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PHYTOGEOGRAPHIC CLASSIFICATION USING MULTIVARIATE APPROACH; A CASE STUDY FROM THE JAMBIL VALLEY SWAT, PAKISTAN

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Abstract

Phytogeography is concerned with the past and present distribution of vegetation on the earth surface. The distribution of plants is neither even nor random on earth surface but follow a definite geographic pattern. The present study was aimed to find out phytogeographic pattern of plants distribution and subsequent classification of plant species of the Jambil Valley, District Swat Pakistan using multivariate statistic techniques. Sampling of vegetation was done using quadrats of 1 × 1 m^2 for herbs, 5 × 5 m^2 for shrubs and 10 × 10 m^2 for trees. The data were analyzed by PCORD v. 5 and CANOCO 4.5. The studies revealed that the vegetation of Jambil valley belongs to eighteen different phytogeographic elements. The highest percentage of elements (19.4%) belongs to Western-Himalayan region, followed by Cosmopolitan (13.9%), Eurasian (10.6%), Irano-turanian (10%), Paleotropical (9.4%), Eastern Asiatic and Mediterranean (6.7% each), Euro-Siberian (5.6%), Holoarctic (3.9%), Pantropical (3.3%), Sub-cosmopolitan (2.8%), Saharo-Arabian (2.2%), Eastern-Himalayan (1.7%), Central Asian and Neotropical (1.1% each), Pantemperate, Australian and Sudano-Zambezian (0.6% each). CANOCO correlated phytogeographical data with environmental factors, which showed significant effect of environmental variables on phytogeographical patterns. It is clear from our results that higher pH, electrical conductivity, moderate sand and silt, phosphorous and nitrogen have great impact on distribution of phytogeographical elements. The Western Himalayan elements having narrow geographic range require immediate attention and conservation efforts.

Key words: Floristic elements; Multivariate analysis; Phytogeography; Jambil Valley; Western Himalaya.

Introduction

Pattern of plant species distribution shows a clear reflection of environmental factors. Understanding plant distribution patterns and the underlying ecological factors is an important step for the management and conservation of plant ecosystems. Plant species are not evenly distributed nor randomly on earth's surface, but they are distributed in definite geographic units, governed so by the physical climate and environment (Qian, 2001; Teixeira *et al*., 2017). Biotic and abiotic factors both affect the distribution of species, such as topography, soil, tectonic plate's movement, geology, uplifting of mountains, climate change, species migration and evolution (Mota *et al.*, 2017; Souza *et al*., 2017). Phytogeography is not only important in tracing the origination, migration and speciation of plants. But it's also important in developing plans for conservation and extremely valuable in tracing the origin of particular flora, in perception of ecological nature of an area and its plant wealth. It is utmost important to find distribution range of species and their evolution and diversification (Harris *et al*., 2012; Abbas *et al*., 2017). A best and useful approach for characterization of plants of an area and knowing its biogeographical affinities with flora of other regions is to classify its component taxa in to phytogeographic elements (Qian *et al*., 2006; Pourrezaei *et al*., 2017). Hooker (1904) recognized two provinces from Pakistan and adjoining areas. Takhtajan (1986) recognized five floristic provinces in Pakistan. These are South Iranian, Sindian, North Baluchistan, Tibetan and Western Himalayan provinces. Phytogeographically the valley is categorized as a representative of Sino-Japanese region (Ali & Qaiser, 1986), while according to (Takhtajan, 1986) classification the valley falls in Western Himalayan province. The western Himalayan province is richer in endemic taxa than other phytogeographic provinces of Pakistan. This province represents the transition between the eastern Asiatic and Mediterranean floras. Himalayan vegetation has attracted the attention of many researchers due to its unique and particular position in world vegetation patterns. The boundary between the Holarctic and Paleotropic kingdoms runs along the southern slopes of Himalayan ranges. The elements of these two realms show gradation in distribution form the humid and wet Eastern, while dry western Himalayan due to major climate patterns. The phytogeographical system of Takhtajan was followed in present research work. Floristic patterns and methods have interested phylogeographers for centuries and the field has been studied in several ways, due to this reason by examining the phytogeographical distribution of single species, or plant communities (Preston & Hill, 1997; Ojeda *et al*., 1998; Ahmad *et al*., 2016). The interpretation and description of distributional data for numerous species at biogeographical scales signify a holistic approach to biogeography that can provide hypothesis to be tested through further observations, and by experimental, deductive and historical studies (Birks, 1976). Phytogeographical classifications and ordinations have been advanced by the introduction of software like TWINSPAN, CANOCO (Ter Braak & Smilauer, 2002) and PC-ORD (McCune & Mefford, 1999; Grandin, 2006) in field of quantitative ecology. Beside this it also overcome human labors in data assessment in a convenient means (Gauch, 2010). Canonical Correspondence Analysis (CCA), Detrended Correspondence Analysis (DCA), Indicator Species Analysis (ISA) (Khan *et al*., 2017; Iqbal *et al*., 2018) and Principal Components Analysis (PCA) are widely used to analyze plant communities, ecological gradients, data summarization, indicator species and so on (Ter Braak, 1987; Dufrêne &

Legendre, 1997; Ahmad *et al.*, 2019). Multivariate statistical techniques summarize data by bringing identical samples and species close together while unlike are separated apart (Shaukat & Siddiqui, 2005). Canonical Correspondence Analysis is most widely used technique for direct ordination gradient exploration and Detrended correspondence Analysis used for indirect analysis (Dufrêne & Legendre, 1997, McCune *et al*., 2002). The aims of the current research were (1) to make a complete updated floristic checklist of the valley; (2) to classify vegetation phytogeographically. Here we present a phytogeographical division for Jambil valley Swat, Pakistan for the first time using a multivariate approach.

Materials and Methods

Vegetation sampling techniques: Regular field trips were conducted throughout the Jambil Valley District Swat during the year 2017 in different localities to study the phytogeographical distribution. River Jambil was chosen as base line to explore the vegetation of study area in a systematic way. A total of four stations were selected that included Jambil, Chinar, Parona, and Kalel. Two transects were laid at each station. The length of each transect was approximately two kilometer. For vegetation analysis quadrat method was used. Quadrat size varied according to habit of the plants i.e., 1×1 m^2, 5×5 m^2 10×10 m^2 for herbs, shrubs and trees respectively (Bano *et al*., 2018).

Data gathering: The plants were studied in their natural habitats, geographic coordinates; altitudes, and phytosociological attributes were recorded for each species. The collected plants were dried and poisoned with ethanol and mercuric chloride and preserved. Plants were identified with the help of available literature (Nasir & Ali, 1971). Moreover, distribution information of plants was extracted from Flora of Pakistan, Flora of Pakistan Tropics and herbarium of Pakistan. Most of the information has been taken from detail published literature of (Siadati *et al*., 2010; López-Pujol *et al*., 2006; Ullah *et al*., 2015). The classification and description of floristic elements are based on (Takhtajan, 1986). A total of 18 floristic elements were identified as described in Table 1.

Data analyses: To access the linkage between plant species and different environmental variables the data were analyzed statistically. The data of four stations and eight transects (228 Quadrats) were prepared in Microsoft Excel sheet 2010. Presence and absence (1, 0) data were analyzed using Two-way Cluster Analysis (TWCA) of PC-ORD v.5 Software (Lepš & Šmilauer, 2003) for geographical elements. The software CANOCO version 4.5 (Ter Braak & Barendregt, 1986, Ter Braak & Prentice, 1988) was employed for Canonical Correspondence Analysis (CCA) and Detrended Correspondence Analysis (DCA) to find out the influence of environmental gradients on species composition (Shaukat & Siddiqui, 2005).

Table 1. Definitions and distribution pattern of global floristic elements.

S. No.	Floristic elements	Definitions
1.	Cosmopolitan	Taxa which are distributed all over the world.
2.	Sub Cosmopolitan	Species which are present all over the world except Australia and south America.
3.	Pantropical	Taxa present in Tropical and sub-tropical areas of the world but some may also spread to temperate regions.
4.	Paleo tropical	Taxa which are distributed in old tropics i.e., tropics of Asia, Australia and Africa.
5.	Western Himalayan	Taxa occur in NW Himalayas, but occasionally some may also extend Northwards to Afghanistan eastward to eastern Himalayas.
6.	Holarctic	Plants usually distributed in cold temperate regions of North America, Asia and Europe.
7.	Eurasian	Elements mostly distributed across the temperate zone of Asia and Europe, but some may also be extend to the northern parts of Africa.
8.	Irano-Turanian	Center of diversity of Irano- Turanian is Western Asia: Anatolia, Mesopotamia, and Irano-Armenia and extend up to Tien-Shan mountains.
9.	Central Asian	Taxa distributed in temperate regions of central Asia, Tien-Shan, Caucasus, Siberia and western Asia but some may also extend to subtropical regions.
10.	Mediterranean	Elements which are distributed Across the Mediterranean regions in Western Asia, North Africa and southern Europe.
11.	Eastern Asiatic	Taxa distributed in eastern Asia including China, Korean Peninsula, Japan, Taiwan, Thailand, Philippines and the pacific islands.
12.	Saharo Arabian	Elements distributed in the entire extra tropical parts of Sahara, Arabian Peninsula and Palestine.
13.	Sodono Zambezian	Taxa present in eastern tropical Africa, tropical parts of Arabian Peninsula and tropical deserts of Iran and Pakistan.
14.	Euro Siberian	Elements distributed in North and South temperate zone and alpine regions of tropics.
15.	Eastern Himalayan	Taxa distributed in China, Western Nepal, Kashmir and Afghanistan.
16.	Neo Tropical	Elements distributed in Neotropical region, tropics of Florida, and entire central America.
17.	Pan-temperate	Found in temperate regions of both the hemispheres.
18.	Australian	Elements endemic to Australia and may extend to the surrounding Pacific islands

Results

Phytogeographic Classification: A total of 180 plant species were collected and classified into 18 different Phytogeographic elements (Table 2 & Fig. 1). The highest percentage of elements 19.4% (35 species) belonging to Western Himalayan category. The second largest proportion belonging to Cosmopolitan elements i.e., 13.9% (25 species), Eurasian 10.6% (19) and Irano Turanian elements represent 10.0 % (18) plants. Furthermore, there are 9.4% (17) species of the Paleo Tropical and 6.7% (12) plant species each of Mediterranean and Eastern Asiatic origin in the present studied Valley. Euro Siberian elements represent 5.6% (10), while Holoarctic 3.9% (7) and Pantropical 3.3% (6). The remaining floristic elements are represented by lower percentages i.e., Sub-cosmopolitan 2.8%, Saharo Arabian 2.2%, Eastern Himalayan 1.7%, Central Asian and Neotropical 1.1% each, and Pantropical, Australian, and Sudano-Zambezian regions, each have 0.6% elements (Fig. 1).

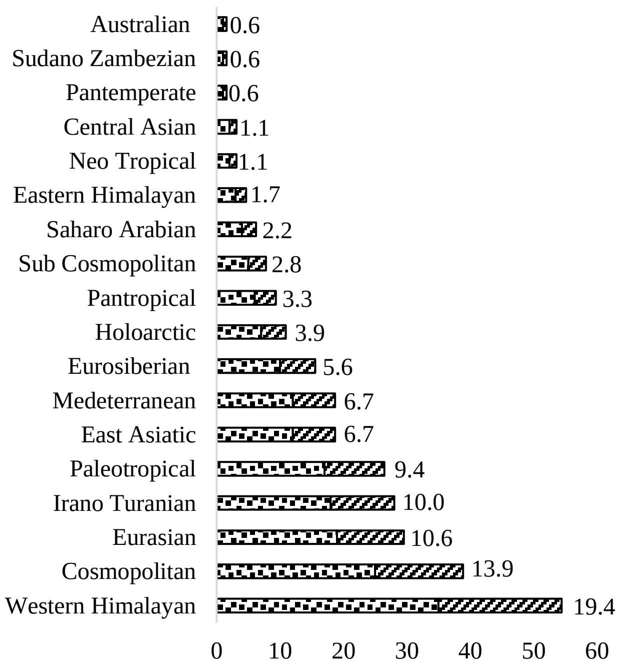

Fig. 1. Percentage of various floristic elements of the Jambil Valley Swat, Pakistan.

Two way cluster analysis (TWCA): Results of Two Way Cluster Analysis comprehend the presence or absence of phytogeographical elements in Jambil valley. The black dot represent the presence while, the white dot showed the absence of phytogeographical element in the region (Table 2 & Fig. 2).

CODES: Paleo Tropical; Paleotro, Eastern Asiatic; East Asia, Western Himalayan; West Him, Mediterranean; Medet, Eurasian; Eurasi, Holarctic; Holoarc, Euro Siberian; EuroSib, Irano Turanian; Iran Tur, Cosmopolitan; Cosmo, Neo Tropical; Neo Trop, Sub Cosmopolitan; S. Cosmo, Saharo Arabian; Sah Ara, Paleo Temperate; Paleo temp, Pantropical; Pantrop, Sudano Zambezian; Sudan Zamb, Eastern Himalayan; East Him, Central Asiatic; Cent Asia, NW; Northwest, SW; Southwest.

CCA bi-plot for Phytogeographic elements: Canonical correspondence analysis (CCA) of floristic elements showed a significant effect (p<0.002) in relation to stations and edaphic variables (Table 3). The first axis showed that dominant elements were Cosmopolitan, Western Himalayan and Irano Turanian with higher grazing pressure on vegetation. The 2nd axis revealed Cosmopolitan, Western Himalayan, Irano Turanian and Mediterranean elements with greater quantity of silt and sand. The 3rd axis corresponds to dominant floristic elements i.e., Cosmopolitan, Mediterranean and Western Himalayan with higher amount of calcium carbonate and organic matter soil condition. The dominant elements of 4th axis were Western Himalayan, Irano Turanian and Mediterranean with higher electrical conductivity, pH and clay. Mostly the study area was dominated by Cosmopolitan, Western Himalayan and Irano Turanian elements. Besides these in first axis had some of the elements form patches which were Pantropical, Sub Cosmopolitan and Eurasian while second axis having Holarctic and Eurasian floristic elements. The 3rd axis showed Pantropical and Sub Cosmopolitan while, 4th axis revealed Central Asiatic and Holarctic phytogeographical elements. It is clear from the results of canonical correspondence analysis that Western Himalayan elements are mostly distributed on southern slopes (Fig. 3).

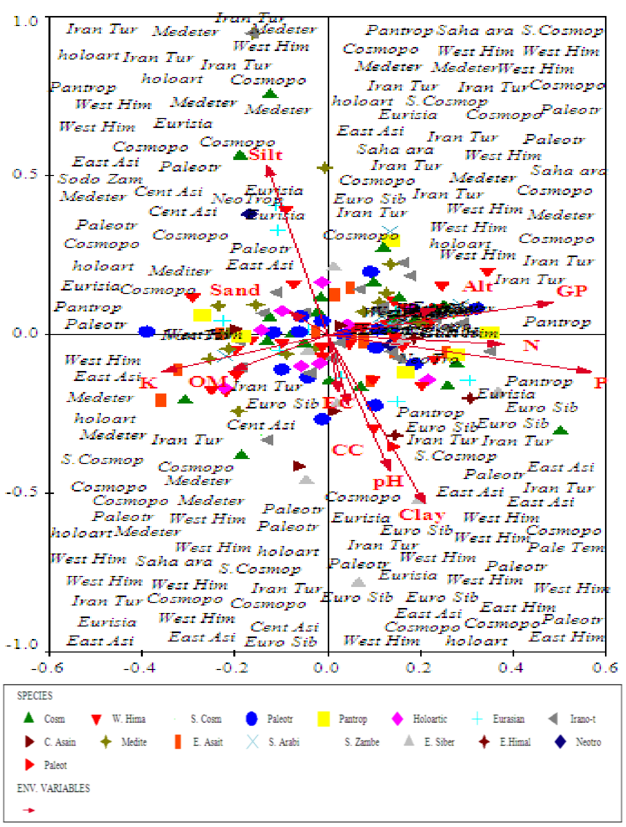

Fig. 3. Canonical correspondence analysis (CCA) showing distribution of phytogeographic elements.

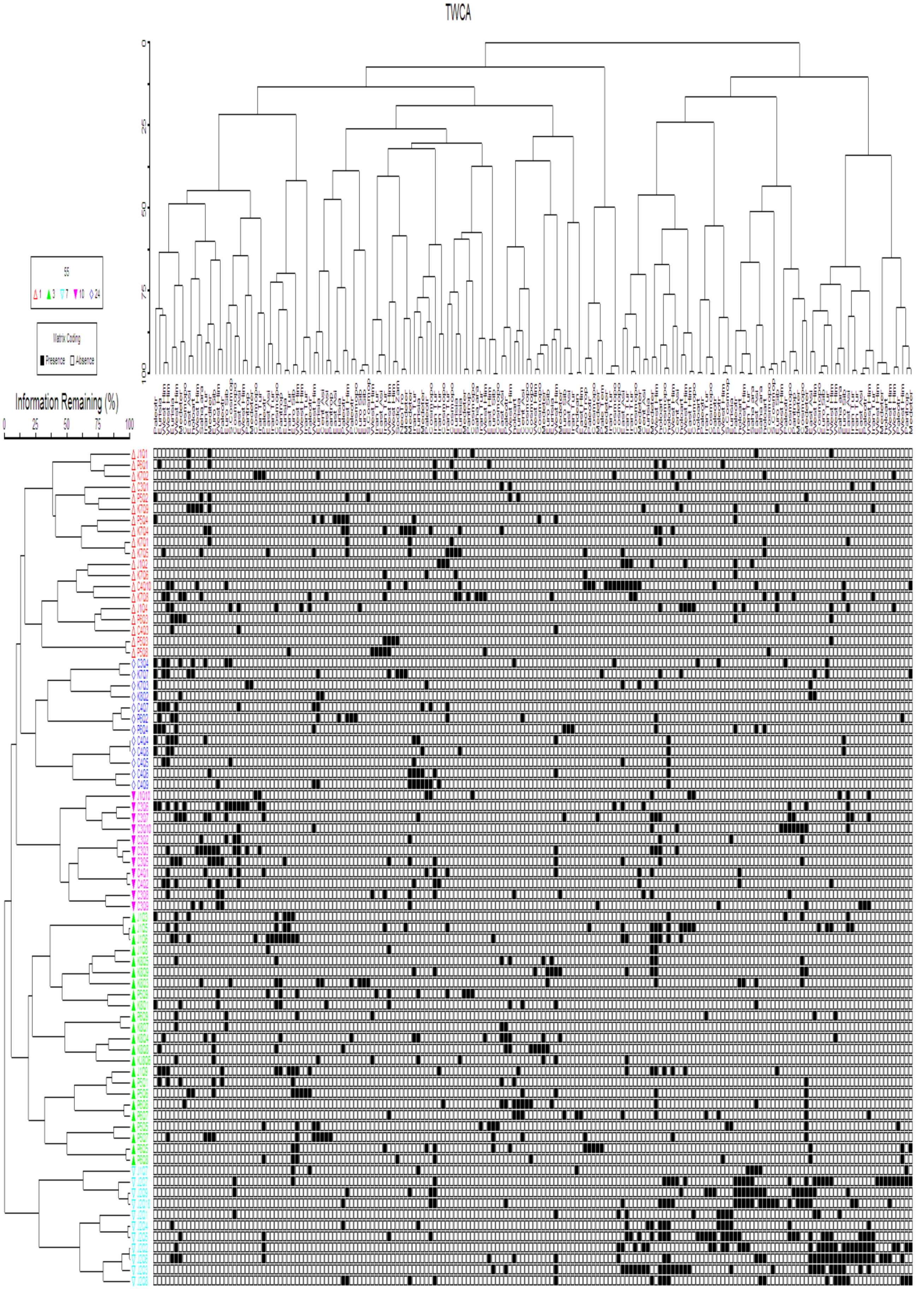

Fig. 2 Two-way Cluster Analysis (TWCA) using PCORD software presenting different Phytogeographical elements in the region.

Table 2. Distribution of Phytogeographical elements in the Jambil Valley Swat, Pakistan.

Botanical name	Codes	Distribution
Acacia nilotica (L.) Delile	Paleotro	Distributed in Indian subcontinent, extending into Southwest Asia and Northern Africa
Ailanthus altissimus (Mill.) Swingle	East Asia	Native to China cultivated in subtropical and temperate regions of the world. In Pakistan it is cultivated as a roadside tree on hills
Alnus nitida (Spach) Endl	West Him	Distributed in the temperate Himalayas, from Kunawar to Swat
Broussonetia papyrifera (L.) L'Hér. ex Vent.	East Asia	Native to Japan, South East Asia and China; introduced and cultivated in Indo-Pakistan subcontinent, Russia, West Asia, tropical Africa, Europe, Philippines, Polynesia, U.S.A. and many other countries as an avenue tree
Cedrus deodara (Roxb. ex D. Don) G. Don	West Him	Kurram eastward to Kashmir, Afghanistan, and West Nepal
Celtis australis L.	East Asia	South, and South East Asia, Australia; Kurram eastward to Kashmir with many cultivated taxa widely naturalized in warm countries
Dalbergia sissoo DC.	Sub-tropical	Pakistan, Afghanistan, India (Sikkim); Iran Iraq.
Diospyros kaki L.f.	East Asia	Native to China and surrounding Eastern Asia
Diospyros lotus L.	Eurasi	Pakistan, Afghanistan, Iran, India, Japan and China.
Eucalyptus globulus Labill.	Australian	A native of Australia, cultivated and naturalized in Asian tropics and subtropics
Ficus carica L.	Medet	Pakistan Afghanistan, Russia, Iran, India, Middle East, Europe and North Africa.
Ficus palmata Forssk.	Iran Tur	Nepal, North West India, and Afghanistan, Pakistan, Iran, Arabian Peninsula, Somalia, Ethiopia, Sudan and South Egypt.
Juglan regia	Eurasi	SE Europe, Western Asia to Himalayas and West China.
Melia azedarach L.	West Him	Native to Western Himalayas, cultivated and naturalized in China, India, East Asia, to Pacific Islands and tropical Australia.
Morus alba L.	East Asia	Malaya, China, Burma, Pakistan, India, South and Central Europe, North Africa.
Olea ferruginea Wall. ex Aitch.	West Him	From Western Himalayas westward to Southwest Asia and Eastern Africa
Pinus roxburghii Sarg.	West Him	Elements of Himalaya from Chitral eastward to Bhutan, Afghanistan, Sikkim.
Pistacia chinensis Bunge	West Him	Afghanistan, Pakistan, N.W and W Himalaya to Afghanistan, Pakistan, N.W. & W. Himalaya to Kumaon.
Pyrus communis L.	Eurasi	Eurasia; introduced also in Mexico.
Quercus baloot Griff	Eurasi	Kashmir, Bhutan, India, Laos, Nepal, Mayanmar, West Pakistan, Thailand, Sikkim, Vietnam.
Quercus semecarpifolia Sm.	West Him	Afghanistan, Kashmir and Pakistan.
Quercus dilatata A. Kern.	Eastern Him	Pakistan, Afghanistan, temperate Himalayas from Kashmir to Nepal.
Quercus incana Batram.	Eastern Him	Upper Burma, North West Himalayas to Nepal.
Robinia pseudoacacia L.	Holoarc	China except Hainan and Xizang. Native to East North America cultivated and sometimes naturalized in many parts of the world.
Agrimonia pilosa Ledeb	Euro Sib	Alpine to sub-alpine and North Temperate zones
Berberis lycium Royle.	Euro Sib	Pakistan, Kashmir and North West Himalayas.
Cotoneaster numularia	Holoarc	Subtropical North Africa and Widespread in temperate, Asia (except Japan), most abundant in South West China; 13 species in Nepal and Europe.
Cotoneaster acuminatus Wall. ex Lindl.	Eastern Him element	West China (Sichuan, Xizang/Tibet, Yunnan), Bhutan, North India, Kashmir, Myanmar, Pakistan, Nepal.
Cotoneaster microphyllus Wall. ex Lindl.	Equally distributed in eastern Him to West Him	South West China (Sichuan, Xizang/Tibet, Yunnan), Bhutan, India, Kashmir, Myanmar, Nepal.
Daphne mucronata Royle.	West Him	Distributed from Garhwali westward to Murree, 1-3000 meter altitude. West Pakistan, Afghanistan, Iran, South Europe and North Africa.
Debregeasia saeneb (Forssk.) Hepper & J.R.I. Wood.	Central Him extending up to NE tropical Africa	Afghanistan, Iran, Kashmir, Nepal, South West Xinjiang, South Xizang, Ethiopia, Yemen.
Desmodium elegans DC.	West Him	Pakistan, Kashmir, Bhutan, Nepal, India (Punjab, Kumaon, Bombay, Madras.
Dodonaea viscosa (L.) Jacq.	Paleotro	South Africa, Australia, China, North America, West Pakistan and India.
Indigofera heterantha Brandis.	East Asia	Bhutan, India, South Xizang, Afghanistan, Sarilanka, Nepal, Pakistan, Africa.
Lespedeza juncea (L.f.) Pers.	Holoarc	Magnolia, Japan, Korea, Russia (Far East, E Siberia.
Ligustrum vulgare L.	Holoarc	Japan, Korea, Australia, Europe, Asia, some species are cultivated all over the world.

Table 2. (Cont'd.).

Botanical name	Codes	Distribution
Myrtus communis L.	Medet extending to Afghanistan and Pakistan	Distributed in Mediterranean region extending to Afghanistan and Pakistan in NW Himalaya up to 500-1500 m asl.
Rosa damascena Herrm.	Iran Tur	Widely distributed from cold-temperate to sub-tropical regions.
Rosa macrophylla Lindl.	East Him	North East Yunnan, Kashmir, Bhutan, India, Sikkim, South Xizang.
Rosa moschata Herrm.	East Him	North East Yunnan, Kashmir, Bhutan, India, Sikkim, South Xizang.
Rosa webbiana Wall. ex Royle.	East Him	West Nepal, North India, Afghanistan, Mongolia, Kashmir, Xizang.
Rubus ellipticus Sm.	Cosmo	Philippines, Pakistan, Laos, Bhutan, India, Sikkim, Mayanmar, Nepal, Sri Lanka, Vietnam, Thailand.
Rubus fruticosus	Cosmo	Abundant in temperate regions of North hemisphere, a few species extending into South hemisphere
Sageretia thea (Osbeck) M.C. Johnst.	Holoarc	Sichuan, Yunnan, Jiangxi, Taiwan, Korea, Thailand, Vietnam, Zhejiang, India, Japan.
Sarcococca saligna (D.Don) Muell.	West Him	West Himalayas from Kumaon to Afghanistan between 1-3000 m.
Spiraea canescens D.Don.	Eastern Him extending to West Him	South and East Xizang, North India, Bhutan, North West Yunnan, Sikkim, Nepal.
Spiraea japonica L.f.	East Asia	Shandong, Shaanxi, Sichuan, Yunnan, Xizang, Jiangxi, Zhejiang Korea, Japan.
Wikstroemia canescens Wall. ex Meisn.	West Him	Pakistan, Japan, Nepal, India, Afghanistan, Bangladesh.
Zanthoxylum armatum DC.	East Asia	Kashia Hills, China, Japan, Korea, Himalayas, from Swat to Bhutan.
Adiantum venustum	West Him	Yunnan Jingdong, Wuliang Shan, Xizang, Nepal, North Myanmar, Bhutan, India, Kashmir.
Ajuga bracteosa Wall. ex Benth.	West Him	Pakistan, Afghanistan, Burma, Malaysia, China, Kashmir, China and Bhutan.
Ajuga parviflora Benth.	West Him	Pakistan, East Afghanistan, NW India, Kashmir.
Amaranthus hybridus L.	Cosmo	Laos, Nepal, Vietnam, Sikkim, Bhutan, Japan, Europe, South and North America.
Anagallis arvensis L.	Cosmo	Mediterranean, North West Africa, West Asia to Europe, North America, Australia, East tropical and temperate.
Androsace rotundifolia Hardw.	West Him	Kashmir, Afghanistan, India, Pakistan, West Nepal.
Andracne cordifolia (Ten.) Steenis.	Neo Trop	Guangdong, Fujian, Beijing, Jiangsu, Hainan, Yunnan, Sichuan, Zhejiang native to South America.
Apluda mutica L.	East Asia	Bhutan, India, Afghanistan, Cambodia, Japan (Ryukyu Islands), Indonesia, Malaysia, Mayanmar, Laos, New Guinea, Nepal, Philippines, Pakistan, Vietnam, Thailand, SW Asia (Oman, Socotra), Sri Lanka, Madagascar, Pacific Islands (New Caledonia), Indian Ocean Islands (Mascarenes), Australia.
Artemisia brevifolia	Medet	North Africa, Temperate Eurasia, introduced and naturalized in Canada and USA.
Artemisia japonica Thunb.	Iran Tur	North India, Afghanistan, Bhutan, Pakistan, Korea, Japan, Nepal, Philippines, Mayanmar, Laos, Vietnam, E Russia, Thailand.
Artemisia scoparia Waldst. & Kitam.	Iran Tur	Central and East Europe, Iraq, Turkey, Iran, Afghanistan, Pakistan (Baluchistan KP, and Punjab), India, China, Mongolia and Russia.
Artemisia vulgaris L.	Iran Tur	Europe eastwards to Caucasia, North Africa, Palestine, Turkestan, Iran, Siberia, Afghanistan, and North West India; introduced and naturalized in N. America.
Arundo donax L.	Cosmo	Mediterranean region eastwards to Burma; Pakistan, North Africa; introduced into many parts of the World.
Asparagus officinalis L.	Medet	Kazakhstan, Russia, Europe, Mongolia, C and SW Asia, North West Africa, China (Xinjiang).
Asplenium antiquum Makino.	East Asia	Hunan, Fujian, Korea, Taiwan and Japan.
Avena sativa L.	Paleotro	Cultivated in non-tropical regions of both hemispheres
Bergenia ciliata (Haw.) Sternb.	West Him	Temperate Himalayas (from Bhutan to Kashmir), East Afghanistan, Assam.
Bidens bipinnata L.	S. Cosmo	Zhejiang, Pacific islands, Taiwan, Cambodia, Yunnan, Nepal, Korea, Laos, Europe, Vietnam, Thailand, South and South America.
Bidens tripartita L.	Cosmo	Indonesia, Bhutan, India, Mongolia, Japan, Korea, Malaysia, Nepal, N Africa, Russia, Philippines, North America, Europe, Australia.
Bromus catharticus Vahl.	Cosmo	Pakistan (Punjab & N.W.F.P.; introduced); South American species widely introduced as a winter forage species under the name "Rescue Grass", and now found as an escape in most temperate countries.

Table 2. (Cont'd.).

Botanical name	Codes	Distribution
Bromus tectorum L.	Holoarc	Elements of Central Asia, Pakistan (N.W.F.P., Baluchistan, Gilgit & Kashmir); Mediterranean region, and Central Europe, throughout the Middle East to the western Himalayas, China and Siberia; Macaronesia and North Africa.
Clinopodium umbrosum (M.Bieb.) Kuntze.	EuroSib	East Africa and Asia to Japan, also in Europe.
Cannabis sativa L.	Iran Tur	Pakistan, Russia, India, China, Iran and cultivated elsewhere
Capsella bursa-pastoris (L.) Medik.	Pan tropical	Taxon widely distributed in temperate regions
Carpesium abrotanoides L.	S. Cosmo	India, Afghanistan, Iran, Korea, Japan, Russia, Nepal, Vietnam, Myanmar, SW Asia (Caucasus, Iran), Europe.
Celosia argentea L.	Paleotro	Tropical Africa, Vietnam, Thailand, India, Malaysia, Laos, Nepal, Myanmar, Sikkim, Russia, Korea, Cambodia, Bhutan, Japan, Philippines.
Chenopodium album L.	Cosmo	Plants common in subtropical to temperate zones, diversity rare in the tropics and cooler region.
Chrozophora tinctoria (L.) A.Juss.	Sah Ara	Northwest Africa eastwards to Arabia, Spain and India. Common weed of fallow fields and dry places.
Chrysanthemum indicum L.	Eurasi	Japan, Bhutan, India, Nepal, Korea, Uzbekistan, Russia.
Cichorium intybus L.	EuroSib	Euro Siberian Southern-temperate distribution, but it is widely naturalized so that its distribution is now Circumpolar Southern-temperate.
Clinopodium umbrosum (M.Bieb.) Kuntze	Holoarc	Asia and Europe to Japan; also in E Africa.
Commelina benghalensis L.	Paleotro	Elements of Tropical and subtropical Africa and Asia.
Cymbopogon jwarancusa (Jones) Schult.	East Asia	Hunan, Fujian, Taiwan Korea, Japan.
Cynodon dactylon (L.) Pers.	Paleotro	Pakistan widely distributed in tropical and warm temperate regions of the Old World; introduced in America.
Cynoglossum lanceolatum Forssk.	Paleotro	Saudi Arabia, Africa (except N.W.), Kashmir, Pakistan, Sri Lanka, India, Burma, Nepal, eastward to China, Malaysia.
Cyperus compressus L.	Cosmo	Bangladesh, Afghanistan, Indonesia, Bhutan, India, Kashmir, Japan, Laos, Nepal, Myanmar, Papua New Guinea, Pakistan, Sri Lanka, Philippines, Vietnam, Thailand, Australia, Africa, Central, South, and North America, Indian Ocean islands, , Pacific Ocean islands, Madagascar.
Cyperus niveus Retz.	Iran Tur	Distributed from Myanmar to East Iran also in East Africa.
Daphne mucronata Royle	Iran Tur	Distributed from Garhwali westward to Murree, 1-3000 meter altitude. Pakistan, Afghanistan, North Africa, Iran and S. Europe.
Dicliptera bupleuroides Nees	West Him	Taxa of Bhutan, Nepal, Pakistan, Afghanistan, Bangla Dash, India to Indo-China and W. China
Dioscorea deltoidea Wall. ex Griseb.	West Him	Taxa of W. Pakistan, Afghanistan and throughout the Himalayas. Very common from 3000-1000 ft. in Swat and Kashmir.
Dryopteris juxtaposita Christ	West Him	Chorotype of India, Nepal, Bhutan, Kashmir.
Dryopteris ramosa (C. Hope) C. Chr.	Cent Asia	Taxa widely distributed in both hemispheres, mainly in Asia, especially from the Himalaya to China, Korea and Japan.
Dryopteris stewartii	Cent Asia	Elements widely distributed in both hemispheres, mainly in Asia, especially from the Himalaya to China, Korea and Japan.
Duchesnea indica (Jacks.) Focke	West Him	Elements of India, Afghanistan, Bhutan, Korea, Indonesia, Japan, Sikkim, Nepal, Europe, naturalized in Africa, and North America.
Dysphania ambrosioides (L.) Mosyakin & Clemants	Cosmo	Taxa cultivated for medicine in Fujian, North China, Guangxi, Guangdong, Jiangsu, Hunan, Sichuan, Jiangxi, Yunnan, Taiwan, Zhejiang native to tropical America; now widely naturalized in tropical, subtropical, and warm-temperate regions of the world.
Eleusine indica (L.) Gaertn.	Cosmo	Fujian, Guangdong, Yunnan, Beijing, Heilongjiang, Hainan, Henan, Hunan, Hubei, Shaanxi, Jiangxi, Shanghai, Shandong, Taiwan, Sichuan, Xizang, Tianjin, Zhejiang .
Erigeron bonariensis L.	Pantro	Taxa widely distributed as a weed in tropical and subtropical regions worldwide.
Erigeron breviscapus (Vaniot) Hand.-Mazz.	Pantro	Sichuan, Guangxi, Hunan, Yunnan, East and South Xizang.
Erigeron canadensis L.	Cosmo	Fujian, Anhui, Guangdong, Gansu, Guangxi, Hebei, Henan, Hubei, Heilongjiang, Hunan, Jiangxi, Jiangsu, Liaoning, Jilin, Shandong, Shaanxi, Shanxi, Taiwan, Sichuan, Xinjiang, Yunnan, Xizang, Zhejiang .(native to North America).
Festuca altissima All.	Iran Tur	Distributed in regions of both hemispheres, regions of the tropics
Filago hurdwarica (Wall. ex DC.) Wagenitz	Iran Tur	Pakistan, Iran, Afghanistan, Central Asia and India.
Galium aparine L.	Eurasi	North Africa, Europe, Siberia, Asia minor, Afghanistan, Iran, India and Pakistan.

Table 2. (Cont'd.).

Botanical name	Codes	Distribution
Galium asperifolium var. *sikkimense* (Gand.) Cufod.	Eurasi	Distributed chiefly in temperate region.
Gallium asplenioides	Eurasi	Taxa distributed chiefly in temperate region.
Geranium himalayense Klotzsch.	Him & Euro Sib	Afghanistan, West and South Xizang, Kashmir, North India, Pakistan, Nepal.
Geranium rotundifolium L.	EuroSib	Siberia, Central and West Europe, Iran, Turkey, Afghanistan, Africa.
Gymnosporia royleana Wall. ex M.A. Lawson	West Him	Pakistan, Kashmir, India, Afghanistan.
Heliotropium strigosum Willd.	Sah Ara	Afghanistan, Fujian, Australia, Guangdong, Cambodia, Bhutan, India. Mayanmar, Kashmir, Laos, Pakistan, Nepal, Thailand, Africa, Vietnam.
Hypericum perforatum L.	Eurasi	North Africa to West China and Europe and North and West India. Introduced into America, East Asia, South Africa and Australia.
Ipomea eriocarpa	Paleotro	Originally from Americas, now circumtropical.
Ipomoea hederacea (L.) Jacq.	Paleotro	Taxon originally from the United States, now widely introduced into tropical and subtropical regions. Not always becoming established.
Ipomoea nil (L.) Roth	Paleotro	Taxa originally from Americas, now circumtropical.
Isodon rugosus (Wall. ex Benth.) Codd	Iran Tur	Pakistan, South and East Arabia (Oman), Himalayas to Nepal, Afghanistan, SW China.
Jasminum grandiflorum L.	Medet	Elements of subtropical NW. Himalaya, 500-1500 m.
Justicia adhatoda L.	Paleotro	Taxon of Panama (probably) introduced in Malaysia, Indonesia, India, South East Asia and Pakistan.
Lactuca dissecta D.Don.	Iran Tur	Taxon cultivated throughout China, probably originating from South West Asia to East Mediterranean.
Lactuca serriola L.	Eurasia	Afghanistan, N India, Kashmir, Kazakhstan, Kyrgyzstan, Mongolia, W Russia, Tajikistan; N and NE Africa, SW Asia, Europe
Lathyrus aphaca L.	Medet	Taxa of Pakistan, Kashmir, North Africa; Europe, South, West and Central Asia, India often cultivated.
Launaea procumbens (Roxb.) Ramayya & Rajagopal	Sah Ara	Kashmir, Afghanistan, India, Kazakhstan, Nepal, Myanmar, Tajikistan, Turkmenistan, Pakistan, Uzbekistan; SW Asia.
Lepidium pinnatifidum Ledeb.	Eurasia	Europe, Central Asia, Himalayas & Caucasus.
Lepidium pinnatum Thunb.	Cosmo	Cosmopolitan
Lepidium sativum L.	Iran Tur	Native to West Asia and Egypt introduced and naturalized elsewhere or cultivated throughout the world.
Lespedeza juncea (L.f.) Pers.	East Asia	Shandong, Mongol, Korea, Shanxi, Japan, Russia (Far East, E Siberia), Mongolia.
Medicago minima (L.) L.	EuroSib	Shaanxi, Liaoning, Shandong, Sichuan, Shanxi, Zhejiang, Africa, Europe, Asia.
Medicago polymorpha L.	Medet	Pakistan; widely distributed throughout the world.
Mentha arvensis L.	Eurasi	Tropical Asia and Eurasia.
Mentha longifolia (L.) L.	Paleotro	South Africa, Europe and Asia.
Micromeria biflora (Buch.-Ham. ex D.Don) Benth.	West Him	Elements of Bhutan, Afghanistan, Nepal, India.
Microstegium nudum (Trin.) A.Camus	Paleotro	India, Japan, Bhutan, Pakistan, Nepal, Vietnam, Philippines, Australia, Africa.
Myrsine africana L.	Medet	Africa and Asia.
Nepeta erecta (Royle ex Benth.) Benth.	West Him	Kashmir, NW India, Pakistan.
Nepeta govaniana (Wall. ex Benth.) Benth.	West Him	Kashmir, Pakistan, West and North India.
Nepeta laevigata (D.Don) Hand.-Mazz.	Iran Tur	Kashmir, Afghanistan, Pakistan, Himalayas to Nepal, North and west India, SW China.
Oenothera rosea L'Hér. ex Aiton	Neo Trop	USA, throughout Mexico and S. America and Central America South and central Texas.
Origanum vulgare L.	Eurasi	Macaronesia, Mediterranean countries, South, West and Central Asia, South Europe, China, Taiwan and Himalaya.
Oxalis corniculata L.	Cosmo	Cosmopolitan weed.
Pennisetum advena Wipff & Veldkamp	Iran Tur	Elements distributed in tropics and subtropics regions
Persicaria barbata (L.) H.Hara	Pantro	Distributed in North temperate regions of both the hemisphere.
Persicaria capitata (Buch.-Ham. ex D.Don) H.Gross	Himalayan element	Distributed in Eastern as well as western Himalayas
Persicaria glabra (Willd.) M.Gómez	Pantro	Pakistan, Tropical Asia, India extending up to Philippine, Malaysia and Africa

Table 2. (Cont'd.).

Botanical name	Codes	Distribution
Phalaris aquatica L.	Medet	Native to the Mediterranean region, Pakistan (Baluchistan: introduced), but widely introduced elsewhere.
Phalaris minor Retz.	Medet	Elements native only in the Mediterranean region, but also distributed in Pakistan (N.W.F.P) and Kashmir.
Physalis divaricata D. Don.	Iran Tur	Distributed eastward to Nepal and Afghanistan.
Pimpinella spp.	Iran Tur	Distributed eastward to Nepal and Afghanistan.
Pimpinella diversifolia DC.	Iran Tur	Himalayas in West Pakistan, Afghanistan, and India extending to Japan and China.
Plantago lanceolata L.	EuroSib	Taxa of Africa, Europe, and South Asia to the mountains of Tien Shan, introduced all over the world.
Poa annua L.	Cosmo	Cosmopolitan.
Poa bulbosa L.	Eurasi	Europe, N. Africa, Asia; introduced into Australia and Americas
Polygala abyssinica R.Br. ex Fresen.	SudanoZamb	Afghanistan, Africa, and Pakistan, Himalayas: from Murree to Kumaon.
Polygonum aviculare L.	Cosmo	Distributed widely in subtropical and temperate regions of both the hemispheres.
Polygonum plebeium R.Br.	Cosmo	Japan, India, Indonesia, Myanmar, Kazakhstan, Philippines, Nepal, Thailand, Russia (Far East), Australia, North Africa.
Ranunculus arvensis L.	Eurasi	Chorotype widely distributed from S. W. Asia to India and the Himalaya, Central and south Europe through S. Siberia.
Ranunculus repens L.	S. Cosmo	Widely distributed as a weed in most parts of the USSR and Europe, West and south west Asia.
Rubia cordifolia L.	Eurasi	North Africa, Greece, Japan, Siberia, China, Manchuria, India, Afghanistan, Bhutan, Pakistan, Tibet and Nepal.
Rubia manjith Roxb. ex Fleming	Eurasi	North Africa, Greece, Japan, Siberia, China, Manchuria, India, Afghanistan, Bhutan, Pakistan, Tibet and Nepal.
Rumex dentatus L.	Eurasi	Europe, East Asia, Himalayas, Indian Subcontinent
Rumex hastatus D. Don.	Sah Ara	North East Afghanistan, North Pakistan, South West China.
Salvia moorcroftiana Wall. ex Benth.	Euro Sib	Temperate and Tropical zones of the Old and New World
Sedum album Linnaeus	Medet	Mexico, Europe, North America, Central America, Africa, Asia, Indian Ocean Islands (Madagascar), Atlantic Islands (Iceland).
Setaria pumila (Poir.) Roem. & Schult	Paleotro	Distributed in warm temperate and tropical areas of the world. Introduced to Pakistan (Sindh, Punjab, KPK, Kashmir and Gilgit).
Silene conoidea L.	Medet	Europe, Africa, Asia.
Sisymbrium irio	Eurasi	North Africa, Asia and Europe.
Solanum nigrum	Cosmo	Cosmopolitan but being absent in the arctic and subarctic regions
Sonchus wightiana	Paleotro	Indian subcontinent, China through whole of the Eastern Asia to Pacific Islands
Sonchus asper	Eurasia	Africa and Madagascar.
Sonchus oleraceus	Medet	Native of Mediterranean Europe, introduced and naturalized in Africa, Asia, N.S America.
Spiraea canescens D. Don	West Him	North West Yunnan, East and South Xizang, North India, Nepal, Sikkim, Bhutan.
Stellaria media (L.) L.	Eurasi	Found in subtropical to temperate regions of Asia and Europe
Strobilanthes urticifolia Wall ex Kuntze	West Him	Nepal, India, Pakistan and Afghanistan.
Tagetes minuta L.	Cosmo	Widespread in Central and South America, naturalized in Africa (Kenya, South Africa), Australia and Taiwan.
Taraxacum officinale	Cosmo	Cosmopolitan weed of temperate areas.
Teucrium royleanum Wall. ex Benth.,	West Him	Pakistan, Nepal, East Afghanistan, North and West India, Kashmir
Themeda anathera (Nees ex Steud.) Hack.	West Him	Afghanistan, Pakistan, Xizang, Nepal, India.
Tussilago farfara L.	Paleo temp	Pakistan, India, Nepal, Russia, SW Asia, N Africa, W Europe.
Verbascum Thapsus L.	Eurasi	Europe and Asia naturalized throughout the Northern Hemisphere.
Verbena officinalis	Paleotro	North Africa, and most of Europe and Asia, introduced in South Africa and North America.
Vernonia acaulis (Walter) Gleason.	Cosmop	China and tropical America.
Veronica persica Poir.	S. Cosmo	Yunnan, Xizang, Zhejiang. Native to SW Asia and since the 19th century spread over most of the world.
Vicia sativa L.	Eurasi	India, Pakistan, Kashmir, Orient (eastern part of Asia), Russia, Europe; and Far East.
Viola betonicifolia Sm.	Paleotro	Ceylon, Himalayas, India, Japan, China, Indo-China, New Guinea, Celebes, Australia, Philippines.
Xanthium strumarium L.	Pantro	Probably originated in New World, Naturalized throughout the tropics and subtropics

Table 3. Summary of monte carlo test of various phytogeographic elements.

Axes	1	2	3	4	Total inertia
Eigen value	0.408	0.383	0.354	0.318	16.457
Species environment correlations	0.927	0.900	0.907	0.931	
Cumulative percentage variance of species data	2.5	4.8	7.0	8.9	
Species environment relation	12.6	24.5	35.5	45.3	
Sum of Eigen values					16.457
Sum of all canonical Eigen values					3.225
Summary of Monte Carlo test (499 permutations under model)					

Test of significance of first canonical axis		Test of significance of all canonical axis	
Eigen value	0.408	Trace	3.225
F-ratio	1.601	F-ratio	1.280
P-ratio	0.0800	P-ratio	0.0020

Discussion

The origin and evolution of biodiversity is firmly related with many historical and ecological factors which include both geological and climatic processes like the movement of earth's continent (continental drift), the uplift of mountains, and fluctuations in climate are linked with ice ages. The interaction between these processes can result new ecological niches and thus provide chances for speciation. Certainly, different selection and adaptation related with diverse habitats are progressively observed as a major cause of speciation in vegetation (Rieseberg & Burke, 2001; Funk & James, 2006; Harman, 2008). The present research work is based on plants collected from Jambil Valley District Swat and its allied areas. A total of 180 plant species were collected by many consecutive exploratory trips belonging to 18 different Phytogeographic elements. The maximum percentage of elements 19.4% (35) belonging to Western Himalayan category floristic province. The center of diversity of these elements is North West Himalayas but some taxa spread to the Central Asia at west side, and eastward to Eastern Himalayas and Eastern Europe. Takhtajan, (1986) explained that the western Himalayan province have many species common to Irano Turanian region and also to eastern Asiatic and eastern Himalayan floras so it occupies a transitional position between the ancient Mediterranean and eastern Asiatic floras. This province has much common plants of Iranian highlands and also Mediterranean floras. The characteristics conifers of this province explained by (Takhtajan, 1986) are *Pinus wallichiana* A.B. Jacks, and *Pinus roxburghii* Sarg etc. and characteristic endemic species is *Cedrus deodara*. In the lower belt of the study area *Quercus incana* Bartram, *Quercus baloot* Griff, *Quercus dilatata* A.Kern and *Pinus wallichiana* are dominant species. (Shinwari & Nasim, 2016) studied the phylogeny of *Carex* genus from Pakistan and found its origin from central Asian elements. (Breckle, 2007) studied the phytogeographic pattern of the alpine vegetation of Afghanistan and reported that flora has a close relationship to central Asian plants. (Shinwari & Qaiser, 2011) studied the diversity and distribution pattern of cosmopolitan genus Carex from Kashmir Himalayas (Ullah *et al*., 2015) studied the distribution of grasses, sedges and rushes from Northern Pakistan and observed western Himalayan and cosmopolitan dominant elements. Our results are correspond with their finding. The second dominant category is Cosmopolitan elements 13.9% (25). The term is used in phytogeography to described distributions of plants as found all over the world and having greater ecological amplitude. A similar pattern of Cosmopolitan genera, dominancy were observed by (Armesto *et al*., 1993) who worked on coastal desert of Chile. These include the genera which are distributed in all continents without special distribution centers, but occasionally have one or more diversity centers. The reasons behind the dominancy of cosmopolitan elements is that these taxa are distributed all over the world in similar habitats, most of the species belong to this category are Alien species, having broad ecological amplitude, and the study area falls in sub-tropical region so there are considerable ecological variations. Therefore cosmopolitan is the dominant category in the region. Irano Turanian elements represent 10% (18) plants. The endemism and distribution pattern of distribution pattern of family Crassulaceae from Pakistan were studied by (Sarwar & Qaiser, 2012) and reported that 15 taxa are of Irano-Turanian elements, 16 elements having Sino-Japanese affinity and only one is Mediterranean element. (Noroozi *et al*., 2011) studied the alpine vegetation of Iran and observed that the vegetation of Iranian alpines is a transition of Anatolia, Caucasus and the mountain Hindu Kush, with (58%) endemism. There are 6.7% (12) plant species of Mediterranean origin as well as of Eastern Asiatic origin. Ocak *et al*., (2009) deliberate the floristic affinities and conservation of Poaceae species from Turkey. The dominant elements were Irano-Turanian followed by Euro-Siberian elements and Mediterranean. Takhtajan, (1986) described that Irano Turanian region have high number of endemic genera and species endemism. The richest flora is of that of Iranian Plateau, and the most impoverished flora is of that of Eastern Central Asia. In the present research work 9.4% (17) species represent the Paleo tropical origin. Paleo tropical genera mainly include the tropics of old world, with the exception of Australia. Pantropical represent 6 species (3.3%). These elements include the genera that are distributed in three sectors of tropical zones America, Asia-Australia, and America-Madagascar. Some genera spread their distributional ranges southward, northward or both into temperate areas. Eurasian represent 10.6% elements while Euro Siberian represent 10 plants (5.6%). Similarly, Ocak *et al*., (2009) also reported minimum number of Euro Siberian elements from Malatya province Turkey. Holarctic represents 7 plants (3.9%), due to its vast territory; the flora of each region of this kingdom is closely related to the floras of other. Saharo Arabian with four plants (2.2%) and Central Asiatic with 2 plant species (1.1%). (Lavrenko, 1962) described that due to extreme temperature and aridity the Central Asiatic sub regions plants are limited and comparatively uniform. The remaining elements are represented by lower percentages i-e, Sudano-Zambezian, Pan temperate and Australian (0.6%), Eastern Himalayan province and Neotropical (1.1%). After the glacial period, the Eastern Himalayan was colonized basically from the East and the South East, but the flora also has number of endemic species and genera. This clearly indicates that the glaciation was not catastrophic, and that many taxa may have developed indigenously since as far back as the Pliocene. Likewise a number of eastern Himalayan plants are also encountered into the southwestern China. After the last glacial period, the plants of this province were colonized basically from east and south east, but the flora also contains a number of endemic species and genera. So it is clear that the glaciation was not absolutely Catastrophic that many taxa have developed indigenously since as far back as Pliocence. Neo tropical represent 1.1% and Sudano Zambezian represent 0.6% elements. (Takhtajan, 1986) described that Neo tropical flora has a common and same origin with the Paleo Tropical, and it may assumed that , only for Angiosperms, that its initial nucleus had its roots in the Paleo Tropical kingdom. Soil is important amongst abiotic factors that play a major role in the proper selection of plant species through evolutionary change (Barbour *et al*., 1980). There is a close relation between vegetation and soil of any geographic zone (Ali *et al*., 2013). Physical properties of soil are in relation with texture, water holding capacity. Depth is an important factor and plays a major role in the development of different units (Rasheed *et al.,* 2017). The chemical properties apply stresses on plant species which effects the relation of water to plant, nutrients availability and toxic effects of chemical elements excesses amount. The optimum pH is considered best for availability of nutrients lies between 5 and 7.5, but a nutrients availability become maximum at 6.5 pH (Monsen & Stevens, 2004). Soil of the Jambil Valley displays a maximum percentage of clay with an average of 47.5 and then sand with an average value of 33.2, and silt with an average of 29.5, pH also varies 5.9 to 8.5. It is clear from our results that higher pH, Silt, moderate Phosphorous, Calcium and nitrogen have great impact on the distribution of phytogeographical elements in the area. The results showed a great variations in soil i.e., pH value ranges from 7.1 to 8.4, Electrical conductivity (EC) from 0.13 to 4, Organic matter (OM) from 0.54 to 0.9%, Calcium Carbonate from 0.21 to 9.46, Nitrogen from 0.025 to 0.045, Sand value ranges from 31 to 56, Silt from 30 to 45, Clay from 10 to 31, Phosphorus (P) from 3.2 to 9.2 and Potassium (K) value ranges from 81 to 125 with sandy loam soil.

Conclusion

A total of 180 plant species were collected and classified into 17 different Phytogeographic elements from the Jambil Valley Swat, Pakistan. The dominant elements were Western Himalayan as most of the species in the area are near endemic (Himalayan endemic), and can be attributed to the location of the province. Cosmopolitan elements form the second dominant group of elements growing in a wide range of habitats. Eurasian elements are the third dominant group, mostly comprised of species distributed in the temperate regions of Asia and Europe. Irano Turanian was the fourth largest element because major parts of Pakistan came in Irano Turanian region. The result of soil concluded that pH, Electrical conductivity and Sand have great impact on the distribution of floristic elements as compare to other environmental variables and can be compared with the recent studies from Hindu-Himalayan and other region of the northern Pakistan (Abbas *et al*., 2019; Anwar *et al*., 2019, Hussain *et al*., 2019, Noreen *et al*., 2019). The valley has high grazing pressure and deforestation rate. It is therefore recommended that Western and Eastern Himalayan elements should be given more focus or importance because of their narrow geographic region.

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