

Phenological Features and Life Forms in Alpine Meadows of Kedarnath, Garhwal Himalaya: India

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Abstract: In present paper phenological behavior and life forms was observed in an alpine pasture of western Himalaya (Kedarnath), India. Total 156 species including two different growth forms herbs and shrubs (76 species in KA and 80 species in KB site) were identified. In the majority of the growth forms, growth initiation was recorded in May whereas senescence in October. Maximum flowering occurred in July-August in alpine regions. Phenological character viz., germination, vegetative growth, flowering, fruiting and senescence depend on the climate of the regions. Most of the species initiate their germination after snow melt in month of April- May. The dominant life forms found in Kedarnath was Chamaephytes, Therophytes and Cryptophytes in both sides.

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Key words: Alpine meadows, Himalaya, phenology, life forms.

Introduction:

Kedarnath is a majestic sight, standing in a middle of a wide plateau surrounded by lofty snow covered peak. The present temple built in the 8th century by Adi Shankaracharya, stands adjacent to the site of an earlier temple built by the Pandavas, the exquisitely architected Kedarnath temple is said to be more than 1000 years old.

Alpine zones represent the highest vegetational zone on mountains of the Himalaya and are delimited by timberline (3350 amsl) and snowline (5400 amsl) in Garhwal. The alpine flora flourishes in severe physical environment which is characterized by a short, cold, unpredictable growing season, strong winds and widely fluctuating temperature of air and soil surface. The alpine flora is mainly composed of herbaceous perennials and prostrate shrubs which are well adapted, successful, autochthonous elements of high altitudes. In alpine regions the growing season is short, about six to seven months at 3000 m, shortening further upwards to about one month at 5500 m altitude. Phenology is the study of periodically occurring natural phenomenon and their relation to climate and changes in season is a central focus of several aspects of ecology (Wieder *et al.*, 1984). In arctic and alpine tundra, the growing season is extremely short, and its duration varies strongly among years (Molau, 1993; Tho'rhallsdo'ttir, 1998). In the scientific literature on ecology, the term is used more generally to indicate the time frame for any seasonal phenomena, including the dates of last appearance (Mier, 2007). At higher elevations, temperature is the most important factor in different phenological stages (Holway and Ward, 1965). Plant phenology in alpine region is strongly influenced by variation in microenvironments related to micro

topography (Bliss, 1956, 1966; Percy and Ward, 1972 and Fareed and Caldwell, 1975).

Materials and Methods:

Study area:

Kedarnath is situated in the Rudraprayag district of Uttarakhand, located at 30° 73'N latitude and 79° 07'E longitude. The alpine zones are started in the study area approximately at 3100m asl. Amidst the dramatic mountain scapes of the majestic Kedarnath range stands one of the twelve 'Jyotirlingas' of Kedar or lord Shiva, lying an altitude of 3553m asl on the head of river Mandakini, the shrine of Kedarnath is amongst the holiest pilgrimages for the Hindus.

The two sites were selected for the present investigation viz., Kedarnath A (KA, at the eastern flank of Kedarnath dham) and Kedarnath B (KB, at the western flank), 500-800m apart from each other, lying at an altitude of 3400-3600masl. Like other alpine and arctic zones of the globe, the climate of this alpine zone is cold, with intense irradiance and low partial gas pressure. Heavy frost, blizzards and hailstorms prevail throughout the year except for a few months. Precipitation was observed in the form of snow, hail, heavy rains and showers during the year. The snowfall occurs from November to April. Snowmelt occurs during April and May, providing an abundance of soil water prior to the monsoon period. Maximum rainfall was recorded in July-August and hardly a day was observed without rain or showers.

On the basis of extensive and frequent survey of the area attempts were made to collect whole plant species from the area to study the phenology and life forms study. Plants were identified from the Garhwal University Herbarium (GUH). Plants were arranged alphabetically while making the floristic composition. Two sites (Kedarnath A & Kedarnath B), which have

been described earlier, were taken into consideration for phenological and life forms study. To facilitate the periodic examination of a sizable number of plants, 10 quadrats (10×10m) for shrub species while 25 quadrats (50×50cm) for herbaceous vegetation; were positioned subjectly at each site. In the selection of quadrat location, an effort was made to include most of the species for that site. These phenological stages were taken into consideration from May to October 2010. Five phenophases, Germination (G), vegetative form (VG), flowering (FL), fruiting (FR) and senescence (SC) were recorded at monthly intervals. The species assigned to various life forms following Raunkier's (1934). The percentage life forms were calculated as follows:

$$\% \text{ Life forms} = \frac{\text{No of species in any life form}}{\text{Total no of species of all life forms}} \times 100$$

Results:

Climatological data in the form of an Ombrothermic diagram are given in Fig. 1. During the study period (May to October 2010) the highest mean maximum monthly temperature was 16.2°C and 17.7°C, respectively, on sites Kedarnath A and Kedarnath B in the month of June. Corresponding mean minimum temperature were 3.6 °C and 3.1°C recorded in the month of October. The total half yearly rainfall was 2237.9mm at Kedarnath A and 2216.5mm at Kedarnath B. The rainfall was heaviest in the month of July and August. October remained dry with occasional showers.

In alpine region, generally growth indication occurred in April and may whereas senescence in September and October in different plant species of different plant forms. In alpine habitat seedling are uncommon. Very few species starts their germination

from seeds. Majority of the species germinate from rhizomes, rootstock or other perennating organs. In perennial herbs and shrubs, sprouting started from the rhizome which was soon followed by vigorous vegetative growth. *Aconitum* sp., *Picrorhiza kurrooa*, *Rheum emodii*, *Rhodiola wallichiana* are some species which starts their germination from rhizome.

The phenological progression of different species in various months of the years is presented in Fig. 2, Table 1 and 2. There occur a definite trend of periodicity in the progression of phenophases. Very few species completed their vegetative growth and initiated their flowering in the month of April- May (10 spp in KA and 24 spp in KB site) such as *Arabis amplexicaulis*, *Cerastium vulgatum*, *Delphinium denudatum*, *Primula denticulate* and *Ranunculus hirtellus* etc. showed very short fl-fr period. Maximum flowering was occurred in the month of July at both alpine (KA & KB) sites. At KA site number of flowering species in the month of July were recorded were 62 spp. while on the second site KB, number of flowering species were 66. Such as *Polygonum spp.*, *Swertia speciosa*, *Anemone species*, *Carex nubigina*, *Dactylorhiza hatagirea*, *Morina longifolia* etc. Some of the earliest flowering species like *Caltha palustris*, *Primula* spp. and *Gentiana* spp. have their perennation buds close to the soil surface, which can initiate growth even below a few cm of snow cover. The majority of the species in fruiting stage were recorded in the month of September (58 spp. in KA & 71 spp. in KB). Minimum number of fruiting was recorded in the month of May only one species *Arabis amplexicaulis* which starts their life cycle in April and end in the August, show very short life-cycle. Senescence were usually started in August and max out in the month of October with the starting of snowfall.

Table-1: Monthly variation in phenophases and life forms in alpine meadow of Kedarnath A site

S No	Name of spp	Life form	May	June	July	August	September	October
Shrub								
1	<i>Aster albescense</i> (DC)Hand .-Mazz	CH	-	GR,VG	VG	VG,FL	FL	FR
2	<i>Cotoneaster microphyllus</i> Wallich ex Lindly	CH	GR,VG	VG,FL	FL,FR	FR	FR	SC
3	<i>Ephedra acuminata</i> (Roxb.)IM Johnson	PH	VG	VG	VG,FL	FL	FL,FR	FR
4	<i>Gaultheria tricophylla</i> Royle.	TH	GR,VG	VG,FL	FL,FR	FR	FR,SC	-
5	<i>Polygonum affini</i> D.Don	CH	GR,VG	VG, FL	FL	FL,FR	FR	SC
6	<i>Polygonum alpinum</i> All.	CH	GR,VG	VG, FL	FL	FL	FL,FR	FR, SC
7	<i>Polygonum amplexicaule</i> D.Don	CH	GR,VG	VG, FL	FL	FL	FL,FR	FR, SC
8	<i>Polygonum macrophyllum</i> D.Don	CH	GR,VG	VG, FL	FL	FL	FL,FR	FR, SC
9	<i>Swertia speciosa</i> D.Don.	TH	-	GR,VG	VG,FL	FL, FR	FR,SC	-
Herb								
1	<i>Aconitum balfourii</i> Stapf	CH	GR,VG	GR,VG	VG	VG,FL	FL,FR	FR,SC
2	<i>Aconitum hetrophyllum</i> Wall.ex Royle	CH	GR, VG	VG	VG	VG,FL	FL,FR	FR, SC
3	<i>Ajuga bracteosa</i> Wallich ex Benth.	TH	VG,FL	FL	FL	FL,FR	FR	FR
4	<i>Allium stracheyi</i> Baker	CR	-	-	GR,VG	VG,FL	FL,FR	SC
5	<i>Allium wallichii</i> Kunth.	CR	-	GR,VG	VG, FL	FL	FR	SC
6	<i>Anaphalis adnata</i> Wallich exDC	CH	-	GR,VG	VG,FL	FL	FL	FR
7	<i>Anaphalis cuneifolia</i> Hook f.	CH	GR,VG	VG,FL	FL	FL	FR	FR, SC
8	<i>Androsace studiosorum</i> Wallich in Roxb.	TH	VG	VG,FL	FL	FL, FR	FR	SC

9	<i>Anemone obtusiloba</i> D.Don	CH	GR, VG	VG, FL	FL, FR	FR	SC	-
10	<i>Anemone rivularis</i> Buch.-Ham.ex DC	CH	GR, VG	VG, FL	FL, FR	FR	SC	-
11	<i>Anemone rupicola</i> Camb.	CH	GR, VG	VG, FL	FL, FR	FR	SC	-
12	<i>Angelica archangelica</i> L.	CH	GR, VG	VG	VG, FL	FL, FR	FR	SC
13	<i>Angelica glauca</i> Edgew.	CH	GR, VG	VG	VG, FL	FL	FL, FR	SC
14	<i>Arabis amplexicaulis</i> Edgew.	TH	FL, FR	FR	VG	VG, SC		
15	<i>Arenaria orbiculata</i> Royle ex Edgew. & Hook.f.	H	-	GR, VG	FL, FR	FR	SC	-
16	<i>Arnebia benthamii</i> Benth.	CR	GR, VG	VG	VG	VG, FL	FL	FR, SC
17	<i>Bupleurum longicaule</i> Wallich ex DC.	CH	VG	VG	VG, FL	FL	FL, FR	FR, SC
18	<i>Caltha palustris</i> Linn.	TH	GR, VG	FL	FL, FR	FR	SC	-
19	<i>Carex nubigena</i> D.Don	CR	GR, VG	VG, FL	FL, FR	FR	FR	FR, SC
20	<i>Carum carvi</i> L.	CH	GR, VG	FL, FR	FR	-	-	-
21	<i>Cerastium cerastoides</i> L.	TH	GR, VG	VG, FL	FL	FR	FR	FR, SC
22	<i>Cerastium vulgatum</i> Edgew & Hook.f.	TH	VG, FL	FL	FL, FR	FR	FR	SC
23	<i>Cyanthus lobatus</i> Wallich ex Benth	CH	GR, VG	VG	VG, FL	FL, FR	FR	FR, SC
24	<i>Cynoglossum zeylanicum</i> (Vahl) Thunb.ex Lehm.	TH	GR, VG	VG	VG, FL	FL	FL, FR	FR, SC
25	<i>Dactylorhiza hatagirea</i> D.Don	CR	GR, VG	VG, FL	FL	FL	FL, FR	SC
26	<i>Danthonia cacymeriana</i> Jaub. & Spach L.	H	GR, VG	VG	VG	VG, FL	FL, FR	FR, SC
27	<i>Delphinium denudatum</i> Wallich ex Hook.f.& Thomson	TH	VG, FL	FL, FR	FL, FR	FR	FR	FR
28	<i>Doronicum falconeri</i> C B Clarke	TH	-	GR, VG	VG	VG, FL	FL	FR, SC
29	<i>Doronicum laylei</i> DC.	TH	-	GR, VG	VG	VG, FL	FL, FR	FR, SC
30	<i>Epilobium latifolium</i> L.	TH	-	GR, VG	VG, FL	FL	FR	FR, SC
31	<i>Eregiron multiradiatus</i> (Lindley ex DC)C.B.Clarke	TH	-	GR, VG	VG, FL	FL, FR	FR	FR, SC
32	<i>Euforbia hirta</i> L.	TH	-	GR, VG, FL	FL, FR	FR	FR, SC	-
33	<i>Euforbia stracheyi</i> Boiss	TH	-	GR, VG, FL	FL, FR	FR	SC	-
34	<i>Festuca gigantea</i> (L.)Villars	CR	VG	VG	VG	VG, FL	FL	FL, FR
35	<i>Foeniculum vulgare</i> (L.)Miller	TH	FL	FL, FR	FR	VG	VG, SC	-
36	<i>Frageria vesca</i> L.	H	GR, VG	VG, FL	FL, FR	FR	FR, SC	-
37	<i>Geranium wallichianum</i> D.Don ex Sweet	CH	GR, VG	VG	VG, FL	FL, FR	FR	SC
38	<i>Geum elatum</i> Hook.f.	CH	GR, VG	VG, FL	FL	FL, FR	FR	FR, SC
39	<i>Heracleum candans</i> DC.	PH	FL	FL	FL	FL	FL, FR	FR
40	<i>Impatiens scarbida</i> DC.	TH	GR, VG	VG	VG, FL	FL, FR	FR, SC	-
41	<i>Impatiens themsonii</i> Hook	TH	GR	GR, VG	VG, FL	FL, FR	FR, SC	-
42	<i>Inula grandiflora</i> Willd	CH	-	GR, VG	VG	VG, FL	FL	FR, SC
43	<i>Iris kumaonensis</i> D.Don ex Royle	CR	-	GR, VG	VG, FL	FL	FL, FR	FR, SC
44	<i>Jurinea dolomiacea</i> Boiss	CH	-	GR, VG	VG, FL	FL	FL, FR	FR, SC
45	<i>Jurinea macrocephala</i> Benth.ex Hook.f.	CH	-	GR, VG	VG, FL	FL	FL, FR	FR, SC
46	<i>Lilium polypylum</i> D.Don ex Royle	CR	GR, VG	VG, FL	FL	VG	FR	FR, SC
47	<i>Leucas lanata</i> Benth	CH	VG, FL	FL	FL	FL, FR	FR	FR, SC
48	<i>Micromeria biflora</i> Buch-Ham.ex D.Don	CH	VG	VG, FL	FL	FL	FL, FR	FR
49	<i>Morina longifolia</i> Wall ex DC	CH	-	GR, VG	VG, FL	FL, FR	FR	FR, SC
50	<i>Nardostachys jatamansi</i> DC.	CH	GR, VG	VG	VG, FL	FL	FL, FR	FR, SC
51	<i>Parnassia nubicola</i> Wall.Ex Royle	CH	-	GR, VG	VG, FL	FL	FR	FR, SC
52	<i>Pedicularis pectinata</i> Wall. ex Benth	TH	GR, VG	VG, FL	FL, FR	FR	FR, SC	-
53	<i>Picrorhiza kurrooa</i> Royle ex Benth.	CH	GR, VG	VG, FL	FL	FL, FR	FR	FR, SC
54	<i>Plantago major</i> non L.	H	GR, VG	VG, FL	FL	FL, FR	FR, SC	-
55	<i>Podophyllum hexandrum</i> Royle.	CH	GR, VG	VG, FL	FL, FR	FR	FR, SC	SC
56	<i>Potentilla atosanguinea</i> Lodd.	CR	GR, VG, FL	VG, FL	FL, FR	FR	FR, SC	-
57	<i>Potentilla fulgens</i> Wall. ex Hook	H	GR, VG	VG, FL	FL, FR	FR	FR, SC	-
58	<i>Primula denticulate</i> Smith	TH	VG, FL	FL, FR	FR	FR, SC		-
59	<i>Prunella vulgaris</i> L.	CR	GR, VG	VG	VG, FL	FL	FL, FR	FR
60	<i>Ranunculus hirtellus</i> Royle. Bot.	CH	GR, VG, FL	FL	FL, FR	FR, SC	SC	-
61	<i>Rheum emodii</i> Wall.	CH	GR, VG	VG, FL	FL	FL, FR	FR, SC	SC
62	<i>Rheum moorcraftianum</i> Royle	CH	GR, VG	VG, FL	FL	FL, FR	FR, SC	SC
63	<i>Rhodiola wallichiana</i> Hook	CH	GR, VG	VG	VG, FL	FL	FL, FR	FR
64	<i>Sassurea auriculata</i> Sprengel ex DC.	CR	GR, VG	VG	VG, FL	FL	FL, FR	FR, SC
65	<i>Saxifrage diversifolia</i> Wallich ex Seringe	H	VG	VG	VG, FL	FL	FL	FL, FR
66	<i>Taraxacum officinale</i> Wieber	CH	GR, VG	VG	VG, FL	FL, FR	FR, SC	-
67	<i>Viola biflora</i> L.	H	GR, VG	VG, FL	FL, FR	FR	FR, SC	-

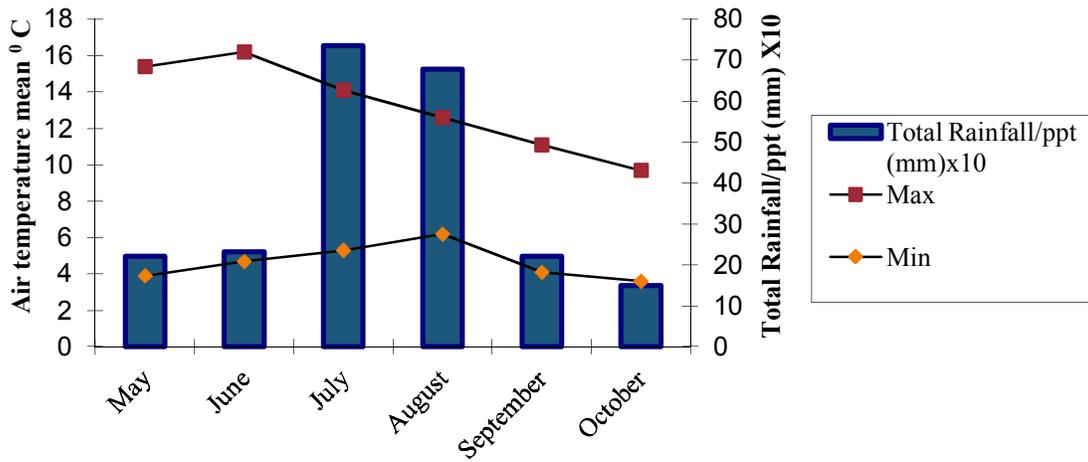
Table-2: Monthly variation in phenophases and life forms in alpine meadow of Kedarnath B site:

S No	Name of spp	Life form	May	June	July	August	September	October
Shrub								
1	<i>Aster albescense</i> (DC)Hand .-Mazz	CH	-	GR,VG	VG,FL	FL	FL	FL,FR
2	<i>Corydalis govaniana</i> Wall.	CH	GR, VG, FL	FL	FL, FR	FR	FR,SC	-
3	<i>Cotoneaster microphyllus</i> Wallich ex Lindley	PH	GR, VG,FL	FL	FL,FR	FR	FR,SC	SC
4	<i>Ephedra acuminata</i> (Roxb.)JM Johnson	PH	VG	VG	VG,FL	FL	FL,FR	FR,SC
5	<i>Gaultheria tricophylle</i> Royle.	TH	GR,VG, FL	FL	FL,FR	FR	FR,SC	-
6	<i>Polygonum affini</i> D.Don	CH	GR,VG	VG, FL	FL	FL,FR	FR	FR,SC
7	<i>Polygonum alpinum</i> All	CH	GR,VG	VG, FL	FL	FL	FL,FR	FR, SC
8	<i>Polygonum amplexicaule</i> D.Don	CH	GR,VG	VG, FL	FL	FL	FL,FR	FR, SC
9	<i>Polygonum macrophyllum</i> D.Don	CH	GR,VG	VG, FL	FL	FL	FL,FR	FR, SC
10	<i>Swertia speciosa</i> D.Don.	TH	-	GR,VG	VG,FL	FL, FR	FR,SC	-
11	<i>Rhododendron campanulaum</i> D.Don	PH	VG,FL	FL	FL,FR	FR	FR,SC	SC
Herbs								
1	<i>Aconitum balfourii</i> Stapf.	CH	GR,VG	VG	VG,FL	FL	FL,FR	FR,SC
2	<i>Aconitum hetrophyllum</i> Wall.ex Royle	CH	GR, VG	VG	VG	FL	FL	FR, SC
3	<i>Ajuga bracteosa</i> Wallich ex Benth.	TH	VG,FL	FL	FL	VG	VG,FR	FR
4	<i>Allium stracheyi</i> Baker	CR	-	-	GR,VG, FL	FL	FL,FR	FR,SC
5	<i>Allium wallichinum</i> Kunth.	CR	-	GR, VG	VG,FL	FL	FL,FR	FR,SC
6	<i>Anaphalis adnata</i> Wallich ex DC	CH	-	GR,VG	VG	VG,FL	FL	FL,FR
7	<i>Anaphalis cuneifolia</i> Hook f.	CH	GR,VG	VG,FL	FL	FL	FL,FR	FR, SC
8	<i>Anaphalis lanuginose</i>	H	GR,VG	VG	VG,FL	FL	FL,FR	FR, SC
9	<i>Androsace studiosorum</i> Wallich in Roxb.	TH	VG,FL	FL	FL	FL, FR	FR,SC	SC
10	<i>Anemone obtusiloba</i> D.Don	CH	GR, VG, FL	FL	FL,FR	FR	FR,SC	-
11	<i>Anemone rivularis</i> Buch.-Ham. Ex DC	CH	GR, FL	FL	FL, FR	FR	FR,SC	-
12	<i>Anemone rupicola</i> Camb.	CH	GR,FL	FL	FL, FR	FR,SC	SC	-
13	<i>Angelica archangelica</i> L.	CH	GR,VG	VG	VG,FL	FL	FL,FR	FR,SC
14	<i>Angelica glauca</i> Edgew	CH	GR,VG	VG	VG,FL	FL	FL,FR	FR,SC
15	<i>Arabis amplexicaulis</i> Edgew.	TH	FL, FR	FR	FR,VG	VG	VG,SC	-
16	<i>Arenaria orbiculata</i> Royle exEdgew. &Hook.f.	H	-	GR,VG, FL	FL, FR	FR	FR,SC	-
17	<i>Arnebia benthamii</i> (Don) Johnston	CR	GR,VG	VG	VG,FL	FL	FL,FR	FR,SC
18	<i>Bupleurum longicaule</i> Wallich ex DC.	CH	VG	VG	VG,FL	FL	FL,FR	FR,SC
19	<i>Caltha palustris</i> Linn.	TH	GR,VG,FL	FL	FL, FR	FR	FR,SC	-
20	<i>Carex infusate</i> Nees	CR	GR, VG	VG,FL	FL, FR	FR	FR,SC	SC
21	<i>Carum carvi</i> L.	CH	GR,VG, FL	FL,FR	FR	FR	FR,SC	SC
22	<i>Cerastium cerastoides</i> L.	TH	GR, VG	VG,FL	FL	FL,FR	FR	FR,SC
23	<i>Cerastium vulgatum</i> Edgew & Hook.f.	TH	GR,VG,FL	FL	FL,FR	FR	FR	FR,SC
24	<i>Cyanthus lobatus</i> Wallich ex.Benth	CH	GR,VG	VG,FL	FL	FL,FR	FR,SC	SC
25	<i>Cynoglossum zeylanicum</i> (Vahl) Thunb.ex Lehm.	TH	GR,VG	VG	FL	FL	FL,FR	FR,SC
26	<i>Dactylorhiza hatagirea</i> D.Don	CR	VG	VG,FL	FL	FL	FL,FR	FR,SC
27	<i>Danthonia cachymeriana</i> Jaub. & Spach L.	H	GR,VG	VG	VG,FL	FL	FL, FR	FR, SC
28	<i>Delphinium denudatum</i> Wallich ex.Hook f.& Thomson	TH	VG,FL	FL,FR	FL,FR	FR	FR	FR,SC
29	<i>Doronicum falconeri</i> C B Clarke	TH	-	GR,VG	VG	VG,FL	FL,FR	FR,SC

30	<i>Doronicum roylei</i> DC.	TH	-	GR, VG	VG	VG,FL	FL, FR	FR, SC
31	<i>Epilobium latifolium</i> L.	TH	GR	GR, VG	VG,FL	FL	FL,FR	FR,SC
32	<i>Eregiron multiradiatus</i> (Lindley ex DC)C.B.Clarke	TH	-	GR, VG	VG,FL	FL, FR	FR	FR,SC
33	<i>Euforbia hirta</i> L.	TH	GR	GR, VG,FL	FL, FR	FR	FR,SC	-
34	<i>Euforbia stracheyi</i> Boiss	TH	GR	GR, VG,FL	FL, FR	FR	FR,SC	-
35	<i>Festuca gigantean</i> (L.)Villars	CR	VG	VG	VG	VG,FL	FL	FL,FR
36	<i>Foeniculum vulgare</i> (L.)Miller	TH	VG,FL	FR	FR	FR,SC	SC	-
37	<i>Frageria vesca</i> L.	H	GR, VG,FL	FL	FL, FR	FR	FR,SC	-
38	<i>Geranium wallichianum</i> D.Don Sweet	CH	GR, VG	VG	VG,FL	FL, FR	FR	FR,SC
39	<i>Geum elatum</i> Hook f.	CH	GR,VG	VG,FL	FL	FL,FR	FR,SC	SC
40	<i>Heracleum candans</i> DC.	PH	VG,FL	FL	FL	FL	FL,FR	FR
41	<i>Hypericum elodeoides</i> Choisy.	TH	-	GR,VG	VG	VG,FL	FL,FR	FR
42	<i>Impatiens scarbida</i> DC.	TH	GR,VG	VG,FL	FL	FL, FR	FR, SC	-
43	<i>Impatiens themsonii</i> Hook	TH	GR	VG,FL	FL	FL, FR	FR, SC	-
44	<i>Inula grandiflora</i> Willd	CH	-	GR,VG	VG,FL	FL	FL,FR	FR, SC
45	<i>Iris kumaonensis</i> D.Don ex Royle	CR	-	GR,VG	VG	VG,FL	FL, FR	FR, SC
46	<i>Jurinea dolomiacea</i> Boiss	CH	-	GR,VG	VG	VG,FL	FL,FR	FR, SC
47	<i>Jurinea macrocephala</i> Benth.ex Hook.f.	CH	-	GR,VG	VG	VG,FL	FL,FR	FR, SC
48	<i>Lilium polypylum</i> D.Don ex.Royle	CR	GR,VG	VG,FL	FL	FL,VG	FR	FR,SC
49	<i>Leucas lanata</i> Benth	CH	VG,FL	FL	FL	FL,FR	FR	FR,SC
50	<i>Micromeria biflora</i> (Buch-Ham.ex D.Don)	CH	VG,FL	FL	FL	FL	FL,FR	FR
51	<i>Morina longifolia</i> Wall ex.DC	CH	GR,VG	VG,FL	FL	FL, FR	FR,SC	SC
52	<i>Nardostachys jatamansi</i> DC	CH	GR,VG	VG,FL	FL	FL,FR	FR	FR, SC
53	<i>Parnassia nubicola</i> Wall.Ex Royle	CH	-	GR,VG	VG,FL	FL	FL,FR	FR, SC
54	<i>Pedicularis pectinata</i> Wall. ex Benth.	TH	GR,VG	VG,FL	FL, FR	FR,SC	SC	-
55	<i>Picrorhiza kurrooa</i> Royle ex Benth.	CH	GR,VG	VG,FL	FL	FL	FL,FR	FR, SC
56	<i>Plantago major</i> non L.	CR	GR,VG	VG,FL	FL	FL,FR	FR, SC	-
57	<i>Podophyllum hexandrum</i> Royle	CH	GR,VG, FL	FL	FL, FR	FR	FR	FR,SC
58	<i>Potentilla atosanguinea</i> Lodd.	CR	GR,VG, FL	FL	FL, FR	FR	FR,SC	-
59	<i>Potentilla fulgens</i> Wall. ex Hook	H	GR,VG	VG,FL	FL, FR	FR	FR,SC	-
60	<i>Primula denticulate</i> Smith	TH	FL	FL,FR	FR	FR,SC	SC	-
61	<i>Prunella vulgaris</i> L.	CR	GR,VG	VG	VG	VG,FL	FL,FR	FR
62	<i>Ranunculus hirtellus</i> Royle. Bot.	CH	GR,VG, FL	FL	FL, FR	FR	FR,SC	-
63	<i>Rheum emodii</i> Wall.	CH	GR,VG	VG,FL	FL	FL,FR	FR	FR,SC
64	<i>Rheum moorcraftium</i> Royle.	CH	GR,VG	VG,FL	FL	FL,FR	FR	FR,SC
65	<i>Rhodiola wallichiana</i> Hook.	CH	GR,VG	VG	VG,FL	FL	FL,FR	FR
66	<i>Sassurea auriculata</i> Sprengel ex DC.	CR	GR,VG	VG	VG,FL	FL	FL,FR	FR,SC
67	<i>Saxifrage diversifolia</i> Wallich ex.Seringe	H	VG	VG,FL	FL	FL	FL,FR	FR
68	<i>Taraxacum officinale</i> Weber	CH	GR,VG	VG,FL	FL	FL, FR	FR,SC	-
69	<i>Viola biflora</i> L.	H	GR, VG,FL	FL	FL, FR	FR	FR,SC	-

PH-Phanerophytes, TH-Therophytes, CH-Chamaephytes, CR-Cryptophytes, H-Hemicryptophytes, GR-Germination, VG-Vegetative, FL- Flowering, FR- Fruiting, SC-Senescence.

Kedarnath A



Kedarnath B

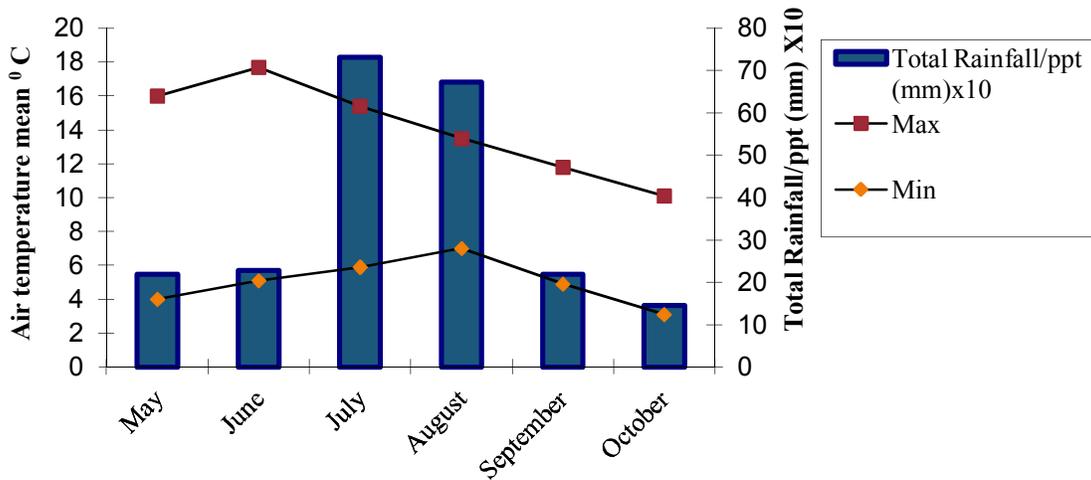


Figure-1: Ombrothermic diagram showing rainfall and atmospheric temperatures at the Alpine region of Kedarnath

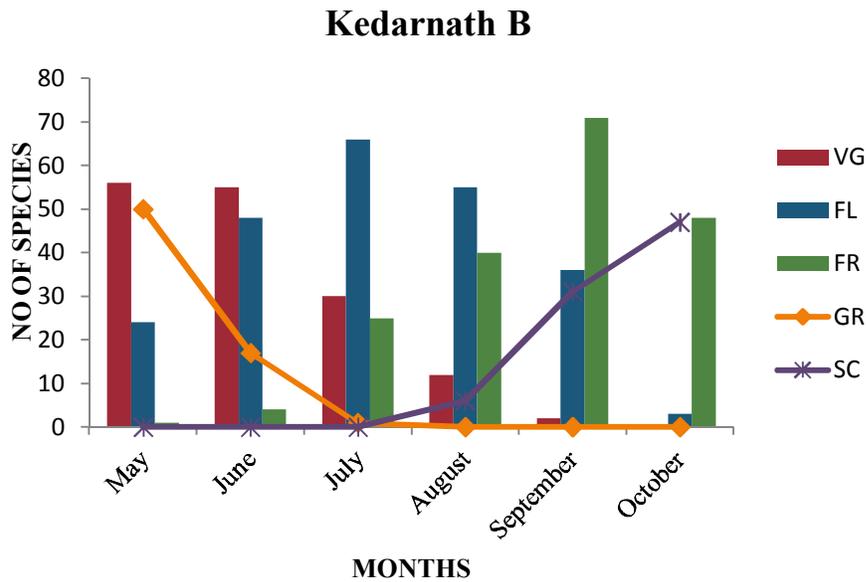
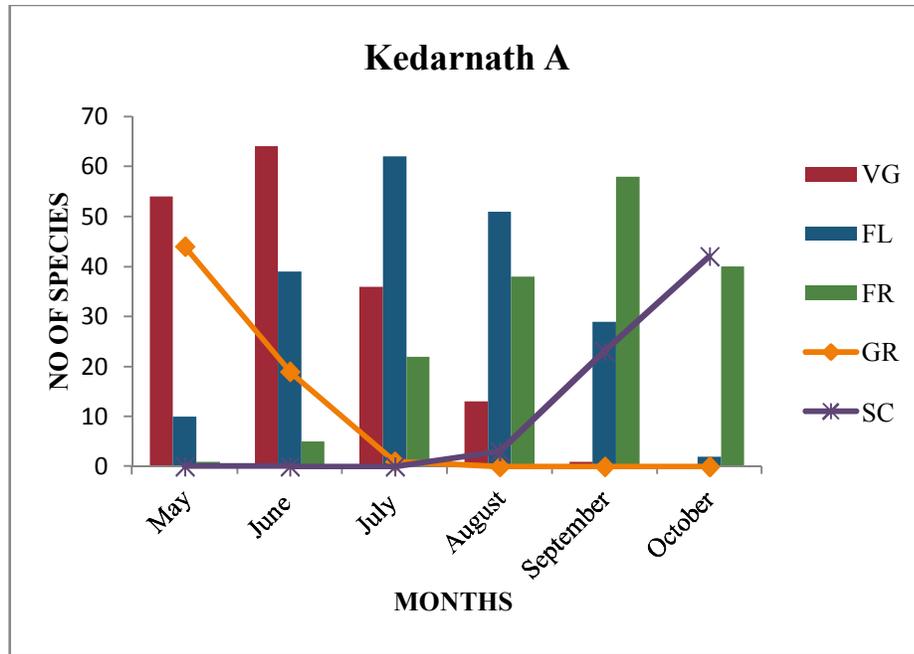


Figure-2: Corroborative phenological behavior of various species on the Kedarnath study sites. (VG-vegetative phase, FL- flowering, FR- fruiting, GR- germination, SC- senescence).

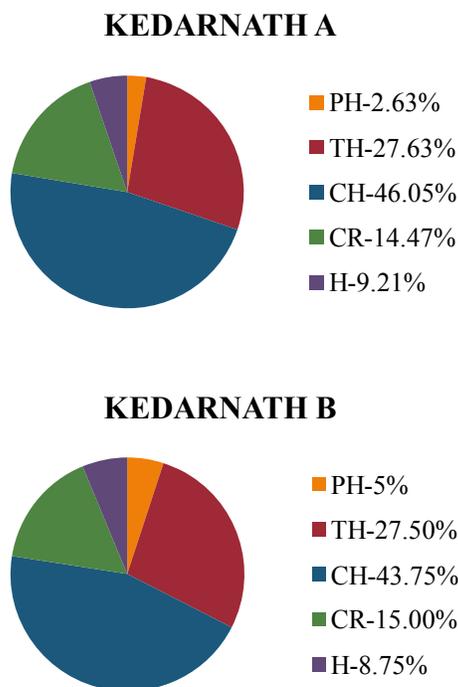


Figure-3: Biological Spectrum for Kedarnath A & Kedarnath B sites

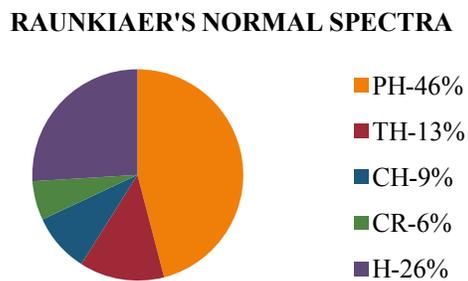


Figure-4: Raunkiaer's Normal Spectra

The work of life forms is based on the result of one year's intensive study of the following plants of the Kedarnath study sites. It is evident from the table 1,2 and Fig.3 that Chamaephytes, Therophytes and Cryptophytes were most dominant life-forms in the both (KA & KB) alpine sites represented by 46.05%, 27.63% & 14.47 % in KA and 43.75%, 27.50% & 15.00% in KB respectively. Phenerophytes 2.63% & 5% and Hemicryptophytes 9.21% & 8.75% respectively site KA & KB gives very less contribution.

Discussion:

In alpiners growth initiation generally occurred in May wherein senescence in October. Formation of reserve tissues in seeds is the most time-consuming

part of seed maturation and ambient low temperature further delays it (Korner 1999). The factor which decides growth initiation is snow melt, which not only supplies soil water but also indicates rise in temperature (Ram et al. 1988). More snow accumulation which melts comparatively later in some sites may also delay the phenological cycling of the species of that site. Holway and Ward (1965) reported that slope and exposure are distinctly secondary factors to control the snow cover. The early growing species can have an unusual water absorbing ability at low soil temperatures, which have perhaps related to high level of soluble carbohydrates in root stocks (Vashistha et al. 2009). The shallow root system of some species viz., *Oxygraphis polypetala*, *Gentiana* spp., *Primula denticulate* etc. also favor early growth because they restrict water use in the upper soil layer, moreover they need little water because of their small size (Oberbauer & Billings 1991). *Ajuga bracteosa*, *Arabis amplexicaulis*, *Delphinium denudatum*, *Ranunculus* etc. also show early growth.

Flowering time varies from species to species because photoperiodic and thermoperiodic responses are different. The peak of flowering in alpine plants occurred during the wet period of the year (July-August) and minimum in the month of April-May. At higher elevations, temperature is the most important factor in different phenological stages (Holway & Ward 1965). In snowbeds where the growing season is very short, high temperature demand for the onset of flowering will contribute to disperse the actual interspecific overlap, but flowering in late season may restrict the season length for fruit development, which results in low seed production (KUDO, 1991).

In alpine sites (KA & KB) the no of Chamaephytes is maximum while that of phenerophytes is minimum. The flora of Kedarnath indicates that the meadows are affected by intense biotic interference (Pharswan et.al, 2010). According to the biological spectrum given by Raunkiaer (1934), the flora of the present meadows may be called as the Chamaephytic. The high percentage of the Chamaephytes characterized the colder climate and high altitude (Braun-Blanquet, 1932) but Hagerup (1931) explained that higher percentage of Chamaephytes is an indication of semi-desert condition at altitudes. Phenerophyte shows smaller percentage (2.63 & 5% respectively) than the normal spectrum (46%). This indicates the effects of biotic operations on the vegetation (Rana et.al, 2002).

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