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Distribution and utilization pattern of herbal medicinal plants in Uttarakhand Himalaya: A case study

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Abstract
The present study was carried out in forest fringe area villages of Garhwal Himalaya to understand the distribution and utilization patterns of medicinal plants. We found 32 plant species that are being used by local communities. Among these plant species, most of the species were found frequently distributed. As per the utilization pattern, 7 medicinal plant species were found underutilized while 5 species were recorded as over-utilized species. The study recommends a sustainable use of over-utilized species and commercial utilization of underutilized species.

Keywords: Medicinal Plants, Distribution Pattern, Utilization Pattern, Uttarakhand Himalaya, Frequency of Use

Introduction

Uttarakhand, a natural environment of the Himalayas also known as 'Dev Bhoomi', is rich with a great wealth of medicinal plants, and traditional medicinal knowledge (Kumar *et al*, 2018) [1]. Several herbal plants are readily available in rural Uttarakhand for the treatment of various diseases at the local level. In Uttarakhand state, these resources have taken a distinguished position in the arena of socio-culture, spiritual, and medicinal (Dangwal *et al*., 2010) [2]. About two-third population live in rural Uttarakhand is depend on diverse natural resources to fulfill their need for food, fuel, fodder, timber, medicine, etc. The local communities use a large variety of medicinal plants for treating diverse diseases (Kala, 2000; Bisht *et al*., 2013) [3, 4]. Although, the traditional knowledge associated with the use of plants is wealthy but still carrying forward and orally transmitted by indigenous people (Deoli *et al*., 2015) [5].

Pimm *et al.* (1995) [6] have reported that the current loss of plant species is between 100 and 1000 times higher than the expected natural extinction rate and that the Earth is losing at least one potential major drug every 2 years. 15,000 plant species are threatened with extinction from over harvesting and destruction (Bentley, 2010) [7]. The accelerated loss of species and habitat destruction worldwide has increased the risk of extinction of medicinal plants, especially in India (Heywood and Iriondo, 2003) [8]. Although, there are plenty of studies available on qualitative aspects of medicinal plants; there is a need to evaluate the relationship between resource availability and resource utilization.

Resource availability, consumption pattern, and frequency of use of these wild plants are now central aspects of this sector in the light of the sustainability of resources. Thus, there is an urgent need to document plant-specific harvesting frequency, plant resource availability, and their extraction intensity. Hence, the present investigation aimed to document and analyze medicinal plants based knowledge in the study area concerning the availability and uses of these resources.

Methodology

Study Area: The present study was carried out in Gwad-Khirsu, a hill station in Pauri Garhwal district of Uttarakhand which is situated at $30^0 17'22''$ N, $78^0 86'$ 80'' E with an altitude of 1700 m. It lies at a distance of 11 KM towards North from Pauri and 92 KM from Dehradun city towards the west. The study area was dominated by Banj-oak forests, whereas the lower reaches of the study area were comprised of Chir-pine forests. The north-facing aspect of the study area

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Forms the watershed area of Khandah gad while the south aspect of the study area comes under the Pabo gad watershed area; the whole study area is the part of the Alaknanda river catchment. Forests play an important role in the local economy as various economic practices are interwoven with the forests.

Methods

Regular field visits were conducted during 2018-19 for the collection of ethnomedicinal information from the local community of Gwad-khirsu village and their surrounding hamlets (small villages). The 75% data were collected from Gwad-khirsu village and remaining from surrounding villages. Most of the medicinal plants are available in the Banj-oak forest which is the major source of collection of medicinal plants. Most of the information has been collected from the elderly person and we observed that younger generations are not interested to participate and they do not have sufficient knowledge about the use of medicinal plants. A questionnaire survey was carried out in the study villages using both open and close-ended questions and a total of 30% of villagers were interviewed in this survey. Later, a group of knowledgeable people among villagers has been deputed for the validation of collected data through a field visit. Most of the plant species were locally identified but few of them were verified with the help of Northern Regional Centre of Botanical Survey of India, Dehradun. Voucher specimens were prepared for the collected medicinal plants and were deposited in the library of Ecology and Biodiversity Services (EBS), Dehradun.

Quadrat based sampling has been carried out for enumeration of basic phytosociological characters like Density, Frequency and Abundance for medicinal plant species. The sampling consisted of randomly placed quadrats of 5 x 5 m^2 for shrubs, and 1 x 1 m^2 for herbs. The data on vegetation were quantitatively analyzed for density, frequency, and abundance as per Curtis & McIntosh (1950) [9].

The distribution Score was calculated (1 to 10 scale) by using the density values of each medicinal plant. The distribution score was higher for densely populated species and lower for those species having sparse distribution; higher distribution score shows higher numerical strength of the species. The distribution pattern was calculated through A/F ratio according to Curtis and Cottam (1956) [10] (<0.025-regular, 0.025 to 0.05-random, >0.05-contagious distribution). Frequency of use (%) indicated the percentage of families using concern medicinal plant species.

Results

The study revealed that the village community using 32 medicinal plants to treat various ailments. They have one or two separate vernacular names for each plant species and they are hard to know the scientific names of any species. The scientific name, vernacular name, habit, habitat, and uses of each medicinal plant are listed in Table 1.

Table 1: Medicinal plants, their habits, habitats and medicinal uses

Sl. No.	Species	Vernacular Name	Habit	Habitat	Medicinal Use
1	*Ajuga bracteosa* Wall. ex Benth.	Neelkanthi, Kadwi patti	Herb	Crop fields, Road and Path edges, Hill slopes, Open places, Loose soil area	Leaves juice used in fever, Plant extracts used as a tonic
2	*Aloe vera* (L.) Burm.f.	Patangwar, Ghigwar	Herb	Crop field edges, Forest field edges, Degraded lands, Cultivated	Leaves juice used for healing wounds and sores, Leaves flesh used in stomache
3	*Asparagus adscendens* Roxb.	Jhirani, Satawar	Under shrub	Forests (Oak, miscellaneous), edges of jungle paths, Shrubby localities	Tubers used in dysuria, diabetes, and dysentery mixing with honey, Ripe fruits are known to cause abortion
4	*Berberis aristata* DC.	Kingod, Kasmod	Shrub	Open forests, Hill slopes, Oak and Pine forests	The bark of stems and roots used in ophthalmia, Infusion of roots given in fever
5	*Berberis asiatica* Roxb. ex DC.	Kilmoda, Kilmod	Shrub	Scrub forests, Edge of forest, Dry hill slopes	Root bark used in ophthalmia
6	*Bergenia ciliata* (Haw.) Sternb.	Silpada, Silpadi	Herb	Wet and shady slope and rocks, Moist places of the north aspect	Rhizomes used as tonic and febrifuge, Digestive and cutaneous disorders
7	*Centella asiatica* (L.) Urb.	Brahmi	Herb	Along paths, Shady and moist places, Edges of agricultural fields	A plant extract used for mental peace and as a blood purifier, Leaf paste applied for skin diseases
8	*Cuscuta reflexa* Roxb.	Amarbel, Akaslaguli	Parasitic Herb	Parasitic twinners on several shrubs and small trees	Dressing of stem used in rheumatic pain and swellings and also other skin ailments
9	*Dicliptera bupleuroides* Nees	Kuladtode	Her or under shrub	Grassy slopes, Exposed localities	Leaves applied to check to bleed, Leaf juice is useful in cough and gastric
10	*Drymaria cordata* (L.) Willd. ex Schult.	Pithpapda	Herb	Moist and shady places, Exposed localities	Plant extracts used in bile complaints
11	*Echinops cornigerus* DC.	Kantyalu, Kandaru	Herb	Hill slopes, Open waste places	Root extracts promote the emergence of teeth in infant, Root juice given in fever and urinary troubles
12	*Euphorbia hirta* L.	Doodhi	Herb	Agricultural fields, Grassy fields, in association with doob	Plant extracts used in bronchial infection and asthma, Latex is applied on warts
13	*Galium acutum* Edgew.	Kuru	Herb	Shaddy places, Along paths	Herbaceous juice used in urinary disorders
4	*Geranium ocellatum* Jacquem. ex Cambess.	Kaflya	Herb	Edges of crop fields, moist places, Shaddy localities	Roots are antiseptic, Plants extract given in liver troubles and fever
15	*Hedychium spicatum* Sm.	Kapoorkachri, Van Haldu	Herb	Grassy slopes, Shaddy and moist places, Banj-oak forests	Rhizome used in asthma and tuberculosis, Seeds believed to cause abortion
16	*Inula cappa* (Buch.-Ham. ex D.Don) DC.	Athhuu	Shrub or under shrub	Open forests, Hill slopes, Oak and Pine forests	Roots extracts given in urinary trouble
17	*Mentha longifolia* (L.)	Podina, Pudeena,	Herb	Wet and moist places, edges of	Leaves juice used in vomiting and indigestion

		L.	Mint		streams and water sources	
18	*Oxalis corniculata* L.	Bhilmodi, Khati buti	Herb	Along paths, waste places	Leaf juice dropped in contract and conjunctivitis
19	*Potentilla fulgens* Wall. ex Sims	Bajardanti	Herb	Open places, Moist localities, Edges of forests	Plant extracts used in stomatitis and aphthae
20	*Reinwardtia indica* Dumort.	Fuinli, Basanta	Herb	Open places, Moist localities, Edges of forests	Petals chewed as tongue wash
21	*Roylea cinerea* (D.Don) Baill.	Kadwi, Kadawi	Shrub	Open places, Moist localities, Edges of forests and crop fields	Leaves extracts used in malarian fever and skin diseases, Garland of wood pieces believed to avoid jaundice
22	*Rubia cordifolia* L.	Manjethi, Lichkura	Herb	Crop fields, Road and Path edges, Hill slopes, Open places	Leaves extracts used in Ringworm, Roots used as a tonic and astringent, Stem used as an antidote of snake-bite
23	*Rumex hastatus* D. Don	Almodu, Kilmodu	Herb	Crop fields, Road and Path edges, Hill slopes, Open places	Leaf extracts applied on cuts and wounds to check to bleed
24	*Scutellaria repens* Buch.-Ham. ex D.Don	Kadwi ghas	Herb or under shrub	Exposed localities, hill slopes	Extracts of leaves are given in dysentery and vomiting
25	*Senecio nudicaulis* Buch.-Ham. ex D.Don	Neelkanthi	Herb	Open places, Grassy slopes, Edges of Forests	Root extracts used in colic and fever, Ash of leaves with mustard oil applied on various skin diseases
26	*Spermadictyon sauveolens* Roxb.	Padedu	Shrubs	Exposed localities, Hill slopes, Forest edges	Root powder used in diarrhea and cholera
27	*Stephania glabra* (Roxb.) Miers	Gindaldu, Gindadu	Twinner	Moist and shady places, Exposed localities, Hill slopes	Tubers used in asthma, tuberculosis, dysentery, and fever
28	*Tridax procumbens* (L.) L.	Kumrya, Kanphuli, Ledaru	Herb	Along road and path sides, Crop fields, Waste places	Paste applied on cut and wounds to check to bleed and healing
29	*Urtica dioica* L.	Kandali, Bichu ghas	Herb	Moist and waste places, Near water sources	Seed oil used in sciatica, rheumatism and skin diseases, Leaves used in hair wash to avoid baldness
30	*Valeriana jatamansii* Wall.	Sumaya, Balchadi	Herb	Moist and shady places, Oak forests	Rhizomes used in mental disorder and as an aphrodisiac, Dried rhizomes used as an insecticide
31	*Viola canescens* Wall.	Vanafsa, Kauru	Herb	Exposed grassy slopes, rock crevices	Plant extracts are useful in malarial fever, bronchitis, and asthma, Leaf juice applied in cut and wounds
32	*Zanthoxylum armatum* DC.	Timru, Timur	Shrub	Degraded forests, Scrublands, Forest edges	Leaves and fruits used as a mouthwash and tooth care, Tender stems used as tooth stick

As per the distribution score, most of the species were found within the bracket of 5 to 7. The least numerical strength (3 Distribution score) was shown by *Aloe vera* (L.) Burm.f. and *Stephania glabra* (Roxb.) Miers whereas *Asparagus adscendens* Roxb. and *Echinops cornigerus* DC. were not in the commanding position in the field with a 4 distribution score. *Oxalis corniculata* L. was found most dense species with a 9 distribution score followed by *Berberis aristata* DC, *Cuscuta reflexa* Roxb., *Hedychium spicatum* Sm with a 8 distribution score (Table 2).

**Table 2:** Medicinal plants and their distribution scores.

Distribution Score	Species
3	*Aloe vera* (L.) Burm. f., *Stephania glabra* (Roxb.) Miers
4	*Asparagus adscendens* Roxb., *Echinops cornigerus* DC.
5	*Centella asiatica* (L.) Urb., *Euphorbia hirta* L., *Galium acutum* Edgew., *Geranium ocellatum* Jacquem. ex Cambess., *Inula cappa* (Buch.-Ham. ex D.Don) DC., *Mentha longifolia* (L.) L., *Spermadictyon sauveolens* Roxb., *Viola canescens* Wall., *Zanthoxylum armatum* DC.
6	*Bergenia ciliata* (Haw.) Sternb., *Ajuga bracteosa* Wall. ex Benth., *Drymaria cordata* (L.) Willd. ex Schult., *Potentilla fulgens* Wall. ex Sims, *Scutellaria repens* Buch.-Ham. ex D.Don, *Senecio nudicaulis* Buch.-Ham. ex D.Don, *Valeriana jatamansii* Wall.
7	*Berberis asiatica* Roxb. ex DC., *Dicliptera bupleuroides* Nees, *Reinwardtia indica* Dumort., *Roylea cinerea* (D.Don) Baill., *Rubia cordifolia* L., *Rumex hastatus* D. Don, *Tridax procumbens* (L.) L., *Urtica dioica* L.
8	*Berberis aristata* DC., *Cuscuta reflexa* Roxb., *Hedychium spicatum* Sm
9	*Oxalis corniculata* L.

Most of the plant species were found regularly (17) followed by contagiously (12) distributed. A random distribution was recorded in *Euphorbia hirta* L., *Geranium ocellatum* Jacquem. ex Cambess. and *Roylea cinerea* (D.Don) Baill. (Table 3).

Table 3: Medicinal plants and their distribution patterns.

Contagious	Random	Regular
Bergenia ciliata (Haw.) Sternb. *Centella asiatica* (L.) Urb., *Cuscuta reflexa* Roxb., *Drymaria cordata* (L.) Willd. ex Schult., *Hedychium spicatum* Sm., *Mentha longifolia* (L.) L., *Oxalis corniculata* L., *Senecio nudicaulis* Buch.-Ham. ex D.Don, *Tridax procumbens* (L.) L., *Urtica dioica* L., *Valeriana jatamansii* Wall, *Viola canescens* Wall.	*Euphorbia hirta* L., *Geranium ocellatum* Jacquem. ex Cambess., *Roylea cinerea* (D.Don) Baill.	*Aloe vera* (L.) Burm. f., *Asparagus adscendens* Roxb., *Berberis aristata* DC., *Berberis asiatica* Roxb. ex DC., *Dicliptera bupleuroides* Nees, *Echinops cornigerus* DC., *Galium acutum* Edgew., *Inula cappa* (Buch.-Ham. ex D.Don) DC., *Potentilla fulgens* Wall. ex Sims, *Reinwardtia indica* Dumort., *Rubia cordifolia* L., *Rumex hastatus* D. Don, *Scutellaria repens* Buch.-Ham. ex D. Don, *Spermadictyon sauveolens* Roxb., *Stephania glabra* (Roxb.) Miers, *Zanthoxylum armatum* DC, *Ajuga bracteosa* Wall. ex Benth.
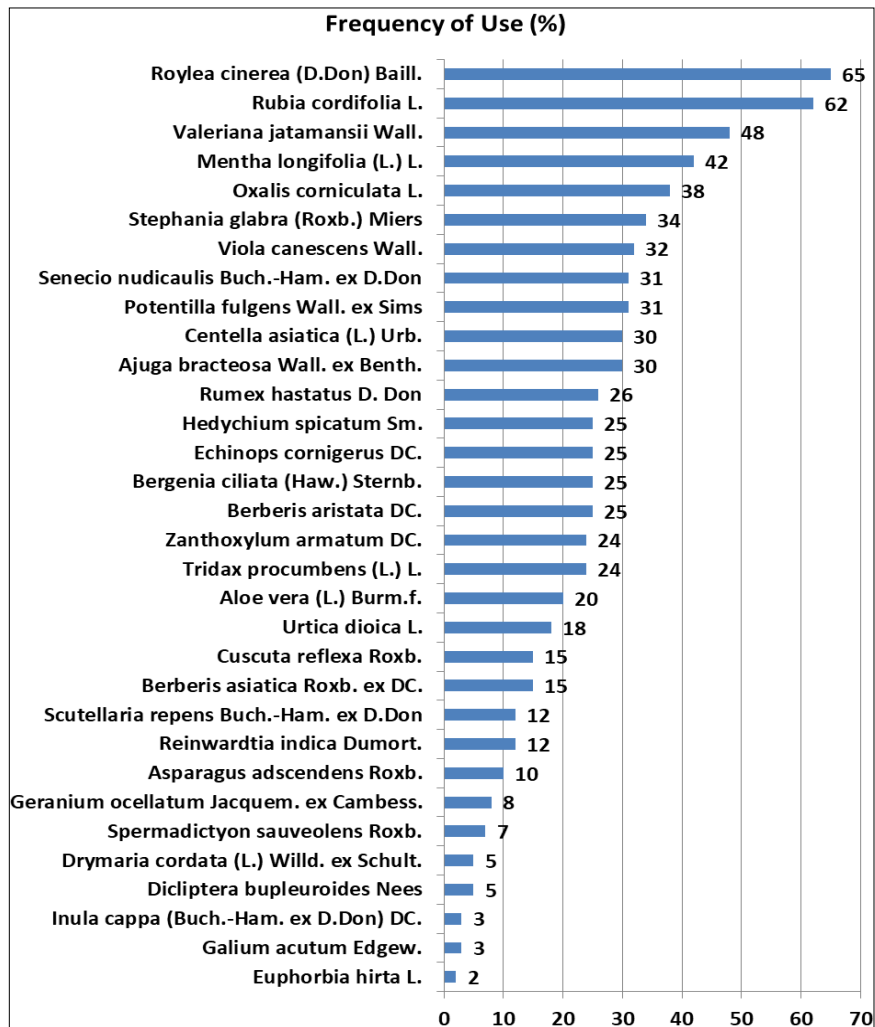
Fig 1: Frequency (%) of the use of Medicinal plants

Frequency of use had shown how many families were using plant resources in the study area. *Roylea cinerea* (D.Don) Baill. (65%), *Rubia cordifolia* L. (62%), *Valeriana jatamansii* Wall. (48%) and *Mentha longifolia* (L.) L. (42%) were the most dominated plant species as far as the frequency of use (%) was concerned. Least usable species were *Euphorbia hirta* L. (2%), *Galium acutum* Edgew. (3%) and *Inula cappa* (Buch.-Ham. ex D.Don) DC. (3%). The frequency of use (%) was found between 20 to 38% in most of the species (Fig. 1). Seven plant species were found as underutilized species as their distribution and numerical strength in the field is good enough but their frequency of use is low. *Euphorbia hirta* L., *Galium acutum* Edgew. *Inula cappa* (Buch.-Ham. ex D.Don) DC. were among these species. Some species like *Echinops cornigerus* DC., *Centella asiatica* (L.) Urb., *Viola canescens* Wall. And *Stephania glabra* (Roxb.) Miers were found as over-utilized plant species as their distribution or numerical strength in the study area is low but the frequency of use (%) is high (Table 4).

Table 4: Medicinal plants and their utilization patterns

Under-utilized medicinal plants	Over-utilized medicinal plants
Distribution Score > or = 5 Frequency of use <10 or = 10	Distribution Score < or = 5 Frequency of use >25 or = 25
Euphorbia hirta L., *Galium acutum* Edgew., *Inula cappa* (Buch.-Ham. ex D.Don) DC., *Dicliptera bupleuroides* Nees, *Drymaria cordata* (L.) Willd. ex Schult., *Spermadictyon sauveolens* Roxb., *Geranium ocellatum* Jacquem. ex Cambess.	*Echinops cornigerus* DC, *Centella asiatica* (L.) Urb., *Viola canescens* Wall., *Stephania glabra* (Roxb.) Miers, *Mentha longifolia* (L.) L.

Discussion

The documented medicinal plants were categorized by habit wise and it was found that 21 out of 32 plants were herbaceous (herb) in nature. Two species were in the category of herb or undershrub while one species was under parasitic herb. Five species were recorded under the shrub category and one each in the shrub or undershrub and undershrub category. There was only one twinner was documented in this study. Tugume and Nyakoojo (2019) [11] have also reported that herbs formed the highest proportion of medicinal plant species. The predominance of herbaceous medicinal species in the study area may be related to the fact that most of them obtained easily from human interference areas (Thomas and Damme, 2010) [12] which is evident in the study area. All the species have their vernacular name either one or two; 21 species have two vernacular names, whereas 11 species have one vernacular name. A good repository of vernacular names of medicinal plants showed the ability of hidden knowledge and wisdom of people in the region as well as their attention on the various characters of plants that help them in local nomenclature.

Most of the recorded medicinal plant species (24 out of 32) come under the bracket of good distribution score (between 5 and 7) showed that most of the plant species have good numerical strength in the study area. This indicates a rich repository of medicinal plants in the study area the region is rich in terms of medicinal resource availability. Low distribution score (3) was recorded for *Aloe vera* that might be due to lower temperature in the study area and due to its particular geographical restriction (Sachedina and Bodeker, 1999) [13] as it is a level-land crop. The low distribution score (3) in *Stephania glabra* might be the result of overexploitation of plant species in the study area as the plant species is marked as endangered in several places of its occurrence (Chhetri *et al.*, 2005) [14].

Oxalis corniculata and *Berberis aristata* were recorded highly distributed plant species in the study area. The ample presence of both species is due to its home range as both species belong to this altitudinal range. Most of the recorded species were found either regularly or contagiously distributed in the study area that is the most common form of distribution in nature. Only a few species like *Euphorbia hirta*, *Geranium ocellatum* and *Roylea cinerea* were recorded as randomly distributed species. This random distribution of species showed unpredictable spacing and it is the least common form of distribution in nature. In this way, these randomly distributed species have emerged as they neither attract nor repel one another. It showed a lack of any strong social interactions with neighboring individuals and abiotic factors.

Roylea cinerea (D.Don) Baill. (65%), *Rubia cordifolia* L. (62%), *Valeriana jatamansii* Wall. (48%) were most frequently used medicinal plants because these species are regularly used by local herbal healers; *Roylea cinerea* (skin diseases and malaria fever), *Rubia cordifolia* (ringworm), *Valeriana jatamansii* (as an insecticide). The study revealed 7 underutilized plant species and 5 species that are overexploited. Most of the underutilized species are being used at the community level and no herbal healer is practicing with these species. On the other hand, all five over-used species (*Echinops cornigerus* DC, *Centella asiatica* (L.) Urb, *Viola canescens* Wall. *Stephania glabra* (Roxb.) Miers, *Mentha longifolia* (L.) L.) are being commercially used by herbal healers of the study area.

Conclusion

High medicinal value plant *Stephania glabra* was found least

distribution and over-utilized plant species in the study area; its pilot cultivation should be started. Titova *et al.* (2012) [15] also suggested a scale-up scheme for the cultivation of this plant on a commercial scale. Randomly distributed species like *Euphorbia hirta*, *Geranium ocellatum* and *Roylea cinerea* have the least interaction with other species as well as the abiotic environment. This indicates an unhealthy growth of these species in the future; we recommend an in-depth scientific study on these species. The study strongly recommends the sustainable use of over-utilized medicinal plants as well as commercial utilization of under-utilized medicinal plants.

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