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A Floristic List and Phenology of Plant Species of Lawat Area District Neelum, Azad Jammu and Kashmir, Pakistan

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Abstract: The objective of this study was to collect the detailed information of plant biodiversity and phenological pattern of plant species in the area. For this purpose, detailed surveys were done during the months of March to November in 2005 and 2006. One hundred and eighty plant species were recorded from Lawat hills belonging to 66 families and 144 genera. The families Asteraceae, Balsaminaceae, Gentianaceae, Lamiaceae, Poaceae, Polygonaceae, Primulaceae, Ranunculaceae, Rosaceae, Scrophulariaceae and Umbellifereae were recorded with major contribution to the flora of the investigated area. Fifty one plant species (29%) flowered from March to May, 83 plant species (45%) flowered from the month of June and July, while 46 plant species (26%) flowered from August to September. Eleven plant species in the investigated area were reported as evergreen.

Key words: Floristic list, biodiversity, phenology, Lawat, Neelum, Kashmir

INTRODUCTION

Phenology is the relationship of plant growth stages and calendar date. The calendar is based on the solar year. The information of Phenology shows relationship of plant growth to seasonal changes and changes in length of daylight or photoperiod to programme their growth stages and biological activities appropriated with the seasonal conditions (Manske, 2006).

Phenology is the timing of recurring biological events, among phases of plant species, which provide a background for collecting and synthesizing detailed quantitative information on rhythm of plant community. Temperate plants with their level of species diversity display phenological events such as leaf drop, leaf flushing, flowering and fruiting etc. in relation to time and space (Singh and Singh, 1992). The study of such events is useful in evolving proper management strategy as well as better understanding of natural forest regeneration potential and community level interaction (Fox, 1976).

According to Van Schaik *et al.* (1993) the flowering and fruiting could be correlated with climatic conditions for offspring survival. The fruiting occurred at beginning of rainy season which helps survival of seeds to the exposure to predators and provides maximum time to

seedling for development of root system. It is now widely accepted that different biological interactions and phylogenetic relationships help in shaping the phenological pattern (Hamann, 2004). Comejo-Tenoria and Ibarra-Manriquez (2007) recorded flowering and fruiting behavior on monthly basis and according to them the most dominant species (11 annual herbs, 72 perennial herbs, 21 shrubs and 8 trees) in a temperate forest, during 2004, in the Cerro Altamirano Core Zone of the Monarch Butterfly Biosphere Reserve in central Mexico. Intraspecific synchrony in flowering and fruiting of eight woody species was estimated by monitoring 20 individuals of each. Flowering and fruiting occurred mainly during the rainy season and at the beginning of the dry season (July-December) and showed a low degree of seasonality. Reproductive activity within growth forms occurred in different periods: (1) annual and perennial herbs flowered principally during the rainy season and at the beginning of the dry season, while their fruiting peaked during the dry season, (2) shrubs produced flowers and fruits throughout the year without peaks in any season and (3) nearly all trees had flowers and fruits during the dry season. Qureshi (2008) presented a botanical inventory of Chotiari wetland complex, Nawab Shah, Sindh, Pakistan. Qureshi (2008) studies revealed

120 plant species from 84 genera and 39 families. Dar (2003) studied some medicinal plants in the Lawat area and his investigation includes 52 plant species that were ethnobotanically used by local people of the area.

Bhat and Muralli (2001) described the climatic factors such as rainfall, water availability, change in day length and temperature are also trigger the phenological events and due to temperature difference, there are different arrays of species in different climatic zones. According to studies by Ragusa-Netto and Silva (2007) shedding of leaves in dry forest in Western Brazil started in early dry period and intensity increased in latter periods where as wet valleys remained evergreen. Anemochorich and autochorich species were tolerant ones in those conditions and were found dominant due to enhanced conditions and favorable diaspore dispersal. According to them the wet conditions were unrelated to the initiation of flowering and fruiting was recorded massive in season just after rainfall.

The objective of this study was to collect the detailed information of plant biodiversity and phenological pattern of plant species in the area which would be helpful in determination of the species response in different climatic conditions and also timings of leaf, flowering and fruiting events.

Lawat is situated in Neelum valley District Neelum Azad Jammu and Kashmir. It is nearly 125 km from Muzaffarabad, the Capital city of Azad Jammu and Kashmir Government and is confined to the right bank of river Neelum as the ceasefire line between Indian held Kashmir and Azad Jammu and Kashmir comes frequently close to the left bank of Neelum river in this area (Dar, 2003).

The climate of the investigated area ranges from moist temperate to alpine vegetation. Winters are extremely cold with heavy snowfalls occurs 3-12 ft. High peaks of the investigated area remain full of snowfall from November to March even longer. In the investigated area, there is no meteorological station, so the nearest station Muzaffarabad's climate was recorded.

The mean monthly daily minimum temperature ranges from 3.2°C in January to 22.8°C in July, whereas the mean of monthly daily maximum temperature ranges from 15.9°C in January to 37.6°C in June (Government of Azad Jammu and Kashmir, 2005). The mean annual rainfall is 1526.7 mm, with a total of 84.5 rainy days per year. The highest rainfall occurs in the month of (327.6 mm), while the driest month is November receiving a mean rainfall of 35.4 mm. The spring (February-April) and monsoon (July-August) are the rainiest seasons of the year. Occasional thunder showers may also be encountered in

spring and autumn months. At the higher elevations, most of the winter and early spring precipitation is received as deep snow. The Mean monthly rainfall ranges from 35.4 mm (with 2.3 rainy days) in November to 327.6 mm (with 13.1 rainy days) in July as recorded in Muzaffarabad. There are no recorded previous studies on the aspects of phenology or the floristic composition from the area and this is the first attempt to botanically explore the area.

MATERIALS AND METHODS

Surveys were done during 2005-2006 to collect flora of the area. Complete specimen of each species were collected in duplicate, dried, preserved and mounted on standard herbarium sheets. The plants were identified with the help of available literature (Nasir and Ali, 1971-1994; Ali and Qaisar, 1995-2006) and confirmed at NARC, Islamabad. A complete floristic list along with families was compiled. Observations on the life form, leaf spectra and phenological behavior were recorded on spot. The voucher specimens were deposited in herbarium, University of Azad Jammu and Kashmir Muzaffarabad. To record the phenological events, the species were permanently tagged to observe the events such as vegetation season (the time period from leaf flushing to leaf drop) and flowering season (from flower initiation to fruit formation). A minimum of 5 individuals of each species were considered for recording each event and mean was taken as a cumulative measure.

RESULTS

One hundred and eighty plant species were recorded from Lawat hills belonging to 144 genera and 66 families. A complete floristic list is presented in the Table 1.

The families Asteraceae, Balsaminaceae, Gentianaceae, Lamiaceae, Poaceae, Polygonaceae, Primulaceae, Ranunculaceae, Rosaceae, Scrophulariaceae and Umbellifereae were recorded with major contribution to the flora of the investigated area. Where as families Betulaceae, Canabinaceae, Campanulaceae, Cupressaceae, Dioscoriaceae, Euphorbiaceae, Iridaceae, Moraceae, Malvaceae, Parnassiaceae, Sambucaceae and Valerianaceae were recorded with least contribution towards the flora of the area. According to phenological pattern, 51 plant species (29%) flowered from March-May, 83 plant species (45%) flowered from the month of June and July while 46 plant species (26%) flowered from August-September. Eleven plant species in the investigated area were reported as evergreen plants.

Table 1: Phenology recorded during 2005-2006 at Lawat District Neelum (All species collected by Dar, MEUT)

Acc. No.	Family	Name of species	Vegetation season	Flowering season
002	Aceraceae	<i>Acer caesium</i> Wall ex. Brandis	April-Nov.	June-July
003	Aceraceae	<i>Acer pictum</i> Gleditsch.	Apr.-Nov.	June-July
013	Alliaceae	<i>Allium griffithianum</i> Boiss	May-Oct.	June
014	Alliaceae	<i>Allium humile</i> Kunth	May-Oct.	June
015	Amaranthaceae	<i>Amaranthus spinosus</i> L.	Apr.-Oct.	May-June
016	Amaranthaceae	<i>Amaranthus viridis</i> L.	Apr.-Oct.	May-June
024	Araliaceae	<i>Aralia cachemirica</i> Decne.	Mar.-Nov.	June-Aug.
077	Araliaceae	<i>Hedra nepalensis</i> K. Koch	WY	Aug.-Sep.
004	Asteraceae	<i>Achillea millefolium</i> L.	Mar.-Oct.	July-Aug.
005	Asteraceae	<i>Achillea wilhemsii</i> C. Koch	May-Sep.	June-July
017	Asteraceae	<i>Anaphalis triplinervis</i> (Sims) C.B. Clarke	May-Oct.	June-July
020	Asteraceae	<i>Anemone falconeri</i> Thoms	Apr.-Nov.	June-Aug.
026	Asteraceae	<i>Artemisia scoparia</i> L.	Mar.-Oct.	May-Aug.
044	Asteraceae	<i>Cirsium arvense</i> (L.) Scop.	Mar.-Sep.	June-July
063	Asteraceae	<i>Echinops cornigerus</i> DC	May.-Sep.	June-July
085	Asteraceae	<i>Inula grandiflora</i> Willd	Apr.-Oct.	July-Aug.
092	Asteraceae	<i>Lentopodium himalayanaum</i> DC	May-Sep.	July
093	Asteraceae	<i>Ligularia thomsonii</i> (Clarke) Kitamura	May-Sep.	July-Aug.
150	Asteraceae	<i>Saussurea lappa</i> Clarke	May-Oct.	July-Aug.
153	Asteraceae	<i>Senecio chrysanthemoides</i> DC.	Apr.-Oct.	Aug.
165	Asteraceae	<i>Taraxacum officinale</i> Weber	Mar-Nov	July-Aug.
168	Asteraceae	<i>Tricholepis stewartii</i> C.B. Clarke ex Hook f.	June-Sep.	July
080	Balsaminaceae	<i>Impatiens bicolor</i> Royle.	Mar.-Oct.	July-Aug.
081	Balsaminaceae	<i>Impatiens brachycentra</i> Kar. and Kir	Mar.-Oct.	July-Aug.
082	Balsaminaceae	<i>Impatiens edgeworthii</i> Hook. F	Mar.-Oct.	July-Aug.
083	Balsaminaceae	<i>Impatiens glandulifera</i> Royle.	Apr.-Sep.	July
028	Berberidaceae	<i>Berberis lyceum</i> Royle	Apr.-Oct.	June-Aug.
031	Betulaceae	<i>Betula utilis</i> D. Don	June-Oct.	July
025	Boraginaceae	<i>Arnebia benthamii</i> Wall ex G. Don.	June-Oct.	July-Aug.
054	Boraginaceae	<i>Cynoglossum lanceolatum</i> Forssk.	Apr.-Aug.	May-June
094	Boraginaceae	<i>Lindelofia longiflora</i> (Benth) Baill.	Apr.-Aug.	May-Jun.
038	Brassicaceae	<i>Capsella bursa pastoris</i> L.	Mar.-Oct.	May-July
046	Campanulaceae	<i>Codonopsis clematideae</i> (Schrenk) C.B Clarke	May.-Oct.	July-Aug.
037	Canabinaceae	<i>Cannabis sativa</i> L.	Mar.-Sep.	May-July
095	Caprifoliaceae	<i>Lonicera glabrata</i> Wallich.	May.-Sep.	Aug.
176	Caprifoliaceae	<i>Viburnum graniflorum</i> Wall ex DC.	Feb.-Sep.	3-Apr.
155	Caryophyllaceae	<i>Silene conoidea</i> L.	Apr.-Sep.	Jun.-July
156	Caryophyllaceae	<i>Silene gonosperma</i> (Rohrb.) Bocquet	Apr.-Sep.	June-July
157	Caryophyllaceae	<i>Silene vulgaris</i> (Moench) Garcke	Mar.-Aug.	May-June
042	Chenopodiaceae	<i>Chenopodium album</i> L.	Apr.-Sep.	June-July
043	Chenopodiaceae	<i>Chenopodium ambrosioides</i> L.	Apr.-Sep.	June
047	Convolvulaceae	<i>Convolvulus arvensis</i> L.	Mar.-Aug.	May
141	Crassulaceae	<i>Rhodiola himalensis</i> (D.Don) S.H. Fu	May-Sep.	July
152	Crassulaceae	<i>Sedum ewersii</i> Ledeb	Apr.-Oct.	May-June
090	Cupressaceae	<i>Juniperus communis</i> Pallas.	WY	July-Aug.
052	Cuscutaceae	<i>Cuscuta reflexa</i> Roxb.	May-Oct.	Aug.
055	Cyperaceae	<i>Cyperus rotundus</i> L.	Mar.-Nov.	Aug.-Sep.
059	Dioscoreaceae	<i>Dioscorea deltoidea</i> Wall.	Apr.-Sep.	June-July
060	Dipsacaceae	<i>Dipsacus inermis</i> Wall.	Apr.-Oct.	July-Aug.
151	Dipsacaceae	<i>Scabiosa speciosa</i> Royle.	Mar-Sep	July
061	Dryopteridaceae	<i>Dryopteris stewartii</i> Fraser-Jenk.	Apr.-Sep.	Aug.
134	Dryopteridaceae	<i>Pteris vitata</i> L.	Mar-Sep	July-Sep.
065	Euphorbiaceae	<i>Euphorbia wallichii</i> Hook f.	Apr-Oct	June-July
135	Fagaceae	<i>Quercus dilatata</i> Griffith	WY	Aug.-Sep.
136	Fagaceae	<i>Quercus incana</i> Roxb.	WY	Aug.-Sep.
050	Fumariaceae	<i>Corydalis stewartii</i> Fedde.	Mar.-Nov.	June-July
070	Fumariaceae	<i>Fumaria indica</i> (Hausskn.) Pugsley	Apr.-Oct.	June-July
071	Gentianaceae	<i>Gentianodes argentea</i> (Royle ex D.Don) Omer, Ali and Qaiser	May-Sep.	June-July
072	Gentianaceae	<i>Gentianodes kurroo</i> (Royle) Omer, Ali and Qaiser	May-Sep.	June-July
161	Gentianaceae	<i>Swertia chirata</i> Ham.	Feb.-Aug.	July
162	Gentianaceae	<i>Swertia ciliata</i> (D.Don ex G.Don) B.L. Burt	Mar.-Sep.	July
163	Gentianaceae	<i>Swertia cordata</i> Wall.	Feb.-Aug.	June-July
164	Gentianaceae	<i>Swertia speciosa</i> D.Don.	Mar.-Sep.	July
073	Geraniaceae	<i>Geranium collinum</i> Steph.ex Willd	Apr.-Oct.	July-Aug.
074	Geraniaceae	<i>Geranium rotundifolium</i> L.	Apr.-Oct.	July-Aug.
075	Geraniaceae	<i>Geranium wallichianum</i> D.Don ex Sweet	Mar.-Oct.	June-Aug.
079	Guttiferae	<i>Hypericum perforatum</i> L.	Apr.-Sep.	July

Table 1: Continued

Acc. No.	Family	Name of species	Vegetation season	Flowering season
111	Hamamelidaceae	<i>Parrotiopsis jacquemontiana</i> (Decne.) Rehder	Apr.-Nov	June-Aug.
009	Hippocastanaceae	<i>Aesculus indica</i> (Wall ex Camb.) Hook f.	Mar.-Nov	June-July
086	Iridaceae	<i>Iris hookeriana</i> Foster	Apr.-Sep.	July
089	Juglandaceae	<i>Juglans regia</i> L.	Mar.-Oct.	Apr.-5
012	Lamiaceae	<i>Ajuga bracteosa</i> Wall ex Benth.	Mar.-Oct.	5-July
100	Lamiaceae	<i>Mentha longifolia</i> L.	Mar.-Oct.	5-July
101	Lamiaceae	<i>Micromeria biflora</i> (Buch-Ham ex D.Don) Benth.	Mar.-Sep.	Apr.-May
103	Lamiaceae	<i>Nepeta laevigata</i> (D.Don) Hand, Mazz.	Apr.-Oct.	May-June
114	Lamiaceae	<i>Phlomis bracteosa</i> Royle ex Benth.	Apr.-Oct.	June-July
119	Lamiaceae	<i>Plectranthus rugosis</i> Wall ex Benth.	Mar.-Nov	Aug.-Sep.
132	Lamiaceae	<i>Prunella vulgaris</i> L.	Apr.-Sep.	June-July
148	Lamiaceae	<i>Salvia nubicola</i> wall ex Sweet	Mar.-Sep.	May-June
167	Lamiaceae	<i>Thymus linearis</i> Benth.	Apr.-Oct.	May-July
069	Liliaceae	<i>Frittilaria roylei</i> Hook f.	Mar.-Oct.	Mar-July
123	Liliaceae	<i>Polygonatum verticillatum</i> (L) All.	Mar.-Sep.	May-June
179	Loranthaceae	<i>Viscum album</i> L.	W.Y	Aug.-Sep.
098	Malvaceae	<i>Malva neglecta</i> Wallr.	Apr.-Oct.	May-June
067	Moraceae	<i>Ficus palmata</i> Wall.	Mar.-Oct.	Apr.-June
097	Morinaceae	<i>M. longicaule</i> Royle	Apr.-Sep.	May-June
102	Morinaceae	<i>Morina coulteriana</i> Royle	Apr.-Sep.	May-June
087	Oleaceae	<i>Jasminum humile</i> L.	Mar.-Oct.	July-Aug.
088	Oleaceae	<i>Jasminum officinale</i> L.	Mar.-Oct.	July-Aug.
064	Onagraceae	<i>Epilobium hirsutum</i> L.	Apr.-Sep.	May-June
104	Onagraceae	<i>Oenothera rosea</i> L'Herit ex Aiton.	Apr.-Sep.	June
076	Orchidaceae	<i>Habenaria pectinata</i> D. Don.	May-Sep.	June-July
107	Osmundaceae	<i>Osmunda regalis</i> L.	Mar.-Sep.	July-Sep.
108	Oxalidaceae	<i>Oxalis corniculata</i> L.	May-Oct.	July-Aug.
099	Papaveraceae	<i>Meconopsis aculata</i> Royle	May-Sep.	Aug.
084	Papilionaceae	<i>Indigofera heterantha</i> Wall ex. Brandis	Mar.-Nov	May-Aug.
096	Papilionaceae	<i>Lotus corniculatus</i> L.	Apr.-Sep.	June-July
169	Papilionaceae	<i>Trifolium repens</i> L.	Apr.-Sep.	June-July
110	Parnassiaceae	<i>Parnassia nubicola</i> Wall ex Royle	Apr.-Sep.	July
001	Pinaceae	<i>Abies pindrow</i> Royle.	WY	Apr.-May
039	Pinaceae	<i>Cedrus deodara</i> (Roxb. ex D. Don) G.Don.	WY	4-May
115	Pinaceae	<i>Picea smithiana</i> (Wall) Boiss	WY	May-July
116	Pinaceae	<i>Pinus wallichiana</i> A.B.Jackson	WY	May-July
117	Plantaginaceae	<i>Plantago lanceolata</i> L.	Apr.-Oct.	July-Aug.
118	Plantaginaceae	<i>Plantago ovata</i> Forsk.	Mar.-Oct.	July-Aug.
010	Poaceae	<i>Agrostis alba</i> Auct.	Mar.-Nov	June-Aug.
011	Poaceae	<i>Agrostis canina</i> Auct.	Mar.-Nov	July-Aug.
027	Poaceae	<i>Arundo donax</i> L.	Mar.-Nov	Aug.-Sep.
032	Poaceae	<i>Bothriochloa annulatum</i> L.	Mar.-Oct.	June-July
033	Poaceae	<i>Bracharia ramosa</i> (L.) Stpf.	Mar.-Nov	Aug.-Sep.
034	Poaceae	<i>Bromus japonicus</i> Thurnb.	Apr.-Oct.	Aug.-Sep.
041	Poaceae	<i>Cenchrus biflorus</i> Roxb.	Apr.-Oct.	Aug.-Sep.
053	Poaceae	<i>Cynodon dactylon</i> Pers.	Mar.-Sep.	Apr.-May
066	Poaceae	<i>Festuca modesta</i> Schreb.	Mar.-Sep.	Apr.-May
113	Poaceae	<i>Phlaris theorosa</i> L.	May-Sep.	June-July
120	Poaceae	<i>Poa alpina</i> L.	May-Sep.	June-July
121	Poaceae	<i>Poa annua</i> L.	Mar.-Sep.	Apr.-May
122	Podophyllaceae	<i>Podophyllum hexandrum</i> Royle	Apr.-Oct.	June-July
109	Polygonaceae	<i>Oxyria digyna</i> (L.) Hill.	Apr.-Sep.	May-June
124	Polygonaceae	<i>Polygonum amplexicaule</i> D. Don	Mar.-Oct.	July-Aug.
125	Polygonaceae	<i>Polygonum humile</i> Meissn.	Apr.-Oct.	July-Aug.
126	Polygonaceae	<i>Polygonum plebium</i> R Br.	Feb-Nov	June-Aug.
140	Polygonaceae	<i>Rheum emodi</i> Royle	Apr.-Sep.	July-Aug.
146	Polygonaceae	<i>Rumex hastatus</i> D.Don	Mar.-Oct.	June-July
018	Primulaceae	<i>Androsace hazarica</i> R.R Stewart ex Y. Nasir	Apr.-Oct.	May-June
018	Primulaceae	<i>Androsace rotundifolia</i> Hardwicke	Apr.-Oct.	May-June
049	Primulaceae	<i>Cortusa brotheri</i> Pax ex Lipsky	May-Sep.	June-July
058	Primulaceae	<i>denticulata</i> Sm.	Mar.-Sep.	May-June
130	Primulaceae	<i>Primula macrophylla</i> D.Don.	Mar.-Sep.	May-June
131	Primulaceae	<i>Primula rosea</i> Royle	Apr.-Sep.	May-June
008	Pteridaceae	<i>Adiantum venustum</i> D.Don	WY	Aug.
105	Pteridaceae	<i>Onychium japonicum</i> (Kunze) Wall.	Apr.-Sep.	Aug.
006	Ranunculaceae	<i>Aconitum chasmanthum</i> Stapf. ex Holmes	Apr.-Oct.	July-Aug.
007	Ranunculaceae	<i>Aconitum heterophyllum</i> Wall.	Apr.-Oct.	July-Aug.

Table 1: Continued

Acc. No.	Family	Name of species	Vegetation season	Flowering season
021	Ranunculaceae	<i>Anemone obtusiolata</i> D. Don	Apr.-Sep.	June-July
023	Ranunculaceae	<i>Aquilegia pubiflora</i> Wall ex Royle	Mar.-Sep.	June-July
036	Ranunculaceae	<i>Caltha alba</i> Jacq. ex Camb	Apr.-Oct.	June-Aug.
045	Ranunculaceae	<i>Clematis connata</i> DC.	Mar.-Oct.	June-Aug.
057	Ranunculaceae	<i>Delphinium ajacis</i> L.	Mar.-Oct.	June-Aug.
137	Ranunculaceae	<i>Ranunculus arvensis</i> L.	Mar.-Nov.	June-July
138	Ranunculaceae	<i>Ranunculus laetus</i> wall ex Hook. f. and Thoms	Mar.-Oct.	June-Aug.
139	Ranunculaceae	<i>Ranunculus muricatus</i> L.	Mar.-Sep.	June-July
171	Ranunculaceae	<i>Trolius acaulis</i> Lindley	Mar.-Sep.	June-July
051	Rosaceae	<i>Cotoneaster microphyllus</i> Wallich.	Apr.-Oct.	July-Aug.
062	Rosaceae	<i>Duchesnea indica</i> (Andr.) Focke	Apr.-Oct.	June-Aug.
068	Rosaceae	<i>Fragaria nubicola</i> Lindl ex Lacaite	Apr.-Sep.	June-July
127	Rosaceae	<i>Potentilla atrosanguinea</i> Lodd.	Mar.-Oct.	June-Aug.
128	Rosaceae	<i>Potentilla eriocarpa</i> Wall ex Lehn.	Apr.-Sep.	June-July
129	Rosaceae	<i>Potentilla nepalensis</i> Hook f	Apr.-Sep.	June-July
133	Rosaceae	<i>Prunus cornuta</i> (Wall ex Royle) Steud.	Apr.-Sep.	June-July
142	Rosaceae	<i>Rosa alpina</i> L.	May-Oct.	May-June
143	Rosaceae	<i>Rosa macrophylla</i> Lindley	May-Sep.	June-July
144	Rosaceae	<i>Rosa webbiana</i> Wall ex Royle	Mar.-Oct.	June-Aug.
145	Rosaceae	<i>Rubus sanctus</i> Schreber.	Mar.-Oct.	July-Aug.
154	Rosaceae	<i>Sibbaldia cuneata</i> O. Kuntze	Mar.-Oct.	June-Aug.
160	Rosaceae	<i>Sorbaria tomentosa</i> (Lindl.) Rehrd	Apr.-Sep.	Apr.-May
158	Rutaceae	<i>Skimnea laureola</i> DC.	Mar.-Oct.	Apr.-June
147	Salicaceae	<i>Salix albida</i> L.	WY	July-Aug.
149	Sambucaceae	<i>Sambucus wightiana</i> Wall ex Wight and Am	May-Oct.	June-July
029	Saxifragaceae	<i>Bergenia ciliata</i> (Haw.) Sternb	Apr.-Sep.	June-July
030	Saxifragaceae	<i>Bergenia stracheyi</i> (Hook f. and Thoms) Engl.	Mar.-Sep.	June-July
091	Scrophulariaceae	<i>Lagotis cashmeriana</i> (Royle) Rupr.	Feb.-Oct.	May-July
106	Scrophulariaceae	<i>Orobancha cernua</i> Pers.	Apr.-Sep.	May-June
112	Scrophulariaceae	<i>Pedicularis punctata</i> Decne.	June-Aug.	June-July
174	Scrophulariaceae	<i>Verbascum thapsus</i> L.	Apr.-Oct.	June-July
175	Scrophulariaceae	<i>Veronica laxa</i> Benth.	Mar.-Oct.	Mar.-May
180	Scrophulariaceae	<i>Wulfenia amherstiana</i> Benth.	Mar.-Sep.	June-July
056	Solanaceae	<i>Datura stramonium</i> L.	Apr.-Sep.	June-July
159	Solanaceae	<i>Solanum nigrum</i> L.	May-Nov.	July-Aug.
166	Taxaceae	<i>Taxus wallichiana</i> Zucc.	Mar.-Oct.	June-Aug.
170	Trilliaceae	<i>Trillium govatanum</i> Wall ex D. Don	WY	Aug.-Sep.
040	Ulmaceae	<i>Celtis eriocarpa</i> L.	Apr.-Oct.	June-July
022	Umbelliferae	<i>Angelica glauca</i> Edgew.	Apr.-Aug.	June-July
035	Umbelliferae	<i>Bupleurum longicaule</i> Wall ex DC	Apr.-Sep.	July-Aug.
048	Umbelliferae	<i>Cortia depressa</i> (D. Don) Norman	Apr.-Sep.	June-July
078	Umbelliferae	<i>Heracleum candicans</i> Wall ex DC.	Mar.-Aug.	Apr.-May
172	Urticaceae	<i>Urtica dioica</i> L.	Feb.-Oct.	June-Aug.
173	Valerianaceae	<i>Valeriana pyrolifolia</i> Decne	Feb.-Oct.	June-Aug.
177	Violaceae	<i>Viola canascens</i> Wall ex Roxb	Apr.-Sep.	June-July
178	Violaceae	<i>Viola odorata</i> L.	Mar.-Aug.	May-July

WY: Whole year

DISCUSSION

The studies from various parts of the world have shown that climatic factors are mainly responsible for vegetative and reproductive phenology both at community and species level. However, different phenological events are triggered by rainfall, water availability, temperature, photoperiod, duration of dry spell and change in day length (Bhat and Muralli, 2001; Hamann, 2004).

The temperate forests have a different array of species from subtropical and alpine forest and it supports various varieties of overstory and understory plant species, which are major food resources for a variety of biota. Present findings in this regard agreed to Bhat and Muralli (2001). In Azad Jammu and Kashmir, no reports are

available on phenological studies of moist temperate tree species in forest ecosystem. However, the phenological pattern of tree species of Lawat hills has not been worked out, therefore the present study aims at analyzing the phenological pattern of tree, shrubs, herbs and grasses to understand their response to climatic factors and periodicity of seasons.

In the investigated area total trees were 15. Maximum flowering in trees were recorded in the months of April (36%) and June (28%), 14% each in May and August and 7% in the month of July. Similarly shrubs flowered in the months of June (33%) and July (27%) while 13% each in April and May and 6% each in March and August. Similarly maximum flowering in herbs was in the month of June (41%) and grasses 33% each in the months of June and August. Mishra *et al.* (2006) reported that in his area

leaf drop, leaf flush and flowering occurred in the months of March-May, respectively in the subtropical zone.

In the investigated area (from 2400 to 3900 m) the variation in phenology might be due to altitude, rainfall, saturation, photoperiod which indirectly signifies soil moisture availability, while the lower area supports dryish conditions. Arjunan and Pannammal (1993) stated that leaf drop is delayed due to rain and high temperature and advanced due to drought and low temperature.

Cool dry winter period is responsible for maximum leaf drop whereas increase in temperature during warm and dry periods induces the leaf flushing and flowering in most of the species.

The peak fruiting period of the trees starts from October-November, Shrubs in October and herbs in September, respectively. The fruit development period for different species of both overstory and understory layers varies from three to eight weeks. A majority of species in both categories showed rapid fruiting activity. A large proportion of species recorded lengthy fruiting behavior but a few species have a multiple fruiting behavior.

Almost all tree species had phenological pattern that synchronized flowering and fruiting in dry months (October and November). Similarly, Mishra *et al.* (2006) reported dry months as April, May and June. Most of the species in the investigated area flowered at the beginning of May and June, respectively and fruited near the end of July and August needing only a short time for the development of fruits. Rest of species flowered during July-August and fruited during October and November with moderate requirement for selective fruit development. The increase in temperature favors the formation of fruits in most of overstory and understory species.

In woody tree species, the ripening of fruits began in late part of rainy season and continued up to end of cool and dry period which is due to differences in time taken for fruit maturation.

CONCLUSION

The area lies in the Himalayan Region and is rich in floral diversity. Present study is an attempt in the exploration of the flora as well as the phenological pattern of different plant species in the area. The vegetation of the area is intensely affected by the nomadic as well as local grazing animals and activities of deforestation. Overexploitation of medicinal plants is another factor contributing to the loss of biodiversity (Dar, 2003). It is suggested that the extraction of different ethnobotanically important species should be stopped for some period to allow the regeneration of rare species which were dominant in the past.

REFERENCES

- Ali, S.I. and M. Qaiser, 1995-2006. Flora of Pakistan. Islamabad, Karachi.
- Arjunan, M.C. and P.S. Pannammal, 1993. Studies on phenology and nursery technology of certain tree species. *J. Indian Bot. Soc.*, 10: 147-150.
- Bhat, D.M. and K.S. Murali, 2001. Phenology of understory species of tropical moist forest of Western Ghats Region of Uttara Kannada District in South India. *Curr. Sci.*, 81: 799-805.
- Cornejo-Tenorio, G. and G. Ibarra-Manriquez, 2007. Plant reproductive phenology in a temperate forest of the monarch butterfly biosphere reserve, Mexico. *Interciencia*, 32: 445-452.
- Dar, M.E.U.I., 2003. Ethnobotanical uses of plants of Lawat District Muzaffarabad, Azad Jammu and Kashmir. *Asian J. Plant Sci.*, 2: 680-682.
- Fox, J.F., 1976. Constraints on the natural regeneration of tropical moist forest. *For. Ecol. Manage.*, 1: 37-65.
- Government of Azad Jammu and Kashmir, 2005. Azad Jammu and Kashmir: Official Website. <http://www.ajk.gov.pk/site/index.php>.
- Hamann, A., 2004. Flowering and fruiting phenology of a Phillipine submontane rain forest: Climatic factors as proximate and ultimate causes. *J. Ecol.*, 92: 24-31.
- Manske, L.L., 2006. Western snowberry biology. Annual report. North Dakota State University Dickinson Research Extension Center. <http://www.ag.ndsu.nodak.edu/dickins/research/2005/PDF/range05b.pdf>.
- Mishra, R.K., V.P. Upadhyay, S. Bal, P.K. Mohapatra and R.C. Mohanty, 2006. Phenology of species of moist deciduous forest sites of Similipal biosphere reserve. *Lyonia*, 11: 5-17.
- Nasir, E. and S.I. Ali, 1971-1994. Flora of Pakistan. Pakistan Agriculture Research Council, Islamabad.
- Qureshi, R., 2008. Preliminary floristic list of Chotiari wetland complex, Nawab Shah, Sindh, Pakistan. *Pak. J. Bot.*, 40: 2281-228.
- Ragusa-Netto, J. and R.R. Silva, 2007. Canopy phenology of a dry forest in Western Brazil. *Braz. J. Biol.*, 67: 569-575.
- Singh, J.S. and V.K. Singh, 1992. Phenology of seasonally dry tropical forest. *Curr. Sci.*, 63: 684-689.
- Van Schaik, C.P., J.W. Terborgh and S.J. Wright, 1993. The phenology of tropical forests: Adaptive significance and consequences for primary consumers. *Ann. Rev. Ecol. Syst.*, 24: 353-377.