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Leaf Phenology of Cassia Sieberiana L. in KSUSTA Campus of Kebbi State, Nigeria

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Abstract

The Aliero local government area is located at approximate latitudes 11^0 03' S, 12^0 47'N and longitudes 3^0 6'W and 4^0 27'E. In kebbi state, north western part of Nigeria, It also has a total area of 412 square kilometers and is bordered in the east by Tambuwal Local government area of Sokoto state in the North West by Birnin Kebbi local government area in the South West by Jega local government area. The study was carried out in Aliero local government area, Kebbi state Nigeria. Leaf exchange is crucial in the lifecycle patterns of a tree species, these also includes leaf fall, leaf emergence, leaf flush, death or senescence (leaf onset and leaf offset). The study of leaf dynamics is termed leaf Phenology. Phonological phases are reoccurring biological events that signal changes in climate, environmental conditions, and genetic factors during the developmental growth of plants. *Cassia sieberiana* L trees maintained significant foliage was recorded in March in individuals which did not become leafless.

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Introduction

Phenology is the study that measures the timing of life cycle events in all living things. (Singh.2015). Life cycle events are also known as **phenol phases**. In plants, this includes first leaf, first flower, last flower, first ripe fruit, seed dispersal, and leaf color change, among others. In animals, the phenol phases include mating, offspring production, hibernation, and migration, among others. The task of plant phenology is to observe and record the periodically reoccurring growth phase/stages and to study the regularities and dependency of the yearly cycles of development on environmental conditions.(Sharma 2010).Leaf phenology is the scientific study of leaf dynamics, including leaf emergence, leaf unfolding, leaf flushing, leaf fall, death or senescence (Singh and Abubakar, 2012). Every year, many house owners are faced with daunting task of dealing with a yard full of fallen leaves, our forest floor is littered with leaves periodically shade from the forest canopy, characteristics of deciduous trees in an attempt to check the environmental influences such as lack of soil moisture or extreme temperature conditions. Plants development and thus phenological phases show great inter-annual variability and also large spatial differences. Individual and environmental factors (weather and climate conditions in the micro and macro scales) soil conditions, water supply, competition, disease influence plants. They can be viewed as interpretative measurement devices for the environment (Singh and Abubakar, 2013). The seasonal cycles of plants, however, is influenced to the greatest extent by temperature, photoperiod, and precipitation (Morellato and Haddad, 2000; Keatly, 2000). In particular spring development in the mid-latitudes depends especially on the temperature in winter and spring, in the tropics and subtropics rainfall regimes is predominant. Thus, phenological events are indeed indicators of the impact of local and global changes in weather and climate on the earth biosphere.

There are several methods, to measure or monitor phenology, but in general they can be broken down as in-situ or in close contact with the living thing observed, or remotely, as with digital camera or earth observatory satellite. In-situ monitoring of plants has traditionally been conducted at the ground level. Whether the new information on phenology is derived from tower base web cameras, satellite data or greatly expanded networks of in-situ observation, the scientist community can use this information to learn more about the timing of life cycle events all around us. Assessing our changing world is a complex task that requires close cooperation from experts in biology, ecology, climatology, geography, oceanography, remote sensing and other areas (Singh and Abubakar, 2013).

Research Method

Study area

The Aliero local government area is located at approximate latitudes 11^0 03' S, 12^0 47'N and longitudes 3^0 6'W and 4^0 27'E. In kebbi state, the northwestern part of Nigeria, It also has a total area of 412 square kilometers and is bordered in the east by Tambuwal Local government area of Sokoto state in the North West by Birnin Kebbi local government area in the South West by

Jega local government area. The study was carried out in Aliero local government area, Kebbi state Nigeria (Singh, 2013).

Topography

Aliero local Government area 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. The alluvial sediment in the flood plains ranges from gravel level to clay level. It is this sediment which gets saturated during the rains, to store water in the sands for dry season use. The geology of Aleiro local government is characterized by thick sedimentary deposited of the Sokoto-Rima basin and it also underlaid by Precambrian Basement Complex rocks (Singh, 2013).

Climatic Condition

Aliero local government area enjoys a tropical type climatic condition, generally, characterize by wet and dry season. The rainfall begins in April with the heaviest rainfall recorded in the month of July and August. The cold harmattan periods characterized by dust-laden wind prevails in the month of November to January while the month of February and March are extremely hot. The mean annual temperature varies considerably but usually stand at $42°C$. the mean annual rainfall is 500 mm (Singh, 2013).

Method

The materials used in this study were five *C. Sieberiana* L stands within the study area. The tree stands chosen for this study were old enough to produce flowers and fruits as well as having a good foliage appearance. The choice of specimen trees, the random sampling method was applied. Five *C. Sieberiana* L tree stands were selected randomly in the study area to include stands of varying, ages having good foliage. (Singh and Aliero, 2013).

In the study site, four twigs (currently growing shoots of last order branches) on each of the four major branches (one on each direction) were marked with metal tags on five adult individuals of *C. Sieberiana* L weekly counts of leaf were made from March 2013 to February 2014 on the marked twigs. The following Phenological events were derived from the weekly leaf phenol phase. Leaf flush period of an individual is the duration (days) from the first leaf flush to the last one. Leaf fall period of an individual represents the time (duration) from the estimated first leaf fall to the last one.

Synchrony indicates for leaf flushing and leaf fall phenol phase of *C. Sieberiana* L was calculated as the ratio between the marked individual's mean duration of a phonological phase and the overall duration of the phase (Devineau, 1999).

The higher the ratio, greater the coincidence between different individual of a species (i.e at ratio 1.0 perfect synchrony will occur, and as the ratio decreases from 1.0 asynchrony will increase). Value of synchrony index was subtracted from 1.0 to get the asynchrony

Results and Analysis

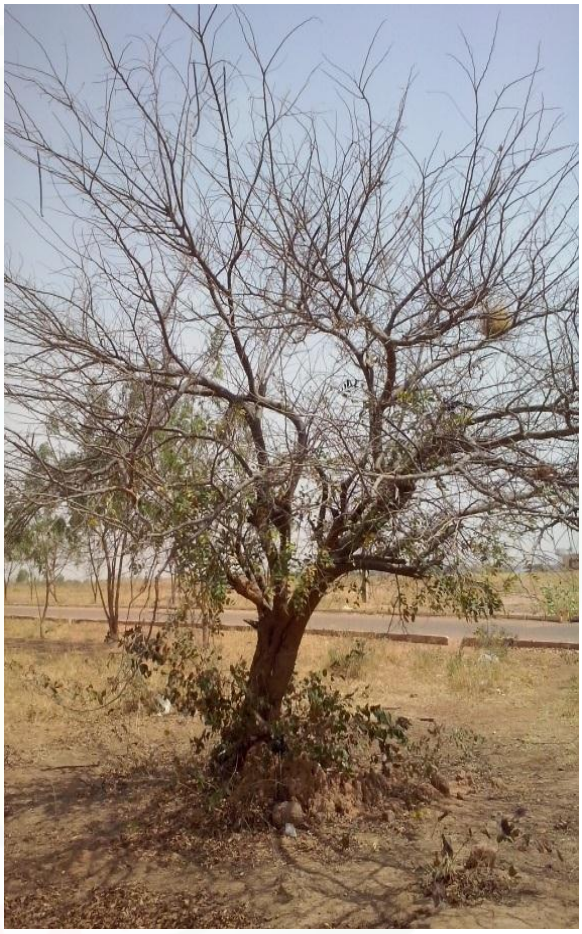
Leaf Penology

Cassia sieberiana L is a tree belonging to the family Caesalpiniaceae native to Africa. It ranges from 6-7 meters in height and has very bright yellow flowers. It is used for multiple medicinal purposes in Africa and is found in the Sudan savannah (grassland) in Northern Nigeria in Kebbi state (lloeje, 1980). The bark ranges from a dark gray to black. The lenticels are horizontal and reddish in color. The leaves are arranged in leaflets that contain 7-10 pair of opposite leaves.The upper side of the leaf is moderately shiny while the bottom has very fine nerves with stipules that are deciduous. The nature of *C. Sieberiana* L in term of leaf phenology has been questionable due to semi-evergreen versus deciduous paradox. The lifespan of leaves is important in that it reflects several ecophysiological attributes (Reich et al., 1992). For example compared to deciduous species, semi-evergreen or evergreen species generally show longer lifespan, deeper root system, earlier leaf flushing during the dry season, higher stem water potential and greater resource requirement to support leaf turnover, and longer duration of the photosynthetic

activity at lower rates (Medina, 1995; Chapin *et al*., 1996; Eamus and Prior, 2001; Borchert et al., 2002). Thus, the phonological term 'deciduous', 'semi-evergreen' and evergreen' have a different connotation in tree physiology and should be applied to a species with great care.

In tropical trees, leaf phenology is important because it reflects the influence of evolution and environment on plant characteristics, and in turn, has substantial implications for plant functioning as reported by Reich et al., (2004). Contrary to the deciduous tree species which are generally summer flushing (vegetative bud breaks in hot dry summer, May-June).*C. Sieberiana* L is also a spring equinox, (March- April) in Sudan Savannah in conspecific trees.

(a) Leaf shading



(b) Leaf shade

(c) With fruit (d) Without fruit

Picture: Different stages of *Cassia sieberiana* L

Justification of Research

The occurrence of the annual leaf exchange in *C. Sieberiana* L. in hot, drier Sudan savannah, in Aliero local Government Area raises several questions. Whether this species is deciduous, semi-deciduous or semi-evergreen? Why does leaf exchange occur always during the mid-dry season? Whether conspecific trees show a similar phonological response? There is a need to precisely document the various phonological events (like leaf flush and leaf fall) in this species and to quantify the extent of the leafless period if any in conspecific trees.

Results

C. sieberiana L trees maintained significant foliage (reflect by leaf number) well beyond the rainy season. Seasonal reduction in foliage occurred during the period January – April, and minimum foliage was recorded in February in individuals which did not become leafless. New leaf formation began during the mid – dry season (March - April) and greater than 75% of total new leaves were produced during hot – dry summer, before the onset of the rainy season (June). Leaf flushing, however, continued until September – October (following the rainy season). Two phonological variants of *C. Sieberiana* L were distinguished on the basis of contrasting leaf phonological events during March. During this month: (i) 60% individuals of (located at the low land the university campus) showed completion of leaf fall and beginning of leaf flush in March variant (A), (ii) 40% individuals (located at university campus site) showed a time gap between completion of leaf fall and initial of production on the new leaves, leaf fall phase was completed but the process of production of new leaves did not set in by the end of March variant (B) it is

interesting to note in the annual cycle the entire population of *C. sieberiana* L never become leafless, only about two – fifth individuals (variant b), situated in relatively dry and shallow soil, become leafless for a short period in march. (1). Conspecific trees of *C. sieberiana*L growing in the same environment showed different phenological patterns with respect to leaving. In contrast to the long duration of leaf flush (January - March), leaf fall duration (November - January) was much shorter. Thus, concentrated fall of leaves of varying longevity occurred during the mid – dry season, resulting in turnover of the total foliage annually. Shedding of old leaves was either accompanied or followed by leaf flush around spring equinox (January - March). In both variants, leaf fall started in January during the annual cycle. Completion of leaf fall invariant (A) (60% individual) in April. Leaf flush was relatively more synchronous in the conspecific trees (indicated by lower asynchrony) index (Table 1) compared to the leaf fall phonological event during the annual cycle. The synchronization was collected using the following formula, (xi = ∑ ij /N-I fi) where ∑ ij is the sum of a number of months in which individual i &j exhibited a particular phenol phase and N = is the total number of individual in the sample. The synchrony index of species Z is calculated by the arithmetic mean of Xi as follows. Z = ∑ Xi / N.

Table 1.
Diversity in seasonal duration of leafing, phenol phase in two phonological variants of C.sieberiana.in tropical dry grass-land (Sudan savannah)

C. sieberiana	N	D	J	F	M	A	M	J	J
Variant A Leaf flushing	0.02	0.03	0.01	0.02	0.02	0.03	0.02	0.03	0.01
Variant B Leaf fall	0.03	0.04	0.02	0.02	0.3	0.4	0.3	O.01	0.02

Table 2.
Asynchrony index for leaf phenological events in *C.sieberiana* L in grassland (Sudan Savannah)

S/N	Phenological event	Annual cycle
1	Leaf flushing	0.19
2	Leaf fall	0.24

Discussion

Phenology of trees in the dry tropics is mainly determined by the duration and intensity of seasonal drought. The degree of drought to which the trees are exposed varies widely, depending on temperature and availability of soil water, and also tree characteristics such as rooting depth.

C. sieberiana L changes foliage in the middle of the dry season around the spring equinox, contrasting with the co-existing deciduous tree species producing new leaves after varying leafless periods during the dry – hot summer(January - March), shortly before the beginning of rainy season. While evergreen species generally show leaf flush in the mid-dry season, the deciduous species leaf out just before or with the onset of the rainy season (Medina et al., 1995). In view of its spring leaf flushing, predominant leaf exchange and substantial re-establishment of foliage during the hottest and driest period of the year (March - May), *C. sieberiana* L cannot be designated as a deciduous species. The occurrence of leaf flushing in *C. Sieberiana* L during the mid dry period of the annual cycle reflects its ability, like many evergreen species, to quickly rehydrate the stem during the dry season. Leaf fall and a high water potential of twigs are prerequisites leafing (Borchert et al., 2002). Leaf exchanging species (like *C. Sieberiana* L are restricted to relatively moist sites and maintain a high water potential during the dry season (Rivera et al., 2002). *C. Sieberiana* L show deep root system, enabling access to sub-soil water. Detection of two leaf phonological variants in *C. Sieberiana* L in my study shows considerable functional diversity among conspecific trees. Individuals of *C. sieberiana* L. respond variously (leaf exchange or ever-greenness to leaflessness or deciduousness, but less than or equal to one

(≤ 1) year leaf life spam) to micro-site conditions, making it essentially a semi-evergreen species. In drier microsites, short leaflessness imposed on few individuals may be due to longer stem rehydration duration and consequently delayed flushing. Semi-evergreen species are hardly ever without green leaves, and if so for a relatively short period.

Conclusion

Annual leaf exchange in *C. Sieberiana* L seems to be a survival strategy during the period of drought. It replaces all old leaves of different longevity with new leaves to reduce water loss due to transpiration. In deep rooted *C. sieberiana*, L. leaf flushing probably depends on prior leaf fall and the availability of sub-soil water reserves, both promoting water status of the trees. *C. Sieberiana* L shows opportunistic leaf phonological nature, its individuals being able to tolerate (evergreen) or ovoid (deciduous) drought depending upon micro-site conditions; most of the individuals tolerate drought, but few (about two-fifth) avoid a drought for a short period. The occurrence of two phonological variants indicates that semi-green *C. Sieberiana* L can leaf out whenever trees or branches have become fully hydrated i.e their opportunistic phenology is mainly determined by seasonal variation in tree water status at a given micro-site. Based on qualitative visual observation, *C. Sieberiana* L does not become leafless on the micro-site, but on dry site, most of the individuals become leafless for a week or so in April. However, in moist of university campus in Aliero, *C. Sieberiana* L is a dominant semi-evergreen species with concentrated early summer leaf fall and simultaneous leafing. I suggest that wide leaf phonological response in *C. Sieberiana* L is a semi – evergreen nature helps in its extensive distribution in the hot drier semi – arid zone, from the moist sites (lowland to dry sites (upland) university campus). Functionally, *C. Sieberiana* L is a semi – evergreen tree species in the presently studied dry Sudan savannah in a university campus in Aliero, and semi- ever-greenness might be indicators of its high adaptability.

Plants can increase their plasticity through phenological asynchrony among individuals. In the present research project study, conspecific asynchrony for leaf flush and leaf fall phonological events varied. Variation in the date of onset of rainy season and the amount and distribution of rainfall during the annual cycle may affect factors regulating the soil – plant – atmosphere water continuum. In dry environments, heterogeneity and periodicity of water availability have been demonstrated as being crucial factors in phonological rhythms of tree populations. Within species asynchrony in tree phenology is guided by differences in water availability and hence tree water status is likely to cause the observed variation in *C. Sieberiana* L phenology. Conspecific asynchrony in phonological behavior is also a functional attribute to species dominance over a range of micro-environmental conditions. Soil water status to substantially modulate the reproductive phase as well as leaf shedding in semi-evergreen species. Intra – species asynchrony at the time of flowering induced by drought-induced leaf shedding varies in a landscape with differences in soil storage.

The presence of semi-evergreen winter flowering *C. Sieberiana* L in the semi-arid region indicates the presence of micro-sites with reliable, large sub-soil water reserves, from which deep-rooted trees can extract water during the dry season.

There is increasing evidence that global climate change is affecting species physiology, distribution, and phenology. Phenology displayed at present in Sudan savannah trees will shift towards savannah of lesser or greater moisture balance, in roughly direct proportion to the way in which any global change element changes the balance. In Nigeria and indeed in Kebbi state, the decline in rainfall may severely affect trees species like *C. Sieberiana* L which show critical phonological events (leaf exchange and flowering) at the end of harmattan. Even a moderate decline in annual rainfall in combination with increasing evapotranspiration resulting from predicted increase in temperature may deplete soil water reserves, thereby further marginalizing the distribution of the semi-evergreen *C. Sieberiana* L in the grassland (Sudan savannah) region.

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