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VEGETATION SURVEYS IN THE INDIAN TRANS-HIMALAYA

A Report on the Surveys conducted during Summer 2000

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Summary

Ladakh and adjacent trans-Himalayan ranges harbor a typical vegetation characterized by steppe formations, sedge-grass meadows and herbaceous communities. A few attempts have been made to classify and describe the major plant communities of the trans-Himalaya in the past. However, most of the descriptions are based on local information from a few pockets. A complete account of life form distribution and ecological characteristics from the entire range is not available. Keeping this in view, we conducted an extensive survey of vegetation in the trans-Himalaya with a view to address the following questions: (i) how similar or dissimilar are the vegetation communities found within various trans-Himalayan ranges viz., north of Pir-Panjal (Lahul), Zanskar, Changthang, Ladakh mountains, and Karakoram region, (ii) what are the proportions of various growth forms (lichens, mosses, graminoids, forbs and shrubs) within the communities of these ranges, and (iii) which are the unique, rare or endemic species within each range and what are the possible threats to such species ?

We sampled the vegetation and related abiotic variables systematically along the Rohtang - Leh - Nubra road following a `Rapid GRADSECT' approach. Data on various parameters were collected at four levels, viz., (i) General physiognomy, cover types and landscape features within 100 m x 2 km belts, (ii) Community composition of woody species and cover abundance of different life forms at a regular intervals of 2 kms, (iii) Species composition at and around 5 high passes covering various aspects and landforms, and (iv) Species composition and cover abundance around a high altitude brackish water lake. The preliminary findings of the survey include: (i) 10 distinct physiognomic units viz., Herbaceous meadow (HM), Sedge meadow (SM), Mixed scrub or steppe (MS), Riverine scrub (RS), Sparse vegetation including degraded slopes (SV), Woodland/Plantation (WP), Cultivation/Habitation (CH), Grasslands i.e., area dominated by grasses (GR) and cushionoid vegetation including mosses and lichens (CV).

were identified along with their percent coverage within various sectors and also along the GRADSECT, (ii) 9 major woody communities along the Gradsect were identified, viz., Juniper woodland, *Artemisia dracunculus - A. maritima, Caragana,*

Eurotia, Caragana - Eurotia, Artemisia gmelinii - A. salsoloides, Hippophae - Myricaria, Salix lindleyana, Lysium ruthinicum, and *Ephedra gerardiana, (iii)* High passes (Rohtang, Baralacha La, Lachulung La, Tanglang La, and Khardung La ranging from 3900-5500 m asl) represented different geological formations and therefore distinct plant communities. General vegetation cover, species richness, density and diversity decreased with increasing altitude and latitude, and (iv) The banks of Tso Moriri (brackish water lake) were dominated by *Carex melanantha, Carex nivalis* and a few other herbs which was quite different from the banks of fresh water lakes and other marsh meadows of the alpine regions.

1.0 Introduction

The rain shadow zone in the north of Great Himalayan range is generally referred as the Trans-Himalaya or `cold desert' represents an interesting biome. The vegetation and plant life in this zone partly resembles with those of other alpine regions, but largely differs in terms of physiognomy, cover and adaptability to environmental and biotic factors.

The flora and vegetation of Indian trans-Himalaya are of considerable interest both from biogeographic as well as ecological points of view. Although this area is generally considered as floristically impoverished as compared to the areas of same altitudes in main Himalayan ranges (Mani, 1978, Schweinfurth 1984), it represents characteristic elements from near by phytogeographic regions such as alpine zone of the Greater Himalaya, Afghanistan, Tibet and Siberia (Kachroo *et al*., 1977). The vegetation of this region has been described by earlier authors under various types such as *Caragana - Lonicera- Artemisia* formation (Osmaston 1922), Zone of dry bushes (Nakao 1955), Alpine steppe (Schweinfurth 1957), Dry alpine scrub (Champion & Seth 1968) and Alpine stony deserts (Puri et al., 1989). Although, a large number of floristic and faunal surveys have been conducted in this region detailed analysis of the plant communities with respect to changing altitude and latitude is lacking. No comprehensive account of key floral elements and distribution of major growth forms within various sub-regions viz., Lahul, Zanskar, Changthang, Ladakh,

and Karakoram ranges is available. Most of the area within this zone is under heavy grazing pressure by the migratory as well as resident livestock. There is a need to assess the general condition of vegetation i.e. Trans-Himalayan rangelands and also identify unique vegetation communities from the area so as to formulate a conservation plan. Therefore, the present survey was conducted in the region during the summer of year 2000.

2. 0 Survey Objectives and Methods

The survey was conducted with the following major objectives:

(i) To classify and characterize the major physiognomic units of vegetation within the Indian Trans-Himalaya along Rohtang – Leh - Karakoram Gradsect.

(ii) To compare the proportions of various growth forms within and between major Trans-Himalayan ranges viz., north of Pir-Panjal (Lahul), Zanskar, Changthang, Ladakh, and Karakoram.

(iii) To compare the patterns of species richness and diversity among the high altitude passes.

(iv) To assess the condition of trans-Himalayan rangelands and identify the threats, if any.

The vegetation parameters and dependent variables were sampled systematically along a **GRADSECT** (***Gradient Directed Transect***) following Austin & Heylingers (1989) and Gillison & Brewer (1985). Specific methods for the characterization of major physiognomic units, quantification of major growth-forms (cover abundance), species diversity along the high passes, and assessment of rangelands (alpine pastures) in various areas were as follows:

i. The major physiognomic units of vegetation were recorded on either side of the survey route within 2 km x 100 m segments (strips). For this purpose we used a vehicle (with two observers for each side) driven at a uniform speed of 15-20 km/hour. For each two-km segment, major physiognomic types, % area under such types, major landforms, general remarks such as land use practice/anthropogenic pressures, altitudinal range, and species and number of livestock were recorded. The physiognomic units recorded were: Herbaceous meadow (HM), Sedge meadow (SM), Mixed scrub or steppe (MS), Riverine scrub (RS), Sparse vegetation including degraded slopes (SV), Woodland/Plantation (WP), Cultivation/Habitation (CH), Grasslands i.e. area dominated by grasses (GR), and cushionoid vegetation including mosses and lichens (CV).

ii. Major plant communities were recorded systematically at a regular interval of 2 kms. At each sampling point (on either side of the road, sufficiently away from the visible impacts of the road) site characteristics such as aspect, altitude, terrain type, slope category and general vegetation cover were recorded. At each site five random plots of 3 m radius were laid to record the % cover of individual shrub species and their number. Concentric to each circular plot quadrates of 1 m^2 were laid to estimate the % cover of other life forms viz., grasses, sedges, herbs, mosses, ferns, and lichens. In addition, % area under barren rocks and soil were also recorded. Occurrence of any rare, threatened or valuable plants (including medicinal) were also recorded within the larger plots.

In all, 469 strips (belt transects along the survey route; 2km long and 100m wide) were laid for the classification of physiognomic units. The number of such transects in Greater Himalaya, Lahul, Zanskar, Changthang, Indus and Nubra region were 4, 55, 83, 117, 137 and 73, respectively. The survey route and important locations have shown in Fig 1.

The data for objective no. 4 was collected during the survey and intensive sampling for this objective would be collected during the summer of 2001.

iii. Vegetation structure and species diversity around passes, viz., Rohtang, (3978 m), Baralacha La (4800 m), Lachulung La (5065 m), Tanglang La (5360 m), and Khardung La (5400 m) and banks of a brackish water lake (Tsomoriri) were studied using stratified random samples. Major strata included important aspects and land forms and within each stratum minimum of 10 random quadrats of 1x1m were laid following standard phytosociological approach (Mueller-Dombois & Ellenberg 1974, Bonham 1988). Plant species, their abundance and overall cover were estimated. The density following Misra (1968) and different diversity indices were calculated using STATECOL programme (Ludwig & Reynolds 1988). In addition, soil samples from each high pass were collected for chemical analysis.

iv. General information on the condition of rangelands based on the predominance of various plant species, grazing pressure by the livestock and indirect use by the wild herbivores were recorded all along the survey route.

3.0 Results and Discussion

3.1 General Physiognomy and Vegetation Cover

The vegetation within the Great Himalayan range (around Rohtang pass) was dominated by the herbaceous meadows (ca. 55 %) followed by sedges (8 %), grasses 4 %), mosses (13 %) and lichens (3 %). The mean ground cover in this sector was about 83 %. The barren rocks and exposed soil covered about 9 and 8 %, respectively. The vegetation cover in relation to major physiognomic units of survey area in the Indian Trans-Himalaya is given in Table 1. The sector-wise description is as follows:

i. The areas immediately north of Rohtang pass have strong affinities with the vegetation of Greater Himalaya in terms of species composition and cover largely due to greater influence of monsoon and topography. This area forms the gateway of migratory

livestock to Lahul & Spiti from the lower parts of Kullu district. A few remnant patches of birch - rhododendron (*Betula utilis- Rhododendron campanulatum*) indicate that the vegetation in this area has undergone tremendous changes due to anthropogenic pressures including excessive trampling by livestock, and tourists as well as due to construction of temporary shops around Rohtang pass. The cover percentage of different life forms with respect to places is shown in Fig. 2a.

ii. The hill slopes on either side of Chandra and Bhaga rivers have been intensively used by the local people for cultivation and livestock grazing. In recent years a considerable area has been brought under cultivation for cash crops such as pea (*Pisum sativum*) and potato (*Solanum tuberosum*). Cultivation of steep hill slopes is likely to aggravate soil erosion in the area. The cover percentage of different life forms with respect to places is shown in Fig. 2a.

iii. The sector between Keylong and Darcha supports juniper (*Juniperus macropoda*) woodland, patches of willow (*Salix alba*) plantations near habitations, and *Artemisia* scrub. The hill slopes beyond Darcha up to Patsio were mainly dominated by two species of *Artemisia* viz., *A. dracunculus* and *A. maritima*. The former occupies the gentle and smooth slopes while the latter is found on rocky and hard substrates. Both are less palatable by the livestock. The slopes around Patseo and areas beyond Baralacha La (up to Sarchu) are grazed by over 5000 sheep and goats during summer months. Most of the shepherds in this area come from Chamba district of Himachal Pradesh who feel that livestock grazing is no more profitable. A couple of the *Gaddi* pastorals have resorted to opening temporary *Dhabas* (restaurants) in this area as there has been a sudden increase in the number of tourists traveling through this area. The cover percentage of different life forms with respect to places is shown in Fig. 2a.

iv. The area around Suraj Tal, Baralacha La, Kinlung Sarai, Sarchu, Lachulung La and other prominent places are heavily degraded as seen by the heaps of non-degradable garbage (such as used tar-coal drums, damaged construction material, and liquor bottles), and

excessive trampling near camping sites. The Border Road Organization (BRO) and Department of Tourism (both HP and J&K) could play very important role in clearing the garbage and maintenance of wilderness in the area. The cover percentage of different life forms with respect to places is shown in Fig. 2a.

The overall zanskar region has highest cover percent of herbs at and around Kenlung and Patsio, grass cover between Kenlung and Nakeela, sedge cover at Pang and Patsio, and lichen cover between Suraj tal and Baralacha la areas.

v. The Changthang plateau (including More plains) is extensively grazed by livestock (yak, sheep, goats, horses and donkeys) belonging to nomadic herders. The major vegetation communities in this area include sedge meadows, *Artemisia –Caragana* steppe, *Stipa* grasslands and sparse herb-grass-sedge (mixed) formations. Owing to relatively large area and rotational nature of grazing this plateau appears to be relatively less degraded compared to the parts of Lahul and other areas in the trans-Himalaya. Signs of degradation in the form of *Caragana* removal (for fuel wood) and lowered vegetation cover can be noticed mainly close to camping sites. Further studies on the ecology of rangelands in this area would be essential to understand the status of these areas. The cover percentage of different life forms with respect to places is shown in Fig. 2a.

In general, the cover percentage of sedges, grasses and herbs were more or less similar throughout the region.

vi. The vegetation communities along the course of the Indus river are represented by patches of marsh meadows, willow plantations near habitation, and sparsely distributed shrubs such as *Ephedra gerardiana, Capparis wightiana, Lysium ruthinicum, Peganum harmala* and *Stachys tibetica*. The cover percentage of different life forms with respect to places is shown in Fig. 2b.

The cover percentage of lichens was high at and around Darkit and Kargil, herbs at Darkit and Wakha, while shrubs percentage was more or less similar throughout the region.

vii. In Nubra valley the vegetation was mainly represented by willow and *Hippophae turkestanica* plantations along the agricultural fields and on flat lands, respectively. However, in gentler slopes, on flat land areas and rocky slopes the vegetation was sparsely distributed which was mainly dominated by shrub species such as *Rosa webbiana, Lycium ruthinicum and Sophora moorcroftiana* etc. The cover percentage of different life forms with respect to places is shown in Fig. 2b.

The cover percentage of grasses was high at and around Khalsar, lichens in between Khalsar and Khardung, while herb and shrub percentages were more or less similar throughout the region.

Table 1 Vegetation cover (%) in relation to physiognomic units in different zones**.**

Physiognomic unit	Cover percentage							
	HM	SM	MS	RS	SV	WP	CH	GR
Rohtang	100	-	-	-	-	-	-	-
Lahul	4.5	3.6	***51.8***	13.6	4.5	4.5	16.4	0.9
Zanskar	4.2	17.5	***41.6***	3.0	19.9	4.8	9.0	-
Changthang	2.6	***43.6***	14.1	-	7.3	-	7.3	***25.2***
Indus	0.7	15.0	***37.6***	1.1	23.7	1.1	0.1	6.6
Nubra	4.8	3.4	***43.8***	2.1	19.9	10.3	2.7	1.4

HM: Herbaceous meadow SM: Sedge meadow MS: Mixed scrub/steppe
RS: Riverine scrub GR: Grasslands SV: Sparse vegetation
CH: Cultivation/Habitation WP: Woodland/Plantation

It was evident from the survey that Indus valley had lowest vegetation cover followed by Nubra, Changthang and upper Lahul. Changthang plateau exhibited most uniformly distributed vegetation communities owing to relatively even topography.

3.1.2 The habitat diversity and life forms

The habitat features (both macro and micro) across the landscape in the survey area considerably according to the topographic and hydrological features. The important habitat types and their characteristic floral elements are as follows:

i. Riverine areas: Valley bottoms are characterised by the presence of *Hippophae* - *Myricaria* association, *Salix daphnoides, Phragmites karka, Equisetum* and other species.

ii. Field borders and valley bottoms: The cultivated fields are usually located in the valley bottoms and are well irrigated. A large proportion of the flora is therefore, associated with this habitat. Common species include: *Capsella bursa-pastoris, Lindelofia anchusoides, Scopolia lurida, Tanacetum artemesioides, Nepeta floccosa, Potentilla nivea, Euphorbia tibetica, Lancea tibetica, Iris ensata, Carum carvii, Lepidium apetalum, Peganum harmala, Stachys tibetica* etc.

iii. Marsh Meadows: The valley bottoms with considerable amount of moisture are characterised by *Catabrossa aquatica, Chaerophyllum villosum, Euphrasia vulgaris, Pedicularis longiflora, Juncus* spp, *Carum carvii, Veronica beccabunga*, etc.

iv. Moist slopes: These are found in north facing slopes close to the glaciers and are characterised by the alpine mesophytic elements e.g. *Delphinium, Potentilla, Leontopodium, Taraxacum, Aster, Polygonum, Astragalus, Poa* etc.

v. Eastern plains: Large, flat areas close to Tibetan plateau are distinct in the vegetation composition. Characteristic species include: *Carex nivalis, Oxyria digyna, Polygonum, Draba lasiophylla, Sedum ewersii, Oxytropis lapponica, Potentilla multifida, Nepeta tibetica, Plantago minima, Lychnis macrorhiza, Atriplex crassifolia, Polygonum sibiricum, Sedum tibeticum, Arabis tibetica, Corydalis crassifolia*.

vi. Rubble slopes and screes: The rubble slopes and stable scree areas are characterised by the species like *Axyris amaranthoides, Crepis tenuifolia, Oxyria digyna, Thermopsis inflata, Euphorbia tibetica, Lagotis globossa, Rheum tibeticum, R. webbianum, Saussurea tibetica.*

vii. Snowline zone: Extreme altitudes along perpetual snow (5200 - 5500 m asl) are with a very short growing season, and very poor in species diversity. A few species of this zone are *Sedum ewersii, S. tibeticum, Draba* spp., *Arenaria kashmirica, Christolea himalayensis, C. crassifolia, Chorispora subulosa.*

3.2 Endemic plants

Following species, endemic to Tibetan plateau were recorded during the survey. *Corydalis adiantifolia, C. tibetica, Braya aenea, Capsella thomsonii, Dianthus deltoides, Stellaria tibetica, Astragalus ciliolatus, A. melanostachys, A. oxydon, A. tribulifolius, Sedum crassipes, Chrysanthemum tibeticum, Crepis stoliczkae, Inula falconeri, Leontopodium nanum, Saussurea subulata, S. thomsoni, Senecio tibeticus, Tanacetum artemesioides, Acantholimon lycopodioides* and *Waldhemia nivea.*

3.3 Floristic structure and composition around high passes

The high mountain ranges are known to act as barriers in the distribution of many plant (and animal) species. The Rohtang - Nubra Gradsect encompasses distinct valleys, plateaus and ridge systems. It is expected that the vegetation around major ridges and high passes would be significantly different from the valleys (owing to higher altitude and harsh climatic conditions) and it would mark the transition in the phytogeographic sub-divisions (if such distinctions occur) within the trans-Himalaya. It may be pointed out that several plant species those are dispersed by domestic livestock (mainly sheep and goats) may not show any distinct pattern along the high passes.

These passes were dominated by *Polygonum - Anaphalis - Kobresia* (Rohtang), *Carex infuscata - Waldhemia glabra* (Baralacha La), *Saussurea gnaphaloides - Carex microglochin* (Lachulung La), *Kobresia pygmaea - Saussurea gnaphaloides* (Tanglang La) and *Waldhemia tomentosa - Saussurea gnaphaloides* (Khardung La) communities (Table 2).

The average density, species richness and diversity of herbaceous vegetation in different high passes is given in Table 2.

Table 2 Average density, species richness (SR), diversity and distribution pattern of vegetation in different high passes.

Pass	Density (individuals m^{-2})	SR (number)	Diversity (Shannon & Weiner 1963)	Evenness (Simpson)
Rohtang	471 ± 109.9	41 ± 3.8	2.388 ± 0.31	0.643 ± 0.09
Baralacha	238.1 ± 106.7	31 ± 0.8	2.379 ± 0.13	0.693 ± 0.05
Lachulung	38.7 ± 9.1	14 ± 1.3	1.890 ± 0.10	0.716 ± 0.03
Tanglang	61.4 ± 25.2	15 ± 2.1	1.853 ± 0.38	0.684 ± 0.17
Khardung	35.0 ± 13.4	11 ± 1.9	1.842 ± 0.42	0.768 ± 0.20

Rohtang had highest vegetation cover (72.6%) followed by Baralacha La (20.1%), Tanglang La (9.3%), Lachulung La (7.5%) and Khardung La (1.0%). This pattern largely reflects the effect of altitude, topography and moisture gradient because the combined effect of these factors lead to low availability of nutrients and soil.

The physico-chemical properties of the soil at different passes are shown in box and whisker plots through SPSS (Figs. 3 a & b), which indicate the distribution of points in an explanatory manner, though it is not in a statistical approach. A thick line within the box represent the median, the box indicates 50% of values and whiskers denotes the distribution of points (positive or negative) and outlier are also pointed out. The textural properties (sand, silt and clay) for all the passes differ from each other. With increasing altitude the percentage of sand also increased and percentage of silt decreased. The pH was more or less same for Lachulung and Tanglang passes but differed for other passes. However, moisture and water holding capacity of the soil was more or less same for all passes, except Rohtang. Among soil nutrients carbon and nitrogen for all passes was more or less same, except Rohtang, while all passes showed wide variations in the potassium and phosphorus values.

The analysis of the data on the floristic structure reveals that the similarity based on species number (i.e. qualitative) and based on species density (i.e. quantitative) were high between Lachulung and Tanglang among the five passes (Tables 3 & 4). This may be due to less water holding capacity, carbon and nitrogen and high pH value of the soil.

Table 3. Similarity (*qualitative*) between high passes.

Pass	Rohtang	Baralacha	Lachulung	Tanglang	Khardung
Rohtang	100				
Baralacha	11.0	100			
Lachulung	7.3	22.2	100		
Tanglang	3.6	21.7	***62.1***	100	
Khardung	3.6	19.0	16.0	23.1	100

Table 4. Similarity (*quantitative*) between high passes.

Pass	Rohtang	Baralacha	Lachulung	Tanglang	Khardung
Rohtang	100				
Baralacha	1.0	100			
Lachulung	1.0	9.0	100		
Tanglang	0	5.0	***39.0***	100	
Khardung	0	2.0	18.0	21.0	100

3.3 Vegetation around a high altitude wetland

Tso-moriri, a typical brackish water lake is the second largest lake (perimeter 69.5 km or 143 km^2) in Changthang region of Ladakh. This lake also receives three major freshwater streams from the surrounding catchment. The major strata sampled for vegetation composition around this lake were: (a) along the shoreline up to 10 m, (b) along the margins of freshwater streams, and (c) elevated areas >150 m from the bank.

The courses of freshwater streams near the junction of the lake were dominated by *Pedicularis tubiflora, Ranunculus aquatilis, Juncus bufonius*, and *Poa* spp. The vegetation along the shore (away from fresh water) was dominated by *Carex melanantha, C. nivalis, Tanacetum tibeticum* and *Agrostis* sp. However, away from the shore *Oxytropis microphylla, O. lapponica* and *Draba altaica* were the most abundant species, while

Agropyron longiaristatus, Stipa sibirica and *Stipa orientalis* were the common grasses. *Eurotia ceratoides, Caragana gerardiana, Potentilla fruticosa* and *Artemisea salsoloides* and *A. tanacetifolia* were the main shrub species on the slopes of Tsomoriri lake. The vegetation characteristics of this area are given in Table 4.

Table 4. Phytosociological data along shore, away from the shore and on islands at and around Tso moriri wetlands.

Distance	Species richness (number)		Density (individuals m^{-2})	Diversity	Evenness
	Shrub	Herb	Herb		
Islands (n=4)	-	11	64.5-194.3	0.110-1.260	0.100-0.573
5-10m (n=9)	4	33	19.1-665.0	0.319-1.642	0.164-0.840
150-200m (n=9)	4	29	7.1-311.9	0.358-2.140	0.258-0.883

4.0 Conclusions

- The mixed scrub (MS), a characteristic feature of steppe community, was the most dominant physiognomic type in all the sectors, except Rohtang (Greater Himalaya) and Changthang plateau. It was interesting to note that Changthang plateau was dominated by sedge meadows followed by grasslands.

- The Zanskar region had highest cover percent of herbs at and around Kenlung and Patsio. Grass cover was highest between Kenlung and Nakeela, sedge cover at Pang and Patsio, and lichen cover between Suraj tal and Baralacha la areas. In Nubra valley, the cover percent of grasses was highest at and around Khalsar. Lichen cover was highest in between Khalsar and Khardung, while herb and shrub percentages were uniform throughout the region.

- Among the high passes Rohtang had highest density and diversity of herbs. These passes show the decrease in the density, richness and diversity of herbaceous plants with the increase in altitude.

- Relict patches of riverine vegetation, patches of *Juniperus macropoda*, *Ephedra gerardiana, Capparis wightiana* and vegetation along the shores of high altitude lakes will need attention in terms of conservation and long term monitoring.

- Further studies on the effects of soil chemistry, micro-topography and nutrient availability would be essential to understand the species distribution and vegetation dynamics around the lake.

- Impacts of livestock grazing would be addressed in detail during summer of 2001.

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