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DIVERSITY PATTERN OF HERBACEOUS PLANTS OF UPPER JOHAR VALLEY, KUMAUN HIMALAYA

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Abstract*:* The present study evaluates the species diversity and phytosociological attributes of the herbaceous layer in the upper Johar valley, Kumaun Himalaya. A total of 200 quadrats (1 x 1 m) were randomly placed across 20 sites during rainy season (July-August 2024) at elevations ranging from 3000-3500 m ASL. The study identified 102 species of herbaceous plants belonging to 79 genera and 28 families, with Asteraceae (18 spp.) being the most dominant family, followed by Orobanchaceae (8 spp.). Phytosociological indices, including density, frequency, and their relative values, as well as dominance based on Important Value Index (IVI), were analysed. Species diversity was assessed using Shannon's diversity index (H), species richness, evenness, and Simpson's index (D) in PAST version 2.0 software. Euphrasia himalayica was the most dominant species in the study area. Species richness varied across the sites, with Site 1 exhibiting the highest diversity, containing 32 species. This study emphasizes the floristic composition of the region, contributing to conservation efforts and sustainable utilization strategies

Keyword: Diversity, IVI, Shannon, Evenness, Richness, Johar valley.

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INTRODUCTION

Phytosociology is fundamental in understanding plant population dynamics, species interaction, and ecosystem stability (Mishra et al., 2012). By examining species diversity, distribution patterns, and ecological roles, it provides insights into ecosystem health and resilience (Kaur et al., 2020). Among different plant groups, herbaceous species play a vital role in ecosystem functioning, yet they often remain underexplored in floristic studies (Nodza et al., 2021). Herbs constitute nearly 60% of all terrestrial plant species (Clark, 2004; Mohammed et al., 2015), serving as primary producers in food chains, contributing to soil fertility, and supporting diverse faunal communities (Quintus and Allen, 2024). Their deep root system helps in soil stabilization, water infiltration, and moisture retention (Federica et al., 2017). Despite these ecological significant, herbaceous plants are frequently overlooked in conservation planning, and their role in ecosystem services remains understudied. The herbaceous layer is highly dynamic, responding to environmental variables such as grazing pressure, fire, and rainfall fluctuations (Shameem et al., 2010). Even minor disturbance can significantly impact biomass production and disrupt ecosystem functions, including regulatory, supporting, and provisioning services. Given their ecological sensitivity, detailed phytosociological assessments are essential for understanding their distribution patterns, conservation status, and sustainable management.

This study focuses on the Upper Johar Valley in the Western Himalaya (Uttarakhand), a region renowned for its high-altitude biodiversity and rich assemblage of medicinal and aromatic plants (MAPs). Uttarakhand harbours approximately 701 MAP species, while the neighboring Himachal Pradesh hosts around 643 species (Kala, 2000; Samant, 1998). Notably, 26% are indigenous to the Himalayan region, while 6% have a restricted distribution across the Himalayas and adjacent regions (Samant, 1998). However, high-altitude ecosystem like Himalayas is particularly fragile and highly sensitive to both natural and anthropogenic pressures (Dhiman and Muthanarasimha, 2022). Medicinal and aromatic plants (MAPs) have been an integral part of traditional medicine and local livelihoods for centuries. However, unsustainable harvesting practices pose a significant threat to their population. Around 90-95% of MAPs in the Western Himalayas are harvested directly form the wild, often through destructive methods (Pauls, 2013). Alpine regions contribute approximately 30% of the MAPs traded in the Western Himalayas, further intensifying extraction pressures. This overexploitation, coupled with habitat loss, climate change, and grazing, is leading to a steady decline in the population of many valuable species. While several floristic studies have extensively documented woody vegetation in the Western Himalayas (Rao, 1959; Pangtey, et al., 1988; Samant, 1987; Rawat, 1998; Shekar et al., 2024), the herbaceous species of the Upper Johar Valley remain poorly studied. This study aims to bridge this knowledge gap by conducting a comprehensive phytosociological analysis of herbaceous species in the region. the study has following objectives: Assess species diversity and distribution patterns of herbaceous flora in the Upper Johar Valley. Identify lesser-known medicinal and aromatic plants (MAPs) with potential for sustainable utilization and cultivation. Highlights the economic and conservation significance of herbaceous species to promote awareness, sustainable harvesting and conservation efforts.

Despite the region's rich floristic diversity, the lack of systematic documentation has limited awareness of the economic potential of herbaceous plants. Many species, through ecologically and medicinally significant, are often misidentified as weeds and remain underutilized. Conducting regular phytosociological surveys is crucial for understanding plant diversity, their ecological roles, and their potential applications in medicine, trade, and conservation. By raising awareness and fostering sustainable utilization strategies, this study aims to contribute to the long-term conservation and management of herbaceous species in the Upper Johar Valley.

EXPERIMENTAL

Study area: Johar Valley, situated within Munsiyari Tehsil, Pithoragarh District, Kumaun Himalaya, covers an area about 2738 km^2. The valley is further divided into three zones—Malla Johar, Talla Johar, and Goriphat, ranging from 2200 m to 3500 m elevation. The valley extends from village Madkot in Talla Johar (2200 m) to Milam in Malla Johar (3500m), following the Gori Ganga River, which originates from the Milam Glacier. The present study was conducted in the Upper Johar valley, which spans approximately 52.7 km^2 and exhibits diverse landscape and ecosystem (Figure 1). The altitude range of 3000–3500 m was selected for its rich diversity of herbaceous species, surpassing that of the middle and lower regions of the Johar Valley. This elevation also holds significant ecological and ethnobotanical value. Despite its remoteness, indigenous communities actively explore the area for subsistence, trade, and medicinal plant collection. The study transects extended from Laspa (3000m) to Milam (3500m) which is the last village in the valley. The region experiences mean annual temperature 10.04°C with the warmest month reaching 15.39°C and the coldest month dropping to −7.43 °C (Ratha et al., 2014). Annual precipitation averages 1242.22 mm, with 263.89 mm occurring in the wettest month and only 18.44 mm in the driest month. Snowfall covers most of the valley from December to April (Pandey 2018) making July and August optimal for botanical surveys (Rawat and Pangtey, 1987). The area exhibits characteristics of both alpine grassland and temperate forest (Gairola et al., 2008). Dominant tree species includes *Betula utilis* (Bhojpatra), *Abies spectabilis* (Fir), and *Quercus* spp. (Evergreen oaks), which form dense forests in the central and western Himalayas (Singh and Singh 1987). Bugyals, or alpine grassy meadows, form a striking feature against the surrounding snow-crowned mountains (Rao ,1959). *Rhododendron campanulatum* is the most common species, often forming pure stands, while *Abies spectabilis* is found mixed with *Juniperus wallichiana*. Tree tends to be stunted (<15m), except for *Betula utilis*, which may grow taller (Singh and Singh 1987).

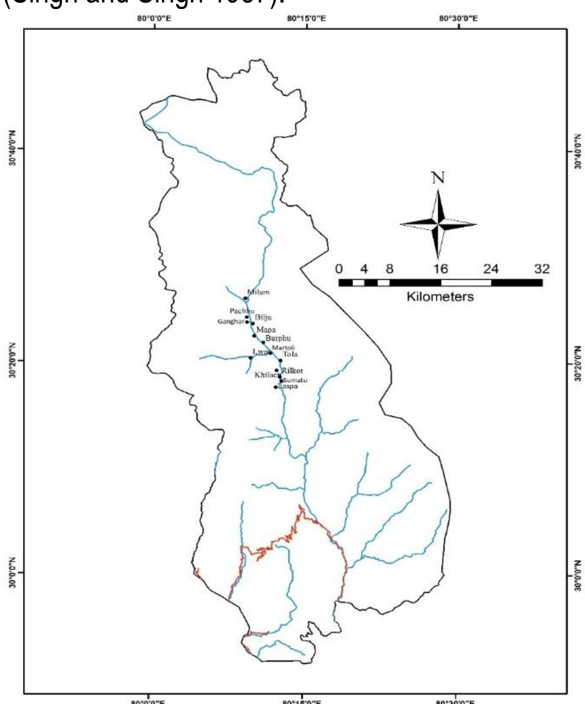

Figure 1. Location map of the study area

Data collection: The present study was conducted during the rainy season between July-August 2024, a period chosen for optimum vegetation growth, as the region remains snow-covered for nearly six months from December-April. This season provides maximum visibility and enables the proper identification of herbaceous species that might otherwise remain obscured. To assess the diversity and distribution of medicinal and aromatic herbs, a stratified-random sampling method was employed (Misra, 1968). To collect the data, whole study area (Upper Johar Valley) was divided into 20 transects, covering diverse microclimatic condition, exposure, physiognomy, accessibility, and elevation gradients. Out of this only four transects were falls into moist, shady, and moderate slopes form 3000-3300 m altitude. However, maximum transects (16) were characterized as dry places and having steep slopes ranged from 3300-3500 m altitude. Burfu, Bilju, Milam, Mapa, Ganghar, and Paachu are among the common villages located along the dry transects of the valley. During the study, ten randomly placed quadrats (1 m × 1 m) were established in each transect to ensure a comprehensive representation of herbaceous diversity, resulting in a total of 200 quadrats evaluated across the study area.

Herbarium Preparation and Identification

Following the conventional approach (Jain and Rao1977), representative specimens from each species within the quadrats were collected, and an herbarium was prepared. Plant identification to species level was done using literature (Pangtey et al. 1988, Rai et al. 2017). Additionally, species names were cross-verified with online databases such as the e-Flora of India (https://efloraofindia.com/) and the Medicinal Plant Name Services of the Kew Botanical Garden (https://powo.science.kew.org/results?). All the voucher specimens were deposited in the Biodiversity Conservation Laboratory, Department of Botany, Soban Singh Jeena University Campus, Almora, Uttarakhand (India).

Data analysis: The species composition analysis was carried out by using standard phytosociological indices to assess the diversity and distribution of herbaceous species of the area. Density, frequency, and their relative values were computed using Microsoft Excel 21, while species richness, species diversity, and species evenness were calculated using PAST software (version 2.0).

Phytosociological parameters: The following indices were used to analyze species composition and diversity:

a) Density: it represents the numerical strength of a species in a community, indicating how many individuals of a species are present per unit area (Curtis and Meintosh 1950).

$$\text{Density} = \frac{\text{Total number of individuals of a species in quadrat}}{\text{Total number of quadrat studied}}$$

b) Frequency (%): it expresses the degree of occurrence of individual species in an area. i.e., how often a species appears in different quadrats.

$$\text{Frequency} = \frac{\text{No. of quadrants in which species occured}}{\text{Total number of quadrat studied}} \times 100$$

c) Abundance: it refers to the average number of individuals of a species per quadrat in which it occurs.

$$\text{Abundance} = \frac{\text{Total no. of induidals of a species in all quadrate}}{\text{Total no. of quadrat in which species occur}}$$

d) A/F ratio: it helps determine the distribution pattern of species in the study area.

$$\text{A/F} = \frac{\text{Abundance}}{\text{Frequency}}$$

A/F < 0.025- Regular distribution

0.025 < A/F < 0.05- Random distribution

A/F > 0.05- Contagious distribution

e) Importance value index: it is used to determine the overall dominance of species in a given habitat (Curtis, 1950). It involves the summation of relative frequency and relative density.

$$\text{IVI} = \text{Relative density} + \text{Relative fequency}$$

Diversity indices

These indices quantify species richness, evenness, and variability to understand community structure and ecological stability.

Species richness: using Margalef's index for richness (D_{mg}), which indicates the number of species present relative to the total number of individuals sampled.

$$(\text{Dmg})\, \frac{(S-1)}{\ln N}$$

Where: S= Total number of species,

N= total number of individual species in a sampling plot

Species diversity: The Shannon-Wiener Index (Shannon and Weaver, 1963) accounts for both species richness, and abundance, measuring how diverse a community is.

Shannon's Weiner diversity index H´

$$\text{H}' = -\sum_{\text{I}=1}^{\text{S}} \text{Pi}(\ln \text{Pi})$$

Here; $\text{Pi} = \frac{\text{Ni}}{\text{N}}$

ln= log base 10

Ni= Number of individuals of one plant species

N= Total number of all individuals plant species

Pielou index (J): species equitability index is used to calculate how evenly the species were distributed within the study area (Pielou 1959).

$$\text{E} = \frac{\text{H}'}{\text{Hmax}}$$

Where, H_{max}= ln(S)

S= Total no. of species in the community.

RESULT & DISCUSSION

In the present investigation, a total of 102 species of medicinal and aromatic herbaceous plants were recorded across all twenty study sites (transects). These species represented 79 genera and 28 families. Among the plant families observed, Asteraceae exhibited the highest diversity, with 18 species documented, followed by Orobanchaceae with 8 species. Other notable families include Lamiaceae, Polygonaceae, and Ranunculaceae, each represented by 7 species. The Rosaceae family contributed 6 species, while Caryophyllaceae represented by 5 species (Table 1). Among the twenty sites, species richness has been seen to decrease with elevation. Site 2nd exhibited the highest species richness, with a total of 36 species recorded. This was followed by Site 1th with 32 species and Site 7th with 29 species (Figure 2). Consequently, ten medicinal herb species were consistently found across all four wetlands, indicating their preference for such habitats. These common species include *Anaphalis contorta*, *Cirsium falconeri*, *Euphrasia himalayica*, *Geranium robertianum*, *G. wallichianum*, *Koenigia polystachya*, *Potentilla atrosanguinea*, *Rumex nepalensis*, *Swertia ciliata*, and *Dolomiaea costus*. Diversity indices were evaluated using frequency as the foundational measure. The result revealed that *Euphrasia himalayica* showed the highest density and relative density in site 5th, 6th and 17th, followed by *Lomatogonium carinthiacum* at site 9th and *Swertia ciliata* in site 3rd respectively. Whereas frequency and relative frequency were found highest from *Fragaria nubicola* at site 13th followed by *Euphrasia himalayica* in site 17th as compared to other sites. Across the study sites, relative density values for species ranged from 0.01% to 11.41%. The herb *Aconitum ferox* and *Corydalis orientalis* recorded the lowest relative density (0.01% each), while *Euphrasia himalayica* exhibited the highest relative density, occupying 11.41% of the surveyed area (Table 1, 2). Similarly, relative frequency values varied from 0.06% to 6.47%. *Taraxacum officinale*, with a relative frequency of 6.47%, displayed the highest occurrence across the quadrats, suggesting its widespread presence in the area. Conversely, highly valued medicinal species, including *Aconitum ferox*, *Geranium collinum*, *Picrorhiza kurroa*, *Rheum australe*, and *Valeriana himalayana*, each exhibited a minimal relative frequency of 0.06%, indicating their more localized distribution (Table 1).

Table 1: Family across all 102 herbaceous plants from Upper Johar Valley

S. No	Family	No. of genera	No. of species recorded form the family
1.	Amaryllidaceae	1	1
2.	Apiaceae	3	3
3.	Araceae	1	2
4.	Asteraceae	13	18
5.	Balsaminaceae	2	2
6.	Boraginaceae	4	4
7.	Brassicaceae	3	3
8.	Campanulaceae	2	2
9.	Cannabaceae	1	1
10.	Caprifoliaceae	2	2
11.	Caryophyllaceae	4	5
12.	Fabaceae	3	3
13.	Gentianaceae	5	6
14.	Geraniaceae	1	3
15.	Iridaceae	1	1
16.	Lamiaceae	7	7
17.	Onagraceae	1	1
18.	Orchidaceae	1	1
19.	Orobanchaceae	3	8
20.	Papaveraceae	1	1
21.	Parnassiaceae	1	1
22.	Plantaginaceae	3	3
23.	Polygonaceae	5	7
24.	Primulaceae	2	2
25.	Ranunculaceae	5	7
26.	Rosaceae	2	6
27.	Scrophulariaceae	1	1
28.	Urticaceae	1	1

Dominant species based on IVI, as shown in Figure 3. The importance value index values ranged from 0.07% to 16.45%, reflecting the varying degrees of ecological influence among the species. *Euphrasia himalayica* emerged as the most dominant species with an IVI (16.45%), followed by *Taraxacum officinale* (12.81%), *Anaphalis contorta* (11.11%), *Lotus corniculata* (8.70%), *Fragaria nubicola* (6.91%), *Thymus linearis* (6.43%), *Senecio laetus* (6.41%), *Rumex nepalensis* (5.47%), *Pedicularis oederi* (5.58%), and *Geranium wallichianum* (5.63%). Each study site displayed unique diversity index values, indicating variations in species composition across the study area. The Shannon-Wiener index (H'), which measures species abundance, revealed values ranging from 1.675 to 3.075. Site second recorded the highest Shannon-Wiener index value (H' = 3.075), which corresponded with its high species richness of 36 species. Site first followed, with 32 species and an H' value of 2.976. Conversely, Site 20th exhibited the lowest diversity, with only 8 species and an H' value of 1.675 (Table 3) (Figure 4).

Margalef index, which assesses species richness, ranged from 1.717 at Site 20th (the lowest) to 5.047 at Site second (the highest), indicating variability in species dominance across the sites (Table 3) (Figure 4). Pielou's evenness index (J) varied between 0.47 and 0.87, with Site 17th showing the least evenness and Site 14th demonstrating the highest evenness among species (Table 3) (Figure 4). A strong correlation between species richness and evenness was anticipated; however, the data did not reveal a prominent relationship. It shows that a site with high species richness does not necessarily exhibit balanced species distribution, and conversely, a site with fewer species may display a more even distribution. This finding shows that species richness alone does not ensure a balanced ecosystem in terms of species distribution. Additionally, Simpson's dominance index values across the study area remained below one, indicating that no single species overwhelmingly dominated any site. This lack of species dominance supports a more balanced community structure, with multiple species contributing to ecosystem stability. Aggregation of plants species results (46.08% random distribution, contagious 29.41%, and 24.51% regular distribution). Random distribution indicates that the environment in which these plants species grown is homogenous and has many environmental factors, favorable microhabitats, seed dispersal mechanisms or reproductive strategies (Ewusie 1980).

Across the 20 sites of the study area maximum number of species richness trend was recorded in maist shady sites, the reasons could be due to the availability of moisture present in the area and other environmental factors. While many floristic surveys were conducted in this region shows high level of reflective biodiversity; nevertheless, there aren't many studies that really address the phytosociology of this area. Similar study conducted by Pandey and Sekar (2019) at Rilkote and the Nanda Devi base camp in the high-altitude alpine region of the Western Himalayas (4235 m) and recorded approximately 216 species, including 206 angiosperms and 10 gymnosperms. Their focus on the traditional high-altitude medicinal plants (THMPs) of the region identified 88 species with medicinal value, among which 22 species were classified as THMPs. Across all study sites, a notable decline in species richness with increasing altitude was observed, aligning with trends reported by Sekar et al. (2024). Specifically, the distribution of flora across altitude zones showed that 72% of the total flora occurred between 3000–3500 m, followed by 62% between 3501–4000 m, 38% between 4001–4500 m, and only 9% between 4501–4800 m. This pattern reflects a continuous decrease in the distribution of higher taxa as altitude increases. The dominant herbaceous species in the region, include *Euphrasia himalayica*, *Taraxacum officinale*, *Anaphalis contorta*, *Thymus linearis*, *Rumex nepalensis*, *Potentilla oederi*, and *Geranium wallichianum*, plays a significant role in the local biodiversity. Despite their widespread medicinal use globally, many of these plants are considered weeds by the inhabitant of the study area. Recognizing the value of these plants can provide a sustainable alternative to widely-known medicinal plants, alleviating pressure on threatened species and contributing to the preservation of local ecological balance.

During the study various shrubs dotted in the study sites were also observed. Common shrubs found include *Berberis*, *Cotoneaster*, *Ephedra*, *Gaultheria*, *Hippophae*, *Juniperus*, *Rhododendron*, and *Rosa*, which add structural diversity to the landscape and provide habitat for local wildlife. The plant species that successfully invade and establish themselves in the dynamic environments of the Johar Valley include *Rosa*, *Berberis*, *Ephedra*, *Junipers*, *Hippophae*, and various species of *Cotoneaster* (Rao 1959). These plants possess unique adaptations that enable them to thrive in challenging high-altitude conditions, such as the newly formed moraine belts created by glacial retreat. The upper Johar valley of Kumaun Himalaya serves as a diverse type of herbaceous plants. However, not all species are well-known or used by the locals. To document the medicinal properties of the recorded herbaceous diversity of the region. Resulted in a total of 83 plants of the 102 herbaceous species have numerous therapeutic qualities to address a variety of illnesses. Major categories of ailments treated include stomach-related disorders, skin-related problems, fever, antidote, muscle and joint pain. It was resulted that 33 plants species were utilized to cure gastrointestinal conditions, including constipation, diarrhoea, dysentery, gastritis, and stomachache. Root and leaves infusion, tonic, decoction, and herbal tea are examples of common usage pattern. Twenty-five plant species were shown to be useful in treating skin-related issues, including acne, pimple, scabies, boils, sunburns, cuts and wounds. Making a plant paste and applying it directly to the affected area is the most popular application technique.

Twelve plant species were found to be effective in managing fevers, while 8 plants species were shown to be useful in treating discomfort connected to muscles and joints. These includes *Aconitum ferox*, *Anaphalis nepalensis*, *Bistorta affinis*, *Blumea mollis*, *Carum carvi*, *Cirsium falconeri*, *Iris kemaonensis*, and *Plantago himalaica*. Five plant species- *Euphrasia himalayica*, *Lomatogonium carinthiacum*, *Plantago himalaica*, *Thymus linearis*, and *Verbascum thapsus* were found to be effective in treating cough and colds. Additionally, 4 plants species were documented for their use as antidotes in traditional medicinal systems across the world, *Arisaema jacquemontii*, *Pedicularis oederi*, *Aconitum ferox*, and *Parnassia nubicola*. The findings indicates that a significant proportion of the region's herbaceous flora holds medicinal value, with notable uses in treating various illnesses. The traditional knowledge of locals regarding these plants is limited, indicating the need for awareness of these valuable resources into broader healthcare practices.

Table 2: Displaying the density, frequency, relative values, abundance, Important Value Index (IVI) and A/F ratio of herbaceous plants in the study area

Name of species	D	RD	F	RF	A	IVI	A/F
Aconitum ferox	0.01	0.01	0.5	0.06	1.00	0.07	2.00
Ajania nubigena	0.05	0.08	2.0	0.24	2.25	0.32	1.13
Ajuga multiflora	1.04	1.83	15.5	1.84	6.71	3.67	0.43
Allium stracheyi	0.38	0.66	3.0	0.36	12.50	1.02	4.17
Anaphalis contorta	3.59	6.30	40.5	4.81	8.85	11.11	0.22
Anaphalis nepalensis	0.08	0.13	2.5	0.3	3.00	0.43	1.20
Anchusa capensis	0.37	0.65	10.0	1.19	3.70	1.84	0.37
Androsace sarmentosa	0.04	0.07	1.0	0.12	4.00	0.19	4.00
Anemone polyanthes	0.10	0.17	3.5	0.42	2.71	0.59	0.78
Arabidopsis thaliana	0.01	0.02	0.5	0.06	2.00	0.08	4.00
Arisaema jacquemonti	0.18	0.31	3.5	0.42	5.00	0.73	1.43
Arisaema propinquum	0.61	1.07	4.5	0.53	13.56	1.6	3.01
Artemisia gmelinii	1.16	2.04	19.0	2.26	6.11	4.3	0.32
Artemisia roxburghiana	0.79	1.38	11.5	1.37	6.83	2.75	0.59
Bistorta affinis	0.31	0.54	1.5	0.18	20.33	0.72	13.56
Bistorta vivipara	0.42	0.73	3.0	0.36	13.83	1.09	4.61
Blumea mollis	0.11	0.18	4.0	0.48	2.63	0.66	0.66
Bupleurum dalhousieanum	0.38	0.67	6.0	0.71	6.33	1.38	1.06
Bupleurum falcatum	0.12	0.20	1.5	0.18	7.67	0.38	5.11
Campanula pallida	0.15	0.25	3.5	0.42	4.14	0.67	1.18
Cannabis sativa	0.01	0.02	0.5	0.06	2.00	0.08	4.00
Cardamine hirsuta	0.11	0.19	3.5	0.42	3.14	0.61	0.90

Carum carvi	1.08	1.89	7.0	0.83	15.36	2.72	2.19
Cerastium cerastoides	0.08	0.13	1.0	0.12	7.50	0.25	7.50
Chaerophyllum villosum	1.65	2.90	16	1.9	10.31	4.8	0.64
Cirsium falconeri	0.17	0.29	10	1.19	1.65	1.48	0.17
Cirsium verutum	0.14	0.25	9.5	1.13	1.47	1.38	0.16
Clematis orientalis	0.01	0.01	0.5	0.06	1.00	0.07	2.00
Clinopodium umbrosum	0.26	0.46	6.5	0.77	4.00	1.23	0.62
Corydalis cornuta	0.05	0.09	1.5	0.18	3.33	0.27	2.22
Cyananthus lobatus	0.23	0.40	4.5	0.53	5.11	0.93	1.14
Cynoglossum glochidiatum	0.83	1.45	14.5	1.72	5.69	3.17	0.39
Dactylorhiza hatagirea	0.32	0.55	5.0	0.59	6.30	1.14	1.26
Dolomiaea costus	0.06	0.10	1.0	0.12	5.50	0.22	5.50
Dubyaea hispida	0.16	0.28	4.5	0.53	3.56	0.81	0.79
Epilobium royleanum	0.01	0.02	0.5	0.06	2.00	0.08	4.00
Erigeron bonariensis	0.27	0.47	6.5	0.77	4.15	1.24	0.64
Erigeron multiradiatus	0.87	1.53	18	2.14	4.83	3.67	0.27
Eriocapitella rivularis	1.38	2.42	12.5	1.48	11.04	3.9	0.88
Eriocapitella vitifolia	0.08	0.13	1.5	0.18	5.00	0.31	3.33
Euphrasia himalayica	6.50	11.41	42.5	5.05	15.28	16.46	0.36
Fagopyrum tataricum	0.01	0.02	1.0	0.12	1.00	0.14	1.00
Fagopyrum esculentum	0.12	0.20	1.0	0.12	11.50	0.32	11.50
Fragaria indica	0.17	0.30	4.5	0.53	3.78	0.83	0.84
Fragaria nubicola	2.11	3.71	27	3.21	7.81	6.92	0.29
Gentiana argentea	0.03	0.04	1.0	0.12	2.50	0.16	2.50
Gentiana pedicellata	0.01	0.02	3.0	0.36	0.33	0.38	0.11
Gentianella bulgarica	0.26	0.45	5.5	0.65	4.64	1.1	0.84
Geranium collinum	0.01	0.02	0.5	0.06	2.00	0.08	4.00
Geranium robertianum	0.51	0.90	6.5	0.77	7.85	1.67	1.21
Geranium wallichianum	1.42	2.48	26.5	3.15	5.34	5.63	0.20
Gueldenstaedtia verna	0.10	0.17	3.5	0.42	2.71	0.59	0.78
Hackelia uncinata	0.02	0.03	1.0	0.12	1.50	0.15	1.50
Halenia elliptica	0.91	1.60	5.0	0.59	18.20	2.19	3.64
Impatiens glandulifera	0.05	0.09	0.5	0.06	10.00	0.15	20.00
Impatiens sulcata	0.07	0.12	2.5	0.3	2.80	0.42	1.12
Iris kemaonensis	0.67	1.17	3.5	0.42	19.00	1.59	5.43
Koenigia polystachya	0.90	1.57	19.5	2.32	4.59	3.89	0.24
Leontopodium himalayanum	1.63	2.86	13.5	1.6	12.07	4.46	0.89
Lomatogonium carinthiacum	0.52	0.91	6.0	0.71	8.67	1.62	1.44

Lotus corniculatus	3.03	5.31	28.5	3.38	10.61	8.69	0.37
Minuartia kashmirica	0.15	0.26	4.5	0.53	3.33	0.79	0.74
Morina longifolia	0.28	0.48	6.5	0.77	4.23	1.25	0.65
Myosotis laxa	0.17	0.29	8.0	0.95	2.06	1.24	0.26
Origanum vulgare	0.39	0.68	11.0	1.31	3.55	1.99	0.32
Orobanche alba	0.13	0.23	8.5	1.01	1.53	1.24	0.18
Parnassia nubicola	0.17	0.30	6.0	0.71	2.83	1.01	0.47
Parochetus communis	0.16	0.27	1.5	0.18	10.33	0.45	6.89
Pedicularis gracilis	0.24	0.42	3.5	0.42	6.86	0.84	1.96
Pedicularis hoffmeisteri	0.04	0.07	0.5	0.06	8.00	0.13	16.00
Pedicularis longiflora	0.01	0.02	4.5	0.53	0.22	0.55	0.05
Pedicularis oederi	1.22	2.14	29	3.44	4.21	5.58	0.15
Pedicularis pectinata	0.14	0.25	1.5	0.18	9.33	0.43	6.22
Pedicularis punctata	0.22	0.38	2.5	0.3	8.60	0.68	3.44
Picrorhiza kurroa	0.13	0.22	0.5	0.06	25.00	0.28	50.00
Plantago himalaica	1.24	2.18	22.0	2.61	5.64	4.79	0.26
Potentilla argyrophylla	0.50	0.88	5.0	0.59	10.00	1.47	2.00
Potentilla atrosanguinea	1.34	2.34	21.0	2.49	6.36	4.83	0.30
Potentilla cuneifolia	0.68	1.19	12.0	1.43	5.63	2.62	0.47
Potentilla eriocarpa	0.12	0.20	2.0	0.24	5.75	0.44	2.88
Prenanthes brunoniana	0.14	0.25	3.0	0.36	4.67	0.61	1.56
Primula nana	0.21	0.37	6.5	0.77	3.23	1.14	0.50
Prunella vulgaris	0.13	0.22	3.0	0.36	4.17	0.58	1.39
Ranunculus diffusus	0.11	0.19	1.5	0.18	7.33	0.37	4.89
Ranunculus hirtellus	0.21	0.37	3.5	0.42	6.00	0.79	1.71
Rheum australe	0.01	0.01	0.5	0.06	1.00	0.07	2.00
Rorippa amphibia	0.07	0.11	1.5	0.18	4.33	0.29	2.89
Rumex nepalensis	1.19	2.08	28.5	3.38	4.16	5.46	0.15
Scutellaria prostrata	0.74	1.30	12.5	1.48	5.92	2.78	0.47
Selinum wallichianum	0.18	0.32	3.5	0.42	5.14	0.74	1.47
Senecio laetus	1.72	3.02	28.5	3.38	6.04	6.4	0.21
Silene setisperma	0.03	0.04	1.0	0.12	2.50	0.16	2.50
Silene vulgaris	0.45	0.78	7.0	0.83	6.36	1.61	0.91
Stachys himalayensis	0.03	1.50	6.0	0.71	0.50	2.21	0.08
Stellaria media	0.86	0.05	2.0	0.24	42.75	0.29	21.38
Swertia ciliata	1.03	1.80	7.0	0.83	14.64	2.63	2.09
Taraxacum officinale	3.61	6.34	54.5	6.47	6.62	12.81	0.12
Thymus linearis	1.30	2.27	35.0	4.16	3.70	6.43	0.11

Urtica dioica	0.06	0.11	0.5	0.06	12.00	0.17	24.00
Valeriana himalayana	0.01	0.02	0.5	0.06	2.00	0.08	4.00
Verbascum thapsus	0.53	0.92	17.5	2.08	3.00	3	0.17
Veronica fruticans	0.52	0.91	4.5	0.53	11.56	1.44	2.57

Abb: D= Density, RD= Relative density, F= Frequency, RF= Relative frequency, A= Abundance, IVI= Important value index, A/F= Abundance/Frequency

Table 3: Displaying diversity indices across different sites

Sites	Taxa	Shannon (H)	Equitability (J)	Evenness (E)	Margalef
Site 1	32	2.976	0.8586	0.6127	4.507
Site 2	36	3.075	0.858	0.6012	5.047
Site 3	23	2.537	0.8093	0.5499	3.18
Site 4	21	2.815	0.9246	0.7948	3.757
Site 5	28	2.756	0.8271	0.5621	3.867
Site 6	17	2.395	0.8453	0.645	2.294
Site 7	29	2.749	0.8163	0.5387	4.332
Site 8	17	2.655	0.9373	0.8372	3.185
Site 9	25	2.621	0.8143	0.5501	3.619
Site 10	24	2.712	0.8533	0.6273	3.626
Site 11	15	2.53	0.9344	0.8372	2.516
Site 12	22	2.64	0.8542	0.6373	3.542
Site 13	24	2.61	0.8212	0.5665	3.78
Site 14	18	2.753	0.9523	0.8713	3.147
Site 15	26	2.754	0.8454	0.6043	3.852
Site 16	19	2.666	0.9054	0.7568	3.302
Site 17	24	2.423	0.7624	0.47	3.445
Site 18	24	2.482	0.7811	0.4988	3.793
Site 19	22	2.565	0.8298	0.5909	3.457
Site 20	8	1.675	0.8053	0.6671	1.717

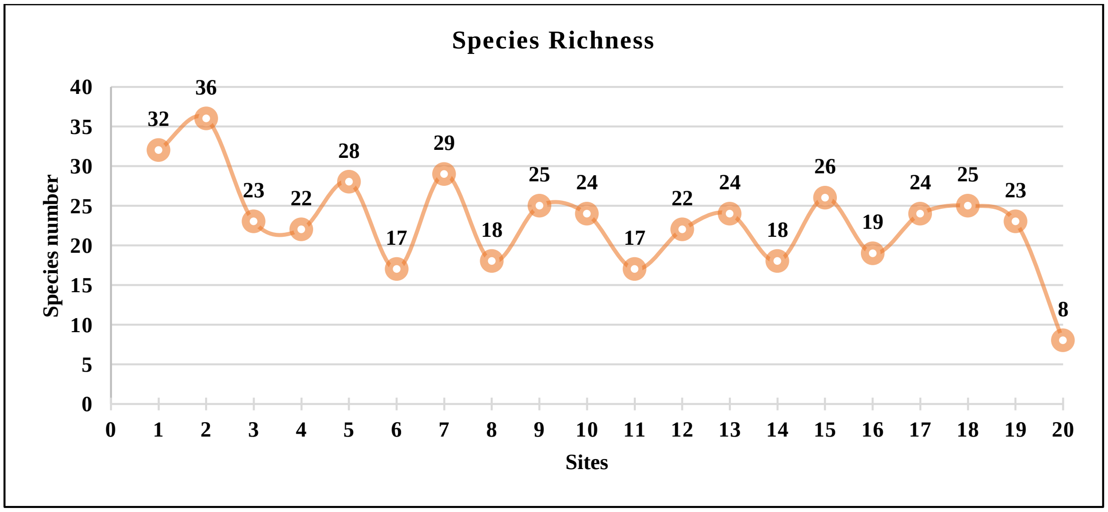

Figure 2: Species Richness Across Different Study Sites

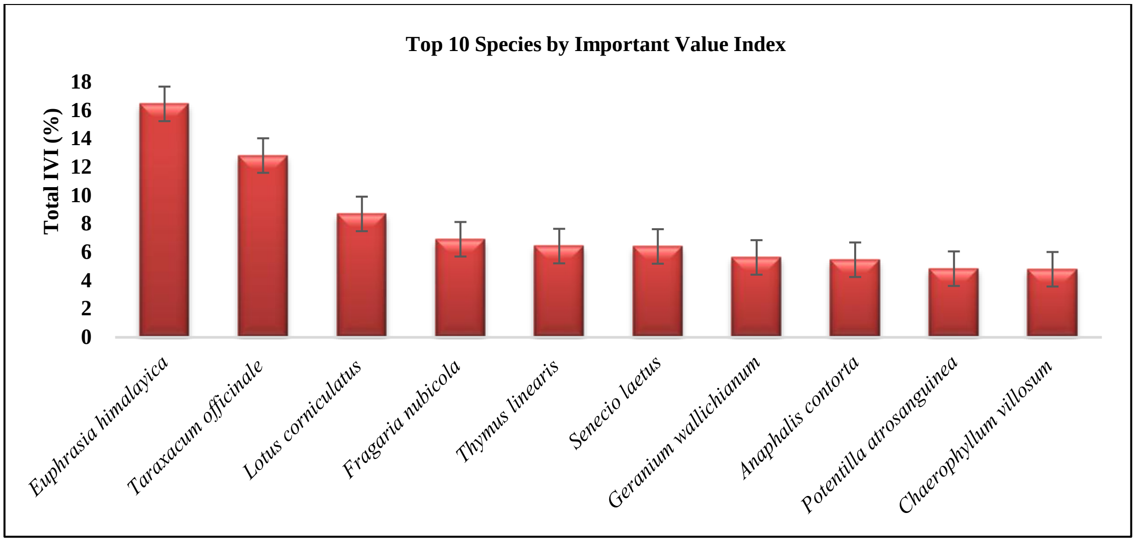

Figure 3: Top 10 species by total Important value index IVI

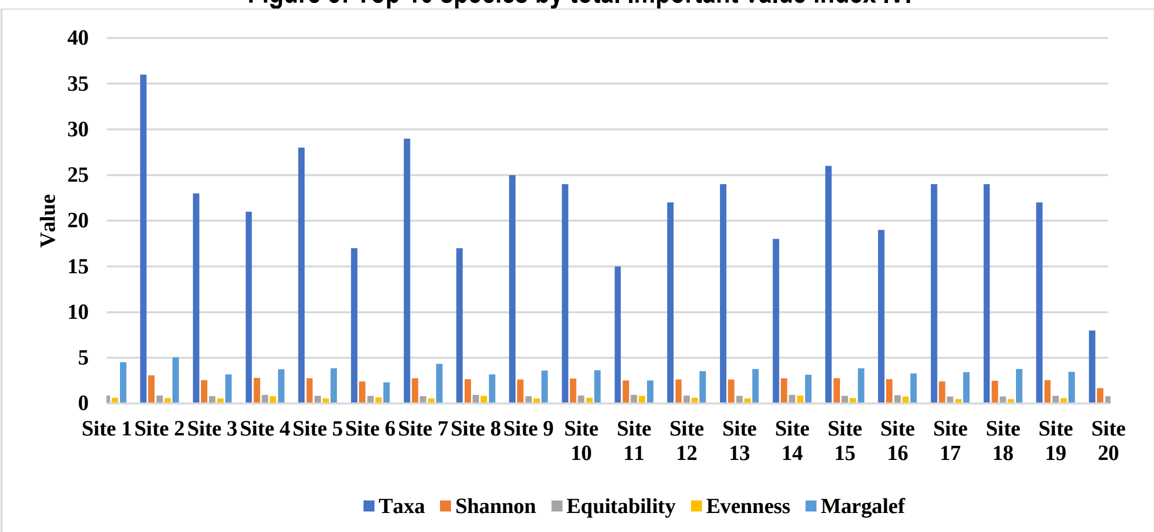

Figure 4. Shannon index, Evenness, Equitability and Margalef of Herbaceous Plants

Figure 5: Herbaceous Plants form Johar Valley, Kumaun Himalaya

CONCLUSION

Across 20 study sites, 102 herbaceous plant species were identified, spanning 28 families and 79 genera, representing the region's rich flora. Asteraceae, with 18 species, emerged as the most prominent family, while *Euphrasia himalayica* dominated with the highest importance value index. Despite Johar Valley's renowned biodiversity, recent decades have seen significant pressures on plant species, including rare and threatened ones, due to over-extraction, livestock grazing, tourism, and other human activities. The retreat of the glacial belt has created a new moraine belt, offering a unique opportunity to study plant colonization and invasion from neighboring alpine meadows. This study provides baseline data on the floristic diversity of the Johar Valley, serving as a valuable reference for conservation efforts. While all identified species possess medicinal properties, they are often overlooked due to limited awareness and research. Habitat loss and climate change pressures have contributed to the extinction of valuable medicinal plants, prompting some communities to domesticate wild varieties for income. This trend underscores the urgent need for sustainable conservation strategies. Additionally, the seasonal diversity of species in relation to climate change remains an underexplored area; investigating seasonal variations could shed light on climate impacts on subalpine ecosystems, enhancing conservation and adaptation strategies.

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