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Floristic Composition and Species Diversity of Wintering Herbs in Blue pine Forest of Thimphu District, Bhutan

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: This study was carried out to document wintering herbs species in the blue pine (*Pinus wallichiana*) forest of Kawang Gewog under Thimphu district, Bhutan. To generate baseline data on species diversity and composition of the winter herbaceous layer in the blue pine forests of the study area.
Study Design: To evaluate the floral diversity and composition of herbs, stratified random sampling was used.
Place and Duration of Study: The study was conducted in Thimphu district within the altitudinal range of 2400 m to 2700 m A.S.L. The fieldwork was conducted during the month of December to January 2019 and during March 2020.

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Methodology: Four line transects were established randomly, with sampling points placed at 25-meter intervals along the transect. For adequate data collection, three 3X3 meter quadrats were laid along a straight line perpendicular to the transect, using species-area Type I curves (strictly nested curves). Each quadrat was then divided into 100 equal sub-quadrats, with a distance of 5 meters separating each quadrat.

Results: A total of 60 herb species belonging to 46 genera and 22 families. The Shannon-wiener index of species diversity (H') showed 1.73 value suggesting higher diversity in the study site with an altitude of 2600 m to 2700 m compared to other sites with an altitude range of 2400 m to 2500 m, H' value of 1.59.

Conclusion: The study conducted reports the finding on diversity and the composition of herbs occurring in the winter season from Kawang Gewog under Thimphu district. The present study also discusses the diversity and evenness of herbs influenced by elevation and anthropogenic influences.

Keywords: Bhutan; blue pine; herbs; diversity; important value index; species richness; thimphu; wintering herb.

1. INTRODUCTION

The herb species layers are mostly defined as the forest stratum or layer composed of all vascular species that are 1 meter or less in height [1]. It is the structure and function of forest ecosystems which constitutes less than 1% of the biomass of the forest, nevertheless can include 90% or more of the plant species and contribute up to 20% of foliar litter to the forest floor generally of higher nutrient content than that of trees [2]. The herbaceous plant layer are composed of maximum number of species in the community of forest and influences the nutrient cycling [3,4]. Not only this, herbaceous vegetation acts as a key strata and share largest proportions of species diversity in many forest ecosystem [5].

According to Gilliam [3], the loss of biodiversity is rampant and occurring on a global scale, especially true for forest ecosystem near the areas of high human population density. The resultant land use, inclusive of forest use, urban development and land conversion to agriculture have led to the loss of native species as a result of habitat destruction or alteration. As per Lalramnghinglova [2], in forest stratum, herbaceous layer undergoes higher natural extinction rates than that of plant species in other strata despite high species richness. Levin and Wilson [6] estimated that the extinction rates of herbs are more than three times that of hardwood tree species. Therefore, threats to herbaceous layer species are most often a function of threat to forest biodiversity [7].

According to Vilardell [8], blue pine (*Pinus wallichiana* A.B. Jackson) forests are semi-mesic meaning dry ecosystems that grow at mid elevations ranging between 2100 m to 3000 m with precipitation ranging from 450 to 1500 mm per year [9]. Blue pines are early successional species that are light demanding [10] and grows rapidly [9], forming secondary monospecific even-aged stands and grow adjacent to human settlements, mainly in previously discarded agricultural fields [11,12,9]. Blue pine ecosystems are highly susceptible to wildfires owing to its thin bark and high flammability [9] and undergo high anthropogenic pressure since it thrives next to settlements [11]. Therefore, the herbaceous vegetation of blue pine forests are at high risk of extinction since the occurrence of wildfires is dominant mostly in blue pines than other types of forest and grows adjacent to human settlements exposing to anthropogenic pressures. On addition, the occurrence of understory vegetation is a wonder amidst harsh conditions of blue pine forest as mentioned above.

This study will contribute to the understanding of herbaceous ecosystem by generating quantitative baseline information on species diversity and composition of herbaceous layer in blue pine forests of Bhutan.

2. METHODOLOGY OF STUDY

2.1 Study Site

The study was carried out in Thimphu district within the altitudinal range of 2400 m to 2700 m A.S.L. The area is dominated by blue pine forest and it lies in the Western part of the country with latitude from 27°8' to 27°59' and longitude from 89°13 to 89°46'. The district has a temperate climatic condition with warm summer and cold and dry winter. The annual rainfall varies between 450 mm and 1500 mm [9]. In Thimphu, four types of forest can be found inclusive of blue pine with an area of 26122.82 ha (14.69%). The district has one Dungkhag and eight Gewogs [13]. Thimphu district is considered as one of the developed District in the country. Out of 1795.87 kms, approximately an area of 1380.18 ha or 0.78 % are inhabited by the human.

2.2 Sampling Method

To evaluate the floral diversity and composition of herbs, stratified random sampling was used. This method divides study area into number of non-overlapping subdivisions (or strata) and samples are randomly selected from each subdivision [14,15]. The field work was conducted in blue pine forest of Kawang Gewog, Thimphu district with different elevation gradient (2400-2700 m). The four line transects were randomly laid in blue pine forest where sampling point was established at every 25 m distance along the transect line. Then three quadrats with the size of 3 X 3 m which was determined using species area Type I curves (strictly nested quadrats) [16] were laid perpendicularly along a straight line for the convenience of collecting sufficient amount of data [17]. This quadrat was further divided into 100 equal parts (sub-quadrat), with each quadrate separated by a distance of 5m from the next quadrate. Then the frequency of the herbaceous species was noted by counting each species that occurred in sub-quadrats in the format as shown in Table 1. The field work was conducted during the month of December to January, 2019 and during March of 2020. All the data collected from the sample plot were enumerated in the data collection sheet and the species were identified with the help of experts from Ministry of Agriculture and Forest.

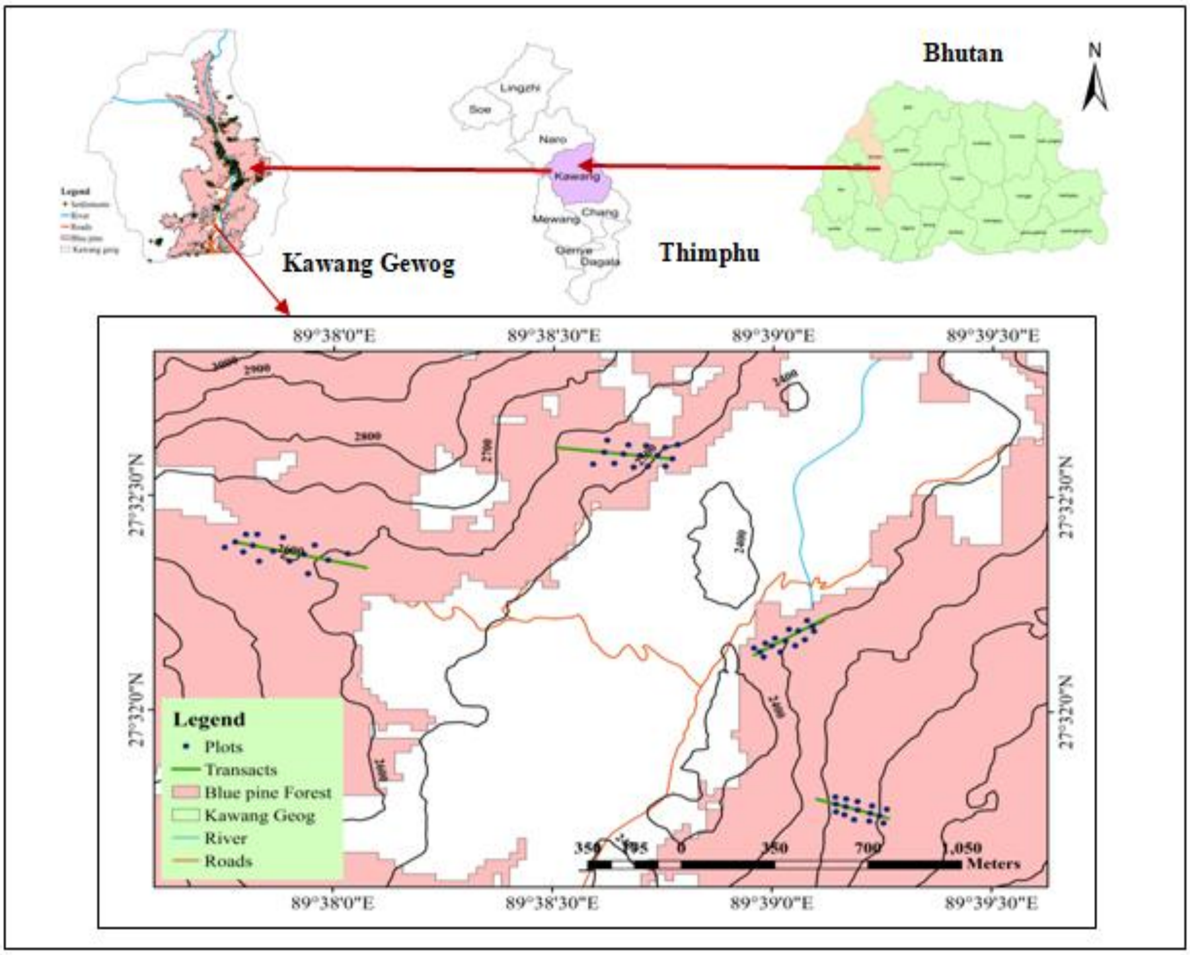

Fig. 1. Map showing the study area

2.3 Data Analysis

2.3.1 Species area curve for determination of sample size

Species-area curve is a graphical visualization of how species diversity changes with sampling area. It provides are snapshot of whether the sampling efforts are adequate to uncover all species of interest in a study area. Adequateness in sampling effort is reached when the species-area curve plateaus or flattens. The sampling area corresponding to the point at which the curve flattens is called the minimal area and it represents the optimal area that could encompass all species of interest. In other words, the species-area curve provides information on whether an area is sufficiently sampled to exhaustively uncover all species of interest in an area [18].

The number of species found in an area is plotted on y-axis coordinate with the area of a sample on x-axis. The species-area points determine a characteristic curve when examined. This curves rises rapidly from the intersection of the y and x axes but later becomes nearly a straight line and nearly horizontal [16]. The data collected from the field were entered and species curve was generated using Microsoft Excel 2013. The graph was plotted using number of species in sampling area with respect to sampled area in y-axis and x-axis respectively.

2.3.2 Vegetation data analysis

Shannon-wiener index:

$$H' = \sum_{i=1}^{s} pi\ In\ pi \quad (1)$$

Where, pi = $\frac{No.of\ individuals\ of\ a\ species}{Total\ no.of\ individuals\ of\ all\ species}$ - (Relative abundance)

In = natural logarithm or log
S = Species richness (total no. of species in a plot or an area)

Shannon diversity index was used to study the plant species diversity (Ambasht, 1982) [19] whereas; species evenness was calculated using Pielou's method of 1969. The evenness is a measure of how similar the abundance of different species is in a plot or an area. The check list of floristic composition data has been processed using pivot-table of the Microsoft excel as follows:

Pielou's species evenness index (Shannon's equitability)

$$J' = \frac{H\prime}{Hmax} = \frac{H}{In\ S} \quad (2)$$

Where, H′ = Shannon-Wiener Index
S = Total number of species in the sample/plot
In = Natural logarithm

2.3.3 Importance value index (IVI)

Importance Value Index (IVI) is a statistical quantity and the most important parameter that shows an overall picture of ecological importance of the species in the vegetative community. It considers the relative values of density, frequency and relative dominance of every species in a study area and the added value obtained ranging from 0-300 is called IVI [20]. Since, it is difficult to determine the basal area for herbaceous species, relative cover was determined in percentage as follows [21];

Importance value index (IVI) = Relative density RD) + Relative frequency (RF) + Relative dominance (RD).

Relative density =
$$\frac{\text{Density of a species}}{\text{Total density of all species}} \times 100 \quad (3)$$

Relative frequency =
$$\frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100 \quad (4)$$

Relative dominance =
$$\frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} \times 100 \quad (5)$$

Density = $\frac{\text{Number of a species}}{\text{Total area sampled}}$ (6)

Frequency = $\frac{\text{Area of plots in which a species occurs}}{\text{Total area sampled}}$ (7)

Relative cover (%) =
$$\frac{\boldsymbol{Total\ \%\ cover\ of\ sp.A\ in\ all\ plots}}{\boldsymbol{Total\ no.of\ plots/quadrats}} \times \mathbf{100} \quad (8)$$

3. RESULTS AND DISCUSSION

3.1 Floristic Composition of Herbaceous Plant

A total of 60 herb species belonging 46 genera and 22 families were recorded. Families with maximum number of species include Asteraceae (19 species) followed by Rosaceae and

Lamiaceae each with 5 and 4 species of herbs respectively from the study site (Table 2). At altitude 2600 m to 2700 m, a total of 49 species belonging to 19 families and 37 genera (Table 2) were observed. Taxonomically, well-represented families were Asteracea followed by Rosaceae with 5 species. Similarly, the most dominant families were Asteracea with 9 species followed by Rosaceae (3 species) at altitude 2400 m to 2500 m as shown in (Table 3). A total of 36 species belonging to 16 families and 32 genera were observed.

Table 1. Species composition of herbs in study site

Species	Family	(2600-2700m)	(2400-2500m)
Geranium procurrens	*Geraniaceae*	+	+
Pyrola corbieri	*Ericaceae*	-	+
Stellaria vestita	*Caryophyllaceae*	+	-
Stellaria media	*Caryophyllaceae*	+	-
Drymaria cordata	*Caryophyllaceae*	-	+
Oxalis corniculata	*Oxalidaceae*	+	+
Verbascum Thapsus	*Scrophulariaceae*	+	+
Hemiphragma heterophyllum	*Scrophulariaceae*	+	+
Selinum wallichianum	*Apiaceae*	-	+
Fragaria nubicola	*Rosaceae*	+	+
Potentilla lineate	*Rosaceae*	+	+
Potentilla indica	*Rosaceae*	+	+
Rubus fockeanus	*Rosaceae*	+	-
Rubus sp	*Rosaceae*	+	-
Bidens pilosa	*Asteraceae*	+	+
Gerbera piloselloides	*Asteraceae*	-	+
Ainsliaea aptera	*Asteraceae*	+	+
Galingsoga ciliate	*Asteraceae*	-	+
Anaphalis contorta	*Asteraceae*	+	+
Senecio scandens	*Asteraceae*	+	+
Senecio vulgaris	*Asteraceae*	+	-
Pseudognaphalium affine	*Asteraceae*	+	-
Taraxacum officinale	*Asteraceae*	+	+
Taraxacum sp 1	*Asteraceae*	+	+
Taraxacum sp 2	*Asteraceae*	+	+
Taraxacum sp 3	*Asteraceae*	+	-
Sonchus asper	*Asteraceae*	+	-
Cirsium verutum	*Asteraceae*	+	-
Cirsium sp	*Asteraceae*	+	-
Artemisia vulgaris	*Asteraceae*	+	+
Dichrocephala sp	*Asteraceae*	+	-
Erigeron sp	*Asteraceae*	+	-
Erigeron Canadensis	*Asteraceae*	+	+
Rumex nepalensis	*Polygonaceae*	+	-
Gentiana capitata	*Gentianaceae*	+	+
Gentiana pedicellata	*Gentianaceae*	-	+
Cynoglossom furcatum	*Boraginaceae*	+	+
Clinopodium umbrosum	*Lamiaceae*	+	+
Ajuga sp	*Lamiaceae*	-	+
Ajuga reptans	*Lamiaceae*	+	-
Salvia sp	*Lamiaceae*	+	-
Trifolium repens	*Fabaceae*	+	+
Lespedeza cuneata	*Fabaceae*	-	+
Cajanus mollis	*Fabaceae*	-	+
Rubia manjith	*Rubiaceae*	+	+
Galium elegans	*Rubiaceae*	+	+
Galium aparine	*Rubiaceae*	+	-

Species	Family	(2600-2700m)	(2400-2500m)
Plantago erosa	*Plantaginaceae*	+	+
Viola betonicifolia	*Violaceae*	+	+
Viola pilosa	*Violaceae*	+	+
Viola sp	*Violaceae*	+	-
Primula denticulate	*Primulaceae*	+	-
Dipsacus inermis	*Caprifoliaceae*	+	-
Capsella bursa-pasteris	*Brassicaceae*	+	-
Cardamine flexuosa	*Brassicaceae*	+	-
Ranunculus chinensis	*Ranunculaceae*	+	-
Ranunculus cantoniensis	*Ranunculaceae*	-	+
Thalictrum foliolosum	*Ranunculaceae*	-	+
Euphorbia griffithii	*Euphorbiaceae*	+	-
Astilbe rivularis	*Saxifragaceae*	+	-

Table 2. Family-wise distribution of species in study sites

Sl. No	Family	2600 to 2700 m		2400 to 2500 m	
		Genera	Species Number	Genera	Species Number
1	*Caryophyllaceae*	1	2	1	1
2	*Scrophulariaceae*	2	2	2	2
3	*Rosaceae*	4	5	3	3
4	*Ericaceae*	0	0	1	1
5	*Geraniaceae*	1	1	1	1
6	*Violaceae*	1	3	2	2
7	*Asteraceae*	11	17	8	9
8	*Polygonaceae*	1	1	0	0
9	*Gentianaceae*	1	1	1	2
10	*Boraginaceae*	1	1	1	1
11	*Lamiaceae*	3	3	2	2
12	*Fabaceae*	1	1	2	2
13	*Rubiaceae*	2	3	2	2
14	*Plantaginaceae*	1	1	1	1
15	*Primulaceae*	1	1	0	0
16	*Caprifoliaceae*	1	1	0	0
17	*Brassicaceae*	2	2	0	0
18	*Ranunculaceae*	1	1	2	2
19	*Euphorbiaceae*	1	1	0	0
20	*Saxifragaceae*	1	1	0	0
21	*Oxalidaceae*	0	0	1	1
22	*Apiaceae*	0	0	1	1

3.2 Diversity and Evenness of Herbs Species

The Shannon-wiener index of species diversity (H') showed 1.73 suggesting higher diversity in the study site with the altitude of 2600 m to 2700 m compared to other site with an altitude range of 2400 m to 2500 m, H' value of 1.59. Similarly the Pielou's Evenness index was recorded highest in 2600 to 2700 m (0.51) than at 2400 to 2500 m (0.26) indicating maximum diversity at that site.

The magnitude of the differences in diversity and evenness among the plots are not high although, in study site of 2600 m to 2700 m, the highest H' was 2.18 of plot 15 and the lowest was 1.23 in plot 28. The evenness or equitability ratio of species was higher in plot 20 (0.96) and lowest in plot 9 (0.8). At 2400 m to 2500 m, the highest and lowest H' value were 2.21 (plot 1) and 1.04 (plot 27) respectively. In terms of evenness, the highest value was 1.06 in plot 1 and lowest in plot 27 (0.75) (Table 4). The result confirms similar findings by Zhang and Zhang [22] that plant diversity is expected to be different with different elevations. Similarly, Sang [23] also reported higher species richness with higher elevation.

Table 3. Species diversity and richness (H': Shannon-wiener index, J: Pielou's species evenness index)

Plot No.	2600 – 2700 m		2400 – 2500 m	
	H'	J	H'	J
1	1.88	0.90	2.21	1.06
2	1.40	0.87	1.71	0.95
3	1.39	0.86	1.78	0.86
4	1.78	0.86	2.01	0.97
5	1.70	0.95	1.62	0.90
6	1.59	0.89	1.66	0.93
7	1.95	0.89	2	0.96
8	1.71	0.88	1.48	0.76
9	1.43	0.80	1.67	0.93
10	1.87	0.90	1.61	0.90
11	1.59	0.89	1.6	0.82
12	2.09	0.95	1.37	0.85
13	1.92	0.92	1.65	0.85
14	1.84	0.88	1.99	0.96
15	2.18	0.95	1.24	0.89
16	2.00	0.91	1.83	0.94
17	2.01	0.91	1.78	0.91
18	2.03	0.92	1.58	0.88
19	1.52	0.85	1.42	0.88
20	1.87	0.96	1.39	0.78
21	1.66	0.93	1.47	0.91
22	1.54	0.86	1.54	0.96
23	1.63	0.84	1.75	0.98
24	1.62	0.90	1.48	0.92
25	1.52	0.85	1.3	0.94
26	1.71	0.95	1.52	0.94
27	1.94	0.93	1.04	0.75
28	1.33	0.83	1.29	0.80
29	1.66	0.93	1.35	0.97
30	1.63	0.91	1.29	0.80

The percent contribution of annuals at 2600 m to 2700 m was greater than at 2400 m to 2500 m while perennials was higher at 2400-2500 m than at 2600-2700 m. The annuals experience rapid growth of flowers and then seeds compared to perennials.

3.3 Importance Value Index

The IVI is commonly used in ecological studies as it shows ecological importance of a species in a given ecosystem. The IVI is also used for prioritizing species conservation whereby species with low IVI value need high conservation priority compared to the ones with high IVI. Since, IVI as an indicator of dominance, *Potentilla lineata* and *Anaphalis contorta* dominated the area having highest IVI of 27.82 and 27.13 respectively followed by *Geranium procurrens* (26.08) (Fig. 2). Thirty seven other species showed IVI range of 25.85 – 10.01 while twenty species showed IVI less than 10.

In study site of altitudinal range of 2600-2700 m, *Potentilla lineate* portrayed the highest IVI value (24.13), followed by *Clinopodium umbrosum* (22.83) and *Geranium procurrens* (21.9) indicating that these species occupy most of the sampled area hence it is important plant species in forest. Whereas, in study site with altitude 2400-2500 m, *Potentilla lineate* (31.4) exhibited highest IVI followed by *Geranium procurrens* (26.06) and *Gerbera piloselloides* (25.85). The high IVI exhibited by these herbaceous species are largely due to its higher relative cover, frequency and density compared to other species.

Table 4. The dominance pattern of herbaceous species in the study area (RD: Relative density, RF: Relative frequency, Cover %: Relative cover, IVI: Family Importance Index)

Botanical Name	RD	RF	Cover %	IVI
Geranium procurrens	1.56	1.71	22.81	26.08
Pyrola corbieri	0.46	0.6	6.45	7.51
Thalictrum foliolosum	1.1	1.13	13.31	15.54
Stellaria vestita	0.44	0.52	23.95	24.91
Stellaria media	0.71	0.51	12.2	13.42
Drymaria cordata	0.58	0.45	7.85	8.88
Oxalis corniculata	0.99	0.65	12.68	14.32
Verbascum Thapsus	0.56	0.6	17.17	18.33
Hemiphragma heterophyllum	0.9	0.74	15.86	17.50
Selinum wallichianum	0.23	0.3	3.94	4.47
Fragaria nubicola	1.12	1.19	17.46	19.77
Potentilla lineate	1.57	1.52	24.73	27.82
Potentilla indica	0.82	0.9	11.18	12.90
Rubus fockeanus	0.36	0.26	5.17	5.79
Rubus sp	0.44	0.53	6.67	7.64
Bidens pilosa	0.8	0.91	11.72	13.43
Gerbera piloselloides	1.36	1.53	22.96	25.85
Ainsliaea aptera	0.75	0.85	12	13.60
Galingsoga ciliate	0.56	0.67	7.66	8.89
Anaphalis contorta	1.55	3.57	22.01	27.13
Senecio scandens	0.67	0.54	8.8	10.01
Senecio vulgaris	0.18	0.26	1.85	2.29
Pseudognaphalium affine	0.44	0.66	3.23	4.33
Taraxacum officinale	1.19	1.37	18.75	21.31
Taraxacum sp 1	0.3	0.28	7.03	7.61
Taraxacum sp 2	0.44	0.6	11.48	12.52
Taraxacum sp 3	0.87	1.06	14.29	16.22
Sonchus asper	0.44	0.53	11.11	12.08
Cirsium verutum	0.2	0.26	2.71	3.17
Cirsium sp	0.22	0.26	5.56	6.04
Artemisia vulgaris	1.09	0.94	15.04	17.07
Dichrocephala sp	0.44	0.26	6.67	7.37
Erigeron sp	1.31	1.59	11.11	14.01
Erigeron Canadensis	0.47	0.38	6.12	6.97
Rumex nepalensis	0.87	0.78	10.25	11.90
Gentiana capitata	0.93	1.02	13.18	15.13
Gentiana pedicellata	1.7	2.18	12.5	16.38
Cynoglossom furcatum	0.44	0.51	9.85	10.80
Clinopodium umbrosum	1.06	1.16	22.62	24.84
Ajuga sp	0.29	0.37	7.39	8.05
Ajuga reptans	0.22	0.26	2.5	2.98
Salvia sp	1.03	1.04	15.35	17.42
Trifolium repens	1.04	0.72	17.99	19.75
Lespedeza cuneata	1.02	1.09	13.8	15.91
Cajanus mollis	0.57	0.73	12.36	13.66
Rubia manjith	0.89	0.76	14.01	15.66
Galium elegans	1.1	1.00	17.07	19.17
Galium aparine	0.66	0.53	10	11.19
Plantago erosa	0.82	0.88	11.63	13.33
Viola betonicifolia	1.16	1	11.53	13.69
Viola pilosa	0.86	0.89	13.32	15.07
Viola sp	0.53	0.77	8.57	9.87
Primula denticulate	1.41	1.28	10.01	12.70

Botanical Name	RD	RF	Cover %	IVI
Dipsacus inermis	0.22	0.26	1.96	2.44
Capsella bursa-pasteris	0.66	0.53	9.8	10.99
Cardamine flexuosa	0.6	0.65	10.81	12.06
Ranunculus chinensis	0.66	0.79	13.33	14.78
Ranunculus cantoniensis	0.54	0.6	7.56	8.70
Euphorbia griffithii	0.64	0.53	16.1	17.27
Astilbe rivularis	0.18	0.26	1.3	1.74

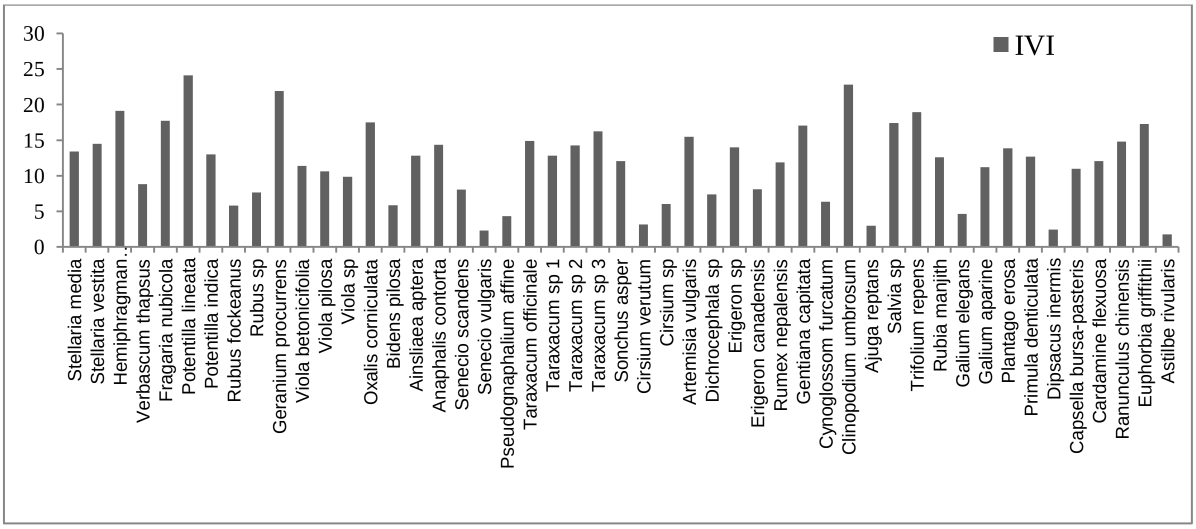

Fig. 2. IVI values of individual plant species in site with altitude 2600-2700 m

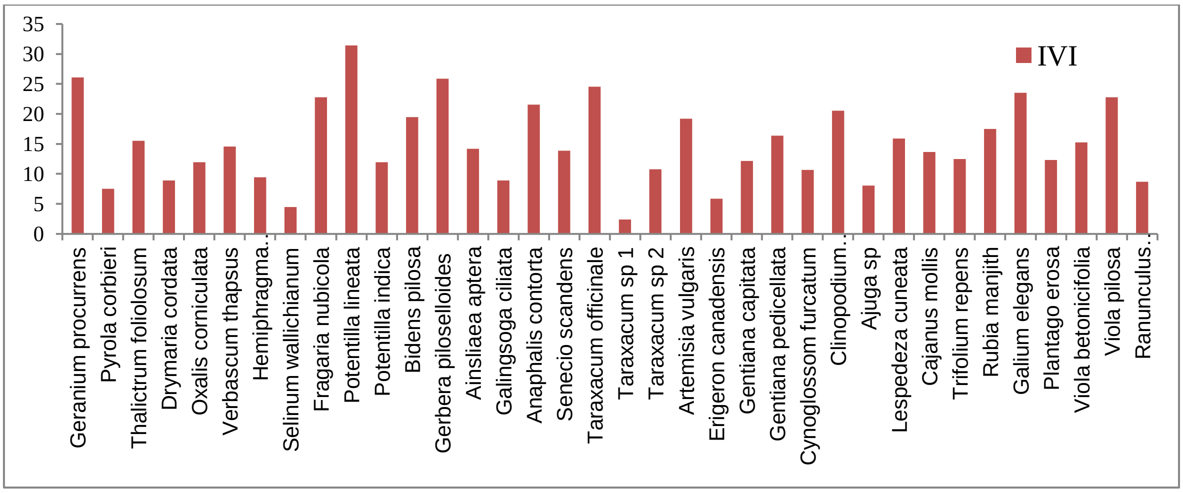

Fig. 3. IVI values of individual plant species in site with altitude 2400-2500 m

4. DISCUSSION

The occurrence of 60 herbaceous understory species in *Pinus wallichiana* forests of Kawang geog of Thimphu indicates its associations with significant diversity of herbs species. The result depicted Asteraceae family as the most dominant in *Pinus wallichiana* understory vegetation followed by Rosaceae and Lamiaceae. Rahman et al. [24] had also reported same trends of family dominance in their studies whereas, Behera et al. [25], Paul (2008), and Bharali et al. [26] reported similar trends of family dominance (Asteraceae, Ericacaea and Rosaceae). The species diversity under monotype forest is possibly due to altitude, topographic and physiographic conditions. The plant diversity and richness was different with different elevations

[22]. The diversity at altitude 2600 m to 2700 m was higher than at altitude 2400 m to 2500 m which could be possibly due to gentle slope and the presence of matured stand of *Pinus wallichiana.* And the soil condition was moist compared to the study site of altitude 2400-2500 m consisting of regeneration stand, steep slope and dry soil.

In the study sites, *Potentilla lineate* portrayed the highest IVI value, followed by *Anaphalis contorta* and *Gentiana capitata* indicating that these species occupies most of the sampled area hence it is important plant species in forest. The high IVI exhibited by these herbaceous species are largely due to its higher relative cover, frequency and density compared to other species. The presence of many species with lower IVI values such as *Ranunculus cantoniensis*, *Ajuga reptans, Astilbe rivularis*, *Crisium verutum*, *Capsella bursa-pasteris, Rubus fockeanus,* etc.,) in this study is an indication that the majority of species are in the forest. The rarity may be due to various reasons, which include (1) poor dispersability of species, (2) natural or anthropogenic disturbances, (3) prevailing environmental conditions and (3) competition within the forest [27,28] (Ahamad et al. 2011).

5. CONCLUSIONS AND RECOMMENDA-TION

In the forest stratum, all the vascular species that are 1 meter or less in height are defined as herbaceous layer [1]. This stratum of forest vegetation is an essential component of forest ecosystem sustaining a great portion of total floristic community providing habitats and food sources for many types of animals. The threats to herbaceous layer species are most often a function of threat to forest biodiversity. The study conducted imparts the information on diversity and the composition of herbs occurring in winter from Kawang geog under Thimphu district. The present study also discloses the diversity and evenness of herbs influenced by elevation and anthropogenic influences.

The herbaceous cover diversity of the studied sites was represented by 60 plant species belonging to 46 genera under 22 families. The species diversity and evenness was observed higher at altitude 2600-2700 m than at altitude 2400-2500 m. The dominant family Asteraceae is represented with 19 species, followed by Rosacaea (5 species) and Lamiacaea (4 species). In the study sites of blue pine forest of Thimphu district, *Potentilla lineate* portrayed the highest IVI value (27.82), followed by *Anaphalis contorta* (27.13) and *Geranium procurrens* (26.08), which indicated that the area is productive and concludes that blue pine forest ecosystem can host numbers of herb species despite its arid nature. The study also revealed that the herb species differs with different altitudes in the study area.

The present study was conducted mainly on floristic composition and diversity neglecting other factors such as humidity, soil pH, biomass, rainfall, canopy coverage and temperatures for a short duration with limited budget during winter. If the research is carried out during different seasons in long run with adequate resources, additional and divers species is expected to be discovered from the study site. And also further study needs to be conducted highlighting on these factors influencing the composition of herb species.

According to Bhandari and Tiwari [29], any species in a community, plays a specific role and there is a definite quantitative relationship between abundant and rare species. The activities such as anthropogenic activities and the surrounding condition changes around the sites could be the reason behind the differences in IVI. Anthropogenic pressure usually leads to the vegetation degradation due to in adequate retrieval time and also contributes to the vanishing of ecologically, medicinally or economically important plant species. Therefore, there is need to further study in the future to explore whole flora and the impact of anthropogenic pressure on the vegetation on these areas as these places are developing at a fast rate. Further, the present study can be used as a source of basic data for the management and preservation of the indigenous species, particularly those herbaceous species having low importance value index (IVI) and lastly, a series of more comprehensive herbaceous ecosystem studies are required to provide knowledge and foundation for future research as herbs dominate the forest.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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