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

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(Manuscript received 26 June, 2001; accepted 2 August, 2001)

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 phytochoric 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 Ninkant, 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 form 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) in 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
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 Uttarakhand has also been discussed by Bir et al. (1987). Yet these studies have only covered the major forested areas, whereas vast stretches of the Uttarakhand 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 in to 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 Kopdatahatch, but sometimes also occur in the moist ravines running down in the Pimus 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 macowanii Boiss., Plectranthus rugosus Wall. ex Benth., Artemisia nilagirica (Clarke) Pamp., Conyza stricta Willd., and grasses like Chrysopogon gryllus (L.) Trin., Drepennostachyum 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., Symlocos 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 dipyrena 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 Meissn., Loniceria quinquelocularis Hardw., etc. The herbaceous undergrowth is constituted by Impatiens ssp., 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 Kopadhatth.

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 ssp., 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 ssp., Plectranthus ssp., Polygonum capitatum Buch.-Ham. ex D. Don., Anaphalis ssp., Salvia nubicola Wall. ex Sw., Conyza ssp., 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 (Coelebr. 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 ooeinensis (Roxb.) Hochr., Viburnum ssp., 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., Anlus 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 falculata (L. f.) Etting. and species of Scourula 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., Verbasum thapsus L.,

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) Rehder., 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., Apulada 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 dry 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 hisalica (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 panicum (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., Fimbristyliis 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., Echinocloa 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., Boehravia diffusa L., Valeriana hardwickii Wall., Sedum rosulatum Edgew., Geranium nepalense Sur., Blumea mollis (D. Don) Merr., B. oblata (L.) Druce, Conyza japonica (Thunb.) Less. ex DC., Erigeron bellidoides (Buch.-Ham. ex D. Don) Bentham, Launaea aspleniiifolia (Willd.) Hook. f., L. procumbens (Roxb.) Ramayya & Rajagopal, Alternanthera pungens Kunth., Myractis 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 rubigena 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., Houttuinya 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–Hornjii, 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 Eurasion 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).

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<tr>
<td>11</td>
<td>Neotropical</td>
<td>17</td>
<td>2.23</td>
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<tr>
<td>12</td>
<td>Cosmopolitan</td>
<td>15</td>
<td>1.97</td>
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</table>
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 macrophyllous 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 amplexicole 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., Impateins balsamina L., Hypericum uralum Buch.-Ham. ex D. Don, Coriaria nepalensis Wall., Desmodium elegans DC., Bupleurum falcatum L., Hedera nepalensis K. Koch., Myriacis 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 euphrasiioides (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 dispermum Wall. ex Roxb., Taxus baccata L. ssp. wallichiana (Zucc.) Pilger, Deutzia compacta Craib., Zanthoxyllum armatum DC., Leucas lanata Benth., Plectranthus japonicus (Burm. f.) Koidz., Paris polyphylla Sm., and Elaeagnus parvifolia Wall. ex Royle.
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 \textit{Paeonia emodi} Wall.ex Royle, \textit{Ephedra gerardiana} Wall.ex Stapf., \textit{Polygonatum verticillatum} (L.) All., \textit{Verbascum thapsus} L., \textit{Origanum vulgare} L., \textit{Taraxacum officinale} Weber, \textit{Ranunculus sceleratus} L., \textit{Oenothera rosea} Ait., \textit{Eruca sativa} Mill., \textit{Malva sylvestris} L., \textit{Galium aparine} L., \textit{Antirrhinum orontium} L., \textit{Vicia hirsuta} (L.) S.F.Gray and \textit{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: \textit{Pupalia lappacea} (L.) Juss., \textit{Geranium mascatense} Boiss., \textit{Trichodesma indicum} (L.) R. Br., \textit{Albizia lebbeck} (L.) Benth., \textit{Evolvulus alsinoides} L., \textit{Solanum incanum} L., \textit{Micromeria biflora} (Buch.-Ham. ex D. Don) Benth., and \textit{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: \textit{Cotinus coggygria} Scop, \textit{Punica granatum} L., \textit{Arundo donax} L., \textit{Phalaris minor} Retz., \textit{Eragrostis minor} Host., \textit{Saussurea heteromella} (D.Don) Hand-Mazz., \textit{Celtis australis} L., \textit{Anagallis arvensis} L., \textit{Cedrus deodara} (Roxb. ex Lam.) D. Don, \textit{Verbena officinalis} L., \textit{Barleria cristata} L. and \textit{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

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., Siesgesbeckia 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.

ACKNOWLEDGEMENTS

The authors are thankful to the Director, National Botanical Research Institute, Lucknow for facilities.

LITERATURE CITED

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

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(收稿日期：2001 年 6 月 26 日；接受日期：2001 年 8 月 2 日)

摘要

1994-98 年間，Garhwal 喜馬拉雅之 Tons 山谷的植生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，植生異度，植物誌。

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