

PHENOLOGY OF SELECTED WOODY SPECIES FOUND IN KEBBI STATE NORTH-WESTERN PART OF NIGERIA

DHARMENDRA SINGH* and AMINA ABUBAKAR

Department of Biological Sciences, Kebbi State University of Science and Technology Aliero, Nigeria.

ABSTRACT : Phenological observations were taken for 16 woody species for three years (2009-2011) in the Kebbi State, North-Western part of Nigeria, Flora of Tropical Africa. Kebbi State is located at approximate latitudes 10° N and 30° N and longitudes 3° E and 6° E. It is situated in the North Western part of the Nigeria and is bordered by the Niger and Benin Republics Countries in the North and West, while on the East and South, surrounded by Sokoto and Niger States respectively. Kebbi State has a total land area of approximately 37,698 sq. km. The phenological behavior of most of the woody species was almost similar in different years; however, drought conditions affected the various phenophases of several species. Leaf-fall in majority of woody species began in December with a peak in January and February. Leaf initiation began in February with a peak in March and April before pre-monsoon showers. Flowering activity in these species continued throughout the year with two peaks; one in March and April and second in July and August. Although the peak of fruit maturation for these species was observed in September and October, the dehiscence of fruits was completed before pre-monsoon showers in April.

Key words : Phenology, Woody species, Flora of Kebbi State, Nigeria.

INTRODUCTION

Periodic behavior of plants in tropical environments has received much attention in recent years. Phenology is the study of relationship between climatic factors and periodic phenomena in organisms. Pattern of phenological events are variously used for characterization of vegetation type (Opler *et al.*, 1980 and Shimwell, 1972). The study of plant phenology provides knowledge about the effects of environment and selective pressures on flowering and fruiting behavior (Zhang *et al.*, 2006) suggested that climate change forced deviations in the length of growing period and competition among species may change the resource use patterns in different species. Karmer (1997) concludes that differences in phenological responses tree species to temperature changes, can have long-term consequences on their geographic distribution. He further suggests that phenology and climate relationship can also reveal the potential impacts of future climatic changes. The initiation of growth in plants and changes in phenology are governed by various environmental factors and the influence of temperature and moisture has been studied by several workers (Dewald & Steiner, 1986 and Walter, 1973). Hamann (2004) suggested that climatic factors are not directly responsible for triggering and synchronization of phenological events. Progress made in the field of phenology of tropical tree species is encouraging (Borchert, 1983; Croat, 1975; Frankie *et al.*, 1974 and Putz, 1979). In India the phenology of tree species has been studied in the subtropical forests of North-Eastern region (Boojh and Ramakrishnan, 1981) in western Himalayas (Ralhan *et al.*, 1985). However, a few attempts have been made to evaluate the phenology of tree species in the tropical dry deciduous forests (Singh and Singh, 1992). The present study was carried out over a three year period (2009-2011) to evaluate the phenology of plant species of the tropical region of Kebbi state, North-Western part of Nigeria, to understand the response of plant species to clima-

tic factors and periodicity of seasons with special reference to the effect of drought.

MATERIAL AND METHODS

Kebbi State is located at approximately latitudes 10° N and 30° N and longitudes 3° E and 6° E. It is situated in the North Western part of the Nigeria and is bordered by the Niger and Benin Republics Countries in the North and West, while on the East and South, surrounded by Sokoto and Niger States respectively. Kebbi State has a total land area of approximately 37,698 sq.km (Kebbi State Statistical Year book, 2007)

Topography : Kebbi State is dominated by massive flood plains of the in-land river valley system. Thus, it typically has a flat but undulating elevation of about 150 m in the flood plains. This increase towards the Niger river basin to about 600 m on the eastern side. The alluvial sediments in the flood plains range from gravel to clay. It is this sediment which gets saturated during the rains, to store water in the sands for dry season use. The geology of Kebbi State is characterized by thick sedimentary deposited of the Sokoto-Rima basin. Other areas in Kebbi State are under laid by Precambrian Basement Complex rocks (Kebbi State Statistical Year book, 2007)

Climatic conditions : Kebbi State enjoys a tropical type of climate, generally characterized by wet and dry seasons. The rainfall begins in April with the heaviest rainfall recorded in the months of July and August. The cold harmattan period characterized by dust laden wind prevails in November to January while the months of February and March are extremely hot. The mean annual temperature vary considerably but usually stand at 42°C. The mean annual rainfall is 500 mm (Kebbi State Statistical Year book, 2007).

Phenological observations were made on 16 woody

*Author for correspondence (email : singhdharmendra12@yahoo.com)

species of the Kebbi state tropical region. Observations were made on leaf initiation, leaf fall, flowering and fruiting of woody species at 15 day intervals from January, 2009 to December, 2011. A species was considered in a particular phenophase when more than 80% of the individuals of that species present in the quadrat were passing through that phase. However, in the case of rare species, observations were made on the basis of individuals present. The observations on phenological events were expressed as number of plant species in particular phenophase. Behavioral patterns of plant species were described following Kikim and Yadav (2001). The inter phenophase duration for dominant woody tree species were calculated following Prasad and Hegde (1986). Brief and extended activity indicates the periodicity of leaf initiation, flowering and fruiting activity by individuals of a species. Brief activity extends for 2 weeks or less while extended activity refers to periods more than 2 weeks. When 50% or more individuals of a tree species are simultaneously in the same phenophases it is referred to as "synchronous" activity (S), while showing same phenophases during distinct periods is known as "asynchronous" (A). On the basis of fruit maturation activity individuals of a species population are grouped into two categories *i.e.* rapid (r) and lengthy (L). When the fruit maturation period is of 4 months or less, it is considered as "rapid" activity and when it is more than 4 months than it is "lengthy" activity.

RESULTS AND DISCUSSION

Leaf-initiation : Leaf initiation started in February continued up to July-August with a peak in May just before the onset of monsoon. Leaf flushing was also a periodic phenomenon in all the woody species with considerable temporal variation (Table.1). Among the 16 woody species, 40% showed brief leaf-flushing activity, whereas 60% exhibited extended activity (Table.2). The observations indicated that, phenological periodicity of woody species in the Kebbi state were similar in leaf flushing, in leaf fall, in flower and in mature fruits. They

completed leaf development by July and August. There was a complete absence of leaf flushing in most of the plant species from September to January.

Leaf-fall initiation : Leaf-fall initiation was a periodic activity in all species, however, the onset of leaf fall initiation is different in various woody species (Table 2). In most plant species, leaf shedding begins in the month of October with peak in November-December. *Launea coromandelica* and *Sterculia urens* also shed their leaves with the onset of dry period from September onwards.

Flowering activity : Flowering continued in different woody species throughout the year. However, two peak periods of flowering were distinguished; the first peak in the month of February and April when *Anacardium occidentale*, *Annona squamosa*, *Azadirachta indica*, *Cassia sieberiana*, *Khaya senegalense*, *Mangifera indica* and *Tamarindus indica* exhibited flower initiation in response to increasing length of photoperiod. The second peak of flowering was observed in May and June when *Balanites aegyptica*, *Cieba pentandra*, *Delonix regia*, *D.senegalense*, *P.thonningii* and *Z.mauritiana* produced flowers. The flowering activity observed in *A.nilotica* sp. *nilotica*, *Adansonia digitata* and *Guira senegalensis* in the month of November-December.

Fruiting activity : The peak period of maturation of fruits was September-October in most of the woody species. In comparison to flowering activity, 64% woody species exhibited brief fruiting activity, whereas 36% species showed extended activity (Table.2). Out of 16 woody species, 72% showed rapid fruit maturation, whereas, 28% had lengthy process of fruit maturation.

The fruit development was shortened, whereas it was extended in *Acacia nilotica* sp. *Nilotica*, *Adansonia digitata*, *Anacardium occidentale*, *Annona squamosa*, *Azadirachta indica*, *Cieba pentandra*, *Delonix regia*, *Daterium senegalense*,

Table. 1 The leaf-initiation (Li), leaf-fall initiation (Lfi) and flower-initiation (Fli) in the woody species in 2009, 2010 and 2011 in the Kebbi state.

Species	2009			2010			2011		
	Li	Lfi	Fli	Li	Lfi	Fli	Li	Lfi	Fli
<i>Acacia nilotica</i>	May	Dec	Aug	Apr	Dec	Jul	Apr	Dec	Jul
<i>Adansonia digitata</i>	May	Dec	Sep	Apr	Dec	Aug	Apr	Dec	Aug
<i>Anacardium occidentale</i>	Mar	Nov	Mar	Apr	Dec	Aug	Nov	Nov	Mar
<i>Annona squamosa</i>	Feb	Jan	Feb	Feb	Jan	Feb	Feb	Jan	Feb
<i>Azadirachta indica</i>	May	Dec	Feb	Apr	Dec	Feb	Apr	Dec	Feb
<i>Balanites aegyptica</i>	Jul	Dec	Jun	Jul	Dec	Jun	Jul	Dec	Jun
<i>Cassia sieberiana</i>	Apr	Mar	Apr	Apr	Mar	Apr	Apr	Mar	Apr
<i>Cieba pentandra</i>	Feb	Dec	Jul	Feb	Dec	Jul	Apr	Mar	Apr
<i>Delonix regia</i>	Apr	Mar	May	Apr	Mar	May	Apr	Mar	May
<i>Detarium senegalense</i>	Jul	Jun	Jul	Jun	Jun	Jul	Jul	Jun	Jul
<i>Guira senegalensis</i>	Jun	Nov	Aug	Jun	Nov	Aug	Jun	Nov	Aug
<i>Khaya senegalense</i>	Feb	Dec	Mar	Feb	Dec	Mar	Feb	Dec	Mar
<i>Mangifera indica</i>	Feb	Dec	Feb	Feb	Dec	Feb	Feb	Dec	Feb
<i>Piliostigma thonningii</i>	May	Dec	Jul	Apr	Nov	Jul	Apr	Nov	Jul
<i>Tamarindus indica</i>	Feb	Jan	Mar	Feb	Jan	Mar	Feb	Jan	Mar
<i>Ziziphus mauritiana</i>	Jun	Dec	Jul	Jun	Dec	Jul	Jun	Dec	Jul

Table. 2 Phenological patterns of woody species in the Kebbi state.

Species	Behavioral patterns			
	Leaf drop	Leaf flushing	Flowering	Fruiting
<i>Acacia nilotica sp. nilotica</i>	PD	Pe	Pes	Per
<i>Adansonia digitata</i>	PD	Pe	Pes	Per
<i>Anacardium occidentale</i>	PE	Pb	Pbs	Pcr
<i>Annona squamosa</i>	PD	Pb	Pbs	Per
<i>Azadirachta indica</i>	PE	Pb	PbA	Per
<i>Balanites aegyptica</i>	PE	Pb	Pes	Pbr
<i>Cassia sieberiana</i>	PD	Pe	Pbs	PbL
<i>Ceiba pentandra</i>	PD	Pe	Pbs	PeL
<i>Delonix regia</i>	PD	Pe	Pbs	PeL
<i>Detarium senegalense</i>	PD	Pe	PbA	PcL
<i>Guira senegalensis</i>	PD	Pc	PbA	PcL
<i>Khaya senegalense</i>	PD	Pc	PcA	PbR
<i>Mangifera indica</i>	PE	Pb	PbA	Pbr
<i>Piliostigma thonningii</i>	PD	Pc	PbA	PcL
<i>Tamarindus indica</i>	PD	Pc	Pbs	Pcr
<i>Ziziphus mauritiana</i>	PD	Pb	PeA	Pbr

(P = Periodic, B = Brief periods, less than 2 weeks per episode, E = Extended periods, equal or more than 2 weeks per episode, S = Synchronous, A = Asynchronous, D = Deciduous, E = Evergreen, R = rapid fruit maturation, less than 4 months L = Lengthy fruit maturation equal to or more than 4 months).

Piliostigma thonningii, *Tamarindus indica* and *Ziziphus mauritiana*. At the community level two peak periods for fruit initiation were observed; first during the month of March and the second in the month of June. Usually the species in which fruit maturation begins during the month of March, fruit dehiscence is completed before pre monsoon period and species in which fruit maturation begins during the month of June have a lengthy period of fruit retention and their fruit dehiscence is completed before the following pre monsoon period.

The tropical dry region of Kebbi state exhibited considerable diversity in leaf initiation, leaf fall, flowering and fruiting activity. However, as per climate of the study site, peaks for all phenophases were distinguished due to defined wet and dry seasons. Leaf initiation peak in May, may be attributed to hot months of the year before rains.

Leaf Behavioral patterns in all these woody species, leaf drop, leaf flushing, flowering, fruiting towards the end of the dry season and before rains has also been observed. This may be attributed to the triggering effect of the rising temperature (Walter, 1968) and increase in length of photoperiods (Lawton & Akpan, 1968 and Njoku, 1964). Borchert *et al.* (2002) also suggested that in dry summer season, the vegetative buds of spring flushing stem of succulent species are in a state of endo-induced dormancy and terminated by declining and increasing photoperiod, respectively. The role of photoperiod has been confirmed by Rivera *et al.* (2002) who reported that spring flushing in tropical semi-deciduous trees is induced by an increase in photoperiod of 30 minutes or less. They further suggested that production of new foliage shortly before the rainy season is likely to optimize synthetic gain in tropical forests with relatively short growing season. In the present study, leaf-initiation in most species was regulated by length of photoperiod. The leaf fall was concentrated in cool and dry winter months *i.e.* from November to February.

Prasad and Hegde (1986) observed a similar pattern of leaf-fall in tropical deciduous forests in the Bandipur Tiger Reserve, South India. Borchert (1994) suggested that the leaf-fall during the dry season was directly influenced by the decline in soil moisture and increasing water stress conditions. The results are also in conformity with Singh and Singh (1992) who reported that initiation of leaf fall coincides with the onset of the post-monsoon low temperature dry period and can be a mechanism maintaining turgidity of shoots. Synchrony type of flowering was quite common in woody species of this forest. Flowering was a brief activity in 50% woody species and most of the population of these species exhibited synchronous activity. As majority of species produced flowers during leaf-less phase, which favours wind pollination as well as floral display to attract pollinators (Singh and Singh, 1992). Synchronization of flowering and leaf flushing seems to be related to moisture, temperature and day length, which is in conformity with observations made by other workers (Boojh & Ramakrishnan, 1981 and Murali & Sukumar, 1994). Thus fruit dehiscence of tree species coincides with the onset of monsoon to allow optimal germination (Frankie *et al.*, 1974; Primack, 1987; Singh & Kushwaha, 2005, 2006 and Singh & Singh, 1992). The pattern of fruiting activity maintains the availability of fruits to herbivores throughout the year.

A strong seasonality exists with respect to vegetative and reproductive phenology in tree species of tropical region of Kebbi state, Nigeria. 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 inter phenophase duration of leaf maturation.

ACKNOWLEDGMENT

The authors are gratefully acknowledged the working facilities provide by the Department of Biological Sciences, Kebbi State University of Science and Technology Aliero, Kebbi State, Nigeria.

REFERENCES

- Boojh, R. and P. S. Ramakrishnan (1981). Phenology of tree in subtropical evergreen montane forest in northeast India. *Geo-Eco-Trop.*, **5** : 189-209.
- Borchert, R. (1983). Phenology and control of flowering in tropical trees. *Biotropica*, **15** : 81-89.
- Borchert, R. (1994). Soil and stem water storage determine phenology and distribution of tropical dry forest trees. *Ecology*, **75** : 1437-1449.
- Borchert, R.; G. Rivera and W. Hagnauer (2002). Modification of vegetative phenology in a tropical semi deciduous forest by abnormal drought and rain. *Biotropica*, **34** : 27-39.
- Croat, T. B. (1975). Phenological behavior of habit and habitat classes on Barro Colorado Island (Panamacanal zone). *Biotropica*, **7** : 270-277.
- Dewald, L. E. and K. C. Steiner. (1986). Phenology, height increment and cold tolerance of *Alnus glutinosa* population in a common environment. *Silvae Genetica*, **35** : 205-211.
- Frankie, G. W.; H. G. Baker and P. A. Opler (1974). Comparative phenological studies of trees in tropical wet and dry forests in the low lands of Costa Rica. *Journal of Ecology*, **62** : 881-919.
- Hamann, A. (2004). Flowering and fruiting phenology of a Philippine submontane rain forest : Climatic factors as proximate and ultimate causes. *Journal of Ecology*, **92** : 24-31.
- Karmer, K. (1997). *Phenology and growth of European trees in relation to climate change*, pp. 39-50.
- H. Kebbi State Statistical Year Book (2007). *Research and Statistics Department, Ministry of Budget and Economic Planning Birnin Kebbi, Kebbi State, Nigeria*, p. 4.
- Kikim, A. and P. S. Yadav (2001). Phenology of tree species in subtropical forests of Manipur in North Eastern India. *Tropical Ecology*, **42** : 269-276.
- Lawton, J. R. S. and E. E. J. Akpan (1968). *Periodicity in Plumeria*. *Nature*, **218** : 384-386.
- Murali, K. S. and R. Sukumar (1994). Reproductive phenology of a tropical dry forest in Mudumala, Southern India. *Journal of Ecology*, **82** : 759-767.
- Njoku, E. (1964). Seasonal periodicity in the growth and development of some forest trees in Nigeria. II. Observations on seedlings. *Journal of Ecology*, **2** : 19-26
- Opler, P. A.; G. W. Frankie and H. G. Baker (1980). Comparative phenological studies of tree and shrubs species in tropical wet and dry forests in the lowlands of Costa Rica. *Journal of Ecology*, **68** : 167-188.
- Prasad, S. N. and M. Hedge (1986). Phenology and seasonality in the tropical deciduous forest of Bandipur, South India. *Proceedings of Indian Academy of Sciences (Plant Sciences)*, **96** : 121-133.
- Primack, R. B. (1987). Relationship among flowers, fruits and seeds. *Annual Review of Ecology and Systematics*, **18** : 409-430.
- Putz, F. E. (1979). A seasonality in Malaysian tree Phenology. *Malaysian Forester*, **42** : 1-24.
- Ralhan, P. K.; R. K. Khanna, S. P. Singh and J. S. Singh (1985). Phenological characteristics of the tree layer of Kumaun Himalayan forests. *Vegetatio*, **60** : 91-101.
- Rivera, G.; S. Elliott, L. S. Caldas, G. Nicolossi, V. T. R. Coradin and R. Borchert (2002). Increasing day length induces spring flushing of tropical dry forest trees in the absence of rain. *Trees*, **16** : 445-456.
- Shimwell, D. W. (1972). *The Description and Classification of Vegetation*. University of Washington Press, Seattle.
- Singh, J. S. and V. K. Singh (1992). Phenology of seasonally dry tropical forest. *Current Science*, **63** : 684-688.
- Singh, K. P. and C. P. Kushwaha (2005a). Emerging paradigms of tree phenology in dry tropics. *Current Science*, **89** : 964-975.
- Singh, K. P. and C. P. Kushwaha (2005b). Paradox of leaf phenology : *Shorea robusta* is a semi-evergreen species in tropical dry deciduous forest in India. *Current Science*, **88** : 1820-1824.
- Singh, K. P. and C. P. Kushwaha (2006). Diversity of flowering and fruiting phenology of trees in a tropical deciduous forest in India. *Annals of Botany*, **97** : 265-276.
- Walter, H. (1973). *Die Vegetation der Erde in Oekophysiologischer Betrachtung*. Fischer, Stuttgart, Vol. 2.
- Zhang, G.; Q. Song and D. Yang (2006). Phenology of *Ficus racemosa* in Xishuangbanna, Southwest China. *Biotropica*, **38** : 334-341.