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PHENOLOGY OF TREES IN A SUB-TROPICAL EVERGREEN MONTANE FOREST IN NORTH-EAST INDIA

Phénologie des arbres dans une forêt sempervirente montagnarde subtropicale du nord-est de l'Inde

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RESUME

La phénologie d'une forêt sempervirente montagnarde subtropicale constituée par un bois sacré et située à une altitude de 1900 m, à proximité de Shillong dans le nord-est de l'Inde a été étudiée. La présente étude prend en considération vingt-six essences dominantes importantes et quarante espèces du sous-bois. Pour la majorité des arbres la foliation coïncide avec l'installation de la période chaude qui précède le retour des pluies. Cette stratégie engendre une production maximale pendant la période chaude et humide de l'année. Le maximum de défoliation se situe pendant les mois secs de l'hiver et cette stratégie est interprétée comme un moyen d'échapper à la rigueur du milieu. Deux maximums de floraison ont été observés; ils correspondent aux mois plus secs de la saison chaude (mars-avril d'une part et octobre de l'autre). La périodicité de la fructification, bien que peu prononcée, montre un maximum en octobre-novembre. La plupart des espèces présentent des diaspores charnues ce qui suggère une adaptation à la zoochorie.

ABSTRACT

Phenology of a sub-tropical montane evergreen forest represented by a sacred grove at an elevation of 1900 m, near Shillong in north-east India was done. Twenty six important overstorey and forty understorey tree species were considered for this study. Leaf flushing in the majority of tree species coincided with the onset of warm period just prior to the rains to optimize production during the warm wet period of the year. Maximum leaf fall occurred during the dry winter months and this strategy is considered to be an escape from stress conditions. Two flowering peaks observed corresponded

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to the relatively drier months of March-April or October of the warm season. The fruiting periodicity though not much pronounced had a peak in the month of October-November. The majority of the species were with fleshy fruits suggesting an adaptation for animal dissemination.

INTRODUCTION

The concepts and significance of phenological studies in the understanding of ecosystem function have been discussed by LIETH (1970) and LIETH & RADFORD (1971). Studies on the phenological patterns of trees are important not only from an applied point of view for conserving gene resources and for a rational forestry management programme (STERN & ROCHE, 1974), but are also significant for a better understanding of the ecological adaptations of individual species as well as community level interactions. Thus, for e.g. the effects of herbivory will vary significantly between plants with short-lived leaves and those which retain them for many years. For a better understanding of productivity, individual leaf phenology is important (BENTLEY, 1979). Further, any understanding of the organization of tropical communities based on plant-animal species interactions must be based on a knowledge of the seasonality of production of plant parts (MOONEY *et al.*, 1980).

Much of the studies on the phenology of trees done in tropics, present only a partial analysis of leafing, flowering and fruiting date (McCLURE, 1960; REES, 1964; NEVLING, 1971) and only recently has there been a systematic attempt to make comparative and quantitative studies on this problem (FRANKIE *et al.*, 1974; MALAISSE, 1974; PUTZ, 1979; OPLER *et al.*, 1980; PRIMACK, 1980).

This study deals with the seasonality patterns in a subtropical, humid, evergreen montane forest community near Shillong (25° 34' N and 91° 56' E) at an altitude of 1900 m. This forest community is a relict sacred forest grove which is maintained in a comparatively undisturbed state because of the faith and tradition of the local Khasi tribe who believe that sylvan dieties would be offended, if trees are cut or flowers and fruits are plucked. Therefore, this is representative of the climax forest type of this area, which otherwise is highly disturbed due to slash and burn agriculture (RAMAKRISHNAN & TOKY, 1978).

CLIMATE AND VEGETATION

The climate is seasonal with monsoonic pattern of rainfall with over 80 % of it occurring during May to September. The year may be divided into four more or less well marked seasons; (i) a period of heavy rain during May-September; (ii) a period which marks the retreat of monsoon characterized by low rainfall and equable temperature in October-November; (iii) a winter period during December-February, marked by low temperature and scanty rainfall and (iv) a warm windy summer during March-April. The summer temperature does not exceed more than an average maximum of 25° C and in winter it goes down to an average minimum of 3° C (Fig. 1).

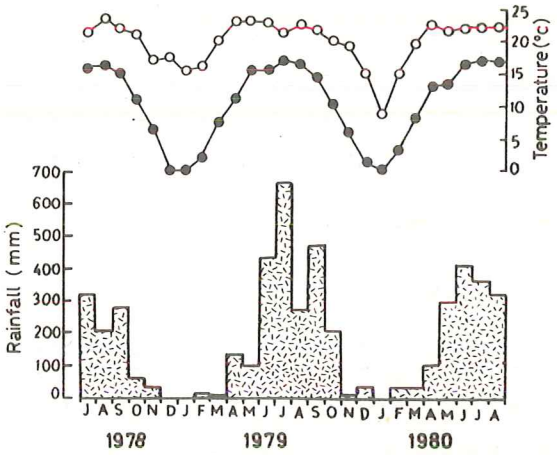

Fig. 1 : Ombrothermic diagram of the study area. Mean maximum temperature (o). Mean minimum temperature (●).

The vegetation is a mixed evergreen broad-leaved forest consisting of oaks and laurels as dominants. At lower levels on the hill, the tall evergreen association has *Quercus dealbata*, *Q. griffithii*, *Pasania spicata*, *Manglitia insignis*, *Schima khasiana*, *Machilus kingii* and *Cinnamomum impressinervum* with an understorey of *Eurya Japonica*, *Myrsine semiserrata*, *Lindera pulcherima*, *Symplocos* and *Litsea* species. At the summit (approximatively 2100 m) the dwarf ericaceous association consists chiefly of *Rhododendron* species alongwith other dwarf trees like *Symplocos spicata*, *Elaegnus pyriformis* and *Quercus dealbata*. The shrub stratum here consists of *Daphne Shillong*, *Osbeckig crenata* and *Coffea khasiana* as

the main elements.

METHODS OF STUDY

Phenological records were noted for tagged individuals of the species along five permanent transects 200 m in length. The transect records were supplemented by general phenological observations on trees at random. All the data presented here are based on 10 replicate individuals or more of each species over a period of two years (January 1978 to January 1980), at monthly intervals. For each tagged tree records were made of leaf development, leaf fall, flowering and fruiting. The categories "none", "few" and "many" were employed and assigned values of 0, 1 and 2 respectively, following OPLER *et al.* (1980). The monthly value for each characteristics for all individuals of each species, were summed separately and divided by the number of individuals. Thereby a mean value was obtained for each phenological characteristic of each species. Using this technique, the maximum possible value for any characteristic for any month is 2.0.

Definitions

Tree

Any woody plant of perennial duration which rises from the ground with a trunk and with a minimum height of about 3 m (FRANKIE *et al.*, 1974). *Overstorey* consisted of canopy and sub-canopy trees of more than 10 m height and the *understorey* had trees less than this height.

Duration of activity

Brief activity (flowering or fruiting) extends for two weeks or less while *prolonged* refers to periods more than two weeks per episode. Flowering and fruiting activity by the members of a species population more or less continuous throughout the year is referred to as *continuous* activity and those having engaged in flowering/fruiting only once during the year are *discontinuous*.

Pattern of activity

Seasonal and *extended* activity refers to flowering/fruiting occurring during a given season or extending into more than one season respectively. *Marginal* activity refers to species that have their activity occurring during transition period of seasonal changes.

When all the members of a species population engage in flowering/fruiting simultaneously the activity is referred to as *synchronous* and if only some members of a species population fruit/flower during a given season, it is called as *asynchronous*.

Fruit maturation

Fruit maturation periods of four months or less following fertilization are considered *rapid* and those greater than four months are termed *lengthy*.

RESULTS

Leafing activity

The forest community maintained its evergreen appearance throughout the year with a majority of both the overstorey and the understorey species showing continuous or periodic evergreen leafing behaviour but with only a small proportion of deciduous elements (Tab. I). However, in the drier months of December to March evergreen aspect of the forest was less conspicuous due to marked leaf drop.

GROUP	ACTIVITY	OVERSTOREY		UNDERSTOREY	
		Number of species	%	Number of species	%
I	Continuous evergreen	1	4	3	7
II	Periodic evergreen	18	69	26	65
III	Periodic deciduous	7	27	11	28

Tab. I : Types of leafing activity of tree species.

Leaf flushing periodicity

Leaf flushing in both overstorey and understorey species showed strong seasonal periodicity. The first peak of flushing was observed in April-May followed by another in July-August. The latter was less pronounced in the understorey species. There was a brief period of lesser activity in May-June. During winter months most of the species were dormant (Fig. 2 a).

Species were divided into four distinct categories according to their flushing behaviour (Tab. II). In the overstorey most of the species were with double determinate flushes, followed by the species with

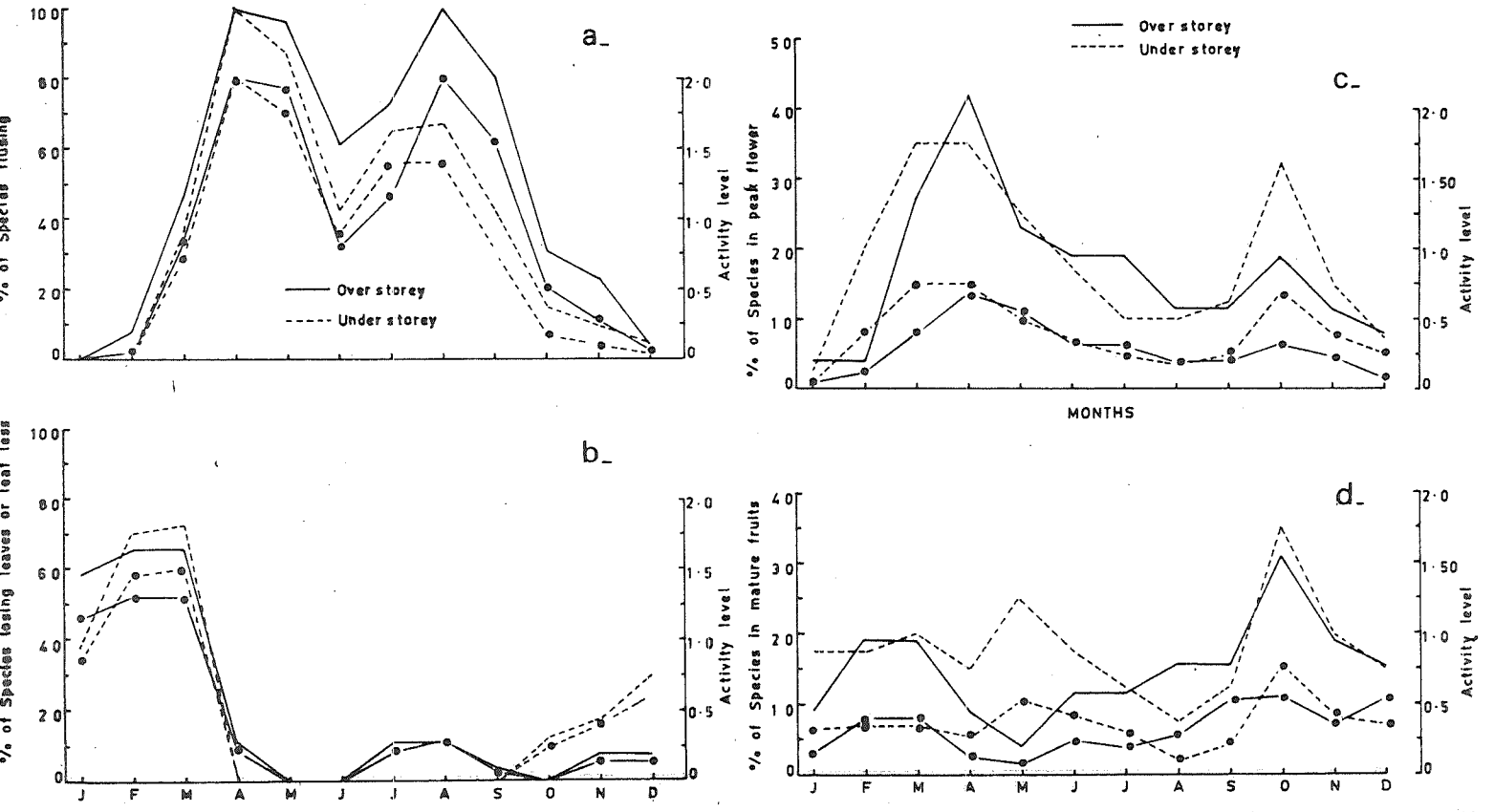

Fig. 2 : Phenological periodicity (%) of overstorey (continuous lines) and understorey (broken lines) trees. Lines with circles represent the activity level (see text for explanation). a.: flushing; b : leaf fall; c : flowering; d : fruiting.

multiple flushes of the indeterminate type but with only one species having continuous flushing activity. Species with single determinate flush were absent in this category. On the contrary, understorey trees had many species with single determinate flush. About an equal number of species also showed double determinate and multiple indeterminate flushes. A few species also showed continuous flushing activity.

ACTIVITY	OVERSTOREY Number	SPECIES %	UNDERSTOREY Number	SPECIES %
Species with single determinate flush	0	0	12	30
Species with double determinate flushes	18	69	11	28
Species with multiple indeterminate flushes	7	27	14	35
Continuous flushing type	1	4	3	7

Tab. II : Flushing behaviour of overstorey and understorey tree species.

Leaf fall periodicity

Leaf fall in the overstorey species was maximum during January to March followed by a steep fall in subsequent months. Another small peak was observed during July-August with leaf fall showed by the species like *Betula*, *Englehardtia* and *Prunus*. The leaf fall in *Quercus griffithii* started in October, becoming completely naked by December and remained so upto the end of March. The understorey trees had only a single peak of leaf fall in the month of February to March. During the rest of the year the fall was at a slow rate (Fig. 2 b).

Flowering activity

The flowering pattern of the overstorey and understorey trees (Fig. 2 c) showed that two peaks occur during the year, one major peak in April and a smaller one in October. An equal number of species belonging to both over and understoreys flowered either during dry or wet months. A few species flowered during the marginal season extending to both wet and dry periods. Two of the understorey species, namely, *Pieris ovalifolia* and *Eurya japonica* showed extended flowering over a long period (Tab. III).

SPECIES	SEASON				
	DRY	WET	MARGINAL	EXTENDED	UNKNOWN
Overstorey	10	10	5	-	1
	(38.5)	(38.5)	(19)	-	(4)
Understorey	13	13	10	2	2
	(32.5)	(32.5)	(25)	(5)	(5)

Tab. III : Overstorey and understorey tree species flowering in wet and dry seasonals (percentage values in parentheses).

Most of the trees both of over and understoreys showed discontinuous flowering behaviour. It was only a few understorey species (*Pieris ovalifolia* and *Eurya japonica*) which showed more or less continuous activity. Majority of the discontinuous flowering individuals had prolonged flowering activity. Asynchrony in flowering was quite pronounced for both the category of species (Tab. IV).

SPECIES	ACTIVITY					
	CONTINUOUS	DISCONTINUOUS				UNKNOWN
		Prolonged		Brief		
		Syn-chronous	Asyn-chronous	Syn-chronous	Asyn-chronous	
Overstorey	0	1	20	0	5	0
	-	(4)	(77)	-	(19)	-
Understorey	2	4	21	1	10	2
	(5)	(10)	(52.5)	(2.5)	(25)	(5)
Total	2	5	41	1	15	2
	(3)	(8)	(62)	(1.5)	(23)	(3)

Tab. IV : Duration of flowering activity of overstorey and understorey tree species (percentage values in parentheses).

A large number of species of both over-and understoreys flowered at intervals more than one year. Majority of individuals of a population of 6 out of 17 overstorey and 3 out of 16 understorey species were observed to flower regularly on an annual basis (Tab. V).

OVERSTOREY	TYPE	UNDERSTOREY	TYPE
Acer laevigatum	B	*Cinnamomum tamala*	B
Betula alnoides	A	*Heptapleurum khasianum*	C
Exbucklandia populea	C	*Ilex khasiana*	A
Castanopsis hystrix	B	*I. theafolia*	A
Cinnamomum impressinervum	B	*Lindera pulcherima*	B
C. obtusifolium	B	*L. latifolia*	B
Daphnephyllum himalayense	A	*L. thomsonii*	B
Englehardtia spicata	A	*Litsea elongata*	B
Eugenia terragona	A	*Mallotus nepalensis*	A
Litsea meissneri	A	*Myrica esculenta*	B
L. sebifera	A	*M. rubra*	B
Machilus kingii	B	*Photinia notoniana*	B
M. odoratissima	B	*Symplocos crataegoides*	B
Quercus dealbata	B	*S. pyrifolia*	B
Q. griffithii	B	*S. spicata*	B
Q. paniculata	B	*S. theafolia*	B
Schima khasiana	B		

Tab. V : Frequency of flowering in overstorey and understorey tree species. A : all individuals flower every year synchronously; B : all or most flower every year but asynchronously; C : only few individuals flower every year.

Fruiting activity

The community showed some rhythmicity in its fruiting pattern for both over-and understorey species. The overstorey species showed a major peak in October and a smaller one in February-March. The understorey species showed a major peak in October and a minor one in May (Fig. 2 d). A majority of species showed discontinuous and prolonged fruiting activity. Further a larger proportion of the species showed lengthy fruit development behaviour. Continuous fruiting activity was shown by two understorey species, *Pieris ovalifolia* and *Eurya japonica* (Tab. VI).

Most of the species of the overstorey and understorey either fruit during the dry season or the wet season, more or less in equal proportions. While a few understorey species showed fruiting for an extended period of time, none of the overstorey species belonged to this category (Tab. VII).

SPECIES	ACTIVITY						
	CONTINUOUS		DISCONTINUOUS				UNKNOW
			Prolonged		Brief		
	Rapid	Lengthy	Rapid	Lengthy	Rapid	Lengthy	
Overstorey	0	0	4	14	3	4	1
	(0)	(0)	(15)	(54)	(12)	(15)	(4)
Understorey	0	2	1	24	0	9	4
	(0)	(5)	(2,5)	(60)	(0)	(22,5)	(10)
Total	0	2	5	38	3	13	5
	(0)	(3)	(8)	(59)	(5)	(20)	(8)

Tab. VI : Duration of fruiting activity of over-and understorey tree species (percentage values in parentheses).

SPECIES	S E A S O N			
	DRY	WET	EXTENDED	BEHAVIOUR UNKNOWN
Overstorey	13	12	0	1
	(50)	(46)	(0)	(4)
Understorey	19	13	4	4
	(48)	(32)	(10)	(10)
Total	32	25	4	5
	(48)	(38)	(6)	(8)

Tab. VII : Seasonal fruiting pattern of tree species (percentage values are in parentheses).

A large majority of the species had fleshy fruits, with less than 25 % species having wind adapted fruits. The number of species producing fleshy fruits did not differ much between wet and dry seasons, both for over and understorey species. Only in the case of understorey species a large number of wind adapted fruits were found during the dry season compared to the wet season. Miscellaneous fruit type consisted of hard fruits such as acorns produced by *Castanopsis* and *Quercus* species (Tab. VIII).

	FRUIT TYPE			
SPECIES	SEASON	FLESHY	WIND ADAPTED	MISCELLANEOUS
Overstorey	Dry	6 (43)	4 (50)	2 (50)
	Wet	7 (50)	4 (50)	2 (50)
	Extended	0 (0)	0 (0)	0 (0)
	Unknown	1 (7)	0 (0)	0 (0)
	Total	14 (100)	8 (100)	4 (100)
Understorey	Dry	12 (42)	6 (75)	1 (33)
	Wet	11 (38)	1 (12.5)	1 (33)
	Extended	3 (10)	1 (12.5)	0
	Unknown	3 (10)	0 (0)	1 (33)
	Total	29 (100)	8 (100)	3 (100)
Total		43	16	7

Tab. VIII : Season of fruit maturity related to fruit type for different tree species (percentage values in parentheses).

DISCUSSION

Biotic activity in a community follows the annual cycles of environmental parameters which regulate the phenological characteristics of individual species. In a forest community, the tree periodicity patterns give an idea of seasonal organization of floral and fruit resources (FRANKIE *et al.*, 1974) which have been viewed as a mechanism of niche separation whereby competition between species is reduced and temporal separation increases diversity of the community which may influence production and stability (CONNEL & ORIAS, 1964). The correlation of phenological activity in the present study with seasonally occurring events is best exemplified by the patterns of leaf fall and leaf flushing. Maximum leaf fall occurred during December to March at a time of water or cold stress while flushing occurred mostly in the warmer months of March-April just before the rains. Thus, the leaf replacement strategy appears to be to minimize stress by leaf fall at such periods and maximize photosynthetic activity during wet warm season of the year through flushing.

The pattern of community seasonality are the averages of the seasonal patterns of many species and though the community pattern may be generally most adaptive, certain species have evolved completely different approaches to leaf flushing and leaf fall which may be due to intrinsic factors. While the overstorey trees are mostly with double determinate flushes, understorey has quite a good number of species with a single determinate flush. The second flush in the overstorey species is in response to favourable environmental conditions during July-August. Leaves in the understorey species are retained for longer periods and this may be attributed to more homogenous environmental conditions like light and moisture which allow them to retain leaves for long periods without the risk of environmental stresses. BENTLEY (1979) has also reported a similar pattern of longevity of individual leaves of 27 understorey species in a Costa Rican tropical rainforest.

Though the relative number of flowerers are more or less equal in both dry (November-April) and wet (May-October) periods, the seasonal pattern of flowering for the forest has two peaks, a major and a minor one which correlates well with the relatively major (April) and minor (October) xeric periods of the warm season. Thus this synchronization of flowering seems to be related to climatic conditions as also reported by others (DUCKE & BLACK, 1953; NJOKU, 1963; FRANKIE *et al.*, 1974).

The peak production of mature fruits in the forest also corresponds with the onset of dry season after October; therefore most of the species have seeds with winter dormancy which is broken only after the warm season rains. The escape of flowering and fruiting by certain species on an annual basis as seen from the present study has also been reported by others (ASHTON, 1969; MEDWAY, 1972; JANZEN, 1978). JANZEN (1978) has discussed the possible significance of this irregular behaviour as an escape from seed predation on a time basis. Departure from intraspecific synchrony in flowering and fruiting observed in a few species in the community may be the result of micro-environmental heterogeneity.

In the tropical trees dissemination of the propagule is usually considered to be by wind occurring at the end of the season of lowest vegetative activity, whereas in temperate trees, it is typically by animals and at the end of the vegetative growth season (DAUBENMIRE, 1972). The forest community in the present case consisting of a majority of temperate elements follow the latter pattern.

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APPENDIX

Lists 1 and 2 of species recorded and their phenological behaviour are given below. Abbreviations used in the lists are as follows :

1-12 : January through to December;
P : periodic;
C : continuous;
b : brief periods - < 2 weeks per episode;
p : extended periods - > 2 weeks per episode;
M : multiple events per year;
S : synchronous;
A : asynchronous;
D : deciduous;
F : rapid fruit maturation - < 4 months;
L : lenghty fruit maturation - > 4 months.

	Flowering		Fruiting		Leaf flushing		Leaf fall	
	Months	Behaviour	Months	Behaviour	Months	Behaviour	Months	Behaviour
ACERACEAE								
Acer laevigatum Wall.	3-6	PpA	8-10	PpF	4-5 & 7-8	PpM	2-3	PD
BETULACEAE								
Alnus nepalensis Don.	10-12	Pps	2-3	PpF	2-12	CS	1-3	CE
Betula alnoides Ham.	4-5	PpA	7-8	PbF	2-4 & 8-9	PpM	7-8	PD
ELAEOCARPACEAE								
Elaeocarpus braceanus Watt.	3-4	Ppa	9-10	PpL	3-5 & 7-8	PpM	1-3	PE
ERICACEAE								
Rhododendron arboreum Sm.	2-3	PpS	9	PpL	4-5 & 7-9	PpM	1-3	PE
EUPHORBIACEAE								
Daphniphyllum himalayense Muell.	3-4	PpA	2-3	PpL	4-6 & 7-9	PpM	1-3	PE
FAGACEAE								
Castanopsis hystrix A. DC	10	PpA	3	PpL	3-5 & 7-9	PpM	1-3	PE
Pasania spicata Smith	4-5	PpA	8-10	PpL	3-5 & 7-9	PpM	1-3	PE
Quercus dealbata Hook F. & Thoms.	7-8	PpA	10-12	PpL	4-5 & 7-8	PpM	1-3	PE
Q. griffithii Hook F. & Thoms	8-9	PpA	10-12	PpL	4-5 & 7-8	PpM	11-12	PD
Q. paniculata	6-7	PpA	9-10	PpL	4-5 & 7-8	PpM	1-3	PE

List 1 : Phenological records for overstorey tree species.

	Flowering		Fruiting		Leaf flushing		Leaf fall	
	Months	Behaviour	Months	Behaviour	Months	Behaviour	Months	Behaviour
HAMAMELIDACEAE								
Exbucklandia populea Br.	11	PpA	12	PpL	3-11	PpM	11-12	PE
JUGLANDACEAE								
Englehardtia spicata Blume	7-8	PpA	12-3	PpL	3-5 & 7-9	PpM	8-9	PD
LAURACEAE								
Cinnamomum impressinervum Meissn.	3-4	PpA	-	-	4-5 & 8-9	PpM	1-3	PE
C. obtusifolium Nees.	3-4	PpA	7-8	PpL	4-5 & 8-9	PpM	1-3	PE
Litsea meissneri HK.F.	9-10	PpA	4	PpL	4-5 & 8-9	PpM	1-3	PE
L. sebifera Pers. Wall.	4-7	PpA	9-10	PpL	4-6 & 8-9	PpM	1-3	PE
Machillus kingii HK.F.	1-4	PpA	6-7	PpF	4-6 & 8-9	PpM	1-3	PE
M. odoratissima Nees.	3-4	PpA	5-6	PpF	4-6 & 8-9	PpM	1-3	PE
MAGNOLIACEAE								
Manglietia insignis(Wall.)Bl.	5	PbA	11-12	PbL	4-6 & 8-9	PpM	1-3	PE
MORACEAE								
Ficus nemoralis Wall.	-	-	11-12	PpL	3-11	PpM	4	PE

List 1 : Phenological records for overstorey tree species.(continued)

	Flowering		Fruiting		Leaf flushing		Leaf fall	
	Months	Behaviour	Months	Behaviour	Months	Behaviour	Months	Behaviour
MYRTACEAE								
Eugenia tetragona Wight	4-4	PbA	7-8	PbF	3-11	PpM	4	PE
OLEACEAE								
Ligustrum confusum Dcne	5-7	PbA	12-4	PbL	3-10	PpM	4	PE
ROSACEAE								
Prunus cerasoides Don.	10-12	PbA	6	PbL	3-11	PpM	7-8	PD
P. puddum Roxb.	9-10	PbA	10-11	PbF	3-11	PpM	7-8	PD
TERNSTROEMIACEAE								
Schima khasiana Dyer	4-4	PpA	2	PbL	4-10	PpM	2-3	PD

List 1 : Phenological records for overstorey tree species. (continued)

	Flowering		Fruiting		Leaf flushing		Leaf fall	
	Months	Behaviour	Months	Behaviour	Months	Behaviour	Months	Behaviour
ANACARDIACEAE								
Rhus semialata Murray	3-5	PpA	9-10	PpL	3-4 & 7-8	PpM	1-3	PD
R. succedanea Linn.	3-5	PpA	1-5	PpL	3-5	PpM	1-3	PD
AQUIFOLIACEAE								
Ilex khasiana Purkayastha	3-4	PpA	10	PpL	4-5 & 7-8	PpM	12-3	PE
I. theafolia Wall.	4-6	PpA	7	PpL	4-5 & 7-8	PpM	12-3	PE
ARALIACEAE								
Heptapleurum khasianum Clarke	12	PpA	-	-	4-5	P_pM	11-12	PE
ELAEGNACEAE								
Elaegnus pyriformis Hook. F.	10-11	PpA	12-1	PpL	4-5	PpM	11-12	PE
EUPHORBIACEAE								
Mallotus nepalensis Muell.	6	PbA	9-10	PpL	4-10	PpM	12-3	PD
Phyllanthus glaucus Wall.	4-5	PpS	-	-	4-10	PpM	2-3	PE
ERICACEAE								
Pieris ovalifolia Don.	6-12	CS	1-12	CL	3-12	C	12-2	CE
Rhododendron formosum Wall.	3-4	PbA	10-12	PbL	4-6	PpM	12-2	PE
FAGACEAE								
Quercus sp.	-	-	-	-	3-4	PpM	2-3	PD

List 2 : Phenological records for understorey tree species.

	Flowering		Fruiting		Leaf flushing		Leaf fall	
	Months	Behaviour	Months	Behaviour	Months	Behaviour	Months	Behaviour
HAMAMELIDACEAE								
Corylopsis himalayana Griff.	2-3	PbA	4-5	PbL	4-5 & 7-8	PpM	2-3	PD
LABIATEAE								
Leucospectrum canum Smith	2-3	PbS	4-5	PbL	4-8	PpM	2-3	PD
LAURACEAE								
Cinnamomum tamala Fr. Nees.	2-5	PbA	6-10	PpL	4-5	PpM	2-3	PE
Lindera pulcherima Benth.	3	PbA	4-5	PbL	4-5	PpM	2-3	PE
L. latifolia HooK F.	10	PbA	2	PbL	4-5	PpM	2-3	PE
L. thomsonii Allen.	10	PbA	2	PbL	4-5	PpM	2-3	PE
Litsaea elongata Wall.	10	PbA	4-5	PbL	4-5	PpM	2-3	PE
LEGUMINOSAE								
Acacia dealbata Link.	2-4	PpS	10	PpL	3-11	PpM	2-3	PD
Erythrina arborescens Roxb.	8-9	PpS	10-11	PpL	3-11	PpM	2-3	PE
MYRICACEAE								
Myrica esculenta Buch. Ham.	10	PpA	5	PpL	3-4	PpM	2-3	PE
M. rubra Sieb. & Zucc.	10-11	PpA	5	PpL	3-4	PpM	2-3	PE
MYRSINACEAE								
Myrsine semiserrata Wall.	9-12	PpS	1-6	PpL	3-12	C	12-3	CE
OLEACEAE								
Ligustrum lucidum Aiton	6-8	PpA	11	PpL	3-9	PpM	3	PE
L. nepalense Wall.	6-7	PpA	10-11	PpL	3-9	PpM	3	PE
L. robustum Bl.	5-7	PpA	12-4	PpL	3-9	PpM	3	PE

List 2 : Phenological records for understorey tree species. (continued)

	Flowering		Fruiting		Leaf flushing		Leaf fall	
	Months	Behaviour	Months	Behaviour	Months	Behaviour	Months	Behaviour
ROSACEAE								
Photinia notoniana Wight & Arn.	2-3	PpA	6-7	PpF	3-4 & 7-8	PpM	12-1	PE
Prunus nepalensis Koch.	3-5	PpA	10	PpL	4-9	PpM	10-11	PD
Pyrus baccata L.	2-4	PpA	10	PpL	4-9	PpM	10-11	PD
P. pashia Don.	2-4	PpA	7	PpL	4-9	PpM	10-11	PD
P. polycarpa Hook. F.	2-4	PpA	10	PpL	4-9	PpM	10-11	PD
RUBIACEAE								
Wendlandia paniculata DC.	3-5	PbA	10-12	PbL	4-5 & 7-8	PpM	10-12	PE
RUTACEAE								
Skimmia laureola Sieb & Zucc.	-	-	-	-	3-4 & 7-8	PpM	2-3	PE
SYMPLOCACEAE								
Symplocos crataegoides Ham.	5	PpA	12-1	PpL	4-5 & 7-8	PpM	1-3	PD
S. pyrifolia Wall.	10	PpA	3	PpL	4-5 & 7-8	PpM	1-3	PE
S. spicata Roxb.	10	PpA	3	PpL	4-5 & 7-8	PpM	1-3	PE
S. theafolia Don.	10	PpA	3	PpL	4-5 & 7-8	PpM	1-3	PE
TERNSTREOMIACEAE								
Eurya acuminata DC.	9-11	PpA	1-6	PpL	4-9	PpM	1-3	PE
E. japonica Thunb.	6-1	CS	5-11	CL	3-9	C	12-3	CE

List 2 : Phenological records for understorey tree species.(continued)