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Phenological Behaviour of Tree Species in Subtropical Broad Leaved Humid Forests of Jaintia Hills in Meghalaya, Northeast India

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Abstract

The phenological behaviour in terms of leaf fall, leaf flushing, flowering and fruit development of 30 woody species was studied at monthly intervals in subtropical broadleaved humid forests of Jaintia Hills in Meghalaya. Peak leaf fall was observed during the dry months (January–March), whereas peak leaf flushing was recorded in April with the onset of rain. There were two peaks for flowering (April and October), while peak fruiting was observed at the end of rainy season (autumn). Majority of the species that were in fruiting during autumn- and winter-season, undergo a brief period of dormancy and germinate during the ensuing spring- and rainy- season. The patterns of reproductive processes and their linkages with vegetative events reflect the variable survival strategies adapted by these tree species under prevailing environmental conditions. The data generated in the present study would help for in-situ as well as ex-situ conservation of the studied species.

Keywords: Phenology, Flowering, Forest, Fruiting, Subtropical, Northeast India.

Introduction

Phenology is the study of the timing of recurring biological events in plants, in relation to biotic and abiotic factors. For trees, the phenological process consists of both vegetative (leaf flushing and shedding) and reproductive (budding, flowering, fruiting and seed germination) events[1,2]. Phenological studies have a direct impact on the productivity of forest ecosystem and its biodiversity[3]. It is often used for characterization of vegetation type[4,5], and natural forest regeneration potential[6]. Phenological studies provides the knowledge about the pattern of plant growth and development as well as the effects of environment on flowering and fruiting behavior[5,7]. Therefore, information regarding the phenological patterns is important for understanding the biology of plant species and also other organisms associated with them. Such studies are essential for the conservation of tree genetic resources and forestry management. It also aids in understanding the ecological adaptations and community level interactions of plant species[4].

Studies have established that various phenological events are triggered by environmental factors such as rainfall, water availability, temperature and photoperiod[8-10]. The optimal time for phenological events (vegetative and reproductive) is determined by biotic[11] and abiotic[12] factors, and a combination of factors related to seed dispersal[13], seed germination[14], competition, herbivory and pollination[15]. Since phenological processes in plants are governed by climate of the area, the change in global climate may influence the timing, duration and synchronization of phenological events in plant species[2,16]. Therefore, recently, a significant interest in phenological analysis of plants have emerged and is often considered as a useful tool to address critical questions related to modeling and monitoring of climate change[17,18].

A number of studies have been carried out during the last few decades in many parts of India to understand the phenological behaviour of the species. There are studies from tropical dry deciduous forests[5,19,20,21], tropical dry evergreen forest[22], and tropical wet evergreen forest[23]. In northeast India, there are very few studies on the phenology of tree species from subtropical forest[1,24,25]. The phenological patterns of tree species in subtropical broad leaved humid forest of Jaintia hills have received little attention. Therefore, the present study was carried out to evaluate the phenological pattern of some tree species from Jaintia hills Meghalaya.

Materials and Methods

Study area: The study was conducted at Jarain near Jowai (Latitude 25°19'08.78" N and longitude 92°08'39.41"E altitude 1100 m asl), in Jaintia Hills district of Meghalaya, northeast India. The vegetation of the area falls under subtropical broadleaved humid forest[26]. The forest is dense with short stature and the height of the trees rarely exceeds 18 m. The climate of the area is monsoonal with a distinct wet and dry period. The wet period extends from April to October during which more than 80% of the total rainfall occurs. The dry period extends from November to March with rainfall <20 mm. The mean annual rainfall for the period 2000 to 2014 was 3440 mm.

The average maximum and minimum temperature was 22°C and 14 °C respectively (Figure-1). The overall climate of the area can be divided into four seasons i.e. winter (December - February), spring (March - May), rainy (June - August) and autumn (September - November). The winter season is characterized by low temperature and dry condition whereas in spring, the temperature begins to rise and there are few showers of rain.

Methods: Phenological observations were recorded for 30 tree species, distributed in 20 families. These include 25 evergreen and five deciduous species. Out of the studied species, 14 species usually forms the canopy layer, eight sub canopy layer and eight species were prevalent in the under canopy (Table-1). Ten mature individuals for each of the selected species were marked with aluminum tags and observations were made on leaf fall, flushing, flowering and fruiting at monthly intervals for a period of two years (January 2013 to December 2014).

Results and Discussion

Leaf fall: The leaf fall pattern varied among the species. In case of deciduous taxa (*Rhus acuminata, Quercus semiserrata* and *Schima wallichii)*, periodical mass leaf fall pattern was observed. Shedding of old leaves was recorded before the start of new ones and the trees were bare for at least a week. However, in evergreen taxa, abscission of old leaves occurred throughout the year, thus, retaining a stable population of functional leaves all the time. Majority of the species showed leaf fall during the winter and dry period (January–March). The peak in leaf fall was observed in March as compared to other months, and there was no conspicuous fall during the rainy season (June to August) (Figure-2). A few species like *Engelhardtia spicata*, shed their leaves during October, whereas, *Magnolia insignis* and *Rhus acuminata* were found to shed their leaves from October onwards. The variation in the leaf fall pattern may be due to micro-environmental factors as reported from sub-tropical forest of Meghalaya[24] and temperate forest of Garhwal Himalaya[27]. Similarly, there are reports that leaf fall and bud emergence take place during the driest part of the year, which coincided with short day length and decrease in temperature and solar radiations[28,29]. Peak leaf fall during dry season is an important adaptation strategy of the plants to minimize the effect of decreased soil moisture or increased water stress conditions[1,5] especially in subtropical forests which experiences at least 2-3 dry months.

Leaf flushing: Leaf flushing in most of the species initiated at the beginning of spring (March) and a peak was observed during rainy season (Figure- 2). Similar results have been observed by many workers from subtropical and tropical forests[1,5,21,25]. The flushing of leaves during spring (March) may be attributed to the triggering effect of the rising temperature and an increase in the length of photoperiods[1]. While cool and dry winter period delays the leaf flush, an increase in temperature induces leaf flushing and flowering in most of the species[5,30]. Some species like *Syzygium macrocarpum* showed flushing of leaves during winter season whereas, *Syzygium tetragonum*, *Eurya acuminata* and *Wendlandia tinctoria* showed leaf growth throughout the year. There were few species (*Castanopsis tribuloides*, *Engelhardtia spicata*, *Helicia nilagirica* and *Ligustrum robustrum*) that showed flushing of leaves more than once in a year (Figure- 2).

Flowering activity: All the species flowered throughout the study period. Peak flowering was observed during April and October when 14 and 13 species flowered respectively (Figure-2). These two months corresponds to the beginning (April) and the end of rainy season (October). There were few species that flowered during rainy- (1 to 3 species) and winter- season (1-6 species). Asynchrony type of flowering was prevalent in the studied species (Table-1). Species that flower at the beginning of the rainy season though overcome the risk of hydric stress but are exposed to the risk of reduced pollination success[31]. Most of the evergreen species flowered after leaf flushing whereas, the deciduous species showed different pattern. While *Engelhardtia spicata* showed flowering after leaf shedding, *Rhus acuminata* and *Ligustrum robustum* showed flowering and leaf flushing simultaneously. Some species (*Castanopsis* spp., *Daphniphyllum himalayense*) showed flowering instantaneously after flushing. The synchronization of flowering with leaf flushing has been related to moisture, temperature and photoperiod[1,24]. Rainfall patterns are associated with seasonal cycles of flowering for a number of tropical and subtropical species. In the present study, flowering occurred in the transition period i.e., dry and rainy season, with peak during March-April. This finding is similar to that recorded from other tropical forest[28,32,33.] Pollination was predominantly carried out by the insects (bees, butterflies, wasps etc.), as evidenced by the presence of large number of these species in the study area.

Fruiting activity: The fruiting behaviour of the selected species showed a marked seasonal variation. There was a distinct peak during autumn (October) with 11species at their peak fruiting stage. Another fruiting peak (7 species) was observed during March-April (Figure-2). In contrast to evergreen species, fruiting phenologies of deciduous species reached a peak in the winter season (December to February). They also had less fruit retention period as compared to evergreen species. The frequency of species with ripe fruits increased during late autumn that extended up to the winter season. A larger proportion of the species recorded brief fruit development behaviour whereas few species (*Castanopsis purpurella*, *Daphniphyllum himalayense*, *Elaeocarpus lancifolius, Helicia nilagirica* and *Magnolia insignis)* showed lengthy fruiting period. This observation is similar to that observed from other subtropical forest of the region at high altitude (>1000m asl)[1]. However, the findings are in contradiction to other subtropical forests at low altitude that showed peak fruiting during the wet season[25]. Species fruiting during September to December undergo a brief period of dormancy and germinates in the ensuing spring (March-April) season with the onset of rain.

Germination during the rainy season is advantageous due to favorable environmental conditions[34]. It is also the period for the seedling to develop a root system that can withstand the subsequent dry season[35]. Other factors affecting fruiting and germination phenology include abiotic conditions[36], seed dispersers and predators[37,38] and ecological traits of the plant[39]. The fruit type observed in the studied species can be arranged in the order of drupe>nut>capsule>berry> follicle.

Table-1
Phenological patterns of tree species in subtropical broad leaved humid forest of Jaintia Hills in Meghalaya

Species	Family	Strata	Behavioral patterns				
			Leaf fall	Leaf flushing	Flowering	Fruiting	Fruit type
Camellia cauduca Cl. ex Brandis	Theaceae	UC	PE	Pe	PeA	PeL	Cp
Camellia caudata Wall.	Theaceae	UC	PE	Pe	PeA	PeL	Cp
Castanopsis armata Spach.	Fagaceae	Can	PE	Pe	PeA	PeL	N
Castanopsis kurzii (Hance) Biswas	Fagaceae	Can	PE	Pe	PeA	PeL	N
Castanopsis purpurella (Miq.)Balak	Fagaceae	Can	PE	Pe	PeA	PeL	N
Castanopsis tribuloides (Sm.) DC.	Fagaceae	Can	PE	Pe	PeA	PeL	N
Daphniphyllum himalayense (Benth.) Muell. Arg.	Daphniphyllaceae	Can	PE	Pe	PeA	PeR	Dr
Daphne involucrata Wall.	Thymelaeaceae	UC	PE	Pe	PeA	PeL	B
*Elaeocarpus lancifolius*Roxb.	Elaeocarpaceae	Can	PE	Pe	PeA	PeL	Dr
Erythroxylum kunthianum Wall. ex Kurz	Erythroxylaceae	UC	PE	Pe	PeA	PeR	Dr
Eurya acuminata DC.	Pentaphylacaceae	UC	CE	C	CS	PeL	Cp
Ilex excelsa Hk.f.	Aquifoliaceae	SC	PE	Pe	PeS	PeR	Dr
Helicia nilagirica Bedd.	Proteaceae	SC	PE	Pe	PeA	PeL	N
Ligustrum robustum (Roxb.) Bl.	Oleaceae	SC	PD	Pb	PeA	PeL	Dr
Lithocarpus dealbatus (Hk.f. and Th. ex Miq.) Rehder.	Fagaceae	SC	PE	Pe	PeA	PeR	N
Lithocarpus fenestratus (Roxb.) Rehder.	Fagaceae	Can	PE	Pe	PeA	PeR	N
Litsea elongate (Nees) Hk.f.	Lauraceae	SC	PE	Pe	PeA	PeR	Dr
Magnolia insignis (Wall.) Blume	Magnoliaceae	Can	PE	Pe	PeS	PeL	F
Myrica esculenta Buch.Ham.ex D. Don	Myricaceae	Can	PE	Pe	PeA	PeL	Dr
Myrsine semiserrata Wall.	Myrsinaceae	UC	PE	Pe	PeA	PeL	Dr
Persea odoratissima (Nees) Koster.	Lauraceae	Can	PE	Pe	PbA	PeL	Dr
Quercus semiserrata Roxb.	Fagaceae	Can	PD	Pe	PeA	PeL	N
Rhus acuminata DC.	Anacardiaceae	SC	PD	Pe	PeA	PeL	Dr
*Sarcosperma griffithii*Cl.	Sapotaceae	Can	PE	Pe	PeA	PeL	Dr
Schima wallichii (DC.) Korth	Theaceae	Can	PD	Pe	PeA	PeL	Cp
Symplocos spicata Roxb.	Symplocaceae	UC	PE	Pe	PeA	Pbr	Dr
Syzygium macrocarpum (Roxb.) Balak	Myrtaceae	UC	PE	Pe	PeA	Pbr	B
Syzygium tetragonum(Wt.) Kurz.	Myrtaceae	SC	CE	Pe	PeA	PeR	B
Wendlandia tinctoria (Roxb.) DC.	Rubiaceae	SC	CE	C	PeA	PeL	Cp
Engelhardtia spicata Leschn. ex Bl.	Juglandaceae	Can	PD	Pe	PeA	PeL	N

Abbreviation: Can= Canopy, SC= sub canopy, UC= under canopy, P= Periodic, C= Continuous, b= Brief periods ≤ 2 weeks per episode, e = Extended period ≥ 2 weeks per episode, S= Synchronous, A= Asynchronous, D= Deciduous, E= Evergreen, r = Rapid fruit maturation ≥ 4months, L= Lengthy fruit maturation > 4 months, Cp= capsule, Dr = drupe, N= nut, F= follicle, B = berry.

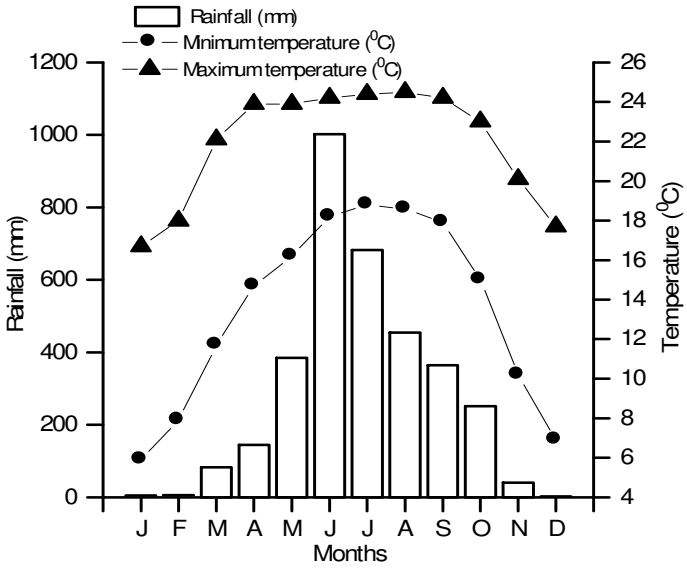

Figure-1
Mean maximum and minimum temperatures and precipitation at Jowai from 2000 to 2014 (Source: en.climate-data.org)

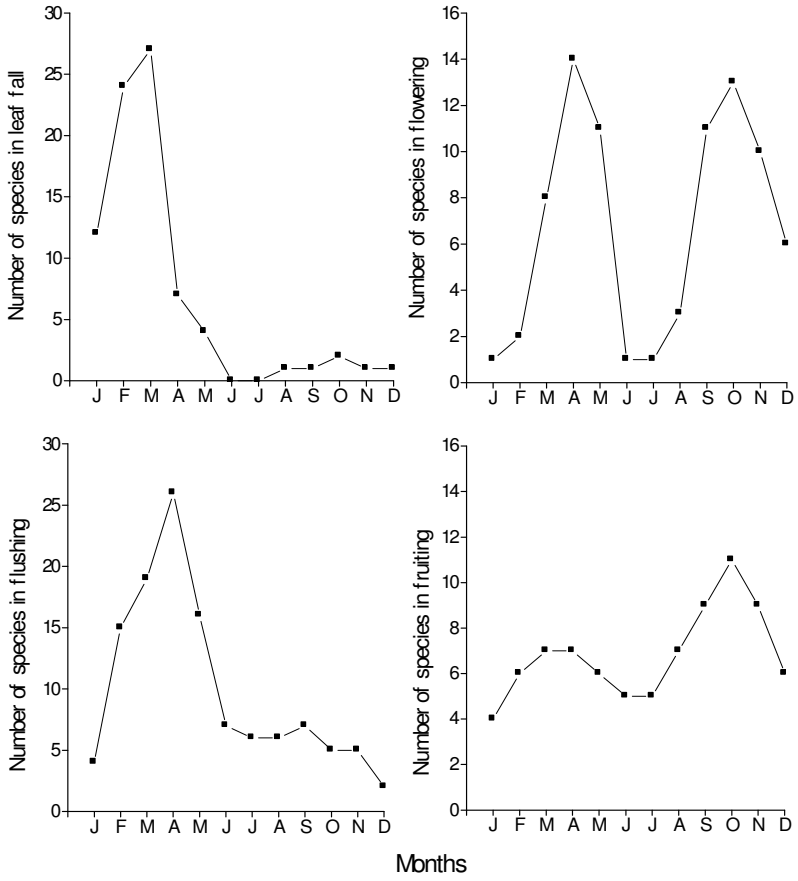

Figure-2
Number of species in leaf fall, leaf flushing, flowering and fruiting stage in subtropical broad leaved humid forest of Jaintia hills

Conclusion

The study reveals that phenological behaviour of the tree species in subtropical broad leaved humid forest is influenced by the prevailing climatic conditions of the area. The onsets of dry season marks the phenological event of leaf fall, while leaf flushing starts with the beginning of rainy season. Species which fruits during post monsoon season undergo a brief winter dormancy indicating that germination is moisture driven activity. Such variation in the phenological behaviour of the species has made the subtropical broad leaved humid forest species rich and productive ecosystem. The information on phenological behaviour of the species can be successfully used for both *in-situ* and *ex-situ* conservation as it aids in collection of seeds at maturity and helps to identify the germination conditions and timings.

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