

Full Length Research Paper

Phenological patterns among the vegetation of Ganga Chotti and Bedori Hills in a moist temperate to alpine forests

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There were 206 plant species of 47 families consisting of 10 trees, 18 shrubs, 140 herbs and 38 grasses harbouring Ganga Chotti and Bedori Hills during 1999 and 2000. The investigated area had two flowering seasons. In the first spell, 111 species (54%) flowered while in the second spell, 46% species flowered. Majority of the herbaceous, shrubby trees species flowered from May to June and the flowering reached the peak during July and August. Most species produced fruits during the first spell

Key words: Phenology, climate, environmental changes, rainfall.

INTRODUCTION

Phenology is a periodic phenomenon in plants that is tied to periodic environmental changes. This type of study investigates the relationship between climate and growing periods of plants of an area. The studies are essential for planning, regeneration, forestation and conservation in rangeland and forestry. Some work has been done on phenology of plants in different areas of the world (Morellato, 1995; Wright and Calderon, 1995; Kim, 1996; Stranghetti and Ranga, 1997; Shrestha et al., 1998; Zhanghe et al., 1999; Kimkim and Yadava, 2001; Osada et al., 2003; Marques et al., 2004; Malik, 2005, 2007).

The investigated area lies in moist temperate to alpine zone. The annual rainfall is 705.12 mm. The minimum rainfall occurs during the month of June to August with 76-167 mm, respectively. The maximum temperature from January to March ranges between 11 and 16°C. From May to August, the temperature ranges between 25 and 29°C. Snow falls frequently at altitude above 2000 m during November to January which melts during the month of May. However, there is no permanent snow cover.

MATERIALS AND METHODS

The phenological observations were recorded every month for two consecutive years from May to November, 1999 and then again from May to November, 2000. The data was averaged. The plants were classified into the following three stages.

1. Prereproductive (vegetatively young and pre-flowering)
2. Flowering (only flowers seen)
3. Fruiting (when fruiting can be seen)
4. Dormant (life cycle completed or fruiting completed).

RESULTS

There were two flowering seasons in the investigated area. One from May to August followed by the second from September to November. From December to April the entire area is covered by snowfall.

In the first periods 111 species (53.88%) flowered, which included 6.89% trees, 10.34% shrubs, 62.06% herbs and 13.79% grasses. There were 6.89% ferns in

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Table 1. Phenology of plants recorded from Ganga Chotti and Bedori hills during 1999-2000.

S/N	Specie Tree layer	Seedling	Flowering	Fruiting	Dormant
1	<i>Abies pindrow</i> Royle	Mar	Apr	May	July
2	<i>Ficus palmata</i> Forssk	Throughout the year	May	Aug	Sep
3	<i>Picea smithiana</i> (Wallich) Boiss	Mar	Apr	May	July
4	<i>Pinus roxburghii</i> Sargent	Mar	Apr	May	July
5	<i>Pinus wallichiana</i> A.B.Jackson	Mar	Apr	June	July
6	<i>Punica granatum</i> L.	Throughout the year	July	Aug	Sep
7	<i>Pyrus pashia</i> Buch	Apr	May	July	Aug
8	<i>Quercus dilatata</i> Royle	Mar	Apr	June	July
9	<i>Machilus odoratissima</i> Nees	May	July	Aug	Sep
10	<i>Astragalus floridus</i> L.	June	Aug	Sep	Oct
Shrub layer					
11	<i>Berberis lycium</i> Royle	Mar	Apr	June	July
12	<i>Cotoneaster acuminatus</i> Lindley	May	June	July	Sep
13	<i>Desmodium multiflorum</i> DC	June	July	Sep	Oct
14	<i>Indigofera heterantha</i> Wallich	June	July	Sep	Oct
15	<i>Jasminum officinale</i> L.	Throughout the year	June	July	Aug
16	<i>Juniperus communis</i> L.	Mar	May	June	July
17	<i>Myriactus nepalensis</i> Bth	Aug	Sep	Oct	Nov
18	<i>Myrsine africana</i> L.	Mar	May	June	July
19	<i>Rosa ellipticus</i> Smith	May	June	July	Sep
20	<i>Rosa macrophylla</i> Lindley	May	June	July	Sep
21	<i>Rosa webbiana</i> Wallich ex Royle	May	July	Aug	Sep
22	<i>Rubus niveus</i> Wallich	May	July	Aug	Sep
23	<i>Salix albeda</i> Anderson	June	July	Aug	Oct
24	<i>Salix denticulata</i> Anderson	May	June	July	Aug
25	<i>Salix grandiflorum</i> L.	May	July	Aug	Sep
26	<i>Sarcococca saligna</i> (D.Don) Muel	Throughout the year	Apr	May	june
27	<i>Viburnum grandiflorum</i> Wallich ex DC	Oct	Nov	May	June
28	<i>Zanthoxylum armatum</i> DC	Mar	Apr	May	June
Herb layer					
29	<i>Achillea millefolium</i> L.	May	July	Aug	Sep
30	<i>Aconitum chasmenthum</i> Stapf	July	Aug	Sep	Oct
31	<i>Aconitum laeve</i> Royle	July	Aug	Sep	Oct
32	<i>Aconitum violaceum</i> jacquem ex Stapf	July	Aug	Sep	Oct
33	<i>Ajuga bracteosa</i> Wallich	Apr	June	July	Oct
34	<i>Allium humile</i> Kunth	May	July	Sep	Oct
35	<i>Amaranthus viridus</i> L.	May	July	Aug	Sep
36	<i>Anaphalis margaritacea</i> (L.) Bth	July	Sep	Oct	Nov
37	<i>Anaphalis nepalensis</i> Spreng. Hand	May	July	Aug	Sep
38	<i>Anaphalis timmua</i> D. Don	May	July	Sep	Oct
39	<i>Androsace rotundifolia</i> Hardw	Mar	Aug	Sep	Oct
40	<i>Aquilegia pubiflora</i> Wallich	May	July	Sep	Oct
41	<i>Arenaria neel</i> Wight and Arn	Mar	Apr	Aug	Sep
42	<i>Arenaria orbiculata</i> Royle	June	Aug	Sep	Oct
43	<i>Arisaema intermedium</i> Blume	May	June	July	Aug
44	<i>Arisaema jacquemontii</i> Blume	May	June	July	Aug
45	<i>Artemisia wallichiana</i> Besser	June	July	Aug	Sep

Table 1. Contd.

46	<i>Artemisia scoparia</i> Waldst and Kit	Apr	July	Aug	Sep
47	<i>Artemisia herba-alba</i> Asso	May	July	Sep	Oct
48	<i>Aster alpinus</i> (Clarke) Hutch	May	June	Aug	Sep
49	<i>Bergenia ciliata</i> (Haw) Sternb	Apr	June	July	Aug
50	<i>Bergenia ligulata</i> (Str) Hot	Apr	May	June	July
51	<i>Biden bipinnata</i> L.	Apr	May	July	Sep
52	<i>Bistorta amplexicaulis</i> (D.Don) Greene	May	July	Aug	Sep
53	<i>Brunella vulgaris</i> .L	May	June	Aug	Sep
54	<i>Bupleurum longicaule</i> Wall Ex DC	May	July	Sep	Oct
55	<i>Calamintha umbrosum</i> (M.Bieb) K.Koch	May	July	Aug	Sep
56	<i>Caltha palustris</i> L.	May	July	Aug	Oct
57	<i>Cannabis sativa</i> L.	May	June	July	Aug
58	<i>Chenopodium ambrosioides</i> L.	May	June	July	Sep
59	<i>Circaea alpina</i> Asch&Mag	June	July	Aug	Sep
60	<i>Cirsium arvense</i> (L).Scop	June	July	Aug	Oct
61	<i>Clematis grata</i> Wallich	Throughout the year	July	Aug	Sep
62	<i>Clinopodium alpinum</i> Cass	Oct	June	July	Aug
63	<i>Codonopsis ovata</i> Bth	June	July	Aug	Oct
64	<i>Convolvulus arvensis</i> Var. <i>linearifolius</i> Choisy	Throughout the year	July	Aug	Sep
65	<i>Conyza canadensis</i> L.	May	June	July	Aug
66	<i>Cotoneaster acuminatus</i> Lindley	May	June	July	Aug
67	<i>Cynoglossum lanceolatum</i> Forssk	Apr	June	July	Aug
68	<i>Cynoglossum glochidiatum</i> Wallich ex Benth	May	July	Aug	Sep
69	<i>Cyperus niveus</i> Retz	May	June	July	Sep
70	<i>Cyperus panicoides</i> L.	June	July	Aug	Sep
71	<i>Cypripedium cordigerum</i> D.Don.Prod	May	June	July	Sep
72	<i>Dipsacus inermis</i> Wall	June	July	Aug	Sep
73	<i>Elsholtzia strobilifera</i> Bth	Throughout the year	July	Sep	Oct
74	<i>Epilobium cylindricum</i> D.Don	May	July	Sep	Oct
75	<i>Epilobium hirsutum</i> L.	May	July	Sep	Oct
76	<i>Erigeron alpinus</i> L.	Apr	June	Aug	Sep
77	<i>Erigeron bellidioides</i> Buch	Apr	June	Aug	Sep
78	<i>Euphorbia helioscopia</i> L.	Apr	July	Aug	Sep
79	<i>Euphorbia wallichii</i> HK..f	Apr	May	Sep	Oct
80	<i>Euphorbia prostrata</i> Ait	Throughout the year	Aug	Sep	Oct
81	<i>Fragaria nubicola</i> Lindl.	Apr	June	July	Aug
82	<i>Fritillaria roylei</i> Hook	May	July	Aug	Sep
83	<i>Galium elegan</i> Wall	June	July	Aug	Sep
84	<i>Gentiana cachmerica</i> DC	July	Aug	Sep	Oct
85	<i>Gentiana decumbens</i> L.P Clarke	July	Aug	Sep	Oct
86	<i>Gentiana kurroo</i> Royle	July	Aug	Sep	Oct
87	<i>Geranium rotundifolium</i> L.	Mar	May	June	Aug
88	<i>Geranium wallichianum</i> D.Don	June	July	Sep	Oct
89	<i>Gerbera gossypina</i> Royle	Oct	May	July	Aug
90	<i>Geum elatum</i> Wall	May	June	Aug	Sep
91	<i>Hedra nepalensis</i> K. Koch	Throughout the year	Aug	Nov	Oct
92	<i>Impatiens edgeworthii</i> H.K.f	June	Sep	Oct	Nov
93	<i>Impatiens glandulifera</i> Royle	July	Aug	Sep	Oct
94	<i>Ipomoea perforatum</i> L.	May	June	Aug	Sep

Table 1. Contd.

95	<i>Iris lactea</i> L.	May	June	Aug	Sep
96	<i>Lactuca dissecta</i> L.	May	July	Aug	Sep
97	<i>Lavaetra cachemiriana</i> Camb	May	July	Aug	Sep
98	<i>Leontopodium alpinum</i> Cass	Apr	June	Aug	Oct
99	<i>Lepidium sativum</i> L.	May	June	July	Aug
100	<i>Lespedeza sericea</i> (Thunb) Miq	June	July	Aug	Sep
101	<i>Malva sylvestris</i> L.	Apr	June	Aug	Sep
102	<i>Malva verticillata</i> L.	Apr	June	July	Sep
103	<i>Medicago falcata</i> L.	May	July	Aug	Sep
104	<i>Medicago lecinia</i> (L) Mill	May	July	Aug	Sep
105	<i>Melilotus indica</i> (L) All	May	July	Aug	Sep
106	<i>Mentha longifolia</i> (L.)Hudson	May	June	July	Sep
107	<i>Micromeria biflora</i> (Ham) Bth	May	June	July	Aug
108	<i>Morina coulteriana</i> Royle	May	July	Aug	Oct
109	<i>Myriactus nepalensis</i> Bth	Aug	Sep	Oct	Nov
110	<i>Nepeta podostachys</i> Bth	July	Aug	Sep	Oct
111	<i>Oenanthe javanica</i> (Blume) DC	Apr	July	Aug	Sep
112	<i>Oenothera rosea</i> (L). Her	May	July	Aug	Oct
113	<i>Oxalis corniculata</i> L.	Apr	May	June	July
114	<i>Phlomis bracteosa</i> Royle ex Bth	May	June	July	Aug
115	<i>Plantago lanceolata</i> L.	Apr	Aug	Sep	Oct
116	<i>Plantago major</i> L	July	Aug	Sep	Nov
117	<i>Plantago ovata</i> Forssk	May	July	Aug	Nov
118	<i>Plectranthus rugosus</i> Wall	July	Sep	Oct	Nov
119	<i>Pleurospermum govianum</i> (DC) Clarke	May	July	Aug	Oct
120	<i>Podophyllum hexandrum</i> Royle	Apr	May	June	July
121	<i>Polygonum album</i> Ham	May	July	Aug	Sep
122	<i>Polygonum amplexicaulis</i> D.Don	May	July	Aug	Sep
123	<i>Polygonum alpinum</i> All	May	June	July	Aug
124	<i>Potentilla cuneata</i> Wallich	June	July	Aug	Sep
125	<i>Potentilla eriocarpa</i> Wallich	June	July	Aug	Sep
126	<i>Potentilla gelida</i> C.A. Meyer	May	July	Sep	Oct
127	<i>Potentilla geradiana</i> L.	June	July	Aug	Sep
128	<i>Primula denticulata</i> Smith	Apr	July	Aug	Sep
129	<i>Pseudomertensia echioides</i> (Bth) Riedl	May	July	Aug	Sep
130	<i>Pseudomertensia moltkoides</i> (Royle) Kazmi	May	July	Aug	Sep
131	<i>Ranunculus repens</i> L.	May	June	July	Aug
132	<i>Ranunculus laetus</i> Wallich	May	June	July	Aug
133	<i>Rubia tinctorum</i> L.	May	June	July	Aug
134	<i>Rumex hastatus</i> D. Don	May	June	July	Sep
135	<i>Rumex dentatus</i> L.	May	Aug	Sep	Oct
136	<i>Rumex nepalensis</i> D.Don	May	July	Aug	Nov
137	<i>Saussurea lappa</i> Clark	Apr	June	July	Sep
138	<i>Saxifraga ciliata</i> Royle	July	Aug	Sep	Oct
139	<i>Scutellaria chamaedrifoleda</i> Bth	Apr	June	Aug	Sep
140	<i>Senecio ligularia</i> Hook	July	Aug	Sep	Oct
141	<i>Senecio chrysanthemoides</i> DC	July	Aug	Sep	Oct
142	<i>Senecio graciliflorus</i> DC	July	Aug	Sep	Oct
143	<i>Senecio nudicaulis</i> DC	July	Aug	Sep	Oct

Table 1. Contd.

144	<i>Senecio quadriflorum</i> Pall	July	Aug	Sep	Oct
145	<i>Selinum tenuifolium</i> Wall	July	Aug	Sep	Oct
146	<i>Sibbaldia cuneata</i> Hornem	June	July	Aug	Oct
147	<i>Solanum nigrum</i> L.	Throughout the year	July	Sep	Nov
148	<i>Sonchus arvensis</i> L.	Apr	July	Sep	Nov
149	<i>Sonchus asper</i> Hill	Apr	July	Sep	Nov
150	<i>Spiraea canescens</i> D.Don	June	July	Aug	Sep
151	<i>Stellaria media</i> (L) Vill	May	July	Aug	Sep
152	<i>Stellaria monosperma</i> Buch	May	July	Aug	Sep
153	<i>Strobilanthes attenuata</i> Nees	May	July	Aug	Sep
154	<i>Swertia petiolata</i> D.Don	June	July	Aug	Sep
155	<i>Taraxacum officinales</i> Weber	Apr	June	July	Aug
156	<i>Thlaspi arvensis</i> L.	May	June	July	Aug
157	<i>Thymus serpyllum</i> L.	May	July	Aug	Sep
158	<i>Trifolium repens</i> L.	May	June	July	Aug
159	<i>Trifolium resupinatum</i> L.	May	June	July	Aug
160	<i>Trillidium repen</i> L	May	June	July	Aug
161	<i>Trilidium govianum</i> (D. Don) Kunth	May	June	July	Aug
162	<i>Tussilago farfara</i> L.	June	July	Aug	Sep
163	<i>Urtica dioica</i> L.	June	Aug	Sep	Oct
164	<i>Valeriana pyrolifolia</i> Dcne	Apr	May	June	Aug
165	<i>Verbascum thapsus</i> L.	June	July	Aug	Oct
166	<i>Veronica melissaefolia</i> Royle	May	June	July	Aug
167	<i>Viola odorata</i> L.	Mar	Apr	June	Aug
168	<i>Viola serpen</i> Wallich	Mar	May	July	Sep
Grasses					
169	<i>Agrostis alba</i> auct	May	July	Aug	Sep
170	<i>Agrostis canina</i> auct	May	July	Aug	Sep
171	<i>Agrostis gigantea</i> Roth	May	July	Aug	Sep
172	<i>Andropogon munroi</i> C.B.Clarke	Mar	Apr	Aug	Sep
173	<i>Arundo donax</i> L.	May	June	Oct	Nov
174	<i>Avena barbata</i> Pott ex Link	Mar	Apr	May	June
175	<i>Brachiaria ramosa</i> (L) Stapf	May	July	Oct	Nov
176	<i>Bromus tectorum</i> L.	May	June	July	Aug
177	<i>Cenchrus biflorus</i> Roxb	Aug	Sep	Nov	Dec
178	<i>Cenchrus uniflorus</i> Ehr	July	Aug	Jan	Feb
179	<i>Chrysopogon aucheri</i> (Boiss) Stapf	Feb	Apr	May	June
180	<i>Cynodon dactylon</i> (L.) Pers	Feb	Mar	Sep	Oct
181	<i>Dactylis glomerata</i> L.	June	July	Aug	Sep
182	<i>Desmostachya bipinnata</i> (L) Stapf	Sep	Oct	Dec	Jan
183	<i>Dichanthium annulatum</i> (Forssk).Stapf	Feb	Apr	Sep	Oct
184	<i>Elymus repens</i> (L.)Gould	June	July	Aug	Sep
185	<i>Festuca modesta</i> Nees	Mar	Apr	Aug	Sep
186	<i>Imperata cylindrica</i> (L.)	Mar	Apr	June	July
187	<i>Koeleria macrantha</i> (Ledeb) Schult	Mar	Apr	Sep	Oct
188	<i>Phalaris minor</i> Retz	Feb	Apr	Aug	Sep
189	<i>Phleum alpinum</i> L.	June	July	Sep	Oct
190	<i>Poa annua</i> L.	Feb	Apr	Sep	Oct
191	<i>Poa bactriana</i> Rozhev	Mar	Apr	May	June
192	<i>Polypogon monspeliensis</i> (L.) Desf	Mar	Apr	July	Aug
193	<i>Saccharum spontaneum</i> L.	June	July	Sep	Oct

Table 1. Contd.

194	<i>Sorghum halepense</i> (L)Pers	Apr	May	Oct	Nov
195	<i>Themeda anathera</i> Ness ex Steud	May	June	Oct	Nov
196	<i>Vetiveria zizanioides</i> (L) Nasch	Aug	Sep	Oct	Nov
197	Ferns				
	<i>Adiantum venustum</i> D.Don	June	July	Aug	Sep
	<i>Adiantum capillus veneris</i> L.	June	July	Aug	Oct
	<i>Asplenium adiantum nigrum</i> L.	June	Aug	Sep	Oct
	<i>Athyrium mackinnoni</i> (Hope) C. Chr	June	Aug	Sep	Oct
	<i>Cystopteris fragilis</i> (L) Bth	May	June	July	Aug
	<i>Dryopteris stewartii</i> Fress	May	July	Aug	Sep
	<i>Onychium japonicum</i> (Kunze) Wall	May	June	July	Oct
	<i>Pteris cretica</i> L.	May	June	Aug	Sep
	<i>Pteris vitata</i> L.	May	June	Sep	Oct
	<i>Thelypteris levinger</i> Clark	May	June	Sep	Oct

Table 2. Comparison of phenological phases between spring and monsoon vegetation.

Season	Total flowering species	Flowering (%)	Trees (%)	Shrub (%)	Herbs (%)	Grasses (%)	Ferns (%)
1	111	53.80	6.89	10.34	62.06	13.79	6.89
2	95	46.11	1.12	2.25	74.15	16.85	5.61

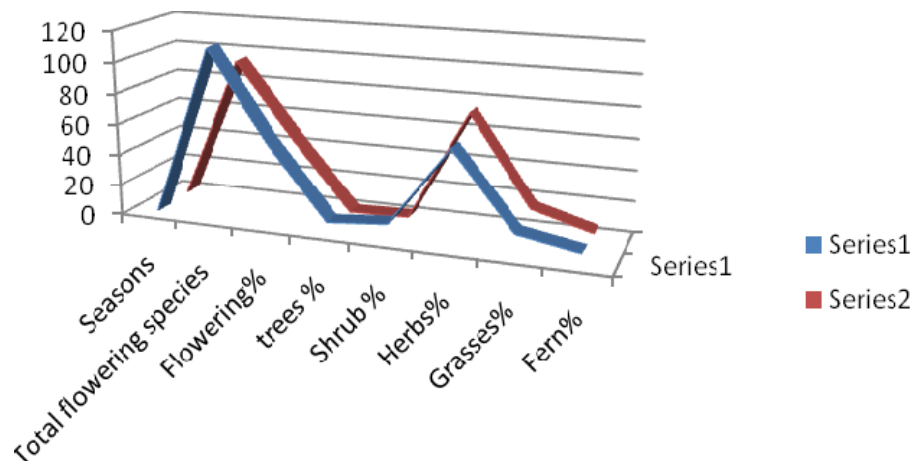


Figure 1. Comparison of phenological phases between spring and monsoon vegetation.

reproductive phase (sori were prominent) (Tables 1 and Table 2; Figure 1).

During the second flowering spell, 95 species (46.11%) were blooming. Out of these, 1.12% were trees, 2.25% were shrubs, 74.15% were herbs, 16.85% were grasses and 5.61% were ferns (in reproductive phase). There were 1% shrubs, 15% herbs and 2% grasses, which exhibited continuous flowering during growing season.

The months of May and June and then July and August appeared to be the peak flowering seasons as 36 (18%),

53 (26%), 81 (39%) and 28 (14%) species were in the flowering stage. The flowering percentage declined to 6 (3%) to 1(.5%) from September to November. Majority of species (55%) became dormant during September while the remaining 45% also become dormant in November.

Trees such as *Abies pindrow*, *Quercus dilatata*, *Picea smithiana*, *Pinus wallichiana* and *Ficus palmata* flowered in April and May and thereafter cones of conifers started maturing within the next 2-3 years. During this time cones remain intact on parent trees. Shrubby species had maxi-

mum flowering around May and June, which decreased to 20% towards the end of September. Thus, during September 80% species became dormant. From there onward with the onset of winter most (80%) species remain dormant till next April.

There were 38 herbaceous species in flowering stage in May, 46 in June and 83 in July, which decline to 27 in August. There was a tendency of declining flowering from September to October. Of the total 127 recorded herbaceous species, only 33% completed their life cycle at the end of June.

Maximum flowering of grass species (46.63%) was observed in May, followed by 28.5% in July. In the remaining months grasses flowered less than 10%.

DISCUSSION

The present study showed that the growing season started at the end of April whereby only few herbaceous and shrubby plants initiated vegetative growth. The blooming of few plants occurred during early May. Plants such as *Ficus*, *Pyrus*, *Juniperus*, *Myrsine*, *Bergenia*, *Biden*, *Euphorbia*, *Geranium*, *Gerbera*, *Oxalis*, *Podophyllum* and *Valeriana*, etc were active during this period.

The majority of herbaceous, shrubby and tree species flowered from May to August. The flowering reached the peak during July and August. The first spell of flowering started at the beginning of spring (May to June), while fructification occurred during July and August. Most species produced fruits during the first spell.

In the first spell, 111 species (53.88%) flowered, which included 7% trees, 10% shrubs, 26% herbs, 4% grasses and 6.89% ferns. During the second flowering spell, lasting from September to November 95 species (46%) were blooming. Of them, there were 1% trees, 2% shrubs, 21% herbs, 17% grasses and 5% ferns. The month of June and July appeared to be the peak flowering season. The flowering declined from September to November. Most trees and shrubs flowered during April to May. The fructification however can be observed in July - August. Shrestha et al. (1998) reported that majority of the plants flowers during April/May in Riyale, Nepal. Similarly, Zhanghe et al. (1999) also reported that peak of flowering occurred during May in different parts of China. Stranghetti and Ranga (1997) stated that in Brazil shrubs exhibited continuous flowering throughout the year. But in our case, majority of shrubs flowered from May to August. Our finding are in line with those of Kim (1996) and Stranghetti and Ranga (1997) who also reported two flowering seasons into their areas. Durrani (2000) also reported two flowering seasons in Harboi range, Kalat. The fruiting occurring during the dry period is probably related to the fact that the beginning of the next rainy period will offer favorable condition for seed germination (Morellato et al., 1989).

Another study in Brazil (Morellato, 1995) indicated that the flowering starts at the end of dry season and begin-

ning of wet period. Fruiting was more intense during dry season. Most species were in flowering session between July to September and fruiting in December, which is the end of dry and beginning of rainy seasons. Morellato and Leitao-Filho (1992) pointed out that this period (December) has the advantage of providing the seeds with more intense luminosity and thus greater probability to germinate. Foster (1982) mentioned that the phenology of fructification is strongly related to the seasons which offer better condition for seed germination. In our case seeds are deposited in November and December that remain dormant during the cold season and are subjected to natural treatments such as chilling, stratification and moisture treatment before they could germinate in the next spring, whereby climate becomes warmer.

Kikim and Yadava (2001) stated that majority of the species exhibited peak of leaf drop in cool dry period January to February and leaf flushing in the beginning of warm dry period (March to April) and another in rainy season (August) of the year. Both over-storey and under-storey species showed a sharp flowering peak in April. The peak period of fruit maturation occurred during September - October. This is what happened in this study. Leaf flush and flowering were simultaneous in over and under storey tree species. While the fruiting of under - storey tree species was one month earlier than that of over-storey tree species. In this study, trees such as *Abies pindrow*, *Picea smithiana*, *Pinus roxburghii* flowered and produced fruits in April and May when temperature was low. *Ficus palmata* flowered in May - August, *Pinus wallichiana* in April - June, *Pyrus pashia* in May - July, *Quercus dilatata* from April to June in low rainfall area, while *Machilus* and *Astragalus* in July-August and August-September during rainy seasons. In cool temperate forest, the proportion of flowerings tree species is small in early spring; this proportion increases around June, and then decreases again (Rathcke, 1988; Inoue et al., 1990; Kato et al., 1990). In the present study, a similar situation was seen because of similarity in climatic factor. The investigated area is of cool temperate type with low temperature in winter that restricts the reproductive timing of woody plants. Wright and Calderon (1995) indicated the importance of phenology in determining the flowering season of a species. The flowering sequence of several genera e.g. *Rhododendron* and *Viburnum* was conducted in cool temperate forest in North America (Rathcke, 1988). This suggests the phenological patterns might not change significantly through the data of one year.

Some trees on Yakushima Island flower even in winter (Yumoto, 1987), probably because of difference in latitude. Evergreen in typical warm tropical forest flower throughout the year, although the proportion of flowering tree is small in winter.

Osada et al. (2003) stated that various tree species bloomed sequentially from the middle of February to the end of October and flowering tree species were particu-

larly abundant around May. This corresponds to the season of leaf emergence, as flowers of most species were produced at the same time. In our case, too, the season started from the month of May whereby some species flowered in May such as *Abies*, *Picea* and *Pinus roxburgii* and shrubs such as *Juniperus*, *Myrsine*, *Bergenia*, *Biden*, *Euphorbi*, *Geranium*, *Gerbera*, *Oxalis*, *Podophyllum*, *Valeriana* and *Viola* flowered sequentially.

During, year 2000, the climate was comparatively moist due to rainfall while in 1999 climate was dry. The phenological activities were almost similar in both years from April to August. Species of spring aspect completed their life cycle one month earlier during 2000 as compared to 1999. The major vegetation elements remained dormant from November onward. Morellato and Leitao-Filho (1992) stated that lack of nutrients during transition from dry to wet season might be an important factor in controlling phenological activities. In the investigated area, low precipitation rate and fall of the leaves of many species during dry season offer a good chance with climatic cycle. Normally plants disperse seeds/fruits after completing the life cycle. During winter, seeds receive cold treatment which triggers germination and sprouting from below ground parts or shoots during early monsoon.

The grazing period was coordinated with phenological cycle. Grazing was allowed in most plants or in vegetative fall. Once the shrubs shed the seeds, they may be allowed for grazing. Grazing of annual and herbaceous plants before flowering will slowly decrease their production as seeds are the only source of survival and regeneration. Seed collection can be achieved after fruiting seasons for storage as a gene bank. The crucial grazing period which is coordinated with flowering can be avoided to ensure a good seed bank for future generation. The annuals usually flush flowering during early spring or during monsoon season. Rainfall in the investigated area is uncertain for the last few years, therefore the amount of seed produced and emergence of seedling might be invariable during different years.

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