

Full Length Research Paper

Management of indigenous medicinal plants in Nigeria using phenological information

Oni, P. I.¹, Jimoh, S. O.² and Adebisi, L. A.²

¹Department of Biological Sciences, Bells University of Technology, P.M.B 1015, Ota, Ogun State, Nigeria.

²Department of Forest Resources Management, University of Ibadan, Oyo State, Nigeria.

Received 18 June, 2013; Accepted 28 March, 2014

Available information on medicinal plants indicates habitat loss and has heightened the need for more proactive conservation strategies. Conservation efforts in this direction resulted in an eco-pharmacological survey in the West African sub-region by three countries (Nigeria, Ghana and Republic of Benin) to assess frequently used medicinal plants. The result of the socio-economic study based on utilization pattern regionally was used to produce a list of ten topmost frequently used and mentioned medicinal plants regionally and was subsequently adopted for the eco-pharmacological study in Nigeria. The list was super-imposed on a vegetation map of Nigeria for study sites selection in the species range. Selection criteria were based on the presence of at least one or more members of the medicinal plants in each location. Subsequently these plants were monitored range-wide for phenological behaviors for two seasons (dry and raining seasons) for two consecutive years. Findings indicated that the ten medicinal plants belonged to nine taxonomic families and are represented in the three plant habits. Flowering was majorly a dry season event (November to February) extending to early rains (March to April) in the species of the southern range (lowland and derived ecozones). Fruiting was typical of early rains increasing northwards (March to July). For short duration flowering species (*Pcynanthus angolensis*, *Alstonea bonnie* and *Rauvolfia vomitoria*), fruiting occurred late in dry season (December to February). Mean flowering duration ranged between (9.45 ± 1.73 to 45.68 ± 4.77) days, while mean fruiting duration ranged between (15.22 ± 2.15 to 145.87 ± 8.59) days. Phenological charts were used to depict the phenological trends for the different species. The provision of this information offers a useful tool-kit for medicinal plants genetic resources monitoring, management and appropriate conservation strategies in Nigeria.

Key words: Indigenous medicinal plants, eco-pharmacological survey, phenology, conservation.

INTRODUCTION

African wealth of biological resources and plant genetic resources in particular is a critical element in alleviating

poverty, ensuring food security and developing new medicines (Van Wyke, 2008). In addition, they possess

*Corresponding author. E-mail: petidowu2000@yahoo.co.uk. Tel: 08067538686/08096395930.

Author(s) agree that this article remain permanently open access under the terms of the [Creative Commons Attribution License 4.0 International License](http://creativecommons.org/licenses/by/4.0/)

immeasurable socio-cultural values and significance (Gillespie et al., 2004). Mgeni (1991) opined that with the unique diversity of plant and animal life, tropical rain forest represents biological renewable resources of food, medicine and fuel if well managed. Within the natural forests in Nigeria abound several valuable non-timber resources of edible and highly nutritive plants whose fruits, leaves, stems, twigs, barks and roots are of high medicinal values (Ugbogu and Odewo, 2004; Oni, 2010). Medicinal plants no doubt, will continue to play significant roles in both rural and peri-urban health care services as evident in the number of herbal practitioners in Nigeria today (pers. com). It had also enjoyed steady and popularity without any religious or ethnic barriers as evident in the number of modern alternative practitioners in many big cities of Nigeria (World Health Organization (WHO), 2001).

They are also important for pharmacological research and drug development either as direct therapeutic agents or as sources of templates for the synthesis of drugs (Farnsworth et al., 1985). According to World Health Organization (2004), despite all advances made in orthodox medicine, traditional medicine will continue to gain renewed interest in health care services of Nigerians. This may be attributable to increased awareness in the potential and curative ability of these alternative medicines and in particular the various shortcomings revealed for several synthetic drugs (Ugbogu and Odewo, 2004). According to Gbile and Adesina (1986), herbs usually serve as the repository materials and have been acknowledged to be generally safe with minimum side effects. The potential of the Nigerian flora as a veritable source for pharmaceutical and other therapeutic materials have been emphasized (Gbile and Adesina, 1986; Anselm-Adodo, 2004). The dwindling economic fortunes, political instability and high cost of orthodox medicines have also forced many people to exploit various plant species for their health service (Odebiyi and Ogunjobi, 2003).

However despite these potentials, many of these valuable plant species are fast disappearing and the current rate of genetic erosion through loss of species, varieties and habitat considered as alarming, has heightened the need to adopt more proactive steps in the conservation and use of these imperative resources (Bada and Popoola, 2005; Food and Agricultural Organization (FAO), 2005). Most of these losses had been traced to rapid rate of natural forest conversion to mono species plantations, commercial agriculture and other economic activities (Olajide, 2003; Owonubi and Otegbeye, 2004; Bada and Popoola, 2005). A major challenge in natural forest resources management in Nigeria is the continuous decline in stock over the years (Ajakaiye, 2001). Muul (1993) indicated that many of the old folks who possess knowledge and information on the

use and conservation of most of these medicinal plants are gradually dying without adequate documentation of their knowledge.

Unlike several tropical timber species and multipurpose tree species (Oni and Fagbenro, 2000) which had received significant domestication research attention, there is dearth of information on several aspects of medicinal plants including their reproductive biology. According to Van Wkye (2008), typically, studies on medicinal plants have focused on the bioactivity of its chemical macronutrients, ethnobotany, pharmacology and taxonomy while information on reproductive biology activities remains scanty in literatures. Perhaps this accounts for why many of them still remain in the wild state. The general opinion especially among collectors is that there will also be enough in the wild; unfortunately the trend is changing. Recent ecological survey indicated various threats (natural and anthropogenic forces) leading to low species biodiversity and poor natural regeneration. In recent times there had been an upward surge in medicinal plants exploitation without corresponding domestication efforts.

Developing appropriate conservation and silvicultural programme for these categories of plants required an initial adequate base line data on their flowering and fruiting behaviors across their range to assist adequate germplasm collections and *ex situ* conservation programme. In Nigeria, onset of flowering in *Parkia biglobosa* and *Vitellaria paradoxa* increased in a south-north direction (Hall et al., 1996). The present study therefore attempts to provide additional information in this regard for future germplasm collection programme, silvicultural studies and *ex situ* conservation strategies for the selected medical plants.

MATERIALS AND METHOD

The study involved three West African countries namely; Nigeria, Ghana and Republic of Benin. At the onset of the study, an initial socio-economic study was carried out by the three collaborating countries to identify frequently used medicinal plants species in the region. After the survey, the data were analyzed using simple descriptive statistics of frequency distribution and the ten most frequently mentioned across the three countries were harmonized and adopted for use in the phenological study and was subsequently used to develop a common protocol of study (Table 1). In Nigeria, the adopted and working list of medicinal plants were reconciled with locations where previous socio-economic survey data were collected and on that basis, the various locations were plotted on a vegetation map of Nigeria to produce a distribution map for the ten selected medicinal plants.

The different medicinal plants coincided with different agro-ecological/vegetation zones of Nigeria (Lowland Rainforest zone, Derived savanna, Guinea savanna and Sudan savanna) as shown in Figure 1. As a way of providing insight into distinct climatic differences among the various agro-ecological zones, a summary of their main physical features and climatic variables were as summarized in Table 2.

Table 1. The ten selected medicinal plants investigated for phenological behaviors in Nigeria.

S/No	Medicinal plants investigated in the study
1	<i>Alstonea bonnie</i>
2	<i>Khaya senegalensis</i>
3	<i>Kigelia Africana</i>
4	<i>Morinda lucida</i>
5	<i>Pycnathus angolensis</i>
6	<i>Rauvolfia vomitoria</i>
7	<i>Securidaca longpenduculata</i>
8	<i>Tamarindus indica</i>
9	<i>Vitellaria paradoxa</i>
10	<i>Zanthoxylum xanthoxyloides</i>

Source: Socio-economic survey (2009).

Table 2. The bio-physical characteristics of the selected study sites in relation to their agro-ecological zones in Nigeria.

Agro-ecological zone	Study site	Latitude (°N)	Longitude (°E)	Altitude (m)	Annual rainfall (mm)	Rainfall pattern
Lowland rain forest	Benin	6 19'	5 41'	120	1440	Bi-modal
	Ekpoma	7 23'	3 56'	120	1450	
	Ibadan	6 20'	5 40'	264	1340	
	Ido/Eruwa axis	7 23	3 54'	264	1340	
Derived savannah	Eruwa	7 35'	3 25'	264	1340	Bi-modal
	Olokemeji	7 35'	3 25'	200	1222	
	Igana-Okeho axis	7 50'	3 55'	102	1040	
	Saki axis	8 41'	3 23	106	1040	
Guinea savannah	Ibilo	7 50'	6 07'	52	1180	Mono-modal
	Okene-Kabba axis	7 49'	6 44'	41	1184	
	Lokoja axis	7 44	8 35'	114	1280	
	Makurdi axis	7 26'	6 04'	120	1180	
Sudan savannah	Kano	12 05'	8 35'	172	886	Mono-modal
	Taraba	8 38'	11 08'	168	920	

Description of the different ecological zones for the study in Nigeria

The Lowland rainforest is located south of the derived savannah. It constitutes a belt varying in width between 50 to 250 km, located inland from the coast and lies below latitude 8°N to the southwest (Figure 1). It corresponds to areas where rainfall generally exceeds 1,300 mm. Humidity is generally high and there is a long wet season lasting from 8 to 10 months. The zone supports high forest vegetation and only about 2% of the zone is estimated to be undisturbed forest. The Derived savanna which is the next ecological zone is a transitional forest-savannah mosaic occurring north of the lowland rain-forest belt, extending from 8° 30'N in the

West to 6° 40'N in the East. It covers an area of approximately 75,707 km² (about 8% of the country), of which constituted forest reserves, covers only 3208 km² (3.34%) of the total area of forest reserves in the country (Figure 1). The Guinea savannah zone covers a land area of about 459,033 km² and is located within latitudes 9 and 12°N of Nigeria. This zone represents Nigeria's broadest vegetation zone constituting approximately one half of the country's total land area. The Sudan savanna zone includes areas that lie above latitude 10°N of the country and is characterized by arid and semi arid conditions. The natural vegetation of the zone has been modified over most of the area by several centuries of human activities, including intensive cultivation, livestock grazing, annual fires and desert encroachment.

Table 3. The ten selected medicinal plants investigated for phenological behavior in Nigeria.

S/No	Selected medicinal plants Taxonomy	Family	Habit
1	<i>Alstonea bonnie</i> De Willd	Apocynaceae	Tree
2	<i>Khaya senegalensis</i> (Desr) A. Juss	Meliaceae	Tree
3	<i>Kigelia africana</i> (Lam.)Benth.	Bignoniaceae	Shrub
4	<i>Morinda lucida</i> Benth.	Rubiaceae	Shrub
5	<i>Pycnathus angolensis</i> (Welw.)Warb.	Myristicaceae	Tree
6	<i>Rauvolfia vomitoria</i> Afzel.	Apocynaceae	Shrub
7	<i>Securidaca longpenduculata</i> Fresen.	Polygalaceae	Herb
8	<i>Tamarindus indica</i> L.	Fabaceae	Tree
9	<i>Vitellaria paradoxa</i> C.F Gaertn.	Sapotaceae	Tree
10	<i>Zanthoxylum xanthoxyloides</i> (Lam.)Zep & Timler	Rutaceae	Tree

Protocol of work for the eco-phenological survey and data collection procedure

In addition to the initial distribution map developed for the medicinal plants, a review of literature was carried out to further obtain additional information on the natural distribution of the ten selected medicinal plants. Results obtained were used to upgrade the medicinal plants distribution map across the different ecological zones. The distribution map was therefore used as guide for the field work. At the onset of the field work, each of the four ecological zone selected was divided into two main sampling sites in east-west directions and study sites selection were based on adequate representation of the different medicinal plant species in each location on ecozone basis. The final sampling sites selection was based on the presence of at least one or more of these medicinal plants in each site. Thereafter, field observations periods were stratified into dry and raining seasons (November to March and April to October, respectively) as typical of climatic conditions in Nigeria. At each sampling site, individual medicinal plant species encountered was assessed for their reproductive biology status (phenology) during each season for the following reproductive characters: (i) onset of flowering, (ii) duration of floral buds opening, (iii) development of flowers to fruits and (iv) fruit maturation duration. These observations were carried out over a two year period for the different medicinal plants. Data collected were subjected to analysis of variance and the means separated by least significant difference (LSD) for each phenological parameter. The observed trends for the flowering and fruiting periods for each medicinal plant species investigated were subsequently depicted using phenological charts for seasonal variations description. The different medicinal plants were also classified into their taxonomic families as well as plant habits. Findings for the various activities were as reported in the result section.

RESULTS AND DISCUSSION

Distribution of the ten selected medicinal plants by taxonomic family and habit

The present study indicated that the ten different medicinal plants belonged to nine taxonomic families and only two members (*Alstonea bonnie* and *Rauvolfia vomitoria*) belonged to the same taxonomic family

(Apocynaceae) (Table 3). The different medicinal plants were also represented in the three major plant habits (Trees, shrub and herbs) (Table 3). The plant habits distribution indicated that six of the medicinal plants are trees, three were shrubs and only one (*Securidaca longpenduculata*) belonged to herb habitat (Table 3). The fewer number of plants belonging to the same taxonomic family may be explained based on their utility selection criterion rather than their natural co-existence which made the present findings different from the work of Ugbogu and Akinyemi (2004) who studied the ethnobotany and conservation of Ribako strict natural reserve in Northern Nigeria.

Flowering behaviors among the different medicinal plants in Nigeria

Generally, flowering behaviors varied greatly among the ten different medicinal plants investigated perhaps due to their taxa differences. Majority of them were observed flowering during the early to late dry season (November to February) in Nigeria and continues till early rains (March to April) especially for the lowland and derived ecozones species (*P. angolenses*, *Morinda lucida*, *Rauvolfia vomitoria* and *A. bonnie*). For typical savannah species (*Vitellaria paradoxa*, *Khaya senegalensis* and *Tamarindus indica*), flowering were observed during the months of May to July coinciding with late dry season to early rains in those agro-ecological zones and this process increased northwards in the species range. Two of the medicinal plant species (*M. lucida* and *R. vomitoria*) demonstrated broad ecological amplitude being conspicuously found in Lowland rainforest and Derived savanna zones. They were observed flowering in the late dry season (January to February) in the lowland rain forest zone (Ibadan) and in the late raining season (September to October) in its Derived savanna range (Eruwa and Saki axis).

Table 4. Mean duration of flowering to fruit for the selected ten different medicinal plants in Nigeria.

S/No	Species	Mean no of days to flowering (days)±sd	Mean Fruit set period (days)±sd
1	<i>Alstonea bonnie</i>	9.45±0.35	15.22±1.15
2	<i>Kigelia qfricana</i>	12.7±0.31	43.56±2.0.26
3	<i>Khaya senegalensis</i>	8.42±0.33	34.39±1.18
4	<i>Morinda lucida</i>	17.25±1.72	27.58±2.26
5	<i>Pycnathus angolenses</i>	27.34±2.35	21.44±1.28
6	<i>Rauvolfia vomitoria</i>	15.68±1.55	25.36±3.22
7	<i>Tamarindus indica</i>	14.25±0.78	31.45±2.37
8	<i>S. longipedunculata</i>	8.35±0.38	15.95±1.51
9	<i>Vitellaria paradoxa</i>	45.68±3.77	145.87±7.86
10	<i>Z. xanthoxyloides</i>	16.68±2.15	18.52±0.43

Onset of flowering for most of the medicinal plants tends to vary with latitude in a south-north direction. Onset of flowering for the same species varies by about 2 to 4 weeks interval in a south-north direction across the species range. Hopkins (1983) observed that within a given species population, two periods of flowering may occur, each lasting 3 to 4 weeks with good synchrony between trees. Pettet (1977) observed that onset of flowering within a distance of 80 km apart (Zaria to Kaduna) in Nigeria varied by seven days and it was suggested that it may be photo-periodically controlled and presumably modified by other environmental factors (Hopkins, 1983; Fatubarin, 1987). In Ghana, Hall et al. (1996) observed similar trend in *V. paradoxa*. *K. senegalensis* was observed flowering between November to February across its range in derived savanna zone in Nigeria (Makurdi and Okene). El-Amin (1990) observed similar trends in the species in Sudan.

In similar studies in Burkina Faso, *K. senegalensis* was observed flowering in November to December while in Guinea (November to February), Sudan (February to March) and (August to December) in Cote' Ivoire (Coalition for National Science Funding (CNSF), 2003). Flowering behaviours in relation to the geographical locations of these countries also agreed with the present findings. For many of the medicinal plants, new flush (emergence of young leaves) tends to be associated with onset of flowering in many locations where data were collected. This is in agreement with the work of Abbiw (1990) and (CNSF, 2003) on *A. bonnie*, *M. lucida* and *R. vomitoria* which are typical lowland rainforest species were observed to have extended to derived savanna agro-ecological zones as a result of climate change and anthropogenic activities and onset of flowerings were found to be closely associated with new flushes. *T. indica*, a savanna species, found in the northern limit of rainforest zone was observed flowering in January to March (Eruwa-Olokemeji axis). However, for the typical

savannah medicinal plants (*V. paradoxa*, *K. senegalensis*, *T. indica* and *Z. xanthoxyloides*), flowering was majorly a late dry season event (November to January) in their derived savanna range but extending northwards of the Guinea and Sudan savanna range. This observation was in agreement with the work of Hall et al. (1996) on *V. paradoxa* and *K. senegalensis* (CNSF, 2003). However, *S. longipedunculata* typical of the derived savannah ecozone (Eruwa and Okeho-Saki) axis had two flowering periods (February to April) and (June to July) though the second flowering period and was heavier perhaps due increase soil moisture, as this period coincided with the rainfall peak. Instances of two flowering periods for indigenous tree species had been indicated in Nigeria by Ladipo et al. (1990).

Duration of flowering period also varied greatly among the different species ranging between 8.35 ± 1.18 days in *S. longipedunculata* to 45.68 ± 4.77 days in *V. paradoxa*. Flowering in *P. angolenses* was very short and rather inconsistent and could not be determined accurately apart from the fact that most of the trees were extremely too tall to allow for effective flowering behaviors monitoring. In the species typical locations, corresponding to the lowland rainforest zone (Auchi and Ibadan), flowering was already over by February when the trees were examined, however two individual trees observed within the University of Ibadan campus showed evidence of flowering in late October to November. This finding tends to agree with the report of Abbiw (1990) in Ghana. Table 4 summarized the mean flowering and fruiting durations for the ten different medicinal plants investigated in Nigeria.

Fruiting behaviours for the selected ten medicinal plants in Nigeria

Fruiting behaviors among the different medicinal plants

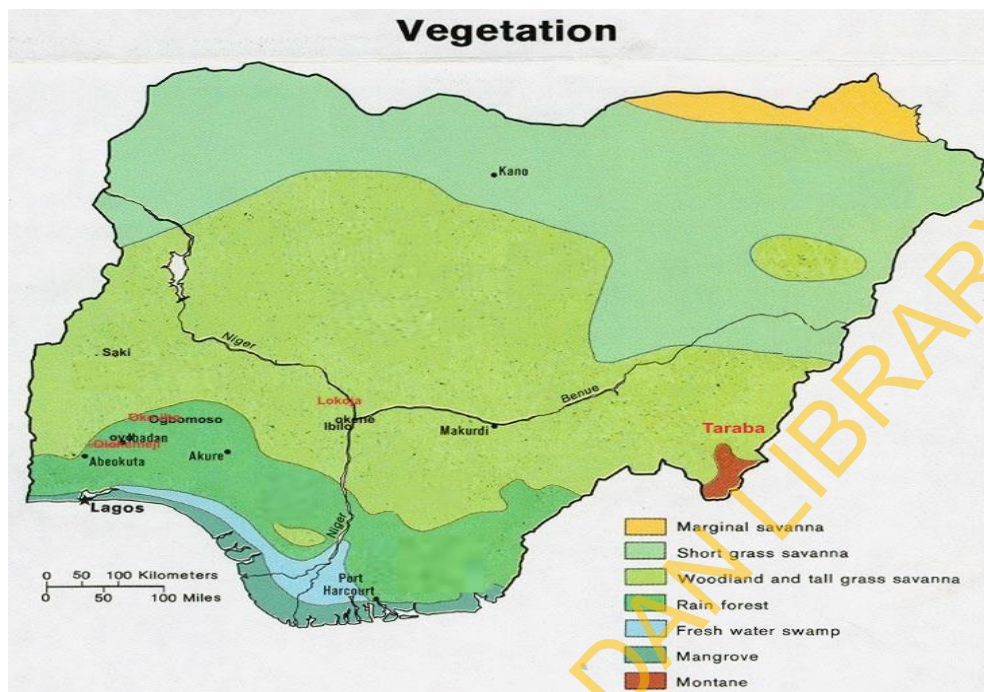


Figure 1. Vegetation map of Nigeria showing the sampling sites.

Source of flowering information	Flowering records in relation to months in Nigeria												Co-ordinates of the location		
	J	F	M	A	M	J	J	A	S	O	N	D			
Eruwa axis															7° 24' N 3° 29' E
Benin axis															6° 19' N 5° 41' E
Saki axis															8°39'N 3° 25'E

Figure 2. Flowering information of *S. longipedunculata* in Nigeria in relation to periods of the year across the various ecological zones.

tend to follow similar pattern like the flowering; though some degrees of overlaps were observed in some of the species. In several locations within the range of *M. lucida* and *R. vomitoria*, flowering and fruiting were observed simultaneously in the early rains (March to April). For instance, along Igana-Okeho axis (Derived savanna), fruiting was observed in March in *R. vomitoria*. Similar reports had been indicated for these species in some tropical West African countries (Burkill, 1985). Onset of flowering to fruit set duration also differs greatly for the individual medicinal plants investigated (Table 3). It ranged between (15.22 ± 1.15) days in *A. bonnie* to (145.87 ± 6.89) days in *V. paradoxa* (Table 3). The varying duration observed tends to be influenced both by varying climatic factors as well as the differences in the tree species.

Similar observations had been indicated by Fatuabrin (1987) in Nigeria. *K. africana* was observed in fruits between (February to March) in Ibillo (Figure 4) while, *S. longipedunculata* was observed fruiting in Eruwa (June to July) both belonging to the derived savanna. This is in agreement with previous observations made for these species in selected countries in West African (FAO, 1985; El- Amin, 1990). The fruiting trends and varying patterns across the different locations also increased in a south-north direction like the flowering behaviors which further corroborated the work of Hall et al. (1996) on *V. paradoxa*. The varying durations of flowering and fruiting for the different medicinal plants were as depicted in phenological charts across the different species range to enable comprehensive seasonality variations to be clearly observed (Figures 1 to 20).

Source of flowering information	Flowering records in relation to months in Nigeria																								Coordinates of the location
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Ibadan																									07°24'N, 3°54'E
Eruwa																									7°35'N, 3° 25'E
Saki																									8° 40'N, 3° 0'E
Makurdi																									7°40' N, 8 °30'E
Lokoja																									7° 49'N 6°44'E
Benin																									6° 19' N 5° 41'E

Figure 3. Flowering information in *K. senegalensis* in relation to periods of the year across the various ecological zones in Nigeria.

Source of flowering information	Flowering records in relation to months in Nigeria																								Co-ordinates of the location
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Benin																									6° 19'N, 5° 41'E
Ibadan																									7° 24'N, 3 °54'E

Figure 4. Flowering information in *Alstonia bonnie* in Nigeria in relation to periods of the year across the various ecological zones.

Source of flowering information	Flowering records in relation to months in Nigeria																								Co-ordinates of the location
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Eruwa																									7 °44'N 3 ° 29'E
Oyo																									7° 50'N 3 ° 55'E

Figure 5. Flowering information in *Tamarindus indica* in Nigeria in relation to periods of the year across the various ecological zones.

Source of flowering information	Flowering records in relation to months in Nigeria																								Coordinates of the location
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Ologuneru road near Ibadan																									7° 23'N 3° 56'E
Unibadan campus																									7° 23'N 3° 56'E

Figure 6. Flowering information in *Pychnatus angolensi* in Nigeria in relation to periods of the year across the various ecological zones.

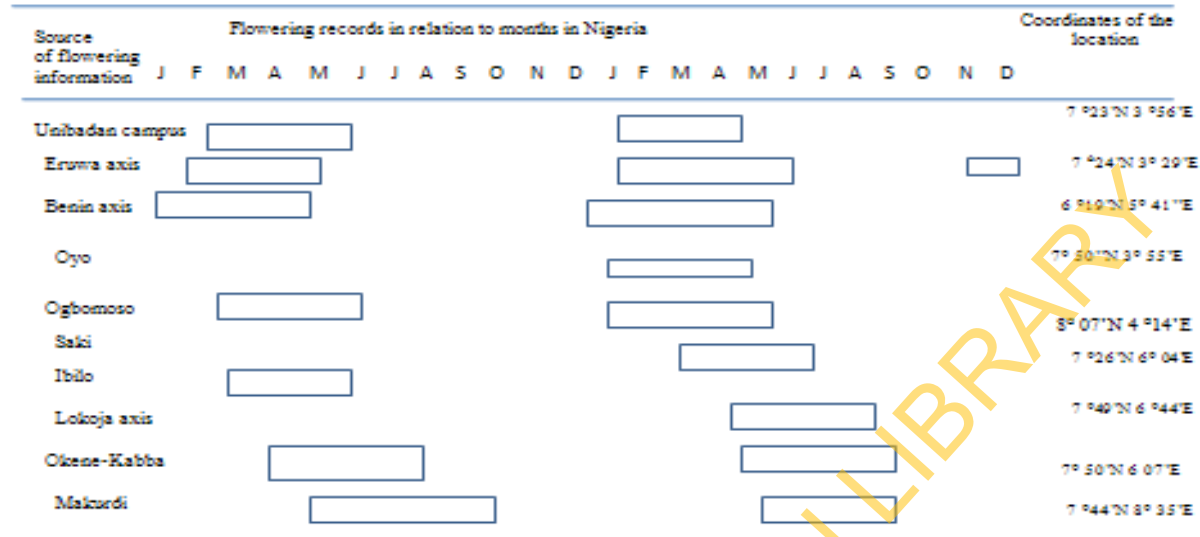


Figure 10. Flowering information in *Rauvolfia vomitoria* in Nigeria in relation to periods of the year across the various ecological zones.

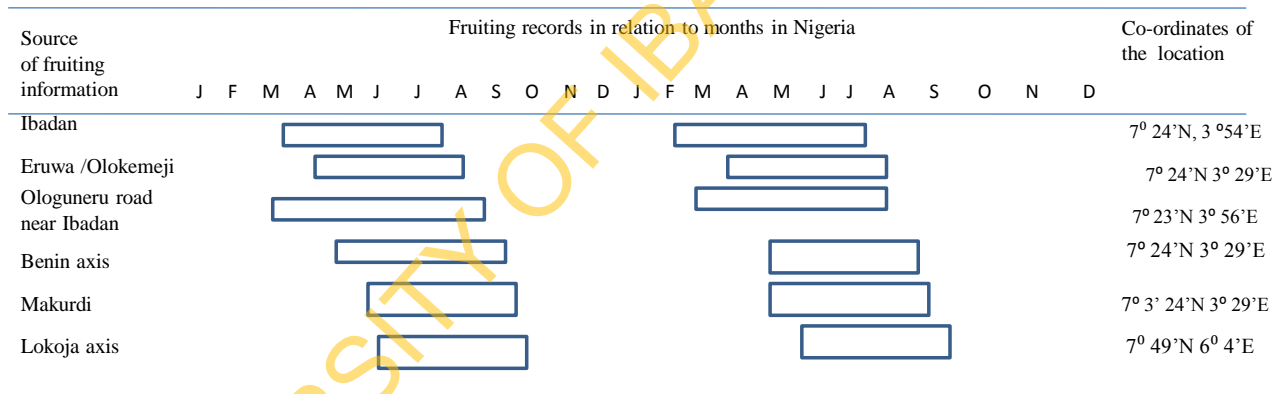


Figure 11. Fruiting information in *M. lucida* in Nigeria in relation to periods of the year across the various ecological zones.

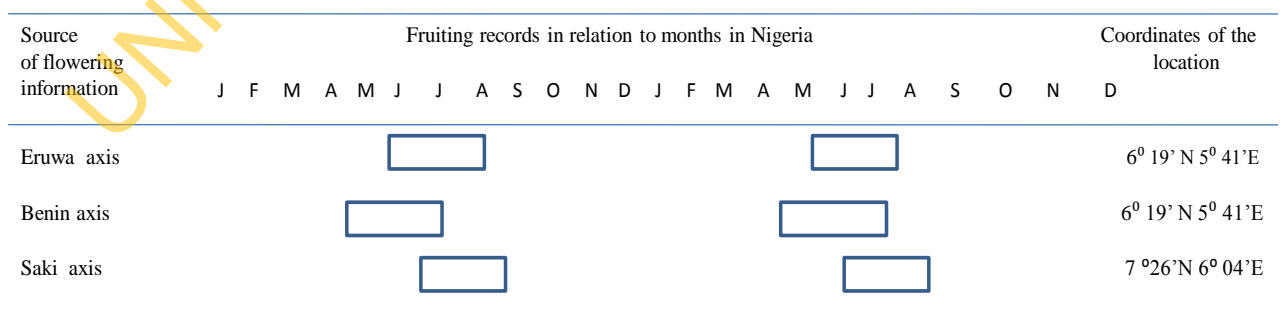


Figure 12. Fruiting information in *S. longipedunculata* in Nigeria in relation to periods of the year across the various ecological zones.

Source of fruiting information	Fruiting records in relation to months in Nigeria												Co-ordinates of the location												
	J	F	M	A	M	J	J	A	S	O	N	D		J	F	M	A	M	J	J	A	S	O	N	D
Unibadan																									7° 24'N, 3 °54'E
Ologuneru –Eruwa road																									7° 24'N, 3 °54'E
Benin axis																									6° 19'N,5° 41'E

Figure 13. Fruiting information in *Alstonia bonnei* in Nigeria in relation to periods of the year across the various ecological zones.

Source of fruiting information	Fruiting records in relation to months in Nigeria												Co-ordinates of the location												
	J	F	M	A	M	J	J	A	S	O	N	D		J	F	M	A	M	J	J	A	S	O	N	D
Eruwa																									6° 19' N 5° 41' E
Benin axis																									6° 19'N,5° 41' E
Kabba																									72°50'N 6° 07'E

Figure 14. Fruiting information in *K.africana* in Nigeria in relation to periods of the year across the various ecological zones.

Source of fruiting information	Fruiting records in relation to months in Nigeria												Co-ordinates of the location												
	J	F	M	A	M	J	J	A	S	O	N	D		J	F	M	A	M	J	J	A	S	O	N	D
Eruwa																									7 °44'N 3 ° 29'E
Oyo																									7° 50'N 3 ° 55'E

Figure 15. Fruiting information in *Tamarindus indica* in Nigeria in relation to periods of the year across the various ecological zones.

Source of fruiting information	Fruiting records in relation to months in Nigeria												Co-ordinates of the location												
	J	F	M	A	M	J	J	A	S	O	N	D		J	F	M	A	M	J	J	A	S	O	N	D
Ibadan																									07°24'N,3°54'E
Eruwa																									7 °44'N 3 ° 29'E
Saki																									8° 39'N 3° 25'E
Lokoja																									7° 49'N 6° 44'E
Makurdi																									7 °44'N 8° 35'E
Benin																									6° 19' N 5° 41'E

Figure 16. Fruiting information in *Khaya senegalensis* in Nigeria in relation to periods of the year across the various ecological zones.

Source of fruiting information	Fruiting records in relation to months in Nigeria												Co-ordinates of the location
	J	F	M	A	M	J	J	A	S	O	N	D	
Ologuneru road near Ibadan	[]												7° 23'N 3° 56'E
Unibadan campus	[]												7° 23'N 3° 56'E

Figure 17. Fruiting information in *Pychnatus angolensis* in Nigeria in relation to periods of the year across the various ecological zones.

Source of fruiting information	Fruiting records in relation to months in Nigeria												Co-ordinates of the location
	J	F	M	A	M	J	J	A	S	O	N	D	
Olokemeji	[]												7° 24'N 3° 29'E
Eruwa	[]												7° 24'N 3° 29'E
Makurdi	[]												7° 44'N 8° 35'E

Figure 18. Fruiting information in *Zhanthoxylum xanthoxyloides* in Nigeria in relation to periods of the year across the various ecological zones.

Source of fruiting information	Fruiting records in relation to months in Nigeria												Coordinates of the location
	J	F	M	A	M	J	J	A	S	O	N	D	
Eruwa	[]												7° 24'N 3° 29'E
Saki	[]												8° 39'N 3° 25'E
Makurdi	[]												7° 44'N 8° 35'E
Kabba	[]												7° 50'N 6° 07'E
Kano	[]												12° 00'N 8° 31'E

Figure 19. Fruiting information in *Vitellaria paradoxa* in Nigeria in relation to periods of the year across the various ecological zones.

Conclusion

Phenological study of this nature cutting across several medicinal plants of ethnobotanical and ethno-pharmacological importance are particularly very vital in the development of any sustainable management programme for genetic resources conservation and use of these different medicinal plants. This is particularly useful as majority of these medicinal plants still come from the wild, while domestication efforts and *ex-situ* conservation efforts still remain low range-wide. A realistic starting point in addressing this shortcoming is the availability of holistic information on the flowering and

fruiting behaviours among these medicinal plants which the current study attempts to provide. From the present study it was observed that the different medicinal plants showed great variations in their onset of flowering and fruiting which were probably due to natural variations among individuals as well as influenced by environmental factors. These two events were observed to sometimes overlap in some of the species especially in *P. angolensis*, *R. vomitoria* *M. lucida* which are typical rainforest ecosystem species. In most instances flowering was majorly a dry season event extending to early rains in some of the species in the lowland and derived savanna while coinciding with late dry season in the

Source of fruiting information	Fruiting records in relation to months in Nigeria												Coordinates of the location												
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
Unibadan campus																								7°23'N 3°56'E	
Eruwa axis																									7°24'N 3°29'E
Benin axis																									6°19'N 5°41'E
Oyo																									7°50'N 3°55'E
Ogbomoso																									8°07'N 4°14'E
Saki																									8°39'N 3°25'E
Ibilo																									7°26'N 6°04'E
Lokoja axis																									7°49'N 6°44'E
Okene-Kabba																									7°31'N 6°14'E
Makurdi																									7°44'N 8°35'E

Figure 20. Fruiting information in *Rauvolfia vomitoria* in Nigeria in relation to periods of the year across the various ecological zones.

northern range of these species. The occurrence and distribution of some typical savannah medicinal plant species in the rain forest zone and perhaps in derived savanna range was evident of climate change and gradual movement of desert southwards.

From the pre-sent study, the general trends observed provided a good guide for germplasm collections, screening and genetic improvement as well as the development of strategies for their domestication and *ex-situ* conservation strategies across the different species range in Nigeria. Various anthropogenic and environmental threats were also observed for the remaining species germplasm ranging from debarking (*K. senegalensis* and *A. boonei*), pollard-ding (*M. lucida*) roots excavation (*S. longipedunculata*, and *R. vomitoria*) as well as seasonal fires and periodic droughts (*Z. xantholxyloides*) among other form of threats

Conflict of Interest

The authors have declared that there no conflict of competing interest.

REFERENCES

Abbiw D (1990). Useful Plants of Ghana. Intermediate Technology and the Royal Botanical Gardens Kew.

- Ajakaiye DO (2001). Socio-economic issues in national development: Forestry perspective. For. Nat. Dev. pp. 236-244.
- Anselm-Adodo OSB (2004). Nature Power A Christian Approach to Herbal Medicine. Benedictine Publication, Nigeria. P 290.
- Bada SO, Popoola L (2005). Sustainable Forest Resources Development in Nigeria. In: Popoola PM, Oni PI (eds.), Proceedings of 30th Annual Conference of Forestry Association of Nigeria. pp. 38-48
- Burkill R (1985). The useful plant of West Tropical Africa Vol 4. Third Edition, Kew London Centre Nationale De-Semences Forestieres (CNSF) (2003). Seed leaflet p., 15.pp
- El-Amin MH (1990). Trees and Shrubs of the Sudan Ithaca Press, Exeter p. 484.
- Farnsworth N, Akerele AO, Bingel AS, Soejarto, DD, Guo Z (1995). Medicinal plants in therapy. Bull. World Health Organ. 63(6):965-981.
- Fatubarin A (1987). Observations on the natural regeneration of wood plants in a savanna ecosystem in Nigeria. J. Trop. Ecol. 28:1-8.
- Gbile ZO, Adesina SK (1986). Nigerian flora and its pharmaceutical potentials. J. Ethnopharmacol. 19:1-16.
- Gillespie TW, Brock J, Wright CW (2004). Prospects of quantifying structure, Floristic composition and species richness of Tropical Forests. Int. J. Remote Sens. 25(14):70-77.
- Hall JB, Danielle PA, Tomlinson Helen F, Osei-Amaning E, Julia RH (1996). *Vitellaria paradoxa*: A Monograph. School of Agricultural and Forest Sciences, Publication. No 8 University of Wales, Bangor. 105pp
- Hopkins HC (1983). The Taxonomy, reproductive biology and economic potential of *Parkia biglobosa* (Leguminosae: Mimosaceae) in Africa and Madagascar. Bot. J. Linn. Soc. 87:135-167.
- Ladipo DO, Soladoye MO, Kapoor L (1990). Conservation of the genetic resources of *Parkia biglobosa* (Jacq. Benth: a multipurpose forest tree species in Nigeria. Paper presented at the International Symposium on the Conservation of Biodiversity, IITA Ibadan, Nigeria 2nd-5th September. P 9.
- Mgeni ASM (1991). A more efficient estate: Natural forest or plantation.

- In: Pyatt N, Williams T (eds.), *Tropical Forestry: Third World priorities versus Western concern*. pp. 43-58.
- Muul I (1993). Tropical forest integrated conservation strategies and concepts of critical mass. MAB Digest No 15. UNSECO. France
- Odebiyi JB, Ogunjobi M (2003). Role of non-timber forest products (NTFPs) in alleviating poverty in Odeda Local Government Area of Ogun State, Nigeria. In: Akindele SO, Popoola L (eds.), *Proceedings of the 29th Annual Conference of FAN held on Calabar, Cross River State*. pp. 59-63.
- Olajide O (2003). Steps towards sustainable natural forest management for non-timber forest products in Nigeria. In: Akindele SO, Popoola L (eds.), *Community Forestry and Stakeholder's Participation in Sustainable Development*. Forestry Association of Nigeria. pp. 303-308.
- Oni PI (2010). Ethno-botanical survey of fallow plot for medicinal plants diversity in Idena, Ijebu Ode. South Western Nigeria. *J. Med. Plant Res.* 3(10):45-52.
- Owonubi JJ, Otegbeye GO (2004). Disappearing forests: A review of the challenges for conservation of genetic resources and environmental management *J. For. Res. Manage.* 1(1, 2):1-11.
- Pettet A (1997). Seasonal changes in nectar feeding by birds at Zaria, Nigeria. *The Ibis* 119:291-300.
- Ugbogu OA, Akinyemi OD (2004). Ethnobotany and conservation of Ribako Strict Natural Reserve in Northern Nigeria. *J. For. Res. Manage.* 1(1, 2):60-69.
- Ugbogu OA, Odewo P (2004). Some medicinal plants in the traditional medicare of Nigeria. *J. For. Res. Manage.* 1(1, 2):29-34.
- Van Wyke BE (2008). A broad review of commercially important South African medicinal plants. *J. Ethno-Pharm.* 199(3):342-355.

UNIVERSITY OF IBADAN LIBRARY