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FIRST INSIGHTS INTO THE FLORISTIC DIVERSITY, BIOLOGICAL SPECTRA AND PHENOLOGY OF MANOOR VALLEY, PAKISTAN

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Abstract

To assess floristic composition, phenology, leaf and biological spectrum of an unexplored remote valley (Manoor Valley), frequent field visits were arranged in different growing seasons during 2015-17. Plant specimens were collected, identified and deposited to the Herbarium at Hazara University, Mansehra. Plants were classified into life form, and leaf sizes classes were determined. The floristic diversity consisted of 307 plant species belonging to 81 families. Asteraceae was the leading family with 31 species, followed by Rosaceae with 22 species, and Lamiaceae with 20 species respectively. An additional, 78 families had fewer than 20 species. Herbaceous growth form contributed maximum with 228 spp. (74.27%), followed by shrubs with 45 spp. (14.66%) and trees with 34 spp. (11.07%) respectively. On the basis of the life form spectrum, our results indicated that the flora was dominated by Therophytes (104 spp., 33.88%), followed by Hemicryptophytes (87 spp., 28.34%), Nanophanerophytes (41 spp., 13.36%), Chamaephytes (24 spp., 7.82%), Mesophanerophytes (20 spp., 6.51%), Geophytes (13 spp., 4.23%), Megaphanerophytes (9 spp., 2.93%), Microphanerophytes (5 spp., 1.66%), and Lianas (3 spp., 0.98%)respectively. Whereas, one parasitic plant species (*Cuscuta reflexa*) was also found and collected. In leaf spectra, Nanophyll dominated the study area with 92 spp. (29.97%), followed by Microphyll (86 spp., 28.01%), Leptophyll (59 spp., 19.22%), Mesophyll (49 spp., 15.96%), and Megaphyll (17 spp., 5.54%)respectively.Moreover,4species (1.30%) were found Aphyllous *i.e., Cuscuta reflexa, Ephedra girardiana, Equisetum arvense* and *Periploca aphylla*. Phenological behavior revealed that July marks the peak of flowering season in 80 plant species (26.06%), followed by June where 77 species (25.08%) had flowering. The fruiting data showed that September month was the peak fruiting season (25.41%) in 78 plant species, followed by August (22.80%) in 70 species. In the present study, a list has been launched of all the possible plants present in this unexplored area, which could serve as a vital resource for all future endeavors in the field of phytosociological studies, phytochemical, and pharmacological activities and conservation of natural resources.

Key words: Floristic composition, Biological spectrum, Phenology, Manoor Valley, Pakistan.

Introduction

The word biodiversity is a contraction of the phrase "biological diversity". In 1985, Walter G. Rosen coined and defined biodiversity as "life that flourish on the earth surface" (Ijaz, 2014). Biodiversity is the life that flourishes on the earth surface. According to him all ecosystems and life forms comprise parts of biodiversity (Jenkins, 2003). Various kind of raw materials such as medicines (Khan *et al.,* 2017; Muhammad *et al.,* 2017), food, fertilizers, shelter, fiber for clothing and sources of energy are directly linked to biodiversity (Ijaz *et al.,* 2017a,b). The maintenance of balance in plant biodiversity has a significant role for human survival (Jeffries, 1997). Biodiversity generally focuses on the species diversity (Ahmad *et al.,* 2016) and measurement on the species level, which is one of the key objectives used for the elevation of ecosystem at different scales (Ardakani, 2004). Biodiversity is facing serious challenges due to anthropogenic activities like deforestation and over grazing (Ijaz, 2014). Vegetation is an umbrella term indicates plant life of a region, where as flora represent particularly to species composition. Vegetation is directly or indirectly affected by human activities in the form of experiments (A.U. Rahman *et al.,* 2016), structural parameters, practices and removal of these species due to crown density that prevent light exposure (Aude & Lawesson, 1997).

Floristic diversity and its biological spectra rely on topography and elevation. Plant-life characters like life form leaf, size spectra, and phenological traits mirror the existing ecological and natural surroundings conditions. Listing of species has dependably been a pre-essential for any biological and/or plant assets administration. Durrani *et al.* (2005) reported 202 plant species of 45 families with Therophytes and Hemicryptophytes as the dominant life form whereas Leptophylls, Nanophylls and Microphylls were dominant leaf-sizes from Harboi rangeland, Kalat. Hussain *et al*., (2015) reported 571 species of 81 families with Therophytes as the dominated life form and leaf size spectra as Nanophyllous from Mastuj Valley, Chitral. Shaheen *et al.* (2016) cited 205 plants of 78 families with therophytes as the dominated life form and Microphyll was dominant leaf size from Tehsil Havelian (Abbottabad), Pakistan.

This study was designed to explore the floristic composition, life form and leaf spectra and phenology of an unexplored remote valley (Manoor Valley). Further, this study provides first insights into the floristic diversity of this area, which is vital for the conservation of natural resources and might be supportive for future researchers.

Study area: There are two sub-valleys in Kaghan Valley *i.e.,* Naran Valley and Manoor Valley. Naran Valley is located in upper Kaghan Valley while Manoor Valley is reached from the main Kaghan Valley road at the junction 'Mahandri' (Fig. 1) and is about 50 Km north of Balakot

(I.U. Rahman *et al.*, 2016a,b). The Valley preserves its natural beauty with dozens of scenic locations, but lack of road facility masks the beauty of this valley from tourists. Furthermore, one of the most panoramic and beautiful lake "Ansoo Lake" is located in this Valley near Malika Parbat in the Himalayan range. Floristically, the valley is very rich, diverse and unexplored. To date, no references are available on floral studies of the area on any aspect except few reports of medicinal studies by I.U. Rahman *et al*., (2016a, b, c).

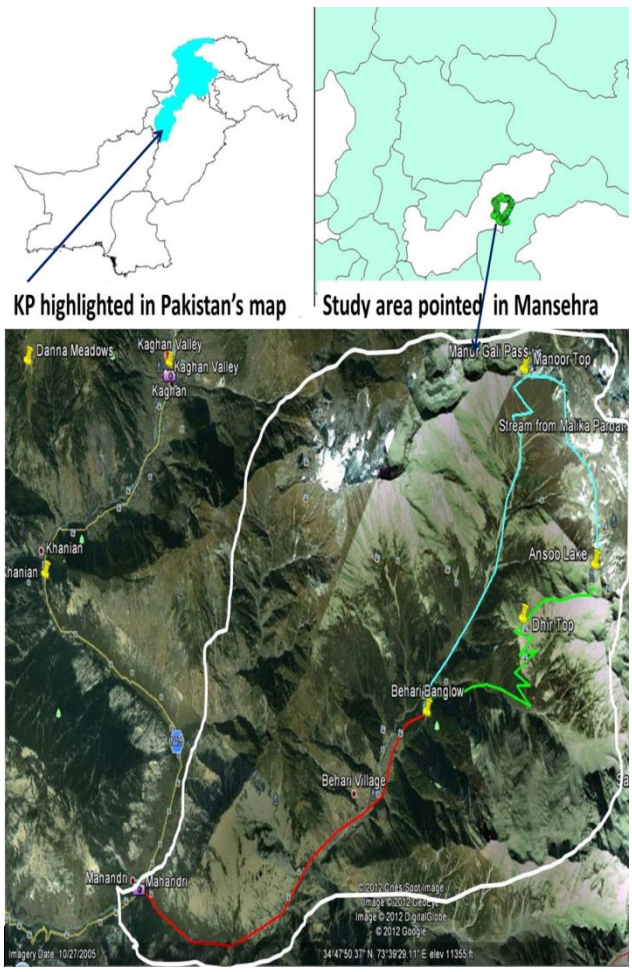

Fig. 1. Map of the study area. (*Source:* https://www.google.com/earth/).

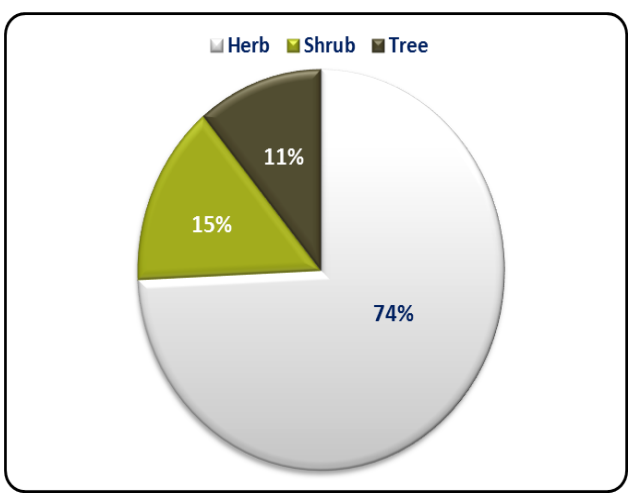

Fig. 2. Growth form of the plant species recorded from Manoor Valley.

Materials and Methods

Frequent field visits were arranged in different growing seasons during 2015-17. Field data was recorded in the field notebook; collected plant specimens were pressed, dried, poisoned and mounted on the herbarium sheets. Identification was carried out using the Flora of Pakistan (Nasir & Ali, 1971-1989; Ali & Nasir, 1989-1991; Ali & Qaiser, 1995-2017). The identified specimens were deposited in the Herbarium of Hazara University, Mansehra (HUP). Scientific name of Plant species were cross-checked and updated with the online website (www.theplantlist.org) of the Royal Botanic Gardens, Kew, accessed on 12 February, 2018. Plants were classified into life form and leaf sizes classes were determined following Raunkiær (1934); Hussain (1989). Phenological behavior of all recorded plant species was recorded during field surveys.

Results

Floristic composition: Floristic structure indicates the vegetation wealth of an area. Flora of the study area consisted of 307 plant species belonging to 81 families. In these 307 species, the dominating growth form was herbaceous having 228 spp., (74.27%), followed by shrubs with45 species (14.66%) and trees with 34 species (11.07%) respectively (Fig. 2). Asteraceae was the leading families with 31 species, followed by Rosaceae with 22 species, Lamiaceae with 20 species (Fig. 3). Poaceae and Papilionaceae had 17 and 16 species respectively, followed by Apiaceae with 14 species, Polygonaceae (10 species), Ranunculaceae (9 species) and Caryophyllaceae (7 species). Euphorbiaceae had 6 species each, followed by sixfamilies *i.e.*, Boraginaceae, Gentianaceae, Pinaceae, Plantaginaceae, Rubiaceae and Salicaceae with 5 species each. Furthermore, 4 species were shared by nine families each *i.e.* Adiantaceae, Amaranthaceae, Berberidaceae, Brassicaceae, Ericaceae, Malvaceae, Onagraceae, Primulaceae and Solanaceae each, followed by six families (Balsaminaceae, Crassulaceae, Cupressaceae, Oleaceae, Papaveraceae and Urticaceae) with 3 species each. Moreover, 21 families (Adoxaceae, Araceae, Araliaceae, Asclepiadaceae, Cannabaceae, Caprifoliaceae, Convallariaceae, Convolvulaceae, Cornaceae, Cyperaceae, Fagaceae, Geraniaceae, Hippocastanaceae, Mimosaceae, Orobanchaceae, Phytolaccaceae, Pteridaceae, Sapindaceae, Saxifragaceae, Thymelaeaceae and Violaceae) were represented by 2 species each. Whereas; the remaining 29 families had than 1 species (Table 1).

Life form: Biological spectra are vital physiognomic attributes that have been broadly used in vegetation analysis. In this study,ten different life forms were recorded (Fig. 4 and Table 2). The flora was dominated by Therophytes (104 spp., 33.88%), followed by Hemicryptophytes (87 spp., 28.34%), Nanophanerophytes (41 spp., 13.36%), Chamaephytes (24 spp., 7.82%), Mesophanerophytes (20 spp., 6.51%), Geophytes (13 spp., 4.23%), Megaphanerophytes (9 spp., 2.93%), Microphanerophytes (5 spp., 1.66%), and Lianas (3 spp., 0.98%) respectively. Moreover, one parasitic plant species (*Cuscuta reflexa*) was also found and collected (Table 1).

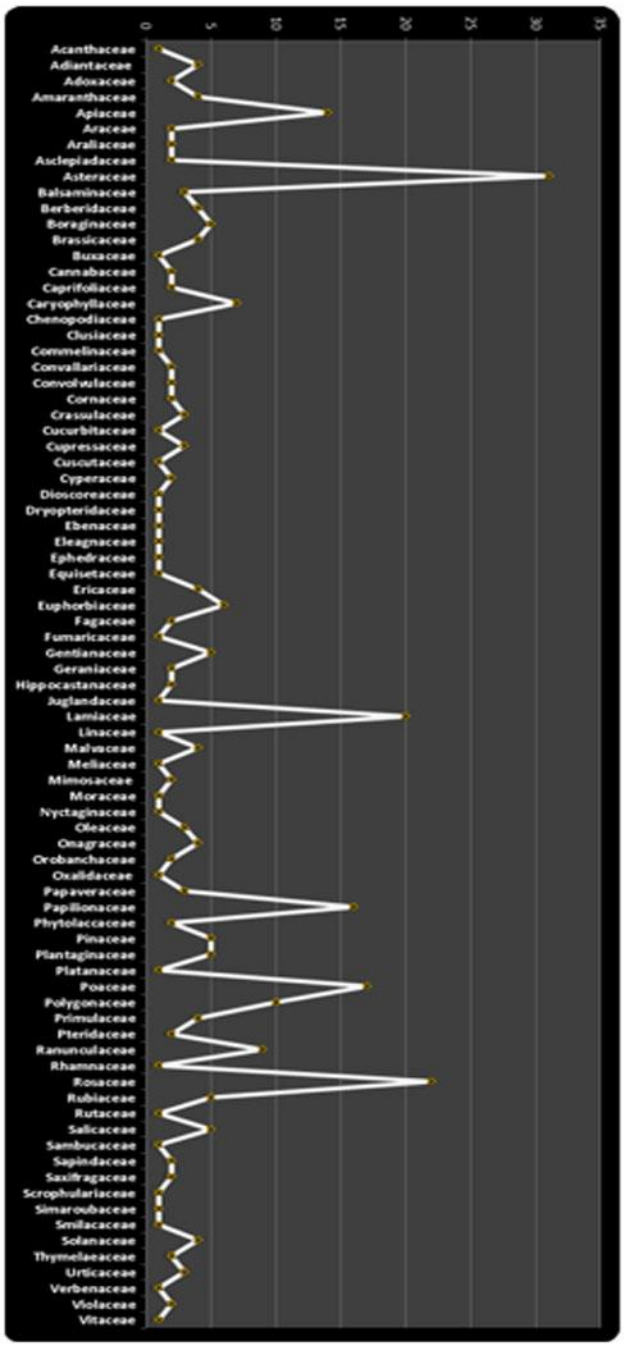

Fig. 3. Plant species family wise distribution of Manoor Valley.

Leaf spectra: On the basis of leaf spectra, the study area was dominated by Nanophyll and Microphyll with 92 spp. (29.97%) and 86 spp. (28.01%), followed by Leptophyll (59 spp., 19.22%), Mesophyll (49 spp., 15.96%), and Megaphyll (17 spp., 5.54%) respectively. Further,4 species (*Cuscuta reflexa*, *Ephedra girardiana*, *Equisetum arvense* and *Periploca aphylla*) were found Aphyllous (1.30%) (Fig. 5 and Table 2). The species with Microphyllous leaves were rich due to ecological variation and shows the percentage of different leaf form classes varied with rising altitude.

Phenological behavior: The flowering data showed that July marked the peak of flowering season where 80 (26.06%) plant species had flowers, followed by June with 77 (25.08%) species. In the May, flowering was observed in 49 (15.96%) species, followed by April where 36 (11.73%) species, August with 23 (7.49%) species, and September with 13 (4.23%) species in flowering stages. Moreover, in March and October9 (2.93%) species each were recorded with flowers while in February and November 3 (0.98%) species each were found in flowering and 2 (0.65%) species had flowering in December. Nonetheless, 3 (0.98%) species flowered throughout the year (Fig. 6 and Table 2).

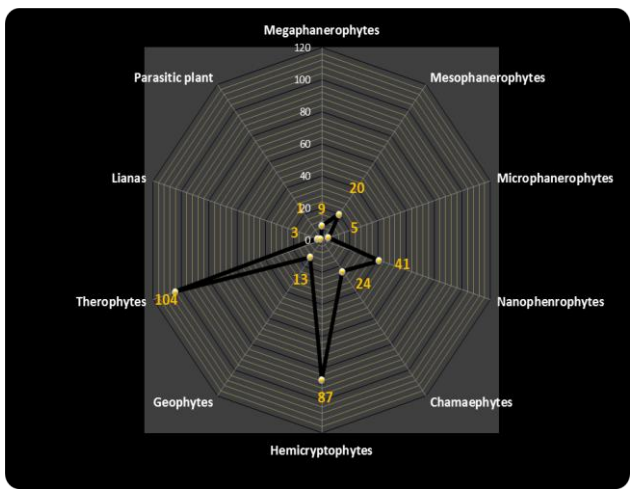

Fig. 4. Life Form of the plant species recorded from Manoor Valley.

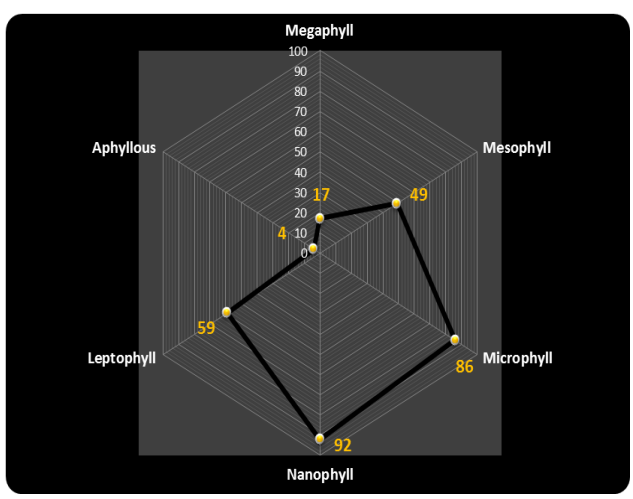

Fig. 5. Leaf Spectra of the plant species recorded from Manoor Valley.

The fruiting data showed that September was the peak fruiting season (25.41%) for 78 plant species, followed by August (22.80%) for 70 species (Fig. 6). In July, fruiting was observed in 50 species (16.29%) , followed by October with fruiting in 47 species (15.31%), June with fruiting in 21 species (6.84%), and May with fruiting in 18 species (5.86%). Furthermore, in November, fruiting was noticed in 11 species (3.58%), followed by April with fruiting in 4 species (1.30%) (Table 2). Finally, the month of February, 0.98% of fruiting was (3 species). Importantly, 3 species (0.98%) were seen with fruits throughout the year. The lowest percentage of fruiting was found in the months of March and December with 1 species (0.33%).

Table 1. Floristic composition, biological and leaf spectra as well as phenology of plants from the study area.

S. No.	Family name / Scientific name	Habit	Biological spectrum		Phenology	
			Life form	Leaf size	Flowering	Fruiting
	Acanthaceae					
1.	*Dicliptera bupleuroides* Nees	H	Th	N	Sept	Feb
	Adiantaceae					
2.	*Adiantum capillus-veneris* L.	H	G	N	July	Sept
3.	*Adiantum indicum* J. Ghatak	H	G	Me	July	Aug
4.	*Adiantum venustum* D. Don	H	G	N	June	Aug
5.	*Asplenium adiantum-nigrum* L.	H	HemC	N	July	Sept
	Adoxaceae					
6.	*Viburnum cotinifolium* D. Don	S	NanP	Ma	March	May
7.	*Viburnum grandiflorum* Wall. ex DC.	S	NanP	Ma	March	May
	Amaranthaceae					
8.	*Achyranthes aspera* L.	H	Th	N	May	July
9.	*Achyranthes bidentata* Blume	H	Th	Mi	Aug	Sept
10.	*Amaranthus viridis* L.	H	Th	Mi	Aug	Sept
11.	*Celosia argentea* L.	H	Th	N	Aug	Sept
	Apiaceae					
12.	*Aegopodium burttii* Nasir	H	HemC	Mi	June	July
13.	*Anthriscus nemorosa* (M.Bieb.) Spreng.	H	Th	Mi	April	Aug
14.	*Bupleurum gracillimum* Klotzsch	H	Th	N	June	Sept
15.	*Bupleurum longicaule* Wall. ex DC.	H	Th	N	June	Sept
16.	*Foeniculum vulgare* Mill.	H	Th	N	July	Sept
17.	*Heracleum candicans* Wall. ex DC.	H	HemC	L	April	June
18.	*Pimpinella stewartii* (Dunn) Nasir	H	Th	N	July	Sept
19.	*Pleurospermum brunonis* Benth. ex C.B. Clarke	H	HemC	L	June	Aug
20.	*Pleurospermum candollei* Benth.ex C.B. Clarke	H	HemC	L	July	Aug
21.	*Pleurospermum stellatum* (D. Don) Benth. ex C.B. Clarke	H	HemC	L	July	Aug
22.	*Pleurospermum stylosum* C.B. Clarke	H	HemC	L	July	Aug
23.	*Sanicula elata* Buch. -Ham. ex D. Don	H	Th	Mi	May	July
24.	*Seseli libanotis* (L.) W.D.J. Koch .	H	HemC	N	April	Aug
25.	*Torilis japonica* (Houtt.) DC.	H	Th	Mi	June	July
	Araceae					
26.	*Arisaema jacquemontii* Blume	H	HemC	Me	June	July
27.	*Sauromatum venosum* (Dryand. ex Aiton) Kunth	H	HemC	Me	May	Aug
	Araliaceae					
28.	*Aralia cachemirica* Decne.	H	HemC	Me	May	June
29.	*Hedera nepalensis* K. Koch	H	L	Me	Oct	April
	Asclepiadaceae					
30.	*Periploca aphylla* Decne.	S	NanP	Aph	May	July
31.	*Vincetoxicum petrense* (Hemsl. & Lace) Rech.f.	H	Ch	Ma	June	July
	Asteraceae					
32.	*Achillea millefolium* L.	H	Th	N	May	Sept
33.	*Ainsliaea aptera* DC.	H	HemC	Ma	Dec	June
34.	*Anaphalis busua* (Buch.-Ham.) DC.	H	HemC	N	Sept	Oct
35.	*Anaphalis contorta* (D.Don) Hook.f.	H	HemC	N	Sept	Oct
36.	*Anaphalis nepalensis* (Spreng.) Hand.-Mazz.	H	HemC	N	May	Sept
37.	*Artemisia absinthium* L.	H	Th	N	July	Aug
38.	*Carpesium nepalense* Less.	H	Th	N	June	Sept
39.	*Chrysanthemum indicum* L.	H	HemC	Mi	Oct	Nov
40.	*Cichorium intybus* L.	H	Th	N	July	Aug
41.	*Cirsium arvense* (L.) Scop.	H	Th	N	Aug	Oct
42.	*Cirsium falconeri* (Hook.f.) Petr.	H	Th	N	July	Aug
43.	*Conyza japonica* (Thunb.) Less.ex Less.	H	Th	Mi	July	Aug
44.	*Cyanthillium cinereum* (L.) H.Rob.	H	HemC	Mi	June	July
45.	*Erigeron canadensis* L.	H	Th	L	July	Aug
46.	*Galinosoga parviflora* Cav.	H	Th	Mi	July	Sept
47.	*Gerbera gossypina* (Royle) Beauverd	H	HemC	Mi	April	June
48.	*Inula cuspidata* (Wall. ex DC.) C.B. Clarke	H	Th	Mi	June	Sept
49.	*Inula falconeri* Hook.f.	H	Th	Me	June	Oct
50.	*Lactuca clarkei* Hook.f.	H	HemC	Me	May	Aug
51.	*Leucanthemum vulgare* Lam.	H	HemC	L	June	Sept
52.	*Ligularia amplexicaulis* DC.	H	HemC	Ma	May	Aug
53.	*Onopordum acanthium* L.	H	G	Me	April	June
54.	*Parthenium hysterophorus* L.	H	HemC	N	All the year	All the year
55.	*Senecio analogus* DC.	H	Th	Mi	Aug	Sept
56.	*Senecio chrysanthemoides* DC.	H	Th	Me	Oct	Nov

Table 1. (Cont'd.).

S. No.	Family name / Scientific name	Habit	Biological spectrum		Phenology	
			Life form	Leaf size	Flowering	Fruiting
57.	*Silybum marianum* (L.) Gaertn.	H	Ch	Me	March	June
58.	*Sonchus asper* (L.) Hill	H	Th	Mi	July	Aug
59.	*Tagetes minuta* L.	H	Th	Mi	Sept	Oct
60.	*Taraxacum campylodes* G.E. Haglund	H	HemC	Mi	May	Aug
61.	*Tussilago farfara* L.	H	Th	Me	Feb	May
62.	*Xanthium strumarium* L.	H	Th	Me	July	Sept
	Balsaminaceae					
63.	*Impatiens bicolor* Royle.	H	Th	Me	July	Sept
64.	*Impatiens brachycentra* Kar. & Kir.	H	Th	Mi	July	Sept
65.	*Impatiens* sp.	H	Th	Mi	Oct	Nov
	Berberidaceae					
66.	*Berberis lycium* Royle	S	NanP	L	June	July
67.	*Berberis pachyacantha* Bien. ex Koehne	S	NanP	L	Feb	July
68.	*Berberis parkeriana* C.K. Schneid.	S	NanP	L	Feb	July
69.	*Epimedium elatum* C. Morren & Decne.	H	Th	Me	April	May
	Boraginaceae					
70.	*Cynoglossum apenninum* L.	H	HemC	N	June	Aug
71.	*Cynoglossum glochidiatum* Wall. ex Benth.	H	HemC	N	June	Aug
72.	*Cynoglossum microglochin* Benth.	H	HemC	N	June	Aug
73.	*Pseudomertensia parviflorum* (Decne.) Riedl	H	HemC	N	May	July
74.	*Pseudomertensia trollii* Stewart & Kazmi	H	HemC	N	May	Aug
	Brassicaceae					
75.	*Brassica campestris* Dunn.	H	Th	Ma	June	July
76.	*Capsella bursa-pastoris* (L.) Medik.	H	Th	N	June	Aug
77.	*Erysimum melicentae* Dunn.	H	Th	Mi	July	Sept
78.	*Sisymbrium irio* L.	H	Th	N	April	June
	Buxaceae					
79.	*Sarcococca saligna* Mull. Arg.	S	NanP	Mi	Dec	March
	Cannabaceae					
80.	*Cannabis sativa* L.	H	Th	Mi	July	Sept
81.	*Celtis australis* L.	T	MesP	Ma	May	Aug
	Caprifoliaceae					
82.	*Lonicera caerulea* L.	S	NanP	Mi	March	May
83.	*Valeriana jatamansi* Jones	H	G	Me	May	July
	Caryophyllaceae					
84.	*Lepyrodiclis holosteoides* (C.A.Mey.) Fenzl ex Fisch. & C.A. Mey.	H	HemC	Mi	May	June
85.	*Minuartia biflora* L.	H	HemC	L	Aug	Sept
86.	*Minuartia kashmirica* (Edgew.) Mattf.	H	Ch	L	July	Sept
87.	*Silene conoidea* L.	H	Th	N	April	May
88.	*Silene vulgaris* (Moench) Garcke	H	Th	N	July	Sept
89.	*Stellaria media* (L.) Vill.	H	Th	N	Oct	Nov
90.	*Stellaria monosperma* Buch.-Ham. ex D. Don	H	Th	Mi	Sept	Oct
	Chenopodiaceae					
91.	*Chenopodium album* L.	H	HemC	N	June	Sept
	Clusiaceae					
92.	*Hypericum perforatum* L.	H	Ch	N	July	Sept
	Commelinaceae					
93.	*Commelina benghalensis* L.	H	Ch	N	Sept	Oct
	Convallariaceae					
94.	*Polygonatum verticillatum* (L.) Allioni	H	Th	N	June	Aug
95.	*Polygonatum* sp.	H	Th	Mi	May	July
	Convolvulaceae					
96.	*Convolvulus arvensis* L.	H	HemC	N	May	July
97.	*Ipomoea nil* (L.)Roth	H	Th	Mi	May	July
	Cornaceae					
98.	*Cornus macrophylla* Wall.	T	MesP	Ma	March	May
99.	*Cornus oblonga* Wall.	T	MesP	Me	June	Sept
	Crassulaceae					
100.	*Sedum album* L.	H	Ch	N	July	Oct
101.	*Sedum ewersii* Ledeb.	H	Ch	Mi	Oct	Nov
102.	*Sedum fischeri* Raym.-Hamet	H	Th	L	July	Sept
	Cucurbitaceae					
103.	*Solena amplexicaulis* (Lam.) Gandhi	H	Th	Mi	Aug	Oct
	Cupressaceae					
104.	*Juniperus communis* L.	S	NanP	L	June	July

Table 1. (Cont'd.).

S. No.	Family name / Scientific name	Habit	Biological spectrum		Phenology	
			Life form	Leaf size	Flowering	Fruiting
105.	*Juniperus squamata* Buch.-Ham. ex D.Don	S	NanP	L	June	Sept
106.	*Juniperus excelsa* M.Bieb.	T	NanP	L	June	Oct
	Cuscutaceae					
107.	*Cuscuta reflexa* Roxb.	H	Pp	Aph	Aug	Sept
	Cyperaceae					
108.	*Cyperus rotundus* L.	H	Th	N	Aug	Oct
109.	*Cyperus odoratus* L.	H	G	N	Aug	Sept
	Dioscoreaceae					
110.	*Dioscorea deltoidea* Wall. ex Griseb.	H	HemC	Mi	Nov	Dec
	Dryopteridaceae					
111.	*Dryopteris wallichiana* (Spreng.) Hyl.	H	G	Me	July	Aug
	Ebenaceae					
112.	*Diospyros lotus* L.	T	MicP	Ma	June	Nov
	Eleagnaceae					
113.	*Elaeagnus umbellata* Thunb.	S	NanP	Mi	April	May
	Ephedraceae					
114.	*Ephedra girardiana* Wall. ex. Stapf	S	Ch	Aph	Aug	Oct
	Equisetaceae					
115.	*Equisetum arvense* L.	H	G	Aph	April	May
	Ericaceae					
116.	*Cassiope fastigiata* (Wall.) D.Don	H	Th	L	May	July
117.	*Lyonia ovalifolia* (Wall.) Drude	S	NanP	Mi	May	Oct
118.	*Rhododendron arboreum* Sm.	T	MicP	Me	April	May
119.	*Rhododendron hypenanthum* Balf. f.	S	NanP	Me	April	May
	Euphorbiaceae					
120.	*Euphorbia helioscopia* L.	H	Th	N	May	June
121.	*Euphorbia prostrata* Ait.	H	Ch	N	All the year	All the year
122.	*Euphorbia hirta* L.	H	Th	N	Aug	Oct
123.	*Euphorbia serpens* Kunth	H	HemC	N	June	July
124.	*Euphorbia wallichii* Hook. f.	H	Th	N	Aug	Oct
125.	*Ricinus communis* L.	S	NanP	Me	June	Oct
	Fagaceae					
126.	*Castanea sativa* Mill.	T	MesP	Ma	May	July
127.	*Quercus incana* Bartram	T	MesP	Mi	May	July
	Fumaricaceae					
128.	*Fumaria indica* (Hausskn) Pugsley	H	Th	N	April	June
	Gentianaceae					
129.	*Gentianodes clarkei* (Kusn.) Omer	H	Th	N	Aug	Oct
130.	*Lomatogonium spathulatum* (A. Kern.) Fernald	H	Th	N	April	May
131.	*Swertia paniculata* Wall.	H	Th	L	July	Aug
132.	*Swertia ciliata* (D. Don ex G. Don) B.L. Burtt	H	Th	L	July	Aug
133.	*Swertia cordata* (Wall. ex G. Don) C.B. Clarke	H	Th	L	July	Aug
	Geraniaceae					
134.	*Geranium nepalense* Sweet.	H	Ch	Mi	July	Oct
135.	*Geranium wallichianum* D.Don ex Sweet	H	Ch	Mi	July	Oct
	Hippocastanaceae					
136.	*Aesculus indica* (Wall. ex Camb.) Hook.	T	MegP	Me	July	Aug
137.	*Hippolytia dolichophylla* (Kitam.) K. Bremer & Humphries	H	HemC	Me	May	Oct
	Juglandaceae					
138.	*Juglans regia* L.	T	MegP	Ma	July	Aug
	Lamiaceae					
139.	*Ajuga integrifolia* Buch.-Ham.	H	HemC	Mi	May	July
140.	*Calamintha umbrosa* (M.Bieb.) Rchb. Benth.) Hedge	H	Th	N	July	Sept
141.	*Colebrookea oppositifolia* Sm.	S	NanP	L	July	Oct
142.	*Dracocephalum nutans* L.	H	Th	N	July	Sept
143.	*Elsholtzia ciliata* (Thunb.) Hyl.	H	Th	N	July	Sept
144.	*Isodon rugosus* (Wall. ex Benth.) Codd	S	NanP	Mi	May	Oct
145.	*Lamium album* L.	H	Th	Mi	July	Oct
146.	*Lamium amplexicaule* L.	H	Th	Mi	July	Oct
147.	*Mentha piperita* L.	H	HemC	N	June	Sept
148.	*Mentha royleana* Wall. ex Benth.	H	HemC	Mi	June	Oct
149.	*Micromeria biflora* (Ham.) Bth.	H	Ch	L	April	June
150.	*Nepeta graciliflora* Benth.	H	Th	Mi	July	Sept
151.	*Nepeta grandiflora* M.Bieb.	H	Th	Mi	July	Sept
152.	*Nepeta laevigata* (D. Don) Hand.- Mazz	H	Th	Mi	July	Sept

Table 1. (Cont'd.).

S. No.	Family name / Scientific name	Habit	Biological spectrum		Phenology	
			Life form	Leaf size	Flowering	Fruiting
153.	*Origanum vulgare* L.	H	Th	N	July	Aug
154.	*Prunella vulgaris* L.	H	HemC	N	Sept	Nov
155.	*Rydingia limbata* (Benth.) Scheen & V.A. Albert	S	NanP	L	July	Aug
156.	*Salvia lanata* Roxb.	H	Th	Me	July	Sept
157.	*Salvia moorcroftiana* Wall. ex. Benth.	S	Th	Me	Aug	Sept
158.	*Thymus linearis* Benth.	H	HemC	N	July	Sept
	Linaceae					
159.	*Reinwardtia trigyna* Planch.	H	Ch	L	June	July
	Malvaceae					
160.	*Grewia optiva* J.R.Drumm. ex Burret	T	MesP	N	April	June
161.	*Malva neglecta* Wallr.	H	HemC	Mi	May	July
162.	*Malvastrum coromandelianum* (L.) Garcke	H	HemC	N	April	Oct
163.	*Sida cordata* (Burm.f.) Borss.Waalk.	H	HemC	N	May	Sept
	Meliaceae					
164.	*Melia azedarach* L.	T	MesP	Me	April	July
	Mimosaceae					
165.	*Acacia modesta* Wall.	T	MicP	L	March	May
166.	*Acacia nilotica* (L.) Delile	T	MesP	L	April	Oct
	Moraceae					
167.	*Ficus carica* L.	T	MicP	Me	May	Aug
	Nyctaginaceae					
168.	*Mirabilis jalapa* L.	H	NanP	Mi	July	Sept
	Oleaceae					
169.	*Jasminum humile* L.	S	NanP	N	June	Aug
170.	*Jasminum sambac* (L.) Aiton	S	NanP	N	June	Aug
171.	*Olea ferruginea* Wall. ex Aitch.	T	MesP	Mi	April	June
	Onagraceae					
172.	*Circaea cordata* Royle.	H	Th	Me	June	Sept
173.	*Circaea alpina* L.	H	Th	Mi	June	Sept
174.	*Epilobium latifolium* L.	H	HemC	L	July	Sept
175.	*Oenothera rosea* L. Her ex Aiton	H	Th	N	June	Aug
	Orobanchaceae					
176.	*Euphrasia sp.*	H	Th	L	July	Oct
177.	*Pedicularis punctata* Decne.	H	HemC	N	July	Aug
	Oxalidaceae					
178.	*Oxalis corniculata* L.	H	HemC	N	May	Sept
	Papaveraceae					
179.	*Corydalis cornuta* Royle	H	Th	L	Oct	Nov
180.	*Corydalis carinata* Lidén & Z.Y. Su	H	Th	L	July	Sept
181.	*Corydalis virginea* Lidén & Z.Y. Su	H	HemC	N	March	April
	Papilionaceae					
182.	*Astragalus grahamianus* Benth.	S	Ch	L	Sept	Nov
183.	*Astragalus psilocentros* Fisch.	H	Ch	N	May	Aug
184.	*Campylotropis meeboldii* (Schindl.) Schindl.	S	NanP	L	June	Aug
185.	*Desmodium elegans* DC.	S	NanP	Me	July	Aug
186.	*Indigofera heterantha* Brandis	S	NanP	L	July	Oct
187.	*Indigofera australis* Willd.	S	NanP	N	May	Aug
188.	*Indigofera hebepetala* Baker	S	NanP	N	May	Aug
189.	*Lathyrus aphaca* L.	H	Th	N	April	June
190.	*Lathyrus sativa* L.	H	Th	N	July	Sept
191.	*Lathyrus odoratus* L.	H	Th	L	July	Sept
192.	*Lotus corniculatus* L.	H	HemC	Mi	Aug	Sept
193.	*Medicago denticulata* Willed.	H	HemC	L	March	April
194.	*Medicago sativa* L.	H	HemC	N	June	Sept
195.	*Robinia pseudo-acacia* L.	T	MesP	Me	April	May
196.	*Trifolium repens* L.	H	G	N	June	July
197.	*Vicia sativa* L.	H	HemC	N	April	May
	Phytolaccaceae					
198.	*Phytolacca americana* L.	H	Th	Mi	Aug	Sept
199.	*Phytolacca latbenia* (Moq.) H. Walter	H	Ch	Ma	June	Aug
	Pinaceae					
200.	*Abies pindrow* (Royle ex D.Don) Royle	T	MegP	L	June	July
201.	*Cedrus deodara* (Roxb. ex Lamb.) G. Don	T	MegP	L	Sept	Oct
202.	*Picea smithiana* (Wall.) Boiss.	T	MegP	L	May	July
203.	*Pinus roxburghii* Sarg	T	MegP	L	May	July

Table 1. (Cont'd.).

S. No.	Family name / Scientific name	Habit	Biological spectrum		Phenology	
			Life form	Leaf size	Flowering	Fruiting
204.	*Pinus wallichiana* A.B. Jacks.	T	MegP	L	May	July
	Plantaginaceae					
205.	*Plantago himalaica* Pilger.	H	HemC	Mi	July	Aug
206.	*Plantago lanceolata* L.	H	HemC	Mi	April	July
207.	*Plantago major* L.	H	HemC	Mi	July	Sept
208.	*Veronica anagallis* L.	H	HemC	Mi	June	July
209.	*Wulfeniopsis amherstiana* (Benth.) D.Y. Hong [Syn. *Wulfenia amherstiana* Benth.]	H	Th	N	April	July
	Platanaceae					
210.	*Platanus orientalis* L.	T	MegP	Ma	June	July
	Poaceae					
211.	*Arundo donax* L.	S	Ch	Mi	July	Sept
212.	*Avena sativa* L.	H	Th	N	May	July
213.	*Bromus diandrus* Roth.	H	Th	L	April	July
214.	*Bromus tectorum* L.	H	Th	L	June	Sept
215.	*Cynodon dactylon* (L.) Pers.	H	HemC	L	June	Sept
216.	*Dactylis glomerata* L.	H	HemC	N	July	Sept
217.	*Paspalum dilatatun* Poir.	H	HemC	N	April	Sept
218.	*Pennisetum orientale* Rich.	H	HemC	L	June	Sept
219.	*Phragmites altissimus* (Benth.) Mabille	H	Th	Mi	Aug	July
220.	*Piptatherum aequiglume* (Duthie ex Hook.f.) Roshev.	H	Th	L	May	Oct
221.	*Poa alpina* L.	H	HemC	N	June	Sept
222.	*Poa falconeri* Hook.f.	H	HemC	L	June	Sept
223.	*Poa annua* L.	H	HemC	L	May	Aug
224.	*Poa infirma* Kunth	H	HemC	L	April	June
225.	*Schismus arabicus* Nees.	H	HemC	L	June	July
226.	*Sporobolus diandrus* (Retz.) P. Beauv.	H	HemC	L	Sept	Sept
227.	*Urochloa panicoides* P. Beauv.	H	HemC	N	July	June
	Polygonaceae					
228.	*Bistorta affinis* (D.Don) Green	H	Ch	Mi	July	Aug
229.	*Bistorta amplexicaulis* (D.Don) Greene	H	Ch	Mi	July	Aug
230.	*Oxyria digyna* (L.) Hill	H	Ch	Mi	June	July
231.	*Persicaria capitata* (Buch.-Ham. ex D.Don) H.Gross	H	Th	L	June	Aug
232.	*Persicaria nepalensis* (Meisn.) Miyabe	H	Th	N	June	Aug
233.	*Polygonum plebeium* R.Br.	H	HemC	Mi	July	Oct
234.	*Rumex dentatus* L.	H	Th	Me	Aug	Oct
235.	*Rumex hastatus* D. Don	H	Th	N	June	Sept
236.	*Rumex nepalensis* Sprenge	H	Th	Me	July	Oct
	Primulaceae					
237.	*Anagallis arvensis* L.	H	Ch	N	May	July
238.	*Androsace rotundifolia* Hardw.	H	HemC	N	June	Aug
239.	*Primula rosea* Y.J. Nasir	H	G	Mi	Oct	Nov
240.	*Primula hazarica* Duthie	H	HemC	Mi	July	Aug
	Pteridaceae					
241.	*Onychium contiguum* C. Hope	H	G	Me	June	June
242.	*Pteris vittata* L.	H	G	Me	June	Aug
	Ranunculaceae					
243.	*Aconitum heterophyllum* Wall. ex Royle	H	HemC	Me	June	Sept
244.	*Anemone obtusiloba* D.Don	H	HemC	L	May	July
245.	*Aquilegia pubiflora* Wall. ex Royle	H	HemC	Mi	June	Aug
246.	*Caltha palustris* var. *alba* (Cambess) Hook.f. & Thomson	H	Th	Ma	July	Aug
247.	*Clematis grata* Wall.	H	L	Mi	July	Sept
248.	*Delphinium cashmerianum* Royle	H	Th	Mi	Aug	Sept
249.	*Ranunculus laetus* Wall. ex Hook. f. & J.W. Thompson	H	HemC	Me	June	Sept
250.	*Ranunculus muricatus* L.	H	HemC	Ma	June	July
251.	*Thalictrum pedunculatum* Edgew.	H	HemC	N	June	Aug
	Rhamnaceae					
252.	*Ziziphus undulata* Reissek	S	NanP	Mi	June	Aug
	Rosaceae					
253.	*Alchemilla cashmeriana* Rothum.	H	HemC	N	June	Sept
254.	*Cotoneaster acuminatus* Wall. ex Lindl.	S	NanP	L	June	July
255.	*Duchesnea indica* (Andx) Fake.	H	HemC	N	April	June
256.	*Fragaria nubicola* (Hook. f.) Lindl. ex Lacaita	H	HemC	N	May	July
257.	*Geum elatum* Wall. ex G.Don	H	HemC	N	Aug	Oct
258.	*Potentilla anserina* L.	H	HemC	L	June	Aug

Table 1. (Cont'd.).

S. No.	Family name / Scientific name	Habit	Biological spectrum		Phenology	
			Life form	Leaf size	Flowering	Fruiting
259.	*Potentilla argentea* L.	H	HemC	L	June	Sept
260.	*Potentilla napalensis* Hook.	H	HemC	Mi	June	Sept
261.	*Potentilla* sp.	H	HemC	L	June	Aug
262.	*Prunus cornuta* (Wall.ex Royle)Steud	T	MesP	Me	May	July
263.	*Prunus armeniaca* L.	T	MesP	Mi	March	April
264.	*Prunus domestica* L.	T	MesP	Me	May	Sept
265.	*Pyrus pashia* Buch.-Ham. ex D.Don	T	MesP	Mi	April	May
266.	*Rosa webbiana* Wall. ex. Royle	S	NanP	N	May	July
267.	*Rosa brunonii* Lindl.	S	NanP	Mi	June	July
268.	*Rubus fruticosus* Agg.	S	NanP	Mi	July	Sept
269.	*Rubus sanctus* Schreber	S	NanP	Mi	July	Sept
270.	*Rubus abactus* L.H. Bailey	S	NanP	Mi	April	May
271.	*Rubus biflorus* Buch.-Ham. ex Sm.	S	NanP	Mi	April	May
272.	*Sibbaldia procumbens* L.	H	HemC	N	Oct	Nov
273.	*Sorbaria tomentosa* (Lindl.) Rehder	S	NanP	Me	June	Aug
274.	*Sorbus tomentosa* Hedl.	S	NanP	Me	July	Aug
275.	*Spiraea affinis* R. Parker	S	NanP	Me	July	Aug
	Rubiaceae					
276.	*Galium aparine* L.	H	Th	L	July	Oct
277.	*Galium asparagifolium* Boiss. & Heldr.	H	Th	L	May	Aug
278.	*Galium elagans* Wall.	H	Th	N	July	Aug
279.	*Himalrandia tetrasperma* (Wall. ex Roxb.) T. Yamaz.	H	HemC	Mi	June	Aug
280.	*Leptodermis virgata* Edgew.ex Hook.f.	H	Ch	N	May	June
	Rutaceae					
281.	*Zanthoxylum armatum* DC.	S	MicP	Mi	July	Sept
	Salicaceae					
282.	*Populus alba* L.	T	MesP	Ma	June	Oct
283.	*Populus ciliata* Wall. ex Royle	T	MesP	Ma	May	June
284.	*Salix alba* L.	T	MesP	Mi	June	Oct
285.	*Salix denticulata* subsp. *Hazarica* (R. Parker) Ali	T	MesP	Mi	June	Oct
286.	*Salix tetrasperma* Roxb.	T	MesP	Mi	June	Oct
	Sambucaceae					
287.	*Sambucus wightiana* Wall. ex Wight & Arn	S	Th	Me	July	Sept
	Sapindaceae					
288.	*Acer caesium* Wall. ex Brandis	T	MegP	L	April	July
289.	*Dodonaea viscosa* (L.) Jacq.	S	NanP	Me	April	Aug
	Saxifragaceae					
290.	*Bergenia ciliata* (Haw.) Sternb.	H	Ch	Me	Aug	Oct
291.	*Bergenia stracheyi* Hook.f & thomes.	H	HemC	Me	Sept	Oct
	Scrophulariaceae					
292.	*Verbascum thapsus* L.	H	Th	Me	July	Aug
	Simaroubaceae					
293.	*Ailanthus altissima* (Mill.) Swingle	T	MesP	Mi	May	July
	Smilacaceae					
294.	*Smilax glaucophylla* Koltzsch	H	L	Mi	June	Aug
	Solanaceae					
295.	*Hyoscyamus niger*L.	H	Th	Me	July	Sept
296.	*Solanum nigrum* L.	H	Th	Mi	July	Oct
297.	*Solanum surattense* Burm F.	H	Th	Me	All the year	All the year
298.	*Withania somnifera* (L.) Dunal	H	Ch	Me	July	Oct
	Thymelaeaceae					
299.	*Daphne mucronata* Royle	S	NanP	N	Nov	Feb
300.	*Daphne papyracea* Wall. ex G. Don	S	NanP	N	Nov	Feb
	Urticaceae					
301.	*Lecanthus peduncularis* (Wall. ex Royle) Wedd. Weed.	H	HemC	Mi	July	Sept
302.	*Pilea umbrosa* Blume	H	Th	Mi	April	June
303.	*Urtica dioica* L.	H	Th	Mi	Sept	Oct
	Verbenaceae					
304.	*Pteracanthus urticifolius* (Wall. ex Kuntze) Bremek.	H	Th	Me	June	Aug
	Violaceae					
305.	*Viola odorata* L.	H	Th	Mi	Sept	Oct
306.	*Viola serpens* Wall. Ex Ging	H	G	Mi	Aug	Oct
	Vitaceae					
307.	*Vitex negundo* L.	S	NanP	Mi	April	Aug

Abbreviations for growth form: H=Herb, S=Shrub and T=Tree

Abbreviations for life form: MegP= Megaphanerophytes, MesP= Mesophanerophytes, MicP= Microphanerophytes, NanP= Nanophanerophytes, Ch= Chamaephytes, HemC=Hemicryptophytes, G=Geophytes, Th=Therophytes, L=Lianas, Pp=Parasitic plant

Abbreviations for leaf size: Aph= Aphyllous, L= Leptophyll, N= Nanophyll, Mi= Microphyll, Me= Mesophyll, Ma= Megaphyll

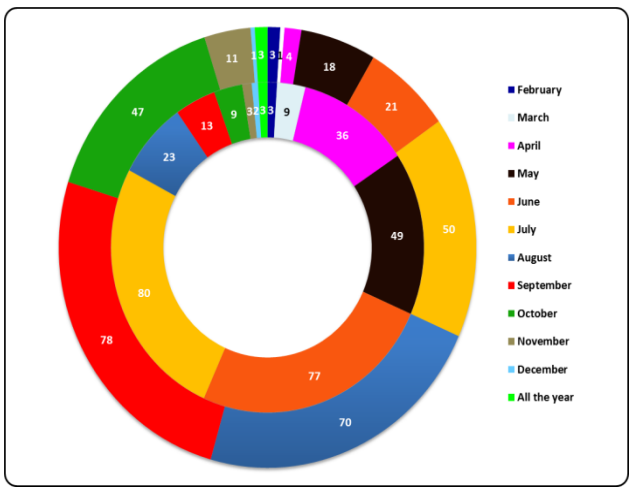

Fig. 6. Phenological behavior of the plant species recorded from Manoor Valley.

Discussion

Floristic composition: Floristic structure of a region can be severely affected by trampling, over grazing, deforestation, soil erosion and natural catastrophes i.e. earthquake and sliding. Vegetation is a group of plants growing together in a particular area and may be characterized by its component species (Malik & Hussain, 1990). In the present study, flora consisted of 307 species, where the dominating growth form was herbaceous and found in 228 spp., (74.27%), followed by shrubs with 45 spp. (14.66%).Furthermore, tree species were found less during survey in the study area (34 spp., 11.07%). In Pakistan, many researchers from different areas also mentioned herbaceous growth form as the leading one from their study areas (Ijaz *et al.*, 2015; K.U. Khan *et al.*, 2015; Shah *et al.*, 2015; Ijaz *et al.*, 2016). Asteraceae was the leading families with 31 species, followed by Rosaceae with 22 species, Lamiaceae with 20 species respectively. Due to wide ecological amplitude, the plant species of Asteraceae family are diverse in habitat (Badshah *et al.*, 2013). Inline results were noticed by Khattak *et al*., (2015) in Karak, Pakistan, and Iqbal *et al*., (2015) in Malakand, Pakistan who also reported Asteraceae. S.M. Khan *et al*., (2015) in Kabal (Swat), Pakistan observed Lamiaceae as the dominant family. Many other researchers reported diverse flora from various zones (Qureshi, 2008; Iqbal *et al.*, 2015).

Life form: The comparative proportion of dissimilar life form for a specific region or spot is called its bio spectrum. The life form spectra are considered to be the indicator of micro and macro climates (Asmus, 1990). Biological spectra are vital physiognomic attributes, which are broadly used for vegetation analysis. Life form reflects the adaptation of plants with respect to its climate. The plants were classified into different life form classes (Raunkiær, 1934). The flora was dominated by Therophytes (104 spp., 33.88%), followed by Hemicryptophytes (87 spp., 28.34%). Similarly, Badshah *et al*., (2013) observed Therophytes as the leading life form in Tank region, Pakistan.

Table 2. Summary of the ecological characteristics of recorded plant species from the study area.

S.No.	Attributes	No. of plant species	% Of plant species
I.	**Plant habit**		
1.	Herb	228	74.27
2.	Shrub	45	14.66
3.	Tree	34	11.07
	Total	**307**	**100**
II.	**Plant families**		
1.	Asteraceae	31	10.10
2.	Rosaceae	22	7.17
3.	Lamiaceae	20	6.51
4.	Poaceae	17	5.54
5.	Papilionaceae	16	5.21
6.	Apiaceae	14	4.56
7.	Polygonaceae	10	3.26
8.	Remaining 74 families	178	57.65
	Total	**307**	**100**
III	**Biological spectrum**		
IIIa.	**Life form**		
1.	Megaphanerophytes	9	2.93
2.	Mesophanerophytes	20	6.51
3.	Microphanerophytes	5	1.63
4.	Nanophanerophytes	41	13.36
5.	Chamaephytes	24	7.82
6.	Hemicryptophytes	87	28.34
7.	Geophytes	13	4.23
8.	Therophytes	104	33.88
9.	Lianas	3	0.98
10.	Parasitic plant	1	0.33
	Total	**307**	**100.00**
IIIb.	**Leaf size**		
1.	Megaphyll	17	5.54
2.	Mesophyll	49	15.96
3.	Microphyll	86	28.01
4.	Nanophyll	92	29.97
5.	Leptophyll	59	19.22
6.	Aphyllous	4	1.30
	Total	**307**	**100.00**
IV.	**Phenology**		
Iva.	**Flowering**		
1.	February	3	0.98
2.	March	9	2.93
3.	April	36	11.73
4.	May	49	15.96
5.	June	77	25.08
6.	July	80	26.06
7.	August	23	7.49
8.	September	13	4.23
9.	October	9	2.93
10.	November	3	0.98
11.	December	2	0.65
12.	All the year	3	0.98
	Total	**307**	**100.00**
IVb.	**Fruiting**		
1.	February	3	0.98
2.	March	1	0.33
3.	April	4	1.30
4.	May	18	5.86
5.	June	21	6.84
6.	July	50	16.29
7.	August	70	22.80
8.	September	78	25.41
9.	October	47	15.31
10.	November	11	3.58
11.	December	1	0.33
12.	All the year	3	0.98
	Total	**307**	**100.00**

Leaf spectra: For various physiological processes of plants and plant communities leaf size plays a vital role (Oosting, 1956). On the basis of leaf spectra, the study area was dominated by Nanophyll and Microphyll with 92 spp. (29.97%) and 86 spp. (28.01%) respectively. Microphyllous species are the indication of steeps (Cain & Castro, 1959). The species with microphyllous leaves were rich due to ecological variation, which shows the percentage of different leaf form classes varied with rising altitudes. Similar findings were observed by Saxina *et al*., (1987) who stated that the percentage of microphyllous species was completely associated with the rising altitude.

Phenological behavior: Phenology is possibly the simplest way in which species ecology changes in response climate change (Rosenzweig *et al.,* 2007). The flowering data showed that July had peak flowering (26.06%) in 80 plant species, followed by June (25.08%) in 77 species. Our results are in agreement with those of Shrestha *et al*., (1998), where the authors noticed the blooming period from May to August in Kavrepalanchok, Nepal. As indicated by Marqueus *et al*., (2004), phenological period and atmosphere are associated with each other in terms of temperature, day length and precipitation or rainfall. In the current investigation, seeds were mostly set in chilly/cold season of December and that germinated in the next spring season. A significant number of plant species, the abscission period of leaves was cool season *i.e.* October to February, leaf flushing period was in March and April, August was blossoming and in September and October fruit development and maturation occurred. In short, in our investigation area, the plant species grew up and matured to blossoming and fruiting stage in the warm and wet season. Moreover, fruiting phase ended at the start of the cool season and seeds shed off which entered the natural laboratory for cold treatment in the winter season and then once again germinates and experiences in favorable season. Similar phenological scenario was reported by Morellato (1995) who reported that the blooming period begins toward the end of the dry season and at the starting of the wet season, thus fruiting takes place in dry season and that the next rainy period will offer appropriate conditions for seed germination (Morellato *et al.*, 1989).

To date, people in modern era are habitually unaware of the importance of phenology in their daily lives. The current understanding of phenology is important to help people understand how species respond to climate change, and to plan how these changes can affect behavior, such as: Planning of public health, resource management and leisure / tourism marketing.

Author's contributions: This manuscript is part of IUR PhD work. IUR, ZI and AA designed the study. IUR conducted the field work, MA helped in data collection, field observations. IUR and FI conducted the herbarium work. JA and AM identified plants. IUR wrote the manuscript. NA helped in interpretation of data and critically reviewed the manuscript. RBU and RH critically revised the manuscript. All the authors read and approved the final manuscript.

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