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# Status of Plant Diversity in Alpine Area of Rakchham- Chitkul Wild life Sanctuary of District Kinnaur, Himachal Pradesh

***R.K. Verma and K.S. Kapoor***
*Himalayan Forest Research Institute,*
*Conifer Campus, Panthaghati, Shimla, (H.P.)*
*(Corresponding author R.K. Verma)*

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**ABSTRACT: A study was conducted to understand the plant diversity along an altitudinal gradient with elevations varying from 3700m to 4700m above msl in alpine area of Rani Kanda in Rakchham Chitkul wild life sanctuary in district Kinnaur, Himachal Pradesh during 2009. Total number of plant species was 102 belonging to 31 families and 66 genera. The dominant families were Asteraceae, Rosaceae, Ploygonaceae, Lamiaceae, Scrophulariaceae and Ranunculaceae. The number of shrub species was 5 and 4 at elevation of 3700-4200m and 4200-4700m with the dominance of *Juniperus indica* at both the elevation. The number of herbs species was 81 and 62 at 3700-4200m and 4200-4700m with the dominance of *Thymus linearis* at both the elevation. The distribution pattern of most of species was contiguous. Index of diversity for herb was 3.54 and 3.66 in these elevations respectively. Out of 50 medicinal plant species recorded from the area, 14 species *i.e., Betula utilis, Meconopsis aculeata, Picrorhiza kurrooa, Heracleum lanatum, Polygonatum multiflorum, Polygonatum verticillatum, Podophyllum hexandrum, Selinum tenuifolium, Rheum australe, Rheum webbianum, Rhodiola heterodonta, Rhododendron anthopogon, Rhododendron campanulatum, Saussurea obvallata* fall in the category of threatened plants.**

***Keywords***: Plant diversity, dominance, diversity index, distribution, threatened plant.

## INTRODUCTION

The alpine regions mainly fall in the great Himalayan ranges, these are approximately 2400 km in length and vary from 240 to 400 km in width with a number of peaks rising well above 7200 m, constituting the most striking feature in the geography of the world and are also characterized by certain geological formations. These regions are characterized by relatively low atmospheric pressure, low temperature, intense insulation, rapid and high ultraviolet radiation alongwith other related effects as chain reactions. All these factors are closely and inseparably inter linked in a complex chain of causes and effects. The entire complex of these closely integrated and interlinked factors constitute a self regulating dynamic alpine ecosystem.

Alpine pastures in India occupy about 1.52 per cent of the total land area in the country. The total geographical area of the Himalaya in India is 61.5 m ha, out of which 17.8 m ha area is covered by alpine pastures usually found at an altitude above 2500 m. These pastures are supposed to be the only true grasslands in India where the grazing density is very high. Western Himalayan pastures are highly affected by heavy grazing pressure. The present level of grass production in the Himalayan grasslands is even less than 25 % of their possible potential. Alpine pastures in Himachal Pradesh cover around 10,052 sq km *i.e.* 17% of the total geographical area of the state. For the sustained development of these resources, proper management is the only way out. Floristic composition, population size and diversity of species are most significant biological elements of an ecosystems. Phytosociological studies at the same time are also useful for comparing different communities. Due to lack of proper management practices, a large number of pastures lands have been converted or are in the process of conversion to degraded lands. Very little scientific attention has been given to the vegetation of the alpine regions. The present study was carried out to know the status of plant species diversity of alpine area, which in turn could be helpful in devising strategies for better management.

## MATERIALS AND METHODS

The study was conducted in alpine area of Ranikanda in Rakchham- Chitkul wild life sanctuary of Kinnaur district in Himachal Pradesh during 2009 between 3700 m to 4700 m elevation range. The site lies at N $31^0$ 18' 50.4" to N $31^0$ 18' 58.9" latitude and E $78^0$ 30' 49.6" to E $78^0$ 30' 28.6" longitude. The whole of the area was divided into two altitudes i.e. 3700-4200m and 4200-4700m for conducting the phyto-sociological study. Quadrats of size 3m x 3m and 1mx1m laid out randomly for shrubs and herbs + regeneration respectively.

The seedlings were considered as herb while saplings as shrubs. The plant species data was analysed for density, frequency and abundance according to formulas given by Curtis and McIntosh (1950). The relative values of density, frequency and dominance were summed to get Importance Value Index (IVI) of individual species. The abundance to frequency ratio (A/F) of different species was determined for eliciting the distribution pattern. This ratio indicates regular (<0.025), random (0.025 to 0.050) and contiguous (>0.050) distribution (Curtis and Cottam, 1956). The plant species diversity was calculated by using Shannon-Wiener diversity Index (H) (Shannon-Wiener, 1963).

$$H = -\sum_{i=1}^{S} (Ni/N) \ln (Ni/N)$$

Concentration of dominance (C) was measured by Simpson's Index (Simpson, 1949).

$$C = \sum_{I=1}^{S} (Ni/N)^2$$

Where Ni = importance value of species i and N = total importance value of all the species in both the indices.

Richness Index was estimated as per Margalef (1958)

*i .e.* $R = S-1/\ln N$

Evenness Index was calculated as per Hill (1973) *i. e.*

$$E = H/ \ln S$$

Where S = total number of species, N = total number of individuals of all the species, H = Index of diversity.

## RESULTS AND DISCUSSION

The total number of plant species was 102 belonging to 31 families and 66 genera. The dominant families were Asteraceae, Rosaceae, Ploygonaceae, Lamiaceae, Scrophulariaceae and Ranunculaceae. Among the 5 species of shrubs, *Juniperus indica* was the dominant species having maximum density (4166.67ha$^{-1}$) and frequency (45%) at 3700-4200m elevation (Table 1). This was followed by *Rhododendron campanulatum*, *Lonicera orientalis* and *Rosa webbiana*. In term of abundance, *Rhododendron campanulatum* observed maximum value (10) followed by *Lonicera orientalis* and *Rosa webbiana*. On the basis of IVI, *Juniperus indica* was dominant species followed by *Rhododendron campanulatum*, *Rosa webbiana* and *Lonicera orientalis.* The distribution pattern of all the species was contiguous. The contiguous distribution is the commonest pattern in nature, random distribution is found in very uniform environment. The general preponderance of contiguous distribution in vegetation has been reported by several workers (Kershaw, 1973; Singh and Yadava, 1974; Kunhikannan *et al.*, 1998).

In case of herbs including regeneration, total number of species was 81 at 3700-4200m elevation (Table 2).

*Anaphalis contorta* was the dominant species having maximum density (5.28m$^{-2}$) and frequency (55%). This was followed by *Thymus linearis*, *Polygonum polystachya* and *Arenaria festucoides* in term of density. The highest value of abundance was recorded for *Thymus linearis* (17.75) followed by *Arenaria festucoides, Polygonum polystachya* and *Potentilla multifida*. *Thymus linearis* recorded the highest value of IVI (43.62) followed by *Anaphalis contorta* (35.16), *Polygonum polystachya* (19.75) and *Betula utilis* (12.43). The lowest IVI (0.31) was recorded for *Lactuca macrorhiza.* The ratio of abundance to frequency indicates that the distribution pattern of all the species was contiguous. The regeneration of *Betula utilis* was recorded.

At elevation 4200-4700m, the total number of shrub species was 4 (Table 3). *Juniperus indica* was the dominant species having maximum density (11805.56ha$^{-1}$) and frequency (62.50%). This was followed by *Rhododendron anthopogon*, *Lonicera hypoleuca* and *Rosa macrophylla*. The highest value of abundance was recorded for *Juniperus indica* (17) followed *Rhododendron anthopogon*, *Lonicera hypoleuca* and *Rosa macrophylla.*

**Table1. Distribution of shrub species in alpine area of Rani Kanda at 3700-4200m elevation.**

| S. No. | Name of the Species | Density (ha$^{-1}$) | Frequ-ency (%) | Abun-dance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Betula utilis D. Don* | 416.67 | 15.00 | 2.50 | 0.17 | 22.93 |
| 2 | *Juniperus indica* Bertol | 4166.67 | 45.00 | 8.33 | 0.19 | 123.09 |
| 3 | *Lonicera orientalis* Lamk. | 1083.33 | 15.00 | 6.50 | 0.43 | 43.15 |
| 4 | *Rhododendron campanulatum* D. Don | 2500.00 | 22.50 | 10.00 | 0.44 | 62.56 |
| 5 | *Rosa webbiana* Wall. ex Royle | 1000.00 | 30.00 | 3.00 | 0.10 | 48.27 |

**Table 2. Distribution of herb species in alpine area of Rani Kanda at 3700-4200m elevation.**

| S. No. | Name of the Species | Density ($m^{-2}$) | Frequ-ency (%) | Abun-Dance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Achillea millefolium* Linn. | 0.28 | 5.00 | 5.67 | 1.13 | 3.13 |
| 2 | *Anaphalis contorta* (D.Don) Hook. f. | 5.28 | 55.00 | 9.61 | 0.17 | 35.16 |
| 3 | *Anaphalis nubigena* DC. | 0.18 | 5.00 | 3.67 | 0.73 | 2.06 |
| 4 | *Anaphalis triplinervis* (Sims) C. B. Clarke | 0.03 | 1.67 | 2.00 | 1.20 | 0.40 |
| 5 | *Androsace rotundifolia* Hardw. | 0.03 | 1.67 | 2.00 | 1.20 | 0.49 |
| 6 | *Anemone obtusiloba* D. Don | 0.10 | 5.00 | 2.00 | 0.40 | 1.27 |
| 7 | *Anemone polyanthes* D. Don | 0.53 | 18.33 | 2.91 | 0.16 | 5.50 |
| 8 | *Anemone rivularis* Buch.-Ham.ex DC. | 0.57 | 16.67 | 3.40 | 0.20 | 4.98 |
| 9 | *Aquilugia pubiflora* Wall. ex Royle | 0.15 | 5.00 | 3.00 | 0.60 | 1.41 |
| 10 | *Arenaria festucoides* Benth. | 1.75 | 10.00 | 17.50 | 1.75 | 10.39 |
| 11 | *Aster flaccidus* Bunge | 0.20 | 6.67 | 3.00 | 0.45 | 2.03 |
| 12 | *Astragalus candolleanus* **Royle ex Benth. | 0.03 | 1.67 | 2.00 | 1.20 | 0.45 |
| 13 | *Bergenia stracheyi* (Hook. f. & Thoms.) Engl. | 0.25 | 10.00 | 2.50 | 0.25 | 3.30 |
| 14 | *Betula utilis*** D. Don | 0.03 | 1.67 | 2.00 | 1.20 | 0.63 |
| 15 | *Bistorta affinis* (D. Don) Greene | 1.65 | 16.67 | 9.90 | 0.59 | 12.43 |
| 16 | *Capsella bursa-pastoris* (L.) Medik. | 0.20 | 5.00 | 4.00 | 0.80 | 1.78 |
| 17 | *Cassiope fastigiata* **D. Don | 0.03 | 1.67 | 2.00 | 1.20 | 0.42 |
| 18 | *Chenopodium album* Linn. | 0.03 | 1.67 | 2.00 | 1.20 | 0.40 |
| 19 | *Conyza viscidula* Wall. | 0.08 | 5.00 | 1.67 | 0.33 | 1.12 |
| 20 | *Cremanthodium arnicoides* (DC. ex Royle) R. Good | 0.47 | 8.33 | 5.60 | 0.67 | 3.64 |
| 21 | *Cynoglossum angustifolium* Willd. | 0.05 | 1.67 | 3.00 | 1.80 | 0.51 |
| 22 | *Cynoglossum wallichii* G. Don | 0.97 | 26.67 | 3.63 | 0.14 | 8.23 |
| 23 | *Elsholtzia cristata* Willd. | 0.28 | 5.00 | 5.67 | 1.13 | 1.82 |
| 24 | *Epilobium angustifolium* Linn. | 0.03 | 1.67 | 2.00 | 1.20 | 0.45 |
| 25 | *Epilobium cylindricum* D. Don | 0.15 | 5.00 | 3.00 | 0.60 | 1.66 |
| 26 | *Erigeron alpinus* Linn. | 0.03 | 1.67 | 2.00 | 1.20 | 0.45 |
| 27 | *Fragaria vesca* Linn. | 0.15 | 5.00 | 3.00 | 0.60 | 1.52 |
| 28 | *Galium elegans* Wall. ex Roxb. | 0.33 | 5.00 | 6.67 | 1.33 | 2.76 |
| 29 | *Gentiana depressa* D. Don | 0.07 | 3.33 | 2.00 | 0.60 | 0.98 |
| 30 | *Gentiana tianschanica* Rupr. ex Kusn. | 0.03 | 1.67 | 2.00 | 1.20 | 0.42 |
| 31 | *Gentianella moorcroftiana* (Wall.ex G.Don.) Airy Shaw | 0.15 | 5.00 | 3.00 | 0.60 | 1.41 |
| 32 | *Geranium pratense* Linn. | 0.65 | 18.33 | 3.55 | 0.19 | 6.09 |
| 33 | *Geranium wallichianum* D. Don ex Sweet | 1.03 | 15.00 | 6.89 | 0.46 | 5.69 |
| 34 | *Heracleum lanatum* Michx. | 0.17 | 11.67 | 1.43 | 0.12 | 3.41 |
| 35 | *Impatiens glandulifera* Royle | 0.07 | 3.33 | 2.00 | 0.60 | 0.80 |
| 36 | *Impatiens scabrida* DC. | 1.03 | 21.67 | 4.77 | 0.22 | 7.76 |
| 37 | *Iris kemaonensis* D. Don ex Royle | 0.03 | 1.67 | 2.00 | 1.20 | 0.40 |
| 38 | *Juniperus communis* **Linn. | 0.05 | 1.67 | 3.00 | 1.80 | 0.42 |
| 39 | *Juniperus indica* **Bertol. | 0.03 | 1.67 | 2.00 | 1.20 | 0.36 |
| 40 | *Lactuca dissecta* Don | 0.13 | 6.67 | 2.00 | 0.30 | 1.51 |
| 41 | *Lactuca macrorhiza* (Royle) Beauv. | 0.02 | 1.67 | 1.00 | 0.60 | 0.31 |
| 42 | *Ligularia amplexicaulis* DC. | 0.02 | 1.67 | 1.00 | 0.60 | 0.37 |
| 43 | *Meconopsis aculeata* Royle | 0.02 | 1.67 | 1.00 | 0.60 | 0.39 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 44 | *Morina coulteriana* Royle | 0.18 | 10.00 | 1.83 | 0.18 | 2.46 |
| 45 | *Nepeta discolor* Royle ex Benth. | 1.08 | 23.33 | 4.64 | 0.20 | 9.05 |
| 46 | *Nepeta laevigata* (D.Don.) Hand.-Mazz. | 0.45 | 10.00 | 4.50 | 0.45 | 5.93 |
| 47 | *Oxyria digyna* (Linn.) Hill. | 0.45 | 15.00 | 3.00 | 0.20 | 6.70 |
| 48 | *Pedicularis hoffmeisteri* Klotzsch | 0.05 | 1.67 | 3.00 | 1.80 | 0.67 |
| 49 | *Pedicularis longiflora* Rudolph | 0.15 | 5.00 | 3.00 | 0.60 | 1.52 |
| 50 | *Pedicularis mollis* Wall. ex Benth. | 0.02 | 1.67 | 1.00 | 0.60 | 0.31 |
| 51 | *Pedicularis oederei* Vahl | 0.03 | 1.67 | 2.00 | 1.20 | 0.42 |
| 52 | *Phlomis bracteosa* Royle ex Benth. | 0.65 | 15.00 | 4.33 | 0.29 | 4.71 |
| 53 | *Picrorhiza kurrooa* Royle ex Benth. | 0.10 | 5.00 | 2.00 | 0.40 | 1.19 |
| 54 | *Plantago tibetica* Hook. f. & Thoms. | 0.03 | 1.67 | 2.00 | 1.20 | 0.45 |
| 55 | *Pleurospermum brunonis* (DC.) C. B. Clarke | 0.32 | 18.33 | 1.73 | 0.09 | 3.84 |
| 56 | *Pleurospermum candollei* (DC.) C. B. Clarke | 0.08 | 6.67 | 1.25 | 0.19 | 1.38 |
| 57 | *Polygonatum verticillatum* (Linn.) All. | 0.03 | 1.67 | 2.00 | 1.20 | 0.45 |
| 58 | *Polygonum polystachya* (Wall. ex Meissner) Gross | 2.70 | 23.33 | 11.57 | 0.50 | 19.75 |
| 59 | *Potentilla atrosanguinea* Lodd. | 1.15 | 21.67 | 5.31 | 0.24 | 11.46 |
| 60 | *Potentilla fruticosa* Linn. | 0.95 | 15.00 | 6.33 | 0.42 | 10.23 |
| 61 | *Potentilla multifida* Linn. | 0.68 | 6.67 | 10.25 | 1.54 | 5.86 |
| 62 | *Primula denticulata* Smith. | 0.05 | 1.67 | 3.00 | 1.80 | 0.47 |
| 63 | *Rheum australe* D. Don | 0.02 | 1.67 | 1.00 | 0.60 | 0.51 |
| 64 | *Rheum webbianum* Royle | 0.05 | 1.67 | 3.00 | 1.80 | 1.01 |
| 65 | *Rhodiola heterodonta* (Hook. f. & Thoms.) Boriss. | 0.18 | 5.00 | 3.67 | 0.73 | 1.37 |
| 66 | *Rosa webbiana* **Wall. ex Royle | 0.02 | 1.67 | 1.00 | 0.60 | 0.39 |
| 67 | *Rumex nepalensis* Sprengel | 0.43 | 21.67 | 2.00 | 0.09 | 4.74 |
| 68 | *Saussurea candicans* (DC.) Sch. Bip. | 0.03 | 1.67 | 2.00 | 1.20 | 0.38 |
| 69 | *Saussurea roylei* (DC.) Sch. Bip. | 0.53 | 26.67 | 2.00 | 0.08 | 7.85 |
| 70 | *Sedum adenotrichum* Wall. | 0.03 | 1.67 | 2.00 | 1.20 | 0.45 |
| 71 | *Sedum ewersii* Ledeb. | 0.03 | 1.67 | 2.00 | 1.20 | 0.45 |
| 72 | *Senecio laetus* Edgew. | 0.20 | 6.67 | 3.00 | 0.45 | 2.22 |
| 73 | *Sibbaldia cuneata* Hornem. ex Kuntze | 0.40 | 5.00 | 8.00 | 1.60 | 2.49 |
| 74 | *Silene conoidea* Linn. | 0.17 | 16.67 | 1.00 | 0.06 | 3.94 |
| 75 | *Silene viscosa* (L.) Pers. | 0.03 | 1.67 | 2.00 | 1.20 | 0.49 |
| 76 | *Solidago virga-aurea* Linn. | 0.03 | 1.67 | 2.00 | 1.20 | 0.42 |
| 77 | *Taraxacum officinale* Wigg. | 0.03 | 1.67 | 2.00 | 1.20 | 0.38 |
| 78 | *Thalictrum foliolosum* DC. | 0.23 | 10.00 | 2.33 | 0.23 | 2.30 |
| 79 | *Thymus linearis* Benth. ex Benth. | 4.73 | 26.67 | 17.75 | 0.67 | 43.62 |
| 80 | *Verbascum thapsus* Linn. | 0.05 | 5.00 | 1.00 | 0.20 | 0.96 |
| 81 | *Viola biflora* Linn. | 0.03 | 1.67 | 2.00 | 1.20 | 0.36 |

** Regeneration

**Table 3. Distribution of shrub species in alpine area of Rani Kanda at 4200-4700m elevation.**

| S. No. | Name of the Species | Density ($ha^{-1}$) | Frequ-ency(%) | Abun-dance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Juniperus indica* Bertol | 11805.56 | 62.50 | 17.00 | 0.27 | 182.01 |
| 2 | *Rhododendron anthopogon* D. Don | 6944.44 | 37.50 | 16.67 | 0.44 | 90.88 |
| 3 | *Rosa macrophylla* Lindl. | 416.67 | 12.50 | 3.00 | 0.24 | 13.24 |
| 4 | *Lonicera hypoleuca* Decne. | 555.56 | 12.50 | 4.00 | 0.32 | 13.86 |

On the basis of IVI, *Juniperus indica* recorded the highest value (182.01) followed by *Rhododendron anthopogon* (90.88), *Lonicera hypoleuca* (13.86) and *Rosa macrophylla* (13.24). The distribution pattern of all the species was contiguous. At elevation of 4200-4700m, total number of herbaceous species was 62 (Table 4). *Thymus linearis* was the dominant species having maximum density ($2.45m^{-2}$) and frequency (58.33%).This was followed by *Cassiope fastigiata, Bistorta affinis* and *Bergenia stracheyi* in term of density. The highest value of abundance was observed for *Arenaria festucoides* (10.14) followed by *Anaphalis triplinervis, Bistorta affinis* and *Cassiope fastigiata*. On the basis of IVI, *Thymus linearis* recorded highest value (33.02) followed by *Bergenia stracheyi* (17.76), *Bistorta affinis* (16.50) and *Cynoglossum micranthum* (11.99). The lowest value of IVI was observed for *Saussurea candicans* (0.35). The ratio of abundance to frequency (A/F) indicates that the distribution pattern of all the species was contiguous. The pattern of distribution depends both on physico-chemical nature of the environment as well as on the biological peculiarities of the organisms themselves. In this study, distribution pattern for the plant species was mostly contiguous which shows that there was no severe competition among the species at all the altitudes since regular type of distribution is almost negligible.

The value of concentration of dominance (C), index of diversity (H), richness index (R) and evenness index (E) for shrubs and herbs at different altitudes was given in Table 5. The higher the value of concentration of dominance, the greater is the homogenous nature of the community and vice- versa (Kohli *et al*., 2004). The lower value of dominance shows that dominance of plants is shared by many species. The diversity indices and richness index was more in lower elevation indicating higher diversity of the species. The species diversity is regulated by long term factors like community stability and evolutionary time as heterogeneity of both macro and micro environment affects the diversification among different communities. The higher values of index of diversity indicate the variability in the type of species and heterogeneity in the communities, whereas, the lesser values point to the homogeneity in the community. The lower value of dominance index and higher value of diversity index was observed by Santvan (1993) in the alpine vegetation near Rahla in Kullu, Himachal Pradesh. Similar findings were also reported by Verma *et al* (2008) while studied alpine pasture of Talra wild life sanctuary of Himachal Pradesh. The evenness index was comparatively more in lower altitudinal range than higher altitudinal range indicating that species are evenly distributed in lower elevations.

The nature of plant community at a place is determined by the species that grow and develop in such environment (Bliss, 1962). Differences in the species composition from altitude to altitude is mostly due to micro environment changes (Mishra *et al;* 1997).

**Medicinal Plants:** The important plants of medicinal value found in alpine area of Rani Kanda in Rakchham Chitkul wild life sanctuary in district Kinnaur of Himachal Pradesh were compiled following Chopra *et al* (1956), Kirtikar and Basu (1987) and Kala (2002). These include; *Anaphalis contorta, Anemone rivularis, Anemone obtusiloba, Aster flaccidus, Bergenia stracheyi, Betula utilis, Bistorta affinis, Caltha palustris, Cassiope fastigiata, Corydalis govaniana, Cynoglossum micranthum, Delphinium brunonianum, Epilobium angustifolium, Fragaria vesca, Gentiana depressa, Gentianella moorcroftiana, Geranium pratense, Geranium wallichianum, Heracleum lanatum, Meconopsis aculeata, Oxyria digyna, Picrorhiza kurrooa, Plantago tebetica, Pleurospermum brunonis, lactuca dissecta, Morina longifolia, Phlomis bracteosa, Pleurospermum candollei, Podophyllum hexandrum, Polygonatum multiflorum, Polygonatum verticillatum, Potentilla nepalensis, Potentilla atrosanguinea, Rheum austral, Rheum webbianum, Rhodiola heterodonata, Rhododendron anthopogon, Rhododendron campanulatum, Rosa macrophylla, Rosa webbiana, Saussurea candicans, Saussurea obvallata, Sedum ewersii, Selium tenuifolium, Swertia purpurascens, Taraxacum officinale, Thalictrum foliolosum, Thymus linearis, Verbascum Thapsus, Viola biflora.*

**Threatened Plants:** Out of 50 medicinal plant species recorded from the area, 14 species i.e. *Betula utilis, Meconopsis aculeata, Picrorhiza kurrooa, Heracleum lanatum, Polygonatum multiflorum, Polygonatum verticillatum, Podophyllum hexandrum, Selinum tenuifolium, Rheum australe, Rheum webbianum, Rhodiola heterodonta, Rhododendron anthopogon, Rhododendron campanulatum, Saussurea obvallata* fall in the category of threatened plants when compared with the available literature like Red Data Book and CAMP Reports (Ved *et al*, 2003). The rarity in these medicinal plants is due to habitat alteration, narrow range of distribution along with other factors. A major threat is for the species those are uprooted and their underground parts such as rhizomes, tubers, bulbs and roots are used in medicine. The habitat of most of the plant species have shrunk due to expansion of human population and environmental degradation primarily due to heavy live stock grazing, uncontrolled and unscientific harvest of species, unregulated tourism and construction of roads etc.

**Table 4. Distribution of herb species in alpine area of Rani Kanda at 4200-4700m elevation.**

| S. No. | Name of the Species | Density ($m^{-2}$) | Frequ-ency (%) | Abun-dance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Anaphalis contorta* ( D. Don) Hook. f. | 0.07 | 3.33 | 2.00 | 0.60 | 0.96 |
| 2 | *Anaphalis nubigena* DC. | 0.48 | 11.67 | 4.14 | 0.36 | 7.49 |
| 3 | *Anaphalis triplinervis* (Sims) C. B. Clarke | 1.40 | 15.00 | 9.33 | 0.62 | 11.84 |
| 4 | *Anemone obtusiloba* D. Don | 0.03 | 1.67 | 2.00 | 1.20 | 0.53 |
| 5 | *Anemone polyanthes* D. Don | 0.03 | 3.33 | 1.00 | 0.30 | 0.90 |
| 6 | *Anemone rivularis* Buch.-Ham. ex DC. | 0.35 | 11.67 | 3.00 | 0.26 | 4.64 |
| 7 | *Arenaria festucoides* Benth. | 1.18 | 11.67 | 10.14 | 0.87 | 11.47 |
| 8 | *Aster flaccidus* Bunge | 0.10 | 5.00 | 2.00 | 0.40 | 1.74 |
| 9 | *Astragalus chlorostachys* Lindl. | 0.05 | 3.33 | 1.50 | 0.45 | 0.91 |
| 10 | *Bergenia stracheyi* (Hook. f. & Thoms.) Engl. | 1.47 | 21.67 | 6.77 | 0.31 | 17.76 |
| 11 | *Bistorta affinis* (D. Don) Greene | 1.65 | 20.00 | 8.25 | 0.41 | 16.56 |
| 12 | *Cassiope fastigiata* D. Don | 1.68 | 21.67 | 7.77 | 0.36 | 11.72 |
| 13 | *Corydalis govaniana* Wall. | 0.03 | 3.33 | 1.00 | 0.30 | 0.78 |
| 14 | *Cremanthodium arnicoides* (DC. ex Royle) R. Good | 0.32 | 15.00 | 2.11 | 0.14 | 5.40 |
| 15 | *Cynoglossum angustifolium* Willd. | 0.03 | 1.67 | 2.00 | 1.20 | 0.53 |
| 16 | *Cynoglossum micranthum* Desf. | 0.57 | 16.67 | 3.40 | 0.20 | 11.99 |
| 17 | *Epilobium angustifolium* Linn. | 0.03 | 1.67 | 2.00 | 1.20 | 0.44 |
| 18 | *Epilobium cylindricum* D. Don | 0.10 | 5.00 | 2.00 | 0.40 | 1.74 |
| 19 | *Fagaria indica* Andr. | 0.03 | 3.33 | 1.00 | 0.30 | 0.78 |
| 20 | *Gentiana depressa* D. Don | 0.40 | 20.00 | 2.00 | 0.10 | 6.97 |
| 21 | *Gentiana tianschanica* Rupr. ex Kusn. | 0.23 | 8.33 | 2.80 | 0.34 | 3.17 |
| 22 | *Gentianella moorcroftiana* (Wall.ex G.Do.n.) Airy Shaw. | 0.03 | 3.33 | 1.00 | 0.30 | 0.73 |
| 23 | *Geranium nepalense* Sweet | 0.27 | 6.67 | 4.00 | 0.60 | 4.17 |
| 24 | *Geranium wallichianum* D. Don ex Sweet | 0.55 | 15.00 | 3.67 | 0.24 | 6.03 |
| 25 | *Heracleum lanatum* Michx. | 0.02 | 1.67 | 1.00 | 0.60 | 0.45 |
| 26 | *Juniperus communis* **Linn. | 0.02 | 1.67 | 1.00 | 0.60 | 0.34 |
| 27 | *Lactuca dissecta* Don | 0.47 | 25.00 | 1.87 | 0.07 | 7.61 |
| 28 | *Lactuca lessertiana* (DC.) C.B. Clarke | 0.07 | 3.33 | 2.00 | 0.60 | 0.96 |
| 29 | *Lactuca macrorhiza* (Royle) Beauv. | 0.25 | 8.33 | 3.00 | 0.36 | 2.51 |
| 30 | *Meconopsis aculeata* Royle. | 0.22 | 11.67 | 1.86 | 0.16 | 4.33 |
| 31 | *Morina longifolia* Wall. ex DC. | 0.13 | 5.00 | 2.67 | 0.53 | 2.64 |
| 32 | *Nepeta discolor* Royle ex Benth. | 0.15 | 5.00 | 3.00 | 0.60 | 1.62 |
| 33 | *Oxyria digyna* (Linn.) Hill. | 0.20 | 13.33 | 1.50 | 0.11 | 3.02 |
| 34 | *Pedicularis hoffmeisteri* Klotzsch | 0.07 | 5.00 | 1.33 | 0.27 | 1.70 |
| 35 | *Pedicularis longiflora* Rudolph | 0.52 | 15.00 | 3.44 | 0.23 | 6.51 |
| 36 | *Pedicularis mollis* Wall. ex Benth. | 0.25 | 8.33 | 3.00 | 0.36 | 2.51 |
| 37 | *Pedicularis oederei* Vahl | 0.15 | 6.67 | 2.25 | 0.34 | 2.24 |
| 38 | *Pedicularis pectinata* Wall. ex Benth. | 0.22 | 6.67 | 3.25 | 0.49 | 2.79 |
| 39 | *Phlomis bracteosa* Royle ex Benth. | 0.87 | 20.00 | 4.33 | 0.22 | 8.95 |
| 40 | *Picrorhiza kurrooa* Royle ex Benth. | 0.50 | 30.00 | 1.67 | 0.06 | 9.47 |
| 41 | *Pleurospermum brunonis* (DC.) C.B. Clarke | 0.18 | 8.33 | 2.20 | 0.26 | 4.32 |
| 42 | *Pleurospermum candollei* (DC.) C. B. Clarke | 0.13 | 6.67 | 2.00 | 0.30 | 3.62 |
| 43 | *Podophyllum hexandrum* Royle | 0.40 | 16.67 | 2.40 | 0.14 | 6.47 |
| 44 | *Polygonatum verticillatum* (Linn.) All. | 0.07 | 5.00 | 1.33 | 0.27 | 1.21 |
| 45 | *Polygonum plebeium* R. Br. | 0.88 | 23.33 | 3.79 | 0.16 | 9.57 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 46 | *Polygonum polystachya* (Wall. ex Meissn.) Gross | 0.30 | 15.00 | 2.00 | 0.13 | 4.00 |
| 47 | *Potentilla multifida* Linn. | 0.20 | 13.33 | 1.50 | 0.11 | 5.36 |
| 48 | *Potentilla nepalensis* Hook. | 0.45 | 20.00 | 2.25 | 0.11 | 7.47 |
| 49 | *Rheum australe* D. Don | 0.12 | 6.67 | 1.75 | 0.26 | 4.07 |
| 50 | *Rumex nepalensis* Sprengel | 0.13 | 5.00 | 2.67 | 0.53 | 1.42 |
| 51 | *Salix fragilis* **Linn. | 0.10 | 8.33 | 1.20 | 0.14 | 2.08 |
| 52 | *Saussurea candicans* (DC.) Sch. Bip. | 0.02 | 1.67 | 1.00 | 0.60 | 0.35 |
| 53 | *Saussurea obvallata* (DC.) Edgew. | 0.17 | 8.33 | 2.00 | 0.24 | 4.05 |
| 54 | *Saussurea roylei* (DC.) Sch. Bip. | 0.62 | 26.67 | 2.31 | 0.09 | 8.25 |
| 55 | *Sedum ewersii* Ledeb. | 0.25 | 6.67 | 3.75 | 0.56 | 2.72 |
| 56 | *Senecio kunthianus*Wall.ex DC. | 0.03 | 3.33 | 1.00 | 0.30 | 0.73 |
| 57 | *Senecio laetus* Edgew. | 0.05 | 3.33 | 1.50 | 0.45 | 0.75 |
| 58 | *Sibbaldia cuneata* Hornem. ex Kuntze | 0.55 | 13.33 | 4.13 | 0.31 | 7.45 |
| 59 | *Silene conoidea* Linn. | 0.18 | 8.33 | 2.20 | 0.26 | 2.32 |
| 60 | *Silene edgeworthii* Bocquet | 0.20 | 5.00 | 4.00 | 0.80 | 3.58 |
| 61 | *Thymus linearis* Benth ex Benth | 2.45 | 58.33 | 4.20 | 0.07 | 33.02 |
| 62 | *Verbascum thapsus* Linn. | 0.02 | 1.67 | 1.00 | 0.60 | 0.35 |

** Regeneration

**Table 5. Concentration of dominance (C), diversity Index (H), Richness Index (R) and Evenness Index (E) of Shrub and Herb at different elevations in alpine area of Ranikanda in Rakchham-Chitkul wild life sanctuary.**

| Altitude | Plant Category | Concentration of Dominance (C) | Index of Diversity (H) | Richness Index (R ) | Evenness Index (E) |
|---|---|---|---|---|---|
| 3700-4100m | Shrub | 0.26 | 1.46 | 1.89 | 0.58 |
| | Herb | 0.05 | 3.54 | 9.46 | 0.83 |
| 4100-4500m | Shrub | 0.46 | 0.94 | 0.30 | 0.86 |
| | Herb | 0.04 | 3.66 | 7.21 | 0.92 |

The better conservation of natural resources can be done by inclusion of a section on the plant conservation especially of rare and endangered medicinal plants in the wild life protection act, promotion of community based conservation, *ex-situ* conservation through tissue culture, developing cultivation technologies and nurseries of medicinal plants and conducting of regular training on the procedure of medicinal plants collection, processing among the local people, traders and real stake holders. It can be concluded from the present study that the dominance of non-leguminous forbs such as *Thymus linearis, Anaphalis contorta, Polygonum polystachya, Bistorta affinis* and *Cynoglossum micranthum* is more than grasses and leguminous forbs. It may be due to heavy grazing pressure. These dominant non-leguminous forbs are not preferred by the animals for eating. The results are in conformity with the earlier studies made by Ellison (1960), Singh (1967), Santvan (1993) and Verma *et al* (2008).

The overgrazing results in changes in botanical composition which however, varies with the type of vegetation cover, its palatability, forage productivity, the way it is utilized and sequence of climate events (Shankaranarayan, 1977; Kapoor and Singh, 1991) which necessitate suitable strategies for management by regulating the grazing. If suitable steps are not taken well in times, there could be further decline in the density of preferred species of leguminous forbs.

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