STRUCTURE AND PHENOLOGY OF AN ALPINE MEADOW AS AFFECTED BY NOMADIC GRAZING

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Abstract: Data were collected for structure and phenology of alpine grassland at Rudranath in Uttarakhand, India. A large number of species of the area are dwarf cushion herbs and most are distributed in mid alpine tract. A total of 21 and 16 species were recorded at control (S1) and grazed (S2) plot respectively. At control or ungrazed site maximum density (211.0 pl/m^2) and basal cover (121.6 pl/m^2) was recorded for *Danthonia cachyymeriana* and for grazed plot maximum density (146.0 pl/m^2) and basal cover (170.9 pl/m^2) was for *Oxygraphis polypatela.* In most of the cases, the various species completes their life cycle within 4-5 months. Germination of various species starts during April-May with luxuriant vegetative growth. Majority of species bear flowers during July and August. Some species bear flowers during later part of June. Seed formation begins in later part of August and increase sharply up to September. Senescence at community level is gradual from September and increases quickly due to lower temperature. Thereafter different phenophases succeeded one after the other and completed their life history up to November.

Keywords: Phenophases, Phenology, Sprouting, Senescence, Vegetative

INTRODUCTION

The alpine zone occupy nearly 33% of total geographic area in the Himalaya, of which the vegetative and snow bound areas constitute about 25.88% and 7.22% respectively (Anonymous, 1989). Bounded by a distinct tree line towards lower elevation, that varies from 3300±200 m in the west to 3800±200 m in the east. The alpine vegetation comprises closely woven strands of scrubs, meadows, bogs and fell fields paved with mosses and lichen. Numerous environmental factors govern the structure and function of these communities (Puri et al., 1989).

The landscape lying between the tree line and glaciers is known as high altitude meadows (Bughyals); represent the alpine zone of great Himalaya where vegetation consists of short stemmed perennial herbaceous plants, semi–prostrate shrubs, ferns, lichens and mosses (Ram and Singh, 1994). The total geographic area of this zone in Central Himalaya is 13528 sq.km., out of which only 1840 sq.km. is covered by alpine vegetation and rest of the area is characterized by permanent snow cover (Tewari *et al.,* 1985). These meadows have been subjected to migratory nomadic grazing during snow free period (May to October). Vegetation in the alpine zone exhibits a characteristic adaptation to the environment. They possess an early growth initiation with a short vegetative span ranging from several days to a few months. The community as a whole usually exhibits seasonal fluctuations, and its structure and composition are strongly influenced by the extent to which periodic phenomena in the individuals are adjusted to each other. Therefore, in pursuance of structural and functional attributes of ground vegetation in alpine meadows, knowledge of different phenophases for individual species is imperative to understand the complexity of the system. In addition, the life forms of species represent the adjustment of perennating organs and plant life history to environmental conditions, an important characteristic in describing vegetation that offers a preliminary picture of the ecological character of the vegetation (Kershaw 1973). A great deal of work has been done on the alpine communities of Garhwal (Semwal *et al*., 1981; Sundriyal et al 1987; Ram and Arya 1991; Nautiyal *et al*., 1997). But there is little information on the phenology and growth form distribution of alpine vegetation at the community level. The present article examines the structure and phenological response of different species of flowering plants in a variety of microhabitats in Rudranath in relation to growth cycle, growth initiation period, timing of flowering and fruiting, and life form distribution.

Study area

The present study was carried out in 2005 at Rudranath in Chamoli District of Uttarakhand of India. The area lies in between 30^0 05' North latitude and 79^0 07' East longitudes, in the North of Uttarakhand at an elevation range of 3300 to 4500 m above msl. The growing season of this zone starts from mid April and ends in mid November (About 200 days). The area remains snow covered in rest of the period. The average temperature does not exceed 20^0 c in June and it recedes to 1.5^0 c in first week of November. Maximum precipitation was recorded in August (450 mm) with a total of 2100 mm rainfall during growing season. Geologically, the area is a complex system of Tertiary Mountain which is nearly parallel and well kwon for having beautiful

landscape. The palaeozoic age rocks are crystalline and metamorphic in nature with sedimentary deposits. The soil of the study area was blackish brown in colour and the soil moisture remains high (over 40%) throughout the growing season. All the soils were slightly basic (ph 7.52), with a carbon percentage of 0.342%. The percentage of nitrogen, phosphorus and potash was found fairly high due to accumulation and slow decomposition of organic matter.

METHODOLOGY

The field study was conducted at Rudranath alpine meadow at an elevation of 3500 m msl during 2009. One plot protected from any type of grazing and treated as control (S1). The adjacent area remained open for all type of grazing and treated as grazed plot (S2). The area was surveyed for several times during the study for extensive plant collection. Collected species were assigned to various life from classes according to the system proposed by Raunkiaer (1934). The phenological data were recorded during each month from 15th April to 15th November, 2009. Five phenophases, *viz.* germination of seeds and sprouting of underground parts (seedlings of 0.2 cm in height in monocots and up to first leaf stage in dicots), vegetative phase, flowering phase, fruiting phase and senescence phase were noted for all collected species.

Community structure of both the sites was determined by laying 50 quadrat of 25 x 25 cm size randomly in both the study sites, covering all the possible slopes and directions. The size of the quadrat was determined by the species area curve method following Misra, 1968. The phytosociological data were quantitatively analyzed for density, abundance and basal cover of each species following the method given by Curtis and McIntosh (1950).

RESULT

A Perusal of results of presence and absence of different species reveals that a total of 21 and 16 species were present at control and grazed plot respectively (Table 1). Asteraceae was the leading family in the area (23 %) followed by Poaceae and Rosaceae (13%) each. Life forms analysis of different species shows that therophyte, chaemophyte and hemi-cryptophytes were 26.08% and geophytes were 21.7% while phanerophytes were found absent in alpine meadows (Table 1).

The results of phytosociological analysis are presented in Table 2. Maximum density was noted for *Denthonia cachymeriana* (211.0 pl/m^2) followed by *Trachydium roylei* (155.7 pl/m^2) at control plot. *Oxygraphis polypetala* represent maximum density at grazed plot (146.00 pl/m^2). However, the minimum density at control plot was found for *Jurinea macrocephala* (0.3 pl/m^2) and *Bupleurum lanceolatus* (1.2 pl/m^2) respectively. Analysis of total basal cover indicates that maximum basal area was covered by *Danthonia cachymeriana* (121.6 cm^2/m^2) at control plot and by *Oxygraphis polypetala* (170.9 cm^2/m^2) respectively. Analysis of A/F ratio indicates regular and random distribution of species in both the plots.

Phenological observations indicate that germination of seed and sprouting of rootstocks started with the melting of snow and rising of temperature during April and May. The growth initiation peaked in June when the day temperature in the open averaged 16^{0}c. Majority of species bear flowers during July and August. Some species bear flowers during later part of June. Seed formation begins in later part of August and increase sharply up to September. Senescence at community level is gradual from September and increases quickly due to lower temperature. Thus in the high altitude meadows, the peak of the various phenophases succeeded one after the other but they occurred in very short period of 4 - 5 months.

Germination of maximum species was recorded in April (47.8%). Maximum vegetative phase of different species was during June (78.26%). Flowering (65.21%) and fruiting (43.47%) was represented by maximum number of species in August and September respectively. Senescence followed the fruiting season and attain by maximum species during November (65.21%). Yellow coloured flowers were found in maximum no. of species (26.08%) and then the white flowers (21.73%).

DISCUSSION

Due to its geographical location between Himalayas and Zanskar range, Rudranath shows high landscape diversity and resultant plant species diversities. In Rudranath, the highest number of plant species represents Asteraceae followed by Roasaceae and Poaceae. In a comparative study between flora of valley of flowers and flora of district Chamoli, Naithani (1984) reveals that Asteraceae possesses first place in both the flora. Kala *et al.* (1998) also found the similar results in Nanda Devi Park flora.

The biological spectrum of the present study site and other biological spectrum of India have been compared with Raunkiaer's normal spectrum. Highest number of the therophytic and hemicryptophytic flora indicates shorter life cycle and mode of perennation due to peculiar environmental conditions at alpine zone (Rikhari and Negi, 1994) and higher influence of human and cattle interaction (Barucha and Dave, 1944). (Cain, 1950) was of the view that a high percentage of therophytes in grasslands was due to overgrazing.

Topography, climate, edaphic factors and aspects influence the growth and establishment of high altitude flowering plants. These species exhibit a

strong seasonality and temporal separation from each other (Kala *et al.,* 1995). The total vegetation density, as well as density of individual species together with the basal cover, fluctuated throughout the study period in response to environmental variation and grazing pressure. The pattern of change in density differs from species to species and shows variable response to growing conditions. Identical results have been observed by Singh and Yadava (1974) and Kala *et al.* (1998). Lower density of some plant species in the grazed plot attribute to their lower resistance towards grazing. High density of *Oxygraphis polypetala* at grazed plot shows that they thrive better in grazing conditions. Change in density due to grazing was also reported by Singh *et al.* (1980).

The relationship between frequency and abundance (Whitford, 1949) revealed that majority of species were randomly and regularly distributed on both the sites. Climatic transition and site conditions affected the distribution of species. According to Odum (1971) random distribution is found only in uniform environment and regular distribution occurs where competition between several individuals exists. The present community also showed contagious distribution which may be due to extensive grazing.

Phenology embraces all studies of relationship between climatic factors and periodic phenomenon of organisms. Seasonal progression in life cycle of different species and periodicity of the various stages varies considerably. This can be correlated with species and environmental reactions after the snow melting, spring air, soil temperature etc. (Sundriyal *et al.,* 1987). Germination, sprouting, vegetative growth, flowering, seed maturation and dormancy induction appear to be directly regulated by absolute or relatively soil temperature. Shading and nutrient availability may be other important factors controlling the germination and sprouting of buds.

In alpine meadows of the Himalayan region, some species grow early while other grows later in the growing season. This is attributed to differences in capacity to absorb water at low temperature and may perhaps be correlated to higher level of soluble carbohydrate (Mooney and Billings, 1961). Flowering of species also varies due to photoperiodic response at high elevation. Temperature is the most important factor for controlling the plant activities (Holway and Ward, 1965). Production of high carbohydrates in some instances also results in development and production of new buds in late season. The late flowers may have resulted from the bolting of floral axis that normally would have been carried in to the next growing season in the perennating organs (Holway and Ward, 1965).

Flowering was followed by fruit development, which is species dependent in most cases. Fruits developed in 3-5 weeks after flowering. Most of the species were found turning dry at the end of October as the result of onset of severe climatic conditions, continuous frost, and sharp decline in temperature and occasional snowfall that prevent further plant growth (Sorenson, 1941).

Active plant growth started with the rising temperature and snow melting (April-May). Vigorous growth of tillers from perennial belowground plant parts initiated which followed high growth rate.

Table 1. Presence (+), Absence (-) and Life Forms of Different Species at Site 1 and 2

S. No.	Name of Species	S1	S2	Life Forms
1	*Agrostis stolonifera* Linn	+	-	G
2	*Anaphalis royleana* D.C.	+	-	Th
3	*Bupleurum lanceolatum* Wall ex D.C.	-	+	Th
4	*Campanula argerotricha* Wall ex D.C.	+	+	Ch
5	*Danthonia cachemyriana* Jaub and Spach.	+	+	G
6	*Dorydalis cashimeriana* Royle	+	-	G
7	*Epilobium royleanum* Haussk.	+	-	G
8	*Geranium wallichianum* D.Don ex Sw	+	+	Ch
9	*Geum elatum* (Royle) Hk.F	+	+	Hcr
10	*Impatience roylei* Walp. Rep.	+	+	Th
11	*Jurinea macrocephala* (Decne) C.B. Clarke	+	+	Ch
12	*Juncus trifidus* L.	+	+	Hcr
13	*Kobressia nitens* C.B. Clarke	+	-	G
14	*Oxygraphis polypetala* H.F and T.Fl.	-	+	Th
15	*Parnessia nubicola* Wall ex Royle	+	-	Ch
16	*Polygonum macrocephyllum* D.Don	+	+	Ch
17	*Polygonum vaccinifolium* Wall ex Meissn	+	+	Ch
18	*Potentiella astrsanguinea* Lodd.	+	+	Hcr
19	*Saxifraga diversifloia* Wall ex Dc.	+	+	Th
20	*Sibbaldia perviflora* Willd.	+	-	Hcr

21	*Sausurea taraxacifolium* Wall ex D.C.	+	+	Hcr
22	*Tenacetum longifolium* Wall ex D.C.	+	+	Hcr
23	*Trachydium roylei* (Edgew.) Clarke	+	+	Th

Fig. 1 Phenological pattern of different species found in the study area during the study year

Name of Species	Apr	May	June	July	Aug	Sep	Oct	Nov
Agrostis stolonifera Linn								
Anaphalis royleana D.C.								
Bupleurum lanceolatum Wall ex D.C.								
Campanula argerotricha Wall ex D.C.								
Danthonia cachemyriana Jaub and Spach.								
Dorydalis cashimeriana Royle								
Epilobium royleanum Haussk.								
Geranium wallichianum D.Don ex Sw								
Geum elatum (Royle) Hk.F								
Impatience roylei Walp. Rep.								
Jurinea macrocephala (Decne) C.B. Clarke								
Juncus trifidus L.								
Kobressia nitens C.B. Clarke								
Oxygraphis polypetala H.F and T.Fl.								
Parnessia nubicola Wall ex Royle								
Polygonum macrocephyllum D.Don								
Polygonum vaccinifolium Wall ex Meissn								
Potentiella astrsanguinea Lodd.								
Saxifraga diversifloia Wall ex Dc.								
Sibbaldia perviflora Willd.								
Sausurea taraxacifolium Wall ex D.C.								
Tenacetum longifolium Wall ex D.C.								
Trachydium roylei (Edgew.) Clarke								

Table 2. Density, A/F and Total Basal Area of Different Plant Species at Site 1 and 2

S.No.	Name of Species	Site 1			Site2		
		D	A/F	TBA	D	A/F	TBA
1	*Agrostis stolonifera*	16.00	0.29	3.01	-	-	-
2	*Anaphalis royleana.*	12.90	0.21	0.07	-	-	-
3	*Bupleurum lanceolatum*	-	-	-	1.20	0.29	0.42
4	*Campanula argerotricha*	4.20	0.13	4.00	1.60	0.09	4.38
5	*Danthonia cachemyriana*	211.00	0.36	121.60	129.00	0.34	74.30
6	*Dorydalis cashimeriana*	9.20	0.05	1.52	-	-	-
7	*Epilobium royleanum*	4.70	0.11	4.47	-	-	-
8	*Geranium wallichianum*	4.80	0.21	2.96	3.60	0.19	2.22
9	*Geum elatum (Royle)*	6.50	0.07	2.31	2.20	0.03	0.78
10	*Impatience roylei*	4.20	0.09	1.49	1.80	0.06	0.64

11	*Jurinea macrocephala*	0.30	0.31	0.09	2.80	0.27	0.90
12	*Juncus elegans*	7.70	0.22	0.68	3.70	0.29	0.63
13	*Kobressia nitens*	6.80	0.19	3.38	-	-	-
14	*Oxygraphis polypetala*	-	-	-	146.00	0.17	170.9
15	*Parnessia nubicola*	9.30	0.14	2.46	-	-	-
16	*Polygonum macrocephyllum*	14.30	0.19	6.05	7.30	0.22	3.09
17	*Polygonum vaccinifolium*	16.20	0.01	3.85	4.90	0.03	1.16
18	*Potentiella astrsanguinea*	9.20	0.12	2.98	1.80	0.19	2.33
19	*Saxifraga diversifloia*	14.60	0.01	3.87	7.20	0.11	0.47
20	*Sibbaldia perviflora*	12.20	0.19	5.16	-	-	-
21	*Sausurea taraxacifolium*	13.30	0.12	3.16	8.20	0.12	3.16
22	*Tenacetum longifolium*	32.00	0.11	30.49	7.60	0.04	7.24
23	*Trachydium roylei*	155.70	0.19	19.30	119.00	0.19	19.30

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