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Phenology of tree species of tropical moist forest of Uttara Kannada district, Karnataka, India

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Abstract. Phenological observations on tree species in tropical moist forest of Uttara Kannada district (13°55′ to 15°31′ N lat; 74°9′ to 75°10′ E long) during the years 1983-1985 revealed that there exists a strong seasonality for leaf flush, leaf drop and reproduction. Young leaves were produced in the pre-monsoon dry period with a peak in February, followed by the expansion of leaves which was completed in March. Abscission of leaves occurred in the post-monsoon winter period with a peak in December. There were two peaks for flowering (December and March), while fruit ripening had a single peak in May-June, preceding the monsoon rainfall. The duration of maturation of leaves was the shortest, while that of full ripening of fruits was the longest. Mature flowers of evergreen species lasted longer than those of deciduous species; in contrast the phenophase of ripe fruits of deciduous species was longer than that of evergreen species.

Keywords. Phenology; tree species; tropical moist forest; Western Ghats.

1. Introduction

Periodic behaviour of plants in tropical environments has received much attention in recent years. The knowledge of phenology of plants has helped to understand the influence of phenological events on feeding, movement patterns, and sociality of insects, birds and mammals (*e.g.* Foster 1982b; Leigh and Windsor 1982; Prasad 1983; Wada 1983; Appanah 1985; Coates-Estrada and Estrada 1986). More recently, efforts have been made to discern the importance of general community patterns in leafing, flowering and fruiting for many species, of which particular forest types are composed (Frankie *et al* 1974a; Lieth 1974; Opler *et al* 1980). A considerable amount of information is available on the major phenological events of plant species from different parts of tropical America, Africa and south-east Asia including continental India (Santapau 1962; Malaisse 1974; Monasterio and Sarmeinto 1976; Liberman 1982; Rai and Proctor 1986; Steven *et al* 1987; Bullock and Solis-Magallanes 1990). While the studies on phenology in north-eastern India (Boojh and Ramakrishnan 1982; Shukla and Ramakrishnan 1982, 1984), in Himalaya (Ralhan *et al* 1985) and in deciduous forest of Bandipur in peninsular India (Prasad and Hegde 1986) do shed light on foliage dynamics, its relation to successional status of a given species, phenodynamics and the variation in the distribution of phenological events, the phenology of tropical moist forest species of Western Ghats region is less understood. The present study describes the phenological patterns in tree species of the Western Ghats district of Uttara Kannada, and the results are compared with those from other tropical sites.

2. Materials and methods

2.1 *Study area*

The district of Uttara Kannada (13° 55′ to 15° 31′ N lat; 74° 9′ to 75°10′ E long), comprising an area of 10,200 km^2, lies on the west coast of India (figure 1). The hill range of the Western Ghats runs parallel to the coast, rising to a little over 1000 m above mean sea level. The altitude of the study sites ranged from 50 to 600 m. Topographically the district may be divided into 3 zones: the flat and narrow coast, abruptly rising ridge, and flatter, elevated eastern zone that joins with the Deccan plateau. Climatically the district is tropical. Annual rainfall in the district ranges from 350 cm near the coast to 500 cm at some places along the ridge of the hills. The eastern side of the district receives about 120 cm of rainfall. The maximum

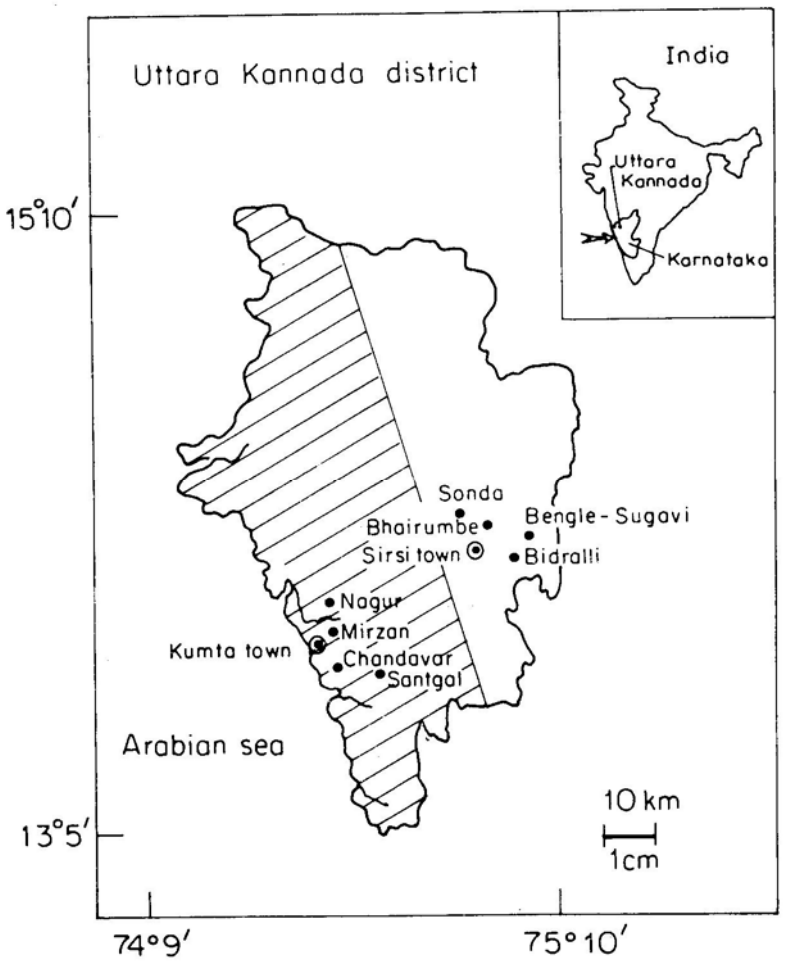

Figure 1. Map of Uttara Kannada district showing broad vegetation types and location of sites.

(▨)Evergreen/semigreen tract; (□) secondary/moist deciduous tract.

temperature in higher elevation (hereafter referred to as above ghat) areas of the district ranges from 25 to 32° C while for the coastal region it is 28 to 33° C. The minimum temperature varies from 13 to 21° C and 20 to 25° C respectively for above ghat and coastal areas (figure 2). Geologically the district is a transitional zone between the younger basaltic rocks of Deccan trap formation and the older crystalline rocks of Archaean shield of Indian Peninsula. The natural forests are of evergreen/semievergreen type along the slopes, and towards the east of the ridge it is secondary/moist deciduous. Based on the annual rainfall and the vegetation types the district was broadly divided into evergreen/semievergreen zone and drier secondary/moist deciduous zone (figure 1). Table 1 gives sampling localities, their vegetation types and other important characters.

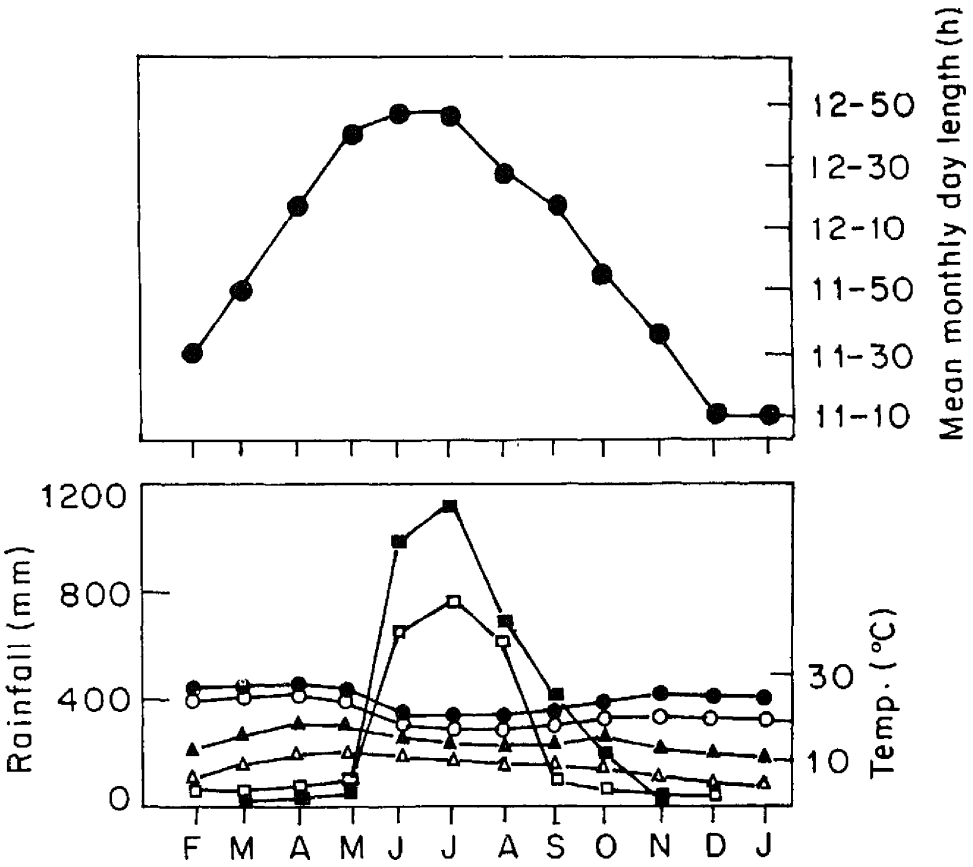

Figure 2. Daylength and climate in Uttara Kannada district.
(□, ○, Δ), Above ghat area;(■, ●, ▲)coastal area; (□, ■), mean monthly rainfall; (○, ●), mean monthly maximum temperature; (Δ, ▲), mean monthly minimum temperature.

2.2 *Methods*

Of the 8 one-hectare plots selected for the present study, 4 were from coastal area representing evergreen/semievergreen zone and remaining 4 plots were from above

Table 1. Some important characteristics of study sites from two different vegetation zones in Uttara Kannada district

	Study locality							
	Evergreen/semievergreen				Secondary/moist deciduous			
	Chandavar	Mirzan	Nagur	Santgal	Bhairumbe	Bengle-Sugavi	Bidralli	Sonda
Number of families	28	21	29	27	23	18	19	24
Species richness (No. of tree species ha)	32	33	51	63	40	44	32	51
Population density (No. of trees/ha)	485	280	1536	888	338	388	279	585
Species type								
Evergreen (%)	50	37	66	76	26	18	24	47
Deciduous (%)	50	63	34	24	74	82	76	53
Dominant species	*Hopea wightiana* *Lagerstroemia microcarpa* *Alseodaphne semicarpifolia* *Aporosa lindleyana* *Flacourtia montana* *Ervatamia heyneana* *Ixora brachiata*	*Spondias accuminata* *Alseodaphne semicarpifolia* *Wrightia tomentosa* *Ervatamia heyneana* *Ixora brachiata* *Ziziphus xylopyra* *Randia spinosa*	*Hopea wightiana* *Holigarna arnottiana* *Pterospermum* sp. *Aporosa lindleyana* *Myristica attenuata*	*Bischofia javanica* *Pterospermum* sp. *Dysoxylum binectariferum* *Nephelium longana* *Nothopodytes foetida* *Nothopegia colebrookiana*	*Terminalia bellerica* *T. paniculata* *T. alata* *Xylia xylocarpa* *Buchanania lanzan* *Phyllanthus emblica* *Ziziphus xylopyra* *Randia spinosa*	*Terminalia bellerica* *T. alata* *T. paniculata* *Lagerstroemia microcarpa* *Adina cordifolia* *Cassia fistula* *Randia spinosa* *Phyllanthus emblica*	*Xylia xylocarpa* *Lagerstroemia microcarpa* *Adina cordifolia* *Schleichera oleosa* *Terminalia paniculata* *Randia uliginosa*	*Terminalia paniculata* *T. alata* *Xylia xylocarpa* *Xantolis tomentosa* *Flacourtia montana* *Ervatamia heyneana* *Aporosa lindleyana*
Level of biotic disturbance	High	Very high	Moderate	Little	High	High	High	Moderate

ghat area representing the secondary/moist deciduous zone. All the individuals of tree species with a girth of 10 cm and above were marked with a metal tag. Each plot was visited once a fortnight from November 1983 to December 1985 to record the changes for the following 9 phenological events: (i) Production of young leaves (YL), (ii) Maturation of leaves (ML), (iii) Abscission of leaves (AL), (iv) Production of young flowers (YF1), (v) Maturation (anthesis) of flowers (MF1), (vi) Abscission of flowers (AF1), (vii) Production of young fruits (YFr), (viii) Maturation of fruits (MFr), and (ix) Ripening of fruits (RFr).

During the fortnightly visits, marked individuals were qualitatively characterized for these 9 phenological events (Prasad and Hegde 1986) and the phenostage of a species was determined by considering the status of majority of individuals. In the case of species represented by only a few individuals, those present in nearby areas were observed to confirm the phenological status of that species. The duration of a phenological event in a species was computed by obtaining the number of days required for the completion of an event from the date of the fortnightly visit when the event was first observed. For each species, interphenophase durations, i.e. periods between successive phenological events, were then obtained.

3. Results

3.1 *Foliage phenology*

Of the 103 species with 4779 individuals observed, 54 species comprising 2933 individuals were evergreen and the rest (49 species; 1846 individuals) were deciduous. Leafing occurred twice in a year in *Dalbergia latifolia* and *Pterocarpus marsupium* and several times in *Ficus infectoria.* In the remaining deciduous species leaf production was seasonal (see appendices 1 and 2). In the palms *Caryota urens* and *Arenga wightii* leafing occurred throughout the year.

Emergence of young leaves peaked in Feb/Mar in all the study plots (figures 3, 4), and the maturation of leaves peaked in March. The abscission of leaves started in November, and lasted up to January with a peak in December. The emergence and

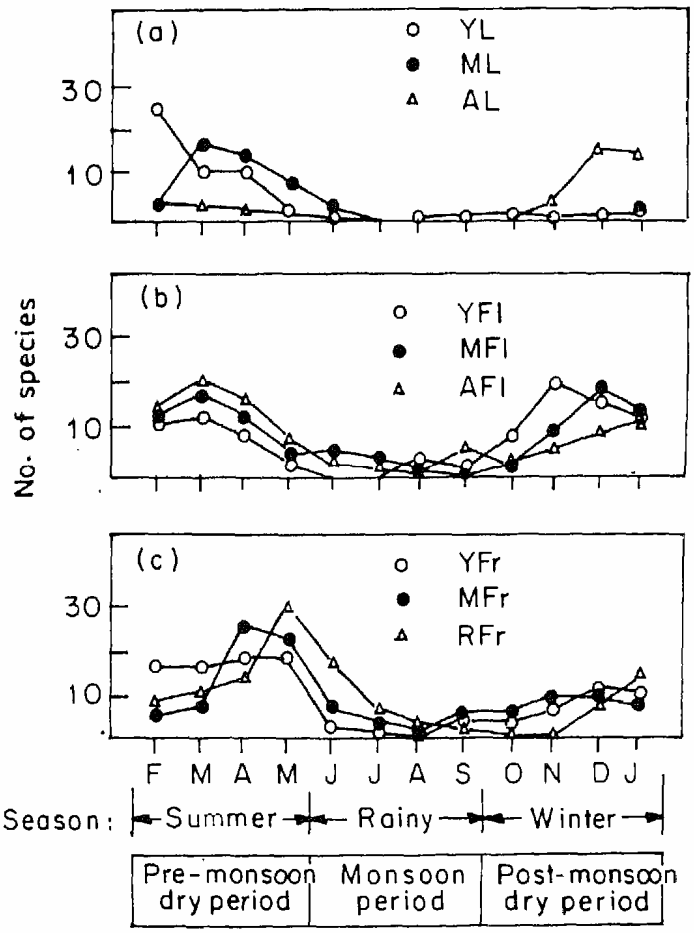

Figure 3. Seasonality in different phenological events in tropical moist forest of Uttara Kannada district.
(a) Leafing and leaf fall (b) Flowering (c) Fruiting.
L, Leaf; Fl, flower; Fr, fruit; Y, young; M, mature; R, ripe; A, abscission.

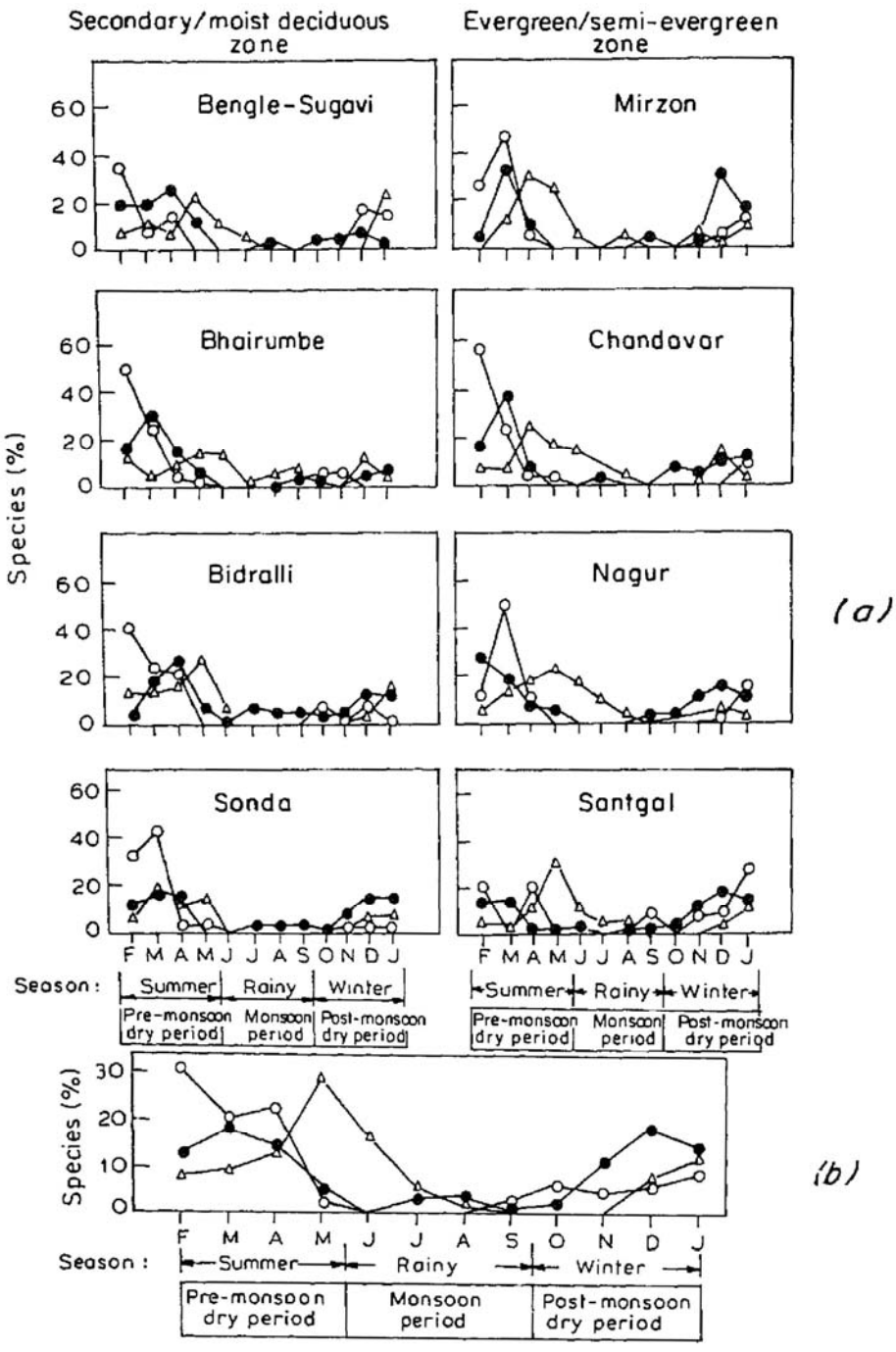

Figure 4. **(a)** Seasonality in major phenological events in the sites located in two different vegetation types in Uttara Kannada district. **(b)** Seasonality in major phenological events in the forest of Uttara Kannada district (pooled over all the eight sites).
(O), Emergence of leaves; ( ), flowering; (Δ), fruits.

maturation of leaves coincided with longer day length and rise in temperature, while leaf abscission coincided with short day length and decrease in temperature (figures 3, 4). The duration of leaf maturation varied from about 2 weeks in *Wrightia tomentosa* to 6 weeks in *Ficus arnottiana.* The period between maturation and abscission of leaves ranged from 185 days in *Sapium insigne* to 362 days in *Mitragyna parviflora* (appendix 1, see also figure 5). Many species remained leafless for quite a long period (see appendix 2), while *Artocarpus lakoocha* and *Chukrassia tabularis* retained the aged leaves till the newly emerged ones attained the full size.

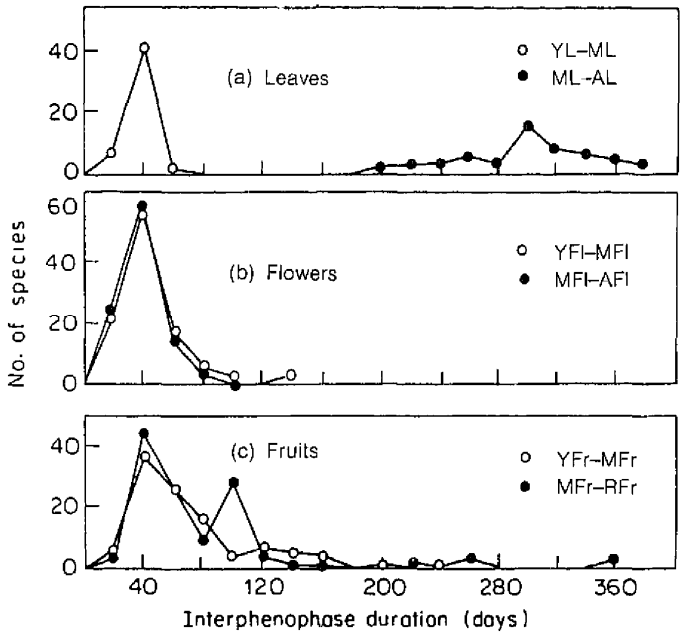

Figure 5. Spread of phenological events in tropical moist forest of Uttara Kannada district. Abbreviations as in figure 3.

3.2 *Reproductive phenology*

Flowering was continuous in the palm *C. urens* while it occurred twice in a year in *D. latifolia* and *P. marsupium,* and more than twice in *F. infectoria.* In the remaining species production of flower buds and anthesis were seasonal with two peaks; the larger peak was in March and smaller peak in December for anthesis (figures 3, 4). In all the study plots inspite of differences in vegetation types and in elevations, larger peak for flowering preceded the monsoon rainfall (figure 4). Similar pattern was observed in canopy trees and understorey trees (figure 6, also see appendix 2). In many species the period of flower abscission was short, and the duration between flower bud stage and anthesis ranged from less than 1 to 18 weeks (figure 5). On average, mature flowers of evergreen species lasted for a longer period than those of deciduous species (figure 7).

Fruit setting closely followed the abscission of flowers and the ripening of fruits occurred before the advent of monsoon rainfall, peaking in May-June (figures 3, 4).

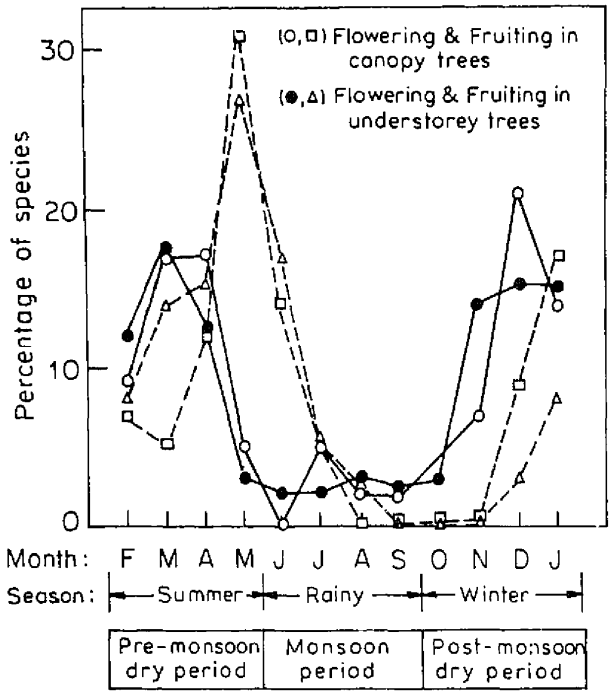

Figure 6. Seasonality in flowering and fruiting in canopy trees and understorey trees in the tropical moist forest of Uttara Kannada district.

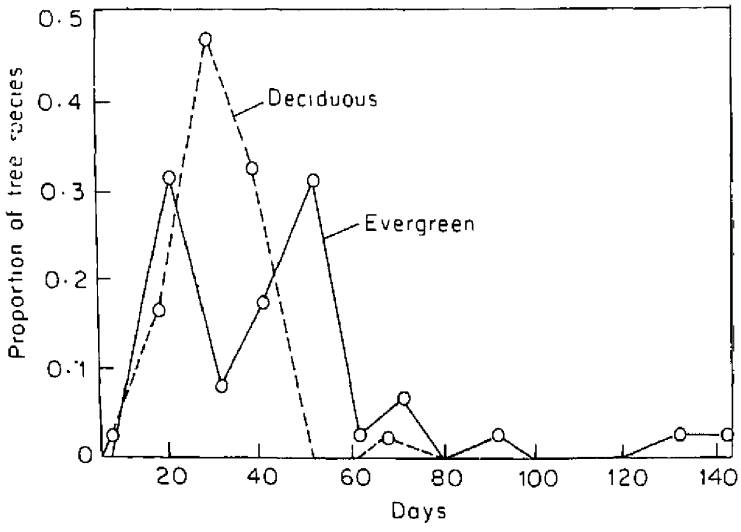

Figure 7. Length of phenophase of mature flowers in evergreen and deciduous species of tropical moist forest of Uttara Kannada district.

No significant shift was observed for peak fruiting between the plots, vegetation types, and among canopy and understorey tree species (figures 4, 6). Few species retained their fruits during the monsoon period and the post-monsoon dry period.

The period between fruit setting and maturation ranged from 3 to 38 weeks and the mature fruits took 2 to 50 weeks to ripen (figure 5). On average, the phenophase of fleshy ripe fruits was shorter than that of dry fruits (figure 8), and the phenophase of ripe fruits in evergreen species was shorter than that in deciduous species (figure 9).

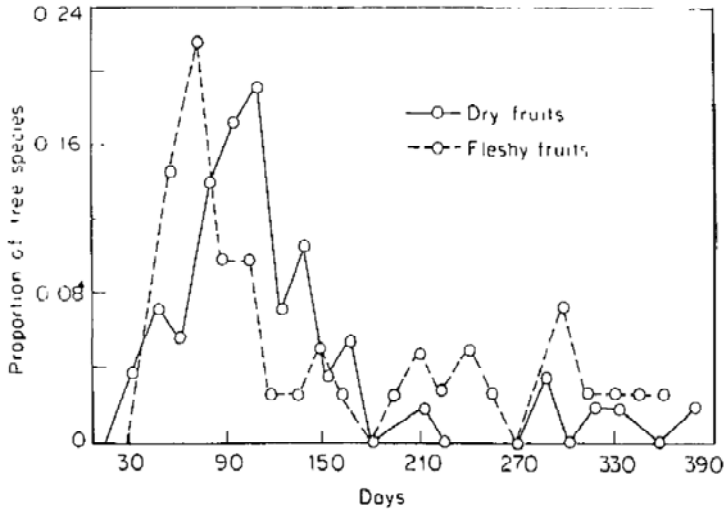

Figure 8. Length of phenophase of ripe fruits in species bearing dry and fleshy fruits in tropical moist forest of Uttara Kannada district.

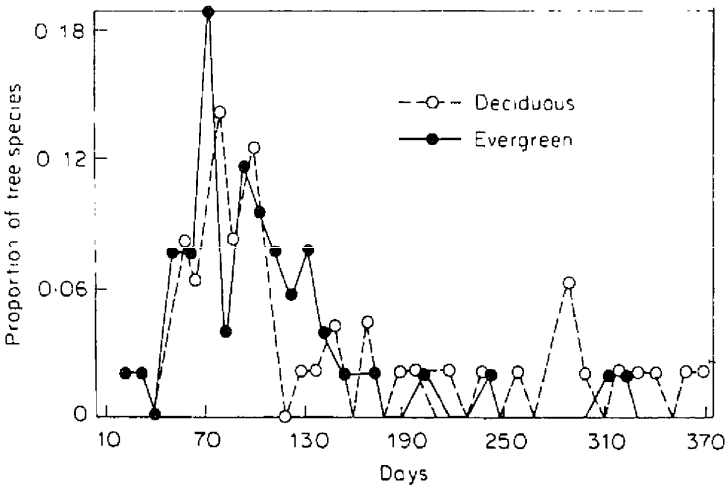

Figure 9. Length of phenophase of ripe fruits (includes dry and fleshy fruits) in evergreen and deciduous species in tropical moist forest of Uttara Kannada district.

3.3 *Ranges of interphenophase durations*

Interphenophase durations between different phenological events varied greatly for the evergreen and deciduous species in the community (table 2). The shortest range

Table 2. Ranges of interphenophase durations between phenological events.

	In community	In evergreen species	In deciduous species
Young leaves to maturation of leaves (days)	29		29
Mature flowers to abscission of flowers (days)	57	53	43
Young flowers to maturation of flowers (days)	127	119	31
Maturation of leaves to abscission of leaves (days)	177	—	177
Young fruits to maturation of fruits (days)	254	254	250
Maturation of fruits to ripening of fruits (days)	344	236	327

was for maturation of leaves and the longest for fruiting. Retention of flowers in evergreen species was for a longer period than that in deciduous species.

4. Discussion

Recent studies have shown that seasonal peaks and depressions for leaf flush and leaf fall are quite common in tropical rainforests with pronounced dry period (Kramer and Kozlowski 1960; Fogden 1972; Kladik 1978). In tropics emergence of leaves peaked either in dry season (Frankie *et al* 1974b; Whitmore 1984) or in the wet season (Fogden 1972; Proctor *et al* 1983). For tropical plants leaf flush is attributed to onset of rain after a spell of dry period (Leigh and Windsor 1982; Prasad and Hegde 1986), water stress (Alvim 1964; Alvim and Alvim 1978), photoperiod (Daubenmire 1972) and temperature (Schaik 1986). In many tropical sites first peak of leaf emergence was in the first dry season of the year when the temperature reached maximum (see table 3). In tropical moist forest of Uttara Kannada leaf flush occurred in the early part of pre-monsoon dry period during which the rainfall was minimum. Inspite of low soil moisture, deciduous species in

Table 3. Comparison of climate and phenological features in a range of tropical forest sites.

	Ulu Gombak, W. Malaysia (Medway 1972)	Bandipur, India (Prasad and Hegde 1986)	Ketambe, Sumatra (Schaik 1986)	Chamela, Mexico (Bullock and Solis-Magallanes 1990)	La Selva, Costa Rica (Frankie *et al.* 1974)	Uttara Kannada India (This study)
Rainfall*	B	U	B	U	B	U
First peak of leaf emergence	Mar–May	Apr–May	Dec–Feb	Jun–Jul	Feb	Feb
Second peak of leaf emergence	*ca.* Dec	Jul–Sep	Aug	—	Sep	—
Peak of leaf fall	—	Dec–Jan	Jan		Feb	Dec
First peak of flowering	Mar–Jul	Apr–May	Feb–Apr	Jun–Jul	May	Mar
Second peak of flowering	—	—	—	Oct	—	Dec
First peak of fruiting	Aug–Sep	Nov–Dec	Jul–Aug	Nov–Dec	Sep	May–Jun
Second peak of fruiting	—	—	—	Aug	—	—
Month of maximum temperature	Mar	—	Mar	—	May	Apr
Period of maximum rainfall	Oct–Dec	Jun–Sep	Sep–Nov	Jul–Oct	Jun–Oct	Jun–Sep

*B. Bimodal rainfall; U. unimodal rainfall.

all the study locations produced new leaves during early part of summer season (figures 3, 4). The reasons for emergence and maturation of leaves in the pre-monsoon period could be that this dry period is short, temperature is at its maximum and day length increases. These environmental factors have been accepted to be favourable for maximizing photosynthesis and vegetative growth (Sharma 1970; Salisbury and Ross 1974). On the other hand, leaf fall coincided with short day length and decrease in temperature; however, leaf abscission occurred over a wider span of time than did leaf emergence. The species specific leaf shedding phenology affecting the shift in peak leaf fall has been discussed elsewhere (Kunkel-Westphal and Kunkel 1979; Songwe *et al* 1988; Bhat 1990).

In all the eight forest localities of Uttara Kannada district, the larger flowering peaks occurred in March/April (figure 4). In other tropical sites also flowering peaked close to the month of highest temperature (see table 3) and increasing day length. Very often synchronous flowering is correlated with rainfall after dry spell (Augspurger 1982) and such flowering is believed to attract pollinators (Bullock and Bawa 1981) as insect activity is probably greatest in the months with warm and dry days (Janzen 1967; Kaul *et al* 1986; Schaik 1986). However, two distinct peaks were observed for emergence of flower buds and anthesis when species were classified with respect to their leaf shedding nature. Deciduous species tended to flower in pre-monsoon dry period while many of the evergreen species flowered in the later part of the winter period (figure 10). Flowering in different seasons may be to avoid competition for pollinators. Unlike species that flower during the later part of the winter season, which do not experience heavy demands for energy for vegetative growth, species that bloom during the pre-monsoon dry period make large investment in reproduction while leafless or flushing and must depend on reserve food (Bullock and Solis-Magallanes 1990). Advantage of dry-season flowering is that it makes flowers more visible to pollinators since the trees lack leaves (Janzen

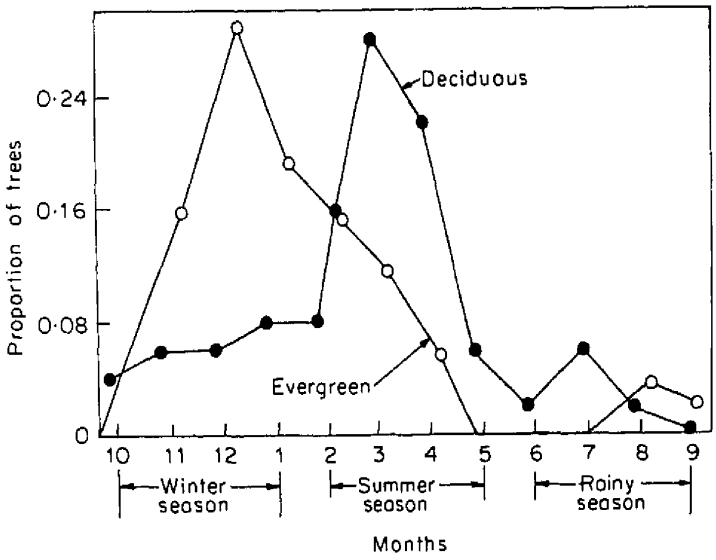

Figure 10. Proportions of evergreen and deciduous species in peak flower in different seasons in tropical moist forest of Uttara Kannada district.

1967). A few species exhibit unusual phenological patterns. For instance, the palm *C. urens* starts reproduction after a long period of growth and continues to produce inflorescences until its last leaf comes out as inflorescence and later the palm dies. Such a pattern of reproduction could be to maximize output of seeds, In *Mappia foetida,* which is an understorey tree, flowering occurs in late rainy season. The odd season flowering is accompanied by strong odour of the flowers.

In majority of species fruits ripen close to monsoon rainfall, As shown in table 3, the fruiting peak in the forest of Uttara Kannada district was similar to that in other tropical sites (*i.e.* ripening of fruits in the later part of premonsoon dry period or close to rainfall). Similar feature observed earlier has been explained to gain post dispersal success (Rathcke and Lacey 1985), escape predation (Janzen 1983), enhance disersal (Foster 1982a; Prasad and Sharatchandra 1984) and avoid pathogen infection (Augspurger 1983). In a few species such as *Lagerstroemia microcarpa, C. tabularis* and *Terminalia paniculate* fruits ripen at odd seasons (post rainy season) when the germination success is usually minimal and incidence of pest and pathogen attack is high. Ripening of fruits in pre-monsoon dry period, especially in species dispersed by wind, could be a consequence of selection to disperse propagules at a time when the wind velocity is maximum. Odd season ripening of fruits in some of the hard seed-coated species such as *Terminalia bellerica, T. chebula, Phyllanthus emblica* may help in. dispersal since many are ingested by wildlife and voided elsewhere. *F. infectoria* produced fruits several times in a year. Many studies of fruit phenology of tropical rainforests have indicated that figs fruit asynchronously at the poulation level (Janzen 1979; Lighton and Leighton 1983), and it has been suggested that this trait may lower intraspecific competition for dispersal services and thus maximize dispersal success (Milton *et al* 1983).

Of the ranges observed for six phenophases the shortest was for maturation of leaves and the longest was for ripening of fruits. Longer duration of fruiting implies the availability of fruits and seeds to frugivores and seed predators for a longer period of time. This could be one of the reasons for predominance of frugivorous birds in the Santgal forest which is in evergreen/semievergreen forest zone of the district (Daniels *et al* 1990). Though the flowering is in two peaks the ripening of fruits is concurrent, resulting in a single peak close to monsoon rainfall. Concurrent ripening of fruits is effected in evergreen species by extending the flowering episode and shortening the fruiting duration.

5. Conclusion

A strong seasonality exists with respect to vegetative and reproductive phenology in tree species of tropical moist forest of Uttara Kannada district. Increasing day length and rise in temperature during the pre-monsoon dry period are probably responsible for leaf flush and maturation, while shorter day length and decrease in temperature may have induced leaf drop during the post-monsoon period. Flowering in two peaks is probably driven by change in temperature, and synchronized flowering in the early part of the pre-monsoon dry period may attract the pollinators. Concurrent ripening of fruits by majority of species in pre-monsoon period may offer post dispersal advantage for seeds to germinate. Avoiding

herbivore damage and maximum photosynthesis under favourable environmental condition are achieved by short interphenophase duration of leaf maturation.

Acknowledgements

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Appendix 1. List of species, number of individuals, interphenophase durations and leaf shedding nature for tree species of tropical moist forest of Uttara Kannada district.

Species	Canopy/ understorey tree	No. of individuals	Interphenophase duration (in days)						Leaf shedding nature
			YL–ML	ML–AL	YF1–MF1	MF1–AF1	YFr–MFr	MFr–RFr	
I Anacardiaceae									
1. *Buchananian lanzan*	unt.	31	33	279	26	24	31	28	D
2. *Holigarna arnottiana*	unt.	164	—	—	48	34	85	51	E
3. *H. grahamii*	cant.	3	—	—	46	20	54	39	E
4. *Mangifera indica*	cant.	15	—	—	41	35	44	61	E
5. *Nothopegia colebrookeana*	unt.	205	—	—	18	28	27	33	E
6. *Odina woodier*	unt.	37	25	283	28	28	59	40	D
7. *Spondias accuminata*	unt.	1	30	304	30	28	37	248	D
II Annonaceae									
8. *Bocagia dalzellii*	unt.	1	—	—	19	32	27	51	E
9. *Polyalthia fragrans*	cant.	14	—	—	16	22	79	45	E
III Apocyanaceae									
10. *Alstonia scholaris*	cant.	9	—	—	44	33	28	39	E
11. *Ervatamia heyneana*	unt.	139	39	323	28	34	54	92	D
12. *Wrightia tomentosa*	unt.	25	16	288	less than a week		35	31	D
IV Bignoniaceae									
13. *Heterophragma dalzellii*	unt.	4	39	316	39	77	30	67	D
14. *Stereospermum* sp.	cant.	10	34	291	21	23	38	217	D
V Boraginaceae									
15. *Ehretia* sp.	unt.	26	—	—	15	48	25	20	E
VI Combretaceae									
16. *Terminalia alata*	cant.	144	25	273	32	31	142	144	D
17. *T. bellerica*	cant.	57	34	305	29	16	152	141	D
18. *T. chebula*	unt.	8	33	231	23	20	58	267	D
19. *T. paniculata*	cant.	323	29	295	38	33	42	105	D
VII Dilleniaceae									
20. *Dillenia pentagyna*	cant.	56	25	328	31	28	35	36	D
VIII Dipterocarpaceae									
21. *Hopea wightiana*	cant.	937	—	—	61	29	23	71	E
22. *Shorea talura*	cant.	3	—	—	50	59	30	23	E

Appendix 1. (*Continued*)

IX Ebenaceae									
23. *Diospyros candoleana*	unt.	116	—	—	43	32	58	57	E
24. *D. melanoxylon*	unt.	4	21	344	34	18	21	344	D
25. *D. microphylla*	cant.	15	—	—	19	22	270	39	E
26. *D. montana*	unt.	29	19	294	22	23	59	37	D
27. *D. pruriens*	unt.	1	—	—	26	14	54	39	E
X Euphorbiaceae									
28. *Aporosa lindleyana*	unt.	217	—	—	43	33	67	60	E
29. *Bischofia javanica*	cant.	29	26	319	26	52	30	64	D
30. *Macaranga tomentosa*	cant.	21	—	—	47	28	37	28	E
31. *Mallotus philippensis*	unt.	19	—	—	44	31	61	41	E
32. *Phyllanthus emblica*	unt.	31	35	284	30	25	120	84	D
33. *Sapium insigne*	unt.	12	31	185	20	22	45	90	D
XI Bixaccaceae									
34. *Flacourtia montana*	unt.	108	—	—	45	26	53	30	E
XII Guttiferae									
35. *Calophyllum inophyllum*	cant.	11	—	—	15	16	51	30	E
36. *Garcinia indica*	unt.	8	—	—	35	42	49	34	E
37. *Ochrocarpus longifolius*	cant.	1	—	—	48	68	30	21	E
XIII Lauraceae									
38. *Actinodaphne hookeri*	unt.	10	—	—	33	15	141	58	E
39. *Alseodaphne semicarpifolia*	cant.	36	—	—	39	26	36	32	E
40. *Cinnamomum* sp.	cant.	30	—	—	43	22	35	44	E
41. *Machilus macarantha*	cant.	15	—	—	20	15	74	42	E
XIV Leguminosae									
42. *Albizzia odoratissima*	cant.	3	—	—	26	18	199	41	E
43. *Butea frondosa*	unt.	2	30	294	23	21	30	79	D
44. *Cassia fistula*	unt.	16	27	258	28	23	136	124	D
45. *Dalbergia latifolia*	unt.	9	30	258	19	21	37	40	D+
46. *D. paniculata*	cant.	1	18	307	18	15	128	34	D
47. *Pterocarpus marsupium*	cant.	6	25	210	30	17	59	26	D+
48. *Xylia xylocarpa*	unt.	240	31	317	32	27	270	64	D
XV Longaniaceae									
49. *Strychnos nuxvomica*	cant.	75	31	326	33	21	112	161	D
XVI Lythraceae									
50. *Lagerstroemia microcarpa*	cant.	37	32	310	27	29	245	113	D
XVII Malvaceae									
51. *Bombax malabarica*	cant.	2	36	259	19	26	26	43	D
52. *Kydia calycina*	unt.	1	34	284	18	12	20	27	D
XVIII Melastomaceae									
53. *Memecylon* sp.	unt.	22	—	—	38	36	49	21	E
XIX Meliaceae									
54. *Aglaia* sp.	unt.	25	—	—	18	29	75	41	E
55. *Chukrassia tabularis*	cant.	4	40	329	33	20	44	235	D
56. *Dysoxylum binectariferum*	cant.	19	—	—	57	40	38	26	E
57. *D. malabaricum*	unt.	42	—	—	19	22	64	42	E

Appendix 1. (*Continued*)

XX Myrsticaceae									
58. *Myrstica attenuata*	unt.	52	—	—	39	27	93	30	E
59. *Myristica malabarica*	unt.	1	—	—	39	27	113	41	E
XXI Myrtaceae									
60. *Careya arborea*	unt.	72.	24	257	29	26	36	30	D
61. *Eugenia corymbosa*	unt.	1	—	—	41	17	52	30	E
62. *E. jambolana*	cant.	12	—	—	125	25	29	37	E
63. *Eugenia* sp.	unt.	29	—	—	39	21	26	16	E
XXII Olacaceae									
64. *Mappia foetida*	unt.	23	18	283	19	19	34	38	D
65. *Strombosia ceylanica*	cant.	57	—	—	18	22	16	29	E
XXIII Oleaceae									
66. *Linociera malabaricum*	unt.	19	—	—	48	20	68	95	E
67. *Olea dioica*	unt.	200	—	—	21	21	35	31	E
XXIV Palmae									
68. *Arenga wightii*	unt.	1	—	—	18	46	29	117	E
69. *Caryota urens*+	unt.	10	—	—	All seasons				E
XXV Rhamnaceae									
70. *Zizyphus xylopyra*	unt.	12	37	281	24	23	123	115	D
XXVI Rhizophoraceae									
71. *Carallia integerrima*	cant.	3	—	—	34	53	28	39	E
XXVII Rubiaceae									
72. *Adina cordifolia*	cant.	31	31	230	38	26	100	88	D
73. *Ixora brachiata*	unt.	188	—	—	66	19	50	32	E
74. *Mitragyna parviflora*	cant.	3	30	362	37	38	135	85	D
75. *Plectronia wightii*	unt.	4	—	—	66	13	67	49	E
76. *Randia dumetorum*	unt.	170	30	290	32	28	224	90	D
77. *R. uliginosa*	unt.	54	33	279	34	41	40	42	D
XXVIII Rutaceae									
78. *Murraya exotica*	unt.	14	16	206	22	29	72	92	D
79. *Zanthoxylum rhetsa*	unt.	23	44	202	21	12	119	80	D
XXIX Samydaceae									
80. *Casearia* sp.	unt.	9	—	—	15	15	28	35	E
81. *Nephelium longana*	cant.	73	—	—	84	49	39	52	E
XXX Sapindaceae									
82. *Sapindus laurifolius*	unt.	3	25	285	29	41	51	40	D
83. *Schleichera trijuga*	unt.	12	28	298	35	23	31	48	D
XXXI Sapotaceae									
84. *Bassia latifolia*	unt.	12	36	288	33	24	21	38	D
85. *B. malabarica*	unt.	6	—	—	18	20	103	30	E
86. *Mimusops elengi*	cant.	15	—	—	24	43	66	41	E
87. *Sideroxylon tomentosa*	cant.	14	—	—	49	46	64	252	E
XXXII Simarubiaceae									
88. *Ailanthus malabaricum*	cant.	1	—	—	45	31	30	30	E
XXXIII Sterculiaceae									
89. *Pterospermum acerifolium*	cant.	71	—	—	20	26	22	39	E

Appendix 1. (*Continued*)

90. *P. heyneanum*	cant.	22	—	—	18	46	79	45	E
91. *Sterculia* sp.	unt.	13	28	327	25	31	32	28	D
XXXIV Styraceae									
92. *Symplocos* sp.	unt.	14	—	—	15	16	46	23	E
XXXV Tiliaceae									
93. *Elaeocarpus serratus*	cant.	8	—	—	37	34	43	46	E
94. *Grewia tiliaefolia*	unt.	11	38	282	36	29	41	33	D
XXXVI Urticaceae									
95. *Artocarpus hirsuta*	cant.	1	25	340	30	31	62	24	D
96. *A. lakoocha*	unt.	3	22	345	20	25	50	53	D
97. *Ficus arnottiana*	unt.	7	45	257	31	17	43	44	D
98. *F. asperrima*	unt.	13	27	249	34	28	20	52	D
99. *F. callosa*	cant.	8	—	—	32	21	47	58	E
100. *F. nervosa*	cant.	1	—	—	16	27	16	42	E
101. *F. infectoria*	cant.	4	—	—	Several	times			D+++
XXXVII Verbeneceae									
102. *Gmelina arborea*	unt.	1	18	304	30	34	78	17	D
103. *Vitex altissima*	unt.	49	28	332	29	31	64	66	D
Total evergreen individuals:	2933	Total evergreen species: 54							
Total deciduous individuals:	1846	Total deciduous species: 49							
	4779			103					

Cant., Canopy tree; unt., understorey tree.

D, Deciduous species; E, evergreen species.

L, leaf; Fl, flower; Fr, fruit; Y, young; M, mature; A, abscission; R, ripe.

+ , Leafing, flowering and fruiting in all seasons; + +, leafing, flowering and fruiting twice in a year; + + +, leafing, flowering and fruiting several times in a year.

Family and nomenclature follows Cooke (1967).

Appendix 2. Foliage, flowering and fruiting phenology in tree species of tropical moist forest of Uttara Kannada district.

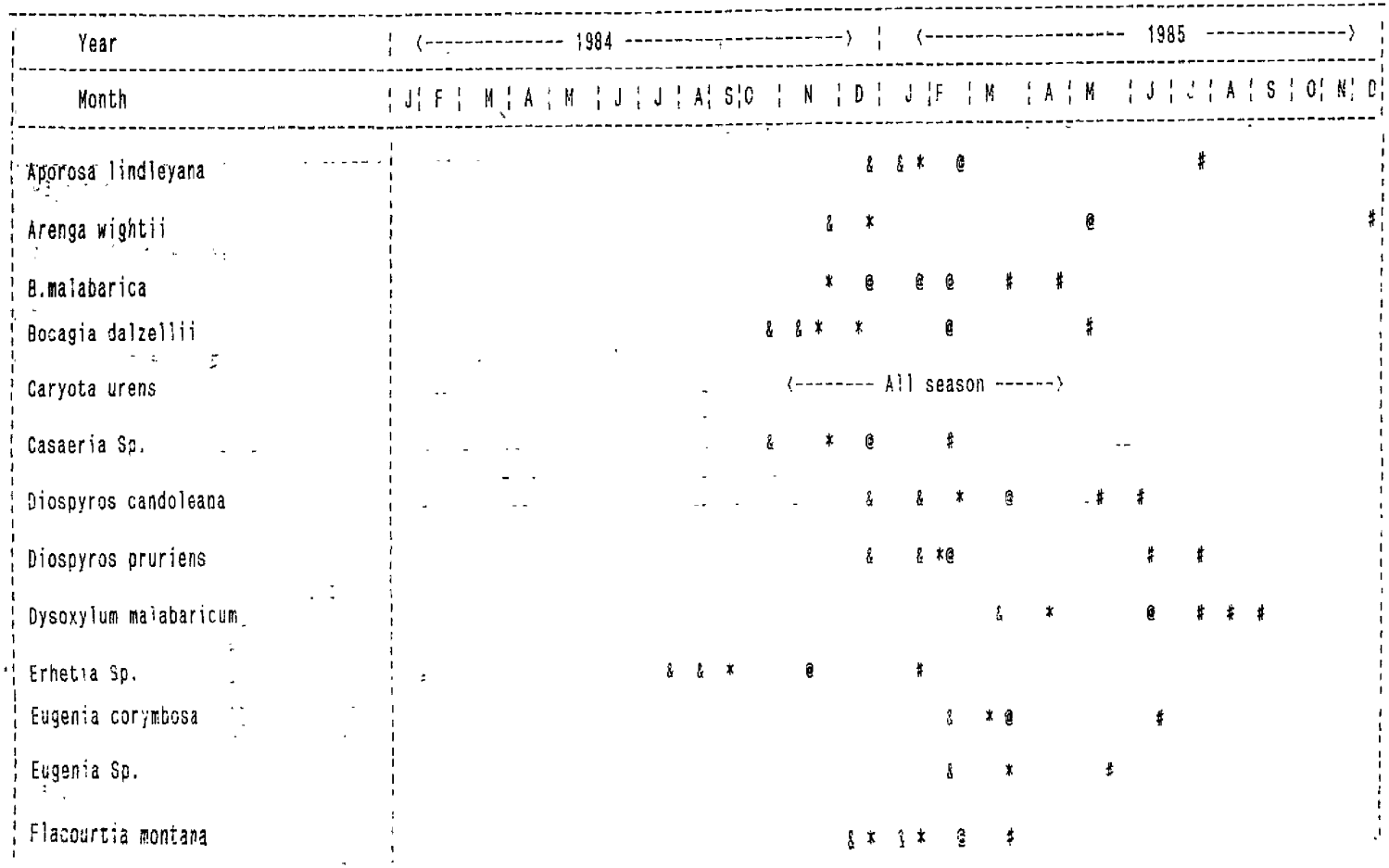
Note :

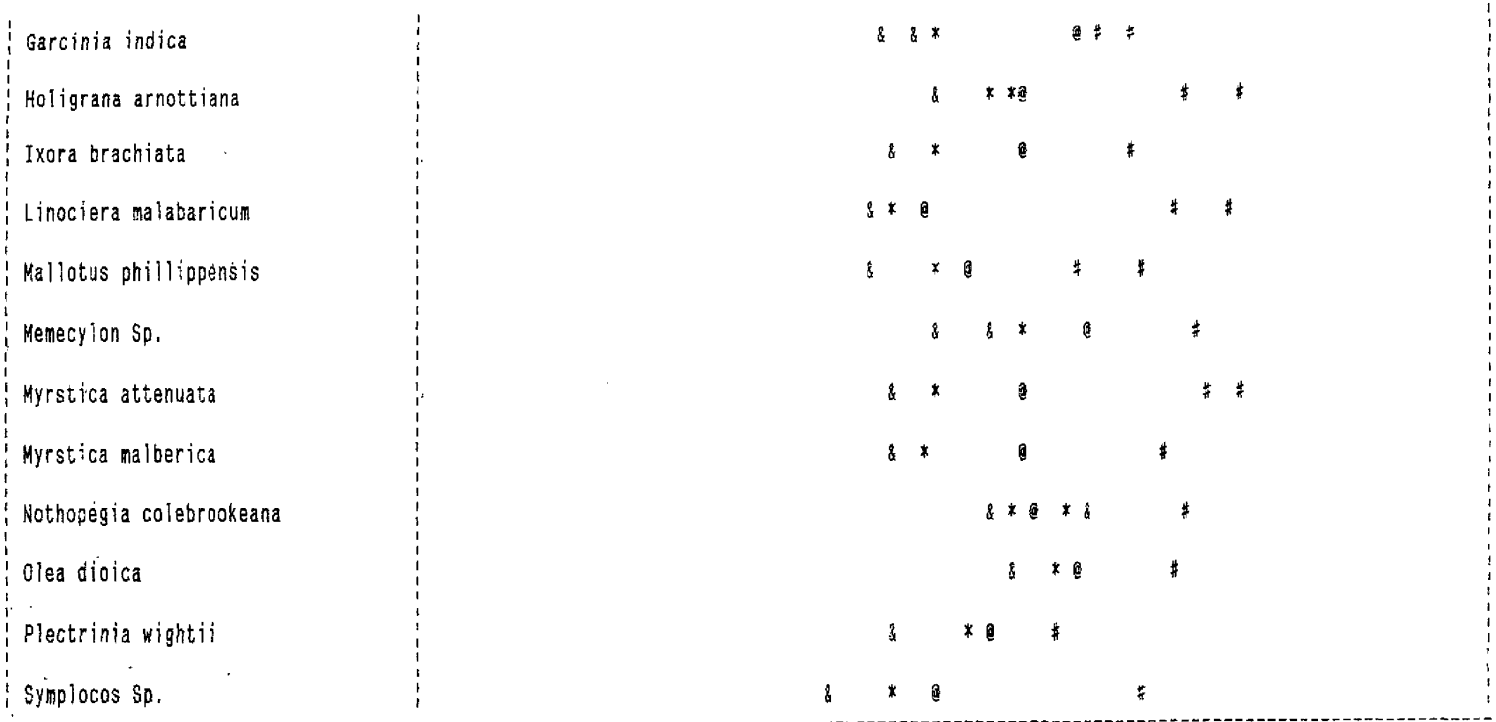
+ indicates emergence of leaves
$,, abscission of leaves
& ,, production of young flowers
* ,, anthesis of flowers
@ ,, production of young fruits
# ,, ripening of fruits

Year	1984												1985											
Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
UNDERSTOREY SPECIES																								
EVERGREEN SPECIES																								
Actinodaphne hookeri										&	&	* @					#							
Aglaia Sp.											&	* @				#	#							
	Summer season			Rainy season			Winter season						Summer season				Rainy season				Winter season			
	Dry period			Wet period			Dry period										Wet period				Dry period			

(Contd.)

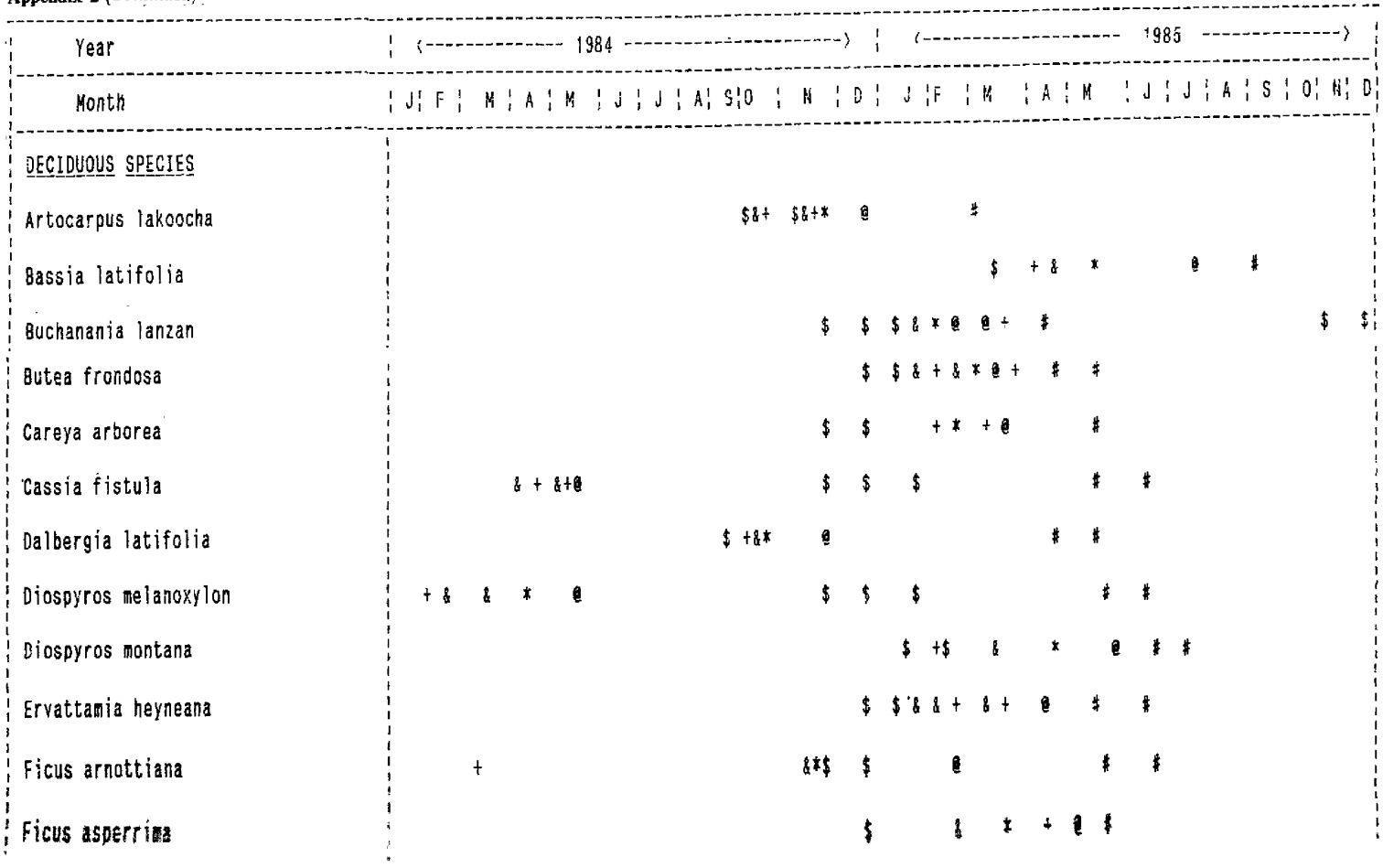
Appendix 2 (*Continued*)

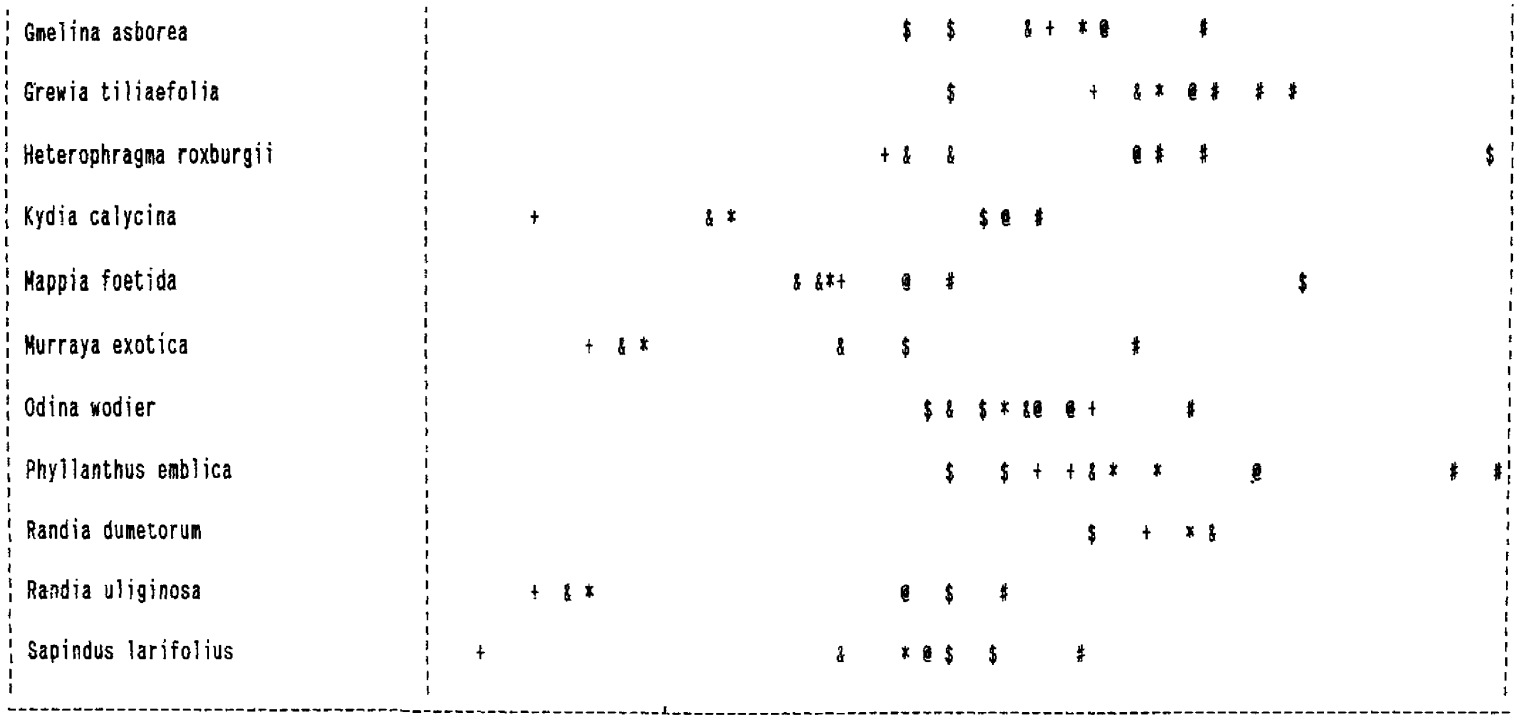



Garcinia indica
Holigrana arnottiana
Ixora brachiata
Linociera malabaricum
Mallotus phillippensis
Memecylon Sp.
Myrstica attenuata
Myrstica malberica
Nothopegia colebrookeana
Olea dioica
Plectrinia wightii
Symplocos Sp.
Summer season
Rainy season
Winter season
Summer season
Rainy season
Winter season
Dry period
Wet period
Dry period
Wet period
Dry period

(Contd.)

Appendix 2 (*Continued*)

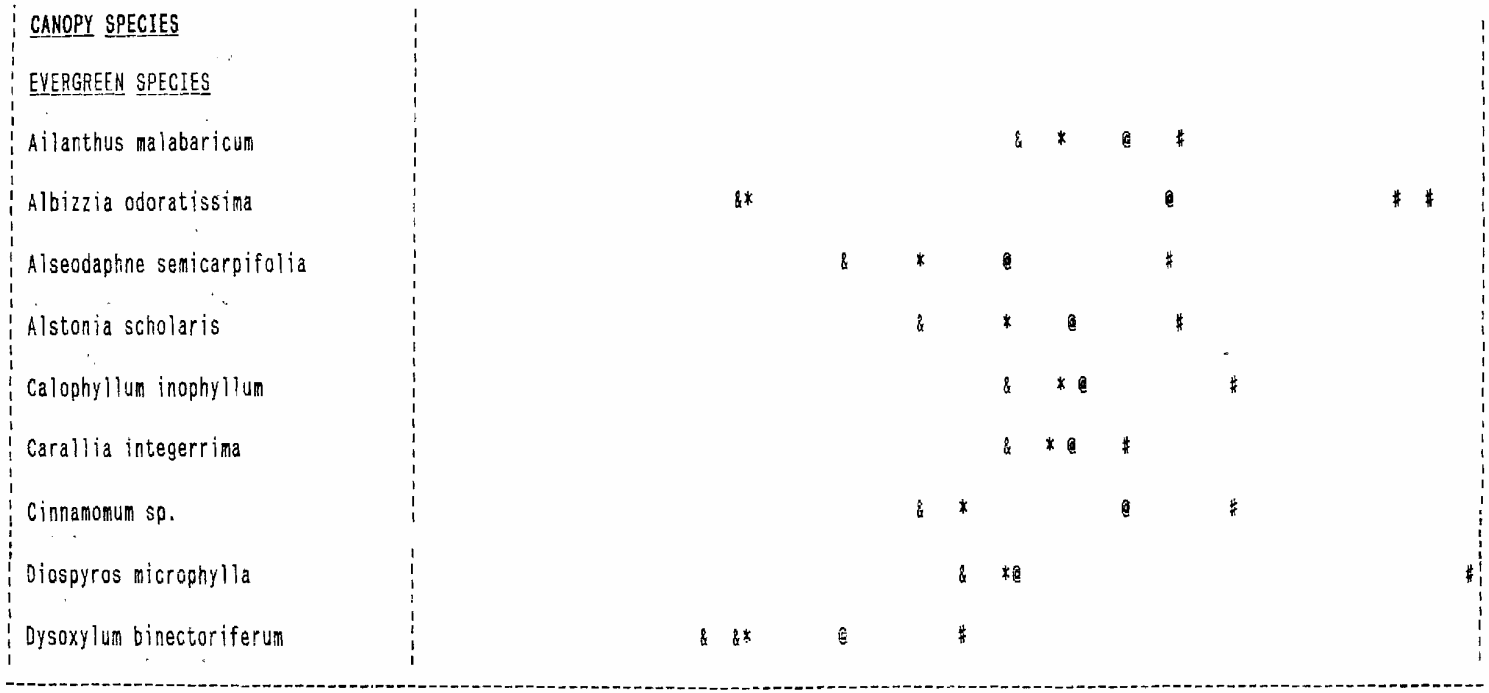



Gmelina asborea
Grewia tiliaefolia
Heterophragma roxburgii
Kydia calycina
Mappia foetida
Murraya exotica
Odina wodier
Phyllanthus emblica
Randia dumetorum
Randia uliginosa
Sapindus larifolius
Summer season
Rainy season
Winter season
Summer season
Rainy season
Winter season
Dry period
Wet period
Dry period
Wet period
Dry period

(Contd.)

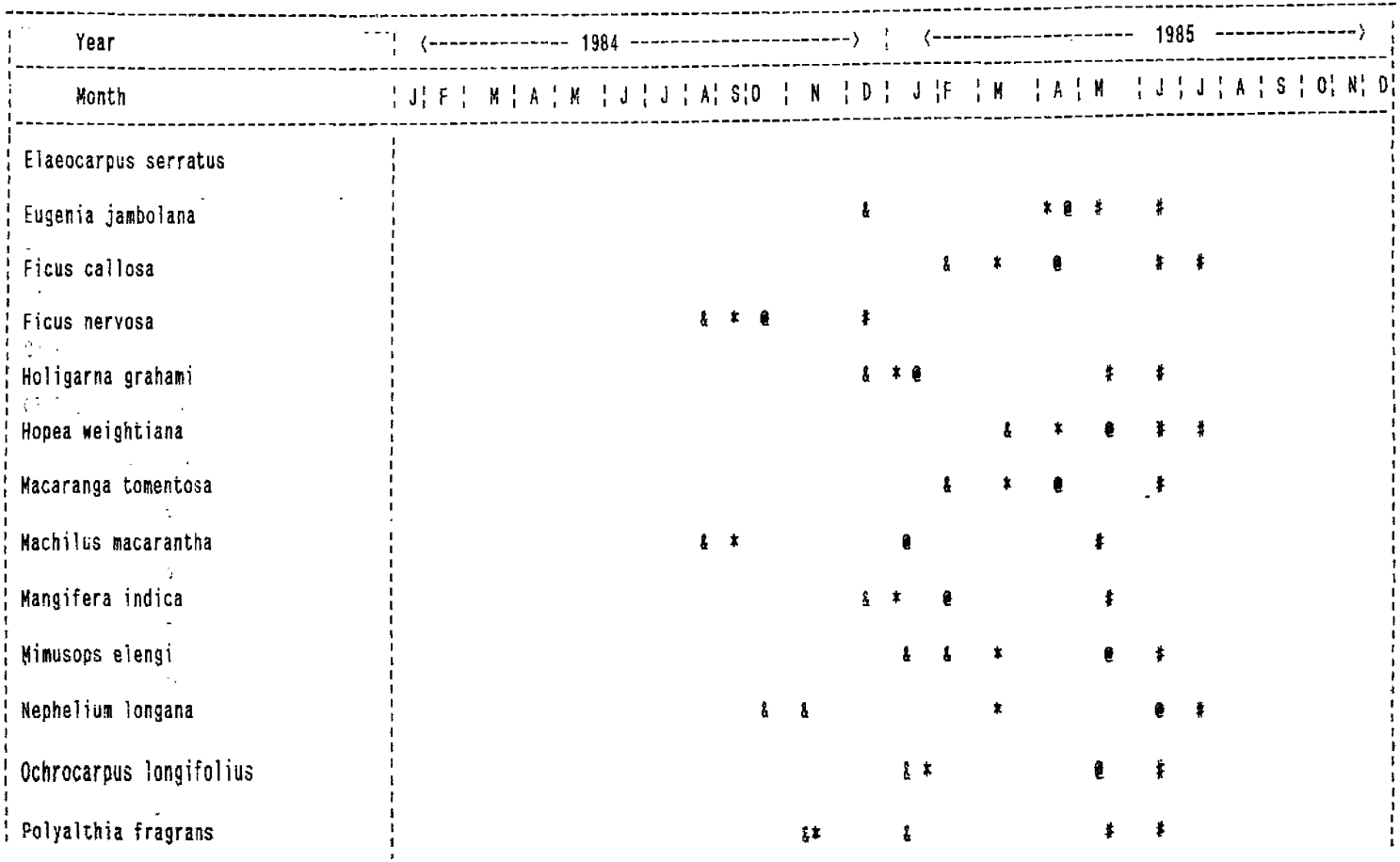
Appendix 2 (*Continued*)

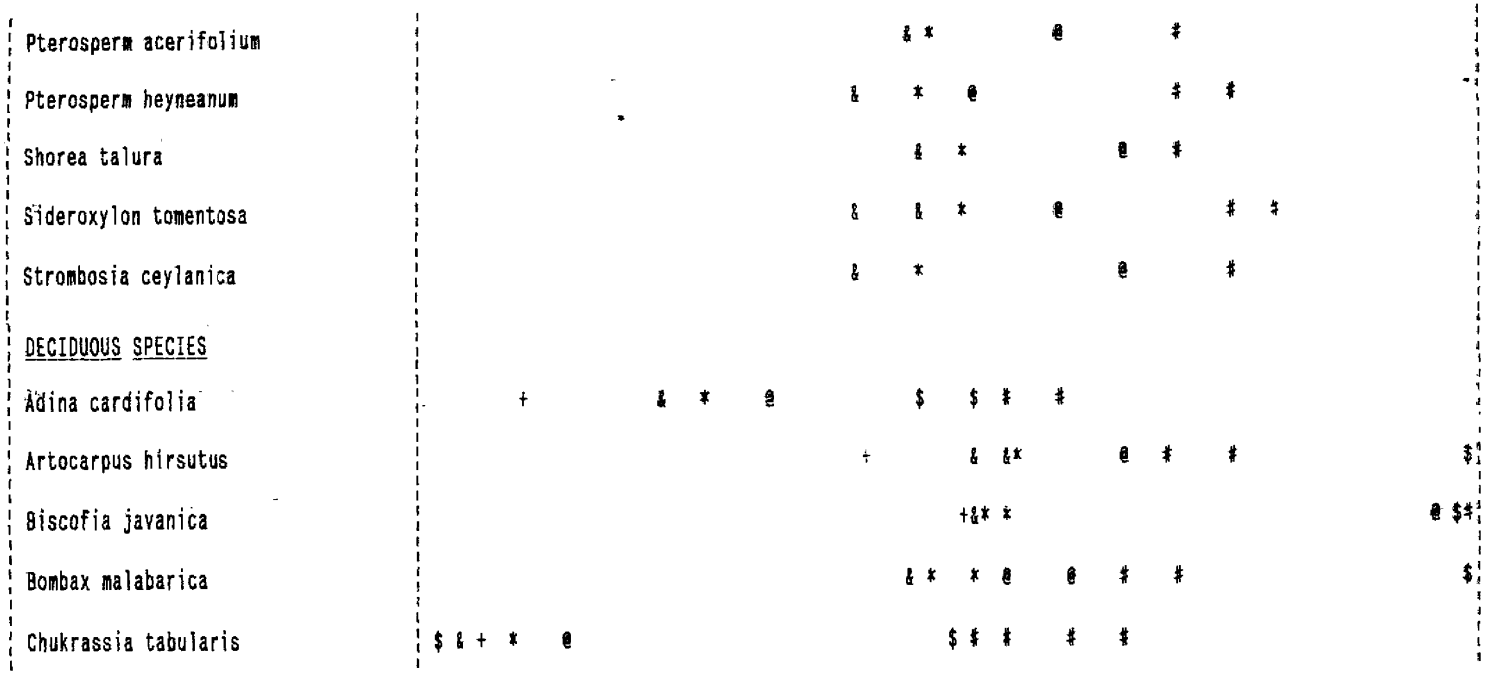
Year	1984												1985											
Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Sapium insigne											$	$	&	*	@		+	#		+	#			
Schleichera trijuga															$		+	&	*	@	#		#	
Spondias accuminata											$		$	&	+		&	+		x+@			#	
Sterculia Sp.														$	&	$	&		+		*	@	#	
Terminalia chebula											$		$					&*+		+	&	*	@		
Vitex altissima															$		+		&	*		@		#
Wrightia tomentosa																$			&	+	*	@	#	
Xylia xylocarpa		+	&	*	@						#	$	#	$										
Zanthoxylum rhetsa						+	+	&	*	@	$	$	#											
Ziziphus xylopyra		+	&	*						@			#	#		$								


CANOPY SPECIES
EVERGREEN SPECIES
Ailanthus malabaricum
Albizzia odoratissima
Alseodaphne semicarpifolia
Alstonia scholaris
Calophyllum inophyllum
Carallia integerrima
Cinnamomum sp.
Diospyros microphylla
Dysoxylum binectoriferum
Summer season
Rainy season
Winter season
Summer season
Rainy season
Winter season
Dry period
Wet period
Dry period
Wet period
Dry period

(Contd.)

Appendix 2. (*Continued*)




Pterosperm acerifolium
Pterosperm heyneanum
Shorea talura
Sideroxylon tomentosa
Strombosia ceylanica
DECIDUOUS SPECIES
Adina cardifolia
Artocarpus hirsutus
Biscofia javanica
Bombax malabarica
Chukrassia tabularis
Summer season
Rainy season
Winter season
Summer season
Rainy season
Winter season
Dry period
Wet period
Dry period
Wet period
Dry period

(Contd.)

Appendix 2. (*Continued*)

Year	⟨---------- 1984 ----------⟩												⟨---------- 1985 ----------⟩											
Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Dalbergia paniculata													$	+&*			@						#	#
Dillenia pentagyna													$	$&	*		@ +	+ #						
Ficus infectoria										⟨--------- Several times ----------⟩														
Lagerstroemia lanceolata		& +	*	@								#		$#	#									
Mitragyna parviflora			+	+	&	×		@					$ #	#										
Pterocarus marsupium	+									&	*@	$		#										
Strychnos nuxromia		+ &	*	@									#	$#										
Terminalia alata	&	*	+	@							$	$ #	#	#										
Terminalia bellerica		+	* &				@				$	$ #	#											
Terminalia paniculata	+							& &*	*	$		$	$ # #											

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