

Vegetation Pattern of Trans-Himalayan Zone in the North-West Nepal

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Abstract

The study area covers the land from Jomsom in Mustang to Kagmara of Dolpo district in west Nepal. It is typically high altitudinal *trans*-Himalayan marginal land of Tibetan plateau, representing *trans*-Himalayan ecology. The area is almost a dry place consisting of rolling hills and is dominated by alpine scrubs and meadows with various kinds of distinct patches of vegetation. The vegetation types are xerophilous, steppe formation and alpine formation with woody shrubs in the river valleys, nival formation (herbaceous and graminoids mats) in the open land. Majority of the study area is bare and covered by hanging cliff and the vegetation differs from other regions of high Himalayan area of Nepal but to some extent it resembles with that of the western Himalayan and the Tibetan marginal land because the area is the rain shadow of high mountain ridges like Mt. Dhaulagiri, Annapurna and Kanjiroba. Specifically the vegetation pattern of study area includes six types such as Xerophile formation, Alpine zone, Alpine scrubs (Dry alpine scrubs, Moist alpine scrubs), Alpine meadows (Dry land meadows, Moist land meadows), Scree vegetation, Nival formation and Agriculture boarder land vegetation.

Key Word: Arid zone, Tibetan plateau, meadows, alpine scrubs, scree flora

Introduction

Nepal is the central Himalayan kingdom which is influenced by six Phytogeographical region namely central Asiatic in the north, Sino-Japanese in the north-east, Asian Malaysian in the south east, Indian in south, Sudano-Zambian in the south west and Irano-Turanian in the west. Besides these, other two regions that occur in the *trans*-Himalayan zone are Tibetan province and southeast Chinese region. Out of the two ranges of the Himalayan system: the *cis*-Himalayan and *trans*-Himalayan, the *trans*-Himalayan range lies to the north of the Great Himalayas and includes the Zaskar, Ladakh, Karakorum and many inner valleys of Nepal (Mani, 1978; Negi, 1994). The great Himalayan range falls in the northern boarder of Nepal, thus Nepal is being completely exposed to the monsoon rains. A more detailed analysis, however, shows that from the massif of the Ganesh Himal towards west there is one region which is not exposed to the monsoon rains but forms rather arid, semi-desertic zone with low precipitation and the respective scarce vegetation. This area is called the *trans*-Himalayan zone of Nepal and it includes several inner valleys with desert type of climate. These valleys includes

the areas of Ganesh Himal towards west, Kaligandaki, Bheri and Mugu valley with altitude more than 3600m fall under the *trans*-Himalayan zone (Donner, 1968; Jackson, 1994; Negi, 1994). The *trans*-Himalayan zone with arid valley politically lies in Nepal but geographically, a part of Tibetan Highlands (Station, 1972; Donner, 1968).

On the north flanks of Dhaulagiri and Annapurna massif, there is a vast stretch of arid land. To the further north near Tibetan borderland a still more landscape is deprived of arboreous vegetation. Sparsely scattered dark green of low bushes of *Juniperus*, *Caragana*, *Lonicera* are dominant. Good (1974) pointed out that most of the plants immigrated westward from western china of older land to Himalayas of the younger land that has been raising since the cretaceous period. Arid Himalayan vegetation extends north of great Himalayan range along Ladakh range in west of India. The study revealed that the alpine flora of *trans*-Himalayan range is closely related to the alpine floras of eastern Tibet and western China, being the arid climate of this area. Central and Western Asiatic elements are more prominent than circumpolar elements. The vegetation and flora of

high and dry country lying towards the north of the Dhaulagiri has characteristics of the Tibetan plateau. Most of the vegetation is composed of scarce and scattered patches of thorny cushion plants like *Caragana*, *Astragalus*, *Lonicera*. The sheltered places have *Juniperus* and blue pine (*Abies spectabiles*) while most of ravines and riverbanks have different species of *Hippophae*, *Myricaria*, *Populus*, and *Salix* plants.

The west of the Kali Gandaki River in western Nepal is dominated by xerophytic and mesophytic patchy vegetation. In the drier *trans*-Himalayan region, cushion plants (Species of *Caragana*, *Astragalus*) occur more profoundly among sedges and grasses. In extreme cold and dry conditions such plants adapt to the environment with spines, woolly hairs and above all with their penetrating live parts remaining underground parts as roots and rhizomes. Plants of high medicinal values such as the species of *Aconitum*, *Nardostachys*, *Neopicrorhiza*, and *Sedum* occur in this zone of stressed environment conditions.

In drier and less humid parts of *trans*-Himalayan zone of Nepal alpine meadows also consist of alpine mats and shrubs (Shrestha, 1982; Anonymous, 2002). The area of *trans*-Himalayan arid zone is almost treeless and the vegetation is dominated by steppe flora. Anonymous (2002) identified three vegetation zones in the *trans*-Himalayan region: a. *trans*-Himalayan upper *Caragana* steppe, b. *trans*-Himalayan lower *Caragana* steppe and c. *trans*-Himalayan high alpine vegetation. The rolling hills of northern Dolpo or the flat lands of northern Mustang have unusual plants at high altitudes (Shrestha, 1982). The vegetation of *trans*-Himalayan zone ranges from upper subtropical and temperate forest types, steppe communities to the high alpine scrub, with the flora representation of Tibetan, West Himalayan and South Himalayan types (Negi, 1994; Shrestha and Ghimire, 1996; Ghimire *et al.* 1999, 2000, 2001; Lama *et al.* 2001, Rokaya, 2002, Shrestha, 2004a, b).

The main aim of the study was to analyze of vegetation pattern in the study area.

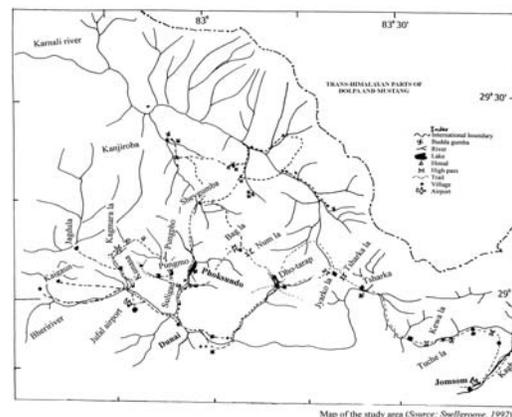
Study Area

The study area covers the land from Jomsom in Mustang to Kagmara of Dolpo district

in west Nepal. It is typically high altitudinal *trans*-Himalayan marginal land of Tibetan plateau, representing *trans*-Himalayan ecology. Climate of this area varies from upper temperate to nival type, with a long dry and cold season. The area located beyond the high mountain ridges of Mt. Dhaulagiri, Annapurna and Kanjiroba massifs is sheltered from the monsoon precipitation that comes from south east side of the country. As a result temperatures and rainfall on the leeward side of the mountains are both low and has affected the vegetation difference. Therefore, the area is almost a dry place consisting of rolling hills and is dominated by alpine scrubs and meadows with various kinds of distinct patches of vegetation.

The vegetation is xerophilous, steppe formation and alpine formation with woody shrubs in the river valleys, and nival formation (herbaceous and graminoids mats) in the open land. Majority of the study area is bare and covered by hanging cliffs and the vegetation differs from other regions of high Himalayan area of Nepal but to some extent it resembles with that of the western Himalayan and the Tibetan marginal land. Stainton (1972); Dobremez *et al.* (1967-2003), Dobremez and Shrestha (1978), Shrestha (1982), Negi (1994), Mani (1978) has described the vegetation of the *trans*-Himalayan zone. The short account of the flora and vegetation of the northern part have been given by Snellgroove (1961); Upreti (1989), Sherpa *et al.* (1996), Shrestha *et al.* (1998), Ghimire *et al.* (1998, 1999, 2000), Manandhar (2001), Yoshida (2002), Rokaya (2002) and Shrestha (2004a, b).

[Fig: Map of trans-Himalayan zone \(Snell groove, 1992\)](#)



Shrestha (1982) identified 36 vegetation types from tropical to alpine zone and mentioned that the northwestern region lies on the frontier of Paleotropic and Holartic regions. He separately described the Dolpa region and mentioned that the most of the area is covered by *Caragana-Lonicera* type of Vegetation. He gave the vegetation types as Scree flora (small herbs and many endemic plants); vegetations of the field with consolidated soils and in the drier slopes (*Rhododendron* sp and the herbs); *Caragana-Lonicera* vegetation. He further identified association such as *Caragana pygmaea-Lonicera spinosa* between 4100-4875m, *Caragana gerardiana-Lonicera spinosa* between 3650-3960m; *Caragana brevifolia-Lonicera spinosa* below 3960m); riverside vegetation (dominated by *Myricarea rosea*, *Hippophae tibetana* and the species of *Salix*.

Materials and Methods

To collect the maximum information on aspects of flora, field notes regarding the plant growth pattern, composition, altitude, aspect and topographic condition were noted down. To obtain detail information on the composition of vegetation, line transect method was employed and each and every species of the plants in the study site was recorded. To have the collection from maximum part of study area transect walk method as explained by Cunningham (2001) was followed. The plants encountered during field visits were collected as voucher specimens. Herbarium of each plant species was prepared following the standard techniques (Martin, 1995; Lawrence, 1967). The plant specimens that were collected and preserved as herbarium were identified with the help of standard literatures (Hara *et al.*, 1978, 1982; Hara and Williams, 1979; Polunin and Stainton, 1984; Stainton, 1988; Press *et al.*, 2000; Lama *et al.*, 2001; DPR, 2001; Zheng-yi *et al.*, 1994). They were also compared with herbarium specimens deposited at Tribhuvan University Central Herbarium (TUCH) and National Herbarium, Godawari (KATH) and some of them were identified by

experts of Taxonomy and by consulting other relevant literatures of geographical sites. The voucher specimens were deposited in TUCH.

Results

From this study, the study area possesses the following types of vegetation:

A. Xerophile formation

In Mustang, from Jomsom upto Sandak valley, and in Dolpo, Tsharka area and Phoksundo area, at the altitudinal range of 3000-3600m is dominated by the species of xerophile vegetation. The plant species include *Juniperus indica*, *Rosa sericea*, *Berberis aristata*, *Lonicera hispida*, *Salix scerophylla*. Other associated species are *Caragana* sp, *Leontopodium stracheyi*, *Tanacetum nubigenium*. Transitional zone of xerophile formation and alpine scrubs is covered with *Betula-Rhododendron* forest. Associate shrubs, herbs and climbers in this type of forest are *Lonicera myrtilus*, *Cotoneaster acuminatus*, *Clematis montana*, *Gentiana depressa*, *Rhodiola himalensis*.

B. Alpine Zone

The alpine zone vegetation that covers the altitudinal range of 3600 m to 6400 m can be classified into two categories on the basis of their habitat and they are described below.

1. Alpine scrubs

The alpine scrub that includes the herbs is further divided into two types: dry alpine scrubs and moist alpine scrubs. They are described below.

i. Dry alpine scrubs

Mostly dry alpine scrubs are prevalent in the *trans-Himalayan* zone from an altitude 3600m to 6400m. The dominant species are *Caragana brevifolia* and *Lonicera spinosa*. While the altitude ascend up, this type of vegetation is replaced by *Rosa sericea*, *Potentilla fruticosa*, *Astragalus candolleanus* and herbs such as *Ephedra gerardiana*, *Primula macrophylla*, *Thermopsis lanceolate*, *Urtica hyperborea*, *Lamiophlomis rotata*, *Androsace tapete*, *Androsace globifera*, *Rheum moorcroftianum*, *Arenaria bryophylla*,

many species of *Potentilla*, *Rhodiola*, *Saxifraga*, *Bistorta*, *Anaphalis*, *Aster* and cruciferae. In this category of vegetation, *Rhododendron nivale* forms a distinct community in the northeastern part of Dho-Tarap and Tsharka Pasture (Between Jhharka la and Tsharka la) above 4400m. This was the only area where distinct patch of *Rhododendron nivale* was recorded during the field visit.

Below this altitude *Rhododendron nivale* is replaced by distinct patches of *Rhododendron anthopogon* and further when altitude descends *Rhododendron lepidotum* forms a dominated patches association with the species of *Caragana*, *Lonicera*, *Berberis*, *Cotoneaster* and one place *Juniperus indica*, species of *Salix*, *Ribes* along with abundant *Artemissia* species were recorded.

ii. Moist alpine scrubs

Moist alpine scrubs occur above the tree line in wetter parts of the country. Vegetation of Dho-Tarap valley, Pungmo valley, Kagamara area and Jagdula area falls under this categories where the moisture is more and precipitation is higher than the other parts of study area. However, the vegetation of other river gullies of drier area also included here. Dominated species of this part are *Myricaria-Salix* and *Hippophae* community. Altitude ranges from 3800-4400m. *Myricaria squamosa* and some species of *Salix* such as *Salix calyculata*, *Salix lindleyana*, *Salix sclerophylla* are more dominant along the shady river gullies. This type of vegetation was found mostly in Dho-Tarap area than the other areas.

The other associated shrub species are *Berberis mucrifolia*, *Astragalus candolleanus*, *Lonicera hispida*, and *Spirea arcuata*. The herb layer is composed of *Bistorta vivipara*, *Primula involucreta*, *P. tibetana*, *Rheum moorcroftianum*, *Roscoea alpina*, *Salvia hians*, *Viola biflora*, *Ranunculus hirtellus*, *Plantago erosa*, *Lagotis kunawurensis*, *Polygonatum cirrhifolium*, species of *Aconitum*, *Anemone*, *Potentilla*, *Pedicularis*, *Cremanthodium*, *Pageophyton*, Orchids like *Dactylorhiza hatagirea*, *Epipactis helleborine*, *Gymendenia conopsea*, and *Poenerochis chusua* and many species of grasses. This type of vegetation extends from

Sandak valley in Mustang to Tsharka Bhot, Dho-Tarap to Num la and Bag la to Phoksundo area of Dolpo region because the area falls under the *trans*-Himalayan inner valleys. The southern part of Kagamara is also occupied by this type of vegetation in minor extent. The open stream banks are completely dominated by *Hippophae tibetana*.

2. Alpine meadows/ Grasslands

The alpine meadows found in this area are also of two types: i. The dry grasslands in the open hills and the fields and ii. Moist grassland along the riversides.

i. Dry grassland in the open hills

Drier grasslands of the study area were recorded around Jomsom valley as well as in between the Kewala and Tsharka bhot, Tsharka la and Jhharka la, Dho-tarap area, area in between the Numa-la and Baga-la and the area of Phoksundo, Viger and Tinngge. These meadows are partly occupied by the grasses in the shady places. The vegetation comprises different patches of *Caragana brevifolia* and *Rhododendron* species. The dominated grass species are *Carex* sp., *Deyeuxia holiciformis*, *D. pulchella*, *Juncus thomsonii* and many species of *Poa*.

The other associated species are *Astragalus candolleanus*, *Caragana brevifolia*, *Potentilla fructicosa*, *Bistorta affinis*, *B. macrophylla*, *Euphorbia stracheyi*, *Glechoma nivalis*, *Gentiana robusta*, *Geranium pratense*, *Incarvillea mairei*, *Jurinea dolomiaea*, *Lamiopholomis rotata*, *Lamium tuberosum*, *Leontopodium jacotianum*, *Morina polyphylla*, *Nardostachys grandiflora*, *Neopicrorhiza scrophulariflora*, *Pterocephalus hookeri*, *Polygonatum hookeri*, *Stellera chamaejasme*, *Tanacetum* species, *Thymus linearis* and species of *Anaphalis*, *Androsace*, *Anemone*, *Arenaria*, *Aster*, *Pedicularis*, *Potentilla*, *Rhodiola*, *Saxifarga*, *Llyodia* etc.

ii. Moist grassland along the riversides

Alpine meadows of moist habitats are found along the riverbanks, near the irrigation channels and water bodies. The greater parts of the grasslands are dominated by the grasses like *Carex* sp., *Deyeuxia holiciformis*, *D. pulchella*, *Juncus thomsonii*, *Poa alpigena*, *p. pagophila*, *P. poophagorum* etc.

Associated species are *Bistorta vivipara*, *Cortia depressa*, *Gentianella paludosa*, *Juncus thomsonii*, *Lanacea tibetica*, *Lagotis kunawurensis*, *Lepidium apetalum*, *Medicago falcata*, *Parnassia nubicola*, *Pedicularis longiflora var tubiformis*, *P. denticulata*, *Stellaria chamaejasme*, *Trigonell emodii* and species of *Thalictrum*, *Anemone*, *Salvia* and many species of Cruciferae family. Many beautiful herbaceous species of *Gentiana*, *Meconopsis*, *Primula* and *Saxifraga* are also found in open alpine moist meadows.

C. Scree Flora

Scree flora is the vegetation in the rocky places and occupied by rocky soil of silty clay and dolomite in nature. This type of flora was recorded in the different slopes and direction of altitudinal range in between 3600-6000m above sea level. These places are occupied by a few shrubby species mainly *Rosa sericea*, *Ephedra gerardiana* and *Cotoneaster microphyllus*. Similarly, the herbs and grasses found in such habitats are *Cortia depressa*, *Glechoma nivalis*, *Pedicularis rhinanthoids*, *Polygonatum cirrhifolium*, *Viola kunawurensis*, *Cardamine loxosteminoides*, *Corydalis alburyi*, *Staintoniella nepalensis*, *Delphinium viscosum*, *Soroseris hookeriana*, *Rhodiola*, *Saxifraga*, *Saussurea gossypiphora*, *S. graminifolia* and species of *Aconitum*, *Allium*, *Carex*, *Delphinium*, *Thalictrum*, etc.

The area of various high altitudinal passes such as Sandak la, Kewa la, Tsharka bhot, Tsharka la, Jhharko la, Numa-la and Bag-la areas have intense sunshine, dry air, open sky and the rocky soil of silty clay and dolomite in nature. So, these areas really are the suitable environments for scree flora to flourish well, however, they occur sparsely. This unique type of environment is some times the reason of endemism in flora.

D. Nival Formation

Beyond the altitude above 5000m where there is snow cover in most of the seasons over the year has no traces of important vegetation except scattered mosses and lichens at different places. As an exceptional record of our research the *Soroseris hookeriana*, *Androsace tapete*, *A.*

globifera, *Oxytropis* sp, *Arenaria bryophylla*, *Ranunculus tricuspis* and *Stellaria decumbens* were found as the part of the nival plants species. Area beyond the 6000m is called "Arctic desert" where even mosses and lichens were not found.

Vegetations of high altitudinal passes of the study area mainly Sandak la (5125m), Kewa la (5600m), Tsharka-la (5100m), Jhharko la (5400m), Numa-la (5200m) and Kagmara pass (5124m) were of the nival type. In Nival area perpetual snow covers all the time of year, a slight change in climate results snowfall and at the moment there is the occurrence of fog blow in the direction of thin cold wind covering all the gliding hills and Himalayas.

E. Vegetation of the Agricultural boarder land

Vegetation found in the fields of consolidated soils near the agricultural fields and marginal lands near the settlements are Agricultural boarder land flora. This type of vegetation grows neither like that of totally dry area nor that of moist area. Available irrigated canal helps to keep the Agriculture land moist and helps to flourish the different types of vegetation. Fields with consolidated soils have bushy plants in the wetter areas and cushions plants on the drier slopes. This type of vegetation was found in Phalek and Sandak area in Mustang and Tsharka Bhot, Dho-Tarap and Ringmo area of Dolpa.

The vegetation includes the plant species such as *Arisaema flavum*, *A. jacquemontii*, *Anisodus tanguticus*, *Epilobium latifolium*, *Heracleum candicans*, *Hyocymus niger*, *Selenium wallichianum*, *Thalspi arvense*, *veronica ciliata*, *Convolvulus arvense*, *Vincetoxium hirundinaria*, *Clematis barbelata*, *Rubia manjith*, *Mirabilis himalaica*, *Capsella bursa-pastoris*, *Polygonatum cirrhifolium*, *Asparagus filicinus*, *Urtica dioica*, *Chenopodium album*, *Elsholtzia*, *Eritricum*, *Oxytropis*, *Pedicularis*, *Pleurospermum*, *Swertia* and various species of *Artimisea*, Cruciferae family and grasses.

Discussion and Conclusion

The vegetation of the inner valleys of *trans-Himalayan Zone* of Mustang up to

Phoksundo of Dolpo is directly affected by precipitation, rainfall, blowing wind, intensity of light, snowfall, and changing climate within a moment. Other factor affecting the alpine Himalayan flora are migration of flora towards north as well as the Rain shadow effect of shielding Himalaya and land made pattern resembling with the Tibetan plateau and above all it should not be free from the effects of global warming. Vegetation of the *trans*-Himalayan zone i.e. Dolpa and Mustang is different from the other parts of Nepal. These districts are located beyond high mountain ridges and are shielded from the monsoon rains that come from the southeast by the high mountain ridges of Mt. Dhaulagiri, Annapurna and Kanjiroba

Study revealed six vegetation types such were Xerophile formation, Alpine scrubs, Alpine meadows, Scree vegetation, Nival formation and Agriculture boarder land vegetation. Furthermore, it was concluded that on the basis of six vegetation

types there are different life forms such are Dwarf perennial herbs-with relatively large flowers, with prostrate rosette leaves, with well branched herbaceous rhizomes, with well branched woody rootstock forming compact tufts mats or cushions, perennials with thick hollow stems, perennial with winter buds or bulbils boon deep underground, flowers covered by bracts, inflorescence covered by leaves or bracts, plants covered with straight hairs, with drooping flowers and Dwarf shrub with stunted or prostrate woody branches.

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