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Timing of Shifts in Phenological Events in Rhododendron arboreum Smith. Influenced by Climatic Irregularities in Kumaun Regions of Central Himalaya

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ABSTRACT

Plants and animals exhibit seasonal patterns in their activities because there is a clear seasonality in the suitability of their environment, there is often only a limited period in the year when conditions are favorable enough to successfully reproduce and grow. If reproduction or growth takes place outside this window of favorable conditions, there are often large fitness consequences. Present study was carried out to study the effect of climatic irregularities on Rhododendron arboreun Smith., an important under canopy species of central Himalaya. The significant changes were observed in flowering initiation and capsule maturation. The results showed that the flowering in *R. arboreum* was 15 days earlier than the previously reported time. However, no major variation in the time of peak flowering time was observed. Besides this there were no major variations in other phenophases. From the present study it appears that these shifts in phenophases are irregular and sporadic phenomena's and generated by the temperature and rainfall pattern of that particular year. Long term studies are required to provide evidences that theses shifts in phenological activities will be long lasting.

Keywords: *Phenophases, Climatic irregularities, Leaf drop, Leaf flushing, Capsule maturation.*

INTRODUCTION

Climate is probably the most important determinant of vegetation patterns globally and has significant influence on the distribution, structure and ecology of forests (Kirschbaum**,** 1996). The world has warmed by about 0.6ºC during the past century and the average global temperature has increased more in the last 100 years that at any other time in the past 10,000 years. The doubling of atmospheric CO_2 concentration is predicted to cause 1.5ºC to 4.5ºC rise in world temperature, most scientist agreeing upto 3ºC rise (Kerr, 2004). In the present condition an understanding of how vegetation responded to past climate is needed for prediction of response of plants to future climate change and to develop an understanding for saving the species. The Indian Himalaya is potentially vulnerable to the impacts of global warming; studies suggest that the forest ecosystems in Himalayas can be seriously impacted by future climate change. Even a rise in 1-2ºC, much less than the most recent projections of warming during this century will impact most ecosystems and landscapes through changes in species composition, productivity and biodiversity (Ravindranath, 2006).

Phenology refers to the study of seasonal appearances and timing of life cycle events. It involves study of the responses of living organisms to seasonal and climatic changes of the environment in which they live. Plants are adapted to the annual seasonal cycle and all the life cycle stages are regulated by seasonal atmospheric changes. It is important to keep track of cyclical events such as appearance of buds, leaves, first bloom, pollination and fertilization and dispersal of seeds from years to years and determine how they relate to the weather patterns. For plants, the seasonal timing of such events can be critical for survival and reproduction (Mozai and Bhatnagar, 2005). Although several species have responded to climate changes throughout their evolutionary history, there is concern as to how different ecosystems and populations will respond to this rapid rate of change.

With increasing warming, species and ecosystems are likely to shift from lower to higher altitudes and latitudes. Due to this the species would need to migrate upwards to survive. However the upward movement of alpine species occurring near the mountain peaks is likely to be restricted by the lack of space and soil. Some of the important alpine species of Himalaya that may face immediate extinction include oak (*Quercus semecarpifolia*) (Singh, 1997) and *Rhododendron* species. *Rhododendron arboreum* (Family Ericaceae) is an under canopy species occurring between 2000m and 3000m altitude in oak dominated forest. It is common in the western Himalayas in association with *Quercus* species and *Pinus roxburghii*.

In the present study attempt has been made to monitor the timing of major phenophases in *R.arboreum* over a three year period and relate it to the climatic pattern (Temperature and rainfall). Comparison with earlier studies (Negi, 1989) and Ralhan, 1982) on available parameters have been attempted for developing a basic understanding of the shifts in phenological events of the species.

Material & Methods:

Present study was carried out at China peak in Nainital district of Kumaun Central Himalaya, located between 29˚27' to 29˚29' N latitude and 79˚23' to 79˚25' E longitudes with an altitude varying between 2500 and 2610m above sea level. For climatic data temperature was recorded by using a thermo hygrometer and rainfall data was collected from ARIES, Nainital. Phenological observations were made for four major phenophases viz. leafing, leaf maturity, flowering and fruiting for a period of three years 2008, 2009 and 2010. For the present study total 1ha area was marked and 20 individuals of similar size were randomly marked. The observations were made at weekly intervals from Ist week of January to last week of August, the period of high phenological activities for the species. During the remaining part of the year observations were made monthly following Ralhan, 1982 & Negi, 1989. Every phenophase was considered to be at peak when more than 70% of the marked trees showed the phenological event. The phenophases was taken to have initiated when less than 15% the event was recorded on the trees.

RESULTS AND DISCUSSION

Result

Leaf Drop: In R. arboreum, leaf drop usually takes place throughout the year. In Yr1 and Yr2 it initiated in 2nd week of November and maximum leaf drop was in last week of May to 1st week of June. In Yr 3, leaf drop started in 1st week of November and maximum in 4th week of May (Table1).

Table 1. Timing of different phenophases in R. arboreum (numerical values represent the months in numeric forms)

Phenophase	Present Study		
	Year 1 (2008)	Year 2 (2009)	Year 3 (2010)
Leaf drop	1-12	1-12	1-12
	Throughout year	Throughout year	Throughout year
Flowering Initiation	2	2	1
	3rd week of February	2nd week of February	4th week of January
Maximum Flowering	3	3	2
	Maximum flowering in 2nd week of March	Maximum flowering in 2nd week of March	Maximum flowering in 3rd week of February
Leaf flushing	6-7	6-7	7
	4th week of June to 4th week of July	3rd week of June to 3rd week of July	1st week of July to 3rd week of July
Commencement of Fruiting	2	3	2
	4th week of February	1st week of March	2nd week of February
Capsule Maturation	11	11-12	11-12
	1st week of November to 4th week of November	3rd week of November to 3rd week of December	3rd week of November to 2nd week of December

Flowering

Flowering occurred in March-April and flowering period ranged between 6-7 weeks. During the study period, in Yr1, flowering started from 3rd week of February and maximum flowering was observed in 2nd week of March and then culminated. In Yr 2 flowering initiation took place from 2nd week of February and maximum was in 2nd week of March. It is interesting to note that in Yr3, the flowering started in last week of January and the maximum flowering was in 3rd week of February (Table 1). In Yr3 flowering initiation and maximum flowering tooks place about 15 days earlier than the Yr1 and Yr2 (Table1).

Leafing: In Yr 1 leaf initiation started from 4th week of June and continued to 4th week of July. The leaf expansion (from bud busting to full leaf expansion) period was long around 8 weeks. In Yr2 leaf initiation commenced from 3rd week of June to 3rd week of July. The leaf expansion period was around 8 weeks. In Yr3 leaf initiation starts from 1st week of July and continued till 3rd week of July. The leaf expansion period was around 6 weeks. (Table1).

Fruiting

The fruit capsule was oblong, curved, greenish brown when ripening, and then turning brown. The fruiting started after flowers had appeared and seed matured within capsule between November and mid January. In Yr1 and Yr3, the fruiting started in 4th week of February, and 2nd week of February on the other hand in Yr2, the fruiting started in 1st week of March. In Yr2 fruiting was delayed by about 15 days when compared with Yr1 and Yr3. (Table1).

In Yr1 capsules matured in 1st week of November to 4th week of November whereas in Yr2 and Yr3 it was between 3rd week of November to 3rd week of December and 3rd week of November to 2nd week of December (Table 1).

Table 2Climatic data of present study (2009 & 2010) and comparison with earlier data (Source: Rainfall data, ARIES, Nainital)

Climatic Factor	Present Study			Negi, 1989	
	2008	2009	2010	1985	1986
Total Rainfall (mm)	1650	2175.6	3739.2	2387.0	2296.0
Mean Max. Temp. (˚C)	19.5^{0}C (January) to 30.0^{0}C (May)	17.5^{0}C (January) to 29.0^{0}C (June)	13.1^{0}C (January) to 27.3^{0}C (April)	11.6^{0}C (January) to 29.5^{0}C (May)	16.0^{0}C (February) to 27.0^{0}C (June)
Mean Min. Temp. (˚C)	3.2^{0}C (January) to 15.5^{0}C (June)	3.8^{0}C (December) to 15.5^{0}C (August)	4.3^{0}C (January) to 17.0^{0}C (April).	2.9^{0}C (January) to 17.4^{0}C (May).	2.5^{0}C (February) to 15.5^{0}C (August.

Discussion

Global climate is probably the most important determinant of vegetation pattern and has significant influence on the distribution, structure and ecology of forest and forest ecosystem. It is therefore logical to assume that changes in climate would alter the configuration of forest ecosystem. Climate change has led to shifts in phenology in many species distributed widely across taxonomic groups. Most species react differently to climate change, the outstanding question is how future climate change will affect the phenology of whole ecosystem under different climate change scenarios (Houghton et al. 2001). One of the main challenges is to determine to what extent the reported correlation between phenology and temperature (usually the mean temperature over a fixed date period) actually reflects the underlying causal mechanisms. This is crucial because extrapolations using climate scenario now sometimes predict that phenological events will occur outside the date period phenology. In this respect, linking studies on the physiologic mechanisms underlying phenology is essential for predicting future shifts. Shifts in phenology means shifts in all phenological activities viz. late flowering, fruiting, seed fall and possibility to loss of seed viability. Shift in phenology also affect the successful natural regeneration of may tree species at high altitudes.

In earlier studies it has been mentioned that winters in the Nainital catchments (location of the present study) have become milder and the winter temperature have a risen by 1.5ºC (Joshi & Tewari; 2009). Climatic data collected over a period of three year (2008-2010) also indicate that the winters are warmer in comparison to earlier studies. (Negi, 1989). The significant changes observed in the timing of phenophases were in flowering initiation and capsule maturation. The initiation from mid flowering in R. arboreum was between the end of January to mid of February across the three years whereas in earlier studied (Ralhan, 1982) the initiation of flowering has been reported in February onwards. The results showed that the flowering in R. arboreum was 15 days earlier in Yr 3 than Yr1 and Yr2.Yr3 was relatively warmer than Yr1 and Yr2 (Table 2) Similar trends were also observed by Maikhuri et al. 2003 and Joshi & Joshi 2011. However, no major variation in the time of peak flowering time was observed. The capsule maturation was earlier in the year when the summers were warmer (Table 1&2). In R. arboreum seed maturation is synchronized with the commencement of winter rains, and its seed viability is very low. Early maturation of seeds due to warming may break this synchronization and thereby suppress the regeneration of such species. In the present study it was observed that there were no major variations in different phenophases except flowering initiation and capsule maturation in R. arboreum and this early flowering and capsule maturation was sporadic. The early capsule maturation can severely impact the regeneration of the species.

From the present study it appears that these shifts in phenophases are irregular phenomena's and generated by the temperature and rainfall pattern of that particular year. Long term studies are required to provide evidences that theses shifts in phenological activities will be long lasting.

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