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# Phyto-sociological studies in Hitch Pawang valley of Rakchham Chitkul wild life sanctuary of district Kinnaur, Himachal Pradesh

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**ABSTRACT : A study was conducted to understand the phytosociological along an altitudinal gradient with elevations varying from 3300m to 4800m above msl in Hitch Pawang valley of Rakchham Chitkul wild life sanctuary in district Kinnaur, Himachal Pradesh during 2008. The total number of plant species in the valley was 142 belonging to 42 families and 95 genera. The dominant families were Asteraceae, Rosaceae, Ranunculaceae, Ploygonaceae and Apiaceae. The number of tree species was 3 with the dominance of *Pinus wallichiana* at 3300-3800m and 3800-4300m elevation respectively. The number of shrub species was 22 and 14 at the elevation of 3300-3800m and 3800-4300m having dominance of *Rhododendron campanulatum* at both the elevations. Whereas, at 4300-4800m elevation number of shrub species was 10 with the dominance of *Rhododendron anthopogon*. The number of herbs species were 67, 51 and 67 with the dominance of *Salix fragilis, Potentilla multifida* and *Cassiope fastigiata* at 3300-3800m and 3800-4300m and 4300-4800m elevation respectively. The distribution pattern of species was mostly contiguous in all the altitude ranges. Index of diversity for herb was 3.83, 3.47 and 3.83 for 3300-3800m, 3800-4300m and 4300-4800m elevation respectively. Out of 48 medicinal plant species as recorded from the area, 13 species fall in the category of threatened plants.**

## INTRODUCTION

The diverse climate and the varied environmental conditions prevailing in the lap of Himalayas support diverse habitat and ecosystems with equally diverse life forms. Variations in terms of its size, climate and altitudinal ranges, have created environments those are unique and characteristic to this region only. Himalayas known for its rich and diverse plant wealth had shown a rapid decline in population of many plant species in recent past. Some of them have already been lost whereas many of them are in the verge of extinction. The current decline in biodiversity largely through human activities is a serious threat to our ecosystem. Hence, attempts are on to preserve this biodiversity in-site and ex-situ conservation. Rakchham-Chitkul wildlife sanctuary is one of the high altitude sanctuary established in 1962 in Kinnaur district of Himachal Pradesh. In this sanctuary, continuous removal of plant species for various uses and overgrazing by migratory and other livestock infact, have resulted in loss of biodiversity. If these naturally occurring plant resources are not conserved timely then they may soon become extinct. The assessment of plant wealth in this sanctuary may provide a key for its conservation. Keeping these aspects in view, a study was undertaken to know the phytosociology in Hitch Pawang valley of Rakchham Chitkul wild life sanctuary in district Kinnaur of Himachal Pradesh.

## MATERIALS AND METHODS

The present study was conducted in Hitch Pawang valley of Rakchham Chitkul wild life sanctuary in district Kinnaur of Himachal Pradesh during, 2008 at an elevation of 3300-4800m. The study site was situated 31° 20’ 58.1" to 31° 19’ 12.4" N latitude and 78° 26’ 14.8" to 78° 26’ 3.3" E longitudes. The whole area of the valley was divided into three altitudes i.e. 3300-3800m, 3800-4300m and 4300-4800m for conducting the phyto-sociological study. Quadrats of size 10 m × 10 m, 3 m × 3 m and 1mx1m laid out randomly for enumerating trees, shrubs and herbs + regeneration respectively. The seedlings were considered as herb while saplings as shrubs. The vegetation 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 Shanon-Wiener diversity Index (H) (Shannon-Wiener, 1963).

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

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

$$C = \sum_{i=1}^{S}\left(\frac{Ni}{N}\right)^2$$

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 142 belonging to 42 families and 95 genera in Hitch Pawang valley. The dominant families were Asteraceae, Rosaceae, Ranunculaceae, Ploygonaceae and Apiaceae. At elevation 3300-3800m, total number of tree species was 3 (Table-1). *Pinus wallichiana* was the dominant species having maximum density (360ha$^{-1}$) and abundance (3.60) and frequency (100%). This was followed by *Abies spectabilis* and *Betula utilis* in term of density, frequency and IVI. 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).

**Table 1 : Distribution of tree species in Hitch Pawang valley at 3300-3800 m elevation.**

| S.N. | Name of the Species | Density (ha-1) | Frequency | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Abies spectabilis* (D. Don) Mirbel | 60.00 | 60.00 | 1.00 | 0.02 | 61.63 |
| 2 | *Betula utilis* D. Don | 20.00 | 20.00 | 1.00 | 0.05 | 18.33 |
| 3 | *Pinus wallichiana* A. B. Jackson | 360.00 | 100.00 | 3.60 | 0.04 | 220.04 |

Among 22 species of shrubs, *Syringa emodi* recorded the maximum frequency (40%) followed by *Betula utilis*, *Rhododendron campanulatum* and *Lonicera myrtillus* at elevation 3000-3800m (Table-2). The highest abundance was observed for *Rhododendron anthopogon* (16) followed by *Berberis coriaria, Rosa macrophylla* and *Juniperus communis*. On the basis of IVI, *Rhododendron campanulatum* recorded the highest value (70.17) followed by *Syringa emodi* (24.56), *Berberis jaeschkeana* (21.03) and *Lonicera hypoleuca* (17.60). The lowest IVI of 2.97 was observed for *Lonicera obovata*. The distribution pattern of all the species was contiguous.

**Table 2: Distribution of shrub species in Hitch Pawang valley at 3300-3800m elevation.**

| S.N. | Name of the Species | Density (ha-1) | Frequency | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Abies spectabilis** (D. Don) Mirbel | 44.44 | 12.50 | 3.20 | 0.26 | 9.74 |
| 2 | *Astragalus chlorostachys* Lindley. | 13.89 | 7.50 | 1.67 | 0.22 | 3.04 |
| 3 | *Berberis coriaria* Royle | 111.11 | 7.50 | 13.33 | 1.78 | 7.96 |
| 4 | *Berberis jaeschkeana* C. K. Schneider | 133.33 | 12.50 | 9.60 | 0.77 | 21.03 |
| 5 | *Betula utilis** D. Don | 86.11 | 32.50 | 2.38 | 0.07 | 15.56 |
| 6 | *Cotoneaster bacillaris* Wall.ex Lindl. | 22.22 | 7.50 | 2.67 | 0.36 | 3.71 |
| 7 | *Juniperus communis* Linn. | 163.89 | 15.00 | 9.83 | 0.66 | 14.62 |
| 8 | *Lonicera asperifolia* (Decne.) Hook. f. & Thoms. | 88.89 | 15.00 | 5.33 | 0.36 | 9.78 |
| 9 | *Lonicera hypoleuca* Decne. | 200.00 | 20.00 | 9.00 | 0.45 | 17.60 |
| 10 | *Lonicera myrtillus* Hook. f. & Thoms | 177.78 | 25.00 | 6.40 | 0.26 | 17.11 |
| 11 | *Lonicera obovata* Royle ex Hook. f. & Thoms. | 13.89 | 7.50 | 1.67 | 0.22 | 2.97 |
| 12 | *Pinus wallichiana* *A. B. jackson | 36.11 | 22.50 | 1.44 | 0.06 | 9.31 |
| 13 | *Rhododendron anthopogon* D. Don | 133.33 | 7.50 | 16.00 | 2.13 | 10.83 |
| 14 | *Rhododendron campanulaum* D. Don | 213.89 | 30.00 | 6.42 | 0.21 | 70.17 |
| 15 | *Ribes alpestre* Wall. ex Decne. | 13.89 | 7.50 | 1.67 | 0.22 | 3.08 |
| 16 | *Rosa macrophyllus* Lindley. | 88.89 | 7.50 | 10.67 | 1.42 | 9.42 |
| 17 | *Rosa webbiana* Wall. ex Royle | 111.11 | 25.00 | 4.00 | 0.16 | 14.31 |
| 18 | *Rubus hoffmeisterianus* Kunth & Bouche | 75.00 | 7.50 | 9.00 | 1.20 | 7.97 |
| 19 | *Salix lindleyana* Wall. ex Andersson | 88.89 | 20.00 | 4.00 | 0.20 | 12.03 |
| 20 | *Spiraea bella* Sims | 13.89 | 12.50 | 1.00 | 0.08 | 4.32 |
| 21 | *Spiraea canescens* D. Don | 133.33 | 12.50 | 9.60 | 0.77 | 10.88 |
| 22 | *Syringa emodi* *Wall. ex Royle | 200.00 | 40.00 | 4.50 | 0.11 | 24.56 |

*Sapling

In case of herbs including regeneration, the total number of species was 67 at elevation 3300-3800m (Table 3). *Salix fragilis* was the dominant species having maximum density (4.83 $m^{-2}$) followed by *Anaphalis triplinervis, Plantago tibetica, Potentilla multifida* and *Polygonum polystachya*. *Plantago tibetica* recorded the maximum value of frequency (41.67) followed by *Anaphalis triplinervis, Geranium pratense, Impatiens glandulifera* and *Salix fragilis. Salix fragilis* observed the maximum value of IVI (26.42) followed by *Polygonum polystachya* (25.12), *Polygonatum verticillatum* (17.33) and *Podophyllum hexandrum* (14.11). The lowest value of IVI was recorded for *Thymus linearis* (1.14). The distribution pattern of all the species was contiguous. The regeneration of *Abies spectabilis* and *Betula utilis* was also recorded.

**Table 3: Distribution of herb species in Hitch Pawang valley at 3300-3800m elevation.**

| S.No. | Name of the Species | Density($m^{-2}$) | Frequency (%) | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Abies spectabilis* (D.Don.)Mirbel | 0.10 | 8.33 | 1.20 | 0.14 | 1.66 |
| 2 | *Anaphalis triplinervis* (Sims) C. B. Clarke | 2.92 | 35.00 | 8.33 | 0.24 | 11.81 |
| 3 | *Anemone rivularis* Buch.-Ham. ex DC. | 0.52 | 8.33 | 6.20 | 0.74 | 2.72 |
| 4 | *Aquilegia pubiflora* Wall. ex Royle | 0.33 | 16.67 | 2.00 | 0.12 | 3.08 |
| 5 | *Arabidopsis thaliana* (Linn.) Heynh. | 0.43 | 16.67 | 2.60 | 0.16 | 3.11 |
| 6 | *Artemisia sieversiana* Willd. | 0.42 | 8.33 | 5.00 | 0.60 | 2.37 |
| 7 | *Astragalus chlorostachys* Lindley. | 0.10 | 8.33 | 1.20 | 0.14 | 1.56 |
| 8 | *Betula utilis* **D. Don | 0.35 | 23.33 | 1.50 | 0.06 | 5.26 |
| 9 | *Bistorta affiniis* (D. Don) Greene | 0.35 | 8.33 | 4.20 | 0.50 | 2.20 |
| 10 | *Bupleurum falcatum* Linn. | 0.35 | 16.67 | 2.10 | 0.13 | 3.09 |
| 11 | *Cassiope fastigiata* (Wall.) D. Don | 0.27 | 6.67 | 4.00 | 0.60 | 1.90 |
| 12 | *Chaerophyllum villosum* Wall. ex DC. | 0.22 | 6.67 | 3.25 | 0.49 | 1.93 |
| 13 | *Chenopodium ambrosioides* Linn. | 0.18 | 8.33 | 2.20 | 0.26 | 2.32 |
| 14 | *Conyza viscidula* Wall. | 0.12 | 8.33 | 1.40 | 0.17 | 1.56 |
| 15 | *Cynoglossum micranthum* Desf. | 0.42 | 16.67 | 2.50 | 0.15 | 3.77 |
| 16 | *Cynoglossum wallichii* G. Don | 0.15 | 10.00 | 1.50 | 0.15 | 1.81 |
| 17 | *Dianthus angulatus* Royle | 0.17 | 8.33 | 2.00 | 0.24 | 1.41 |
| 18 | *Elsholtzia cristata* Willd. | 0.18 | 6.67 | 2.75 | 0.41 | 1.85 |
| 19 | *Epilobium angustifolium* Linn. | 0.43 | 8.33 | 5.20 | 0.62 | 2.15 |
| 20 | *Epilobium cylindricum* D. Don | 0.38 | 20.00 | 1.92 | 0.10 | 3.48 |
| 21 | *Fragaria vesca* Linn. | 1.08 | 16.67 | 6.50 | 0.39 | 4.72 |
| 22 | *Fagopyrum esculentum* Moench | 0.20 | 16.67 | 1.20 | 0.07 | 2.83 |
| 23 | *Galium elegans* Wall. ex Roxb. | 0.67 | 8.33 | 8.00 | 0.96 | 2.63 |
| 24 | *Gentiana depressa* D. Don | 0.32 | 11.67 | 2.71 | 0.23 | 2.46 |
| 25 | *Geranium pratense* Linn. | 1.42 | 33.33 | 4.25 | 0.13 | 8.16 |
| 26 | *Heracleum lanatum* Michx. | 0.50 | 25.00 | 2.00 | 0.08 | 11.32 |
| 27 | *Impatiens glandulifera* Royle | 1.17 | 33.33 | 3.50 | 0.11 | 7.53 |
| 28 | *Iris kemaonensis* D. Don ex Royle | 0.33 | 8.33 | 4.00 | 0.48 | 2.52 |
| 29 | *Juniperus communis* **Linn. | 0.35 | 10.00 | 3.50 | 0.35 | 3.37 |

*Contd.*

| S.No. | Name of the Species | Density($m^{-2}$) | Frequency (%) | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 30 | *Lactuca macrorhiza* (Royle) Beauv. | 0.30 | 6.67 | 4.50 | 0.68 | 1.68 |
| 31 | *Lepidium latifolium* Linn. | 0.83 | 16.67 | 5.00 | 0.30 | 5.23 |
| 32 | *Lonicera asperifolia* **(Decne) Hook. f. & Thoms. | 0.87 | 6.67 | 13.00 | 1.95 | 4.85 |
| 33 | *Lotus corniculatus* Linn. | 0.42 | 8.33 | 5.00 | 0.60 | 2.16 |
| 34 | *Malva rotundifolia* Linn. | 0.42 | 8.33 | 5.00 | 0.60 | 2.34 |
| 35 | *Medicago falcata* Linn. | 0.83 | 16.67 | 5.00 | 0.30 | 5.47 |
| 36 | *Morina coulteriana* Royle | 0.40 | 8.33 | 4.80 | 0.58 | 3.28 |
| 37 | *Nepeta laevigata* (D. Don) Hand.-Mazz. | 0.83 | 8.33 | 10.00 | 1.20 | 3.93 |
| 38 | *Pedicularis longiflora* Rudolph | 0.23 | 10.00 | 2.33 | 0.23 | 1.93 |
| 39 | *Phlomis bracteosa* Royle ex Benth. | 0.27 | 8.33 | 3.20 | 0.38 | 2.30 |
| 40 | *Plantago tibetica* Hook. f. & Thoms. | 2.92 | 41.67 | 7.00 | 0.17 | 14.11 |
| 41 | *Podophyllum hexandrum* Royle | 0.18 | 6.67 | 2.75 | 0.41 | 1.58 |
| 42 | *Polygonatum verticillatum* (Linn.) All. | 2.67 | 25.00 | 10.67 | 0.43 | 17.33 |
| 43 | *Polygonum filicaule* Wall. | 0.27 | 6.67 | 4.00 | 0.60 | 1.90 |
| 44 | *Polygonum plebeium* R. Br. | 0.27 | 8.33 | 3.20 | 0.38 | 2.20 |
| 45 | *Polygonum polystachya* (Wall. ex Meissn.) Gross | 1.58 | 25.00 | 6.33 | 0.25 | 25.12 |
| 46 | *Polygonum rumicifolium* (Royle ex Bab.) Hara | 0.37 | 8.33 | 4.40 | 0.53 | 3.03 |
| 47 | *Potentilla multifida* Linn. | 1.92 | 25.00 | 7.67 | 0.31 | 9.13 |
| 48 | *Potentilla nepalensis* Hook. | 0.68 | 10.00 | 6.83 | 0.68 | 3.48 |
| 49 | *Ranunculus arvensis* Linn. | 0.38 | 8.33 | 4.60 | 0.55 | 2.18 |
| 50 | *Rheum webbianum* Royle | 0.10 | 8.33 | 1.20 | 0.14 | 2.53 |
| 51 | *Rhododendron campanulatum* **D. Don | 0.53 | 18.33 | 2.91 | 0.16 | 4.98 |
| 52 | *Rumex hastatus* D. Don | 0.20 | 8.33 | 2.40 | 0.29 | 3.81 |
| 53 | *Rumex nepalensis* Sprengel | 0.67 | 8.33 | 8.00 | 0.96 | 11.35 |
| 54 | *Salix fragilis* **Linn. | 4.83 | 31.67 | 15.26 | 0.48 | 26.42 |
| 55 | *Senecio laetus* Edgew. | 0.25 | 16.67 | 1.50 | 0.09 | 2.68 |
| 56 | *Sibbaldia cuneata* Hornem. ex Kuntze | 0.37 | 18.33 | 2.00 | 0.11 | 3.21 |
| 57 | *Silene conoidea* Linn. | 0.43 | 16.67 | 2.60 | 0.16 | 3.26 |
| 58 | *Stellaria media* Linn. | 0.68 | 8.33 | 8.20 | 0.98 | 2.84 |
| 59 | *Tanacetum tibeticum* Hook. f. & Thoms. ex C. B. Clarke | 0.10 | 6.67 | 1.50 | 0.23 | 1.18 |
| 60 | *Taraxacum officinale* Wigg. | 0.18 | 8.33 | 2.20 | 0.26 | 1.56 |
| 61 | *Taxus wallichiana* **(Zucc.) Pilger | 0.53 | 6.67 | 8.00 | 1.20 | 3.66 |
| 62 | *Thalictrum foliolosum* DC. | 0.27 | 5.00 | 5.33 | 1.07 | 1.50 |
| 63 | *Thalictrum pedunculatum* Edgew. | 0.15 | 10.00 | 1.50 | 0.15 | 1.78 |
| 64 | *Thalictrum reniforme* Wall. | 0.17 | 8.33 | 2.00 | 0.24 | 1.89 |
| 65 | *Thymus linearis* Benth ex Benth | 0.07 | 8.33 | 0.80 | 0.10 | 1.14 |
| 66 | *Urtica dioica* Linn. | 1.00 | 8.33 | 12.00 | 1.44 | 3.56 |
| 67 | *Verbascum thapsus* Linn. | 0.25 | 8.33 | 3.00 | 0.36 | 4.85 |

** *Regeneration*

At elevation 3800-4300m, total number of tree species was 3 (Table 4) with the dominance of *Pinus wallichiana* followed by *Betula utilis* and *Abies spectabilis* in term of density, frequency and IVI. The distribution pattern of all the species was random. At elevation 3800-4300m, the total number of shrub species was 14 (Table 5). *Rhododendron anthopogon* was the dominant species having maximum density (11500 $ha^{-1}$) and abundance (21.79). This was followed by *Rhododendron campanulatum, Rosa webbiana* and *Juniperus communis* in term of density. On the basis of IVI, the highest value was recorded for *Rhododendron campanulatum* (100.08), followed by *Rhododendron anthopogon* (72.57), *Rosa webbiana* (24.53) and *Betula utilis* (17.07). The lowest value of IVI was observed for *Lonicera asperifolia* (2.45).

**Table 4: Distribution of tree species in Hitch Pawang valley at 3800-4300m elevation.**

| S.No. | Name of the Species | Density ($m^{-1}$) | Frequency (%) | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Abies spectabilis* (D. Don) Mirbel | 100.00 | 65.00 | 1.54 | 0.02 | 67.98 |
| 2 | *Betula utilis* D. Don | 215.00 | 75.00 | 2.87 | 0.04 | 96.93 |
| 3 | *Pinus wallichiana* A. B. Jackson | 250.00 | 90.00 | 2.78 | 0.03 | 135.10 |

**Table 5: Distribution of shrub species in Hitch Pawang valley at 3800-4300m elevation.**

| S.No. | Name of the Species | Density ($m^{-1}$) | Frequency (%) | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Abies spectabilis* *(D. Don) Mirbel | 666.67 | 12.50 | 4.80 | 0.38 | 10.75 |
| 2 | *Betula utilis* *D. Don | 1166.67 | 30.00 | 3.50 | 0.12 | 17.07 |
| 3 | *Juniperus communis* Linn. | 1777.78 | 17.50 | 9.14 | 0.52 | 14.66 |
| 4 | *Juniperus indica* Bertol | 527.78 | 5.00 | 9.50 | 1.90 | 4.28 |
| 5 | *Lonicera asperifolia* (Decne.) Hook. f. & Thoms. | 138.89 | 5.00 | 2.50 | 0.50 | 2.45 |
| 6 | *Lonicera hypoleuca* Decne. | 1055.56 | 17.50 | 5.43 | 0.31 | 11.04 |
| 7 | *Lonicera parvifolia* Edgew. | 194.44 | 5.00 | 3.50 | 0.70 | 2.88 |
| 8 | *Pinus wallichiana* *A. B. jackson | 583.33 | 22.50 | 2.33 | 0.10 | 11.52 |
| 9 | *Rhododendron anthopogon* D. Don | 11500.00 | 47.50 | 21.79 | 0.46 | 72.57 |
| 10 | *Rhododendron campanulaum* D. Don | 4638.89 | 40.00 | 10.44 | 0.26 | 100.08 |
| 11 | *Ribes alpestre* Wall. ex Decne. | 138.89 | 5.00 | 2.50 | 0.50 | 2.51 |
| 12 | *Rosa webbiana* Wall. ex Royle | 2472.22 | 35.00 | 6.36 | 0.18 | 24.53 |
| 13 | *Salix lindleyana* Wall. ex Andersson | 1694.44 | 17.50 | 8.71 | 0.50 | 15.15 |
| 14 | *Syringa emodi* *Wall. ex Royle | 861.11 | 17.50 | 4.43 | 0.25 | 10.51 |

**Sapling*

At elevation 3800-4300m, the total number of herb species was 51 (Table 6). *Potentilla multifida* recorded the highest value for density (11.33 $m^{-2}$) followed by *Cassiope fastigata* (7.00 $m^{-2}$), *Polygonatum verticillatum* (5.60 $m^{-2}$) and *Bistorta affinis* (4.00 $m^{-2}$). The highest frequency was recorded for *Euphrasia himalayica* (50%) followed by *Bistorta affinis*, *Polygonatum verticillatum* and *Anaphalis triplinervis*. In term of abundance, *Potentilla multifida*, recorded the highest value (37.78) followed by *Cassiope fastigiata, Picrorhiza kurrooa* and *Thymus linearis*. On the basis of IVI, *Potentilla multifida* (39.23) observed the maximum value followed by *Polygonatum verticillatum* (26.42), *Cassiope fastigiata* (23.44) and *Bistorta affinis* (14.48). The lowest IVI of 1.25 was observed for *Swertia paniculata*. The distribution pattern of all species was contiguous.

**Table 6: Distribution of herb species in Hitch Pawang valley at 3800-4300m elevation.**

| S.No. | Name of the Species | Density ($m^{-2}$) | Frequency (%) | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Abies spectabilis* (D.Don.) Mirbel. | 0.10 | 8.33 | 1.20 | 0.14 | 1.51 |
| 2 | *Anaphalis contorta (*D. Don) Hook. f. | 1.30 | 10.00 | 13.00 | 1.30 | 3.42 |
| 3 | *Anaphalis triplinervis* (Sims) C. B. Clarke | 3.20 | 38.33 | 8.35 | 0.22 | 9.89 |
| 4 | *Anemone rivularis* Buch.-Ham. ex DC. | 0.90 | 20.00 | 4.50 | 0.23 | 4.37 |
| 5 | *Aster flaccidus* Bunge | 0.20 | 10.00 | 2.00 | 0.20 | 1.55 |
| 6 | *Betula utilis*** D. Don | 0.10 | 8.33 | 1.20 | 0.14 | 1.51 |
| 7 | *Bistorta affinis* (D. Don) Greene | 4.00 | 41.67 | 9.60 | 0.23 | 14.48 |
| 8 | *Bupleurum falcatum* Linn. | 0.78 | 30.00 | 2.61 | 0.09 | 5.12 |
| 9 | *Bupleurum himalayensis* Klotz. & Garcke Garcke | 0.20 | 10.00 | 2.00 | 0.20 | 1.61 |
| 10 | *Bupleurum tenue* Buch. Ham ex D.Don. | 0.30 | 6.67 | 4.50 | 0.68 | 1.46 |
| 11 | *Cassiope fastigiata* (Wall.) D. Don | 7.00 | 21.67 | 32.31 | 1.49 | 23.44 |
| 12 | *Corydalis govaniana* Wall. | 0.20 | 8.33 | 2.40 | 0.29 | 1.56 |
| 13 | *Cynoglossum micranthum* Desf. | 0.20 | 6.67 | 3.00 | 0.45 | 1.40 |
| 14 | *Epilobium angustifolium* Linn. | 0.50 | 10.00 | 5.00 | 0.50 | 2.22 |
| 15 | *Epilobium cylindricum* D. Don | 0.80 | 20.00 | 4.00 | 0.20 | 3.96 |
| 16 | *Epilobium latifolium* Linn. | 0.30 | 6.67 | 4.50 | 0.68 | 1.49 |
| 17 | *Euphrasia himalayica* Wettst. | 2.50 | 50.00 | 5.00 | 0.10 | 11.08 |
| 18 | *Fragaria vesca* Linn. | 0.30 | 20.00 | 1.50 | 0.08 | 2.80 |
| 19 | *Gentiana depressa* D. Don | 0.37 | 20.00 | 1.83 | 0.09 | 3.19 |
| 20 | *Gentiana tianschaniaca* Rupr. ex Kusn. | 1.20 | 30.00 | 4.00 | 0.13 | 6.51 |
| 21 | *Gentianella moorcroftiana* (Wall. ex G. Don) Airy Shaw | 0.42 | 10.00 | 4.17 | 0.42 | 5.31 |
| 22 | *Gentianella paludosa* (Hook.) Harry Smith | 0.40 | 5.00 | 8.00 | 1.60 | 1.60 |
| 23 | *Geranium nepalense* Sweet. | 0.30 | 10.00 | 3.00 | 0.30 | 1.64 |
| 24 | *Geranium pratense* Linn. | 0.50 | 8.33 | 6.00 | 0.72 | 1.77 |
| 25 | *Geranium wallichianum* D. Don ex Sweet | 1.60 | 30.00 | 5.33 | 0.18 | 6.78 |
| 26 | *Lactuca macrorhiza* (Royle) Beauv. | 0.50 | 20.00 | 2.50 | 0.13 | 3.32 |
| 27 | *Lomatogonium carinthiacum* (Wulfen) Reichb. | 0.20 | 10.00 | 2.00 | 0.20 | 1.58 |
| 28 | *Lotus corniculatus* Linn. | 1.30 | 21.67 | 6.00 | 0.28 | 4.96 |
| 29 | *Phlomis bracteosa* Royle ex Benth. | 0.60 | 21.67 | 2.77 | 0.13 | 4.65 |
| 30 | *Picrorhiza kurrooa* Royle ex Benth. | 3.30 | 20.00 | 16.50 | 0.83 | 13.29 |
| 31 | *Podophyllum hexandrum* Royle | 1.00 | 10.00 | 10.00 | 1.00 | 4.31 |
| 32 | *Polygonatum cirrihifolium* (Wall.) Royle | 0.80 | 8.33 | 9.60 | 1.15 | 4.16 |
| 33 | *Polygonatum verticillatum* (Linn) All. | 5.60 | 40.00 | 14.00 | 0.35 | 26.42 |
| 34 | *Polygonum plebeium* R. Br. | 0.50 | 6.67 | 7.50 | 1.13 | 2.43 |

*Contd....*

| S.No. | Name of the Species | Density ($m^{-2}$) | Frequency (%) | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 35 | *Polygonum polystachya* (Wall. ex Meissner) GrossGross | 1.10 | 10.00 | 11.00 | 1.10 | 12.98 |
| 36 | *Potentilla atrosanguinea* Lodd. | 1.30 | 20.00 | 6.50 | 0.33 | 5.29 |
| 37 | *Potentilla multifida* Linn. | 11.33 | 30.00 | 37.78 | 1.26 | 39.23 |
| 38 | *Potentilla nepalensis* Hook | 2.40 | 31.67 | 7.58 | 0.24 | 10.82 |
| 39 | *Primula denticulata* Smith. | 0.20 | 10.00 | 2.00 | 0.20 | 1.61 |
| 40 | *Rheum webbianum* Royle | 0.10 | 8.33 | 1.20 | 0.14 | 2.62 |
| 41 | *Sedum ewersii* Ledeb. | 0.80 | 11.67 | 6.86 | 0.59 | 2.86 |
| 42 | *Selinum vaginatum* C. B. Clarke | 0.40 | 18.33 | 2.18 | 0.12 | 5.06 |
| 43 | *Senecio chrysanthemoides* DC. | 0.40 | 6.67 | 6.00 | 0.90 | 1.60 |
| 44 | *Senecio laetus* Edgew. | 1.90 | 31.67 | 6.00 | 0.19 | 7.60 |
| 45 | *Sibbaldia cuneata* Hornem. ex Kuntze | 1.20 | 10.00 | 12.00 | 1.20 | 3.59 |
| 46 | *Silene conoidea* Linn. | 0.70 | 28.33 | 2.47 | 0.09 | 4.58 |
| 47 | *Swertia paniculata* Wall. | 0.20 | 6.67 | 3.00 | 0.45 | 1.25 |
| 48 | *Swertia purpurascens* Wall. | 0.40 | 10.00 | 4.00 | 0.40 | 2.12 |
| 49 | *Thalictrum reniforme* Wall. | 1.10 | 18.33 | 6.00 | 0.33 | 6.62 |
| 50 | *Thymus linearis* Benth ex Benth | 1.50 | 10.00 | 15.00 | 1.50 | 4.00 |
| 51 | *Verbascum thapsus* Linn. | 1.20 | 10.00 | 12.00 | 1.20 | 3.43 |

** Regeneration

At elevation 4300-4800m, the total number of shrub species was 10 (Table-7). *Rhododendron anthopogon* was the dominant species having maximum density (11583.33$ha^{-1}$) and abundance (20.85). This was followed by *Salix lindleyana*, *Salix fragilis* and *Lonicera myrtillus* in term of density. *Rhododendron anthopogon* was dominant followed by *Salix lindleyana*, *Salix fragilis* and *Lonicera myrtillus* in term of IVI. The distribution pattern of all the species was contiguous.

**Table 7: Distribution of shrub species in Hitch Pawang valley at 4300-4800m elevation.**

| S.No. | Name of the Species | Density ($ha^{-1}$) | Frequency (%) | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Betula utilis** D. Don | 750.00 | 7.50 | 9.00 | 1.20 | 11.18 |
| 2 | *Lonicera quinquelocularis* Hardw. | 1388.89 | 7.50 | 16.67 | 2.22 | 14.92 |
| 3 | *Lonicera asperifolia* (Decne.) Hook. f. & Thoms. | 472.22 | 17.50 | 2.43 | 0.14 | 14.00 |
| 4 | *Lonicera myrtillus* Hook. f. & Thoms | 1861.11 | 25.00 | 6.70 | 0.27 | 24.94 |
| 5 | *Rhododendron anthopogon* D. Don | 11583.33 | 50.00 | 20.85 | 0.42 | 117.83 |
| 6 | *Ribes glaciale* Wall. | 916.67 | 7.50 | 11.00 | 1.47 | 11.56 |
| 7 | *Rosa webbiana* Wall. ex Royle | 638.89 | 17.50 | 3.29 | 0.19 | 14.26 |
| 8 | *Salix fragilis* Linn. | 2138.89 | 25.00 | 7.70 | 0.31 | 35.38 |
| 9 | *Salix lindleyana* Wall. ex Andersson | 3250.00 | 25.00 | 11.70 | 0.47 | 42.99 |
| 10 | *Sorbus microphylla* Wenzig | 1111.11 | 7.50 | 13.33 | 1.78 | 12.95 |

At elevation 4300-4800m, the total number of herb species was 67 (Table 8). The highest frequency was recorded for *Anaphalis nubigena* (50%) followed by *Rhododendron anthopogon*, *Anaphalis triplinervis* and *Primula denticulata*. In term of abundance maximum value was observed for *Cassiope fastigiata* (17.77) followed by *Potentilla multifida*, *Polygonatum verticillatum* and *Anaphalis nubigena*. The maximum value of IVI was recorded for *Cassiope fastigiata* (20.46) followed by *Anaphalis nubigena* (18.66), *Potentilla multifida* (17.96) and *Polygonatum verticillatum* (12.80). The lowest value of IVI was observed for *Galium aparine* (0.56). 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.

**Table 8: Distribution of herb species in Hitch Pawang valley at 4300-4800m elevation.**

| S.No. | Name of the Species | Density ($ha^{-2}$) | Frequency (%) | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 1 | *Aconitum heterophyllum* Wall. ex Royle | 0.15 | 8.33 | 1.80 | 0.22 | 1.42 |
| 2 | *Aconitum violaceum* Jacquem. ex Stapf | 1.20 | 15.00 | 8.00 | 0.53 | 5.48 |
| 3 | *Anaphalis contorta* (D.Don.) Hook.f. | 0.15 | 3.33 | 4.50 | 1.35 | 0.74 |
| 4 | *Anaphalis nubigena* DC. | 5.42 | 50.00 | 10.83 | 0.22 | 18.66 |
| 5 | *Anaphalis triplinervis* (Sims) C. B. Clarke | 2.35 | 38.33 | 6.13 | 0.16 | 9.99 |
| 6 | *Androsace rotundifolia* Hardw. | 0.22 | 8.33 | 2.60 | 0.31 | 1.96 |
| 7 | *Anemone polyanthes* D. Don | 0.08 | 3.33 | 2.50 | 0.75 | 0.67 |
| 8 | *Anemone rivularis* Buch.-Ham. ex DC. | 0.80 | 23.33 | 3.43 | 0.15 | 4.62 |
| 9 | *Aster flaccidus* Bunge | 0.12 | 3.33 | 3.50 | 1.05 | 0.83 |
| 10 | *Bergenia stracheyi* (Hook. f.& Thoms.) Engl. | 0.27 | 15.00 | 1.78 | 0.12 | 2.96 |
| 11 | *Bistorta affinis* (D. Don) Greene | 2.08 | 20.00 | 10.42 | 0.52 | 9.89 |
| 12 | *Bupleurum falcatum* Linn. | 0.20 | 8.33 | 2.40 | 0.29 | 1.56 |
| 13 | *Caltha palustris* Linn. | 0.38 | 6.67 | 5.75 | 0.86 | 2.97 |
| 14 | *Cassiope fastigiata* **(Wall.) D. Don | 3.85 | 21.67 | 17.77 | 0.82 | 20.46 |
| 15 | *Corydalis govaniana* Wall. | 0.58 | 11.67 | 5.00 | 0.43 | 3.34 |
| 16 | *Corydalis rutifolia* (Smith) DC. | 1.03 | 16.67 | 6.20 | 0.37 | 6.73 |
| 17 | *Cremanthodium arnicoides* (DC. ex Royle) R. Good | 0.70 | 20.00 | 3.50 | 0.18 | 5.55 |
| 18 | *Cynoglossum furcatum* Wall.ex Roxb | 1.50 | 20.00 | 7.50 | 0.38 | 9.73 |
| 19 | *Delphinium brunonianum* Royle | 0.47 | 6.67 | 7.00 | 1.05 | 2.10 |
| 20 | *Elsholtzia cristata* Willd. | 0.15 | 3.33 | 4.50 | 1.35 | 1.43 |
| 21 | *Epilobium angustifolium* Linn. | 0.20 | 8.33 | 2.40 | 0.29 | 1.58 |
| 22 | *Epilobium cylindricum* D. Don | 0.23 | 8.33 | 2.80 | 0.34 | 1.68 |
| 23 | *Epilobium latifolium* Linn. | 0.97 | 10.00 | 9.67 | 0.97 | 3.40 |
| 24 | *Epipactis helleborine* (Linn.) Crantz | 0.08 | 3.33 | 2.50 | 0.75 | 0.70 |
| 25 | *Euphrasia himalayica* Wettst. | 2.23 | 26.67 | 8.38 | 0.31 | 10.05 |
| 26 | *Fritillaria oxypetalum* D. Don | 0.35 | 20.00 | 1.75 | 0.09 | 3.23 |
| 27 | *Galium aparine* Linn. | 0.08 | 3.33 | 2.50 | 0.75 | 0.56 |
| 28 | *Gentiana depressa* D. Don | 0.38 | 11.67 | 3.29 | 0.28 | 3.12 |

*Contd....*

| S.No. | Name of the Species | Density ($ha^{-2}$) | Frequency (%) | Abundance | A/F | IVI |
|---|---|---|---|---|---|---|
| 29 | *Gentianella moorcroftiana* (Wall. ex G.Don.) Airy Shaw. | 0.23 | 8.33 | 2.80 | 0.34 | 2.11 |
| 30 | *Geranium nepalense* Sweet. | 0.70 | 31.67 | 2.21 | 0.07 | 5.68 |
| 31 | *Geranium pratense* Linn. | 0.42 | 11.67 | 3.57 | 0.31 | 2.33 |
| 32 | *Hackelia uncinata* (Royle ex Benth.) C. Fischer | 0.23 | 8.33 | 2.80 | 0.34 | 1.86 |
| 33 | *Impatiens glandulifera* Royle | 0.08 | 3.33 | 2.50 | 0.75 | 0.64 |
| 34 | *Lomatogonium carinthiacum* (Wulfen) Reichb. | 0.38 | 8.33 | 4.60 | 0.55 | 2.15 |
| 35 | *Meconopsis aculeata* Royle | 0.38 | 8.33 | 4.60 | 0.55 | 2.85 |
| 36 | *Orobanche alba* Stephen ex Willd. | 0.08 | 3.33 | 2.50 | 0.75 | 0.70 |
| 37 | *Oxyria digyna* (Linn.) Hill. | 0.12 | 3.33 | 3.50 | 1.05 | 0.70 |
| 38 | *Oxalis corniculata* Linn. | 0.27 | 8.33 | 3.20 | 0.38 | 1.92 |
| 39 | *Phlomis bracteosa* Royle ex Benth. | 1.15 | 11.67 | 9.86 | 0.84 | 7.95 |
| 40 | *Picrorrhiza kurrooa* Royle ex Benth. | 0.08 | 3.33 | 2.50 | 0.75 | 0.82 |
| 41 | *Pleurospermum candollei* (DC.) C. B. Clarke | 0.20 | 11.67 | 1.71 | 0.15 | 2.66 |
| 42 | *Podophyllum hexandrum* Royle | 0.47 | 8.33 | 5.60 | 0.67 | 3.27 |
| 43 | *Polygonatum verticillatum (*Lin.) All. | 1.77 | 15.00 | 11.78 | 0.79 | 12.80 |
| 44 | *Polygonum polystachya* (Wall. ex Meissner.) Gross | 0.27 | 11.67 | 2.29 | 0.20 | 6.26 |
| 45 | *Polygonum rumicifolium* (Royle ex Bab.) Hara | 0.15 | 8.33 | 1.80 | 0.22 | 1.95 |
| 46 | *Potentilla cuneata* Wall. ex Lehm. | 0.58 | 15.00 | 3.89 | 0.26 | 3.54 |
| 47 | *Potentilla multifida* Linn. | 3.08 | 23.33 | 13.21 | 0.57 | 17.96 |
| 48 | *Potentilla nepalensis* Linn. | 0.35 | 8.33 | 4.20 | 0.50 | 2.59 |
| 49 | *Primula denticulata* Smith. | 1.03 | 35.00 | 2.95 | 0.08 | 7.54 |
| 50 | *Rhodiola heterodonta* (Hook. f. & Thoms.) Boriss. | 0.77 | 10.00 | 7.67 | 0.77 | 3.35 |
| 51 | *Rhododendron anthopogon* **D. Don | 1.73 | 43.33 | 4.00 | 0.09 | 11.68 |
| 52 | *Rumex acetosa* Linn. | 0.08 | 8.33 | 1.00 | 0.12 | 2.74 |
| 53 | *Salix fragilis* **Linn. | 0.77 | 16.67 | 4.60 | 0.28 | 5.94 |
| 54 | *Saussurea candicans* (DC.) Sch. Bip. | 0.08 | 3.33 | 2.50 | 0.75 | 0.82 |
| 55 | *Saussurea obvallata* (DC.) Edgew. | 0.42 | 8.33 | 5.00 | 0.60 | 2.90 |
| 56 | *Saussurea roylei* (DC.) Sch. Bip. | 0.75 | 21.67 | 3.46 | 0.16 | 6.42 |
| 57 | *Sedum ewersii* Ledeb. | 1.08 | 20.00 | 5.42 | 0.27 | 5.40 |
| 58 | *Selinum tenuifolium* Wall. ex C. B. Clarke | 0.42 | 8.33 | 5.00 | 0.60 | 4.39 |
| 59 | *Selinum vaginatum* C. B. Clarke | 0.15 | 3.33 | 4.50 | 1.35 | 1.69 |
| 60 | *Senecio latetus* Edgew. | 0.70 | 8.33 | 8.40 | 1.01 | 3.08 |
| 61 | *Sibbaldia cuneata* Hornem. ex Kuntze | 0.83 | 8.33 | 10.00 | 1.20 | 3.42 |
| 62 | *Silene conoidea* Linn. | 0.92 | 20.00 | 4.58 | 0.23 | 4.77 |
| 63 | *Swertia paniculata* Wall. | 0.12 | 3.33 | 3.50 | 1.05 | 0.81 |
| 64 | *Swertia purpurascens* Wall. | 0.58 | 8.33 | 7.00 | 0.84 | 3.08 |
| 65 | *Tanacetum longifolium* Wall. ex DC. | 0.65 | 8.33 | 7.80 | 0.94 | 3.90 |
| 66 | *Taraxacum officinale* Wigg. | 0.15 | 8.33 | 1.80 | 0.22 | 1.45 |
| 67 | *Thalictrum alpinum* Linn. | 2.27 | 26.67 | 8.50 | 0.32 | 9.95 |

** Regeneration

The value of concentration of dominance (C), index of diversity (H), richness index (R) and evenness index (E) for trees, shrubs and herbs at different altitudes was given in **Table-9**. 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 evenness index was comparatively more in lower altitudinal ranges than higher altitudinal ranges 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).

**Table 9: Concentration of dominance (C), diversity index (H), richness index (R) and evenness index (E) for trees, shrubs and herbs at different elevations in Hitch Pawang Valley.**

| Altitude | Plant Category | Concentration of Dominance (C) | Index of Diversity (H) | Richness Index (R ) | Evenness Index (E) |
|---|---|---|---|---|---|
| 3300-3800 m | Tree | 0.58 | 0.72 | 0.45 | 0.66 |
| | Shrub | 0.09 | 2.76 | 3.15 | 0.89 |
| | Herb | 0.03 | 3.83 | 8.43 | 0.91 |
| 3800-4300 m | Tree | 0.36 | 1.06 | 0.43 | 0.97 |
| | Shrub | 0.19 | 2.04 | 1.89 | 0.77 |
| | Herb | 0.04 | 3.47 | 6.02 | 0.88 |
| 4300-4800 m | Shrub | 0.21 | 1.93 | 1.33 | 0.84 |
| | Herb | 0.03 | 3.83 | 8.22 | 0.91 |

**Medicinal Plants**

The important plants of medicinal value found in Hitch Pawang valley of 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; *Acontium heterophyllum, Acontinum violaceum, Anaphalis contorta, Anemone rivularis, Arbidopsis thaliana, Bergenia stracheyi, Betula utilis, Bupleurum falcatum, Caltha palustris, Cassiope fastigiata, Chenopodium ambrosioides, Corydalis govaniana, Cynoglossum micranthum, Delphinium brunonianum, Epilobium angustifolium, Fagopyrum esculentum, Galium aparine, Gentiana depressa, Geranium pratense, Geranium wallichianum, Heracleum lanatum, Lotus corniculatus, Malva rotundifolia, Meconopsis aculeata, Medicago falcata, Oxyria digyna, Picrorhiza kurrooa, Plantago tebetica, Polygonatum multiflorum, Polygonatum verticillatum, Potentilla nepalensis, Ranunculus arvensis, Rheum alpinum, Rheum webbianum, Rhodiola heterodonata, Rhododendron anthopogon, Rhododendron campanulatum, Rosa macrophylla, Rumex hastatus, Saussurea candicans, Saussurea obvallata, Selium tenuifolium, Selium vaginatum, Swertia purpurascens, Taraxacum officinale, Taxus wallichiana, Thalictrum reniforme, Thymus linearis, Urtica dioica, Verbascum Thapsus.*

**Threatened Plant**

Out of 50 medicinal plant species recorded from the area, 13 species i.e. *Aconitum heterophyllum, Saussurea obvallata, Betula utilis, Meconopsis aculeata, Picrorhiza kurrooa, Taxus wallichiana, Aconitum violaceum, Heracleum lanatum, Polygonatum verticillatum, Rheum webbianum, Rhodiola heterodonta, Rhododendron anthopogon, Rhododendron campanulatum* fall in the category of threatened plants when compared with the available literature like Red Data Book and CAMP Reports. 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. 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, *in-situ* conservation

through the establishment of nature reserves, *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.

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