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Understanding Species Diversity, Phenology and Environmental Implications of Different Life Forms in Coniferous Forests: A Case Study from Bhallesa Hills of Pir Panjal Mountain, Western Himalaya, India

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Abstract: We assessed, for the first time, the plant assemblages in coniferous forests of temperate and alpine ecosystems of the Himalayas to understand the diversity of species and their phenological behaviours that lead to different growth forms in the climax forest community. In this study, we selected the coniferous forests of Bhallesa Hills, situated in Pir Panjal Mountain (Jammu and Kashmir) of the Himalayan biodiversity hotspot as a study area and used the quadrat method to document the floristic diversity over four years (2018–2021). The study sites were divided into four sub-sites (Chilli, Kahal, Chanwari, Gandoh), and at each site, 25 replicated plots (each measuring 2500 m^2, 50×50 m^2) were established for repeated surveys and documentation. We then analysed species diversity, lifeforms, phenology and leaf size spectra of coniferous plant communities. We consulted various pieces of literature to understand native and non-native plants. The results showed that the species diversity and species richness, growth forms and phenology varied in the experimental plots. In total, we found 328 plant species belonging to 228 genera and 78 families from different localities of various growth forms. Approximately 68.51% of the plant species were native, and 31.49%of the species were non-native. In angiosperms, dicotyledon species were found to be dominant, with 83.23% of the total plant species, while the family Asteraceae was common, with 38 species. The biological spectrum analysis showed 29% of the species were chamaephytes, followed by 28% as therophytes and 21% as phanerophytes. We observed that plant communities respond differently to the existing environment drivers, with chamaephyte and therophytes being more tightly linked to temperate mixed-coniferous and alpine ecosystems, affected by climates and the availability of substrates for their growth and existence. The leaf size spectra analyses showed nanophyll (42.81%) as the dominant group. Conservation-prioritised species (IUCN, regional most threatened species in India), such as *Taxus wallichiana* Zucc., *Picrorhiza kurroa* Royle ex Benth., *Trillium govanianum* Wall. ex D.Don, *Aconitum heterophyllum* Wall. ex Royle and *Euphorbia obovata* Decne were found to be the most endangered plants. The results indicated more indigenous species, but there is a slow process of depletion of wild species, leading to colonisation by exotic alien species. This study indicated forests of the Himalayan regions are degrading at a faster rate, species are showing a shift in phenological behaviour due to anthropogenic factors leading to climate change, and indigenous species need conservation measures.

Keywords: biological spectrum; conservation; Himalayas; plant composition; phenology; temperate-to-alpine flora

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1. Introduction

A rapid decline in plant diversity, mainly due to human involvement, is considered a major driver of changes in the ecosystem [1–3]. The high plant diversity promotes ecosystem multifunctionality, ensures the sustainability of the rangeland, and provides various services to mankind, as supported by comprehensive experimental studies [4,5]. Therefore, gathering reliable information on species diversity is needed to help wildlife managers properly plan and formulate efficient conservation actions [6,7]. Natural forests provide a wide range of ecosystem services and are considered a critical habitat for biodiversity [8] as this accounts for the ecological structure, functions and processes in forest ecosystems [9]. Aside from providing food, medicine, fuel and other necessities to billions of people, forests also support water-flow regulation and carbon storage and provide services such as habitat preservation, pollution control and soil protection [10]. Knowledge of plant species diversity, composition and viability is essential to achieving more efficient forest preservation and conservation via policymaking and management [11,12]. Technical exploration and inventorisation of biodiversity provide important data for studying aspects of conservation and sustainable use [13–15] and also help in monitoring changes in plant communities over time [16–18]. Plant communities and their structure can be assessed and explored through field sampling and then by arranging the species into various categories that reflect their dependency and relationship with the existing environmental parameters [19–21]. However, these studies can be costly and time-consuming and depend on the total area chosen for study. Therefore, efficient methodologies and tools that estimate and assess species diversity are needed [9,22]. For this, one parameter considered is the plant communities categorised based on leaf form and leaf size spectra [23,24]. An investigation of the biological spectrum (BS) and floristic composition is considered an important study in comparing the geographical separation of different plant communities and is also used as an indicator to investigate environmental changes over time [12,25]. The BS is also considered an indicator of the prevailing conditions of the environment favouring the growth of plant species and environmental stress, if any, faced by the residing species in that particular environment [26]. The phenological attributes, such as life forms (LFs), leaf spectra (LS) and other phenotypic features, reflect the existing ecological conditions, microclimate and evolutionary processes that help in understanding the pattern of species' lifecycles [27–30]. Thus, it can be used for assessing the ecological health of the given ecosystem [31–38]. Raunkiaer's normal spectrum shows a phanerophytic community, and the deviation from the normal spectrum determines the phytoclimatic nature of the vegetation of an ecological habitat [39]. The difference between Raunkiaer's normal spectrum and the biological spectrum of life forms helps to determine the dominant life forms that characterise the phytoclimate of a given ecosystem [40]. Therefore, the study of BS is one of the important factors in ecological studies and the description of vegetation rankings next to floristic composition and biodiversity surveys [41,42].

Approximately 3% of the world's surface has a high mountainous region [42,43], and most of the species' diversity is concentrated in the hills and valleys [44]. Mountainous environments provide a home to various endemic, rare and threatened species [45,46], but in the recent past, climate change and land use patterns have played critical roles in species threats with respect to the exploitation of this natural heritage in most parts of the globe [47–50]. This is one of the main reasons for attracting more research activities in the mountains, including botanisation and registering the collection of plant species of great value [51]. In particular, coniferous forests have great importance worldwide, both from an ecological point of view and in the face of climate change [52–59]. The Indian Himalayas are one of the mountainous belts rich in both biological and cultural diversity [60,61]. It covers a 70,074.54 km^2 area, distributed as tropical, subtropical, temperate, sub-alpine and alpine ecosystems enriched with 50% of Indian species [62,63]. Interestingly, plant communities of the Himalayas have been a major attraction for research since ancient times [64–91], but still, many interior regions in the Himalayas are found to be unexplored, which needs botanical investigation and proper documentation.

The Bhallesa Hills are considered a part of the Pir Panjal mountain range, situated in the district of Doda in the Indian union territory of Jammu and Kashmir (J and K), and is one of the unexplored belts of the Himalayan biodiversity hotspot. This belt of Himalayas is bestowed with a typical mountainous climate, the beauty of lofty mountains and unique vegetation, attracting botanists and forest department planners in the recent few years for the study of natural resources. With this research, we have attempted, for the first time, to investigate the biological spectrum and floristic composition of Bhallesa Hills. We reveal that the data on the phytoclimate variables and floristic composition of this region can transmit a lot of knowledge to mankind and fill the gap of one of the unexplored belts of the Himalayas. We hypothesised that climate change in the current scenario might decrease ecosystem functioning and lead to a loss of plant diversity. In this research, we specifically tried to address the current state of knowledge and research gaps on floristic diversity and the threatened species in the absence of any such previous attempts for Jammu and Kashmir. The major aim of this study was to assess the plant assemblages in the Himalayas coniferous forests of temperate and alpine ecosystems and understand species diversity and their phenological behaviours leading to different lifeforms. In this study, we selected the coniferous forests of Bhallesa Hills and then analysed the species' diversity, lifeforms, phenology and leaf size spectra of coniferous plants. Key questions, such as (a) how diverse are the life forms of plants from different altitudinal gradients in coniferous forests of the temperate and alpine climate of the Himalayas, and how are they distributed in a drastic cold climate? (b) What are the key drivers controlling the population of different plant community compositions? (c) Do species of plants of special interest (from a conservation point of view) occur in the studied forest regions? Based on the results, we have attempted to discuss the species diversity, species richness, growth forms, phenology and species of conservation importance.

2. Materials and Methods

2.1. Study Area

Plant species were sampled from the Bhallesa Hills, having typical Himalayan temperate mixed-coniferous and alpine forests, which come under the Pir Panjal mountainous belts of Kashmir Himalaya. This study site lies between the latitude of 32°54′ to 33°05′ N and a longitude of 75°55′ to 75°51′ E (Figure 1). The altitude varies from 1500 to 4500 m above sea level (m.a.s.l.), having an area of approximately 950 km^2. The Kalguni river originates from Bhallesa Hills and serves as a lifeline for the local inhabitants residing in the lower valleys of the study area. Due to the less connectivity to towns and the lack of modern health facilities, the people mostly rely on this river and the available forest resources for their livelihood. According to the 2011 Indian Census, the total population of the Bhallesa region recorded was 71,889 people, with a density of 94 people per km^2. The population of males was 36,754 persons, whereas the number of females was 35,135 persons. The difference in the altitudinal gradients leads to species variations coupled with climate change and nutrient resources. However, the temperate climate prevails in the lower regions of the Bhallesa belts, whereas the upper reaches enjoy a cold alpine climate. During the investigation (2018–2021), the maximum temperature recorded was 31.5 °C in June, and the minimum temperature was 7.8 °C in January. The forest vegetation composition leading to plant species diversity varies depending on the altitude. In the lower regions, plant communities are characterised by temperate mixed forest species, such as *Aesculus indica* (Wall. ex Cambess.) Hook., *Fraxinus excelsior* L., *Acer caesium* Wall. ex Brandis and *Pinus wallichiana* A.B.Jacks. As the altitudinal gradient increases, the typical Himalayan coniferous tree species, such as *Cedrus deodara* (Roxb. ex D.Don) G.Don, *Picea smithiana* (Wall.) Boiss., *Abies pindrow* (Royle ex D.Don) Royle and *Betula utilis* D.Don dominates the forests. The sub-alpine and alpine meadows were represented by typical high-altitude Himalayan bushy shrubs and hardy herbaceous species of the genera *Berberis* L., *Androsace* L., *Anemone* L., *Gentiana* Tourn ex L., *Impatiens* Riv. ex L. and *Primula* L.; species, such as *Jaeschkea oligosperma* Knobl., *Cynoglossum wallichii* G.Don, *Codonopsis ovata* Benth., *Salvia* *hians* Royle ex Benth. *Morina longifolia* Wall. ex DC. and *Thermopsis barbata* Benth. were the other dominant species found in the herbaceous community. No tree species were recorded at the alpine belts; however, few open pockets were recorded to have a stagnant growth of *Juniperus recurva* Buch.-Ham. ex D.Don., *Juniperus communis* L. and *Syringa emodi* Wall. ex Royle. The upper regions of the study area, with more than 2000 m amsl, experience heavy snowfall from December to February; the alpine zones remain covered with snow for about six months, whereas the lower reaches (<2000 m a.m.s.l.) receive snowfall for about one month. For the past few decades, annual rainfall has been recorded to be very little and varies from 920 to 940 mm. The physiographic factors (relief, slope, altitude) are strikingly apparent in the soil formation in the Bhallesa Hills and other mountainous regions of the Western Himalayas.

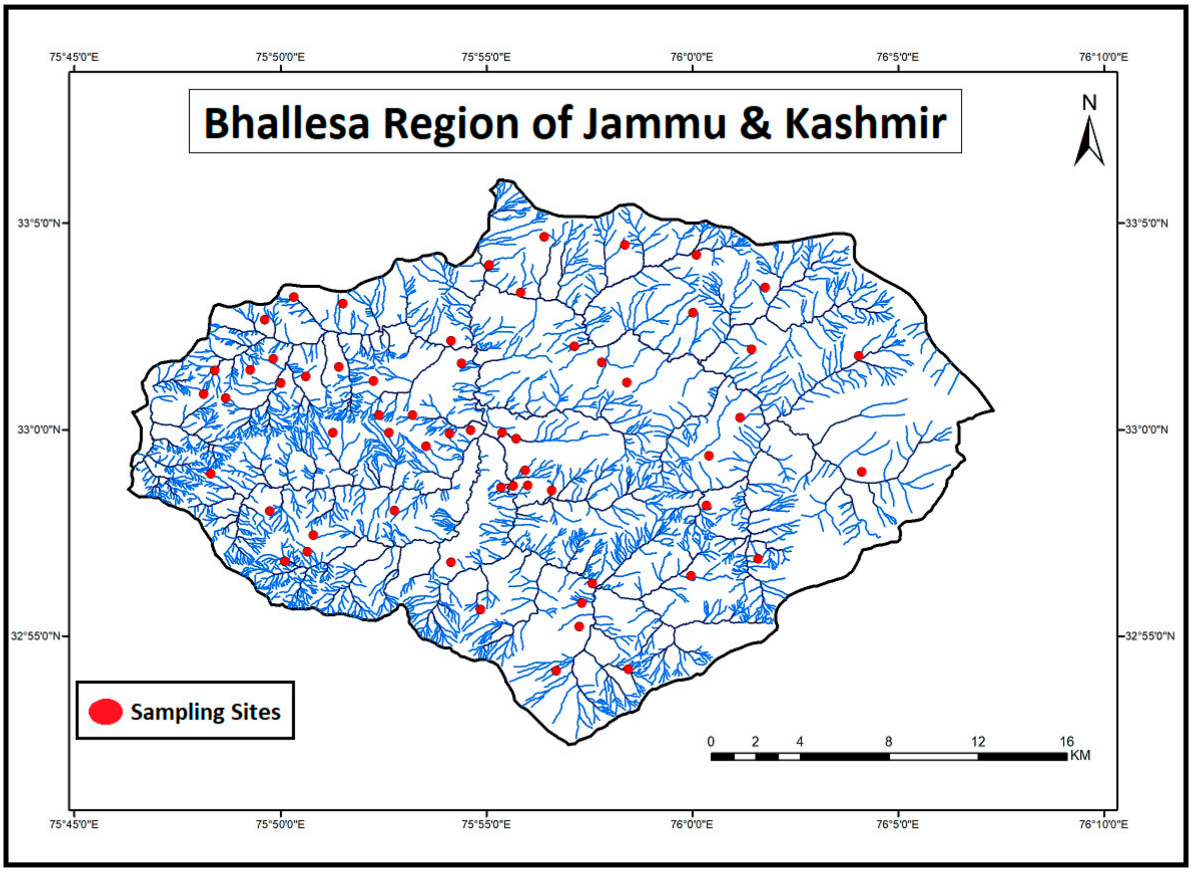

Figure 1. Location map of the study area.

The soils, in general, were recorded to be shallow, mostly skeletal, coarse-textured, calcareous and strongly alkaline in nature. The soil scape of the lower reaches is represented by cryorthents and cryorthids and is shallow, coarse-textured and low in organic matter. The low to medium organic carbon contents recorded and their variations usually occur with the change in altitude, land use and geology of the study area.

2.2. Data Collection

2.2.1. Plant Surveys, Collection and Identification

For inventorying different plant species (higher plants), twenty-four field exploration surveys were carried out from 2018 to 2021 in different growing seasons in the Bhallesa region of the Pir Panjal mountain range. At the onset, the study area was divided into four sub-sites (Chilli, Kahal, Chanwariand Gandoh), and at each site, 25 replicated plots (each measuring 2500 m^2, 50×50 m^2) were established and further divided into plots of 10×10 m for convenience. In order to reduce the effects of spatial autocorrelation, the least distance between the plot ranges was maintained between 500 and 100 m, depending on the geography of the site chosen for surveying and studying. Altogether, 100 plots measuring 250,000 m^2 (or 250 km^2), randomly placed quadrats, were studied to document the entire floristic wealth of Bhallesa. The unapproachable sites and tough mountainous terrains were excluded from laying the quadrat study. The multiple surveys were carried out to account for plant species-specific variations with timing and the duration of fruiting [92] within each sampling plot between 2018 and 2021. Each selected plot was visited six times per year in February, April, June, July, September and November (totalling 24 field tours, covering 119 days).

We inventoried and collected the plant samples categorised as angiosperms, gymnosperms, lycophytes and ferns from four sub-sites located in the study area. The lower groups of plant species belonging to lichens, fungi, algae, bryophytes, etc., were excluded from this study. We focused on collecting the maximum number of species with flowers and fruits from the study area. All the samples collected were first dried and then pressed and processed according to the standard operating procedure of Jain and Rao [93]. Digital photographs, along with the GPS (Manufacturer: Garmin, Country: China) coordinates of all the specimens collected, were taken from the study area. All plant samples were collected in triplicate, and the herbarium sheets (42 × 28 cm) were prepared as per the standard protocols. Most species were identified on-site, and to confirm field identification and for those specimens whose identification was not possible on-site, specimens were taken to the laboratory and identified from the housed specimens at Janaki Ammal Herbarium (JAH) (acronym RRLH). The herbarium acronym is according to Janaki Ammal Herbarium [94]. The microscopic works were undertaken using a light microscope (Olympus Bx 53). The identity of the collected taxa was determined using published regional flora texts, such as *Flora of Udhampur* [95], *Flora of Jammu and Plants of Neighbourhood* [96], *Flora of Trikuta Hills* [97] and *Illustration of Jammu Plants* [98], consulting various monographs, recent research papers and books. Finally, the legitimate scientific names were verified using the World Checklist of Vascular Plants (www.WCVP.org, accessed on 1 December 2021). The representative vouchers of all taxa were accessioned and deposited in the JAH of CSIR-Indian Institute of Integrative Medicine Jammu (J and K, India).

2.2.2. Presentation of Data

In order to investigate the community structure and vegetation composition, the plant specimens were collected from the study area and identified based on their morphological characteristics. During the field surveys, the observations on field characteristics of plants, such as growth form, habitat, ecology, habit, leaf size and lifeforms (Raunkiaer's life form), were focused on and recorded. The distribution of the flowering period of the collected plant samples was included in the study. The extent of the growth form is determined by the direction of the growth of the plant's main axis, categorised into trees, shrubs and herbs [99]. The life forms that were determined by the place of location of the penetrating bud during the favourable season (14) were sub-categorised as geophyte (GE), therophyte (TH), phanerophyte (PH), chamaephyte (CH), hemicryptophyte (HC), liana (L) and epiphyte (Ep). The phanerophyte group of plant communities were again sub-divided into megaphanerophytes (mgPH), mesophanerophytes (msPH), microphanerophytes (mcPH) and nanophanerophytes (nnPH). Investigating the size of the leaves with morphological observations provides a better understanding of studying the climate and the floristic gradients of a given ecosystem [100]. Therefore, the plant species of the study area were investigated based on leaf size and categorised as megaphyll (MG), leptophyll (LP), mesophyll (ME), nanophyll (NP) and microphyll (MI). The angiosperm families were classified and arranged under genera based on the Angiosperm Phylogeny Group IV classification [101]. Other plant groups, such as the gymnosperm, lycophyte and fern, were placed after the flowering plants. The threatened status of each taxon in the study area was cross-checked with the website of the IUCN Red List of Threatened Species (www.iucnredlist.org, accessed on 1 December 2021): NE stands for Not Evaluated, Data

Deficient as DD, Least Concern (LC), Neat Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR) and EW as Extinct in the Wild.

2.3. Data Analysis

The total species richness of the study area was recorded as the cumulative number of plant species present in 100 plots of four sub-sites of the study area during four consecutive years of investigation. The density, frequency and basal cover of each species within each plot were measured according to Misra [102]. The mean species richness was estimated by averaging the number of plant species (higher plants) recorded in 100 plots. The frequency of individual plant species was defined as the number of plots on which the given species was recorded (maximum 100 for all plots or 25 for individual sub-sites). The relative values were summed up to obtain the importance value index (IVI). The plant species diversity was calculated using the Shannon–Wiener function (H′) as

$$H' = -\sum_{i=1}^{n}\left(\frac{ni}{N} \times \ln\frac{ni}{N}\right)$$

where ni indicates the number of individuals of a given species; i and N are the total number of individuals [103].

The Simpson index of diversity (D) was calculated following Magurran [104] as

$$D = \sum_{i=1}^{n}\left(\frac{ni}{N}\right)^2$$

The distributional behaviour of the species was calculated using Pielou's evenness index [105] as

$$J = \frac{H'}{\ln(S)}$$

where S = the total number of species.

The PAST 4.10 statistical analysis software was used to analyse the diversity results easily.

2.4. Literature Sources

The identification of the collected plant specimens was confirmed from earlier scientific studies published in floras, books, revisionary works, journals and monographs, available in the CSIR-Indian Institute of Integrative Medicine (IIIM), CSIR-National Botanical Research Institute (NBRI) and the University of Jammu libraries. All the plant species were botanically compared with the help of the texts *Flora of Udhampur* [95], *Flora of Jammu and Plants of Neighbourhood* [96], *Flora of TrikutaHills* [97], *Illustration of Jammu Plants* [98], and *Flowers of the Himalayas* [106]. APG IV was used for the classification of the flowering plants, and the species' names were verified using the POWO (available at http://www.powo.org, accessed on 12 July 2022), World Checklist of Vascular Plants (available at www.kew.org, accessed on 13 July 2022), International Plant Names Index (available at http:// www.ipni.org, accessed on 13 July 2022), and Tropicos (available at https://www.tropicos.org, accessed on 14 July 2022). For the phenological studies, the collected specimens were categorised according to their flowering seasons as summer (April–June), rainy (July–September), winter (October–December) and spring (January–March). The flowering season of the collected specimens was recorded in the field surveys at different locations in the study area.

3. Results and Discussion

3.1. Floristic Composition and Diversity of Species and Families

In this study, we collected 328 plant taxa samples belonging to 228 genera that were distributed in 78 families under 35 orders (Table 1). Out of the collected samples, 83.23% of species were dicots, followed by monocots at 11.89%, lycophytes and ferns at 2.74% and gymnosperms at 2.13%. The dominant orders included Lamiales with 41 genera

(11.01%), Asterales and Rosales with 23 genera (10.13% each), Poales with 19 genera (8.37%), Caryophyllales with 16 genera (7.04%), Ranunculales with 15 genera (6.60%) and Saxifragales with 7 genera (4.80%). All the flowering plants were arranged according to the APG IV system of classification [101], followed by gymnosperms, lycophytes and ferns.

Table 1. Floristic composition of Bhallesa Hills, Pir PanjalMountain Range, Jammu and Kashmir, India.

Groups	Categories (APG IV)	Selected Plots in Bhallesa Study Area											
		Gandoh			Kahal			Chaunwari			Chilly		
	GPS Coordinates	33°01′56″N, 75°54′47″E			33°01′30″N,76° 01′50″E			32°04′ 52″N, 75 47′42″E			33°02′60″N, 76°02′42″E		
	Elevation (m.a.s.l.)	1625 to 2989			2132 to 3799			1760 to 2887			2225 to 4000		
	Sub-Categories	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.	Fam.	Gen.	Sp.
A. Angiosperms *	I. Magnoliids	1	1	1	0	0	0	0	0	0	0	0	0
	II. Monocots	7	16	18	7	18	21	6	19	24	10	23	27
	II. Eudicots	4	13	14	3	12	15	3	12	15	3	13	18
	III. Superrosids	2	2	2	3	6	9	3	3	3	3	6	10
	IV. Rosids	21	48	57	15	33	36	19	43	52	16	33	39
	V. Superasterids	4	13	16	3	8	13	4	10	16	3	13	14
	VI. Asterids	20	46	56	19	50	66	20	48	63	17	59	76
	Sub-Total	59	137	164	50	127	160	55	135	173	52	147	184
B. Gymnosperms		2	4	5	2	4	4	2	4	4	3	6	7
C. Lycophytes and Ferns		4	5	6	5	7	8	4	5	7	4	4	4
** Total		65	146	175	57	138	172	61	144	184	59	157	195

* For angiosperms only; ** total 328 species, 228 genera, 78 families and 35 orders; total 256 herbs, 43 shrubs, 29 trees; m.a.s.l. (meter above sea level); total 273 dicotyledons; total 39 monocotyledons; total 7 gymnosperms; total 9 lycophytes and ferns.

The ten dominant families, with respect to the species richness recorded from the area, are Asteraceae (34), Lamiaceae (21), Rosaceae (21), Poaceae (20), Ranunculaceae (18), Polygonaceae (14), Apiaceae (10), Brassicaceae (10), Plantaginaceae (9) and Fabaceae (8). A total of 28 monotypic families with single species were found in the study area, where 3 families were recorded as having 5 species, 9 families with 4 species, 13 families with 3 species and 9 families with 2 species were collected from the study area. These research studies show a similar pattern of work carried out by Dar and Khuroo [80] in the Kashmir Himalayan region and found Asteraceae, Lamiaceae, Poaceae, Rosaceae and Polygonaceae as the most important and dominant families. Similar studies conducted by Chawla et al. [81] reported Poaceae and Asteraceae as the dominant families in the Bhabha valley of the Western Himalayas. In another similar work carried out by Sharma et al. [107], in the Sangla valley of Northwestern Himalaya, Asteraceae, Rosaceae, Apiaceae and Ranunculaceae were reported as the dominant families. Other studies published by Bhat et al. [87], Agrawal [108], Shaheen et al. [109] and Haq et al. [110] also show and support this research finding carried out in the Bhallesa regions of the Himalayas.

As a general observation, the species richness varies depending on the site selected for a research study. The results show that the number of species varies from 173 (Kahal plots) to 197 (Gandoh plots). We found great variation in the basal area of tree species, which varies from 44.16 ± 14.29 m^2 ha^{-1} (Gandoh plots) to 144.52 ± 29.60 m^2 ha^{-1} (Chilli plots). The density of tree species also varies from 136 (Kahal plots) to 240 plants ha^{-1} (Chilli plots). The highest density of the shrub community was recorded at Chilli (1056 ha^{-1}), whereas the lowest was found at 656 plants ha^{-1} in Gandoh. In the herb community, the density was found to be highest at Chanwari (206,000 plants ha^{-1}), whereas the lowest density was recorded at the Gandoh site (146,400 plants ha^{-1}) (Table 2). The results showed that the species richness (S) did not reveal any significant ($p > 0.05$) changes. The results of the diversity measures (H′: Shannon–Wiener index; D: Simpson index of diversity; J: Pielou's evenness index) across plots are provided in Table 2. The highest H′ is recorded at 2.78 ± 0.41 for the trees and shrubs (H′ = 2.92 ± 0.77) at the Gandoh site, whereas

Chilliwas recorded to have the highest H′: 4.77 for herbs. The highest Simpson index of diversity (D) was recorded for the trees (D = 0.91 ± 0.28) and shrubs (0.94 ± 0.33) at the Gandoh site. The Chilli site recorded the highest Simpson index for herbs (0.99). The highest Pielou's evenness index (J) was recorded at the Chanwari site for trees (0.83 ± 0.04), followed by Gandoh (0.71 ± 0.11), Kahal (0.64 ± 0.04) and Chilli (0.54 ± 0.08). The details are provided in Table 2. The plant species having the highest importance value index (IVI) varies location-wise. *Pinus wallichiana* A.B.Jacks., *Cedrus deodara* (Roxb. ex D.Don) G.Don, *Picea smithiana* (Wall.) Boiss, *Abies pindrow* (Royle ex D.Don) Royle, *Acer caesium* Wall. ex Brandis, *Aesculus indica* (Wall. ex Cambess.) Hook., *Rhododendron arboreum* Sm. and *Juglans regia* L. were the plant species with the highest IVIs in the study area. The lowest IVIs were recorded for *Corylus colurna* L. (IVI=4.93), followed by *Crataegus songarica* K.Koch (5.18), *Morus alba* L. (5.60), *Litsea glutinosa* (Lour.) C.B.Rob. (5.69) and *Alnus nitida* (Spach) Endl. (5.82) (Table 3). The IVI varies for *Pinus wallichiana*(IVI = 58.72 to 107.42), *Cedrus deodara* (34.53 to 69.11), and *Picea smithiana* (21.98 to 36.04) in the study area. The soil depth, high moisture retention capacity and relatively high temperatures are all factors that contribute to the high diversity of ecosystems. In a recent study undertaken by Wen et al. [111], in the alpine meadows of Qinghai-Tibet Plateau in China, proven ecosystems in the high-altitude regions are more sensitive, ecologically fragile and respond more rapidly than any other ecosystems to global climate warming. The results showed that short-term warming increases the air temperature by 0.31 °C and decreases relative humidity by 2.54%, which leads to a decrease in the importance value of grasses by 47.56% and sedges by 3.67%. In this study, it is reported that the species diversity indices increased at the early stage of warming and decreased at the late stage of warming, but none of them reached significant levels ($p > 0.05$), and also, the species diversity had no significant correlation with the soil temperature and soil moisture under both short-term and long-term warming. Many earlier botanists and ecologists carried out similar research studies in the different pockets of the Western Himalayas at different periods. Some renowned works showing similar findings include Malik and Bhatt [112], Tiwari et al. [113] and Haq et al. [114].

Table 2. Plant species richness, basal area, density and diversity indices for Bhallesa forested regions (Chilli, Kahal, Chanwari, Gandoh) of Pir Panjal Range, Jammu and Kashmir, India.

Categories	Tree Community				Shrub Community				Herb Community			
	Cl	Ka	Ch	Gd	Cl	Ka	Ch	Gd	Cl	Ka	Ch	Gd
Plant species richness	13	13	15	23	25	19	20	22	157	139	150	130
Number of families	9	9	10	15	18	16	16	17	45	43	43	41
Basal area (m^2 ha^{-1})	144.52 ± 29.60	85.08 ± 20.43	119.24 ± 15.18	44.16 ± 14.29	-	-	-	-	-	-	-	-
Density (ha^{-1})	240	136	216	192	1056	816	672	656	191,200	196,800	206,000	146,400
H′	1.95 ± 0.50	2.12 ± 0.47	2.52 ± 0.32	2.78 ± 0.41	2.81 ± 0.36	2.73 ± 0.87	2.71 ± 0.67	2.92 ± 0.77	4.77	4.68	4.67	4.59
D	0.77 ± 0.27	0.82 ± 0.13	0.89 ± 0.32	0.91 ± 0.28	0.91 ± 0.37	0.92 ± 0.45	0.91 ± 0.38	0.94 ± 0.33	0.99	0.98	0.98	0.98
J	0.54 ± 0.08	0.64 ± 0.04	0.83 ± 0.04	0.71 ± 0.11	0.66 ± 0.06	0.81 ± 0.13	0.79 ± 0.09	0.84 ± 0.12	0.75	0.78	0.72	0.76

Cl: Chilli, Ka: Kahal, Ch: Chanwari, Gd: Gandoh; H′: Shannon–Wiener index, D: Simpson index of diversity, J: Pielou's evenness index.

Table 3. Proportion (%) of basal area, density and IVI for various tree species ofBhallesa forested regions (Chilli, Kahal, Chanwari, Gandoh) of Pir Panjal Range, Jammu and Kashmir, India.

Taxa	Basal Area (m^2 ha^{-1})				Density (ha^{-1})				IVI			
	Cl	Ka	Ch	Gd	Cl	Ka	Ch	Gd	Cl	Ka	Ch	Gd
Abies pindrow (Royle ex D.Don) Royle	7.68	0.00	0.00	0.00	24	0	0	0	25.84	0.00	0.00	0.00
Acer caesium Wall. ex Br.	0.00	1.84	4.60	1.84	0	8	20	8	0.00	16.76	22.46	11.07
Aesculus indica (Wall. ex Camb.) Hook.f.	3.84	1.92	5.76	1.68	8	4	12	4	11.25	9.55	17.28	6.15
Alnus nepalensis D.Don	5.88	1.96	0.00	0.00	12	4	0	0	14.33	9.59	0.00	0.00
Alnus nitida (Spach) Endl.	0.00	0.00	3.92	1.28	0	0	8	4	0.00	0.00	10.44	5.82
Betula utilis D.Don	2.16	2.16	0.00	0.00	4	4	0	0	5.79	9.83	0.00	0.00
Cedrusdeodara (Roxb. ex D.Don) G.Don	39.16	24.92	17.80	42.00	44	28	20	28	69.11	62.92	34.53	56.77
Celtis australis L.	0.00	3.00	6.00	3.44	0	4	8	4	0.00	10.82	12.18	7.58
Corylus colurna L.	0.92	0.00	0.00	1.98	4	0	0	8	4.93	0.00	0.00	11.13
Crataegus songarica K.Koch	1.28	0.00	0.00	0.00	4	0	0	0	5.18	0.00	0.00	0.00
Ficus hispida L.	0.00	1.36	4.08	1.32	0	4	12	4	0.00	8.89	12.43	5.86
Ficus palmata Forssk.	0.00	0.00	0.00	1.44	0	0	0	4	0.00	0.00	0.00	5.95
Fraxinus excelsior L.	0.00	1.28	1.28	1.56	0	4	4	4	0.00	8.79	6.37	6.05
Juglans regia L.	5.92	2.96	8.88	3.48	8	4	12	4	12.69	10.77	16.45	7.61
Juniperus communis L.	3.84	0.00	0.00	2.88	12	0	0	8	12.92	0.00	0.00	11.91
Litsea glutinosa (Lour.) C.B.Rob.	0.00	0.00	0.00	1.12	0	0	0	4	0.00	0.00	0.00	5.69
Morus alba L.	0.00	0.00	2.80	1.00	0	0	8	4	0.00	0.00	9.50	5.60
Picea smithiana (Wall.) Boiss	11.76	11.76	19.60	12.72	12	12	20	12	18.40	31.34	36.04	21.98
Pinus wallichiana A.B.Jacks	57.00	27.36	29.64	18.24	100	48	52	48	107.42	97.89	73.07	58.72
Platanus orientalis L.	0.00	0.00	0.00	1.84	0	0	0	4	0.00	0.00	0.00	6.28
Populus ciliata Wall. ex Royle	0.00	0.00	0.00	3.04	0	0	0	8	0.00	0.00	0.00	12.04
Quercus floribunda Lindl. ex A.Camus	0.00	0.00	5.04	1.96	0	0	12	4	0.00	0.00	1.68	6.38
Quercus ilex L.	0.00	0.00	1.44	4.64	0	0	4	8	0.00	0.00	6.51	10.63
Quercus semecarpifolia Sm.	0.00	2.88	0.00	0.00	0	8	0	0	0.00	13.62	0.00	0.00
Rhododendron arboreum Sm.	1.68	1.68	5.04	3.56	4	4	12	4	5.48	9.26	13.23	7.67
Robinia pseudoacacia L.	0.00	0.00	0.00	2.28	0	0	0	4	0.00	0.00	0.00	6.64
Taxus wallichiana Zucc.	3.40	0.00	0.00	0.00	4	0	0	0	6.65	0.00	0.00	0.00
Trema orientale (L.) Blume	0.00	0.00	0.00	6.96	0	0	0	8	0.00	0.00	0.00	15.22
Ulmus wallichiana Planch.	0.00	0.00	3.36	3.04	0	0	12	4	0.00	0.00	11.82	7.25

Cl: Chilli, Ka: Kahal, Ch: Chanwari, Gd: Gandoh; IVI: importance value index; m^2: square meter; ha^{-1}: per hectare.

3.2. Species Diversity in Different Growth Forms

Of the total number of the collected species, 256 (78.28%) of the species were herbs, followed by shrubs (44 sp., 13.45%), and 27 species (8.25%) of plants represent trees. Our study reveals that the trees and shrub community decrease with the increase in altitude, and the herb species follow a reverse trend because they increase as the altitude increases. Herbs show the most advanced and successful growth forms as they easily adapt to a wide range of habitats.

Out of the total collected specimens, 271 (82.87%) are dicots, 40 (12.32%) are monocots, 9 (2.75%) are lycophytes and ferns, and 7 (2.14%) are gymnosperms. In this study, 51 species (15.59%) represent an annual life span. The most common annuals collected from the study area were: *Arabis alpina* L., *Digitalis purpurea* L., *Draba nuda* (Bel.) Al-Shehbaz & M. Koch, *Impatiens balfourii* Hook.f., *Mazus pumilus* (Burm.f.) Steenis, *Galinsoga parviflora* Cav., etc. A total of 276 plant taxa were found to be perennial, comprising 84.40% of the total flora collected from the study area. The perennial plants were mostly shrubs and trees. The majority of trees and shrubs growing in the study area are evergreen coniferous species, such as *Abies pindrow*, *Cedrus deodara*, *Pinus wallichiana* and *Piceasmithiana*. Deciduous plants, such as the *Acer caesium*, *Aesculus indica*, *Celtis australis* L., *Viburnum grandiflorum* Wall. ex DC. and *Parrotiopsis jacquemontiana* (Decne.) Rehder, are also frequent in the study area. Data on the life-span findings from the study area was found similar to that of Subramani et al. [115], in which the research on life-span studies was carried out in the Northwestern Himalayas. Torresani et al. [22] estimated tree species diversity from space in an alpine conifer forest and attempted to test the spectral variation hypothesis (SVH). The results of this study showed that the spectral variation in species is season and sensor-dependent, and the coefficient of variations depends on the temporal tendency of the species. Other research findings by Saha [116] on the dominant lifeforms in the Darjeeling regions of the

Northeastern Himalayas show a similar pattern to our findings. Rawat and Adhikari [117] studied the Changthang plateau of the Ladakh region for altitudinal gradients showing similar patterns to these findings, and the results correlate with the already existing research study. Other similar research includes Namgail et al. [118] and Pharswan and Mehta [119] in the Western Himalayas. Nautiyal et al. [120] conducted studies in the Tungnath area of the Kumaon Himalaya that show a similar pattern to the research findings in our study of the Bhallesa region. In these research findings, the angiosperms species, their diversity and growth forms in the Bhallesa Hills were the most dominant in the lower altitudes, whereas the members of the gymnosperm show their presence in the higher regions of the study area. Earlier research findings, such as Mir et al. [121] in the Kashmir Himalayas and Dogra et al. [122], studied plant diversity in the Western Himalayas in Himachal Pradesh with similar types of elevation and climate, and these studies also support our research findings from Bhallesaof Pir Panjal Mountain.

Another study by Gaston et al. [123], carried out in the Western Himalayas, also shows a similar pattern to our research and also proves that the destruction of habitat and hunting threatens temperate forest resources. Another research study by Gairola et al. [124] shows floristic analyses in the Western Himalayas of the Gharwal division of Uttarakhand and reported similar outcomes to our research findings.

3.3. Life Forms and Biological Spectrum

The biological spectra of Bhallesa Hills show chamaephytes as the most dominant group, representing a total of 27.74% (91 taxa), followed by therophytes having 82 taxa (25%), 65 phanerophytes (19.82%), 46 hemicryptophytes (14.02%) and 37 geophytes (11.28%) (Figure 2). Lianas (6 taxa, 1.83%) and epiphytes (1 taxon, 0.3%) represent the lowest life forms of coniferous forests of the Bhallesa region. Among the phanerophytes, the nano-phanerophytes (nnPH), represented by 19 taxa (29.23%), were more dominant than the megaphanerophytes (mgPH) comprising 18 taxa (27.69%), microphanerophytes (mcPH) comprising 17 taxa (26.15%) and mesophanerophytes (msPH) with 11 taxa (16.92%) (Figure 3, Table 4). The chamaephytes, followed by the therophytes growing in the Bhallesa regions, show a maximal divergence from Raunkiaer's normal spectra. An increase in the number of phanerophytes and therophytes shows that the community has a warmer climate [125,126], whereas the chameophytes and hemicryptophytes were confined to the cold regions. The biotic and abiotic disturbances in a particular area tend to increase the number of therophytes in the area. A study carried out by Deljouei et al. [127] in the temperate hornbeam-beech forests of Northern Iran recorded hemicryptophytes (54.8%) as the dominant biological spectrum group, followed by the cryptophytes (25.8%), therophytes (11.3%), phanerophytes (4.8%), and chamaephytes (3.3%). Furthermore, the diversity index of different species decreases when the distance of disturbance increases; this decreasing trend continued up to 60m from the forest road margin, and after this threshold, the index slightly increased.

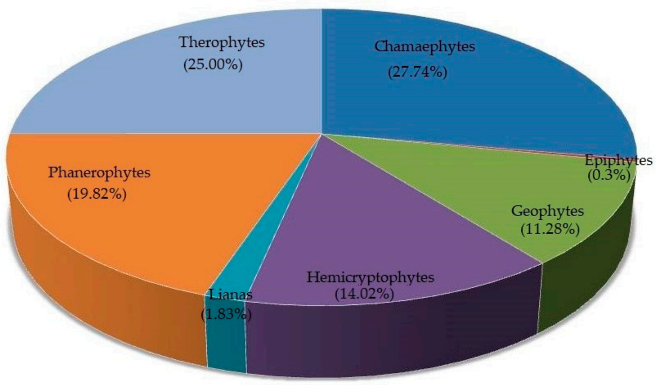

Figure 2. Biological spectra of the taxa recorded in the Bhallesa region (Jammu and Kashmir), Western Himalayas, India, based on Raunkiaer's system of classification.

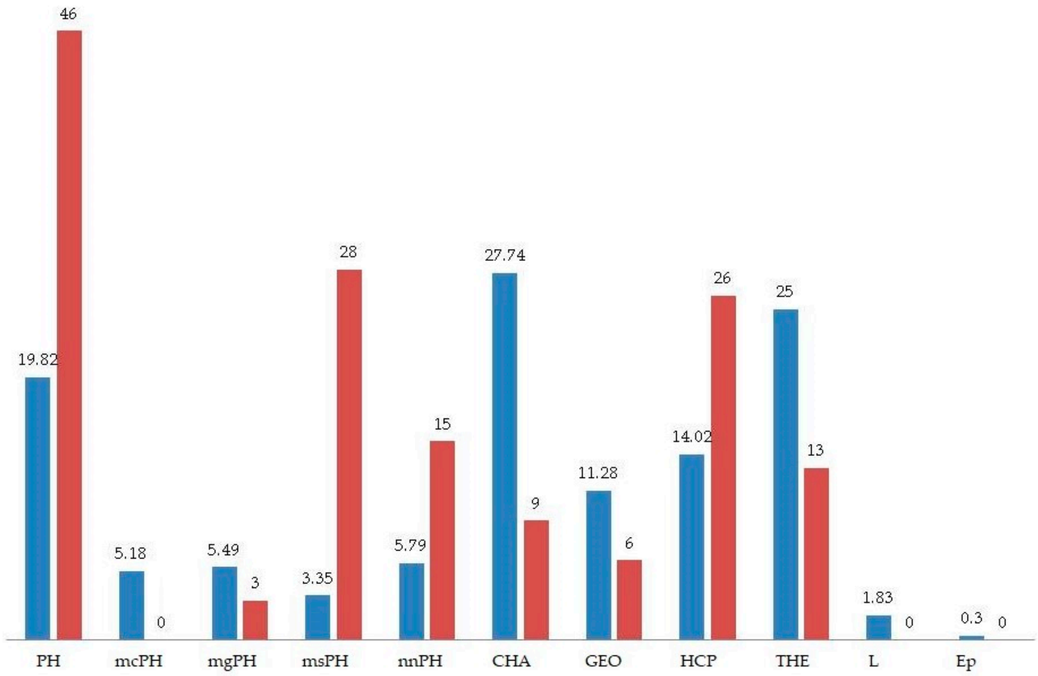

Figure 3. Comparison of the biological spectra of the taxa recorded in the Bhallesa region (Jammu and Kashmir), Western Himalayas, India, with Raunkiaer's normal spectra (PH: phanerophytes; mcPH: microphanerophytes; mgPH: megaphanerophytes; msPH: mesophanerophytes; nnPH: nanophanerophytes; CH: chamaephytes; GE: geophytes; HC: hemicryptophytes; TH: therophytes; L: lianas, Ep: epiphytes; 0* was taken into consideration for deviation analysis).

Table 4. Biological spectra (% of all lifeforms) of Bhallesa Hill (Jammu and Kashmir), Pir Panjal Mountain, India and its comparison with Raunkiaer's normal spectra.

Raunkiaer's Life Forms	Number of Plant Taxa	Biological Spectra (%) of Study Area	Raunkiaer's Normal Worldwide Spectra (%)	Deviation = Raunkiaer's Normal Spectra–Biological Spectra (%) of Study Area
PH *	65 *	19.82	46.00	26.18
mcPH	17	5.18	0.00 **	–5.18
mgPH	18	5.49	3.00	–2.49
msPH	11	3.35	28.00	24.65
nnPH	19	5.79	15.00	9.21
CH	91	27.74	9.00	–18.74
GE	37	11.28	6.00	–5.28
HC	46	14.02	26.00	11.98
TH	82	25.00	13.00	–12.00
L	6	1.83	0.00 **	–1.83
Ep	1	0.30	0.00 **	−0.30
Total	328	100.00	100.00	-

Raunkiaer's lifeforms: GE—geophyte (perennial herbaceous species with complete periodic reduction of shoot system to storage organs); TH—therophyte (annuals whose root and shoot system dies after seed production within a year); PH *—phanerophyte (woody plants that grow >50 cm, whose shoots do not die back periodically to that height); CH—chamaephyte (woody perennial plants that grow <50 cm above the ground surface, whose shoots die back periodically to that height and above); HC—hemicryptophyte (perennial herbaceous species with periodic remnant reduction of shoot system that lies on the ground); L—liana (plants that grow by supporting themselves with other plants and are rooted in the ground); Ep—epiphyte (plants that grow by supporting themselves with other plants, bears roots on other plants and germinates). Raunkiaer's sub-type phanerophyte life forms: mgPH—megaphanerophyte (>30 m tall); msPH—mesophanerophyte (8–30 m); mcPH—microphanerophyte (2–8 m); nnPH—nanophanerophyte (0.5–2 m). ** Value zero (0) was taken into consideration for deviation data.

Similar studies by Cain [128], Daubenmire [129], Vashistha et al. [130], and Saxena et al. [131] also reported a decrease in woody flora in the higher altitudes with an increase in the percentage of cryptophytes and hemicryptophytes. In our study, the correlation between altitude and lifeforms was carried out, and we found that the phanerophytes decrease with increasing altitude. Thus, the low temperature at high altitudes is a controlling factor for the growth of phanerophytes and therophytes. Our study revealed that the chamaephytes with geophytes and hemicryptophytes were found at higher altitudes, and the phanerophytes and therophytes were confined to the lower heights in the study area. Similar research studies were conducted by Saxena et al. [131] on the lifeforms at high altitudes in the Kumaon Himalayan regions; Singh and Bedi [132] studied similar research in different regions of the Western Himalayas, supporting our research findings. Regarding the research study by Das et al. [133] in different pockets of the Western Himalayas, we found similar results by comparing our research findings. During the field study, we found the population of many plant taxa was decreasing and were at risk of extinction; therefore, we feel that interactions and support with the local people and the forest department of the area should take proper management steps to protect the declining plant species and the vegetation composition of the Bhallesa region.

Workers such as Dobhal et al. [134] conducted comparable experiments in the Western Himalayas and found similar types of biological spectra in similar environmental conditions. According to their findings, therophytes were dominant, which is similar to our observations. Ghildiyal and Meenakshi [135] carried out similar studies in a similar region of the Western Himalayas and showed phanerophytes as dominant life forms along with therophytes. Ghildiyal et al. [136] had undertaken a similar study in the identical topographical zone in Garhwal Himalaya and presented 'thero-phanerophytic' rich life forms, which again support our studies. Furthermore, many other researchers, such as Thakur et al. [137], have undertaken similar studies in the Himachal of the Western Himalayas. According to their observations, therophytes were dominant in the region, which has very similar types of climatic conditions. Kapoor and Singh [138] have undertaken similar studies in the Shimla hills of the Western Himalayas and have very much achieved the same findings, which validate our results. Particularly in Jammu and Kashmir, many botanists have carried out studies on the biological spectrum in different regions of UT. Sharma and Raina [139] have undertaken similar studies in the Jammu region of the Western Himalayas. According to their observations, therophytes were dominant, similar to our research in the Himalayan ecosystem/habitat of Jammu and Kashmir, the Western Himalayas. Raina and Kumar [140] carried out studies on biological spectra in the Kishtwar district of Jammu and Kashmir, and our study also shows certain similarities with respect to species composition and family abundance. Again, according to their work, therophytes were the dominant lifeforms that experienced similar topographic conditions of Bani Valley and Sarthal Hill. In district Kathua, Singh et al. [84] carried out similar studies and indicated a thero-phanerophytic type, which again validates our research findings obtained from Bhallesa mountain.

3.4. Leaf Size Spectrum

Leaf size spectra of the study area show 27 leptophyllous (8.23%), 139 nanophyllous (42.38%), 72 microphyllous (21.95%), 80 mesophyllous (24.39%) and 10 megaphyllous (3.05%) (Table 5). Nanophyllous were found to be the highest among the collected specimens, followed by mesophyllous, microphyllous, leptophyllous and megaphyllous. In this study, we have seen that the large-leaved species are found to occur in moist and warm climates, and smaller leaves are found in dry and cold climates. The data provided by Wright et al. [31] for the study of leaves for 7670 plant taxa, along with the climate data from 682 different sites of the world, also suggests that plants with large leaves occur in a wet and hot climate, whereas plants with small leaves occur in high-altitude areas [141]. Haq et al. [110] and his group also suggested that plants with microphyllous and nanophyllous leaves were mostly confined to the higher altitude reaches of the Himalayas. The study on the floristic composition and biological spectrum, conducted in the Keran valley of Kashmir Himalaya, recorded 183 species, where the herbaceous growth form was dominant (67% species) and mesophylls (34%) followed by nanophylls (29%) and microphylls (27%) were major leaf size categories, and therefore, these results confirm the similar findings which we observed in the Bhallesa Hills [120]. This study also confirms that the herbaceous taxa are dominant in the upper regions of the mountains. Shaheen et al. [109] also studied similar patterns of life forms in the Western Himalayas.

Table 5. Leaf spectra (% of all life forms) of Bhallesa regions (Jammu and Kashmir), Pir Panjal Mountain, Himalayas, India.

Raunkiaer's Life Forms	Number of Plant Taxa	Percentage (%)
LP	27	8.23
MS	80	24.39
MI	72	21.95
MG	10	3.05
NP	139	42.38
Total	328	100.00

MG: megaphyll, LP: leptophyll, MS: mesophyll, NP: nanophyll (NP), MI: microphyll.

3.5. Phenological Periods

The flowering periods of the plant specimens collected from the study area were categorised into four different groups. From January to March, a total number of 20 species were recorded in the flowering stage (6.10%), followed by 118 taxa observed flowering in April to June (35.98%), 171 taxa in July to September (52.13%), and only 19 taxa were seen flowering from October to December (5.79%) (Figure 4). It has been observed that the species growing in the Bhallesa mountain area prefer flowering between July and September, as most of the study regions fall under the temperate zone, which experiences extreme snowfall in the winter season. The plants growing in the region flourish by making their penetrating buds dormant to overcome harsh conditions. Due to this, the plants growing in various habitats mostly bloom in the summer and spring seasons. From July to September, the study area received the maximum of its rainfall; therefore, the high rain allowed the plants to bloom and grow. Several studies, which were undertaken in the past on phenology and the discovery of new plants in the last fifty years, supported the quantitative and phonological studies, better providing a clear picture of the vegetation composition of the area [142]. Kala [143] studied the phenology of sub-aline and alpine plants in the Valley of Flowers National Park and Hemkund, situated in Uttarakhand (Western Himalaya), and recorded April as the month of a favourable growing season, and seed dehiscence was completed from September to October. Another study, undertaken by Pangtey et al. [144], recorded the various developmental stages of 148 species of high-altitude regions of the Pindari glacial moraine area of Kumaun of Central Himalaya (India), concluding that most of the plants on high hills and valleys complete their growth cycles within a short period of favourable conditions to ensure the survival of their progeny—the June to October months are the peak phenophase period. Furthermore, this finding of our study shows similar patterns to the existing studies carried out in mountainous regions by several various other researchers across the globe [145].

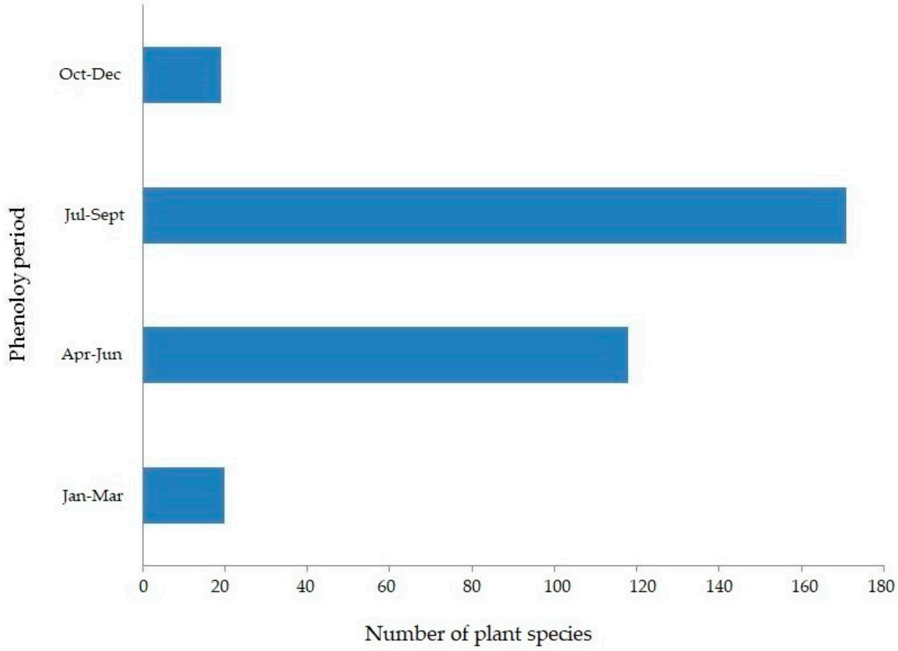

Figure 4. Phenology of the studied plant taxa in Bhallesa region, Pir Panjal Range, Himalayas.

3.6. Alien Taxa

Out of the total 328 taxa inventoried from the Bhallesa region, 31.49% (103 taxa) are alien species, while 68.50% (224 taxa) are native to the Asian or Himalayan regions (Table 6). Mostly, the alien plant taxa found growing in the season show affinities with European and American origins. The most common alien species found in the area are: *Achillea millefolium* L., *Cirsium arvense* (L.) Scop., *Cerastium glomeratum* Thuill., *Carum carvi* L., *Arisaema jacquemontii* Blume, *Campanula pallida* Wall., *Galinsoga parviflora* Cav., *Jasminum grandiflorum* L., *Amaranthus caudatus* L. and *Oenothera biennis* L. Alien species are the potential invaders of the Himalayas. Some earlier studies by Maheshwari [146], who studied naturalised flora, have shown that Indian flora constitutes nearly 18% of the alien flora. A few more studies have also shown the alien taxa of the different regions of India without any perspective on plant invasion in their mind, and important studies include Sharma and Pandey [147], Pandey and Parmar [148] and Nagar et al. [149]. A study conducted by Shrestha [150] on invasive alien plant species in Nepal reported that both the population and number of alien plant species are continuously increasing, and climate changes are likely to intensify the biological invasions in time to come by increasing climatically suitable areas. Alien taxa have more phenotypic plasticity than native plant species, and due to their various superior characteristics, they can easily colonise the wastelands and natural habitats compared to the native species [151–154]. The families with most of the alien species in India include taxa belonging to Asteraceae, Poaceae, Brassicaceae, Fabaceae and Lamiaceae [155], and these families are found consistent with similar findings undertaken in India [156], Australia [157] and New Zealand [158]. A total of 31.25% of alien species were recorded from the study area, and the values are comparable with the studies reported by Kohli et al. [159] from the Northwestern Himalayan region of Himachal Pradesh, India. Various studies have also reported *Ageratum conyzoides* L., *Lantana camara* L. and *Parthenium hysterophorus* L. as the most dangerous invasive species regarding the Indian climate, and these species would exert a significant impact on the native communities, resulting in drastic displacement and imbalance in the natural and agriculture ecosystems [159].

Table 6. Plant composition of Bhallesa region of District Doda, Jammu and Kashmir, Pir Panjal Himalayan Mountain of India.

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer′s Life Forms	Raunkiaer′s Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Magnoliids										
Laurales Juss. ex Bercht. & J.Presl										
Lauraceae Juss.										
Litsea glutinosa (Lour.) C.B.Rob. (54,761)	T	P	Sep–Oct	Sparse forests and thickets	PH	msPH	MI	LC	Himalayas	N
Monocots										
Acorales Mart.										
Acoraceae Mart.										
Acorus calamus L. (56,255)	H	P	Jul–Sep	River Banks	GE		NP	LC	North America	A
Alismatales R.Br. ex Bercht & J.Presl										
Araceae Juss.										
Arisaema flavum (Forssk.) Schott. (56,347)	H	P	Jun–Jul	Field margins	GE		MS	NE	Asia	N
Arisaema jacquemontii Blume (57,631)	H	P	Apr–Jun	Open forests	GE		MS	LC	North America, Eurasia	A
Dioscoreales Mart										
DioscoreaceaeR.Br										
Dioscorea bulbifera L. (57,667)	S	A	Jul–Sep	Mixed forests	L		NP	NE	Himalayas	N
Liliales Perleb										
Liliaceae Juss.										
Fritillaria cirrhosa D.Don (56,291)	P	H	Aug–Oct	Alpine thickets and scrubs	HC		LP	NE	Asia	N
Asparagales Link										
Orchidaceae Juss.										
Calanthe tricarinata Lindl. (57,667)	H	P	Apr–Jun	Grassy slopes	GE		NP	NE	Himalayas	N
Dactylorhiza hatagirea (D.Don) Soo (56,210)	H	P	Jul–Sep	Alpine scrubs and thickets	GE		NP	NE	Indian subcontinent	N
Epipactis helleborine (L.) Crantz (57,602)	H	P	Jul–Sep	Moist shady places	GE		MI	LC	Asia and Africa	A
Iridaceae Juss.										
Iris hookeriana Foster (55,708)	H	P	Apr–Jun	Grassy slopes	GE		NP	NE	Himalayas	N
Iris kashmiriana Baker (55,721)	H	P	Jun–Jul	Grassy areas, graveyards	GE		NP	NE	Himalayas	N
Amaryllidaceae J.St.Hil										
Allium humile Kunth (56,229)	H	P	Jun–Jul	Alpine thickets and rocky crevices	GE		MI	NE	Himalayas	N
Allium stracheyi Baker (56,228)	H	P	Jun–Jul	Alpine thickets and rocky crevices	GE		MI	NE	Himalayas	N
Asparagaceae Juss.										
Asparagus filicinus Buch.–Ham. ex D.Don (54,548)	H	S	May–Jul	Moist shady places	PH	nnPH	MI	DD	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Maianthemum purpureum (Wall.) La Frankie (56,231)	H	P	Jun–Jul	Forest Thickets and slopes	CH		MS	NE	Himalayas	N
Polygonatum cirrhifolium (Wall.) Royle (56,230)	H	P	Jun–Aug	Forest Thickets and margins	GE		LP	NE	Himalayas	N
Polygonatum verticillatum (L.) All. (56,224)	H	P	Jun–Aug	Forest Thickets and margins	GE		LP	NE	Eurasia	A
Poales Small										
Cyperaceae Juss.										
Carex nivalis Boott (55,767)	P	H	May–Jun	Hill slopes	HC		MI	NE	Eurasia	A
Cyperus niveus Retz. (56,348)	H	A	Sep–Oct	Stream sides	TH		MI	NE	Asia	N
Cyperus rotundus L. (56,408)	H	A	May–Jun	Grasslands	TH		MI	LC	Africa and Europe	A
Poaceae Barnhart										
Alopecurus arundinaceus Poir. (56,319)	H	P	Jul–Sep	Grasslands and slopes	HC		NP	LC	Eurasia	A
Arthraxon lanceolatus (Roxb.) Hochst. (56,336)	H	A	Jul–Sep	Rocky surfaces	TH		NP	LC	Eurasia	A
Bothriochloa ischaemum (L.) Keng (56,337)	H	A	May–Jun	Grasslands	TH		MI	NE	Indian subcontinent	N
Capillipedium parviflorum (R.Br.) Stapf (57,651)	H	P	Jul–Sep	Mountain slopes	TH		NP	NE	Europe	A
Cenchrus flaccidus (Griseb.) Morrone (56,421)	H	A	May–Jun	Waste areas	HC		MS	LC	South Africa	A
Chrysopogon fulvus (Spreng.) Chiov. (56,317)	H	A	Jun–Jul	Moist shady places	TH		MS	NE	Asia	N
Chrysopogon gryllus (L.) Trin. (56,339)	H	P	Aug–Sep	Moist shady places	HC		MS	NE	Eurasia	A
Cynodon dactylon (L.) Pers. (56,260)	H	P	Sep–Dec	Road sides open areas	HC		NP	NE	Africa	A
Echinochloa crus–galli (L.) P.Beauv (56,403)	H	P	May–Jun	Forest margins and road sides	HC		NP	LC	South Africa	A
Elymus semicostatus (Steud.) Melderis (56,432)	H	P	Jul–Aug	Mountain slopes	HC		NP	NE	Indian subcontinent	N
Isachne himalaica Hook.f. (65,322)	H	P	May–Jun	Moist, swampy areas	HC		NP	NE	Himalayas	N
Melinis minutiflora P.Beauv. (56,323)	H	P	Jul–Aug	Field margins and road sides	HC		MS	NE	Africa	A
Miscanthus nepalensis (Trin.) Hack. (56,326)	H	P	Aug–Sep	Mountain slopes and valleys	HC		MS	NE	Himalayas	N
Panicum virgatum L. (56,329)	H	P	Jul–Aug	Field sides	TH		NP	LC	NorthAmerica	A
Poa annua L. (56,304)	H	A	Apr–Jun	Moist shady places	TH		MS	LC	SouthAmerica	A
Polypogon fugax Nees ex. Steud. (56,328)	H	A	Jul–Aug	Moist shady places in forests	TH		NP	NE	SouthAmerica	A
Saccharum fillifolium Steud. (56,309)	H	P	Apr–Jun	Grasslands	TH		NP	NE	Himalayas	N
Saccharum spontaneum L. (56,318)	H	P	Jul–Aug	Hill slopes	HC		NP	LC	Indian subcontinent	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Setaria italica (L.) P.Beauv. (56,330)	H	P	Jul–Aug	Slopes and Waste lands	TH		MS	NE	Africa	A
Setaria viridis (L.) P.Beauv. (56,331)	H	P	May–Jun	Roadsides and field margins	TH		LP	NE	Asia	N
II. Eudicots										
Ranunculales Juss. ex Bercht. & J. Presl										
Papaveraceae Juss.										
Corydalis diphylla Wall. (57,665)	H	P	Apr–Jun	Steam sides, shady places	GE		NP	NE	Himalayas	N
Corydalis vaginans Royle (57,665)	H	P	Apr–Jun	Stream sides, rock crevices	GE		NP	NE	Himalayas	N
Corydalis govaniana Wall. (54,515)	H	P	Apr–Jun	Forest understories, moist places	GE		NP	NE	Himalayas	N
Fumaria indica (Hausskn.) Pugsley (56,374)	H	P	Mar–Jun	Field margins and thickets	TH		LP	NE	Himalayas	N
Papaver guilelmi–waldemarii (Klotzsch) Christenh. & Byng (55,715)	H	P	Jul–Sep	Rocky crevices	CH		MS	NE	Himalayas	N
Berberidaceae Juss.										
Berberis aristata DC. (56,315)	S	P	Apr–Jun	Open waste lands	PH	mcPH	NP	LC	Himalayas	N
Berberis jaeschkeana C.K.Schneid (57,637)	S	P	Apr–Jun	Forest Thickets, Wastelands	PH	mcPH	NP	NE	Himalayas	N
Berberis lycium Royle (54,312)	S	P	Apr–Jun	Forest margins, open waste lands	PH	mcPH	NP	LC	Himalayas	N
Podophyllum hexandrum Royle (56,285)	H	P	Jun–Jul	Alpine region open areas	HC		MI	NE	Asia	N
Ranunculaceae Juss.										
Aconitum heterophyllum Wall. ex Royle (55,769)	H	P	Jul–Sep	Alpine thickets and scrubs	CH		NP	EN	Indian subcontinent	N
Aconitum lethale Griff (55,751)	H	P	Jul–Sep	Alpine thickets and scrubs	CH		NP	NE	Indian subcontinent	N
Actaea spicata L. (56,297)	H	P	Jul–Aug	Moist shady places in forests	CH		MS	LC	Europe	A
Anemonastrum obtusilobum (D.Don) Mosyakin (57,645)	H	P	Apr–June	Forest margins and alpine meadows	CH		MS	NE	Himalayas	N
Anemonastrum polyanthes (D.Don) Holub (55,732)	H	P	Jun–Jul	Steep slopes near glaciers	CH		MS	NE	Himalayas	N
Anemonstarum tetrasepalum (Royle) Holub (54,513)	H	P	Jun–Jul	Steep slopes, alpine scrubs	CH		MS	NE	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Aquilegia pubiflora Wall. ex Royle (54,766)	H	P	Apr–Jun	Forests, shady places	HC		NP	NE	Himalayas	N
Caltha alba Cambess (55,771)	H	P	Jul–Sep.	Stream sides	CH		NP	NE	Himalayas	N
Caltha palustris L. (54,528)	H	P	Jul–Sep	Stream sides	CH		MS	LC	Himalayas	N
Clematis barbellata Edgew. (57,626)	S	P	Apr–Jun	Forests, Grassy slopes	L		NP	NE	Himalayas	N
Delphinium denudatum Wall. ex Hook.f. & Thomson (54,789)	H	P	May–Jun	Hill slides, forest margins	TH		MS	NE	Himalayas	N
Delphinum cashmerianum Royle (54,508)	H	P	Jul–Sep	Alpine scrubs and thickets	TH		MS	NE	Indian subcontinent	N
Hepatica falconeri (Thomson) Steward (54,362)	H	P	Apr–Jun	Shady places in forests	CH		MS	NE	Indian subcontinent	N
Ranunculus distans D.Don (54,380)	H	P	Jul–Oct	Stream sides, slopedareas	GE		NP	NE	Asia	N
Ranunculus bulbosus L. (54,787)	H	P	Apr–Jun	Disturbed woods, waste lands	GE		NP	NE	Himalayas	N
Ranunculus hirtellus Royle (56,218)	H	P	Apr–Jul	Forest margins and alpine meado3ews	CH		MS	NE	Himalayas	N
Thalictrum foliolosum DC. (56,217)	S	P	Jun–Aug	Alpine thickets and scrubs	CH		MI	NE	Indian subcontinent	N
Thalictrum virgatum Hook.f. & Thomson (56,314)	S	P	Jun–Aug	Forrest margins	CH		MI	NE	Himalayas	N
Proteales Juss. ex Bercht. & J.Presl										
Platanaceae T.Lestib										
Platanus orientalis L. (57,677)	T	P	Apr–May	Open areas village sides	PH	mgPH	MS	VU	Europe	A
III. CORE EUDICOTS										
SUPER–ROSIDS										
Saxifragales Bercht. & J. Presl										
Hamamelidaceae R.Br.										
Parrotiopsis jacquemontiana (Decne.) Rehder (7632)	S	P	Apr–Jun	Dense forests	PH	msPH	NP	LC	Central America	A
Saxifragaceae Juss.										
Bergenia ciliata (Haw.) Sternb.(54,359)	H	P	Apr–Jun	Rocky crevices	CH		NP	LC	SouthAmerica	A
Saxifraga cernua L. (54,542)	H	P	Aug–Sep	Stream sides in alpine regions	CH		MI	NE	North America	A
Saxifraga parnassifolia D.Don (55,724)	H	P	Aug–Sep	Stream sides in alpine regions	CH		NP	NE	Eurasia	A
Saxifraga sibirica L. (55,472)	H	P	Aug–Sep	Stream sides in alpine regions	CH		NP	LC	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer′s Life Forms	Raunkiaer′s Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Crassulaceae J.St.–Hil.										
Hylotelephiu mewersii (Ledeb.) H.Ohba (55,740)	H	P	Jul–Sep	Forests, rock crevices	CH		NP	NE	Afghanistan to Siberia	A
Rhodiola bupleuroides (Wall.ex Hook.f. & Thomson) S.H.Fu. (55,797)	H	P	Jul–Aug	Forest Thickets, Rocky slopes	CH		LP	NE	Himalayas	N
Rhodiola himalensis (D.Don) S.H.Fu (56,204)	H	P	Jul–Sep	Rocky crevicesin alpine areas	CH		LP	NE	Himalayas	N
Rhodiola wallichiana (Hook.) S.H.Fu (55,797)	H	P	Jul–Aug	Forest thickets and Rocky scrubs	CH		LP	NE	Himalayas	N
Rosularia adenotricha (Wall. ex Edgew) C.–A.Jansson (57,666)	H	P	May–Jun	Rocky crevices	TH		MI	NE	Himalayas	N
Sedum orades (Decne.) Raym.–Hamet (55,723)	H	P	Jul–Sep	Rocky crevices	TH		MI	NE	Himalayas	N
Rosids										
Fabales Bromhead										
Fabaceae Lindl.										
Indigofera heterantha Wall. ex Brandis (57,625)	S	P	Apr–Jun	Forest margins waste lands	PH	mcPH	MS	LC	Himalayas	N
Lotus corniculatus L. (RRLH57635)	H	P	Apr–Jun	Alpine meadows	CH		MS	LC	Asia	N
Medicago lupulina L. (56,295)	H	P	Jul–Sep	Woodland marginsriverbanks	TH		NP	LC	Europe	A
Oxytropis lapponica (Wahlenb.) J.Gay (56,406)	H	P	Jun–Aug	Alpine meadows	GE		MI	NE	Eurasia	A
Phyllodium elegans (Lour.) Desv. (57,633)	S	P	Jul–Sep	Field margins, waste lands	PH	nnPH	MI	NE	Eurasia and North America	A
Robinia pseudoacacia L. (57,638)	T	P	Apr–Jun	Waste lands, road sides	PH	mgPH	MS	LC	Europe	A
Thermopsis barbata Benth. (54,531)	H	P	Jul–Aug	Alpine high areas	CH		MS	NE	Eurasia	A
Trifolium pratense L. (57,641)	H	P	Apr–May	Grasslands meadows	HC		NP	LC	Himalayas	N
Rosales Bercht. & J.Presl										
Rosaceae Juss.										
Agrimonia pilosa Ledeb. (57,622)	H	P	Jul–Sep	Inside forests	TH		MS	NE	Himalayas	N
Cotoneaster micrphyllus Wall. ex Lindl. (54,527)	S	P	May–Jun	Alpine rich regions	PH	mcPH	NP	NE	Himalayas	N
Crataegus songarica K. Koch (54,737)	T	P	Apr–Jun	Field margins	PH	mgPH	NP	LC	Himalayas	N
Filipendula vestita (Wall. ex G.Don) Maxim. (55,738)	H	P	May–Aug	Alpine meadows and scrubs	CH		NP	NE	Himalayas	N
Fragaria nubicola (Lindl. ex Hook.f.) Lacaita (55,768)	H	P	May–Aug	Meadows, forest valleys	TH		MS	NE	Himalayas	N
Geumelatum Wall. ex G.Don (55,707)	H	P	Apr–Jun	Inside forests	CH		NP	NE	Indo–Malayan region	N
Geum urbanum L. (54,725)	H	P	Jul–Sep	Forest disturbed areas	CH		NP	LC	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Potentilla argyrophylla Wall. ex Lehm. (55,786)	H	P	May–Jun	Forest thickets and meadows	CH		LP	NE	Himalayas	N
Potentilla atrosanguinea G.Lodd. (54,538)	H	P	May–Jun	Forest thickets and meadows	CH		NP	NE	Europe and America	
Potentilla indica (Andrews) Th.Wolf (54,340)	H	P	Jun–Aug	Forest scrubs and margins	CH		NP	NE	Himalayas	N
Potentilla nepalensis Hook. (54,759)	H	P	Jul–Aug	Forest margins and thickets	CH		LP	NE	Asia and North America	A
Potentilla reptans L. (54,355)	H	P	Apr–Jun	Forest margins and thickets	CH		NP	NE	Egypt and North Africa	A
Prinsepia utilis Royle (54,702)	H	P	Apr–Jun	Waste lands, forest slopes	PH	nnPH	MI	NE	Himalayas	N
Rosa moschata Herrm. (54,304)	S	P	May–Jun	Forest margins	PH	nnPH	MS	NE	Himalayas	N
Rosa webbiana Wall. ex Royle (54,742)	S	P	May–Jun	Forrest slopes and margins	L		NP	NE	Himalayas	N
Rubus ellipticus Sm. (54,734)	S	P	Apr–May	River sides, sparse forests	PH	nnPH	MS	LC	Himalayas	N
Rubus idaeus L. (57,642)	S	P	Apr–Jun	River sides and forest margins	PH	nnPH	NP	LC	Asia	N
Rubus niveus Thunb. (57,623)	S	P	May–Jul	River sides and forest	PH	nnPH	NP	NE	Himalayas	N
Sibbaldia cuneata Edgew. (55,735)	H	P	Jul–Sep	Alpine scrubs and meadows	CH		NP	NE	Eurasia and Africa	A
Sorbaria tomentosa (Lindl.) Rehder (54,783)	S	P	Jul–Aug	River sides, forest margins	PH	mcPH	MI	NE	Himalayas	N
Spiraea canescens D.Don (57,630)	S	P	Jul–Aug	Forest margins, waste lands	PH	mcPH	NP	LC	Himalayas	N
Elaeagnaceae Juss										
Elaeagnus umbellata Thunb. (54,747)	S	P	Apr–Jun	Forest thickets and margins	L		NP	LC	Himalayas	N
Ulmaceae Mirb.										
Ulmus wallichiana Planch. (57,606)	T	P	Mar–Apr	Temperate forests, village sides	PH	mgPH	MS	UV	Indian subcontinent	N
Cannabaceae Mart.										
Cannabis sativa L. (56,223)	H	P	Aug–Sep	Waste lands, field margins	CH		NP	NE	Asia	N
Celtis australis L. (54,719)	T	P	Mar–Apr	Roadsides, field margins	PH	mgPH	NP	LC	Europe	A
Trema orientale (L.) Blume (56,236)	T	P	Jul–Sep	Dry scrubs and open slopes	PH	mgPH	NP	LC	Asia	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer′s Life Forms	Raunkiaer′s Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Moraceae Gaudich.										
Ficus hispida L.f. (54,723)	T	P	Jun–Jul	Forest margins	PH	msPH	MS	LC	Himalayas	N
Ficus palmata Forssk. (56,205)	T	P	Aug–Nov	Forest slopes	PH	msPH	MS	NE	Himalayas	N
Morus alba L. (56,377)	T	P	Apr–May	Waste lands and village sides	PH	msPH	MS	LC	Himalayas	N
Urticaceae Juss.										
Girardinia diversifolia (Link) Friis (54,728)	H	A	Oct–Nov	Disturbed areas,	CH		MS	NE	Himalayas	N
Pilea umbrosa Wedd. ex Blume (54,326)	H	P	Jul–Aug	Shady, moist places	CH		NP	NE	Indian subcontinent	N
Urtica dioica L. (54,501)	H	P	Jun–Sep	Waste lands	HC		MS	NE	Indian Subcontinent	N
Fagales Engl.										
Fagaceae Dumort.										
Quercus floribunda Lindl. ex A.Camus (56,305)	T	P	Aug–Oct	Wastelands, forest margins	PH	mgPH	MI	LC	Himalayas	N
Quercus ilex L. (54,376)	T	P	Apr–May	Field margins, Waste lands	PH	mgPH	MI	LC	Europe	A
Quercus semecarpifolia Sm. (56,235)	T	P	Aug–Oct	Sparse forests and field margins	PH	mgPH	MI	LC	Indian subcontinent	N
Juglandaceae DC. ex Prleb.										
Juglans regia L. (54,336)	T	P	Apr–Sep	Field margins	PH	msPH	MI	LC	Western Himalayas	N
Betulaceae Gray										
Alnus nepalensis D.Don (56,292)	T	P	Jul–Sep	Sparse forests and river banks	PH	mcPH	MI	LC	Himalayas	N
Alnus nitida (Spach) Endl. (56,383)	T	P	Sep–Oct		PH	mcPH	MI	LC	Himalayas	N
Betula utilis D.Don (56,289)	T	P	May–Jun		PH	msPH	MI	LC	Himalayas	N
Corylus colurna L. (56,290)	T	P	Mar–Apr		PH	msPH	MS	LC	Asia	N
Cucurbitales Juss. ex Bercht. & J.Presl										
Cucurbitaceae Juss.										
Solena heterophylla Lour. (54,790)	S	P	Apr–Jun	Mixed forest thickets	L		MI	NE	Himalayas	N
Datiscaceae Dumort.										
Datisca cannabina L. (56,374)	S	P	May–Aug	Forest margins and river sides	PH	nnPH	MS	NE	Europe and Himalayas	NMA
Celastrales Link										
Celasteraceae R.Br.										
Parnassia nubicola Wall. ex Royle (55,709)	H	P	Jul–Sep	Aline meadows and scrubs	CH		MS	NE	Himalayas	N
Oxalidales Juss. ex Bercht. & J.Presl										
Oxalidaceae R.Br.										
Oxalis acetosella L. (54,328)	H	P	Jul–Sep	Forest shady places	TH		MS	NE	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Malpighiales Juss. ex Bercht. & J. Presl										
Hypericaceae Juss.										
Hypericum elodeoides Choisy (54,740)	H	P	Jul–Sep	Damp areas in forests	PH	nnPH	NP	NE	Himalayas	N
Hypericum hookerianum Wight & Arn. (54,723)	S	P	Apr–Jun	Forest margins	PH	nnPH	NP	NE	North America	A
Hypericum perforatum L. (57,662)	S	P	Jul–Sep	Forest scrubs, open areas	PH	nnPH	NP	LC	Himalayas	N
Violaceae Batsch										
Viola canescens Wall. (54,376)	H	P	Mar–Apr	Shady, moist places in forests	TH		NP	NE	Eurasia	A
Salicaceae Mirb.										
Populus ciliata Wall. ex Royle (56,248)	T	P	May–Jun	Road sides and waste lands	PH	mgPH	MS	LC	Himalayas	N
Salix daltoniana Andersson (54,711)	T	P	May–Jun	Forest thickets and slopes	PH	msPH	NP	NE	Europe	A
Euphorbiaceae Juss.										
Euphorbia obovata Decne. (57,620)	H	P	Jul–Sep	Slopy grasslands	TH		NP	EN	Himalayas	N
Euphorbia prolifera Buch.–Ham. ex D.Don. (57,620)	H	P	Jun–Aug	Grasslands and forest margins	TH		NP	NE	Himalayas	N
Euphorbia wallichii Hook.f. (56,394)	H	P	Jun–Aug	Grasslands and forest margins	TH		NP	NE	Himalayas	N
Gerianales Juss. ex Bercht. & J.Presl										
Geraniaceae Juss.										
Geranium mascatense Boiss. (54,748)	H	P	Jul–Sep	Forest thickets and scrubs	TH		NP	NE	Indian subcontinent	N
Geranium wallichianum D.Don ex Sweet (54,334)	H	P	Jul–Sep	Forest thickets and scrubs	TH		NP	LC	IndianSubcontinent	N
Melianthaceae Horan.										
Trillium govanianum Wall. ex D.Don (55,710)	H	P	May–Jun	Forest thickets and scrubs	GE		MS	EN	Himalayas	N
Myrtales Juss. ex Bercht. & J.Presl										
Onagraceae Juss.										
Oenothera biennis L. (55,789)	H	P	Jul–Sep	Open and disturbed areas	TH		MS	NE	Himalayas	N
Oenothera rosea L'Hér. ex Aiton (57,663)	H	P	Jul–Sep	Field margins, open areas	TH		NP	NE	Europe	A
Sapindales Juss. ex Bercht. & J.Presl										
Sapindaceae Juss.										
Acer caesium Wall. ex Brandis (54,717)	T	P	Apr–Jun	Mixed coniferous forests	PH	mgPH	MG	LC	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer′s Life Forms	Raunkiaer′s Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Aesculus indica (Wall.ex Cambess) Hook. (57,672)	T	P	Apr–Jun	Mixed coniferous forests	PH	mgPH	MG	LC	Himalayas	N
Rutaceae Juss.										
Skimmia laureola (DC.) Decne. (54,526)	S	P	Apr–May	Mixed coniferous forests	PH	mcPH	MG	NE	Himalayas	N
Malvales Juss. ex Bercht. & J.Presl										
Malvaceae Juss.										
Hibiscus syriacus L. (57,673)	S	P	Jul–Sep	Hill slides along stream sides	PH	mcPH	NP	NE	Himalayas	N
Malva cachemiriana (Cambess.) Alef. (56,241)	H	P	Jul–Sep	Field margins and Waste lands	TH		MS	NE	Himalayas	N
Malva neglecta Wallr. (57,650)	H	P	Jul–Sep	Disturbed areas	TH		LP	LC	Asia	N
Brassicales Bromhead										
Brassicaceae Burnett										
Arabis alpina L. (54,307)	H	A	May–Jul	Road sides, slopes	CH		NP	NE	Eurasia	A
Arabis amplexicaulis Edgew. (54,369)	H	A	Jun–Jul	Forest and field margins	TH		NP	NE	Eurasia	A
Barbarea intermedia Boreau (56,221)	H	P	Jul–Aug	Open areas and forest margins	TH		MI	NE	Europe	A
Capsella–bursa pastoris (L.) MediK. (56,354)	H	P	Mar–Apr	Field margins and open lands	TH		MI	LC	Eurasia and Africa	A
Cardamine impatiens L. (56,226)	H	A	May–Jul	Field margins and Wastelands	HC		MI	NE	Eurasia	A
Crucihimalaya stricta (Cambess.) Al Shebaz, O′Kane & R.A.Price (57,601)	H	A	Apr–Jun	Forest margins, grassy slopes	TH		NP	NE	Indian subcontinent	N
Draba nuda (Bél.) Al–Shehbaz & M.Koch (54,324)	H	A	Apr–Jun	Stream sides, moist places	TH		NP	NE	Himalayas	N
Lepidium virginicum L. (57,610)	H	A	Jul–Sep	Forest margins and filed edges	TH		NP	NE	NorthAmerica	A
Nasturtium officinale W.T.Aiton (55,798)	H	P	Apr–Sep	Moist, damp areas along streams	TH		NP	LC	Asia and Africa	N
Rorippa islandica (Oeder) Borbás (54,356)	H	A	Apr–Jun	Shady crevices, river sides	TH		NP	LC	Himalayas	N
Super Asterids										
Caryophyllales Juss. ex Bercht. & J.Presl										
Polygonaceae Juss.										
Bistorta affinis (D.Don) Greene (55,718)	H	P	Jul–Sep	Alpine scrubs and scrubs	CH		LP	NE	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Bistorta amplexicaulis (D.Don) Greene (57,643)	H	P	Jul–Sep	Mountain scrubs, field margins	CH		LP	NE	Africa and SouthAmerica	A
Bistorta vivipara (L.) Delarbre (54,512)	H	P	Jul–Aug	Mountain scrubs	CH		LP	NE	Himalayas	N
Fagopyrum cymosum (Trevir.) Meisn. (55,762)	H	P	Jul–Sep	Field margins and open areas	CH		LP	NE	Himalayas	N
Fagopyrum esculentum Moench (67,644)	H	P	Jul–Sep	Field margins, Waste lands	CH		MS	NE	Indian subcontinent	N
Koenigia rumicifolia (Royle ex Bab.) T.M.Schust. & Reveal (55,734)	H	P	Jul–Sep	Alpine thickets and scrubs	TH		MS	NE	Himalayas	N
Koenigia alpina (All.) T.M. Schust & Reveal (54,766)	H	P	Jul–Aug	Mountain slopes, field margins	TH		NP	NE	Himalayas	N
Oxyria digyna (L.) Hill (56,384)	H	P	May–Aug	Alpine scrubs and thickets	CH		MI	NE	Europe and America	A
Persicaria glabra (Willd.) (56,358)	H	P	Sep–Nov	Moist shady places in forests	CH		MI	LC	Eurasia	A
Persicaria lapathifolia (L.) Delarbre (56,281)	H	A	Aug–Nov	Moist shady places along roadsides	CH		MI	LC	Eurasia	A
Rheum webbianum Royle (55,777)	H	P	Aug–Sep	Alpine scrubs, meadows	GE		MG	NE	Himalayas	N
Rumex dentatus L. (56,357)	H	P	Jun–Jul	Mountain slopes and moist valleys	GE		MS	LC	Asia	N
Rumex hastatus D.Don (54,703)	H	P	Apr–Jun	Dry mountain slopes	CH		MI	NE	Indian subcontinent	N
Rumex nepalensis Spreng. (56,273)	H	P	Jun–Jul	Field margins and waste lands	HC		MS	NE	Asia and Africa	N
Caryophyllaceae Juss.										
Acanthophyllum cerastioides (D.Don) Madhani & Zarre (54,512)	H	P	Jul–Sep	Rocky slopes in alpine meadows	CH		NP	NE	Himalayas	N
Cerastiumdavuricum Fisch. ex Spreng. (54,314)	H	P	Apr–Jun	Stream sides, damp areas	TH		NP	NE	Europe and NorthAmerica	A
Cerastiumglomeratum Thuill. (54,343)	H	P	May–Jun	Moist damp areas along streams	TH		NP	NE	Europe	A
Silene indica Roxb. ex Otth (55,878)	H	P	Jul–Aug	Mountain scrubs and forest margins	TH		NP	NE	Europe and NorthAmerica	A
Silene vulgaris (Moench) Garcke (57,616)	H	P	Jul–Aug	Mountain scrubs	TH		NP	LC	Europe	A
Amaranthaceae Juss.										
Achyranthyes aspera L. (54,755)	H	P	Jul–Aug	Forest slopes, waste lands	CH		NP	NE	South America	A
Amaranthus caudatus L. (576,04)	H	A	Jul–Sep	Field margins	TH		MI	NE	Eurasia	
Amaranthus viridis L. (563,95)	H	A	Jun–Aug	Field margins	TH		MI	NE	America	A

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Blitum virgatum L. (557,83)	H	A	Jul–Sep	Forest margins	TH		MI	NE	Himalayas	N
Chenopodium album L. (55,770)	H	A	Jul–Sep	Field margins, waste lands	TH		MI	NE	Himalayas	N
Dysphania ambrosioides (L.) Mosyakin & Clemants (56,360)	H	A	Jul–Sep	Field margins and Waste lands	TH		MI	NE	America	A
Phytolaccaceae R.Br.										
Phytolacca acinosa Roxb (57,619)	H	P	Jul–Aug	Forest understories	GE		MG	NE	America	A
Asterids										
Ericales Bercht. & J.Presl										
Balsaminaceae A.Rich.										
Impatiens balfourii Hook.f. (54,762)	H	P	Jul–Aug	Stream sides, field margins	CH		LP	NE	Australia	A
Impatiens brachycentra Kar. & Kir. (55,785)	H	A	Aug–Sep	Forest margins, along streams	CH		MS	NE	Eurasia and Africa	A
Impatiens edgeworthii Hook.f. (55,782)	H	A	Jul–Sep	Inside forests, moist areas	CH		MS	NE	Eurasia and Africa	A
Polemoniaceae Juss.										
Polemonium caeruleum L. (55,761)	H	P	Apr–Jun	Moist areas in forests	CH		MS	NE	Asia	N
Primulaceae Batsch ex Borkh.										
Androsace rotundifolia Hardw. (54,789)	H	P	Apr–Jun	Grassy slopes in the forests	HC		NP	NE	Himalayas	N
Androsace sarmentosa Wall. (56,215)	H	P	Jun–Jul	Rocky surfaces in high alpine regions	HC		NP	NE	Himalayas	N
Primula denticulata Sm. (57,689)	H	P	Apr–Jun	Alpine thickets and moist scrubs	GE		MS	NE	Himalayas	N
Primula matthioli (L.) V.A. Richt. (56,219)	H	P	Jun–Jul	Alpine thickets and moist scrubs	GE		MS	NE	Europe	A
Primula rosea Royle (56,225)	H	P	Jun–Jul	Alpine thickets and moist scrubs	GE		MI	NE	Himalayas	N
Ericaceae Juss.										
Rhododendron anthopogon D.Don (55,741)	S	P	Apr–Jun	High mountain scrubs	PH	mcPH	NP	NE	Eurasia	A
Rhododendron arboretum (54,394)	T	P	Apr–Jun	Mixed temperate forests	PH	msPH	MS	LC	Himalayas	N
Rhododendron campanulatum D.Don (55,725)	S	P	May–Jun	High alpine scrubs	PH	mcPH	NP	NE	Eurasia	A
Gentianales Juss. ex Bercht. & J.Presl										
Rubiaceae Juss.										
Rubia cordifolia L. (57,636)	H	P	Jul–Sep	Sparse forest	HC		NP	NE	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer′s Life Forms	Raunkiaer′s Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Gentianaceae Juss.										
Gentiana carinata (D.Don ex G.Don) Royle ex D.Don (56,208)	H	A	Jul–Aug	Alpine meadows and thickets	HC		NP	NE	Himalayas	N
Gentiana argentea (Royle ex D.Don) Royle ex D.Don (54,332)	H	A	Mar–Apr	Waste lands, grassy slopes	HC		NP	NE	Europe and North America	A
Jaeschkea oligosperma Knobl. (55,701)	H	A	Jul–Sep	Grassy slopes, grasslands	TH		MS	NE	Himalayas	N
Swertia chirayita (Roxb.) H.Karst. (55,796)	H	P	Aug–Sep	Grassy slopes, grasslands	TH		NP	NE	Himalayas	N
Apocynaceae Juss.										
Vincetoxicum hirundinaria Medik. (57,669)	H	P	May–Jun	Thickets, forest margins	CH		MS	NE	Himalayas	N
Boraginales Juss. ex Bercht. & J.Presl										
Boraginaceae Juss.										
Arnebia benthamii (Wall. ex G.Don) I.M.Jhonst. (56,240)	H	P	Jun–Jul	Mountain slopes, rock cervices	CH		MI	NE	Himalayas	N
Cynoglossum lanceolatum Forssk. (55,779)	H	P	Jun–Aug	Forest margins and thickets	TH		NP	NE	South Africa	A
Cynoglossum wallichii G.Don (54,792)	H	P	May–Aug	Hill slides, meadows	TH		NP	NE	NorthAmerica	A
Hackelia macrophylla (Brand) I.M.Jhonst. (563,362)	H	P	Jun–Jul	Alpine thickets and scrubs	TH		Mi	NE	Himalayas	N
Hackelia uncinata (Royle ex Benth.) C.E.C Fisch. (56,238)	H	P	Jun–Jul	Alpine thickets and scrubs	TH		MI	NE	Asia	N
Lindelofia longiflora (DC.) Baill. (57,615)	H	P	Apr–Jun	Grasslands and slopes	CH		MI	NE	Asia	N
Myosotis scorpioides L. (54,760)	H	P	May–Jun	Forest margins slopes	HC		MS	NE	Indian subcontinet	N
Trichodesma indicum (L.) Sm. (54,319)	H	P	Mar–Apr	Shady and moist places	TH		NP	NE	Eurasia	A
Solanales Juss. ex Bercht. & J.Presl										
Convolvulaceae Juss.										
Ipomoea purpurea (L.) Roth (57,612)	H	P	Jul–Sep	Fields, waste lands	TH		MS	NE	Himalayas	N
Solanaceae Juss.										
Datura stramonium L. (57,639)	H	P	Jul–Sep	Wastelands, road side	HC		MG	NE	Japan and South Korea	A
Lamiales Bromhead										
Oleaceae Hoffmanns.										
Chrysojasminum humile (L.) Banfi (56,247)	S	P	Jul–Sep	Riversides	PH	mcPH	MI	NE	Indian subcontinent	N
Fraxinus excelsior L. (54,725)	T	P	Apr–Jun	Field margins, roadsides	PH	mgPH	NP	NT	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Jasminum grandiflorum L. (54,767)	S	P	Jul–Sep	Forest margins, slopy areas	L		MI	NE	Eurasia	A
Syringa emodi Wall. ex Royle (56,284)	S	P	Sep–Oct	Alpine scrubs and thickets	PH	nnPH	MS	NE	Himalayas	N
Plantaginaceae Juss.										
Digitalis lanata Ehrh. (56,288)	H	A	Jun–Aug	Open areas and scrubs	TH		NP	LC	Europe and America	A
Digitalis purpurea L. (57,607)	H	A	May–Jun	Forest margins	TH		NP	LC	Himalayas	N
Lagotis cashmeriana (Royle ex Benth.) Rupr. (55,753)	H	P	Jul–Aug	Alpine thickets and scrubs	HC		NP	NE	Asia	N
Lagotis kunawurensis (Royle ex Benth.) Rupr. (56,222)	H	P	Jul–Aug	Alpine scrubs and meadows	HC		NP	NE	Himalayas	N
Picrorhiza kurroa Royle ex Benth. (55,758)	H	P	Jul–Sep	Alpine scrubs and thickets	CH		NP	EN	Himalayas	N
Plantago himalaica Pilg. (56,284)	H	P	Jul–Aug	Mountain slopes and margins	HC		MI	NE	Indian subcontinent	N
Plantago lanceolata L. (56,261)	H	P	Jul–Aug	Forest thickets and edges	HC		MS	LC	Eurasia	A
Plantago major L. (54,794)	H	P	Jul–Aug	Forest margins, slopes	HC		MS	LC	Himalayas	N
Wulfeniopsis amherstiana (Benth.) (54,741)	H	P	Jul–Aug	Rock crevices and shady areas	CH		NP	NE	Himalayas	N
Scrophulariaceae Juss.										
Verbascum thapsus L. (57,608)	H	P	Jun–Jul	Mountain slopes	CH		NP	LC	NorthAmerica	A
Acanthaceae Juss.										
Strobilanthes attenuata (Wall. ex Nees) Jacq. ex Nees (5578)	H	P	Jun–Oct	Forest thickets	HC		LP	NE	Himalayas	N
Lamiaceae Martinov										
Ajuga integrifolia Buch.–Ham. ex D.Don (54,331)	H	P	May–Jun	Grassy slopes	TH		MS	NE	Himalayas	N
Elsholtzia ciliata (Thunb.) Hyl. (54,779)	H	P	Jul–Oct	Waste lands	HC		MI	NE	India and Australia	N
Elsholtzia fruticosa (D.Don) Rehder (57,681)	H	S	Aug–Oct	Wastelands and forest margins	PH	nnPH	MI	NE	Himalayas	N
Isodon coesta (Buch.–Ham. ex D.Don) Kudo (54,553)	S	P	Sep–Oct	Woodland thickets	PH	nnPH	MI	NE	Himalayas	N
Isodon japonicus (Burm.f.) H.Hara (54,552)	S	P	Sep–Oct	Woodland thickets	PH	nnPH	MI	NE	Himalayas	N
Isodon rugosus (Wall. ex Benth.) Codd (57,629)	S	P	Jul–Oct	Wastelands and forest scrubs	PH	nnPH	MI	NE	Himalayas	N
Lamium album L. (54,551)	H	P	Jul–Sep	Forest margins Shady places	TH		MS	LC	Asia	N
Lamium amplexicaule L. (54,303)	H	A	Mar–Apr	Forest margins	TH		MS	NE	Asia	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer′s Life Forms	Raunkiaer′s Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Leucas ciliata Benth. (54,780)	H	A	Jul–Oct	Roadsides, stream sides	TH		NP	NE	Indiansubcontinent	N
Mentha arvensis L. (56,354)	H	P	Jul–Sep	Field margins and wastelands	GE		NP	LC	Eurasia	A
Mentha longifolia (L.) L. (56,363)	H	P	Jul–Sep	Field margins and wastelands	GE		NP	LC	Eurasia	A
Nepeta clarkei Hook.f. (54,731)	H	P	May–Aug	Wastelands, field margins	GE		NP	NE	Himalayas	N
Nepeta laevigata (D.Don) Hand.–Mazz. (55,763)	H	P	May–Aug	Road sides, field margins	GE		NP	NE	Himalayas	N
Nepeta lamiopsis Benth. ex Hook.f. (54,766)	H	P	Apr–Jun	Forest margins and thickets	HC		MS	NE	Himalayas	N
Origanum vulgare L. (55,745)	H	P	Jul–Sep	Forest thickets	CH		NP	NE	Eurasia	A
Pimpinella diversifolia DC (56,394)	H	P	Aug–Sep	Mountain scrubs and field margins	CH		MS	NE		
Prunella vulgaris L. (57,634)	H	P	Jul–Aug	Waste lands	CH		NP	NE	Himalayas	N
Salvia hians Royle ex Benth. (55,749)	H	P	Jul–Sep	Alpine thickets near stream sides	CH		NP	NE	Himalayas	N
Salvia nubicola Wall. ex Sweet (57,668)	H	P	Jul–Sep	Grassy slopes	TH		NP	NE	Asia	N
Thymus linearis Benth. (57,611)	H	P	Jul–Aug	Rocky slopes	HC		MI	NE	Eurasia	A
Thymus serpyllum L. (57,671)	H	P	May–Jun	Rocky slopes	HC		MI	LC	Himalayas	N
Mazaceae Reveal										
Mazus pumilus (Burm.f.) Steenis (54,777)	H	A	Jul–Sep	Grasslands and thickets	CH		NP	NE	Africa and Asia	A
Mazus surculosus D.Don (RRLH57685)	H	P	Jun–Sep	Forest edges and thickets	CH		NP	NE	South America	A
Orobanchaceae Vent.										
Pedicularis multiflora Pennell (54,507)	H	A	Jul–Sep	Alpine meadows, slopy areas	GE		NP	NE	Himalayas	N
Pedicularis pectinata Wall. ex Benth. (54,540)	H	A	Jul–Sep	Alpine meadows, slopy areas	GE		MS	NE	Eurasia and America	A
Pedicularis pyramidata Royle ex Benth. (54,796)	H	A	Jul–Sep	Alpine meadows, slopy areas	GE		NP	NE	Himalayas	N
Asterales Link										
Campanulaceae Juss.										
Campanula latifolia L. (57,670)	H	P	Jul–Sep	Field margins, grassy areas	CH		LP	NE	Himalayas	N
Campanula pallida Wall. (54,776)	H	P	Jul–Sep	Forest margins and scrubs	CH		MS	NE	SouthAmerica	A
Codonopsis ovate Benth. (55,728)	H	P	Jul–Sep	Alpine thickets and scrubs	CH		MI	NE	NorthAmerica	A

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Cyananthus lobatus Wall. ex Benth. (55,736)	H	P	Jul–Sep	Alpine meadows and thickets	CH		NP	NE	Himalayas	N
Asteraceae Bercht. & J.Presl										
Achillea millefolium L. (55,759)	H	P	Jul–Sep	Grassy slopes and field margins	HC		MS	LC	Himalayas	N
Anaphalis margaritacea(L.) Benth. & Hook.f. (54,799)	H	P	Jul–Sep	Shady areas in forests	CH		NP	NE	Himalayas	N
Anaphalis nepalensis (Spreng.) Hand–Mazz. (54,539)	H	P	Jul–Sep	Forest margins, river banks	CH		NP	NE	Eurasia	A
Anaphalis nubigena DC. (54,341)	H	P	Jul–Sep	Forest margins, river banks	CH		NP	NE	Himalayas	N
Anaphalis triplinervis Sims ex C.B.Clarke (55,792)	H	P	Jul–Sep	Forest margins, river banks	CH		NP	NE	Himalayas	N
Aster albescens (DC.) Wall. ex Hand.–Mazz. (54,546)	H	P	Jun–Aug	Alpine scrubs and thickets	TH		MI	NE	Asia	N
Aster flaccidus Bunge (56,293)	H	A	Jun–Jul	High alpine regions	TH		MI	NE	Himalayas	N
Aster falconeri (C.B.Clarke) Hutch. (56,293)	H	A	Jun–Jul	High alpine regions	TH		MI	NE	Eurasia	A
Aster himalaicus C.B.Clarke (55,730)	H	P	Jul–Sep	High grasslands	TH		MI	NE	Europe	A
Artemisia maritima L. (54,330)	H	P	Jul–Sep	Rocky areas, wasteland	CH		NP	NE	Europe	A
Artemisia roxburghiana Besser (54,544)	H	P	Jul–Sep	Forest slopes, waste lands	CH		NP	NE	Himalayas	N
Artemisia vestita Wall. ex Besser (55,799)	H	P	Jul–Sep	Rocky slopes, grasslands	CH		NP	NE	Eurasia Africa	A
Carduus edelbergii Rech. f. (55,704)	H	P	Jul–Sep	Alpine thickets	TH		NP	NE	Indian subcontinent	N
Cirsium arvense (L.) Scoop (57,612)	H	P	Apr–Jun	Field margins, waste lands	GE		NP	NE	Europe	A
Cirsium falconeri (Hook. f.) Petr. (54,543)	H	P	Apr–Jun	Forest scrubs, wastelands	GE		NP	NE	Himalayas	N
Dolomiaea macrocephala DC. ex Royle (55,706)	H	P	Jul–Sep	Alpine scrubs and thickets	CH		NP	NE	Himalayas	N
Erigeron annuus (L.) Desf. (54,718)	H	A	Jul–Sep	Grassy slopes and forest margins	TH		MI	NE	SouthAmerica	A
Erigeron bonariensis L. (57,647)	H	A	Jul–Sep	Field margins, grassy slopes	TH		MI	NE	Africa	A
Erigeron multiradiatus (Lindl. ex DC.) Benth. & Hook.f. (55,754)	H	P	Jul–Sep	Forest Thickets and scrubs	TH		MI	NE	Eurasia	A
Galinsoga parviflora Cav. (57,648)	H	A	Jul–Sep	Stream sides	TH		NP	NE	Africa	A

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Heliopsis helianthoides (L.) Sweet (55,780)	S	P	Jul–Sep	Field margins, road sides	PH	nnPH	NP	NE	Himalayas	N
Hippolytia longifolia (Rech.f.) C.Shih (55,703)	H	P	Jul–Sep	Forest thickets, grassy slopes	CH		MS	NE	Himalayas	N
Inula grandiflora Willd. (55,729)	H	P	Jul–Sep	Moist shady places in forests	CH		MS	NE	Eurasia	A
Inula royleana DC. (55,722)	H	P	Jul–Sep	Steam sides in high areas	CH		MG	NE	Eurasia	A
Jacobaea nudicaulis (Buch.–Ham ex D.Don) B.Nord (57,640)	H	P	Aug–Sep	Grassy slopes and thickets	TH		NP	NE	Asia and North America	N
Jurinea albescens (DC.) N.Garcia, Herrando & Susanna (55,714)	H	P	Jun–Sep	Mountain scrubs and thickets	HC		LP	NE	Himalayas	N
Lactuca dolichophylla Kitam. (54,503)	H	P	June–Sep	Field margins, road sides	TH		LP	NE	Indian subcontinent	N
Ligularia fischeri (Ledeb) Turcz. (54,528)	H	P	Apr–Jun	Stream sides	HC		MG	NE	Indian subcontinent	N
Ligularia jacquemontiana (Decne.) M.A.Rau (55,726)	H	P	Apr–Jun	Stream sides	HC		MG	NE	Himalayas	N
Pseudog naphalium affine (D.Don) Anderb. (54,791)	H	P	May–Jun	Wastelands and forest margins	TH		MI	NE	NorthAmerica	A
Saussurea candolleana (DC.) Sch.Bip. (55,717)	H	P	Aug–Sep	Forest thickets, mountain scrubs	CH		MI	NE	Himalayas	N
Saussurea roylei (DC.) Sch.Bip. (55,781)	H	P	Aug–Sep	Forest margins, alpine scrubs	CH		MS	NE	Himalayas	N
Taraxacum officinale F.Wigg. (54,350)	H	P	Apr–Jun	Grasslands, forests, road sides	TH		NP	LC	NorthAmerica	A
Tussilago farfara L. (54,785)	H	P	Mar–Apr	Forest understories	TH		MG	LC	America	A
Dipsacales Juss. ex Bercht. & J.Presl										
Adoxaceae E.Mey.										
Viburnum grandiflorum Wall. ex DC (54,377)	S	P	Apr–Jun	Inside forests	PH	mcPH	NP	NE	Himalayas	N
Caprifoliaceae Juss.										
Dipsacus inermis Wall. (55,776)	H	P	Jul–Sep	Filed margins, waste lands	CH		MI	NE	Asia	N
Leycesteria formosa Wall. (54,715)	S	P	Apr–Jun	River sides	PH	nnPH	NP	NE	Europe	A
Lonicera obovata Royle ex Hook.f.& Thomson (54,542)	S	P	May–Jul	Alpine scrubs and thickets	PH	nnPH	MI	NE	Himalayas	N
Morina longifolia Wall. ex DC. (55,705)	H	P	Jul–Aug	Alpine scrubs ana slopes	CH		NP	NE	Himalayas	N
Valeriana jatamansi Jones ex Roxb. (54,310)	H	P	Mar–Apr	Forest thickets and margins	GE		MI	NE	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer's Life Forms	Raunkiaer's Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
Valeriana pyrolifolia Decne (57,688)	H	P	Mar–Apr	Forest thickets and margins	GE		MI	NE	Himalayas	N
Apiales Nakai										
Apiaceae Lindl.										
Angelica glauca Edgew (54,331)	H	P	Jun–Aug	Alpine thickets and scrubs	TH		MS	EN	Indian subcontinent	N
Bupleurum longicaule Wall. ex DC. (55,719)	H	P	Jul–Sep	Forest thickets grassy slopes	CH		MS	NE	Indian Subcontinent	N
Carum carvi L. (55,778)	H	P	Jul–Sep	Bushy alpine meadows	TH		NP	LC	Eurasia	A
Chaerophyllum reflexum Aitch. (54,797)	H	P	Jul–Sep	Open forests	CH		MS	NE	Himalayas	N
Chaerophyllum villosum Wall. ex DC. (56,355)	H	P	Jul–Sep	Field margins and forest margins	CH		MS	NE	Indian subcontinent	N
Cortia depressa (D.Don) C.Norman (55,731)	H	P	Jul–Sep	Alpine meadows	TH		NP	NE	Himalayas	N
Heracleum candicans Wall. ex DC. (55,711)	H	P	Jul–Sep	Alpine thickets and rocky slopes	HC		MS	NE	Himalayas	N
Hymenidium brunonis (DC.) Lindl. (55,739)	H	P	Jul–Sep	Sparse forests, forest margins	CH		NP	NE	Himalayas	N
Hymenolaena candollei DC. (55,773)	H	P	Jul–Sep	Forest thickets and rocky scrubs	CH		MI	NE	Himalayas	N
Tetrataenium canescens (Lindl.) Manden. (55,756)	H	P	Aug–Sep	Forest margins and scrubs	CH		MS	NE	Africa and Europe	A
Araliaceae Juss										
Hedera nepalensis K.Koch (54,365)	S	P	Oct–Apr	Forest thickets	PH	mcPH	NP	NE	Himalayas	N
Gymnosperms										
Pinales Gorozh.										
Pinaceae Spreng ex E.Rudolphi										
Abies pindrow (Royle ex D.Don) Royle (54,367)	T	P	Mar–Apr	Alpine regions	PH	mgPH	LP	LC	Himalayas	N
Cedrus deodara (Roxb. ex D.Don) G.Don (57,645)	T	P	May–Jun	Coniferous forests	PH	mgPH	LP	LC	Himalayas	N
Picea smithiana (Wall) Boiss (54,305)	T	P	May–Jun	Coniferous forests	PH	mgPH	LP	LC	Himalayas	N
Pinus wallichiana A.B.Jacks. (57,675)	T	P	Mar–Apr	Coniferous forests	PH	mgPH	LP	LC	Himalayas	N
Cupressaceae										
Juniperus communis L. (56,251).	T	P	Sep–Oct	Alpine regions	PH	msPH	LP	LC	Himalayas	N
Juniperus polycarpos K.Koch (55,737)	S	P	Sep–Oct	Alpine regions	PH	mcPH	LP	LC	Himalayas	N
Taxaceae										
Taxus wallichiana Zucc. (56,225)	T	P	Aug–Dec	Coniferous forests	PH	mgPH	LP	EN	Himalayas	N

Table 6. *Cont.*

Plant Groups as APG IV (Voucher Number)	Habit	Life Span	Phenology Period	Habitat	Raunkiaer′s Life Forms	Raunkiaer′s Sub-Types	LeafSpectra	Conservation Status (IUCN)	Specific Distribution	Native (N)/Alien (A)
LYCOPHYTES AND FERNS										
Polypodiales Link										
Aspleniaceae Newman										
Asplenium dalhousieae Hook. (54,334)	H	P	Oct–Nov	Moist shady places along rocks	HC		MS	NE	Himalayas	N
Asplenium trichomanes L. (54,317)	H	P	Oct–Nov	Moist rocky surfaces	HC		MS	NE	Himalayas	N
Pteridaceae E.D.M Kirchn										
Adiantum venustum D.Don (54,367)	H	A	Jan–Apr	Stream sides	HC		MI	NE	Himalayas	N
Onychium japonicum (Thumb.) Kunze (54,371)	H	P	Oct–Dec	Moist and damp areas	CH		MS	NE	Himalayas	N
Pteris biaurita L. (54,370)	H	P	Mar–Apr	Forest margins, rocky slopes	HC		NP	NE	Himalayas	N
Pteris cretica L. (54,379)	H	P	Mar–Apr	Forest margins	HC		NP	NE	Himalayas	N
Polypodiaceae J.Presl & C.Presl										
Polystichum luctuosum (Kuntze) T.Moore (54,335)	H	P	Mar–Apr	Moist shady places	HC		MI	NE	Himalayas	N
Equisetales DC. ex Bercht. & J.Presl										
Eqisetaceae Michx. ex DC.										
Equisetum arvense L. (54,322)	H	A	Jan–Apr	Field margins	GE		MI	LC	Indian subcontinent	N
Selaginellales Prantl										
Selaginellaceae Willk										
Selaginella eurynota A.Braun (55,774)	H	A	Mar–Apr	Moist shady places along streams	Ep		NP	NE	Himalayas	N

3.7. Red List IUCN and Conservation Status

Out of the collected 328 plant taxa, 245of these, from the Bhallesa regions, were found to be not categorised in any category (NE) by IUCN (https://www.iucnredlist.org/, accessed on 12 August 2022). Seventy-four plant species are placed as LC, six as EN, one as NT and two as VU (Table 6). No species recorded in the study area falls under the CR category of IUCN. The endangered species *Aconitum heterophyllum* Wall. ex Royle, *Euphorbia obovata* Decne, *Trillium govanianum* Wall. ex D.Don, *Taxus wallichiana* Zucc. and *Picrorhiza kurroa* Royle ex Benth. were collected from the study area; *Platanus orientalis* L. and *Ulmus wallichiana* Planch. were vulnerable, and *Fraxinus excelsior* L. was found to be a nearly threatened species. The major threats faced by these plant species include the destruction of the natural habitats/ecosystems of plants for developmental activities, livestock grazing and the smuggling of a few high-valued indigenous plant species by locals for their economic upliftment. *Trillium govanianum* (locally called Nag-Chatri), *Picrorhiza kurroa*, *Podophyllum hexandrum* Royle, *Saussurea roylei* (DC.) Sch.Bip. and *Aconitum heterophyllum* were recorded as well-known among the local people for sale. These illegal and illicit extraction activities lead to a decline in the population of keystone species from the forest of Bhallesa Hills and its adjoining areas of the Pir Panjal mountainous range of the Himalayas.

4. Conclusions

Scientifically proven, the biological spectrum accurately describes the vegetation physiognomy, and the floristic analysis indicates the natural ecological wealth of the ecosystem. Traditional, sample-based research appeared to be the best to demonstrate the diversity of the plant communities from different ecological groups in Himalayan mixed-coniferous forests. The high-altitude plant species of the Bhallesa regions responded differently to the environmental drivers, with chamaephytes and therophytes being tightly linked to the temperate and alpine ecosystems. Documentation of the floristic compositions with the associated environmental parameters provides a better understanding of the vegetational structure and conservation status of the Himalayan ecosystem, on the one hand, by contributing to the feasible management of unique natural resources. The Pir Panjal range of the Himalayas has a rich plant diversity and natural resources, as evidenced by the occurrence of 328 species of higher plants in a small forest zone. This research will serve as a baseline of informative data for studies pertaining to the field of ecology and the environment. This study would be useful in the comparison and differentiation of vegetation composition in the Himalayas and their ecosystems. In our present study, phanerophytes, therophytes and hemicryptophytes share importance in depicting the phenero-, thero-, and hemicryptophytic phytoclimates. This provides an important database for policymakers to make proper management plans for the conservation and feasible use of plant resources. Our study also suggested the important role of biotic factors in shaping the vegetation structure of the landscape, and thus, anthropogenic stress is required to be minimised for the conservation of natural flora. In the upcoming future, different conservation programmes will be required to protect economically valuable flora by providing proper education and knowledge among the people.

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