**ASIAN JOURNAL OF FORESTRY**
Volume 8, Number 1, June 2024 E-ISSN: 2580-2844
Pages: 81-87 DOI: 10.13057/asianjfor/r080108

# Plant species diversity along altitudinal gradient of Chamkhar River Basin, Central Bhutan

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Manuscript received: 8 January 2024. Revision accepted: 26 April 2024.

**Abstract.** *Thukten K. 2024. Plant species diversity along altitudinal gradient of Chamkhar River Basin, Central Bhutan. Asian J For 8: 81-87.* Chamkhar River Basin in Bumthang District, Bhutan, plays an important role in water discharge due to the presence of forest vegetation at elevation range between 2,000-6,800 masl. This study was carried out between June-October 2023 to assess the plant species diversity, composition and abundance of vegetation along the Chamkhar River Basin representing different forest types and altitudes. In this study, 13 grids comprising 38 plots (one grid had 3 sampling plots) were established along Chamkhar River Basin through systematic sampling. The plots within the grid were selected to include tri-confluence formed by tributaries joining the Chamkhar River for the water discharge assessment. As many as 108 species and 1,294 individuals of trees, 154 species and 1,959 individuals of shrubs, and 101 species and 1,136 individuals of herbs, totaling of 363 species, 233 genera and 100 families were enumerated from different altitudes and across 4 different forest types (Blue Pine, Mixed Conifer, Cool and Warm Broadleaved forest) across the 38 sampling plots. Mixed Conifer and Blue Pine forests form the major forest type in the upstream ecosystem, while Cool Broadleaved and Warm Broadleaved forests form the major downstream ecosystem. The species richness and diversity were found higher in the Broadleaved forests at a lower altitude than in Blue Pine and Mixed Conifer forests at a higher altitude. However, species abundance did not show any definite pattern. The results of this study might be useful to better manage Chamkhar River basin and also serve as a baseline data for any future research along the Chamkhar River.

**Keywords:** Bhutan, Chamkhar River Basin, relative abundance, species diversity, species richness

## INTRODUCTION

Chamkhar River Basin is located in the Bumthang District in the North-Central part of Bhutan, with an elevation range between 2,000-6,800 masl and consisting of 51.79% of mainly Blue pine forest (Tshering et al. 2020). Chamkhar River Basin is fed mainly by the snowfields and glaciers of the eastern Himalayas, draining into the Manas River and eventually feeding into the Brahmaputra River in India (Hill et al. 2020).

Of the 36 biodiversity hotspots, the Eastern Himalayan Range is among the richest, with Bhutan constituting 7.60% of its total area. Bhutan, a biodiversity hotspot, is a part of 23 important birding sites, 8 ecoregions, and wetlands with 2 RAMSAR sites (Banerjee and Bandopadhyay 2016) and is home to 5,603 higher plant species, of which over 600 species are considered to have medicinal uses (Lakey and Dorji 2016). Besides being rich in biological diversity, the country is endowed with a rich network of riverine systems, generating 70,572 million $m^3$ of water annually (Tshewang et al. 2018), while (Rizal 2020) states that on average, 75 billion tons of freshwater flows out of the country every year.

Over the last few decades, ecologists have highlighted the intricate linkages between the riparian zone and surface streams and the need to incorporate riparian zones in the stream-catchment ecosystem. Riparian zones provide numerous ecosystem services, such as nutrient modification, erosion control, temperature regulation, and water quality improvements in adjacent ecosystems (Saklaurs et al. 2022). As an area of transition between two biological communities, ecological processes in riparian zone are directly integrated between the aquatic and terrestrial ecosystems (Gregory et al. 1991). The riparian ecotone possesses a high diversity of flora and fauna with a multi-layered structure due to variable flow above and below the surface.

The vegetation along the stream is an integral component of a stable riparian ecosystem (Medina 2012), playing a critical role in regulating the quality and quantity of water in the waterbodies by acting as a filter and storehouse by improving infiltration. A healthy streamside vegetation can reduce the stream's nitrogen and phosphorus load, reducing the risk of algal blooms (Frazer 2005). In addition, many wildlife species use vegetation zones along streams and rivers for foraging and breeding (Tucker Schulz and Leininger 1990).

Many factors dictate certain species composition, abundance, and diversity along the streams and rivers, like the environmental factors, stream size and hydrological conditions. There was a positive relationship between stream size and the number of plant community types in Danish riparian areas, with different community types being influenced by nutrient and moisture preferences (Dybkjær et al. 2012). Decreased nutrient content due to increased erosion resulting from flood raises species richness and uniqueness at the river level (Bornette et al. 2001). Elevation, flooding duration, and water chemistry influenced plant community composition, distribution, and diversity along a hydrological gradient in a complex wetland (Gaberščik et al. 2018). However, any disturbances to the riparian vegetation can severely affect the nutrient exchange, population of aquatic organisms, water temperatures, quality and quantity of flow in the streams and rivers (Knight and Bottorff 1981), and a moderate degree of disturbance in a plant community can give rise to a highly diverse species composition (Vasilevich 2009).

Since no previous vegetation studies were conducted along the entire stretch of Chamkhar River Basin, we carried out a vegetation survey as part of the Bhutan for life project across different forest types and altitudes. This study aimed to assess species composition, richness, abundance, frequency, and diversity and analyze contributing factors that explain such occurrences. We expect the results of this study might assist concerned protected area managers in better managing the river and riparine resources and also serve as a baseline data for any future research along Chamkhar River Basin.

## MATERIALS AND METHODS

### Study area

The study area is along the Chamkhar River (27º46'13.6" to 27º01'5.724" N and 90º39'42.1" to 90º50'24.312"E) which covers surface area of 3170.16 km$^2$ and stretches over 119.33 km from the base of Gangkarpuensum and Moenlakarchung peaks to Rendibi-confluence where Chamkhar River meets Mangde river of Bhutan (Figure 1). The forest type changes from Alpine scrubs at the sources to Bluepine forest in the middle belt and cool broadleaved forest at lower altitudes.

### Data collection procedures

As part of rapid biodiversity assessment, 13 grids (Table 1) were laid systematically along Chamkhar River Basin using GIS software. The survey sites within the grid were selected in such a way as to include tri-confluence formed by tributaries joining the Chamkhar River for the water discharge assessment. A vegetation study was also done at the water discharge sampling points.

From the tri-confluence of the river, we took 100 meters upstream for both the right and left tributaries and 100 meters downstream of Chamkhar River while maintaining a buffer of 100 meters from the banks on either side for vegetation sampling. In each grid, we laid three 20×20m square sample plots through simple random sampling to enumerate trees and within this plot, we laid 4×4m square plots to enumerate shrubs and 2×2m for herbs in accordance to the Biodiversity Monitoring and Social Surveying Protocol of Bhutan (DoFPS 2020). Sampling plots were laid on the right side of the river and tributaries in the starting grid and then alternated in the following grids to avoid selection biases. Therefore, 38 sampling plots were laid in 13 grids, with one sampling plot falling in an inaccessible area.

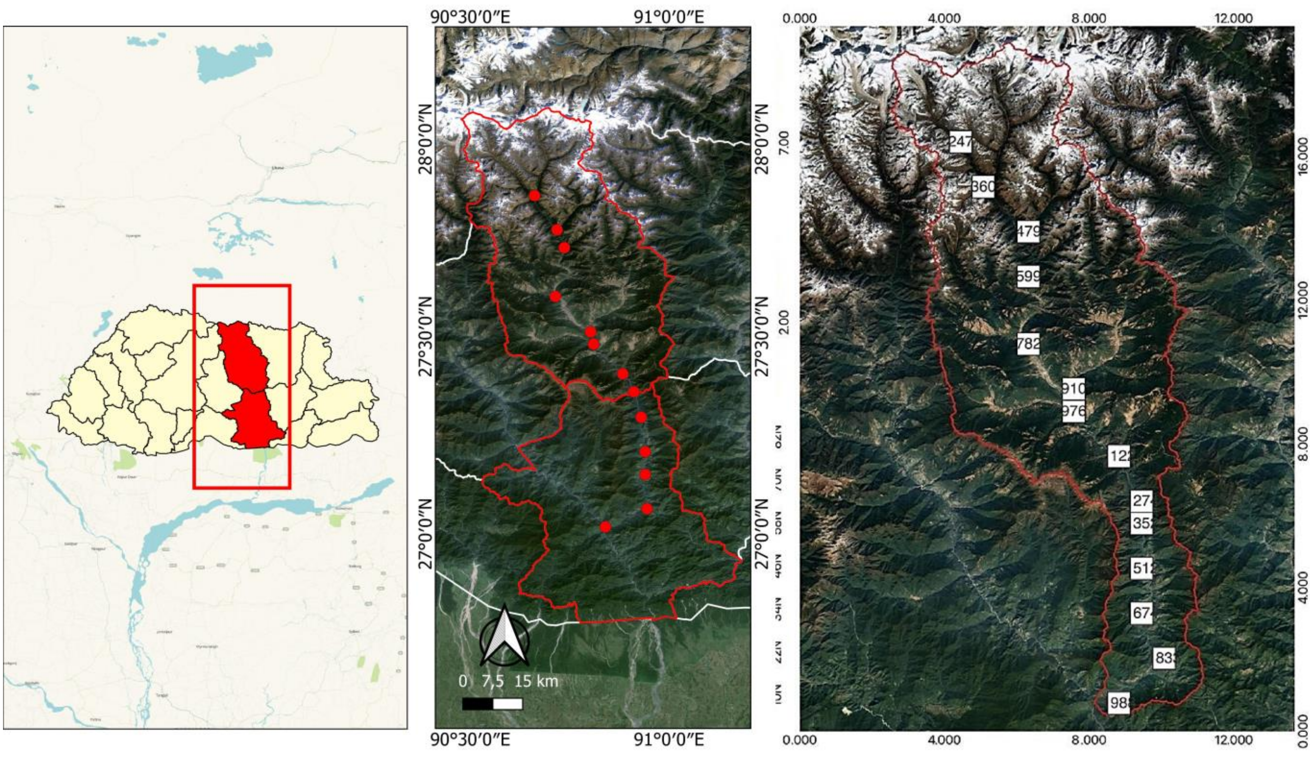


**Figure 1.** Map of study area in Chamkhar River Basin, Bumthang District, Bhutan and the survey grids

**Table 1.** Summary of grids along Chamkhar River Basin, Bhutan

| Grid no. | Place Name | GPS Coordinates | Altitude (m asl.) | Forest/Habitat Type | Vegetation Type |
|---|---|---|---|---|---|
| 1 | Tshampa | 27º51'25.9" N, 90º39'42.1"E | 3700 | Forest, thicket/pole stage, shrubland | Mixed conifer |
| 2 | Zampa Nyipa | 27º46'13.6" N, 90º43'05.5"E | 3071 | Forest | Mixed conifer |
| 3 | Zampa Dangpa | 27º43'30.8" N, 90º44'12.2"E | 2942 | Forest, thicket/pole stage, shrubland | Mixed conifer |
| 4 | Thangbi | 27º36'06.4" N, 90º42'50.1"E | 2591 | Forest | Blue pine |
| 5 | Kurkurbithang | 27º30'42.9" N, 90º48'09.7"E | 2512 | Forest | Blue pine |
| 6 | Gektong Zam | 27º28'51.6" N, 90º48'37"E | 2467 | Forest | Blue pine |
| 7 | Ura-Chamkhar chhu confluence | 27º24'20.2" N, 90º53'00.5"E | 2165 | Forest | Cool broad leaved |
| 8 | Murgang | 27º21'37.4" N, 90º54'41.0"E | 1840 | Forest | Cool broad leaved |
| 9 | Doptaru | 27º17'44.904" N, 90º55'48.642"E | 1241.1 | Forest/shrubland | Warm broad leaved |
| 10 | Radi chhu | 27º12'30.342" N, 90º56'23.358"E | 918.5 | Forest | Warm broad leaved |
| 11 | Khomshar chhu | 27º09'3.624" N, 90º56'23.910"E | 730.1 | Forest/shrubland | Warm broad leaved |
| 12 | Langdurbi-Murgang chhu | 27º03'50.210" N, 90º56'40.413"E | 425.6 | Forest/pole stage | Warm broad leaved |
| 13 | Ringdribi | 27º01'5.724" N, 90º50'24.312"E | 213.9 | Forest | Warm broad leaved |

## Data analysis

*Species richness and abundance*

Different species of trees, shrubs and herbs occurring within the three sampling plots of the grid were enumerated and filled in their respective survey forms. For species richness, we recorded several species found in the sampling plots of the grid and used MS Excel to compute the total species richness of that grid. For species abundance, the study recorded the total number of individuals of the species found in the sampling plot of the grid and computed the species abundance of that grid. The study arranged species occurrences for species frequency according to their respective forest types and calculated frequency by dividing individual species count by total species count in that particular forest type.

*Shannon & Simpson diversity index*

To calculate species diversity, we used both Shannon and Simpson indices. We combined the tally of trees, shrubs, and herbs of the three sampling plots to calculate a combined diversity index. Then, diversity indices of trees, shrubs and herbs were averaged to find a common diversity index of the vegetation. The Shannon and Simpson indices were calculated using the equation below:

$$\text{Shannon Index (H)} = -\sum_{i=1}^{s} p_i \ln p_i$$

$$\text{Simpson Index (D)} = \frac{1}{\sum_{i=1}^{s} p_i^2}$$

Where p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

## Statistical analysis

The Pearson correlation test was used to observe the correlation between altitude and species abundance to investigate how the altitude impacted species abundance. The significance of diversity differences between grids was calculated using the one-way Analysis of Variance (ANOVA).

## RESULTS AND DISCUSSION

## Total plant species

A total of 1,294 individuals of trees (108 species), 1,959 individuals of shrubs (154 species.), and 1,136 individuals of herbs (101 species) belonging to 363 species, 233 genera and 100 families were enumerated from different altitude gradients and across 4 different forest types, i.e., Blue Pine, Mixed Conifer, Cool and Warm Broadleaved forest. Asteraceae (n=18) and Poaceae (n=14) were the most dominant family (Table 2) while *Rhododendron* (tree), *Pteridium* (shrub) and *Potentilla* (herb) were the most represented genera in their respective vegetation types (Table 3) in the Chamkhar River Basin.

**Table 2.** Top 10 families in the Chamkhar River Basin, Bhutan

| Family | Number of species |
|---|---|
| Asteraceae | 18 |
| Poaceae | 14 |
| Fabaceae | 10 |
| Urticaceae | 8 |
| Rosaceae | 7 |
| Lamiaceae | 7 |
| Ericaceae | 6 |
| Araliaceae | 6 |
| Lauraceae | 5 |
| Rutaceae | 5 |

**Table 3.** Top 10 representative genera in each vegetation type in Chamkhar River Basin, Bhutan

| Tree | No. of Ind. | No. of occurrences | Shrub | No. of ind. | No. of occurrences | Herb | No. of Ind. | No. of occurrences |
|---|---|---|---|---|---|---|---|---|
| *Rhododendron* | 53 | 17 | *Pteridium* | 131 | 13 | *Potentilla* | 130 | 12 |
| *Acer* | 71 | 16 | *Berberis* | 19 | 11 | *Poa* | 145 | 11 |
| *Pinus* | 212 | 9 | *Artemisia* | 54 | 10 | *Pilea* | 125 | 10 |
| *Tsuga* | 49 | 9 | *Rubus* | 25 | 10 | *Ainsliaea* | 58 | 9 |
| *Macaranga* | 38 | 9 | *Rosa* | 38 | 9 | *Digitaria* | 84 | 7 |
| *Alnus* | 44 | 8 | *Tetrastigma* | 37 | 9 | *Anaphalis* | 38 | 6 |
| *Betula* | 36 | 8 | *Strobilanthes* | 107 | 8 | *Ageratum* | 41 | 4 |
| *Ostodes* | 22 | 7 | *Pteris* | 23 | 7 | *Synotis* | 35 | 4 |
| *Ficus* | 18 | 7 | *Piper* | 102 | 6 | *Selaginella* | 28 | 4 |
| *Duabanga* | 42 | 6 | *Elsholtzia* | 23 | 6 | *Equisetum* | 11 | 4 |

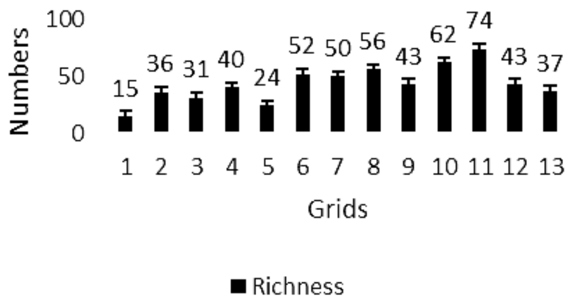


**Figure 2.** Comparison of species richness among the grids in Chamkhar River Basin, Bumthang District, Bhutan

**Species richness**

Grid 1 (Tshampa region, alt:3,700 masl, forest type: Mixed Conifer) had the least species richness (n=15) as the area falls in the sub-alpine region, where the harsh environment supports the growth of only a few cold hardy species like the *Abies densa*, *Juniperus* sp., *Rhododendron* shrubs, *Betula utilis*, *Bamboo* and *Acer* sp.

Grid 11 (Khomshar region, alt: 730.1 masl, forest type: Warm Broadleaf) had the most species richness (n=74), followed by Grid 10 (Radi region, alt: 918.5 masl forest type: Warm Broadleaf n=62). The predominant trees that grow in these regions included *Erythrina arborescens*, *Altingia excelsa*, *Lithocarpus* sp., *Terminalia tomentosa*, *Pterospermum acerifolium*, *Tetrameles nudiflora*, *Pandanus furcatus* and *Macaranga denticulata*.

Grids 6, 7, 8, 10 and 11 had similar species richness and were higher than other grids with more or less similar species richness (Figure 2)

Shrubs had a higher richness compared to other vegetation types along Chamkhar River Basin. Shrub richness were more prounounced in the altitude range of 730.1 m to 2467 masl comprising Bluepine, Cool-broadleaved and Warm-broadleaved forests (Table 4)

**Species abundance**

While most grids showed equal number of individuals, Grid 1 (Tshampa region) showed the most abundance per grid (n=653) (Table 5 and Figure 3). *Acer campbellii* was the most abundant tree in Grid 1, while *Rhododendron lepidotum* and *Arundinaria racemosa* dominate the shrub type and *Sphagnum* moss, *Aster himalaicus*, *Astragalus* sp., *Agrostis* sp. at the herb type.

Grid 13 (Rindribi, alt: 213.9 masl, forest type: Warm Broadleaf) had the least species abundance (n=194) among the grids. *Phoebe hainesiana* was the dominant tree species, *Strobilanthes multidens* the shrub species, and *Potentilla indica* the dominant herb species in this grid.

**Table 4.** Richness of each vegetation type along Chamkhar River Basin, Bhutan

| Grids | Richness (number of species) | | |
|---|---|---|---|
| | Trees | Shrubs | Herbs |
| 1 | 7 | 4 | 4 |
| 2 | 11 | 15 | 10 |
| 3 | 7 | 14 | 10 |
| 4 | 6 | 14 | 20 |
| 5 | 7 | 13 | 4 |
| 6 | 13 | 19 | 20 |
| 7 | 16 | 24 | 10 |
| 8 | 9 | 34 | 13 |
| 9 | 17 | 19 | 7 |
| 10 | 17 | 31 | 14 |
| 11 | 29 | 26 | 19 |
| 12 | 21 | 17 | 5 |
| 13 | 18 | 17 | 2 |
| Total | 178 | 247 | 138 |

**Table 5.** Abundance of each vegetation type in Chamkhar River Basin, Bhutan

| Grids | Abundance | | |
|---|---|---|---|
| | Trees | Shrubs | Herbs |
| 1 | 68 | 525 | 60 |
| 2 | 109 | 110 | 82 |
| 3 | 64 | 73 | 148 |
| 4 | 67 | 122 | 195 |
| 5 | 177 | 86 | 10 |
| 6 | 109 | 73 | 126 |
| 7 | 85 | 158 | 70 |
| 8 | 23 | 153 | 107 |
| 9 | 58 | 147 | 84 |
| 10 | 136 | 220 | 94 |
| 11 | 94 | 115 | 110 |
| 12 | 193 | 106 | 38 |
| 13 | 111 | 71 | 12 |
| Total | 1294 | 1959 | 1136 |

**Table 6.** Pearson correlation between species abundance and altitude in Chamkhar River Basin, Bumthang District, Bhutan

| Coefficient (r) | N | T statistics | DF | P value |
|---|---|---|---|---|
| 0.422756 | 13 | 1.547182 | 11 | 0.15009 |

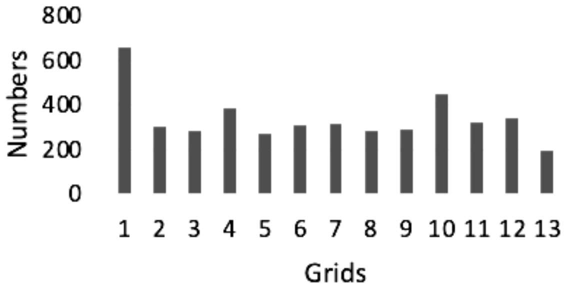


**Figure 3.** Comparison of species abundance among the grids in Chamkhar River Basin, Bumthang District, Bhutan

Grid 5 had the most trees (n=177) while Grid 1 had the most shrubs (n=525) and Grid 4 had the most herbs (n=195). In general, shrubs were more abundant than the two other vegetation types in the Chamkhar River Basin.

The result of Pearson correlation test indicated that species abundance showed a moderate positive correlation (Table 6), suggesting that species abundance is affected by altitude.

## Diversity indices

The Shannon diversity index ranged from 1.15-2.86 and Simpson diversity index ranged from 0.58-0.93. According to Shannon and Weiner, a diversity index of 2.5 and above is considered "high diversity," while a diversity index of 1.5 and below is considered "low diversity." As per these indices, two grids (Grid 1: Tshampa region, alt:3,700 masl, forest type: Mixed Conifer and Grid 5: Kurkurbithang region, alt: 2,512 masl, forest type: Blue Pine) fall under low diversity while only one grid (Grid 11: Khomshar region, alt: 730.1 masl, forest type: Warm Broadleaf) fall under high diversity and rest of the 10 grids under medium diversity (Figure 4). Simpson's Diversity Index also yields the same result, with Grid 11 showing the highest diversity (SDI-0.93) and Grid 1 showing the least diversity (SDI-0.58).

Grid 11 consisted of major tree species, including *P. furcatus, Toona ciliata, Schima wallichii, T. tomentosa, Quercus lamellosa, E. arborescens, A. excelsa, Lithocarpus* sp., *P. acerifolium, T. nudiflora,* and *M. denticulata.* While major shrubs in this grid included *Tetrastigma rumucispermum, Eupatorium* sp., *Piper mullesua, Cynoglossum* sp., *Artemisia* sp. and *Thysanolaena latifolia*; and major herbs: *Pilea symmeria, Drymaria cordata, Setaria palmifolia, Ageratum conyzoides, Acmella repens, Pollia hasskarlii* and *Plantago erosa.*

To evaluate the diversity significance between the grids (p=0.05), we ran a one-way Analysis of Variance (ANOVA) test. The study revealed the diversity difference was significant (p=0.000108, p<0.05) between the grids, indicating that species diversity decreased with the increase in altitude (Table 7).

## Species Relative Frequency (RF)

In the Mixed Conifer Forest type, *Acer* sp. (RF=0.245) was the most frequent tree species, followed by *Tsuga* sp. (RF=0.170), while *R. lepidotum* (RF=0.182) was the most frequent shrub species, followed by *R. setosum* (RF=0.121). With almost 60% representation, *A. racemosa* (RF=0.598) was the most frequent herb species, followed by *P. indica* (RF=0.075) (Table 8).

**Table 7.** The results of ANOVA to evaluate the diversity between the grids in Chamkhar River Basin, Bumthang District, Bhutan

| Source of Variation | SS | df | MS | F | P-Value | F Crit |
|---|---|---|---|---|---|---|
| Between Groups | 164.2044 | 1 | 164.2044 | 21.38579 | 0.000108 | 4.259677 |
| Within Groups | 184.2769 | 24 | 7.678204 | | | |
| Total | 348.4814 | 25 | | | | |

**Table 8.** Species relative frequency in each forest type in Chamkhar River Basin, Bumthang District, Bhutan

| Forest Type | Habit | | | | | |
|---|---|---|---|---|---|---|
| | Tree | RF | Shrub | RF | Herb | RF |
| Mixed Conifer | *Acer* sp. | 0.245 | *Rhododendron lepidotum* | 0.182 | *Arundinaria racemosa* | 0.598 |
| | *Tsuga* sp. | 0.17 | *R. setosum* | 0.121 | *Potentilla indica* | 0.075 |
| Blue Pine | *Pinus wallichiana* | 0.589 | *Pteridium aquilinum* | 0.26 | *Poa* sp. | 0.284 |
| | *Populus* sp. | 0.272 | *Artemisia* sp. | 0.139 | *Potentilla indica* | 0.157 |
| Cool Broadleaved | *Symplocos* sp. | 0.389 | *Cocculus* sp. | 0.148 | *Pilea* sp. | 0.243 |
| | *Alnus nepalensis* | 0.176 | *Strobilanthes* sp. | 0.071 | *Poa* sp. | 0.147 |
| | *Duabanga grandiflora* | 0.1 | *Piper mullesua* | 0.135 | *Digitaria cruciata* | 0.152 |
| | *Alnus nepalensis* | 0.1 | *Strobilanthes multidens* | 0.121 | *Bambusa* sp. | 0.134 |
| Warm Broadleaved | *Macaranga denticulata* | 0.087 | | | | |

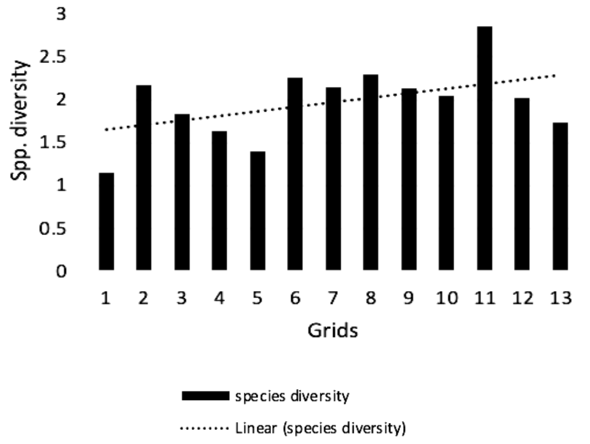


**Figure 4.** Comparison of species diversity among the grids in Chamkhar River Basin, Bumthang District, Bhutan

*Pinus wallichiana* (RF=0.589) was the most frequent tree species in the Blue Pine Forest type, followed by *Populus* sp. (RF=0.272). *Pteridium aquilinum* (RF=0.260) was the most frequent shrub species, followed by *Artemisia* sp. (RF=0.139). The most frequent herb species in the blue pine forest was *Poa* sp. (RF=0.284), followed by *P. indica* (RF=0.157).

In the Cool Broadleaved Forest type, *Symplocos* sp. (RF=0.389) was the most frequent tree species, followed by *Alnus nepalensis* (RF=0.176). *Cocculus* sp. (RF=0.148) was the most frequent shrub species, followed by *Strobilanthes* sp. (RF=0.071). *Pilea* sp. (RF=0.243) was the most frequent herb species, followed by *Poa* sp. (0.147).

In the Warm Broadleaved Forest type, *Duabanga grandiflora* (RF=0.1) and *A. nepalensis* (RF=0.1) were the most frequent tree species, followed by *M. denticulata* (RF=0.087). The *P. mullesua* (RF=0.135) was the most frequent shrub species, followed by *S. multidens* (RF=0.121). The most frequent herb species in the Warm Broadleaved Forest was *Digitaria cruciata* (RF=0.152), followed by *Bambusa* sp. (RF=0.134).

**Discussion**

Families with the most genera in Chamkhar River Basin were found to be from Asteraceae (18 genera), Poaceae (14 genera), and Fabaceae (10 genera). This result is similar with the studies by Leck and Leck (2005) in Delaware River of United States where the top two families having the most species were Asteraceae and Poaceae. Factors like seasonal flooding and anthropogenic activities lower species richness, whereas natural vegetation zones exhibited a higher species richness when left undisturbed (Jiang et al. 2005). The other finding states that the ungrazed meadow communities had comparatively lower species richness and diversity than their grazed counterparts (Green and Kauffman 1995). The entire stretch of Chamkhar River Basin is not dammed for hydroelectricity production, unlike other major rivers in Bhutan; therefore it is largely undisturbed by anthropogenic activities or major flooding as of now.

The study neither suggests increasing species richness with the decreasing altitude (Stevens 1992) nor increasing species richness with the increasing altitude (Dorji et al. 2014). On the forest type-wise, species richness along Chamkhar River Basin was higher in the broadleaved forest than conifer and blue pine forest. The reason is that the broadleaved forest, compared to the conifer and blue pine forest, occurs at a lower altitude where shrubs and herbs grow well (Xu et al. 2017) and is attributable to higher precipitation (Sekar et al. 2023). The other plausible reason is that the lower altitude is warmer than the higher altitude, where light availability and transmittance affect understory species richness (Dormann et al. 2020).

However, one study involving *K. pygmaea* revealed that moisture was the delimiting factor behind their dominance (Dorji et al. 2014). Therefore, we couldn't identify the definite and notable pattern of how the altitude or the environmental factors affected species abundance in our grids. The change in species diversity is due to changes in resource availability, like temperature and water, that change along the altitude (Shimono et al. 2010); geographic direction, humidity, and elevation influence vegetation distribution and diversity (Heydari and Mahdavi 2009). The $13^{th}$ grid showed lower diversity than other grids from the broadleaved forests, as one of the plots was inaccessible and may have contributed to a lower diversity index.

In conclusion, the broad-leaved forest, found at a lower elevation, generally had comparatively better species richness than those found in the mixed conifer and blue pine forests at a slightly higher elevation. Species abundance showed no significant difference concerning the altitude or the forest type in our study area. Therefore, 10 out of the 13 grids along the Chamkhar River Basin fell under "medium diversity," Grid 1 and Grid 5 fell under "low diversity," and only Grid 11 fell under "high diversity". The general trend in the study was that the species diversity decreased with the increase in altitude. The study revealed that combined anthropogenic and ecological factors influence species richness, abundance, and diversity.

## ACKNOWLEDGEMENTS

The author would like to thank Bhutan For Life for funding the project and the staff and management of Ugyen Wangchuck Institute for Forestry Research and Training, Bhutan, without whom the fieldwork would not have been possible.

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