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Vegetative and Reproductive Phenophases in *Aesculus indica* Colebr at different altitudes in temperate Kashmir Valley

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ABSTRACT

Phenological features of Aesculus indica Colebr were studied in Kashmir Valley in relation to leaf sprouting, anthesis, pollen production, fruit setting, development and retention, and leaf and fruit drop at different altitudes during 2014-2015. Results revealed that the leaf initiation in this species started in the first week of April in lower altitudes and fourth week of April in higher altitudes. Initiation of flowering was observed during the fourth week of Aprilin lower altitudes and in higher altitudes it started in second week of June. Whereas the total period of flowering oscillated between 45 days (on higher elevation) and 60 days (on lower elevation).The peak period of anthesis was noticed between 12.00 and 14.00 h of the day. Fruiting initiation started in third week of May in lower altitudes and continued up to first week of July, but in higher altitudes fruit initiation started in third week of June and continued to first week of August. Fruit fall started fourth week of September and completed in the second week of December in lower altitudes but in higher altitudes it started in second week of October and completed in fourth week of December. Leaf fall started in the first week of September and continued to fourth week of December at lower altitudes but in higher altitudes it started in the fourth week of September and continued up to first week of January, after which the tree remains leafless up to March.

Keywords: *Aesculus indica*, Kashmir, altitudes, phenological features

INTRODUCTION

The ecological significance of phenological research lies in the fact that it constitutes a dynamic approach for evaluating plant response to the local environment. Phenological observations provide a background for information on functional rhythms of plant and plant communities. Phenological adaptations allow utilization of specific resources, which exhibit temporal periodicity and may lead to temporal separation of species Phenological divergence exposes a species to different environmental characteristics, especially those which have relatively wide elevational distribution. The phenological events of a species are markedly affected by microclimate, viz. north and south-facing slopes, precipitation (seasonal variation in water availability), altitude and topography. Moreover, with increasing altitude, fall in temperature changes the time of occurrence of various phenophases of a species, as phenological events are frequently controlled by temperature. Each phenophase is scheduled to occur at a certain temperature range, above and below which it is replaced by other phenophases. In dry areas, however, precipitation may be more important for regulating the phenological events than temperature, but even in humid temperate areas, it has some effect. Therefore, it is worthwhile to observe the phenology of a species at different altitudes and microclimates to understand its complete phonological behaviour in nature. Similarly the phenology of trees in subtropical evergreen montane forest, shrub species in forest fallows developed after slash and burn (Baruah *et al* 2004), and dominant tree species in forest ecosystems at Kang chup hills, Manipur (Kikim and Yadava 2001). The vegetative and reproductive phenology of overstorey and understorey species of Similipal Biosphere Reserve (SBR) located in Orissa, India was revealed by Mishra *et al.* (2006). The reproductive phenology of angiosperm plant species in a Savanna-forest mosaic of Venezuelan Central Plain (Nelson. 2002) and in tree assemblages of large Amazonian forest landscape (Storbjorn and Peres 2005) was studied in different forest cover types. The pollination ecology of Pterocarpussantalinus landscape (Solomon *and Rao* 2005) and pollen

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release in Pongamia pinnatan (Rao *and Splomon* 2005) of Fabaceae in the Eastern Ghats of India have also been worked out. Knowledge of anthesis and pollen production is relevant to the study of pollination, developing a functional model for forecasting pollen concentrations and to understand more about the ecological background of pollen dispersal. Yet attempts for gaining such knowledge are few and the methods employed are not uniform. The available literature on anthesisand pollen production is meagre, except for a few scanty reports (Sharma *and Khanduri* 2002). Aesculus indica Colebr is a large deciduous tree of temperate climate, which is found growing abundantly on the wide elevational gradients in the hills of Western and Central Himalaya between 1500 and 3000 m amsl. The tree is commercially important and has higher food value as the fruits are fed to cattle and goats and the embryo ground and mixed with flour is eaten by the hill people. The seeds oil which is used for making soaps. The wood is used to make utensils and pots. In Himalaya very few studies have been made pertaining to the phenology of trees. Keeping in view the aforesaid facts, this study has been designed to understand the phenological attributes, anthesis, pollen production, fruit setting and leaf drop in *A. indica* at different altitudes in the temperate region of Kashmir Himalaya.

MATERIALS AND METHODS

The study was carried out during year 2014-2015 on the isolated trees of *A. indicia* at different altitudes of Kashmir Himalaya.

Location	Altitude (m asl)	Latitude and longitude	Climatic Zone	Habitat
Gund, Ganderbal	2250	34°12'54.18"N 74°46'18.35"E	Plain	Moist open slope
Anantnag	1700	33°43'57.24"N 75° 9'37.28"E	Plain	Sunny open field
Badgam	1609	33°56'5.48"N 74°38'24.15"E	Plain	Moist open field
Baramulla	1593	34°12'41.31"N 74°20'38.03"E	Plain	Moist Open slopy field
Srinagar	1580	34° 5'1.17"N 74°47'50.52"E	Plain	Sunny Open fields

At each forest site a permanent plot of 0.1 ha, which usually represented the most temperate growth conditions of *A. indica* trees and free from biotic disturbances was established. Detailed phenological records on 20 randomly chosen individuals of the species were made on four phenophases, namely, leaf sprouting, flowering and anthesis, fruit setting (development and retention), and leaf and fruit drop, during April 2014 to March 2015. The phenological events were categorized. In *A. indica* the inflorescences remained grouped in bunches on the main branches. First, the main branches were counted, and then a sample of five branches were selected randomly and a count was made of all their bunches. The number of inflorescences per bunch and subsequently for 20 bunches was taken into account, and the number of flowers per inflorescence was ascertained from 20 randomly chosen inflorescences.Pollen grains were counted using five anthers from different flowers. The anthers were obtained from closed flowers, kept in 70% ethanol that were washed in distilled water, and placed in test tubes. They were taken apart with the aid of a glass rod and the pollen grains were suspended in 1 ml distilled water. From this concentrate, a drop of 10 μl was transferred to a microscopic slide and the number of pollen grains was counted under a microscope. Counting was replicated five times and the number of pollen grains per anther was calculated. In order to estimate the total pollen production per individual tree, first the total number of anthers per tree was calculated. Multiplying the number of total inflorescences to the average number of flowers per inflorescence and to the fixed number of anthers per flower, the result was finally multiplied by the average number of pollen grains produced per anther.

Thus, an estimate of the total pollen production per tree was made. For recording fruit setting, five trees of A. indica with two branches each were tagged on each site and observations were made after 20 and 50 days of pollination. Development of fruits was observed regularly, but the final dimensions were recorded after full ripening of the fruits. The length and diameter of the fruits were calculated using a verniercalliper. The average weight and size of fruits and stone were calculated on the basis of ten representative fruits from each of the five trees.

RESULTS AND DISCUSSION

Leaf sprouting and development

In *A. indica* leaf initiation was started in the first week of April during both the years, when about 1 cm long leafy buds emerge from the tip of some branches first. The higher temperature immediately following the low temperatures may aid in this process by inducing bud bursting, which ultimately gives red-coloured new leaves in late April. Lower altitude starts sprouting about 15-20 days earlier. The colour of the new leaves remains pinkish red or yellowish till the end of June, after which it turns bright green to dark green up to October. Leaf fall started in the first week of September and continued to fourth week of December in lower altitudes but in higher altitudes it started in the fourth week of September and continues up to first week of January, after which the tree remains leafless up to March.

Table 1.1: Phenology of *Aescules Indica* at different altitudes of Kashmir Himalaya

Phenophase		Population				
		Srinagar 1580 m	Badgam 1609 m	Anantnag 1700 m	Gund 2250 m	Tangmarg 2300 m
Leaf Initiation	I	4(1)	4(1)	4(2)	4(3)	4(4)
	C	6(1)	6(1)	6(2)	6(3)	6(4)
	D	61	60	58	56	52
Formation of buds	I	4(2)	4(3)	4(3)	4(4)	5(1)
	C	5(1)	5(2)	5(3)	5(4)	6(1)
	D	27	24	22	25	26
Flowering	I	4(3)	4(4)	5(1)	5(3)	6(2)
	C	6(3)	6(4)	7(1)	7(3)	7(4)
	D	60	58	57	51	45
Fruiting	I	5(3)	5(4)	6(1)	6(2)	6(3)
	C	7(1)	7(2)	7(3)	7(4)	8(1)
	D	47	46	44	41	40
Fruit Fall	I	9(4)	10(1)	10(2)	10(2)	10(2)
	C	12(2)	12(2)	12(3)	12(4)	12 (4)
	D	72	65	64	70	67
Senescence	I	10(1)	10(1)	10(2)	10(3)	10(4)
	C	12(4)	12(4)	12(4)	1(1)	1(1)
	D	78	75	72	69	64
Duration		345	328	317	312	294

I=Initiation of the phase, C=Completion of the phase, D= Duration of the phase
Number outside the parenthesis is month and inside week

Flowering

The first floral bud in *A. indica* was observed on second week of April at lower altitudes and first week May at higher altitudes and this phase lost for about 26 -23 days. Flowering started from third week of April on lower altitudes and second week June at higher altitudes and this phase lost for about 60 -45 days. Fifty per cent flowering was noticed on third week of May and full bloom on third week June at lower altitudes and third week of July on higher altitudes. The end of flowering at lower altitudes was on third week of June but at higher altitudes completion of this phase was on fourth week of July. Thus, the total period of flowering in *A. indica* was about 60 days at lower altitudes to 45 days at higher altitudes. Maximum anthesis occurred between 1200 and 1400 h when more than 30 to 50% flowers of the total anthesis within a day had opened at both the altitudes. Within a single day 20.79 ± 1.74% of total flowers observed on the twig, usually opened. The number of inflorescences, flowers, anthers and pollen grains per anther varied considerably from individual to individual. Production of pollen grains ranged from 27416 ± 88.0.79 to 28320.00 ± per flower, and 6031666 to 610000 per inflorescence (Sharma and Khanduri 2012).

Fruit setting development and retention

Fruit setting in *A. indica* started in the third week of May to the third week of June in lower and higher altitudes respectively. Average fruit setting percentage was 72.42 × 6.39 after 22 days of pollination on lower altitudes, whereas it was 65.87 × 6.92 on higher altitudes after the same period. By the end of July the fruits were 1.5 to 2.0 cm long. They matured by the end of October. The fruits were one to three-celled capsules with an average weight of 25.30 g. The average size of the fruits after full ripening was 3.8 × 3.5 cm. They were long, ovoid and rough from out- side. The average weight of the stone was 15.30 g. The seeds were exalbuminous, about 2.5 cm in diameter, dark brown, smooth, shining; hilum about 1.5 cm in diameter. During September the fruits become brown and by the end of October they started dehiscing to disperse the seeds. Fruit development and maturation during summer and the rainy season indicates the retention of photosynthetic organs throughout this period, which maintained continuous supply of metabolites. This factor along with other favourable conditions, like day length, temperature, etc., possibly favoured the maturation of fruits during this period. This appeared to be a possible strategy of the species to exploit the maximum favourable conditions available during the rainy season for fruit maturation (Bhat and Murali 2001).

Leaf and fruit drop

In the first fortnight of November the leaves turned yellowish brown, and rapid leaf drop started from the end of November to the last week of December. In January and February, the tree remained completely leafless. *A. indica* showed concentrated leaf drop in early winter (November –December). This has resulted in the maximum trees completely leafless, leading to dormancy during severe winters (December to February). The activity of leaf drop seems positively related with decreasing atmospheric temperature (October onwards). On the other hand, the fruits become brown in colour during September-October and by the end of September, they start dehiscing. Fruit dropping starts more or less along with the leaves, which is completed by the end of November. Due to high food and commercial value of fruits, we observed that the mode of fruit/seed dispersal was therefore brought about by both biotic and abiotic means, although biotic means of dispersal were dominant. The late maturation and lengthy retention of fruits provide better chances for wind dispersal in *A. indica* during early winters. Seasonality (such as temperature, humidity, rainfall, day length, soil moisture and wind speed) exposes plants to regular periodic changes in the quality and abundance of resources. All these factors are known to play a role alone or in combination in triggering phenological changes. The synchronization of flowering with leaf flushing seems to be related to moisture, temperature and photoperiod (Murali and Sukumar 1994). At the onset of summer, melting of snow takes place vigorously due to rise in temperature, which acts as a powerful trigger to terminate the prolonged winter dormancy of both vegetative and floral buds. The protected dormant buds of the aerial shoots suddenly burst out at the advent of this favourable period around mid-April. Besides temperature, isolated rain showers, which break the long, dry spell, do favour the leafing of plants in this region during March–April. In many forests, increased leaf fall has been linked with the onset of the dry season and leaf initiation prior to the commencement of the rainy season. Number of pollen grains per inflorescence ranges from 5943213 ± 1293814 to 6031666 ± 1293814. Reproductive phenology can be described at community level for flowering, fruit maturation and seed dispersal (Khanduri and Sharma 2001) and at population and individual levels. Anthesis is an important criterion for judging the onset of pollen release and subsequent dispersal, which is a prerequisite for plant breeding system. The pattern and quantum of daily anthesis reflect the best time and duration of pollination within a day. In *A. indica* diurnal pattern of anthesis has been recorded; the peak period of anthesis was between 1200 and 1400 h of the day, which ultimately refers to the middle-day pattern of pollen release. Wind-pollinated plants shed their pollen almost entirely during daytime because pollen grains are set free under conditions suitable for effective dispersal, since wet cold weather retards the escape of pollen from the anther sacs while dry weather accelerates it. It is an established fact that the air is more turbulent at higher altitudes compared to lower altitudes.

Table 2: Variation in pH, EC and OC at different altitudes of Kashmir

Sites	pH	EC (dSm^{-1})	OC(%)
Shopian	6.25	0.15	4.10
Tangmargh	6.63	0.16	4.10
Gund Kangan	6.35	0.22	4.12
Budgam	5.69	0.50	3.9
Srinagar	4.65	0.40	3.7

The results of the present study reveal that pollen production was slightly more at higher altitude, compared to lower altitude This ultimately results in relatively more fruit setting, i.e. 71.53 and 62.54%, at the higher altitude after 45 days of pollination (Baruah and Ramakrishnan 2004).

The data revealed that there was variation in pH, EC, and organic carbon. Highest PH was recorded in Tangmarg (6.63) followed by Gund (6.35) Shopian (6.25), Budgam (5.69) and least pH was recorded at Srinagar (4.65). Higher altitudes show higher pH while lower altitudes show lower pH Electrical conductivity is widely used to indicate the total ionized constituents. It is directly related to the sum of cations or anions. As far as conductivity is concerned, maximum conductivity was recorded at Budgam (0.50 dSm^{-1}) followed by Srinagar (0.40 dsm^{-1}), Gund (0.22 dsm^{-1}), and minimum Electrical conductivity were recorded at tangmarg (0.16 dSm^{-1}) and Shopian (0.15 dSm^{-1}). Results revealed that higher percentages of organic carbon were recorded at Gund (4.12%) followed by Shopian, Tangmarg (4.12%) and lower percentage of organic carbon were recorded at Budgam (3.39%) and Srinagar (3.37%).

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