Quantitative ethnobotanical assessment of three medicinal plant species in the Hindu Kush-Himalayan region of Swat, Pakistan

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Abstract

Background: Traditional plant knowledge remains an important component of healthcare and livelihood systems in the mountainous regions of Pakistan. Traditional plant knowledge remains an important component of healthcare and livelihood systems in the mountainous regions of Pakistan. This study documents the ethnobotanical uses, literature-based phytochemical evidence, and conservation implications of three selected medicinal plant species while providing the first comparative quantitative ethnobotanical and ethnoveterinary assessment of these underexplored taxa in District Swat, Pakistan.

Methods: Ethnobotanical data were collected between July 2025 and March 2026 from 45 key informants using purposive sampling through semi-structured interviews, guided field walks and participatory discussions. Data collection continued until information saturation was achieved. Quantitative indices including Frequency of Citation, Relative Frequency of Citation, Use Value, and Fidelity Level were used to assess cultural significance.

Results: A total of 167 use reports were recorded throughout the survey. *Allium filidens* showed the highest ethnobotanical importance with 82 use reports, FC (40), RFC (0.89), UV (1.82) and FL (85%). *Astragalus kanjuensis* accounted for 58 use reports with FC (32), RFC (0.71) and UV (1.29), while *Delphinium suave* recorded 49 use reports with FC (28), RFC (0.62) and UV (1.09). The recorded uses included food, medicine, ethnoveterinary care, fodder, and wound healing. Literature reports indicate that related species within these genera contain flavonoids, saponins, polysaccharides, organosulfur compounds and diterpenoid alkaloids associated with antioxidant, antimicrobial, and anti-inflammatory activities.

Conclusions: The studied species are important biocultural resources supporting local healthcare traditions. Field observations and informant perceptions suggest localized population pressures associated with overharvesting and habitat degradation, highlighting the need for precautionary conservation measures

Keywords: Ethnopharmacology; Cultural heritage; Use value; Indigenous knowledge systems; Conservation; Sustainable utilization

Background

Medicinal plants remain a fundamental component of primary healthcare systems, particularly in developing regions where access to modern medical facilities is limited. Ethnobotany provides a structured framework for documenting traditional plant knowledge and understanding human-plant relationships within cultural and ecological contexts (Martin, 1995). In recent decades, quantitative ethnobotanical approaches have strengthened this discipline by enabling systematic evaluation of plant use patterns and cultural importance using indices such as Frequency of Citation (FC), Relative Frequency of Citation, Use Value, and Fidelity Level (Phillips & Gentry, 1993; Tardío & Pardo-de-Santayana, 2008; Heinrich *et al.* 2009). These tools support the identification of culturally significant species and assist in prioritizing taxa for pharmacological validation and conservation planning (Vitalini *et al.* 2013).

The Hindu Kush-Himalayan region is recognized as a global biodiversity hotspot due to its high species richness, ecological heterogeneity, and endemism (Myers *et al.* 2000; Sharma *et al.* 2010). Northern Pakistan, particularly Khyber Pakhtunkhwa, harbors a rich diversity of medicinal plants and retains long-standing traditional knowledge systems that remain essential for rural healthcare (Ali *et al.* 2018; Ali *et al.* 2026). District Swat, situated within this mountainous landscape is particularly notable for its ethnobotanical richness where local communities rely heavily on medicinal plants for treating gastrointestinal, respiratory, dermatological and inflammatory conditions (Akhtar *et al.* 2013; Ahmad *et al.* 2022; Ali *et al.* 2023). However, increasing anthropogenic pressures such as overharvesting, habitat degradation, overgrazing, deforestation, and climate change are threatening both plant populations and the continuity of traditional ecological knowledge (Shinwari, 2010; Pieroni *et al.* 2014). These challenges highlight the need for systematic documentation and quantitative assessment of ethnobotanical resources to support sustainable utilization and conservation strategies (Ahmad *et al.* 2014; Ali *et al.* 2023). Despite several ethnobotanical surveys conducted in Swat Valley, most studies are broad floristic inventories and lack species-level quantitative comparisons integrating ethnoveterinary and ecological perspectives. No study has specifically evaluated *Astragalus kanjuensis*, *Allium filidens*, and *Delphinium suave* using standardized ethnobotanical indices in a comparative framework. This study addresses this gap by providing a focused, species-level quantitative assessment integrating medicinal, ethnoveterinary, and ecological dimensions. By applying standardized ethnobotanical indices, the research aims to evaluate cultural importance, use patterns and relative significance of the selected taxa while generating baseline information for future pharmacological validation, sustainable resource management, and conservation planning.

Materials and Methods

Study area

District Swat is located in the northwestern region of Pakistan within Khyber Pakhtunkhwa Province and forms part of the Hindu-Kush mountain system. It lies between 34°34′-35°55′ N latitude and 72°08′-72°50′ E longitude (Ali *et al.* 2018; Ali *et al.* 2023). The district comprises a highly mountainous landscape characterized by deep valleys, steep slopes, narrow gorges and high peaks with elevations ranging from approximately 600 m in the southern valleys to more than 6,000 m in the northern mountainous regions (Figure 1). The hydrology of the region is dominated by the Swat River and its tributaries, which originate in the high mountains and flow southward through the valley. These river systems have significantly influenced local geomorphology through erosion, sediment transport, and deposition processes, creating fertile alluvial plains in lower elevations and rugged terrain in upper mountainous areas. The climate of Swat is temperate montane with pronounced altitudinal variation. Lower elevations experience relatively mild conditions with hot summers and cool winters, whereas higher elevations remain cold for most of the year and receive substantial snowfall during winter. Precipitation is derived from both winter westerlies and summer monsoon systems, contributing to soil moisture availability and seasonal vegetation dynamics (Ali *et al.* 2018; Ali *et al.* 2026). The pronounced elevational gradients support distinct ecological zones and vegetation types. The subtropical zone at lower elevations is characterized by shrubs, grasses, and drought-tolerant species. Mid-elevation temperate forests are dominated by *Pinus wallichiana*, *Cedrus deodara*, and *Picea smithiana*, accompanied by a diverse understory of shrubs and medicinal herbs. The sub-alpine zone consists primarily of shrub communities and cold-tolerant herbaceous vegetation, whereas alpine areas support seasonal grasslands and specialized high-mountain flora. Soil characteristics also vary considerably across the district, ranging from fertile alluvial deposits in valley bottoms to shallow, rocky soils on steep mountain slopes. These climatic, edaphic, and altitudinal gradients support exceptional biodiversity, high plant species richness, and diverse vegetation communities, making District Swat one of the most important medicinal plant regions within the Hindu Kush-Himalayan landscape. The livelihoods of local communities are predominantly based on agriculture, livestock rearing, small-scale trade, and the collection of natural resources. Traditional knowledge regarding medicinal plants remains an integral component of rural healthcare systems, particularly in remote mountainous areas where access to modern medical facilities is limited. Many plant species are utilized for treating human and livestock ailments, providing both subsistence and supplementary income to local households. Consequently, medicinal plants constitute an important element of the biocultural heritage and socioeconomic resilience of communities throughout District Swat.

Study Site and Informant Selection

The ethnobotanical survey was conducted in four localities of District Swat, namely Barikot, Kabal, Mingora, and Matta, representing diverse ecological and sociocultural settings within the region. A total of 45 informants were selected through purposive and snowball sampling techniques, which are widely employed in ethnobotanical research to identify individuals possessing substantial traditional knowledge regarding medicinal plants (Martin, 1995; Bernard, 2017). The study specifically focused on knowledgeable community members, including traditional healers, farmers, pastoralists, and elderly residents, rather than on achieving large population-based samples. Interviews were continued until no substantially new use reports and preparation methods were obtained, indicating an adequate level of information saturation for the focal species studied. Although the number of participants was relatively modest, the selected informants represented key custodians of local ethnobotanical knowledge. Similar sample sizes have been considered adequate in qualitative and quantitative ethnobotanical studies when information is obtained from experienced knowledge holders and data saturation is achieved (Guest *et al.* 2006; Vogl *et al.* 2004). The present study emphasized depth and reliability of information, particularly because it focused on three specific plant species rather than conducting a broad floristic inventory. The demographic composition included both male (62.2%) and female (37.8%) participants across all study sites. The predominance of male informants reflects the sociocultural context of the region, where men are generally more

involved in field activities and the exchange of ethnobotanical knowledge. Informants aged 18-30 years constituted 24.4% of the sample, while those aged 31-50 years and above 50 years each represented 37.8%, indicating that traditional plant knowledge is largely retained among middle-aged and older generations. Educational backgrounds included uneducated individuals (26.7%), participants with primary to middle education (35.6%), and those with secondary to higher education (37.8%), demonstrating that ethnobotanical knowledge transcends formal literacy levels. Occupationally, farmers and pastoralists represented the largest group (55.6%), followed by local residents (31.1%) and traditional healers (11.1%) (Table 1). This diversity ensured the inclusion of multiple perspectives on medicinal and ethnoveterinary plant use within the study area.

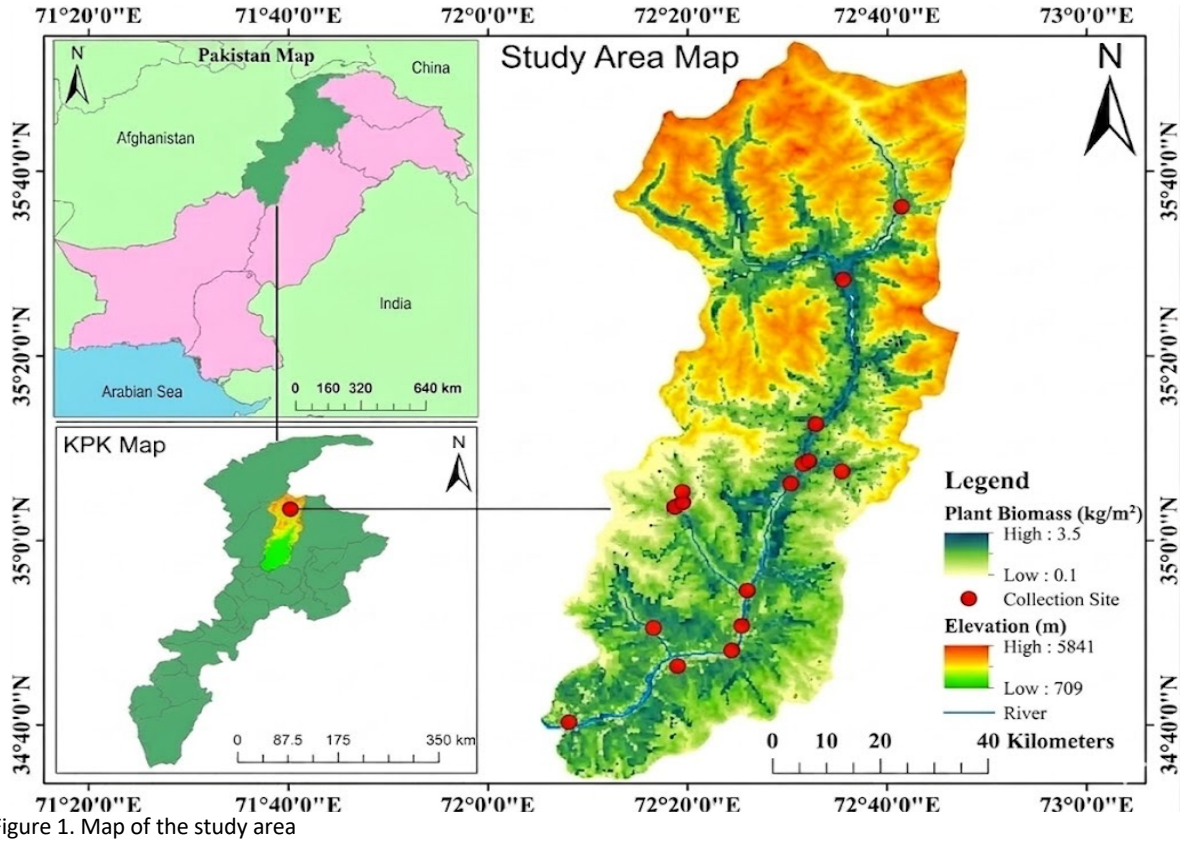

Figure 1. Map of the study area

Table 1. Demographic characteristics and distribution of informants across the selected study sites in the area

Parameter	Barikot	Kabal	Mingora	Matta	Total %
Male	6	7	8	7	62.2
Female	4	4	5	4	37.8
Age 18-30	2	3	3	3	24.4
Age 31-50	4	4	5	4	37.8
Age Above 50	4	4	5	4	37.8
Uneducated	3	3	3	3	26.7
Primary to Middle	3	4	5	4	35.6
Secondary to Higher	4	4	5	4	37.8
Farmers & Pastoralists	6	6	7	6	55.6
Local Residents	3	4	4	3	31.1
Traditional Healers	1	1	2	1	11.1

Ethnobotanical Survey and Data Collection

An ethnobotanical survey was conducted in selected villages of District Swat to document traditional medicinal knowledge associated with *Delphinium suave*, *Allium filidens*, and *Astragalus kanjuensis*. Fieldwork was carried out between July 2025 and March 2026 following standard ethnobotanical protocols (Martin, 1995; Cotton, 1996) and the ethical guidelines of the International Society of Ethnobiology (ISE, 2006). A total of 45 informants were selected through purposive sampling based on their recognized expertise in traditional medicinal plant use. Informants included traditional healers (Hakims), herbal practitioners, shepherds, farmers, wild plant collectors, and elderly community members. Prior informed consent was obtained from all participants after clearly explaining the objectives of the study. Participation was voluntary, and confidentiality of informants was strictly maintained throughout the study. All interviews were conducted in the local

Pashto language to ensure accurate communication and reliable documentation of traditional knowledge. Data were collected using semi-structured interviews, open-ended questionnaires, and informal group discussions. The interview protocol included information on vernacular plant names, plant parts used, preparation methods, dosage forms, routes of administration, frequency of use, and ailments treated for humans and livestock, preparation methods, dosage, and traditional applications. Additional information was recorded on plant availability, seasonal occurrence, harvesting practices, and perceived conservation status. Field verification was carried out through guided transect walks with knowledgeable informants to confirm species identity in their natural habitats. Voucher specimens were collected, documented in situ, and identified using standard floristic keys and regional botanical references. Species identification and reported uses were further cross-validated through repeated interviews and comparison with previously published ethnobotanical studies from the region. All ethnobotanical data were systematically organized for quantitative analysis. The collected ethnobotanical data were organized and analyzed using standard quantitative ethnobotanical indices to evaluate cultural importance, utilization patterns, and the relative significance of the selected medicinal plant species.

Voucher Specimens and Plant Identification

Voucher specimens were collected with the assistance of local informants during field surveys in the area. Fresh plant samples were documented in their natural habitats through in situ photography and subsequently processed and preserved following standard herbarium techniques for future reference and verification. Taxonomic identification of the collected plant specimens was performed using authoritative floristic and taxonomic references, including the *Flora of Pakistan*, *Flora of China*, and the Tropicos database. Species identification was further confirmed through comparison with authenticated herbarium specimens and consultation with plant taxonomists and relevant specialists. Scientific nomenclature was verified and updated according to currently accepted botanical classification systems for angiosperms. For each voucher specimen precise geographic coordinates (GPS), altitude, and habitat characteristics were recorded to document ecological context. These data included slope, aspect, vegetation type, and associated plant communities at the collection sites. Ecological observations were recorded strictly to describe habitat conditions and environmental settings associated with each species and were not used for inferential ecological interpretation. Voucher specimens (RM-001 to RM-003) were deposited in the Herbarium of the Department of Botany, University of Swat, Pakistan, for future reference and verification.

Quantitative Ethnobotanical Indices

Ethnobotanical indices were employed to provide an objective assessment of the cultural importance, utilization patterns, and relative significance of the selected medicinal plant species. These standardized indices facilitate comparisons among species by quantifying the frequency of citation, diversity of uses, and degree of informant agreement, thereby reducing subjective interpretation and improving the reliability of ethnobotanical data (Phillips & Gentry, 1993; Tardío & Pardo-de-Santayana, 2008; Heinrich *et al.* 2009). All indices were calculated using established mathematical formulas and independently verified through repeated cross-checking of the raw interview data to ensure accuracy, internal consistency, and reproducibility of the quantitative analyses.

Use Value (UV)

UV reflects the relative importance of a species based on the number of uses reported by informants. Higher UV indicates species with greater cultural significance.

$$UV = \frac{\sum Ui}{N}$$

Where, *Ui* = number of use reports cited by each informant for a given species and *N* = total number of informants

Number of Uses (NU)

NU quantifies the total number of distinct applications reported for a species, highlighting multifunctional taxa.

$$NU = Total\ distinct\ uses\ reported\ for\ a\ species$$

Fidelity Level (FL)

FL indicates the proportion of informants citing a specific use for a species, highlighting the most widely recognized applications.

$$FL\ (\%) = Np/N \times 100$$

Where, *Np*= number of informants citing a specific use for a species and *N* = total number of informants reporting any use of that species.

Frequency of Citation (FC)

FC is the number of informants who mention a given species. It provides a simple measure of recognition within the community.

$$FC = Number\ of\ informants\ mentioning\ the\ species$$

Relative Frequency of Citation (RFC)
RFC standardizes FC by the total number of informants, allowing comparison among species. Higher RFC indicates species with greater local prominence.

$$RFC = FC/N$$

Where FC = frequency of citation and N = total number of informants

Conservation Assessment Criteria
Conservation-related information was obtained through field observations, semi-structured interviews, and local perceptions regarding harvesting practices, habitat conditions, and species availability. The assessment was qualitative and based on ethnobotanical evidence rather than formal ecological surveys or IUCN Red List evaluations, providing preliminary information on sustainable utilization and potential conservation concerns of the studied species. Consequently, these observations should be interpreted as indicative rather than definitive and are intended to guide future ecological and population-based conservation assessments.

Results

Ecological and Taxonomical Characteristics of Selected Plant Species
The three selected medicinal plant species belong to different taxonomic families and exhibit distinct ecological adaptations within the mountainous landscapes of district Swat. They occur across a range of habitats and altitudinal gradients contributing to regional floristic diversity.

***Astragalus kanjuensis* Z. Ullah, Amjad Khan & A. Sultan**
It is a perennial herb to subshrub belonging to the family Fabaceae. It is characterized by pinnately compound leaves, papilionaceous flowers, inflated to narrow pods and a well-developed taproot system. The species is largely restricted to the Kanju township region of the area and nearby localities. It typically grows on rocky slopes, dry grasslands and stony substrates at elevations of approximately 1,000-1,500 m a.s.l. The species shows clear xerophytic adaptations including a deep root system for water acquisition and dense trichome coverage that reduces water loss enabling survival in dry and exposed habitats (Figure 2).

Figure 2. *Astragalus kanjuensis* A) habitat, B), capsule, C) plant with flowers, D) roots.

***Allium filidens* Regel**
It is a bulbous perennial herb belonging to the family Amaryllidaceae. It is characterized by an underground bulb; linear hollow leaves, an umbellate inflorescence and star-shaped flowers. The species occurs in meadows, forest margins, moist slopes and rocky grasslands at elevations ranging from approximately 1,800-3,800 m a.s.l. It is widely distributed across the Hindu-Kush and western Himalayan regions. Its bulbous structure enables storage of nutrients and survival under seasonal climatic stress, allowing it to persist in high-altitude environments with strong temperature variation (Figure 3).

Figure 3. *Allium filidins* in Nawagai, swat, A) Habitat B) A close up of inflorescence C) *Allium* stem and inflorescence close up, D) *Allium* Bulb

Delphinium suave **Huth**

It is a perennial herb of the family Ranunculaceae and characterized by deeply lobed palmate leaves, erect flowering stems and zygomorphic flowers with a prominent spur. The species occurs in moist alpine and subalpine meadows, forest margins and grassy mountain slopes at elevations of approximately 2,200-3,600 m a.s.l. It is primarily distributed in higher mountainous regions and adjacent valleys. The species is adapted to cold, moist environments and shows strong association with high-altitude meadow ecosystems, which are often sensitive to climatic and anthropogenic disturbances (Figure 4).

Figure 4. *Delphinium suave* A) habitat, b) Rhizome, B) whole plant, C) inflorescence

Local informants possessed substantial ecological knowledge regarding the occurrence, seasonal availability, and utilization of the studied species. Community perceptions indicated that *Allium filidens* remains relatively abundant in suitable habitats, whereas *Astragalus kanjuensis* and *Delphinium suave* may experience localized pressures from grazing, habitat disturbance and unsustainable harvesting. These observations represent preliminary field-based and community-derived information rather than formal ecological assessments, but they underscore the importance of sustainable resource management and conservation awareness in mountainous ecosystems.

Table 2. Comparative overview of the ecological distribution, and habitat characteristics of the selected plant species.

Species	**Growth form**	**Habitat preference**	**Altitudinal range (m a.s.l.)**	**Approximate flowering period**	**Traditional harvesting season**	**Local abundance perception**
Astragalus kanjuensis Z. Ullah, Amjad Khan & A. Sultan	Perennial herb	Rocky slopes, dry grasslands, and stony substrates	1,000-1,500	May-July	June-August	Moderately common
Allium filidens Regel	Bulbous perennial herb	Meadows, forest margins, moist slopes, and rocky grasslands	1,800-3,800	April-June	May-July	Locally abundant
Delphinium suave Huth	Perennial herb	Moist alpine and sub-alpine meadows, forest edges, and mountain slopes	2,200-3,600	June-August	July-September	Relatively scarce

Plant Part Usage and Preparation Methods

The selection of plant parts and preparation methods reflects important components of traditional ethnobotanical knowledge and is influenced by plant availability, ease of collection, customary practices, and perceived therapeutic effectiveness. Across the three studied species, distinct patterns of plant-part utilization and preparation methods were observed, indicating differences in traditional applications and resource use (Figure 5). *Allium filidens* showed a strong preference for bulbs (60%), followed by leaves (40%). The frequent use of bulbs is consistent with the species' dual role as a wild food and medicinal plant. Bulbs were commonly consumed fresh, used as a seasoning, or prepared as decoctions to manage gastrointestinal and respiratory ailments, demonstrating the close integration of nutritional and medicinal uses within local healthcare practices. In *Astragalus kanjuensis*, roots were the most frequently utilized plant part (55%), followed by aerial parts (35%) and gum or resin (10%). Root use was primarily associated with remedies for general weakness, inflammatory conditions, and digestive disorders. Decoction was the predominant preparation method (65%), followed by infusions (25%) and powders (10%), indicating a preference for water-based extraction methods in traditional medicine. *Delphinium suave* exhibited a different utilization pattern, largely reflecting its specialized medicinal role and the cautious handling of the species by local communities. Leaves (30%) and roots (25%) were the most frequently used plant parts, followed by the whole plant (20%), seeds (15%), and flowers (10%). Most preparations were intended for external application, with poultices and pastes accounting for 50% of reported preparations, followed by herbal washes (30%) and limited decoctions (20%). Informants emphasized that internal use was uncommon because of concerns regarding the potential toxicity associated with the species. Overall, decoction was the most frequently reported preparation method across all three species (45%), followed by direct consumption (25%), topical applications (20%), and infusions (10%). Fresh plant material (70%) was preferred over dried material (30%), suggesting that local communities generally favor freshly collected plants for traditional medicinal preparations. These patterns illustrate the diversity of traditional plant-use practices and provide insight into the ethnobotanical knowledge systems associated with medicinal plant utilization in District Swat (Figure 6; Table 6).

Use Categories of Selected Species

The ethnobotanical use categories of the three medicinal plant species showed clear interspecific variation (Table 3). *Astragalus kanjuensis* was primarily used for medicinal purposes (33%), followed by fodder (22%), soil conservation and nitrogen fixation (20%), ethnoveterinary applications (18%), anti-inflammatory uses (12%), and tonic preparations (10%). These findings indicate that the species is valued for both medicinal and ecological purposes within local communities. *Allium filidens* exhibited the greatest diversity of use categories among the studied species. Food use represented the largest proportion of reported applications (38%), followed by medicinal uses (28%), condiment use (13%), antimicrobial and anthelmintic applications (11%), and fodder use (10%). The species was therefore documented as an important food and medicinal resource in the study area. *Delphinium suave* showed a comparatively specialized pattern of utilization. Medicinal applications accounted for 43% of reported uses, followed by ethnoveterinary uses (18%), antimicrobial and dermatological applications (17%), anti-inflammatory uses (16%), insect repellent applications (11%), and ornamental and cultural uses (10%). Most reported medicinal applications involved external use, reflecting local knowledge regarding the safe utilization of the species (Table 3)

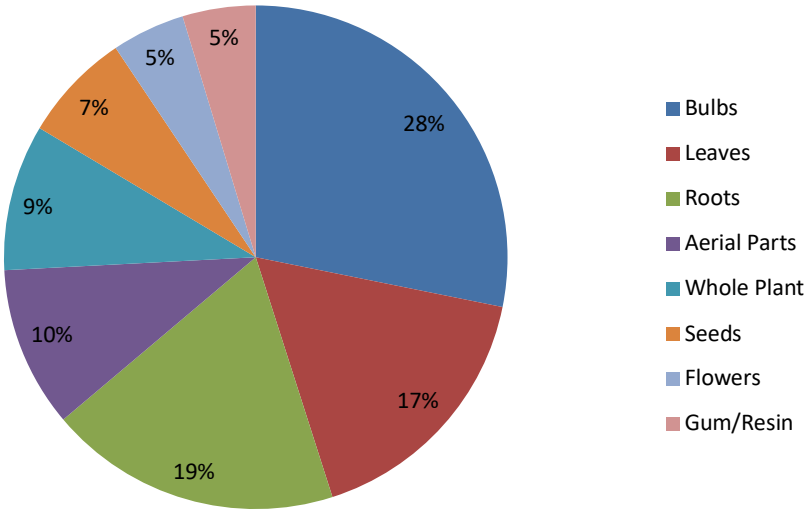

Figure 5. Distribution of plant parts used in the study for medicinal and phytochemical applications

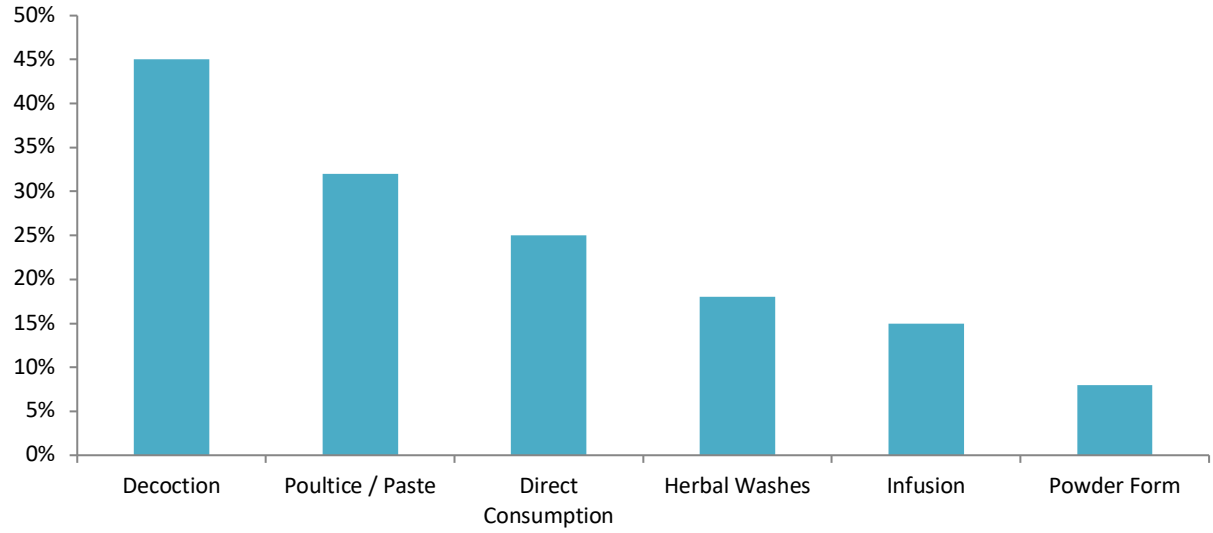

Figure 6. Method of uses of the selected plants the area

Table 3. Ethnobotanical use categories of *Astragalus kanjuensis*, *Allium filidens*, and *Delphinium suave* based on reported local applications (✓ = present, - = absent).

Use Category	***Astragalus kanjuensis* Z. Ullah, Amjad Khan & A. Sultan**	***Allium filidens* Regel**	***Delphinium suave Huth***
Traditional Medicine	✓	✓	✓
Digestive Disorders	✓	✓	-
Antimicrobial Activity	-	✓	✓
Anti-inflammatory Use	✓	-	✓
Food Source	-	✓	-
Condiment	-	✓	-
Veterinary Use	✓	-	✓
Fodder Value	✓	✓	-
Soil Conservation	✓	-	-
Insect Repellent	-	-	✓
Ornamental Value	-	-	✓

Ethnoveterinary Applications of the Studied Species

Ethnoveterinary information recorded from informants in District Swat showed that the studied medicinal plants were used for the management of livestock ailments, particularly digestive disorders, loss of appetite, general weakness, external parasitic infections, and skin problems. Similar uses were reported across all study sites (Table 4). *Astragalus kanjuensis* was reported by more than 60% of informants as a livestock tonic and for digestive disorders and physical weakness. The whole plant or aerial parts were commonly prepared as a decoction and administered orally with water. *Allium filidens* was reported by approximately 50% of informants for gastrointestinal infections and loss of appetite in livestock. Bulbs and leaves were used either as a fresh extract or as a mild decoction mixed with feed. *Delphinium suave* was cited by approximately 35-40% of informants for the treatment of external parasites, including ticks and lice, and for minor skin infections. Leaf paste was prepared and applied externally to affected areas. Informants consistently reported that the species was used primarily for topical applications because of concerns regarding its potential toxicity. The documented ethnoveterinary applications demonstrate the continued use of traditional plant-based remedies in livestock healthcare within the study area (Table 4).

Table 4. Ethnoveterinary uses of the three species in the area

Species	Animal disease and condition	Plant part used	Preparation method	Purpose
Astragalus kanjuensis Z. Ullah, Amjad Khan & A. Sultan	Digestive disorders, general weakness in livestock	Whole plant	Decoction administered orally with water	Used as tonic and to improve digestion and vitality
Allium filidens Regel	Gastrointestinal infections, loss of appetite	Bulbs and leaves	Raw extract or decoction mixed in feed	Enhances appetite and treats digestive problems
Delphinium suave Huth	External parasites (ticks, lice), skin infections	Leaves	Crushed into paste and applied externally	Used for parasite control and skin treatment

Comparative Ethnobotanical Importance of Selected Species

The comparative analysis of the selected plants reveals clear variation in cultural importance as reflected by quantitative ethnobotanical indices. These differences appear to be associated with variations in ecological distribution, accessibility and patterns of traditional use. *Allium filidens* exhibited the highest ethnobotanical importance FC (40), RFC (0.89), UR (82), UV (1.82) and FL (85%). Its relatively broad altitudinal distribution (1,800-3,800 m a.s.l.) and dual role as both food and medicinal plant contribute to its frequent use and high cultural visibility. A considerable proportion of its applications include food use (38%) alongside medicinal uses (28%), indicating strong integration into daily subsistence and healthcare practices. *Astragalus kanjuensis* showed intermediate ethnobotanical importance FC (32), RFC (0.71), UR (58), UV (1.29) and FL (75%). Its use is primarily medicinal and ethnoveterinary, with limited dietary application. Its comparatively restricted distribution (1,000-1,500 m a.s.l.) and localized availability likely contribute to moderate frequency of citation and use intensity. *Delphinium suave* demonstrated comparatively lower ethnobotanical importance FC (28), RFC (0.62), UR (49), UV (1.09) and FL (75%). Its higher altitudinal range (2,200-3,600 m a.s.l.) and known toxicity-related constraints limit its use to specific medicinal applications, primarily external treatments. As a result, its ethnobotanical role remains more specialized rather than broadly integrated into daily use (Figure 7). Consistency between reported use-reports and calculated indices was verified to ensure reliability of quantitative results. The comparative analysis demonstrates a clear gradient in ethnobotanical importance among the three species. *Allium filidens* ranked highest across all quantitative indices followed by *Astragalus kanjuensis* and *Delphinium suave*. The study indicates that species combining multiple functions, broader ecological distribution, and frequent human interaction achieve greater cultural importance than species with restricted habitats or specialized medicinal uses. The consistency between reported use reports and the calculated ethnobotanical indices was independently verified through cross-checking of the raw dataset, confirming the reliability and internal consistency of the quantitative analyses (Figure 7).

Phytochemical Basis of Traditional Medicinal Uses

The phytochemical information discussed for *Delphinium suave*, *Allium filidens*, and *Astragalus kanjuensis* was compiled from previously published literature and represents secondary evidence derived mainly from studies conducted on related species within the same genera rather than direct phytochemical analyses of the investigated taxa. No laboratory-based phytochemical profiling was performed in the present study; therefore, the reported compounds should be interpreted as a genus-level chemical background supporting the possible pharmacological relevance of the documented traditional uses, rather than as confirmed species-specific constituents. Further phytochemical characterization of the studied species is required to establish their actual chemical profiles and validate the relationship between metabolites and ethnomedicinal applications. Medicinal plants are known to contain diverse classes of secondary metabolites, including flavonoids, phenolic compounds, alkaloids, saponins, terpenoids, and sulfur-containing compounds, many of which have demonstrated antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory activities (Newman & Cragg, 2020; Li *et al.* 2023). These broad pharmacological properties provide a general biochemical framework for understanding the therapeutic importance of traditionally used plants; however, the presence, concentration, and biological activity of individual compounds may vary considerably among species, populations, and environmental conditions. Within the genus

Delphinium, numerous phytochemical investigations have reported the occurrence of bioactive diterpenoid alkaloids and other secondary metabolites with pharmacological and toxicological significance. Yin *et al.* (2020) summarized the chemical diversity of *Delphinium* species and highlighted the contribution of diterpenoid alkaloids to analgesic, anti-inflammatory, and other biological effects. These genus-level findings may provide a possible explanation for the traditional use of *D. suave* in pain relief, wound management, and skin-related ailments. However, because species-specific chemical confirmation for *D. suave* is currently unavailable, these associations should be considered preliminary. Moreover, several *Delphinium* species contain toxic alkaloids, and therefore traditional applications of *D. suave* require careful evaluation regarding dosage, preparation methods, and safety before therapeutic recommendations can be made.

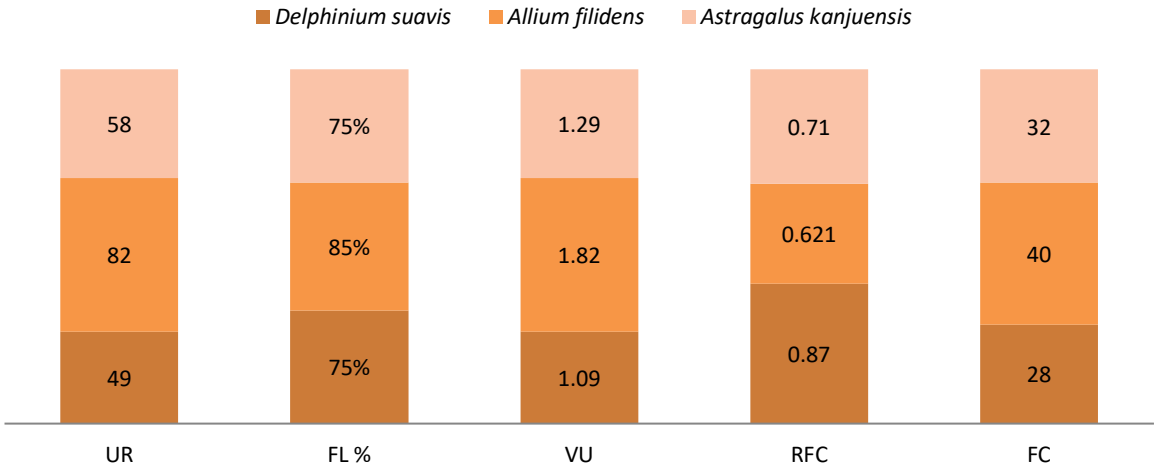

Figure 7. Comparison of ethnobotanical indices (FC, RFC, UR, UV, and FL) among the three selected medicinal plant species from District Swat.

The genus *Allium* is extensively recognized for its organosulfur compounds, flavonoids, and phenolic constituents, which are associated with antioxidant, antimicrobial, anti-inflammatory, and digestive health-related effects. Studies on *Allium* species, particularly garlic and onion, have demonstrated the biological importance of sulfur-containing metabolites and flavonoids (Iciek *et al.* 2009; Lanzotti, 2006; Rivlin, 2001). These findings provide a genus-level scientific basis for interpreting the traditional uses recorded for *Allium filidens*, including applications related to gastrointestinal disorders, respiratory complaints, and parasitic infections. Nevertheless, the specific phytochemical composition and therapeutic potential of *A. filidens* remain to be experimentally determined. Similarly, species belonging to the genus *Astragalus* are widely reported to contain polysaccharides, flavonoids, triterpenoid saponins, and other bioactive compounds responsible for immunomodulatory, antioxidant, anti-inflammatory, and protective effects. The pharmacological importance of *Astragalus* metabolites has been highlighted in numerous natural product studies (Newman & Cragg, 2020). These genus-level reports provide a possible explanation for the traditional use of *Astragalus kanjuensis* as a tonic and for managing inflammatory and digestive conditions. However, direct confirmation of these compounds in *A. kanjuensis* through chromatographic and spectroscopic approaches is necessary before species-specific pharmacological conclusions can be established. The available phytochemical literature offers indirect support for the ethnomedicinal importance of the three investigated species by demonstrating the chemical and pharmacological potential of their respective genera. The overlap between traditional knowledge and reported biological activities suggests promising therapeutic potential; however, future studies involving species-specific phytochemical profiling, bioactivity-guided fractionation, toxicity assessment, and pharmacological validation are essential to confirm the medicinal value and ensure the safe utilization of these plants.

Table 5. Representative phytochemical classes reported for related species within each genus

Species	**Major Traditional Uses**	**Major Phytochemicals**	**Reported Biological Activities**
Astragalus kanjuensis Z. Ullah, Amjad Khan & A. Sultan	General weakness, digestive disorders, inflammatory conditions	Flavonoids, triterpenoid saponins, polysaccharides, phenolics	Antioxidant, anti-inflammatory, immunomodulatory, gastroprotective (Shahrajabian *et al.* 2019; Newman and Cragg, 2020)
Allium filidens Regel	Gastrointestinal infections, respiratory ailments, parasitic diseases, antimicrobial uses	Organosulfur compounds, flavonoids, phenolic acids, saponins	Antimicrobial, anthelmintic, antioxidant, anti-inflammatory (Iciek *et al.* 2009; Lanzotti, 2006; Rivlin, 2001)
Delphinium suave Huth	Pain relief, skin infections, wound healing, inflammation, insect repellent	Diterpenoid alkaloids, flavonoids, phenolic compounds	Analgesic, antimicrobial, anti-inflammatory, insecticidal (Chen *et al.*2020; Yin *et al.* 2020)

Table 6. Ethnobotanical profile of three medicinal plant species showing family, parts used, and traditional applications

Plant Species	Family	Voucher Number	Traditional Use Category	Part Used	Traditional Uses
Astragalus kanjuensis Z.Ullah, Amjad Khan, & A.Sultan.	Fabaceae	RM-001	Medicinal	Whole plant, roots and aerial parts	Used for general weakness, tonic purposes, digestive disorders, stomach pain, and traditional healing remedies
			Anti-inflammatory	Roots and aerial parts	Applied for body pain, joint pain, and inflammatory conditions
			Livestock Medicine	Whole plant	Used in traditional veterinary treatments for animal ailments
			Fodder	Aerial parts	Grazed by livestock in alpine and subalpine pastures
			Soil Conservation	-	Prevents soil erosion through extensive root systems
			Ecological Importance	-	Nitrogen fixation and improvement of soil fertility
Allium filidens Regel	Amaryllidaceae	RM-002	Food	Leaves and bulbs	Consumed as a wild vegetable and flavoring agent
			Medicinal	Bulbs and leaves	Used for digestive disorders, stomachache and gastrointestinal problems
			Antimicrobial	Bulbs	Traditionally used against infections and microbial diseases
			Anthelmintic	Bulbs	Used for intestinal worms and parasitic infections
			Respiratory Disorders	Bulbs	Used for cough, cold, and flu-like symptoms
			Cardiovascular Health	Bulbs	Traditionally believed to improve blood circulation and heart health
			Spice and Condiment	Bulbs and leaves	Added to local foods as seasoning
			Fodder	Leaves	Occasionally fed to livestock
Delphinium suave Huth	Ranunculaceae	RM-003	Medicinal	Whole plant, leaves and roots	Used in traditional remedies for various ailments
			Analgesic	Roots, aerial parts	Used to relieve pain and discomfort
			Anti-inflammatory	Whole plant	Applied for swelling and inflammatory conditions
			Antimicrobial	Leaves, roots	Used against infections and wounds
			Skin Disorders	Leaves	Applied externally for skin infections and wounds
			Parasitic Diseases	Whole plant	Used traditionally against ectoparasites and some internal parasites
			Veterinary Medicine	Whole plant	Utilized in livestock healthcare practices
			Insect Repellent	Leaves	Used to repel insects and pests
			Ornamental	Flowers	Valued for attractive blue-purple flowers
			Cultural Significance	Whole plant	Used in traditional local medicinal practices of mountain communities

Discussion

The present study demonstrates that the ethnobotanical importance of *Astragalus kanjuensis*, *Allium filidens*, and *Delphinium suave* in District Swat is influenced by ecological accessibility, multifunctionality, and culturally transmitted knowledge systems. These findings are consistent with the ecological apparency hypothesis proposed by Phillips and Gentry (1993), which suggests that plant use intensity is closely associated with species availability, accessibility, and the frequency of human interaction. Similarly, (Tardío and Pardo-de-Santayana 2008) emphasized that multifunctional plants generally attain higher cultural significance because they simultaneously satisfy nutritional, medicinal, and economic needs.

The predominance of *Allium filidens* in the present study corresponds well with previous ethnobotanical investigations conducted in Swat and other Himalayan regions. (Hamayun *et al.* 2005, Akhtar *et al.* 2013, Ahmad *et al.* 2014 and Kayani *et al.* 2015) reported the extensive utilization of wild edible and medicinal plants in mountain communities, where species that combine dietary and therapeutic functions tend to possess greater cultural importance. The strong food-medicine continuum observed for *A. filidens* is consistent with broader ethnobotanical patterns described by (Reyes-García *et al.* 2006), who demonstrated that wild edible plants frequently serve dual nutritional and medicinal roles in traditional societies. Likewise (Tardío and Pardo-de-Santayana 2008) emphasized that edible medicinal species often achieve high use values because of their integration into everyday subsistence practices. At the genus level, the cultural prominence of *Allium* species has been widely documented throughout Eurasia. (Fritsch and Friesen 2002) highlighted the long evolutionary and ethnobotanical association between humans and *Allium* taxa while (Block 2010) demonstrated that organosulfur compounds constitute the biochemical basis for many traditional applications, including antimicrobial, digestive, and anti-inflammatory uses. These observations are further supported by (Iciek *et al.* 2009), who reported significant antioxidant and pharmacological activities of sulfur-containing metabolites in *Allium* species. Although phytochemical analyses of *A. filidens* are currently unavailable, species within the genus Allium are characterized by sulfur-containing compounds, flavonoids, and phenolic antioxidants that provide a plausible biochemical basis for its traditional medicinal applications.

Astragalus kanjuensis exhibited a more specialized medicinal and ethnoveterinary profile. Similar patterns have been documented in other mountain regions of Pakistan where *Astragalus* species are primarily valued for therapeutic rather than dietary purposes. (Qureshi *et al.* 2007) reported the use of *Astragalus* taxa for digestive disorders and livestock health management in Azad Kashmir, whereas (Ahmad *et al.* 2014) recorded comparable medicinal applications in Chail Valley, Swat. (Kayani *et al.* 2015) observed that alpine medicinal plants with restricted distributions often possess lower frequencies of citation despite their recognized therapeutic value. The medicinal importance of the genus is strongly associated with the presence of bioactive polysaccharides, flavonoids, and triterpenoid saponins that exhibit immunomodulatory, antioxidant, and anti-inflammatory properties (Shahrajabian *et al.* 2019). Similar cross-cultural patterns have been reported by (Pieroni *et al.* 2014), who noted that mountain communities frequently maintain specialized knowledge of habitat-restricted medicinal plants that are not integrated into daily food systems. Consequently, the intermediate cultural importance of *A. kanjuensis* in Swat appears to reflect ecological limitation and specialized medicinal use rather than reduced pharmacological relevance. These reported phytochemical characteristics provide a plausible explanation for the ethnomedicinal importance of *A. kanjuensis,* although species-specific phytochemical studies are still needed.

The ethnobotanical profile of *Delphinium suave* differed markedly from the other two species reflecting both ecological specialization and toxicological constraints. (Hamayun *et al.* 2005, Akhtar *et al.* 2013 and Kayani *et al.* 2015) reported that medicinal plants occurring in alpine and subalpine habitats generally exhibit lower use frequencies because of limited accessibility and seasonal availability. In addition, species belonging to *Delphinium* are traditionally utilized with considerable caution because of the occurrence of diterpenoid alkaloids, many of which possess both therapeutic and toxic properties. (Chen *et al.* 2020 and Yin *et al.* 2020) demonstrated that these compounds exhibit analgesic, anti-inflammatory, antimicrobial, and insecticidal activities, thereby supporting many traditional applications while simultaneously restricting internal consumption. Similar patterns have been reported across Himalayan communities, where *Delphinium* species are predominantly employed for topical remedies and ethnoveterinary treatments rather than routine medicinal use. The lower quantitative importance of *D. suave* should therefore be interpreted as evidence of specialized and risk-aware traditional knowledge rather than limited medicinal significance. Although phytochemical evidence for *D. suave* remains unavailable, its traditional medicinal applications may be associated with diterpenoid alkaloids and related secondary metabolites reported from other *Delphinium* species. However, because these compounds may also possess considerable toxicity, local healers employ the species cautiously with well-established traditional dosage practices. The observed patterns of informant consensus in the present study are consistent with previous quantitative ethnobotanical investigations conducted in the Western Himalaya and northern Pakistan. Studies from Swat, Chail Valley, and adjacent Himalayan regions have similarly reported that medicinal plants with greater ecological availability, multiple therapeutic applications, and frequent use by local communities generally exhibit higher citation frequencies, use values, and fidelity levels than habitat-restricted or less accessible taxa (Hamayun *et al.* 2005; Ahmad *et al.* 2014; Kayani *et al.* 2015). These similarities suggest that ethnobotanical consensus across Himalayan mountain communities is shaped not only by cultural traditions but also by ecological accessibility, long-term knowledge transmission, and continued reliance on plant-based healthcare systems.

From a broader perspective, these findings support previous observations that ecological accessibility, multifunctionality, and cultural familiarity are key determinants of ethnobotanical importance in mountain societies (Phillips & Gentry, 1993; Reyes-García *et al.* 2006; Tardío & Pardo-de-Santayana, 2008). Earlier investigations in Swat have primarily emphasized regional medicinal plant diversity and broad ethnobotanical inventories (Akhtar *et al.* 2013; Ali *et al.* 2018), whereas the present study provides a species-level comparative assessment integrating medicinal, ethnoveterinary, phytochemical, and ecological dimensions. Such an approach contributes to a more comprehensive understanding of underexplored medicinal taxa and provides baseline information for future pharmacological investigations, sustainable utilization strategies, and community-based conservation initiatives. Consistent with the recommendations of Hamilton (2004), Pieroni *et al.* (2014), and Bussmann *et al.* (2018), safeguarding both biological resources and associated traditional knowledge remains essential for maintaining biocultural diversity in the Hindu Kush-Himalayan region. We further recommend the development of community-based conservation programs, regular population monitoring, sustainable harvesting guidelines, ex situ cultivation of vulnerable medicinal species, and stronger collaboration between local communities, forest authorities, and conservation agencies to ensure the long-term persistence of these valuable plant resources.

Scientific Contributions and Novelty of the Study

The present study provides novel insights into the ethnobotanical importance of *Astragalus kanjuensis*, *Allium filidens*, and *Delphinium suave* in District Swat, Western Himalaya, Pakistan. Unlike previous regional ethnobotanical surveys that primarily document broad plant diversity, this research adopts a species-focused comparative quantitative approach**,** allowing detailed evaluation of the cultural importance, utilization patterns, and knowledge associated with three ecologically distinct and culturally significant medicinal plants. Such focused assessments are particularly valuable for underrepresented taxa that may remain overlooked in broader ethnobotanical inventories. A major contribution of this study is the documentation of *Astragalus kanjuensis*, a species with limited ethnobotanical representation in previous literature. The study provides baseline information on its medicinal, ethnoveterinary, and ecological significance, contributing to the understanding of how locally restricted mountain plant resources are integrated into traditional healthcare and livelihood systems. Similarly, the comparative assessment of *Allium filidens* and *Delphinium suave* highlights differences in resource utilization, cultural importance, and traditional applications among the studied taxa. Methodologically, the study strengthens ethnobotanical analysis by integrating multiple quantitative indices, including frequency of citation, relative frequency of citation, use value, fidelity level, and informant consensus analysis. The combined application of these approaches provides a more comprehensive assessment of species importance than reliance on a single ethnobotanical measure and enables comparison of medicinal, food, ethnoveterinary, and ecological roles. Furthermore, the integration of traditional knowledge with preliminary conservation observations represents an important contribution of this research. The study identifies potential pressures affecting wild populations and provides baseline information for sustainable harvesting strategies, habitat monitoring, and community-based conservation initiatives. Although phytochemical information presented in this study is literature-based and requires species-specific validation, the documented traditional uses provide a framework for future pharmacological investigations, including phytochemical profiling, bioactivity evaluation, and toxicity assessment. This research expands the ethnobotanical understanding of underdocumented Himalayan plant resources by linking species-level traditional knowledge, quantitative analysis, conservation considerations, and future pharmacological research priorities. The findings contribute to broader efforts aimed at preserving biocultural diversity and promoting sustainable utilization of medicinal plant resources in the Hindu Kush-Himalayan region.

Conservation Implications and Sustainable Utilization

The present study provides preliminary insights into conservation concerns based on ethnobotanical observations, informant perceptions, harvesting practices, and habitat observations rather than comprehensive ecological assessments or formal IUCN Red List evaluations. Therefore, the conservation concerns discussed here should be considered indicative rather than official conservation categories. The studied species are primarily collected from wild populations and may be affected by multiple pressures, including grazing, habitat disturbance, land-use changes, overharvesting, and climate variability in mountain ecosystems. *Allium filidens*, due to its dual importance as a food and medicinal resource, experiences frequent harvesting by local communities, which may increase pressure on naturally occurring populations if collection intensity exceeds regeneration capacity. *Astragalus kanjuensis*, with its restricted mountain habitat distribution, may represent a species of high local conservation concern because specialized habitats are often more sensitive to environmental changes, grazing, and land transformation. Similarly, *Delphinium suave* may require conservation attention due to wild collection pressure, habitat degradation, and the need for careful management considering the potential toxicity associated with some members of the genus. Comparable conservation challenges have been documented for medicinal plants across the Hindu Kush-Himalayan region, where unsustainable harvesting, climate change, habitat degradation, and declining traditional ecological knowledge threaten plant diversity and associated cultural practices (Hamilton, 2004; Shinwari, 2010; Pieroni *et al.* 2014). To reduce these pressures, conservation strategies should include community-based resource management, sustainable harvesting guidelines, promotion of cultivation or ex situ conservation approaches, and strengthening of traditional ecological knowledge transmission. The conservation of these species should also be aligned with broader biodiversity frameworks, including national biodiversity conservation strategies and community-based natural resource management initiatives. At the regional level, forestry and wildlife authorities, local communities, and research institutions should collaborate to establish participatory monitoring programs for wild

medicinal plant populations, regulate harvesting in ecologically sensitive habitats, and promote cultivation of economically important species to reduce pressure on natural populations. Integrating these species into provincial biodiversity action plans and medicinal plant management programs would further support their long-term conservation and sustainable utilization. Long-term ecological monitoring should include periodic population censuses, regeneration assessments, habitat quality evaluation, and sustainable harvesting audits. Future studies integrating ecological surveys, population genetics, climate vulnerability assessments, and ex situ propagation experiments will provide a stronger scientific basis for conservation planning and evidence-based management of these medicinal plant resources.

Table 7. Preliminary conservation assessment of the studied species based on ethnobotanical observations and field evidence

Species	**Global IUCN Status**	**Preliminary Regional Conservation Concern***	**Potential Threats**	**Conservation Considerations**
Allium filidens Regel	Not Evaluated (NE)	Local harvesting pressure requiring monitoring	Wild collection, grazing pressure, habitat disturbance	Sustainable harvesting practices and population monitoring are recommended due to frequent food and medicinal use.
Astragalus kanjuensis Z. Ullah, Amjad Khan & A. Sultan	Not Evaluated (NE)	High local conservation concern due to restricted habitat occurrence	Restricted habitats, land-use change, overgrazing, climate variability	Habitat protection, ecological surveys, and long-term population monitoring are required.
Delphinium suave Huth	Not Evaluated (NE)	Local conservation attention required	Wild collection, habitat degradation, grazing pressure, climate stress	Sustainable utilization, habitat conservation, and toxicity-aware management approaches are recommended.

Note: Conservation observations are based on field observations, informant perceptions, and regional literature rather than formal IUCN assessments or population-based ecological studies.

Conclusions

This study presents the first species-specific comparative quantitative ethnobotanical assessment of *Astragalus kanjuensis*, *Allium filidens*, and *Delphinium suave* in District Swat, Western Himalaya. By integrating traditional medicinal knowledge, ethnoveterinary applications, ecological observations, and conservation perspectives, it provides baseline information on the cultural importance and sustainable use of these underreported medicinal plants. Among the three species, *Allium filidens* exhibited the highest ethnobotanical importance owing to its dual role as a wild food and medicinal resource, whereas *Astragalus kanjuensis* and *Delphinium suave* demonstrated more specialized medicinal and ethnoveterinary applications linked to their ecological distribution and traditional knowledge systems. The findings highlight the need to promote sustainable harvesting, habitat protection, community-based conservation, and long-term ecological monitoring to support the persistence of these valuable medicinal plant resources. Although the conservation concerns presented are preliminary and require ecological validation, they identify important priorities for future management and conservation planning. Future research should focus on comprehensive phytochemical characterization, pharmacological and toxicological validation, population ecology, cultivation potential, and long-term monitoring of wild populations. Integrating traditional ecological knowledge with biodiversity conservation and natural product research will enhance the sustainable utilization of Himalayan medicinal plants while supporting the preservation of the region's rich biocultural heritage.

Declarations

Conflict of Interest: The authors declare that there are no conflicts of interest associated with this study. The research was conducted independently, and no financial, commercial, or personal relationships influenced the results and interpretation of data.

Ethical Approval and Consent to Participate: Prior informed consent was obtained from all informants before conducting interviews and collecting ethnobotanical data. The purpose of the study was clearly explained to participants in their local context. Ethical considerations were strictly followed to respect indigenous knowledge systems, cultural values, and confidentiality of informants. No sensitive and restricted traditional knowledge was disclosed without permission.

Data Availability: The datasets generated and/or analyzed during the current study are included in this published article. Additional data are available from the corresponding author upon reasonable request

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Consent for Publication: All informants provided verbal consent for the use of ethnobotanical information in scientific publication, with assurance that no personal identifiers would be disclosed.

Authors' Contributions: Rizwan Malik conducted the field surveys including ethnobotanical data collection, informant interviews, guided field walks and voucher specimen documentation. He also prepared the initial draft of the manuscript and contributed to the organization of tables and figures. Shujat Ali guided the research throughout all stages including study design, methodological framework, data interpretation and statistical analysis. He played a key role in interpreting the ethnobotanical results and critically refining the analytical approach. Shazia Sakhi, Saira Malik, Salahud Din and Naveed Alam contributed to the review of the manuscript and participated in revising and improving the intellectual content of the paper. All authors provided feedback during manuscript revision and approved the final version for submission and publication.

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Literature Cited

Ahmad M, Sultana S, Fazl-i-Hadi S, Ben Hadda T, Rashid S, Zafar M, Khan MA, Khan MPZ, Yaseen G. 2014. An ethnobotanical study of medicinal plants in high mountainous region of Chail Valley (District Swat, Pakistan). Journal of Ethnobiology and Ethnomedicine 10:36. doi: 10.1186/1746-4269-10-36

Akhtar N, Rashid A, Murad W, Bergmeier E. 2013. Diversity and use of ethno-medicinal plants in the region of Swat, North Pakistan. Journal of Ethnobiology and Ethnomedicine 9:25. doi: 10.1186/1746-4269-9-25

Ali K, Khan N, Rahman IU, Khan W, Ali M, Uddin N, Nisar M. 2018. The ethnobotanical domain of the Swat Valley, Pakistan. Journal of Ethnobiology and Ethnomedicine 14:39. doi: 10.1186/s13002-018-0237-4

Ali S, Sayed AS, Saeed RF, Iqbal J, Ijaz S, Munazir M. 2023. Ethnomedicinal plant use value in Lower Swat, Pakistan. Ethnobotany Research and Applications 25:1-22. doi: 10.32859/era.25.1

Ali S, Shah SA, Din S. 2026. An ethnobotanical study of wild plant resources used among locals of high mountainous regions of Swat Valley, Pakistan. Ethnobotany Research and Applications 34:1-37. doi: 10.32859/era.34.6.1-37

Bernard HR. 2017. Research Methods in Anthropology: Qualitative and Quantitative Approaches. 6th edition. Lanham, Maryland, USA: Rowman and Littlefield.

Block E. 2010. *Garlic and Other Alliums: The Lore and the Science.* Cambridge, United Kingdom: Royal Society of Chemistry.

Bussmann RW, Batsatsashvili K, Kikvidze Z, Ghorbani A, Paniagua-Zambrana NY, Khutsishvili M, Kikodze D, Tchelidze D. 2020. Ethnobotany of Mountain Regions: Far Eastern Europe. In: Ethnobotany of the Mountain Regions of Far Eastern Europe: Ural, Northern Caucasus, Turkey, and Iran. Cham, Switzerland: Springer International Publishing. Pp. 3-43.

Chen S, Meng L, El-Demerdash FM, Zhou L, Rizvi SAH, Cui L, Kang W. 2020. Review of compounds and pharmacological effects of *Delphinium.* Journal of Chemistry 2020:9375619. doi: 10.1155/2020/9375619

Fritsch RM, Friesen N. 2002. Evolution, domestication and taxonomy. In: Rabinowitch HD, Currah L, editors. *Allium Crop* Science: Recent Advances. Wallingford, United Kingdom: CABI Publishing. Pp. 5-30.

Guest G, Bunce A, Johnson L. 2006. How many interviews are enough? An experiment with data saturation and variability. Field Methods 18(1):59-82. doi: 10.1177/1525822X05279903

Hamayun M. 2005. Ethnobotanical profile of Utror and Gabral Valleys, District Swat, Pakistan. Ethnobotanical Leaflets 2005(1):9.

Hamilton AC. 2004. *Medicinal plants, conservation and livelihoods.* Biodiversity and Conservation 13:1477-1517. doi: 10.1023/B:BIOC.0000021333.23413.42

Heinrich M, Edwards S, Moerman DE, Leonti M. 2009. Ethnopharmacological field studies: A critical assessment of their conceptual basis and methods. Journal of Ethnopharmacology 124:1-17. doi: 10.1016/j.jep.2009.04.010

Iciek M, Kwiecień I, Włodek L. 2009. Biological properties of garlic and garlic-derived organosulfur compounds. Environmental and Molecular Mutagenesis 50(3):247-265. doi: 10.1002/em.20474

Kayani W. Floristic diversity and ethnobotany of Senhsa, District Kotli, Azad Jammu and Kashmir (Pakistan). Pakistan Journal of Botany.

Martin GJ. 1995. *Ethnobotany: A Methods Manual.* London, United Kingdom: Chapman and Hall.

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853-858. doi: 10.1038/35002501

Phillips O, Gentry AH. 1993. The useful plants of Tambopata, Peru. Economic Botany 47:15-32. doi: 10.1007/BF02862204

Pieroni A, Dibra B, Grishaj G, Grishaj I, Maçai SG. 2014. Local knowledge on plants and domestic remedies in Albania. Journal of Mountain Science 11:180-193. doi: 10.1007/s11629-013-2873-7

Qureshi RA, Ghufran MA, Gilani SA, Sultana K, Ashraf M. 2007. Ethnobotanical studies of medicinal plants of Azad Kashmir, *Pakistan.* Pakistan Journal of Botany 39:2275-2283.

Reyes-García V, Huanca T, Vadez V, Leonard WR, Wilkie DS. 2006. Cultural, practical and economic value of wild plants: A quantitative study in the Bolivian Amazon. Economic Botany 60:62-74. doi: 10.1663/0013-0001(2006)60[62:CVO]2.0.CO;2

Shahrajabian MH, Sun W, Cheng Q. 2019. A review of *Astragalus* species as food and medicine. Applied Ecology and Environmental Research 17:13371-13386.

Sharma H, Kumar A. 2011. Ethnobotanical studies on medicinal plants of Rajasthan (India): A review. Journal of Medicinal Plants Research 5(7):1107-1112.

Sher H, Aldosari A, Ali A, de Boer HJ. 2015. Indigenous knowledge of folk medicines among tribal minorities in Khyber Pakhtunkhwa, northwestern Pakistan. Journal of Ethnopharmacology 166:157-167. doi: 10.1016/j.jep.2015.03.022

Shinwari ZK. 2010. *Medicinal plants research in Pakistan.* Pakistan Journal of Botany Special Issue.

Singh H, Dhole PA, Baske PK, Saravanan R. 2015. Ethnobotanical observations on Deogarh district, Odisha, India. Journal of Economic and Taxonomic Botany 39(2):223-265.

Tardío J, Pardo-de-Santayana M. 2008. Cultural importance indices: A comparative analysis based on the useful wild plants of southern Cantabria. Economic Botany 62:24-39. doi: 10.1007/s12231-008-9024-x

Vitalini S, Iriti M, Puricelli C, Ciuchi D, Segale A, Fico G. 2013. Traditional knowledge on medicinal and food plants used in Val San Giacomo. Journal of Ethnopharmacology 145:517-529. doi: 10.1016/j.jep.2012.11.017

Vogl CR, Vogl-Lukasser B, Puri RK. 2004. Tools and methods for data collection in ethnobotanical studies of homegardens. Field Methods 16(3):285-306. doi: 10.1177/1525822X04266844

Yin T, Cai L, Ding Z. 2020. An overview of the chemical constituents from the genus Delphinium reported in the last four decades. RSC Advances 10(23):13669-13686. doi: 10.1039/D0RA01875F