

## **Vegetational Diversity in Tons Valley, Garhwal Himalaya (Uttaranchal) India with Special Reference to Phytogeographical Affinities of the Flora**

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**ABSTRACT:** The diversity in vegetation and flora of Tons Valley in Garhwal Himalaya has been extensively studied during 1994-98. On the whole 761 species of phanerogams referable to 480 genera and 132 families could be recognised in the flora of Tons Valley. The vegetation predominantly is of forest communities which is evergreen type intermixed with deciduous species. The vegetational diversity of the area is discussed broadly under: forest vegetation, seasonal vegetation, and aquatic and marshy vegetation. An analysis of the phytogeographical affinities of the flora shows that the flora of Tons Valley has affinities with surrounding regions. There is predominance of Indian, Indo-Malayan, African-Asiatic-Australian and Palaeotropical elements in the flora. Euro-Siberian and Sino-Japanese species have also found their ways to the Tons Valley.

**KEY WORDS:** Tons Valley, Garhwal Himalaya, Vegetational diversity, Floral elements.

### **INTRODUCTION**

The varied physiographic and climatic conditions in different parts of India have resulted in a high level of biodiversity in the country. India has one of the largest array of environmental conditions, by virtue of very significant altitudinal variations, from sea level to the highest mountain ranges in the world, the long coast-line, hot arid conditions in the west, cold desert conditions in the north and humid tropical conditions in parts of the country. Thus India, with a geographical area of *ca* 329 million ha, has representation of almost all the ecological zones found in the world. The fact that India is the meeting place for three major global biogeographic realms: the Indo-Malayan, Eurasian and Afro-tropical, has further enhanced these biological attributes and contributed significantly towards the country assuming the status of one of the twelve megadiversity centres in the world.

Physiographically, there are three distinct regions in India-the Himalaya, the Indo-Gangetic plain and the Peninsular India or the Deccan region. The Himalaya is in the extreme northern margins of India has a great influence on the climate of the entire region. The Himalayan chain consists of the complex system of nearly three parallel ranges of tertiary mountains namely (I) Great Himalaya or Trans Himalaya (6000 m) (II) Lesser Himalaya or Middle Himalaya (4500 m) and (III) Outer Himalaya or Siwalik ranges (upto 1200 m), rising between the Indian Peninsula and Central Asia as a young system of mountains stretching over nearly 3000 km almost from the borders of Afghanistan in the west to the north of Myanmar in the east with an altitude ranging from few hundred to over 8000 m.

Phytogeographically, the Himalayas have been variously divided by different biogeographers (Hooker, 1904; Clarke, 1898; Chatterjee, 1940; Rao, 1974, Rau 1974; Mani,

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1978; Rodgers and Pawar, 1988), most of them divide Himalaya into Western Himalaya, Central Himalaya and Eastern Himalaya, and recognize tropical, subtropical, temperate and alpine zones, based on elevation. The Western Himalaya consists of two separate phytogeographic regions *i.e.*, i) the Kumaon Himalaya covering Kumaon and Garhwal Sectors and ii) N. W. Himalaya comprising the Himachal Pradesh and Jammu & Kashmir States. The Kumaon and Garhwal sectors of the Himalaya with magnificent snow-capped mountains of the world like Nilkant, Kamet, Nanda Devi, *etc.* constitutes a unique habitat and has contributed to the great biological diversity. The Himalaya, in fact, are considered an emporium of bioresources, botanical curiosities and valuable medicinal herbs has been of great interest to the people of various professions, besides botanists. The major interest on plant collection started with Strachy and Winterbottom, the two surveyors who passed through these hills to Tibet in 1844-49. Since then, frequent visits were made by several others, which resulted in several publications on the flora of the region. However, due to vastness and inaccessibility of the region, numerous areas still remain unexplored or underexplored. The Tons Valley was one of such area lacking the attention of botanists. Therefore, in order to fill in this lacuna, intensive explorations were undertaken in the area during 1994-98 and the present study is based on the work carried out during this period.

The Tons Valley lies between 30°35' and 30°18' north latitude and 77°49' and 78°37' east longitude. The valley is bounded on the north and north-east by Shimla district of Himachal Pradesh, on the south-west by Chakrata forest division of Dehra Dun district, on the east by Yamuna forest division of Uttarkashi district (Fig. 1). The total area of the Tons Valley is *ca* 4500 sq. km. Its length is *ca* 150 km and width is *ca* 30 km. The area is composed, entirely, of a succession of hills and mountains. The Tons River forms the main drainage system of the Valley. Rupin, Supin, Kothigad, Pabar are its main tributaries. The Tons River flows towards South-East and at Tiuni it merges with Pabar River and then it turns towards south. The area forms the krol belt which extends from Shimla in the North to Nainital in the West. Since the Valley is situated in the Himalayan zone, the rocks of this area can broadly be divided into two zones, *viz.* Metamorphic and sedimentary rocks. The soils of this tract can be differentiated into red loam, brown forest soil, podsol and meadow soil.

Due to great variations in altitudes and physical features, the climate of Tons Valley varies from hot and dry at lower elevations below 1600 m, becomes moderate to intensely cold at higher elevations up to 2000 m. At lower elevations summer (April-June) is hot and almost dry; monsoon season (July-mid September) is humid with moderate rain and is hot; winter (November-February) is cold and dry except during January and February when there is snow fall at higher elevations. While spring (mid February-March) is the pleasant season and experiences frequent showers as well. The mean maximum rain fall is in the month of July (259.99 mm.), while the mean minimum rain fall is in the month of April (31.08 mm.). December and January are the coldest months of the year, with maximum temperature 14-15 °C and minimum temperature falling below freezing point. June is the hottest month with maximum temperature 42-43°C and minimum 9-14°C in the Valley.

## MATERIALS AND METHODS

The entire vegetation of the area was thoroughly scanned by repeated visits in different seasons of the year covering all ecological habitats. Sampling was done to prepare a complete herbarium for future reference. Relevant field notes were made on spot noting down

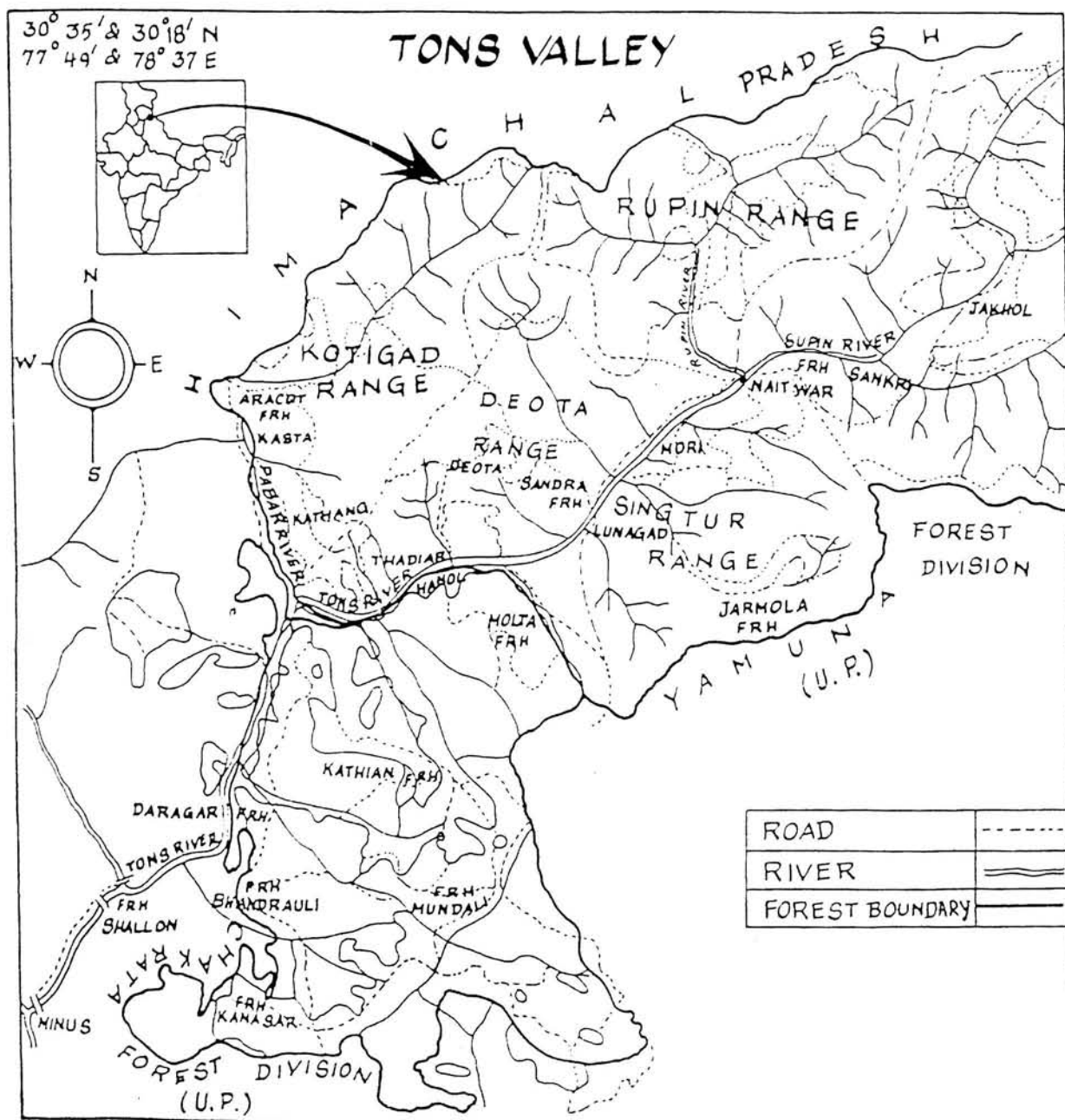


Fig. 1. The location of Tons Valley (Garhwal Himalaya) in India.

interesting and diagnostic features of plants. Due attention were paid to plants of medicinal importance as well as plants of rare occurrence. Phenological data was also collected. Distribution status of each species in terms of abundance or otherwise was also carefully noted. All the collected specimens have been properly processed. Specimens of all plants were critically identified in different herbaria with the help of relevant Floras and available revisions and monographs as well as comparing with earlier authentic specimens. All the specimens were housed in the Herbarium of National Botanical Research Institute, Lucknow (LWG). A detailed and up to-date inventory of all available Angiosperm plants was made. All the species categorised into various phytogeographical groups according to their world distribution.

## VEGETATIONAL DIVERSITY

Owing to great variations in physiography, altitude and climatic conditions, with altitudinal range from 350 m to 2000 m, the Tons valley represents an admixture of tropical, temperate and sub-alpine species. Floristically, the valley is very rich and supports as many as 761 species of phanerogams belonging to 480 genera and 132 families. The vegetation is predominantly of forest communities which are evergreen type, intermixed with the deciduous species, particularly at lower elevations. The vegetational diversity of the area is discussed broadly under three categories: 1. Forest vegetation; 2. Seasonal vegetation; 3. Aquatic and marshy vegetation.

### 1. Forest Vegetation

The forest vegetation of India has been variously classified by several phytogeographers (Hooker, 1904; Clarke, 1898; Chatterjee, 1940, 1962; Puri, 1960). Recently Singh & Singh (1987) classified the forests of the Himalaya into 11 formation types using basic information from the classical descriptions of Champion & Seth (1968). The forest vegetation characteristic of the Uttaranchal has also been discussed by Bir *et al.* (1987). Yet these studies have only covered the major forested areas, whereas vast stretches of the Uttaranchal including Tons Valley have almost remained un-investigated so far.

The forests occur in all aspects and therefore, vary greatly in composition from place to place ranging from river catchments, steep well drained slopes to moist shady ridges and spurs. About 60% area of the Tons Valley is under forests cover. For management purposes, the forest department has divided the forests of the area into 10 ranges namely, Kothigad, Devta, Rupin, Sandra, Singtur, Supin, Bawar, Deoghar, Kanasar, Molta. Each range has been further divided into several blocks. The forests in general are dense and the tree height in canopy usually varies from 15-30 m. There is an admixture of the species of tropical, temperate and sub-alpine in these forests. The deciduous species in these forests shed their leaves usually from January to middle of March. The forests bordering habitations suffer heavily from lopping and felling. Fortunately, considerable area of the valley is still not under serious threat and supports luxuriant growth of dense forests. Based on the vegetation composition, the forests of the area are classified into following major types.

#### I. Pine Forests

These forests are most widely distributed, occupying the lower slopes in all river catchments, chiefly at the altitudes between 750 m to 800 m, occasionally extending above and below this zone. The pine forests go down to ca 600 m where these gradually pass into scrub and thorn forests. Towards upper limit these forests extend upto 2,300 m, confining to hotter exposed sites, like ridges and spurs. In all pine forests *Pinus roxburghii* Sargent, the sole dominant species attains optimum growth in the area, as evident by the occurrence of a tallest pine tree of Asia at 'Kiroli tappar' with the height of 60.65 m and girth of 2.50 m. Generally, the pine forests are almost pure, however, at some places *Pinus roxburghii* Sargent, is associated with trees like *Lyonia ovalifolia* (Wall.) Drude, *Phyllanthus emblica* L., *Ougenia oojeinensis* (Roxb.) Hochr., *Pyrus pashia* Buch.-Ham. ex D. Don, and in drier rocky places with *Euphorbia royleana* Boiss. In shady and moist pockets *Quercus leucotrichophora* A. Camus and *Alnus nepalensis* D. Don, are typical associates of pine, however, in upper zone there is an admixture of *Cedrus deodara* (Roxb. ex Lam.) G. Don and *Pinus wallichiana* Jacks.



There is discontinuous undergrowth of shrubs often so widely scattered that at a very short distance their presence is scarcely observed. Among these are *Rubus ellipticus* Sm., *Rhus parviflora* Roxb., *Coriaria nepalensis* Wall., *Berberis lycium* Royle., *Indigofera cassioides* Rottl. ex DC., and *Woodfordia fruticosa* (L.) Kurz. Most of the species growing in the pine forests are fire resistant, which can withstand frequent fires during summers. With the onset of rainy season these perennate vegetatively.

The ground vegetation is almost negligible, except few species like *Imperata cylindrica* (L.) P. Beauv., *Heteropogon contortus* (L.) P. Beauv. ex. Roem. & Schult., *Anaphalis triplinervis*, (Sims.) Clarke, *Lespedeza gerardiana* Wall. ex Maxim., *Conyza canadensis* Ait., *Reinwardtia indica* Dumort., *Achyranthes aspera* L., and *Artemisia nilagirica* (Clarke) Pamp., are noticeable.

## II. Oak Forests

There are three principal species of oak in the Tons Valley viz. *Banj* (*Quercus leucotrichophora* A. Camus), *Moru* (*Q. dilatata* Lindl.) and *Kharshu* (*Q. semecarpifolia* Sm.) which occupy more or less distinct altitudinal zones. The chief characteristic feature of the oak forests is that the soil is usually moist due to high degree of atmospheric humidity throughout the monsoon period, which results in the rich epiphytic flora of mosses, ferns and lichens. The *Quercus* forests are dominated by *Quercus leucotrichophora* A. Camus.

The *Banj* forests stretch from Mautad village (near Sankri) to Kopdathatch, but sometimes also occur in the moist ravines running down in the *Pinus* zone, where it often reaches as low as an elevation of 1200 m. There are few common tree species associated with *Banj* forests such as *Lyonia ovalifolia* (Wall.) Drude, *Neolitsea umbrosa* (Nees) Gamble, *Ilex dipyrena* Wall., *Cornus capitata* Wall., *Phoebe lanceolata* (Nees) Nees and *Rhododendron arboreum* Sm., which are locally common. With shrubby species, there is altogether a different composition, and the number of common shrubby species are very large. The commonest among them are *Berberis chitria* Lindl., *Desmodium elegans* DC., *Indigofera heterantha* Wall. ex Maxim., *Daphne papyracea* Wall. ex Steud., *Myrsine africana* L., *Spiraea canescens* D. Don, *Prinsepia utilis* Royle, *Elsholtzia fruticosa* (D. Don) Rehder, *Leptodermis lanceolata* Wall., etc. Commonly seen climbers are *Rosa brunonii* Lindl., *Hedera nepalensis* K. Koch., *Smilax aspera* L., *Clematis montana* Buch. – Ham. ex DC. and *Rubus paniculatus* Sm. The epiphytic flora of ferns, lichens and mosses are quite common. The herbaceous elements on rocks and forest floors are composed of *Boehmeria macrophylla* Hornem., *Erigeron acre* L., *Geranium mascatense* Boiss., *Plectranthus rugosus* Wall. ex Benth., *Artemisia nilagirica* (Clarke) Pamp., *Conyza stricta* Willd., and grasses like *Chrysopogon gryllus* (L.) Trin., *Drepenostachyum falcatum* (Nees) Keng. f., *Bromus ramosus* Huds., etc.

The *Moru* (*Q. dilatata* Lindl.) forests are sporadically found between 2000 m to 2500 m elevation and these forests occupy to a large extent, an intermediate zone between the *Quercus leucotrichophora* A. Camus and *Q. semecarpifolia* Sm.. There are usually a few scattered trees of other species competing with *Q. dilatata* Lindl. for dominance, the commonest of which are *Q. leucotrichophora* A. Camus, *Q. semecarpifolia* Sm., *Acer caesium* Wall. ex Brandis, *Ilex dipyrena* Wall., *Symplocos paniculata* (Thunb.) Mir., *Neolitsea umbrosa* (Nees) Gamble, etc., all of these being evergreen species. Many of the shrubs and undershrubs, commonly found as in the *Banj* forests, and also few additional species are *Sarcococca saligna* (D. Don) Muell.-Arg., *Abelia triflora* R. Br. ex Wall., *Deutzia staminea* R. Br. ex Wall., and *Strobilanthes wallichii* Nees. The herbaceous element is composed of

*Leucas lanata* Benth., *Boehmeria macrophylla* Hornem., *Arisaema tortuosum* (Wall.) Schott, *Primula denticulata* Sm. and several ferns.

The *Kharshu* (*Q. semecarpifolia* Sm.) occupies highest zone amongst the oaks, and is found between an elevation from 2200 m to 3500 m over very extensive tracts. *Q. semecarpifolia* Sm. has very few successful competitors like *Abies pindrow* Royle, *Quercus dilatata* Lindl., *Ilex diphyrena* Wall., *Acer caesium* Wall. ex Brandis and *Taxus baccata* ssp. *wallichiana* (Zucc.) Pilger. Some of the common shrubs are *Rosa macrophylla* Lindl., *Cotoneaster obtusa* Wall. ex Lindl., *Wickstroemia canescens* Meisn., *Lonicera quinquelocularis* Hardw., etc. The herbaceous undergrowth is constituted by *Impatiens* spp., *Paeonia emodi* Wall. ex Royle, *Salvia nubicola* Wall. ex Sw., *Scutellaria scandens* Buch.-Ham. ex D. Don, *Ajuga bracteosa* Wall. ex Benth., *Clinopodium umbrosum* (M. Bieb.) Koch., etc. The patches of *Moru* and *Kharshu* forests are seen between Sankri and Kopdathatch.

### III. Deodar Forests

The dominating tree in the deodar forests is *Cedrus deodara* (Roxb. ex Lam.) G. Don, which forms more or less pure formations between 2300 m to 3200 m. A few species like *Pinus wallichiana* Jacks., *Abies pindrow* Royle, *Quercus leucotrichophora* A. Camus, *Q. dilatata* Lindl. are scattered in the deodar forests and the undergrowth is usually scanty consisting of *Lonicera* spp., *Mahonia borealis* Takeda, *Prinsepia utilis* Royle., *Sarcococca saligna* (D. Don) Muell.-Arg., *Spiraea canescens* Buch.-Ham. ex D. Don, *Daphne papyracea* Wall. ex Steud., *Boehmeria macrophylla* Hornem. and *Rosa brunonii* Lindl.

The herbaceous undergrowth is constituted by *Justicia* spp., *Plectranthus* spp., *Polygonum capitatum* Buch.-Ham. ex D. Don., *Anaphalis* spp., *Salvia nubicola* Wall. ex Sw., *Conyza* spp., *Anisomeles indica* (L.) Kuntze and several species of ferns.

### IV. Mixed Forests

The mixed forests being invariably found in the moist depressions upto 1800 m, and seldom occur over a large continuous areas. The tree species are usually deciduous and found mixed, but at some places *Aesculus indica* (Colebr. ex Camb.) Hook, *Acer caesium* Wall. ex Brandis and *Toona serrata* (Royle) M. Roem., dominate the vegetation. Other common species found in these forests are *Cotinus coggygria* Scop., *Celtis australis* L., *Albizia julibrissin* Durazz., *Olea ferruginea* Royle, *Symplocos paniculata* (Thunb.) Miq., *Mallotus philippensis* (Lam.) Muell.-Arg., *Ougeinia oojeinensis* (Roxb.) Hochr., *Viburnum* spp., *Rhus parviflora* Roxb., *Lyonia ovalifolia* (Wall.) Drude, *Hovenia acerba* Lindl., *Phoebe lanceolata* (Nees) Nees, *Cinnamomum tamala* (Buch.-Ham.) Nees & Eberm., *Trema politoria* (Planch.) Blume, *Euonymus tingens* Wall., *Alnus nepalensis* D. Don, *Prinsepia utilis* Royle, *Rubus ellipticus* Sm., etc. At shady depressions on way to Sankri, abundance of *Toona serrata* (Royle) M. Roem. can be observed.

Common climbers are *Cissampelos pariera* L. var. *hirsuta* (Buch.-Ham. ex DC.) Forman, *Vitis lanata* Roxb., *Cryptolepis buchananii* Roem. & Schult., *Rubia manjith* Roxb. ex Flem., *Clematis montana* Buch.-Ham. ex DC., *Pueraria tuberosa* (Roxb. ex Willd.) DC., and *Aspidopteris nutans* var. *wallichii* (Hook) Niedenze. Whereas epiphytes like *Viscum articulatum* Burm. f., *Dendrophthoe falcata* (L. f.) Etting. and species of *Scurulla* and *Dendrobium* are often seen on the trees. The ground floor is well represented with the annuals and perennials. Among the common are *Cyathula tomentosa* (Roth) Miq., *Boehmeria macrophylla* Hornem., *Crotalaria prostrata* Roth, *Euphorbia hirta* L., *Verbascum thapsus* L.,

*Capsella bursa-pastoris* (L.) Medik., *Solanum surattense* L., *S. nigrum* L., *Justicia* spp. and *Ajuga bracteosa* Wall. ex Benth.

## V. Scrub and Thorn Forests

These forests, being a successional community, resulted due to an indiscriminate exploitation of the natural forests by uncontrolled felling and cutting of trees and over-grazing. These forests are found upto 1500 m. Due to frequent grazing and biotic disturbances, regeneration of species are very poor and hence vegetation is very sparse. These forests are characterized by bushy or thorny stunted trees and shrubs with crooked stems. They are usually scattered over the rocky and exposed hill slopes. *Euphorbia royleana* Boiss. forms the pure patches over rocky hill slopes, it seldom occurs in association with other species. The common species of the scrub and thorny forests are *Rhus parviflora* Roxb., *Zanthoxylum armatum* DC., *Murraya koenigii* Spreng., *Rhamnus virgatus* Roxb., *R. procumbens* Edgens., *Vitex negundo* L., *Berberis asiatica* DC., *Prinsepia utilis* Royle, *Abelia triflora* R. Br. ex Wali, *Achyranthes bidentata* Bl., *Plectranthus rugosus* Wall. ex Benth, *Holmskioldia sanguinea* Retz., *Adhatoda zeylanica* Medik., *Elsholtzia fruticosa* (D. Don) Rehr., *Artemisia nilagirica* (Clarke) Pamp., *Eriophorum comosum* (Wall.) Wall. ex Medik., *Flemingia semialata*, etc., and grasses like *Phragmites karka* (Retz.) Trin., *Heteropogon contortus* (L.) P. Beauv. ex Roem. & Schult., *Apluda mutida* L., *Arundinella nepalensis* Trin., etc., being the most common in the scrub forests.

## 2. Seasonal Vegetation

The remarkable feature of the seasonal vegetation is the change that sets in with the advancement of different seasons. Basically, rainy, winter and summer seasons have been distinguished for the study of seasonal vegetation of the valley.

### I. Rainy Season

Following the first fall of rains in the month of May, almost all the dried patches begin to green. The species like *Euphorbia prostrata* Ait, *E. hirta* L., *E. hypericifolia* L., *Cyperus difformis* L., *Phyllanthus fraternus* Webster, *Arthraxon lancifolius* (Trin) Hochst. and *Cynodon dactylon* (L.) Pers. start appearing in the fallow fields and wastelands. About two or three weeks later, a variety of grasses are sprouted up and the whole ground appears like a green carpet. By the end of July and first week of August, several species of other groups are also found growing with the grasses. Some of the common species are: *Achyranthes aspera* L., *Anaphalis* spp., *Aster* spp. *Aeschynomene indica* L., *Origanum vulgare* L., *Alysicarpus* spp., *Cassia occidentalis* L., *C. pumila* Lam., *C. tora* L., *Nasturtium officinale* R.Br., *Kickxia ramosissima* (Wall.) Janchen, *Inula* spp., *Tagetes minuta* L., *Commelina benghalensis* L., *Corchorus aestuans* L., *C. olitorius* L., *Desmodium* spp., *Indigofera* spp., *Elsholtzia pilosa* (Benth.) Benth., *Ajuga bracteosa* Wall. ex Benth., *Portulaca oleracea* L., *Parthenium hysterophorus* L., *Arabidopsis himalaica* (Edgew.) O. E. Schutz., *A. stricta* (Comb.) N. Busch., *Cleome viscosa* L., *Arisaema* spp. The common grasses during rainy season are *Iseilema laxum* Hack., *Pogonatherum paniceum* (Lam.) Hack., *Chrysopogon gryllus* (L.) Trin., *Digitaria* spp., *Eleusine indica* (L.) Gaertn., *Eragrostis* spp., *Setaria pumila* (Poir.) Roem. & Schult. etc. and sedges are *Cyperus* spp., *Eleocharis* spp., *Fimbristylis* spp. and *Eriophorum comosum* (Wall.) Wall. ex Clarke.

During the rainy season, there are optimum temperature and moisture conditions for the plant growth. Most of the species of this season complete their flowering and fruiting by the



end of October or November. The bulk of the rainy season vegetation disappears towards the end of November with the same rapidity as it came up during the rains.

## II. Winter Season

With the commencement of winter season from October to first week of March, temperature goes down and the top soil as well as the atmosphere becomes dry. By this time, most of the species of high altitudes make their appearance. The common among them are: *Anagallis arvensis* L., *Fumaria indica* (Haussk.) Pugsley, *Gnaphalium* spp., *Ajuga bracteosa* Wall., *Anisomeles indica* Ait., *Verbascum thapsus* L., *Cyathula tomentosa* (Roth) Moq., *Capsella bursa-pastoris* (L.) Medik., *Anemone obtusiloba* D. Don, *Thalictrum foliolosum* DC., *Campanula colorata* Wall., *Conyza aegyptiaca* Ait., *C. canadensis* (L.) Cronq., *Cotula anthemoides* L., *Polygonum capitatum* Buch.-Ham ex D. Don, *Rumex dentatus* L., *R. hastatus* D. Don, *Euphorbia thymifolia* L., *Arundinella setosa* Trin., *Echinochloa crusgalli* (L.) P. Beauv., *Setaria pumila* (Poir) Roem. & Schult., and *Themeda arundinacea* (Roxb.) Ridley.

## III. Summer Season

The summer is very short starting from April to May or first week of June. May is the hottest period during summer season. The decreasing moisture content and increasing temperature during April and May result in the disappearance of most of herbaceous species except those found in moist habitats. The seeds of several annual herbs lie dormant in soil throughout the rainy and winter seasons. On the onset of favourable conditions they germinate and occupy lawns, fields and wastelands. Most of the plants in dry habitats show various xerophytic features such as development of thorns, coating of wax, thick cuticle, leathery foliage, woolly, tomentose or stellate hairs. Typical plants in this season are: *Argemone mexicana* L., *Stellaria media* (L.) Vill, *Hypericum urallum* Buch.-Ham. ex D. Don, *H. perforatum* L., *Juncus bufonius*, *Plumbago zeylanica* L., *Boerhavia diffusa* L., *Valeriana hardwickii* Wall., *Sedum rosulatum* Edgew., *Geranium nepalense* Sur., *Blumea mollis* (D. Don) Merr., *B. obliqua* (L.) Druce, *Conyza japonica* (Thunb.) Less. ex DC., *Erigeron bellidioides* (Buch.-Ham. ex D. Don) Benth., *Launea aspleniifolia* (Willd.) Hook. f., *L. procumbens* (Roxb.) Ramayya & Rajagopal, *Alternanthera pungens* Kunth., *Myriactis nepalensis* Less., *Scutellaria* spp., *Saussurea heteromella* (D. Don) Hand-Mazz., *Senecio nudicaulis* Buch.-Ham ex D. Don, *Siegesbeckia orientalis* L., *Taraxacum officinale* Weber, and *Tridax procumbens* L. Besides these, there are a number of grasses and sedges associated with these species such as *Apluda mutica* L., *Pennisetum setosum* (Sw.) L. C. Rich., *P. orientale* L. C. Rich., *Poa nemoralis* L., *P. annua* Retz., *Phalaris minor* Retz., *Carex nubigena* D. Don ex Tillock & Taylor, *C. wallichiana* Spr. and *Kyllinga nemoralis* (J. R. & G. Forst.) Dandy.

## 3. Aquatic and Marshy Vegetation

The aquatic and marshy plants normally grow and develop in water and complete at least a part of their life cycle in water. The common habitats for aquatic and marshland species are rivers, ponds, streams, pools, ditches and depressions along the roads and villages, formed during rainy season. Some of the common species inhabiting such areas are: *Veronica anagallis-aquatica* L., *Houttuniya cordata* Thunb., *Acorus calamus* L., *Spirodela polyrhiza* (L.) Schleid., *Typha domingensis* Pers. L., *Ranunculus sphaerospermus* Boiss. & Blanch, *Mentha arvensis* L., *Nasturtium officinale* R. Br., *Leucanthus peduncularis* (Royle) Wedd., *Paspalum scrobiculatum* L., *Fimbristylis dichotoma* (L.) Vahl, *Cyperus difformis* L., *C. iria* L., and *C. exaltatus* Retz.



The maximum diversity in the aquatic flora is noticed during monsoon season. With the onset of cold weather, coupled with gradual drying up of marshy habitats, a carpet of green cover appears on the dried up muddy depressions and monsoonal ponds. A number of species like *Potentilla supina* L., *Duchesnea indica* (Andr.) Fock, *Vicia sativa* L., *V. hirsuta* (L.) S. F. Gray, *Ranunculus sceleratus* L., *Cotula anthemoides* L., *Galinsoga parviflora* Cav., *Gnaphallium luteo-album* L., *Centella asiatica* (L.) Urban, etc., make their appearance in such habitats. The diversity in aquatic flora is very poor during autumn.

## PHYTOGEOGRAPHICAL AFFINITIES OF THE FLORA OF TONS VALLEY

The Himalaya, a very young system of high mountains, situated between Indian Peninsula and Central Asia, connect mountains of near East and Central Asia with those of East Asia. From phytogeographical point view it is a transition zone between Palaeotropic and Holarctic Kingdoms. The phytogeographical affinities of the Himalayan flora have been discussed by several workers (Meher-Homji, 1973; Gupta, 1964, 1982; Hara, 1966; Meusel, 1971; Rau, 1974; Rao, 1974 and Rao, 1994). With rising of the Himalaya the native Gondwana flora and fauna were not only greatly modified but also came into contact with those of Eurasia in the north and to a limited extent with northern Africa. The North Myanmar-Assam region in the north-east brought the Indian land mass into direct land connection with South China, Tibet, Vietnam and Malaya forming a meeting place of the floras of these countries. The Himalayan flora also came into contact with those of Arctic region through east and west margins of Central Asiatic Corridor. This corridor formed an important pass for the migration of the flora between arctic regions and the Himalaya as well as East Tibet and South China (Ohba, 1988). Kitamura (1955) explained the floristic connection between central and eastern Himalaya and the Sino-Japanese region. Further, the Himalayan region forms a part of holarctic region and its ranges acted as a bridge between Sino-Japanese and Irano-Turanian regions, the two important centres of holarctic and the extratropical Eurasian flora (Puri *et al.*, 1983).

The present day Himalayan flora has close affinities to those of north-western and western China in the east while the Mediterranean elements are more numerous westward.

Being situated in the Himalayan region, the Tons Valley shares a large number of species from surrounding regions. Based on geographical distribution of species, the flora of Tons Valley can be categorised into 12 phytogeographical groups (Table 1, Fig. 2).

Table 1. Analysis of the floral elements of Tons Valley.

| S. No. | Floral elements                              | No. of species | % of species |
|--------|--|----------------|--------------|
| 1      | Indian                                       | 203            | 26.69        |
| 2      | Indian wides                                 | 83             | 10.91        |
| 3      | Sino-Japanese                                | 49             | 6.44         |
| 4      | Indo-Malayan                                 | 110            | 14.59        |
| 5      | African-Asiatic-Australian                   | 75             | 9.86         |
| 6      | Euro-Siberian                                | 53             | 6.97         |
| 7      | Mediterranean                                | 28             | 3.68         |
| 8      | Western and Central Asiatic (Irano-Turanian) | 25             | 3.29         |
| 9      | Palaeotropical                               | 62             | 8.15         |
| 10     | Pantropical                                  | 41             | 5.38         |
| 11     | Neotropical                                  | 17             | 2.23         |
| 12     | Cosmopolitan                                 | 15             | 1.97         |

### 1. Indian species

This group of species forms most dominant element in the flora of the area, constituting 26.69% (203 species) of total species. Members of this group are mostly confined to the Himalaya, however, some of the species have extended distribution to their mountainous region of southern India. Among the common examples are *Anemone obtusiloba* D. Don, *Delphinium denudatum* Wall. ex Hook. f. & Thoms., *Prinsepia utilis* Royle, *Clematis buchananiana* DC., *Spiraea canescens* D. Don, *Cotoneaster mocrophyllous* Wall. ex Lindl., *Pyracantha crenulata* (D. Don) M. Roem., *Daphne papyracea* Wall. ex Steud., *Rhododendron arboreum* Sm., *Viburnum mullaha* Buch.-Ham. ex D. Don, *Rubus ellipticus* Sm., *Eriophorum comosum* (Wall.) Wall. ex Nees, *Abies pindrow* Royle, *Polygonum amplexicale* D. Don and *Phlomis bracteosa* Royle ex Benth.

### 2. India wides

This group includes those species which are common to India, Indo-Malayan Sino-Japanese and Western and Central Asiatic regions. The percentage of such species in the flora is 10.92% (83 species) the common among them are *Lawsonia inermis* L., *Impatiens balsamina* L., *Hypericum uralum* Buch.-Ham. ex D. Don, *Coriaria nepalensis* Wall., *Desmodium elegans* DC., *Bupleurum falcatum* L., *Hedera nepalensis* K. Koch., *Myriactis nepalensis* Less., *Fagopyrum debotrys* (D. Don) Hara, *Viola biflora* L. and *Mallotus philippensis* (Lam.) Muell.-Arg.

### 3. Indo – Malayan species

This group forms second dominant element of the flora and constitutes 14.59% (110 species) of the total flora. For example, *Dendrophoe falcata* (L.f.) Etting, *Viscum articulatum* Burm. f., *Toona ciliata* M. Roem., *Clematis gouriana* Roxb. ex DC., *Tinospora cordifolia* (Willd.) Miers., *Deeringia amaranthoides* (Lam.) Merr., *Murraya paniculata* (L.) Jack., *Duchesnea indica* (Andr.) Fock., *Clerodendrum viscosum* Vent., *Ardisia solanacea* Roxb., *Bauhinia purpurea* L., *Striga euphrasioides* (Vahl) Benth., and *Adhatoda zeylanica* Medik.

### 4. African – Asiatic – Australian species

The representatives of this group are distributed throughout the tropical zone of Asia, Africa and Australia (Old World Tropics) constituting 9.86% (75 species) of the total flora. Such species are *Cocculus hirsutus* (L.) Diels, *Hibiscus lobatus* (Murr.) Kuntze, *Woodfordia fruticosa* (L.) Kurz., *Ipomoea pes-tigridis* L. *Justicia simplex* D. Don, *Euphorbia thymifolia* L., *Vitex negundo* L., *Salvia plebeia* R. Br., *Tribulus terrestris* L. and *Mallotus philippensis* (Lam.) Muell.-Arg.

### 5. Sino – Japanese species

This group constitutes 6.44% (49 species) of the total flora, of which the representative species are: *Artemisia japonica* Thunb., *Symplocos paniculata* (Thunb.) Miq., *Calotropis gigantea* (L.) R. Br., *Jasminum dispernum* Wall. ex Roxb., *Taxus baccata* L. ssp. *wallichiana* (Zucc.) Pilger, *Deutzia compacta* Craib., *Zanthoxylum armatum* DC., *Leucas lanata* Benth., *Plectranthus japonicus* (Burm. f.) Koidz., *Paris polyphylla* Sm., and *Elaeagnus parvifolia* Wall. ex Royle.

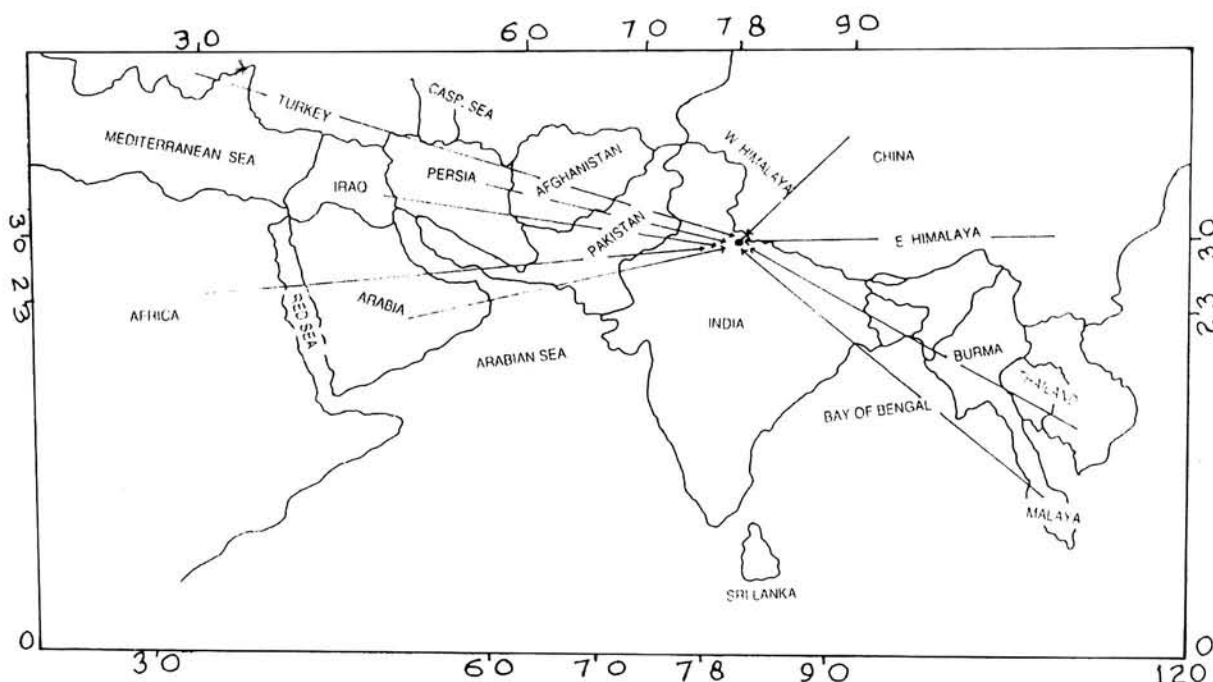


Fig. 2. Map showing possible route of migration of flora from neighbouring countries towards Tons Valley.

### 6. Euro-Siberian species

Several species from Europe, Russia, whole Siberia have found their way to the Tons Valley and constitute 6.97% (53 species) of the total flora. The typical among them are *Paeonia emodi* Wall.ex Royle, *Ephedra gerardiana* Wall.ex Stapf., *Polygonatum verticillatum* (L.) All., *Verbascum thapsus* L., *Origanum vulgare* L., *Taraxacum officinale* Weber, *Ranunculus sceleratus* L., *Oenothera rosea* Ait., *Eruca sativa* Mill., *Malva sylvestris* L., *Galium aparine* L., *Antirrhinum orontium* L., *Vicia hirsuta* (L.) S. F.Gray and *V. sativa* L.

### 7. Western and Central Asiatic species

This group is poorly represented and constituting 3.29% (25 species) of the total flora. Some of these species are: *Pupalia lappacea* (L.) Juss., *Geranium mascatense* Boiss., *Trichodesma indicum* (L.) R. Br., *Albizia lebbeck* (L.) Benth., *Evolvulus alsinoides* L., *Solanum incanum* L., *Micromeria bifloa* (Buch.-Ham. ex D. Don) Benth., and *Cannabis sativa* L.

### 8. Mediterranean species

Some species of Mediterranean region have also found their way to the area, constituting only 3.68% (28 species) of the total flora. The typical among them are: *Continus coggygia* Scop, *Punica granatum* L., *Arundo donax* L., *Phalaris minor* Retz., *Eragrostis minor* Host., *Saussurea heteromella* (D.Don) Hand-Mazz., *Celtis australis* L., *Anagallis arvensis* L., *Cedrus deodara* (Roxb. ex Lam.) D. Don, *Verbena officinalis* L., *Barleria cristata* L. and *Ficus hispida* L.

### 9. Palaeotropical species

The species included in this group are largely distributed in African continent and several such species have also extended their distribution to Indian region. As many as 8.15% (62

species) are palaeotropical in the flora of Tons Valley. For example, *Abelmoschus moschatus* Medik., *Borreria pusilla* (Wall.) DC., *Diplocyclos palmatus* (L.) Jeffrey, *Ipomoea eriocarpa* R.Br., *Indigofera linifolia* (L. f.) Retz., *Saccharum spontaneum* L., *Imperata cylindrica* (L.) P. Beauv. *Heteropogon contortus* (L.) P. Beauv., ex Roem., *Setaria pumila* (Poir.) Roem. & Schult., *Cyperus iria* L., *Asparagus racemosus* Willd., *Blumea mollis* (D. Don) Merr. and *Vernonia cinerea* (L.) Less.

#### 10. Pantropical species

This group includes those species which are common in three tropical sectors of the world, namely America, Africa and Asia- Australia. Some common representative of this group are : *Abrus precatorius* L., *Abutilon indicum* (L.) Sweet, *Ageratum conyzoides* L., *Alternanthera sessilis* (L.) D. C., *Boerhavia diffusa* L., *Caesalpinia bonduc* (L.) Roxb., *Cassia tora* L., *Desmodium triflorum* (L.) D. C., *Dodonaea viscosa* (L.) Jacq. *Eclipta prostrata* (L.) L., *Eleusine indica* (L.) Gaertn., *Galinsoga parviflora* Cav., *Momordica charantia* L., *Mucuna pruriens* (L.) D. C., *Sida cordifolia* L., *S. rhombifolia* L., *Tridax procumbens* L. and *Urena lobata* L. The pantropical species constitute 5.38% (41 species) of the total flora.

#### 11. Neotropical species

This category comprises species like *Martynia annua* L., *Opuntia stricta* (Haw.) Haw., *Argemone mexicana* L., *Corchorus aestuans* L., *Tagetes minuta* L., *Parthenium hysterophorus* L., *Physalis minima* L., *Jatropha curcas* L., *Lantana camara* L., *Passiflora edulis* Sims., *Cestrum nocturnum* L. and *Nicandra physaloides* (L.) Gaertn. This group of species constitutes only 2.23% (17 species) of the total flora.

#### 12. Cosmopolitan species

This group comprises those species which are world-wide in distribution and occur in both tropical and temperate parts of the world, constituting 1.97% (15 species) of the total flora. For example, *Portulaca oleracea* L., *Oxalis corniculata* L., *Solanum nigrum* L., *Spirodela polyrhiza* (L.) Schleid., *Cleome viscosa* L., *Siegesbeckia orientalis* L., *Veronica anagallis-aquatica* L., *Amaranthus viridis* L. and *Datura stramonium* L.

### RESULTS AND DISCUSSION

From the above phytogeographical analysis, it is observed that the flora of Tons Valley is dominated by Indian and Indo-Malayan species with fairly well representation of 'wides', African - Asiatic - Australian, Palaeotropical and Euro - Siberian species. Other important elements constituting the flora are Sino-Japanese and Pantropical. Sino - Japanese region is the richest of the whole temperate zone (Good, 1964), however, due to high Himalayan barriers many species could not been able to penetrate from this zone. The Sino - Japanese species are mostly confined to the higher reaches of Tons Valley. Indo-Malayan species are denizens of humid climate and their occurrence is as high as 53% in the humid regions like that of Bengal. Its relatively poor representation in the area can be explained by the fact that climate of Tons Valley in general is not humid. However, at places along the Tons River, the climate is more or less semi-arid type and there are found Western and Central Asiatic flora.

A number of Euro-Siberian species are also found in the area. Most of these species are



not exclusively European but extend most of the Asia and much farther. According to Puri *et al.* (1983) as many as 570 European species form a Part of Indian flora and an equal number are believed to have mid eastern affinities. As such there is blending of European form with proper Himalayan flora in western sector, just as to eastward we find Chinese and Malayan flora, intermixed with it.

The probable migration of eastern and western elements in the Tons Valley is through the Himalaya itself. It is very likely that some of the eastern (Indo – Malayan) species might have been introduced through the sub-Himalayan tract. A major part of eastern element, however seems to have find their way through eastern Himalaya. The species of western regions which are mainly European and Afro-Asiatic must have migrated via Central Asia, Iran, Afghanistan and Pakistan. It is also observed that species common with Neotropical, Mediterranean, Western and Central Asiatic regions as well as Pleuri-regional (Cosmopolitan) species are rather poorly represented in the flora. The small number of tropical and subtropical species may be explained on the basis that only a small area fall under this zone.

Thus the flora of Tons Valley has affinities with those of the flora of the surrounding regions. Contaminants of food grains and other economic plants, importation of seeds and propagules by plant introduction agencies, botanic gardens and general migration of people seem to be main sources of introduction of alien plants to the area.

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### LITERATURE CITED

- Bir, S. S., Y. S. Bedi, B. S. Gill and V. K. Singhal. 1987. Forest Vegetation Characteristics of the Garhwal Himalaya, Bull. Bot. Surv. India **29**: 292-318.
- Champion, H. G. and S. K. Seth. 1968. A Revised Survey of Forest types of India. Delhi. 653 pp.
- Chatterjee, D. 1940. Studies on the endemic flora of India and Burma. J. Roy. Asiat. Soc. Bengal. (N. S.) **5**: 19-67.
- Chatterjee, D. 1962. Floristic patterns of Indian Vegetation In: Maheshwari, P., B. M. Johri, & I. K. Vasil (eds.). Proc. Summer School in Botany, Darjeeling. pp. 32-42.
- Clarke, C. B. 1898. Sub – areas of British India, illustrated by the detailed distribution of the Cyperaceae in that Empire. J. Linn. Soc. Bot. London **34**: 1-146.
- Good, R. 1964. The Geography of the Flowering Plants. 3<sup>rd</sup> ed. Longman Group Ltd., London. 518 pp.
- Gupta, R. K. 1964. The bio-climatic types of the Western Himalaya and their analogous types towards the mountain chains of the Alps and Pyrenees. Indian For. **90**: 557-577.
- Gupta, R. K. 1982. Mediterranean influence in the flora of the Western Himalaya. In: Paliwal, G. S. (ed.). The Vegetational Wealth of the Himalayas. Puja Publishers, Delhi, pp. 175-193.
- Hara, H. (ed.). 1966. The Flora of Eastern Himalaya. University of Tokyo, Japan.

- Hooker, J. D. 1904. A Sketch of the Flora of British India. London. 55 pp.
- Kitamura, S. 1955. Flowering Plants and Ferns. In: Kihara, H. (ed.). Fauna and Flora of Nepal Himalaya. 1: 73-77. Kyoto.
- Mani, M. S. 1978. Ecology and Phytogeography of High Altitude Plants of the Northwest Himalaya. Oxford and I. B. H. Publishing Co., New Delhi. 205 pp.
- Meher – Homji, V. M. 1973. Phytogeography of the Indian subcontinent. In: Misra, K. C. (ed.). Progress of Plant Ecology in India, pp. 9-33.
- Meusel, H. 1971. Mediterranean elements in the flora and vegetation of the west Himalayas. In: Davis, P. H., P. C. Harper and I. C. Hedge (eds.), Plant life of South – West Africa, pp. 53-72.
- Ohba, H. 1988. The alpine flora of the Nepal Himalayas: Introductory note, In: Ohba, H. and S. B. Malla (eds.). The Himalayan Plants. Vol. 1, Bull No. 31. The University of Tokyo, Japan.
- Puri, G. S. 1960. Indian Forest Ecology. Vols. 1-2. Oxford and I. B. H. Publishing Co., New Delhi. 710 pp.
- Puri, G. S., R. K. Gupta, V. M. Meher – Homji, and S. Puri. 1983. Forest Ecology. Vol. 1 2<sup>nd</sup> ed., Oxford and I. B. H. Publishing Co. New Delhi.
- Rao, A. S. 1974. The Vegetation and Phytogeography of Assam – Burma. In: Mani, M. S. (ed.). Ecology and Biogeography in India, pp. 204-246. Junk. The Hague.
- Rao, R. R. 1994. Biodiversity in India. Bishen Singh, Mahendra Pal Singh, Dehra Dun. 315 pp.
- Rau, M. A. 1974. Vegetation and Phytogeography of Himalaya. In: Mani, M. S. (ed.). Ecology and Biogeography in India. pp. 247-280 Junk. The Hague.
- Rodgers, W. A. and H. S. Pawar. 1988. Planning a Wildlife Protected Area Network in India. Vols. 1-2. Wildlife Institute of India, Dehra Dun (Mimeographed).
- Singh, J. S. and S. P Singh. 1987. Forest Vegetation of the Himalaya. Bot. Review 53: 80-192.

## 印度 Garhwal 喜馬拉雅之 Tons 山谷的植生歧異度 尤其是有關植物地理的親緣性

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### 摘 要

1994-98 年間，Garhwal 喜馬拉雅之 Tons 山谷的植生歧異度及植物誌曾經被深入研究，整體而言，在 Tons 山谷植物誌可鑑定 132 科，480 屬，共 761 種之顯花植物，植生以常綠及落葉樹種之混淆林森林社會具優勢。分析植物地理之親緣性，Tons 山谷植物誌與鄰近地區具有親緣性。植物誌之主要份子為印度、印度—馬來西亞、非洲—亞洲—澳大利亞及舊熱帶省者，歐洲—西伯利亞及中日份子亦出現。

關鍵詞：Tons 山谷、Garhwal 喜馬拉雅、植生歧異度、植物誌。

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