Phenological Study of Flamboyant Tree (*Delonix regia* (Boj.)Raf.) Growing in Onitsha, Anambra State, Nigeria

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Abstract- Phenology is the study of the timing of recurring biological events in plant and animal world, especially with regard to seasonal and interannual variations in climate, as well as habitat factors. Phenological study of *Delonix regia* (Boj.) Raf. occurring in Onitsha with a tropical dry deciduous vegetation was carried out to collect information about the different phenological phases of the tree. The early to late stages of four phenophases, leafing, flowering, fruiting and ripening were observed and recorded once in every two weeks for a yearly cycle. Two-digit codes were used for inclusion of the principal growth stages and the secondary growth stages, and these defined the phenological phases observed. The results showed that changes in the prevailing seasons influenced the leafing and flowering phenology in *D. regia.* Flowering phenology started soon after the tree had resumed leafing with the early rains in the rainy season. Leafing, flowering and fruiting phenology started at different time periods and peaked synchronously. Also, the result showed that deciduousness in *D. regia* started with the onset of dry season in November and ended shortly before the rains in February. In addition, the study has provided baseline information on the phenology of *D. regia*, and this will, in the future, serve as a correlation between phenology and climate change in the area. Thus, it is suggested that functional and effective meteorological station be established in the area for integration of climatic records.

Index Terms- Phenology, Delonix regia, seasons and climate

I. INTRODUCTION

Plants tend to possess definite recurring growth and developmental phases in any given environment over time. The entire developmental cycles of plants occur as rhythmic events. This phenomenon is termed phenology. Phenology is an aspect of science that deals with the study of the timing of recurrent biological events in plant and animal world, the causes of their timing with regard to biotic and abiotic factors, and the interrelations among phases of the same or different species (Snell, 1955; Lieth, 1974). Phenological events include, among others, the dates of emergence of leaves and flowers, the dates of leaf colouring and fall in deciduous trees, dates of egg-laying of birds and amphibians, or the timing of the developmental cycle of temperate-zone honey bee colonies. In ecology, the term is used more generally to indicate the time frame of any seasonal biological phenomena, including the dates of last appearance (e.g., the seasonal phenology of a species may be from April through September (Singh and Kushwaha, 2006).

The task of plant phenology is to observe and record the periodically recurring growth stages and to study the regularities and dependency of the yearly cycles of development on environmental conditions. Individual (genes, age) and environmental factors (weather and climate conditions in the micro- and macro- scales, soil conditions, water supply, diseases, competition, e.t.c.) influence plants. They can be viewed as the integrative measurement devices for the environment. The seasonal cycle of plants, however, is influenced to a great extent by temperature, photoperiod and precipitation (Sarvas, 1974; Morellato and Haddad, 2000; Keathy and Fletcher, 2003).

In particular, spring development in the mid-latitudes depends especially on temperature, in the tropics and sub-tropics rainfall regime is predominant (Morellato and Haddad, 2000). Studies of multiple species show differences among species in the extent of the phenological change. Many phenological series recorded have shown significant advances and delays in the flowering and leafing phenology (Menzel, 2000). These variations are influenced to a great extent by temperature changes and precipitation (Keathy and Fletcher, 2003). Seasonal duration of leafing, flowering and fruiting maturity determine phenological behaviour in tropical trees.

In view of the prolonged drought in the dry tropics, the predominant tree species are expected to be deciduous, showing early dry season leaf fall, leaf-flushing after the first rains, and the onset of the reproductive phase (flowering) in the early dry period following cessation of rains. The tropical dry forests harbour several phenological functional types showing widely varying leafless periods and rates of resource use during vegetative growth which increases with deciduousness (Kushwaha and Singh, 2005).

The actual timing of phenological events can be of importance for issues in tourism and recreation, giving information on events that potentially can interest people; biodiversity and ecology, assessing the impacts of mismatch of timing of phenological events on species interactions and community patterns; and education, involving students and the public in scientific research by a cost-effective and easy-to-observe method. The information on characteristics of the current year (especially early to late year) may increase the public awareness and may act as a motivation for people to actively observe natural processes and their seasonal chronologies (Vliet *et al.*, 2003). Determination of the sequence in the seasonal appearance of phenophases in *D. regia* in a yearly cycle and the establishment of baseline information on the phenology of *Delonix regia* found in Onitsha are the specific objectives of this study.

II. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Onitsha, Anambra State, Nigeria. Onitsha is in a tropical region with dry deciduous vegetation and experiences two seasons, rainy season (March-October) with temperature ranges from 23.9^0 C to about 31.2^0 C and dry season (November-February) where temperature can reach 33.9^0 C. Onitsha is an urban area with patches of trees mainly ornamental trees and is located in the south-eastern Nigeria between latitude $6^0$10' 0'' N and longitude $6^0$47'0'' E. Onitsha urban covers a land area of 36.19 km^2. The average daily minimum and maximum temperatures of Onitsha is 26^0 C and 33^0 C respectively, with mean annual rainfall of 1886.88 mm (Ifeka and Akinbobola, 2015).

2.2 Data Collection

The extended BBCH-scale of Meier (1997) based on Zadoks *et al.* (1974) was used for data collection. Here, all the phases from the species under study were grouped in one line following their natural development. Four principal growths (leafing, flowering, fruiting and fruit ripening) were used for the study. They were denoted with the ordinal numbers 1, 6, 7 and 8 as they appear in the (10) chronologically arranged principal growth stages of plants according to Meier (1997). The principal growth stages range from 0 to 9. The secondary growth stages were introduced to define the short developmental stages in the principal growth. They were also coded with numbers ranging from 0 to 9, where 0 denoted the beginning and 9 the end in the principal growth stage. The values 1, 2, 3, 4, 5, 6, 7, 8 that are intermediate between 0 and 9 denoted the percentile values (10%, 20&, 30%, 40%, 50%, 60%, 70%, 80%) of the secondary growth stages respectively.

Thus, the combination of the principal growth stages and the secondary growth stages provided the 2-digit codes, BBCHXY, which denoted the phenophases appearance. ''X'' denoted the principal growth while ''Y'' denoted the secondary growth. Estimations of changes in the phenophases were made by visual observation, which exploited colour changes for fruit ripening, the numbers of flower buds that opened as in flowering, the numbers of fruits and developing leaves. Since light and visibility exert an influence on the sensitiveness for colour of the human eye, the researcher ensured uniform condition by taking the observations at 1:00 pm when the sun was high and behind the observer. Observations were made once every 2 weeks for a yearly cycle between March 2013 and February, 2014.

III. RESULTS

The results of the phenological study of *Delonix regia* are presented in the table below:

Table 1: The Observed Phenophases of *Delonix regia* (Boj.) Raf.

DURATION (Month) (Week)	March		April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.	
	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th	1st – 2nd	3rd – 4th
Principal Growth Stages																								
Leafing	*BBCH 10	BBCH 11	BBCH 13	BBCH 14	BBCH 15	BBCH 16	BBCH 17	*	BBCH 18	BBCH 19	*	*	*	*	*	*	BBCH 91	*	BBCH 92	BBCH 94	BBCH 95	BBCH 96	*	BBCH 97
Flowering	*	BBCH 60	BBCH 61	BBCH 63	BBCH 64	BBCH 65	BBCH 66	BBCH 67	BBCH 68	BBCH 69	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Fruiting	*	*	*	*	BBCH 70	BBCH 72	BBCH 75	BBCH 77	BBCH 78	BBCH 79	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Fruit Ripening	*	*	*	*	*	*	*	*	*	*	*	*	BBCH 81	BBCH 86	BBCH 89	*	*	*	*	*	*	*	*	*	*
	Phenological Phases																								

Note: The asterisks (*) in the table denote the absence of observed phenophases

RESULTS

Table 1 above shows the time frames of phenophases occurrence in the yearly cycle of development in *Delonix regia*. Leafing phenology started 1st to 2nd week of March, 2013 and by the 3rd to 4th week of March, 10% had developed (Table 1). Thirty per cent developed in the 1st to 2nd week of April; 40% in the 3rd to 4th week of April and 50% of the leaves developed in the 1st to 2nd week of May. Leafing ended in the 4th week of July (Table 1). Leaf fall began in the 1st to 2nd week of November with 10% leaf fall. By the 1st to 2nd week of December, 20% of the leaves had fallen. Half of the entire leaves fell in 1st to 2nd week of December, whereas 70% fell in the 3rd to 4th week of January, 2014. These show that *D. regia* is deciduous.

Flowering phenology started with bud formation in the 3rd to 4th week of March. Ten percent of the buds opened in the 1st to 2nd week of April, and by the 3rd to 4th week of April, 30% of the flowers had opened. Forty percent of the flowers opened in the 1st to 2nd week of May and by 3rd to 4th week of May, 50% had opened. Flowering phenology ended by the 4th week of July (Table 1).

Fruiting phenology started in May, and by the 3rd to 4th week of May, 20% of fruits had developed (Table 1). Fifty percent developed in the 1st to 2nd week of June and 70% in the 3rd to 4th week of June. Fruiting ended in the 3rd to 4th week of July.

Fruit ripening started in the 1st to 2nd week of September when 10% of the fruits ripened. Sixty per cent was ripened in the 3rd to 4th week of September and ripening ended in the 1st to 2nd week of October (Table 1).

In the extent of life span in development, leafing started in March and peaked in July, covering a period of approximately 5 months. Flowering started immediately after new foliage began to emerge in April and peaked in July, covering a period of approximately 4 months. Fruiting started in May and peaked in the 4th week of July, covering a period of approximately 3 months. Fruit ripening started in September and peaked in 2nd week of October, covering a period of approximately 1 month and 2 weeks (Table 1).

IV. DISCUSSION

The study clearly outlined the phenological activities of *Delonix regia* in a yearly cycle. The results show that the flowering comes shortly after the tree has resumed foliage growth after a period of approximately four months of deciduousness. This agrees with the analysis of the proximate controls of flowering in tropical deciduous forest species by River *et al.* (2002) as they concluded that the timing of vegetative phenology strongly determines the flowering period, and thus flowering at least depends indirectly on environmental periodicity. This shows that flowering depends on the leaf development. This is accentuated by van Schaik *et al*. (1993) as they opined that phenological events are not mutually independent in woody species and flowering may be partly or wholly dependent on leafing activity.

Luna (1996) observed that *D. regia* in India remained leafless from March to May and the new leaves appeared at the end of the hot season in May or June. This, however, does not agree with the present study as leafing resumed in March after prolonged period of dryness, which started in November and ended in February. These variations in time frames can be attributed to seasonal differences in the two study areas.

From the result, leaf development lasted approximately eight months from March to October prior the start of leaf fall. This shows that vegetative growth is favoured by the long rainy season. It is concluded here that the study area has longer growing season, thus it is expected to have a high productivity. This is corroborated by Lieth (1974) as he asserted that areas with longer growing seasons have greater average productivity than those with shorter growing seasons unless moisture or another limiting factor intervenes. The study also revealed that *D. regia* shed its leaves progressively from January reaching its peak in February when almost 70% of the leaves had dropped. In view of the prolonged drought in the dry tropics, the predominant tree species are expected to be deciduous, showing early to late dry season leaf fall. Kushwaha and Singh (2005) also observed that the tropical dry forests harbour several phenological functional types showing widely varying leafless periods and rates of resource use during vegetative growth which increases with deciduousness

V. CONCLUSION

Phenology in *D. regia* is influenced by seasonal changes. Leaf development in *D. regia* spanned the rainy season. Leafing and flowering in *D. regia* start with the advent of rain and both occur once in a yearly cycle. Flowering phenology depends of

leaf development. Leafing, flowering and fruiting phenology of *D. regia* start at different times and peak approximately at the same time period. Difference in phenology among regions can be attributed to different climate conditions and this reflects on the difference in the prevailing environmental periodicity. This study can provide baseline information on the phenology of *D. regia*, and this will, in the future, serve as a basis for attempting a correlation between climate change and phenology in the tropics. Thus, it is suggested that functional and effective meteorological station needs to be established in the area for easy integration of climatic records.

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