.	Tere& Lit	200-1900	Se(SQ,1875), Gl(CS,1320), Am(S,1070), Do(S,230)
60	Pteridaceae	*Pteris wallichiana* J. Agardh	Tere	1400-2100	Kh(SQ,2065), Pn(CS,1400)
61	Selaginellaceae	*Selaginella fulcrata* (Buch.-Ham. Ex D.Don) Spring	Tere	700-1500	Kc(W,770),Bh(SC,1205), Gl(CS,1490)
62	Selaginellaceae	*Selaginella pallida* (Hook. &Grev.) Spring	Tere	900-1900	Ro(CS,910),Se(SQ,1880), Gl(CS,1380)
63	Selaginellaceae	*Selaginella subdiaphana* (Wall. Ex Hook & Grev.) Spring	Tere	500-1400	Do(S,505),Bh(SP,1160), Gl(CS,1410)
64	Selaginellaceae	*Selaginella vaginata*	Tere& Lit	900-1500	La(CS,910),Gl(CS,1480)
65	Tectariaceae	*Tectaria gemmifera* (Fée) Alston	Tere& Lit	800-1600	Bh(S,810),Pn(CS,1350), Gl(SC,1580)
66	Thelypteridaceae	*Thelypteris arida* (D.Don) C.V.Mortum	Tere	800-1500	Du(W,780),Gl(CS,1470), Bh(SP,1120)
67	Thelypteridaceae	*Thelypteris cana* (J.Sm.) Ching	Tere	1100-1800	Pa(SS,1325),Th(SS,1120), Ka(SC,1810)
68	Thelypteridaceae	*Thelypteris clarkei* (Bedd.) C.F.Reed	Tere	900-1600	Ra(S,910), Ja(PS,1220), Ml(SC,1610)
69	Thelypteridaceae	*Thelypteris dentata* (Forssk.) E.P. St. John	Tere	500-1700	Do(S,520),Th (SS,1250), Da(SC,1670)
70	Thelypteridaceae	*Thelypteris glanduligera* (Kunze) Ching	Tere	600-1600	Si(SC,650), Sa(SC,1420),Gl(SC,1590)
71	Thelypteridaceae	*Thelypteris nudata* (Roxb.) C.V. Morton	Tere	900-1500	Bh (S,920),De(PS,1260), De(SC,1510)
72	Thelypteridaceae	*Thelypteris procera* (D.Don) Fraser-Jenk	Tere	1200-1900	Se(SQ,1910), Bh(SP,1220)
73	Thelypteridaceae	*Thelypteris prolifera* (Retz.) C.F.Reed	Tere	600-1300	Do(S,580), ,Th(S,1310)
74	Thelypteridaceae	*Thelypteris tylodes* (Kunze) Ching	Tere	1000-1800	Se(SC,1780), Pn (CS,1020)
75	Vittariaceae	*Vittaria linearifolia* Ching	Lit	1300-2000	Dh(SC,1620),Ms(RS,1980), Pn(SP,1290)

Note: Ag-Argha, Al-Alamnagar, Am-Amadanda, Ar-Arichour, Ba-Baseri, Bh-Bhuwandanda, Da-Dahakhola, Dd-Daduwa, Dh-Dhakaband, Di-Diverna, Dn-Dhanchour, Do-Dohote, Du-Durghaphat, Ga-Gargare, Gl-Goldhung, Go-Gokhunga,Ha-Halde, Hi-Hilekhola, Ja-Jalkanda, Ka-Kalikathi, Kc-Khanchikhola, Kh-Khanchi, la-Lamdanda, Ma-Maidan, Ml-Malarani, Ms-Masina, Na-Narapani, Ny-Nayagaun, Pa-Patauti, Pn-Panku, Pk-Pokhadanda, Po-Poudikhola, Ra-Rajiya, Ro-Rosa, Sa-Sanodeva, Se-Sengleng, Si-Sitkhola, Th-Thada & Wa-Wangla
Types of forest: S= Sal, SC=Schima-Castonopsis, SQ= Schima-Quercus; SP=Sal-Pinus; SS=Sal-Schima; P=Pinus; CS=Chiuri-Sal; PS=Pinus-Schima, RS=Rhododendron-Schima; W=Wetland; B=Bushes