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Review

A Review of Taxonomic Perspective of Diversity in Gymnosperms of Kashmir Himalaya

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Abstract. Varied floristic works relevant to Kashmir Himalaya were thoroughly examined to compile taxonomic contributions of various taxonomists *viz*. a *viz*. diversity in gymnosperms of this region. Extensive field surveys and standard taxonomic methods were used to locate, collect, identify and prepare an updated list of the target group. A total of 25 species of gymnosperms belonging to 13 genera in 6 families and 4 orders have been documented from the Kashmir Himalaya. Wild gymnosperms are represented by 11 species with conifers forming the most dominant group. Among families, Pinaceae is highest represented with 6 species, while Taxaceae is least represented. Cultivated gymnosperms exceed wild growing species, and Cupressaceae is most dominant with 9 species whereas Ginkgoaceae is least represented. Out 25 species 19 (7 wild + 12 cultivated) are trees, 5 (3 wild + 2 cultivated) are shrubs and only 1 is sub-shrub.

Keywords: floristic diversity, gymnosperm, Kashmir Himalaya, cultivation

Introduction

Gymnosperms are distributed throughout the world with about 1079 species in 12 families and approx. 83 genera (Christenhusz and Byng, 2016). The three 'non-conifer' groups comprise about 337 species of cycads in 10 genera, one extant ginkgophyte, and 111 species of gnetophytes in three genera (Christenhusz and Byng, 2016). Farjon (2010) has reported about 615 species of conifers in 70 accepted genera, however according to Christenhusz and Byng (2016) their number is 629 species in 69 genera and 06 families. The genus *Juniperus* L. represented by 75 species is considered to be one of the most diverse genera of gymnosperms distributed from sea level to above tree-line zone (Lakusic and Lakusic, 2011).

India is abode to about 101 species, 9 varieties and 1 form of gymnosperms belonging to 33 genera under 10 families with about 44 species in wild (Srivastava, 2006). A total of 63 species of gymnosperm are reported from western Himalaya (Tewari *et al*., 2010). Although much less in numbers gymnosperms still constitute dominant element of forests of world in temperate areas of both the northern and southern Hemispheres. They occur in all continents except Antarctica and form outstanding feature of landscape of the Himalaya. The existing gymnosperms belong to six orders: Cycadales, Ginkgoales, Coniferales, Gnetales, Welwitschiales and Ephedrales.

Forests are verily the green gold of the State of Jammu and Kashmir play a vital role in the maintenance of natural balance which is of paramount importance in a mountainous region like ours. Despite their immense ecological and socio-economic values the taxonomy of gymnosperms has been neglected in the Indian sub-continent, especially in the Kashmir Himalaya. Even though Hooker (1888) gave the first taxonomic treatment of gymnosperms of India, but he cited very little material. Since then some local researchers (Dar and Christensan, 2003; Javeid, 1979, 1970; Singh and Kachroo, 1976; Dhar, 1966) attempted to deal with gymnosperm floristics in this region, but the taxonomic intricacy regarding this group in the Kashmir Himalaya still persists.

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It is for these reasons that present investigation was carried out to compile contributions of various taxonomists *viz*. a *viz*. diversity in gymnosperms of this region, validate and augment it with extensive field studies so as to present an updated inventory of gymnosperm species in the Kashmir Himalaya.

Study area. Kashmir Himalaya being located at the bio-geographically pivotal position, represents a unique biotic province in the northwestern extreme of the Himalayan range. The region lies between coordinates 32° 17' to 37° 20' north latitude and 73° 25' to 80° 30' east longitude spreading over an area of about 2, 22, 235 km2 (Hussain, 2001). It comprises mostly of rugged terrain, except for small plains of Jammu and vale of Kashmir, and encompasses four categories of bio-geographic biomes: Tundra, Alpine, Temperate and Subtropical (Rodgers and Panwar, 1988). The valley of Kashmir is an oval plain that lies between 32° 20' to 34° 50' north latitude and 73° 55' to 75° 35' east longitude covering an area of about 16,000 sq. km. It is formed by a girdling chain of the Himalayan mountains, namely the Pir Panjal range in the south and the great Himalayan range all along the southeast through northeast to the west. The entire territories of the Kashmir valley form two distinct topographic divisions, the mountain ranges and the valley proper. It extends roughly 187 km in length and about 116 km in breadth along the latitudes of Srinagar. On an average, the climate of valley is temperate with bixeric regimes, having two dry spells in June and September, and high precipitation during the winter season.

Materials and Methods

After thorough study of the available herbarium specimens in Kashmir University Herbarium (KASH) and comprehensive literature evaluation from varied sources, different forest habitats in the Kashmir Himalaya were explored for collection of specimens of different gymnosperm species. They were assigned a specific field number and on spot diagnostic characters were noted in the field book. In case of *Abies*, *Picea* and *Cedrus*, where all the leaves (needles) fell down the twigs a few days after direct pressing, the method proposed by page (1979) proved effective. Female cones of *Cedrus* and *Abies*, where bract and ovuliferous scales fall, while still on the tree, were collected just prior to dismembering stage and kept air tight in small polythene bags so as to keep them intact. The specimens were identified using the available literature on floristics of this region. Data pertaining to enumeration and distribution of taxa along with altitude (wherever available) has been tabulated.

Taxonomic appraisal. The preliminary work on taxonomy of gymnosperms in India actually commenced from Drury, who in (1869) reported a few gymnosperms from India. Hooker's work (1888) is however, considered to be the first solid step in this direction. Treated the gymnosperms as Gymnospermae and reported 30 species in 16 genera belonging to 3 families (natural orders) from the British India. Out of these, 11 species spread over 5 genera and 2 families have been cited from the Kashmir Himalaya (Table 1). Hooker also recognized six tribes in order Coniferae on the basis of position of ovule, as follows:

A. Ovule erect:	I. Cupressinae II. Taxodiaceae III. Taxeae
B. Ovule reversed:	I. Podocarpeae II. Araucarieae III. Abietineae

Hooker (1888) and Gamble (1902), each recognized four Juniper species from India. These are as follows:

Juniperus macropoda	- Inner drier regions of the Himalaya from Afghanistan to Nepal (1500-4500m).
J. communis	- Western Himalaya from Nepal westwards (2000-5000m).
J. recurva	- Himalaya from Afghanistan to Bhutan (3000-4500m).
J. pseudosabina	- Himalaya from Afghanistan to Bhutan (3000-4500m).

Brandis (1906) reported 47 species of gymnosperms belonging to 12 genera and 3 families from the British Indian Empire. Out of these, 14 species belonging to 8 genera within 2 families were cited from Kashmir Himalaya (Table 2). Lambert (1933) in his list of trees and shrubs for Kashmir and Jammu forest circles reported 13 species of gymnosperms belonging to 7 genera (Table 3).

Raizada and Sahni (1960) have reported 42 species of gymnosperms belonging to 14 genera in 7 families from the Indian sub-continent. Out of these, 13 species belonging to 7 genera in 3 families have been cited

from the Kashmir Himalaya (Table 4). Raizada and Sahni (1960) have documented 6 species of Junipers from the Himalaya: two species with scaly leaves in the adult stage, *viz*. *Juniperus wallichiana* and *J. macropoda* and other 4 species with acicular adult foliage, namely *J. coxii*, *J. recurva*, *J. squamata* and *J. communis*.

Wali and Tiko (1964) have reported 7 species belonging to 6 genera in a single family Coniferae from the Lolab valley in Kashmir. These are as follows:

Coniferae:

Juniperus	-	*J. communis*, *J. recurva*
Taxus	-	*T. baccata*
Pinus	-	*P. wallichiana*
Cedrus	-	*C. deodara*
Picea	-	*P. smithiana*
Abies	-	*A. pindrow*

Table 1. Gymnosperm taxa reported from British India (Hooker, 1888)

Name of family	Genus Number	Genus Name	Species Number	Species Name	Taxa cited from Kashmir Himalaya
Gnetaceae	2	Ephedra	3	*E. vulgaris* *E. pachyclada* *E. peduncularis*	*E. vulgaris* (Western Tibet). *E. pachyclada* (Western Himalaya, Western Tibet).
		Gnetum	6	*G. gnemone* *G. neglectum* *G. macrostachyum* *G. scandens* *G. funiculare* *G. macropodum*	--
Coniferae	13	Cupressus	3	*C. torulosa* *C. sempervirens* *C. funebris*	*C. sempervirens* (Northwest India). *C. torulosa* (Western Himalaya).
		Juniperus	4	*J. communis* *J. pseudosabina* *J. recurva* *J. macropoda*	*J. pseudo-sabina* (Kashmir to Bhutan). *J. communis* (Western Himalaya, Kumaon westwards). *J. macropoda* (Western Tibet, 5000 - 14000f).
		Cephalotaxus		*C. manii* *C. griffithi*	--
		Taxus		*T. baccata*	*T. baccata* (Temperate Himalaya).
		Dacrydium Podocarpus		*D. elatum* *P. latifolius* *P. neriifolius* *P. cupressine*	--
		Agathis		*A. loranthifolia*	
		Pinus	5	*P. excelsa* *P. longifolia* *P. khasya* *P. gerardiana* *P. merkusii*	*P. excelsa* (Temperate Himalaya, 6000-12000f). *P. longifolia* (Indus-Bhutan, 1500-6000f). *P. gerardiana* (Dry interior valleys of North-west Himalaya, 5000-12000f).
		Cedrus	1	*C. libani*	--
		Picea	1	*P. morinda*	
		Tsuga	1	*T. brunoniana*	
		Abies	1	*A. webbiana* var. *webbiana*	
		~~Larix~~	~~1~~	~~*L. griffithii*~~	
Cycadaceae	1	Cycas	5	*C. circinalis* *C. rumphii* *C. pectinata* *C. siamensis* *C. beddomei*	-- --
Total = 3	16	--	39	--	11

Dhar (1966) while dealing with distribution of Pinaceae in India has cited 14 indigenous species of gymnosperms belonging to 12 genera and 6 families of order Coniferales. Out of these, 7 species in 4 genera of family Pinaceae have been cited from the Kashmir Himalaya (Table 5). Dallimore and Jackson (1966) have reported only 5 species of Junipers from Himalaya, *viz*. *J. communis*, *J. macropoda*, *J. recurva*, *J. squamata* and *J. wallichiana* (=*J. pseudosabina*). It is worth mentioning here that *J. coxii has* been treated as a variety of *J. recurva*.

Table 2. Gymnosperm taxa reported from Kashmir Himalaya (Brandis, 1906)

Name of family	Genus		Species		Distribution in Kashmir Himalaya
	Number	Name	Number	Name	
Gnetaceae	1	Ephedra	3	*E. gerardiana (E. vulgaris)* *E. nebrodensis* *E. intermedia*	Himalaya: Kuram Valley, Yarkand, Tibet. Baltistan. Northern Himalaya: Gilgit, Zanskar, Upper Chenab.
Coniferae	13	Pinus	2	*P. excelsa* *P. gerardiana*	Bhutan to Afghanistan. Northwest Himalaya: Gilgit, Indus between Astor and Iskardo, Upper Chenab.
		Cedrus	1	*C. deodara (C. libani var. deodara)*	Northwest Himalaya (4000-10000f).
		Abies	2	*A. pindrow* *A. webbiana*	Kurram valley, eastwards to Nepal. Northwest Himalaya (10000-14000f).
		Picea	1	*P. morinda (Abies smithiana)*	Himalaya: Common from Kashmir to Garhwal and Gilgit.
		Cupressus	1	*C. sempervirens*	Planted in gardens of Northwest India.
		Juniperus	3	*J. communis* *J. recurva* *J. macropoda (J. excelsa)*	Northwest Himalaya (5400-14000f). Kashmir to Bhutan (7500-12000f). Inner arid ranges and valleys of Northwest Himalaya.
		Taxus	1	*T. baccata subsp. wallichiana*	India.

Table 3. Gymnosperm taxa reported from Kashmir and Jammu forest circles (Lambert, 1933)

Name of genus	Species		Distribution in Kashmir Himalaya
	Number	Name	
Ephedra	2	*E. gerardiana* *E. intermedia*	Gurez, Jhelum Valley. Kishanganaga, Sind Valley. Kashmir, Baltistan, Chenab valley, Jammu, Mirpur, Muzaffarabard, Udhampur.
Pinus	3	*P. longifolia* *P. gerardiana* *P. excelsa*	Baltistan, Chenab valley, Jammu, Kamraj, Mirpur, Muzaffarabard, Udhampur. Mainder, Kashmir. Jhelum Valley, Gurez, Kamraj, Kishanganaga, Mainder, Muzaffarabad, Sind Valley, Udhampur.
Picea	1	*P. smithiana*	Gurez, Jhelum Valley. Kishanganaga, Kashmir, Mainder, Muzaffarabard, Sind Valley, Udhampur.
Abies	1	*A. pindrow*	Gurez, Jhelum Valley. Kamraj, Kishanganaga, Kashmir, Sind Valley, Udhampur.
Cedrus	1	*C. deodara*	Gurez, Jhelum Valley, Kamraj, Kishanganaga, Kashmir, Mainder, Muzaffarabard, Sind Valley, Pir Panjal, Udhampur.
Juniperus	4	*J. communis* *J. squamata* *J. macropoda* *J. pseudosabina*	Gurez, Jhelum Valley. Kashmir, Mainder, Sind Valley. Gurez, Jhelum Valley. Kishanganaga, Kashmir. Mainder, Sind Valley, Gurez, Kishanganaga, Sind Valley, Kashmir.
Taxus	1	*T. baccata*	Gurez, Jhelum Valley. Kamraj, Kishanganaga, Kashmir, Mainder, Muzaffarabard, Sind Valley, Udhampur.

Gaussen (1968) has reported 7 species of Junipers from the Himalaya, as follows:

Name of species		Distribution
J. pseudosabina	-	Throughout the Himalaya.
J. wallichiana	-	Indus to Bhutan (2700-4500m).
J. religiosa (*J. excelsa*)	-	Drier ranges of Northwest Himalaya from Kashmir to Nepal (1500-3000m).
J. macropoda (4000m).	-	Afghanistan to western Nepal
J. squamata	-	Himalaya (3,000-5,000m) in Alpine zone.
J. recurva	-	Eastern Himalaya in temperate or sub-alpine zone in Sikkim and Bhutan (3,000-4000m); Afghanistan, Kashmir, Tibet.

Javeid (1970) has described 11 species of gymnosperms belonging to 10 genera and 5 families from Srinagar Kashmir (Table 6). Stewart (1972) treated gymnosperms as class Gymnospermae and cited 35 species in 14 genera belonging to 5 orders of them from Pakistan and Kashmir. Out of these, 17 species in 7 genera have been recognized from the Kashmir Himalaya (Table 7). Koul and Sarin (1974) studied the vertical distribution of plant communities between 1,000 and 3900m altitudes in Bhaderwah hills (western Himalaya) and found a well marked zonation of vegetation from lower to upper elevation. The lower zone (1,600-1,900m) comprises *Quericus incana*, *Q. floribunda* and *Pinus wallichiana*; the intermediate slopes (2,000-2,600m) consists of almost pure stands of *Cedrus deodara*, while locations from 2,000-3,700m are dominated by *Abies pindrow* forests. The oaks were restricted to drier situations and conifers to moist slopes. Dhar (1975) has reported a healthy, well-grown fertile specimen of a prodigious

Table 4. Gymnosperm taxa reported from Kashmir Himalaya (Raizada and Sahni, 1960)

Name of family	Genus		Species		Distribution
	Number	Name	Number	Name	
Pinaceae	4	Abies	2	*A. pindrow*	Afghanistan to Nepal (2300-3300m).
				A. spectabilis	West Pakistan to Bhutan (3300-4000m).
		Cedrus	1	*C. deodara*	Afghanistan to Garhwal.
		Picea	1	*P. smithiana*	Afghanistan to Kumaon (2150-3200m).
		Pinus	5	*P. gerardiana*	From Bashahar westwards to Kashmir.
				P. roxburghii	Afghanistan to Bhutan (450-2300m).
				P. wallichiana	All along Himalaya 1800-3700m).
Taxaceae	1	Taxus	1	*T. baccata*	All along Himalaya 1800-3700m).
Cupressaceae	2	Cupressus	1	*C. torulosa*	West Pakistan and Kashmir.
		Juniperus	4	*J. communis*	Afghanistan to Kumaon (1700-4300m).
				J. macropoda	Kashmir, (1500- 4300m).
				J. recurva	All along Himalaya from West Pakistan to Bhutan (2300-4600m).
				J. wallichiana	Indus Nepal (3300-4200m).

Table 5. Gymnosperm taxa reported from Kashmir Himalaya (Dhar, 1966)

Name of family	Genus		Species		Distribution
	Number	Name	Number	Name	
Pinaceae	4	Pinus	3	*P. roxburghii*	Kashmir to Bhutan.
				P. wallichiana	Northwestern Himalaya.
				P. gerardiana	Bashahar to Kashmir.
		Cedrus	1	*C. deodara*	North-west Himalaya from Garhwal to Kashmir.
		Picea	1	*P. smithiana*	Western Himalaya from Kashmir to Kumaon.
		Abies	2	*A. pindrow*	Western Himalaya from Kashmir to Nepal. Western Himalaya.
				A. spectabilis	

conifer- *Sequoiadendron giganteum* growing in the Yarikha Drug Farm, Tangmarg Kashmir.

Mehra (1975) using taxonomic and anatomical tools has tried to resolve the Abies and Juniperus complexes existing in the Himalaya. According to author 4 types of firs are met within the western Himalaya *viz*. (1) high-level *Abies spectabilis* (2) high-level hybrid (3) low-level hybrid and (4) low-level *A. pindrow*. Regarding *Juniperus* complex, the author has concluded that in all there are 9 species of Junipers in the Himalaya, of these 5 are trees and 4 shrubs. *Juniperus pseudosabina* is a shrub occurring all-along the Himalayan range from west to east. Out of the other 8 species, 4 are met within the western Himalaya and an equal number in the eastern Himalaya. The western Himalayan Junipers are: *J. communis*, *J. squamata* (both shrubs), *J. macropoda* and *J. excelsa var. Farreana* (both trees).

Singh and Kachroo (1976) have reported 6 species of gymnosperms in 5 genera belonging to 2 families from Srinagar. These are as follows:

Pinaceae:

Abies - *A. pindrow*
Juniperus - *J. communis*, *J. recurva*
Picea - *P. smithiana*
Pinus - *P.griffithii*

Taxaceae:

Taxus - *T. wallichiana*

Based on extensive survey of *Juniperus* populations in various parts of the Himalaya and the details of morphological and anatomical characters, Jain (1976) has reported 8 distinct taxa of Juniper from the entire Himalayan range. In the eastern Himalaya 5 taxa are present, 3 (*J. wallichiana*, *J. recurva* and *J. fargesii*) are trees and restricted to the eastern Himalaya, while the other 2 also extend to the western Himalaya. The west Himalayan taxa are also 5 in number: *J. macropoda* and *J. excelsa* being trees, whereas *J. communis* ssp. *Nana*, *J. squamata* and *J. pseudo-sabina* are shrubs.

Table 6. Gymnosperm taxa reported from Kashmir Himalaya (Javeid, 1970)

Name of family	Genus		Species	
	Number	Name	Number	Name
Ginkgoaceae	1	Ginkgo	1	*G. biloba*
Pinaceae	4	Pinus	2	*P. wallichiana* *P. halepensis*
		Cedrus	1	*C. deodara*
		Picea	1	*P. smithiana*
		Abies	2	*A. pindrow*
Cupressaceae	3	Thuja	1	*T. orientalis*
		Cupressus	1	*C. arizonica*
		Juniperus	1	*J. communis*
Taxaceae	1	Taxus	1	*T. wallichiana*
Ephedraceae	1	Ephedra	1	*E. gerardiana*

Dhar (1978) has reported 8 species of gymnosperms from the Kashmir Himalaya. Among these 6 species *viz*. *Pinus wallichiana*, *P. excelsa*, *Cedrus deodara*, *Picea smithiana*, *Abies pindrow*, *Taxus baccata* are distributed along temperate and subalpine region, while the rest 2 species i.e., *Juniperus communis* and *Juniperus recurva* are distributed along subalpine to alpine region. Javeid (1979) has reported 19 species of gymnosperms belonging to 19 genera in 4 orders and 5 families under a single class Gymnospermae from the Kashmir Himalaya. Out of these, 3 species are grown as ornamentals, while the rest occur as wild (Table 8). Lancaster (1980) has reported 6 species of gymnosperms from Kashmir *viz*. *Abies pindrow*, *Pinus wallichiana*, *Taxus wallichiana*, *Picea smithiana*, *Juniperus communis* spp. *Montana* (*nana*), and *Juniperus macropoda*. The specimens of these taxa have been collected from Lidder valley, Gulmarg and Lashpatri, Sonamarg and Vishensar in Sind valley regions of Kashmir. Polunin and Stainton (1984) have reported 22 species of gymnosperms belonging to 11 genera and 5 families from the entire Himalayan region (Table 9). Bhat (1984) has reported 5 species of gymnosperms (*Pinus wallichiana*, *Picea smithiana*, *Cedrus deodara*, *Abies pindrow* and *Juniperus communis*) from Gulmarg area. These are distributed along forest slopes from Tangmarg to Khillanmarg.

Mehra (1988) has described 38 species of gymnosperms belonging to 13 genera from India. Out of these, 29 species falling into 11 genera have been treated under conifers and the rest 9 species belonging to 2 genera have been treated under Gnetophytes (Table 10). Conifers are mostly confined to Himalaya especially in north-west and western regions. Pinaceae among conifers has the maximum representation with 14 species in 2 genera. Cephalotaxaceae, Podocarpaceae and Taxaceae are each represented by a single genus with 2 species each in the first two and only one species in last one. Taxodiaceae and Araucariaceae are not represented in wild. Out of total, 15 species of gymnosperms belonging to 7 genera have been reported from the Kashmir Himalaya. Among these, 12 species belonging to 6 genera fall under conifers and the rest 3 species belonging to 1 genus fall under Gnetophytes.

Sahni (1990) has reported 61 species of gymnosperms belonging to 16 genera in 8 families from the Indian sub-continent. Out of these, 54 species belonging to 15 genera in 8 families have been cited from India; these includes 23 species belonging to 8 genera in 4 families reported from the Kashmir Himalaya (Table 11).

Singh and Kachroo (1994) have reported 7 species of gymnosperms belonging to 6 genera in 3 families from the Pir Panjal range. These are as follows:

Pinaceae:

Abies - *A. pindrow*
Cedrus - *C. deodara*
Pinus - *P. wallichiana*

Cupressaceae:

Juniperus - *J. communis, J. recurva*
Picea - *P. smithiana*

Taxaceae:

Taxus - *T. baccata*

Table 7. Gymnosperm taxa reported from Pakistan and Kashmir (Stewart, 1972)

Name of order	Family		Genus		Species		Taxa cited from Kashmir Himalaya
	Number	Name	Number	Name	Number	Name	
Cycadales	-	-	2	Cycas	2	*C. revoluta*	
						C. rumphii	-
				Zamia	1	*Z. integrifolia*	-
Ginkgoales	-	-	1	Ginkgo	1	*G. biloba*	-
Ephedrales	-	-	1	Ephedra	9	*E. ciliata*	*E. gerardiana*
						E. gerardiana	(Kashmir, 5500-17000f).
						E. intermedia	*E. intermedia* var. tibetica (Kashmir).
						var. *gluaca*	*E. pachyclada* (W. Tibet, probably Ladakh).
						E. intermedia	*E. procera* (Kishtwar).
						var. *tibetica*	*E. przewalskii* (Nanga Parbat).
						E. pachyclada	*E. regeliana* (Ladakh).
						E. procera	
						E. przewalskii	
						E. regeliana	
						E. sarcocarpa	
						E. monosperma.	
Coniferales	4	Pinaceae	4	Abies	2	*A. pindrow*	*A. pindrow*
						A. spectabilis	(Afghanistan to Kumaon, 7-10000f).
						A. spectabilis	(Afghanistan to Bhutan, 8-13000f).
				Cedrus	1	*C. deodara*	*C. deodara* (Kashmir, 4-10000f).
				Picea	1	*P. smithiana*	*P. smithiana* (Kashmir, 6-11000f).
				Pinus	4	*P. gerardiana*	*P. gerardiana* (Kishtwar).
						P. roxburghii	*P. roxburghii* (Afghanistan to Bhutan 1500-6000f).
						P. wallichiana	
						P. halepensis	
		Taxodiaceae	1	Taxodium	1	*T. mucronatum*	-
		Araucariaceae	1	Araucaria	1	*A. cookie*	-
		Cupressaceae	3	Cupressus	5	*C. funebris*	
						C. lusitanica	
						C. macrocarpa	
						C. sempervirens	
						C. torulosa	-
				Juniperus	5	*J. communis*	*J. communis* var. saxatilis (Dras, Ladakh,
						var. *saxatilis*	Kashmir 8-14000f).
						J. excelsa	*J. squamata* (Kashmir 8-14000f).
						J. squamata	*J. turkistanica* (Nanga Parbar).
						J. turkistanica	*J. wallichiana* (Kishtwar, chiefly east of Kashmir).
						J. wallichiana	
				Thuja	1	*T. orientalis*	-
Taxales	-	-	1	Taxus	1	*T. wallichiana*	*T. wallichiana* (Poonch, Kashmir 6-11000f).
Total = 5	4	-	14	-	35	-	17

Ara *et al*. (1995) have reported 295 indigenous and exotic species in 12 genera under 60 families from the Kashmir Valley. Out of these, 18 species in 11 genera under 5 families belong to gymnosperms; 15 species in 10 genera under 5 families being trees and the remaining 3 species in one genus being shrubs. Further out of these gymnosperms, 9 species in 6 genera and 4 families are exotic, while the remaining 9 species in 7 genera and 3 families are indigenous to Kashmir (Table 12). Dar *et al*. (2002) have reported 26 species (both wild as well as cultivated) of gymnosperms belonging to 12 genera and 6 families from the Kashmir valley. These are as follows:

Wild growing gymnosperms in Kashmir

Cupressaceae:

Cupressus - *C. torulosa*
Juniperus - *J. communis, J. semiglobosa, J. squamata*

Ephedraceae:

Ephedra - *E. gerardiana*

Pinaceae:

Pinus - *P. wallichiana, P. roxburghii*
Abies - *A. pindrow, A. spectabilis*
Cedrus - *C. deodara*
Picea - *P. smithiana*

Taxaceae:

Taxus - *T. wallichiana*

Exotic gymnosperms grown as ornamentals in Kashmir

Cupressaceae:

Cupressus - *C.arizonica, C. cashmeriana, C. corneyana, C. glabra, C. guadalupensis, C. sempervirens*
Juniperus - *J. chinensis*
Thuja - *T. orientalis*

Ginkgoaceae:

Ginkgo - *G. biloba*

Pinaceae:

Pinus - *P. canariensis, P. halepensis, P. radiata*

Taxodiaceae:

Cyptomeria - *C. japonica*
Sequoiadendron - *S. giganteum*

Khan (2002) has reported 5 species of gymnosperms in 5 genera belonging to 3 families from Bijhama (Uri) and its adjacent areas in Kashmir as below:

Pinaceae:

Pinus - *P. wallichiana*
Cedrus - *C. deodara*
Abies - *A. pindrow*

Taxaceae:

Taxus - *T. baccata*

Ephedraceae:

Ephedra - *E. gerardiana*

Table 8. Gymnosperm taxa reported from Kashmir Himalaya (Javeid, 1979)

Name of order	Family		Genus		Species		Distribution in the Kashmir Himalaya
	Number	Name	Number	Name	Number	Name	
Ginkgoales	-	-	1	Ginkgo	1	*G. biloba*	Lanlmandi garden (cultivated).
Ephedrales	-	-	1	Ephedra	3	*E. gerardiana* *E. vulgaris* *E. intermedia*	Gurez, Jhelum and Sind valley. Srinagar, Ldakh, Zanskar. Gurez.
Coniferales	2	Pinaceae	4	Pinus	4	*P. wallichiana* *P. roxburghii* *P. gerardiana* *P. halepensis*	Gurez, Jhelum, Lolab and Sind valley, Gulmarg, Pahalgam. Chenab Valley, Shankarachaya Hill (planted). Chenab Valley. Shankaracharya (planted).
				Picea	1	*P. smithiana*	Gurez, Jhelum, Lolab and Sind valley.
				Abies	1	*A. pindrow* *A. spectabilis*	Gurez, Jhelum, Lolab and Sind valley. Common in eastern Himalaya and also reported from western Himalaya.
				Cedrus	1	*C. deodara*	Gurez, Jhelum, Lolab and Sind valley.
		Cupressaceae	2	Cupressus	1	*C. torulosa*	Srinagar (planted).
				Juniperus	3	*J. communis* *J. squamata* *J. wallichiana*	Gurez, Drass, Jhelum, Lolab and Sind valley. Common and often with J. communis above the tree line. Keran, Kishtwar.
				Thuja	1	*T. orientalis*	Kashmir Valley (planted).
Taxales	1	Taxaceae	1	Taxus	2	*T. wallichiana* *T. baccata* subsp. *wallichiana*	Gurez, Jhelum, Lolab and Sind valley.

Table 9. Gymnospermous taxa reported from Kashmir Himalaya (Polunin and Stainton, 1984)

Name of family	Genus		Species		Distribution
	Number	Name	Number	Name	
Ephedraceae	1	Ephedra	1	*E. gerardiana*	Afghanistan to Bhutan.
Pinaceae	6	Pinus	3	*P. wallichiana*	Afghanistan to South Tibet.
				P. roxburghii	Afghanistan to Bhutan.
				P. gerardiana	Afghanistan to Uttar Pradesh.
		Cedrus	1	*C. deodara*	Afghanistan to West Nepal.
		Picea	2	*P. smithiana*	-
				P. spinulosa	Afghanistan to Nepal.
		Tsuga	1	*T. dumosa*	-
		Abies	3	*A. pindrow*	Afghanistan to West Nepal.
				A. spectabilis	Afghanistan to Bhutan.
				A. densa	-
		Larix	2	*L. griffithiana*	-
				L. himalaica	- Tibet.
Taxodiaceae	1	Cryptomeria	1	*C. japonica*	-
Cupressaceae	2	Cupressus	2	*C. arizonica*	-
				C. corneyana	-
		Juniperus	5	*J. communis*	Afghanistan to Nepal.
				J. recurva	Pakistan to South-west China.
				J. squamata	Pakistan to South-west China.
				J. indica	Pakistan to South-west China
				J. macropoda	Pakistan to Uttar Pradesh
Taxaceae	1	Taxus	1	*T. wallichiana* subsp. wallichiana	Afghanistan to Southwest China

Table 10. Gymnospermous taxa reported from Kashmir Himalaya (Mehra, 1988)

Name of order	Family		Genus		Species		Chromosome no.	Distribution
	Number	Name	Number	Name	Number	Name		
Coniferales	3	Pinaceae	4	Pinus	3	*P. gerardiana*	2n = 24	Inner ranges of Northwest Himalaya (1100-3300m).
						P. roxburghii	2n = 24 n = 12	Northwest Himalaya Bhutan to Afghanistan (500-2500m). Northwest temperate Himalayan
						P. griffithii	2n = 24 n = 12	forests (200-3000m).
				Cedrus	1	*C. deodara*	2n = 24 n = 12	Throughout western Himalaya (1300- 3200m), extending from Afghanistan to Garwhal.
				Picea	1	*P. smithiana*	2n = 24	Western Himalaya, Nepal to Afghanistan.
				Abies	2	*A. pindrow*	2n = 24	Western Himalaya, Nepal to Afghanistan
						A. spectabilis	n = 12	(2400-2700m). Inner west Himalayan ranges at higher elevations than that of A. pindrow.
		Cupressaceae	1	Juniperus	4	*J. macropoda*	2n = 22	Western Himalaya, Sonamarg.
						J. communis	2n = 22	Western Himalaya, Baltal.
						J. pseudo-sabina	2n = 22	Western Himalaya, from Kashmir (Baltal) to
						J. squamata		Kumoan. Western Himalaya.
		Taxaceae	1	Taxus	1	*T. wallichiana*	n = 12	Himalaya (2000-3000m), Afghanistan to Bhutan.
Gnetophytes	1	Ephedraceae	1	Ephedra	3	*E. intermedia*	n = 14	Kashmir.
						var. tibetica	2n = 28	
						E. gerardiana	n = 14	Kashmir.
						var. wallichii	n = 14	
						E. saxatilis	2n = 22	Zanaskar, South Tibet.

Khanday (2002) has reported 3 species of gymnosperms belonging to 3 genera and 2 families from Lower-Mundah and its adjacent area in Kashmir as below:

Pinaceae:
Abies - *A. pindrow*
Pinus - *P. wallichiana*

Taxaceae:
Taxus - *T. wallichiana*

Khuroo (2003) has documented 5 species of gymnosperms belonging to 5 genera in 2 families from Langate (Kupwara) as below:

Pinaceae:
Pinus - *P. wallichiana*
Cedrus - *C. deodara*
Abies - *A. pindrow*
Picea - *P. smithiana*

Taxaceae:
Taxus - *T. wallichiana*

Dar (2004) has cited a total of 20 species of gymnosperms belonging to 12 genera in 6 families from the Kashmir valley. Of these, 9 species in 7 genera ad 5 families occur in cultivation only (Table 13). The conifers, with 16 species in 9 genera and 3 families form the most dominant group. Among families, Pinaceae with 7 species in 4 genera is highest represented, while as Ginkgoaceae with 1 species is least represented.

Dar and Dar (2005) described gymnosperm specie *viz*. *Taxodium distichum* from the Kashmir Himalaya. Dar and Dar (2006) reported 16 species spread over 9 genera in 3 families of conifers from Kashmir Himalaya. They stated that family Pinaceae is dominant with 7 species and Taxodiaceae is represented by 2 species only. Further, 7 species in 5 genera have been reported to exist in cultivation. Dar and Dar (2011) updated information on *Sequoiadendron giganteum* growing in Tangmarg area of Kashmir.

Singh *et al*. (2018) documented *Juniperus chinensis* from Gurez valley in the innermost northern part of Kashmir Himalaya. Their findings suggest an extension of known geographic distribution of this species from central and southeast Asia to south Asia hence strongly supporting a relationship between northern Himalayan range of India and southern hill ranges of China.

Table 11. Gymnosperm taxa reported from Kashmir Himalaya (Sahni, 1990)

Name of family	Genus		Species		Distribution
	Number	Name	Number	Name	
Taxaceae	1	Taxus	1	*T. baccata*	Himalaya: Pakistan to Arunachal Pradesh (1800-3700m).
Pinaceae	4	Pinus	3	*P. wallichiana*	Himalaya: Pakistan to Arunachal Pradesh (1800-3700m).
				P. gerardiana	Bashahar westwards to Kashmir Chitral.
				P. roxburghii	Himalaya: Pakistan to Arunachal Pradesh (450-2300m).
		Cedrus	1	*C. deodara*	Afghanistan, Kashmir.
		Picea	1	*P. smithiana*	Western Himalaya from Afghanistan to Kumaon (2150-3200m).
		Abies	2	*A. pindrow*	Western Himalaya to Nepal (2300-3300m).
				A. spectabilis	Himalaya: Pakistan to Arunachal Pradesh, Tibet, commonly at (3300-4000m).
Cupressaceae	2	Juniperus	6	*J. polycarpos*	Kashmir, western Tibet (2500-4300m).
				J. recurva	Himalaya: inner valleys to Arunachal Pradesh.
				J. communis	Kumaon westwards to Afghanistan.
				J. squamata	Afghanistan, Himalaya.
				J. indica	Northeast Burma.
				J. turkistanica	Himalaya: Indus to Sikkim, Bhutan Naga Parbat.
		Cupressus	2	*C. corneyana*	Tibet.
				C. cashmeriana	Unknown in wild, Ladakh (?).
Gnetaceae	1	Ephedra	7 + 3 var	*E. przewalskii*	Nanga Parbat, Ladakh
				E. pachyclada	Chitiral, Kurram valley.
				E. regeliana	Karakorum, Ladakh.
				E. gerardiana	Karakorum, Chitral, Gilgit, Baltistan, Kashmir, Ladakh, Zanskar.
				E. saxatilis var. sikkimensis	Tibet.
				E. nebrodensis var. procera	Kashmir.
				E. intermedia var. tibetica	Ladakh.

Results and Discussion

In present study through examination of herbarium specimens, literature investigation and extensive field surveys a total of 25 species of gymnosperms belonging to 13 genera, 6 families and 4 orders were documented from the Kashmir Himalaya (Table 16). Out of these, 11 species in 7 genera, falling within 4 families and 3 orders occur in wild (Table 14). The conifers with 9 species in 5 genera and 2 families form the most dominant group. Among families Pinaceae with 6 species in 4 genera is highest represented while Taxaceae with 1 species is least represented. It has been found that over the years several species of gymnosperms have been introduced and cultivated in gardens, parks, bare rocky

Table 12. Gymnosperm taxa reported from Kashmir Himalaya (Ara *et al*., 1995)

Name of family	Genus		Species		Distribution in Kashmir Himalaya
	Number	Name	Number	Name	
Ginkgoaceae	1	Ginkgo	1	G. biloba	Lalmandi.
Pinaceae	3	Pinus	4	*P. canariensis*	Shankaracharya.
				P. roxburghii	Uri, University Campus.
				P. halepensis	Shankaracharaya park, Bandipora, University
				P. radiata	Botanical Garden, Gulmarg. Shankaracharya.
		Cedrus	1	*C. deodara*	On lower altitudes in almost all forests, Chitarnar.
		Picea	2	*P. smithiana*	Afghanistan to Nepal
				P. spinulosa	-
		Abies	1	*A. pindrow*	All forest divisions, Yusmarg Dachigam, Tangmarg, Aharbal.
Taxodiaceae	2	Cryptomeria	1	*C. japonica*	University Botanical Garden, Shankaracharya.
		Sequoiadendron	1	*S. giganteum*	One old tree in Drug Research Farm Tangmarg.
Cupressaceae	2	Cupressus	3	*C. arizonica*	Parks and Gardens, University Campus. Parks and Gardens,
				C. sempervirens	University Campus. Generally growing between
				C. torulosa	2000-3000m, Chitarnar.
		Juniperus	3	*J. communis*	Zaberwan, Harwan,
				J. squamata	Parimahal, Gadsar, Wakulwan.
				J. wallichiana	Common above tree line, Gadsar. Gadsar, Apharwat.
		Thuja	1	*T. orientalis*	Gardens, Parks, Srinagar, Bandipora.
Taxaceae	1	Taxus	1	*T. wallichiana*	Zaberwan, Dachigam.

Table 13. List of Gymnosperm taxa reported from Kashmir Himalaya (Dar, 2004)

Name of order	Name of family	Name of genus	Name of species	Wild growing	Cultivated
		Pinus	*P. wallichiana*	+	-
			P. roxburghii	+	-
			P. halepensis	-	+
		Picea	*P. smithiana*	+	-
		Cedrus	*C. deodara*	+	-
		Abies	*A. spectabilis*	+	-
			A. pindrow	+	-
		Cryptomeria	*C. japonica*	-	+
		Sequoiadendron	*S. giganteum*	-	Single tree growing in Yarikhah Drug farm
		Cupressus	*C. torulosa*	-	+
			C. cashmeriana	-	+
			C. sempervirens	-	+
		Juniperus	*J. communis*	+	-
			J. squamata	+	-
			J. semiglobosa	+	-
		Thuja	*T. orientalis*	-	-
Taxales	Taxaceae	Taxus	*T. wallichiana*	+	Single shrub growing in Botanical garden
			T. baccata	-	Kashmir University
Ephedrales	Ephedraceae	Ephedra	*E. gerardiana*	+	-
Ginkgoales	Ginkgaoceae	Ginkgo	*G. biloba*	-	+
Total= 4	6	12	20	11	9

slopes and road sides in the State. Out of the total gymnosperms in our State, 14 species in 8 genera and 4 families and 2 orders occur in cultivation only (Table 15). Out of these, order Coniferales represents the dominant proportion with 13 species in 7 genera and 3 families while Ginkgoales is represented by only 1 species. Family Cupressaceae is most dominant with 9 species in 3 genera while as Ginkgoaceae is least represented (Table 15).

There is considerable difference of opinion as to whether there are one, two or more species of Himalayan silver firs. According to Troup (1921) the specific distinction in the Himalayan Silver fir is controversial in spite of the fact that two forms (*A. pindrow* Royle and *A. spectablis* Spach.) were raised true to seed. Turrill (1937) forwarded an explanation that it might be due to earlier evolutionary conditions from which *Abies alba* separated northwards and *Abies cephalonica* southwards through loss of different genes. Turrill's suggestion does not appear to be likely in the case of *Abies spectabilis* and *Abies pindrow*, as it involves the supposition that a new species is being evolved in more or less isolated locality. As per Brandis (1921) the low-level fir changes to high level species on ascending to higher ranges. Elwas and Henry (1906-1913) treated *A. spectabilis* Spach. as a mere variety of *A. pindrow* (*A. pindrow var brevifolia*).

Parker (1940) stated that the two species *viz. A. pindrow* and *A. spectablis* hybridize rather freely and that, in consequence, it is not always possible to make a sharp distinction between them. It seems likely that before the ice age there were two distinct Silver firs in the Northwest Himalaya and that during ice age they were forced to migrate. If change in climate was sufficiently rapid, one species might have invaded the zone of other and hybridization would have resulted in a mixed population with perhaps more or less complete submergence locally of one or the other species. As per author what is now occurring may be separation of the hybrid population into two species similar to original ones. The suspected hybrids can be recognized by upcurved tips of branches and trees with this character usually also show the hairy shoots of *A. spectabilis*, but they do not always do so. Parker further states that at some places there appears to be a polymorphic population showing the combination of these characters and this appears to be comparable with the intergrading of *A. alba* and *A. cephalonia* in Europe. This has been suggested to be due to hybridization. *Abies densa* Griff. which is treated as a separate species, is considered by

Table 14. Gymnosperms growing as wild in Kashmir Himalaya

Name of order	Name of family	Name of genus	No. of species	Name of species
Coniferales	Pinaceae	Pinus	2	*P. wallichiana*
				P. roxburghii
		Cedrus	1	*C. deodara*
		Picea	1	*P. smithiana*
		Abies	2	*A. pindrow*
				A. spectabilis
	Cupressaceae	Juniperus	3	*J. cummunis*
				J. squamata
				J. semiglobosa
Taxales	Taxaceae	Taxus	1	*T. wallichiana*
Ephedrales	Ephedraceae	Ephedra	1	*E. gerardiana*
Total = 3	4	7	11	

Table 15. Gymnosperms existing in cultivation in Kashmir Himalaya

Name of order	Name of family	Name of genus	No. of species	Name of species
Coniferales	Pinaceae	Pinus	1	*P. halepensis*
	Cupressaceae	Cupressus	6	*C. torulosa*
				C. cashmeriana
				C. guadalpensis
				C. gigantea
				C. sempervirens
				C. arizonica
		Juniperus	2	*J. chinensis*
				J. horizontalis
		Thuja	1	*T. occidentalis*
	Taxodiaceae	Cryptomeria	1	*C. japonica*
		Sequoia-dendron	1	*S. giganteum*
		Taxodium	1	*T. distichum*
Ginkgoales	Ginkgoaceae	Ginkgo	1	*G. biloba*
Total = 2	4	8	14	

Table 16. Summary of gymnosperm flora of Kashmir Himalaya

Name of family	Total number of genera	No. of genera in wild	No. of genera in cultivation	Total no. of species	No. of species existing in wild	No. of species existing in cultivation
Pinaceae	4	4	1	7	6	1
Cupressaceae	3	1	3	12	3	9
Taxodiaceae	3	0	3	3	0	3
Taxaceae	1	1	0	1	1	0
Ephedraceae	1	1	0	1	1	0
Ginkgoaceae	1	0	1	1	0	1
Total= 06	13	7	8	25	11	14

Dallimore and Jackson (1948) as a synonym of *Abies spectabilis* Spach. but Raizada and Sahni (1960) on the basis of their study of herbarium material are inclined to regard them as two distinct species.

Rao (1953) stated that hybridisation between *A. spectabilis* and *A. pindrow* in going on even today, because the zonal difference is narrow and Abies pollen is wind-dispersed. He argued that Turrill's idea corresponds to the concept of the cline (topocline, ecoline) but his postulate, 'loss of different genes' seems uncalled for. What he probably means is adapted mutations for a northern or a southern situation which after natural selection culminated in the divergence of two species. Yet these two species are compatible in hybridization, hence the intergrading forms. Parker wrongly interpret Turrill when he says, 'it involves the supposition that a new species is being evolved in a number of more or less isolated localities". Turill does not refer to present day divergence and species promotion but to an 'earlier evolutionary conditions'. If Parker is correct in doubting whether *A. spectabilis* and *A. pindrow* are two different species at all, then the altitudinal clinal concept will hold good, the two species being considered as only two clinal races which are quite compatible in hybridity. He further states that Parker's speculation that there were two distinct species before the ice age which hybridized under ice age conditions and that subsequent hybridizations is going on till today seems quite unnecessary. The hybridizations are going on today because the zonal difference is narrow and the *Abies* pollen is wind-dispersed. This question might be solved by raising self pollinated progeny of suspected hybrids and studying the segregation, if any.

Also, a lot of confusion exists regarding the *Juniperus* sp. occurring in the Kashmir Himalaya. Hooker (1888), Gamble (1902) and Parker (1924) recognized two species of *Juniperus* with scaly leaves occurring in the Himalaya *viz*., *J. pseudosabina* and *J. macropoda*. Hooker regarded *J. wallichiana* as synonymous of *J. pseudosabina*. However, Brandis (1874) recognized *J. pseudosabina* and *J. wallichiana* as separate species. These authors are of the view that *Juniperus wallichiana* is an evergreen tree attaining a height of 18m in Sikkim, but is a gregarious shrub in north-west Himalaya. Dallimore and Jackson (1966) hold the view that *J. pseudosabina* does not occur in India and the species that has been reported as occurring under this name is *J. wallichiana*. They have treated *Juniperus coxii* as a variety of *J. recurva*. However, none of the authors gave satisfactory criteria for delimitation of these two species.

Conclusion

In *Abies* complex, besides its two-parent species - *A. pindrow* and *A. spectabilis* there exist swarms of hybrids between these two species. These hybrids show various degrees of intermediacy in characters, such as bark, leaves (arrangement, apex notching, margin recurving, groove prominence), cone characteristic (axis length, thickness, swollen or pointed tips). In case of *Juniperus* complex, it has been found that *J. recurva* reported by previous workers (Sahni, 1990; Singh and Kachroo, 1976; Gaussen, 1968; Gamble, 1902; Hooker, 1888) from our area is actually *Juniperus squamata*. Furthermore, *J. macropoda* reported from northern Himalaya under various names (e.g *J. excelsa*, *J. polycarpos*) by various workers (Sahni, 1990; Raizada and Sahni, 1960; Lambert, 1933; Parker, 1918) has been found to be actually *J. semiglobosa*, an entirely distinct species. *J. pseudosabina* has been reported from Kashmir by many previous workers (Mehra, 1988; Gaussen, 1968; Lambert, 1933; Gamble, 1902; Hooker, 1888), but we have not found it in the valley. Also, *Juniperus chinensis* reported by Singh *et al*. (2018) to exist in wild in Kashmir Himalaya is doubtful, as it has been recorded to exist in cultivation only.

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