Original Research Article

Aspects of Tree Species Phenology and Diversity for Conservation in the Chimpanzee Forest Habitat Kwano, GashakaGumti National Park, Nigeria

ABSTRACT

Changes in lifecycle forms of tree species seriously affect their production leading to global warming which has a lot of influence on peoples' economic status through the provision of ecosystem services. It is important to study the lifecycle changes occurring in tree species and their diversity as a result of global warming since a lot of tree species serves as food to wild animals their absence means animals which depend on them for food will starve to death or migrate thereby affecting conservation activities as well as the wellbeing of people who depends on the park and conservation projects operating within the park for a means of livelihood.

An aspect of Tree species Phenology and Diversity for Conservation in Chimpanzee Forest Habitat at Kwano, Gashaka Gumti National Park, Nigeria was conducted with the view to examine the phenology and diversity of tree species in the forest for better conservation strategy. An 8km transect with tagged trees was monitored on foot for phenological activities of leafing, flowering, fruiting and leaf shedding for 3 months. Shannon-Wiener's Diversity Index (SWDI) was used to determine tree species diversity. ANOVA was used to compare the phenological data among the months of study. SWDI was 4.115. A total of 867 individual tree species consisting of 127 species from 45 families and with 4 unidentified tree species found on this transect indicated that Anogeissus leiocarpus (7.04%) is the highest in the number of the tree species, Trichilia martineani (6.34%) and Crossopteryx febrifuga (5.65%). Euphorbiaceae family (17.42%) was the highest among the diverse tree species observed in Kwano forest followed by Combretaceae (9.80%) and third by Caesalpinoideae (8.65%). Capparidaceae, Lecythidaceae, Calophyllaceae, Melianthaceae, Celtidaceae, Celastraceae, Maesaceae, Burseraceae, Rutaceae, and Dracaeroaceae each with 0.12% were the least families observed. Only 0.12% tree species was observed leafing, 3.92%, 2.19% and 1.73% flowering in June, July and August respectively while 3.92%, 7.27% and 7.96% were fruiting in June, July and August respectively, none was observed shedding leaves. Comparison of the phenological data reveals significant differences in fruiting and flowering ($P < 0.05$), none in leafing and leaf shedding ($P > 0.05$). Understanding the phenology and tree species diversity of this forest could enhance better conservation strategies. More phenological studies are recommended in the Park.

Key words: Aspects, Tree species, Phenology, Diversity, Conservation, and Chimpanzee forest habitat

INTRODUCTION

Plant phenology refers to the cyclic plant growth events, and is one of the most important indicators of climate change. Integration of plant phenology information is of great significance for understanding the response of ecosystems to global change and simulating the material and energy balance of terrestrial ecosystems (Zhu *et al*., 2023).

Phenology is perhaps the simplest and most frequently used bio-indicator to track climate changes. A very charming definition of phenology comes from Sparks (Menzel, 2003) which says that phenology is pastime with a considerable history. Following the definition of Lieth (2013), which goes back to Schnelle (1955), modern phenology is the study of the timing of recurring biological events in the animal and plant world, the causes of their timing with regard to biotic and abiotic forces, and the interrelation among phases of the same or different species. Leaf unfolding, flowering of plants in spring, fruit ripening, colour changing and leaf fall in autumn as well as the appearance and departure of migrating birds and the timing of animal breeding are all examples of phenological events. 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. Once considered the harmless activity of a selected few country gentlemen and clerics it has now taken on a new importance since its value as (probably) the oldest written biological records has been recognized. Phenology is the study of recurring life-cycle events, classic examples being the flowering of plants and animal migration (Morellato, 2003).

Plant phenology is not only important for comprehending ecosystem responses to global change (Inouye, 2022; Menzel *et al*., 2020), but also a significant factor in simulating material and energy balance of terrestrial ecosystems (Wang *et al*., 2020b) as reported by (Zhu *et al*., 2023) .

The oxford advanced dictionary (8th edition) defines phenology as the study of patterns of events in nature, especially in the weather and in the behaviour of plants and animals and defines conservation as: (1) the protection of the natural environment and (2) the act of preventing something from being lost, wasted, damaged or destroyed while the English Dictionary defines phenology biologically as the study of the effect of climate on periodic biological phenomenon and defines conservation as: (1) the act of preserving, guiding, or protecting; the keeping (of a thing) in a safe or entire state; preservation, (2) The wise use of natural resources, (3) Biologically as the discipline concerned with protection of biodiversity, the environment, and natural resources; genes and associated characteristics of biological organisms that are unchanged by evolution, for example similar or identical nucleic acid sequences or proteins in different species descended from a common ancestor.

Changes in lifecycle forms of tree species seriously affect their production. Climate change has a lot of influence on peoples' economic status through the provision of ecosystem services. It is important to study the lifecycle changes occurring in tree species as a result of global warming. A lot of tree species also serve as food to wild animals. Their absence means animals which depend on them for food will starve to death. The park will cease to exist in the absence of animals and the closure of the park means a lot of people will lose their jobs. This will also affect the host communities whose economic wellbeing depends on the park and conservation projects operating within the park.

(Meier *et al.*, 2007) reported that scientists now understand that plants and animals take their cue from their local climate. Climate change is impacted by non- biological factors such as temperature, precipitation and available sunlight. Species use the predictable yearly changes in the climate to determine when they start natural events such as breeding or flowering. Because many such phenomena are very sensitive to small variations in climate, especially to temperature, phenological records can be useful proxy for temperature historical climatology, especially in the study of climate change and global warming. For example, viti- cultural records of grape harvest in Europe have been used to reconstruct a record of summer growing season temperatures going back more than 500 years.

Many cultures have traditional indications of the progress of the natural calendar phenological proverbs and sayings which indicate a time for action: “when the sloe tree is white as a sheet, sow your barley whether it is dry or wet” or attempt to forecast future climate: “If oak’s before ash, you are in for a splash. If ash before oak, you are in for a soak”. But the indications can be pretty unreliable, as an alternative version of the rhyme shows: “If the oak is out before the ash, “Twill be a summer of wet and splash; if the ash is out before the oak, “Twill be a summer of fire and smoke”. Theoretically, though these are not mutually exclusive, as one forecast immediate and future conditions (Menzel *et al.*, 2006).

Phenology is an important subject to study because it helps to understand the health status of species and ecosystems. Plants and animals do live in bubbles- every species has an impact on those in its food chain and community. The timing of one species’ phenological events can be very important to the survival of another species. Phenology is of great interest in agriculture, where the timing of flower and fruiting production can be critical in determining crop yield.

In the face of growing concerns about the effects of changes in climate, phenology, or the study of the timing of seasonal biological events, has emerged as one of the clearest and most responsive mechanisms for exploring the relationship between climate conditions and the biosphere (Schwartz, 2003). However, as phenological science progresses toward the development of long- term assessments and predictive models of regional and continental phenological change, the limitations of existing phenological records are becoming increasingly apparent. Satellite imagery, the predominant sources of data for phonological modeling at regional or continental scales (Reed *et al.*, 2009; White *et al.*, 2009), is limited both by its inability to discriminate among plant taxa and by the comparatively recent development of satellite systems capable of phonological monitoring.

The timing of this transition from leafless, dormant trees to branches tinged with green- has enormous implications across ecological scales ranging from individual trees to the global climate. The study of the timing of developmental events is known as phenology (Badeck *et al.*, 2004; Forrest and Miller- Rushing, 2010).During the past few years, the range of people interested in leafing-out phenology has grown, as have the methods employed to study it, largely as a result of its relevance to global climate change (Forrest and Miller-Rushing, 2010; Polgar and Primack, 2011a). While several studies found spring phenology to advance due to climate warming (Meier *et al.*, 2021), findings regarding autumn phenology 40 are more ambiguous (Piao et al., 2019; Menzel *et al.*, 2020) but tend to indicate a backward shift (e.g. Bigler and Vitasse, 2021; Mei er *et al.*, 2021) as reported by Meier and Bigler (2023).

Tree species diversity is an important aspect of forest ecosystem diversity and is also fundamental to tropical forest biodiversity (Naidu and Kumar, 2016). Disturbances of both natural and human origin influence forest dynamics and tree diversity at local and regional scales (Sapkota *et al.*, 2009; Neelo *et al.*, 2015), and consequently species extinction (Todou *et al.*, 2016). These disturbances do not only influence diversity, but also density, dominance and important value index of tree species (Lawes *et al.*, 2007).Current spatial distribution of tree species diversity is strongly linked to spatially structured environmental variables. High-diversity areas of tree species are characterized by stable, but relatively cool annual temperatures, high annual rainfall and relatively coarse textured acidic soils. Similarly climate stability, in combination with sufficient rainfall and the right soil type can promote high woody diversity (Jetz *et al.*, 2004; Ara-ujo *et al.*, 2008). Any alteration of these variables can cause instability in the ecosystems.

Due to the diversity of habitats in Nigeria and the tropical climate, there is a great diversity of plant species found in the country. There have been many localized studies of woody plant species in Nigeria, but few sources of consolidated information. According to National Biodiversity Strategy and Action Plan [NBSAP], (2003), more than 5,103 higher plant species have so far been identified, although the number of these woody species may be definitely much higher.

Nigeria's tree species also include many species with traditional value as food items and medicinal as well as various domestic applications. A number of these trees have been catalogued in various specific areas of the country. Of special importance in Nigeria are the many tree crop species that originated here. Nigeria is thought to be the origin of many land races of important tree crops now grown worldwide. Although a number of land races of these species still exist, some are being lost as improved hybrid species are increasingly used to fulfill farming objectives. Many of these land races are dying out in favor of more "modern" strains that are being cultivated instead. These diverse older tree crop strains may hold a key to human food security as environmental conditions change due to global warming and anthropogenic activities and their inherent genetic characteristics of disease resistance and drought tolerance may become necessary to recapture (United States Agency for International Development [USAID], 2008). The rapid inventory of tree species that provides information on diversity will represent an important tool to enhance our ability to maximize biodiversity conservation that results from deforestation and degradation (Naidu and Kumar, 2016).

Conserving the forests in this sector of the park is of great importance as they will go a long way to offer services such as:

a) Provisioning services: these are ecosystem services that describe the material or energy outputs from ecosystems. They include food, water and other resources
b) Regulating services: These are services that ecosystems provide byacting as regulators, for example regulating the quality of air and soil or by proving flood and disease control
c) Habitat or supporting services underpin almost all other services. The forest ecosystems provide living spaces for plants and animals; they also maintain a diversity of different breeds of plants and animals
d) Cultural services which include the non- material benefits people obtain from contact with ecosystems. They include aesthetic, spiritual and psychological benefits (Millennium Ecosystem Assessment [MA], 2005 and de Groot *et al.*, 2002).Securing infrastructure, protecting coastal zones, managing water supply and flood protection account for the bulk of the expected costs. Managing water supply and flood protection offer the greatest potential for reducing costs (World Bank, 2010).

This study was carried out with the view to achieve the following set of objectives:

i) evaluate the tree species diversity in the chimpanzee’s forest habitat.
ii) examine the periodic occurrences of life cycle changes of tree species (leafing, flowering, fruiting, and leaf shedding).

METHODOLOGY

The Study Area

Location

This study was carried out in Gashaka Gumti National Park (GGNP) which covers an area of approximately 6,700 square kilometers. It is the largest National Park in Nigeria, located in the North Eastern part of the country, and represents an area of significant national and international conservation priority. From the edge of the plateau in Taraba state, GGNP stretches northwards along the international border with Cameroon and Africa's Gulf of Guinea forests, on into Adamawa state as far as the small town of Toungo, considered a hotspot of biodiversity (Oates *et al.*, 2004). Geographically the area lies between latitude $06^{o}55^{1}$and $08^{o}13^{1}$North, and between longitude $11^{o}13^{1}$and $12^{o}11^{1}$ East (Figure1). Despite being located in what may be classified politically and culturally as a Northern state, in ecological terms, GGNP bears many similarities with Nigeria's southern regions. This study was located in Kwano forest (approx. $583m^{2}$; $07^{o}30^{1}$N-$011^{o}30^{1}$E) at the foot of the hill of Chappal Tale which is about three hours walk(11aerial km) from the nearest village of Gashaka the Southern part of the park (Buba, 2013),.

Topography

The park harbours extensive mountainous areas, which form part of the Eastern highlands of Nigeria. Altitude ranges from 350m to over 2,400m above sea level, which is characterized by steep slopes, deep plunging valleys, precipitatious escarpments, and swiftly flowing rivers (Dunn, 1993). As reported by Buba (2013), the highest mountain in Nigeria, ChabbalWadde (a fulani term meaning mountain of death), with a height of 2,647m above sea level is located in the Southeast of the Park adjoining the Nigerian-Cameroon border. The rugged terrain made commercial exploitation and road building difficult, a fact nowadays works to the advantage of the National Park's conservation effort

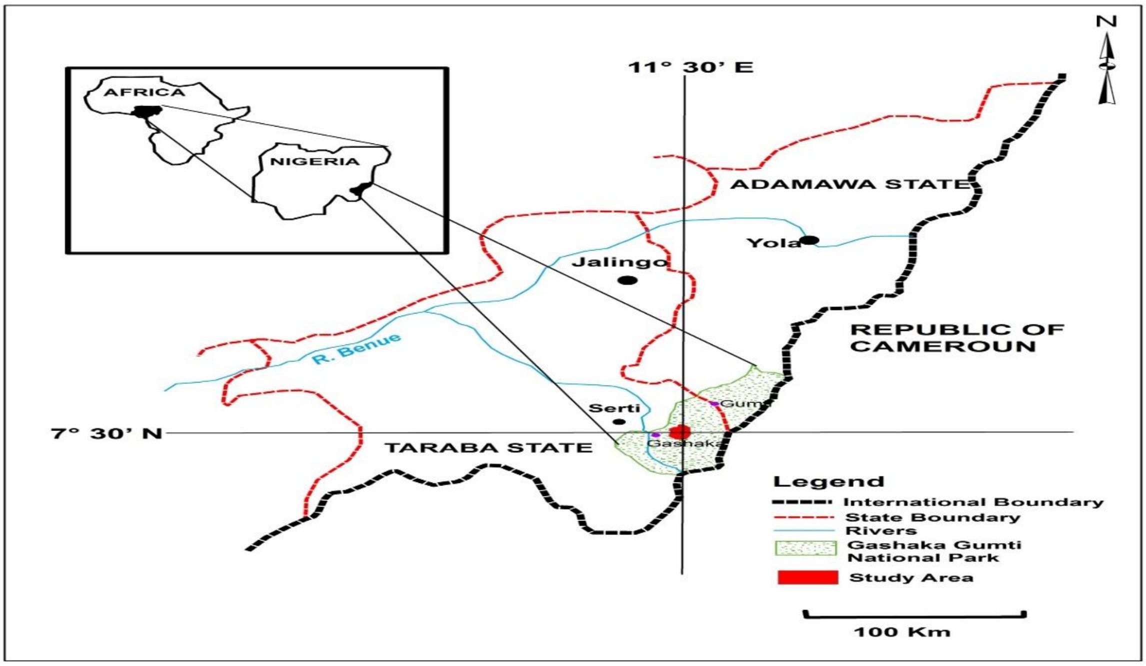

Figure 1: Map of GGNP showing Kwano forest. Source: Warren (2004) as adopted by Scombi *et al*. (2023).

Study Design

The two straight-lines phenology transects of 4km each (Figure 2) with a width of 4m along which trees with at least 30cm Diameter at Breast Height (DBH) have been labeled with engraved metals in the chimpanzee forest habitat Kwano established by Gashaka Primate Project (GPP) was used. The transect cuts through the north-western part of the home-range of the chimpanzee community of Gashaka community, Kwano. As observed by Buba (2013), the transect direction was determined with the intention to incorporate sections of different elevations as well as varying types of habitat, thus allowing for a relatively unbiased quantification of the vegetation cover. The reason for choosing this forest was because it habituates the chimpanzee which is one of the animals (mammals) that attracts a lot of researchers, tourists and conservators to the park.

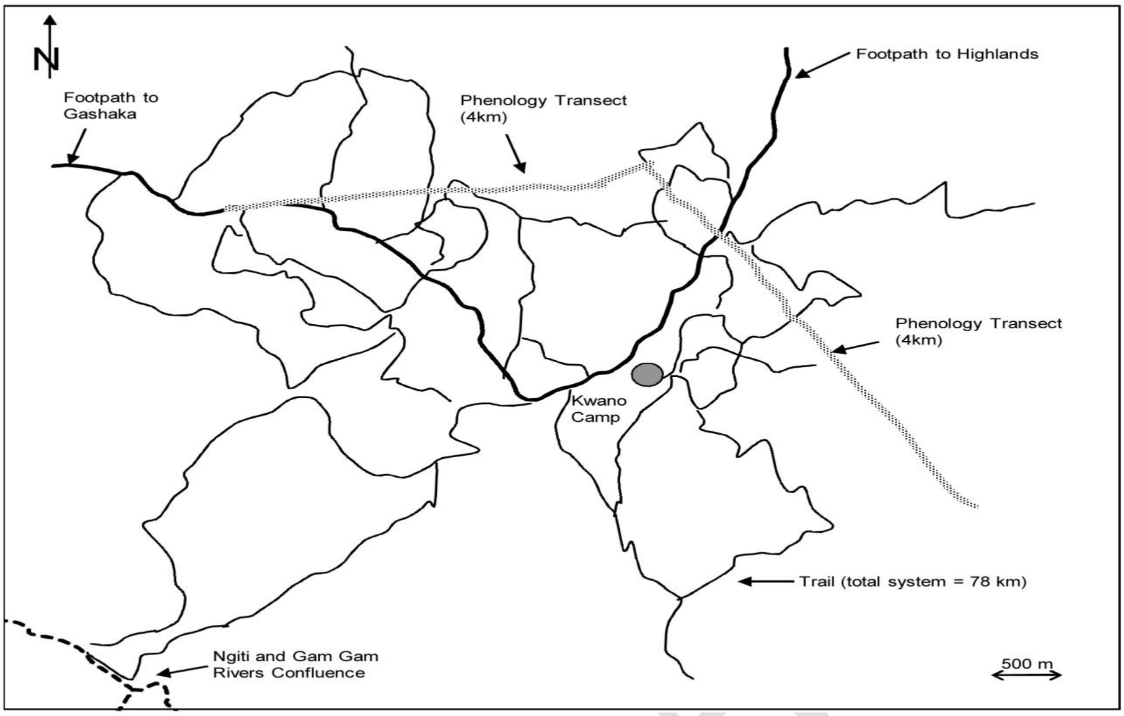

Figure 2: Map Showing the Trails and Transects Cut across the Field Study Site: Source: Buba (2013).

Data Collection

The total number of marked tree species along the 8km transect was counted manually. Data on the presence of leafing, flowering, fruiting and leaf shedding were recorded using a phenology data sheet. Quantitative data on leafing, flowering, fruiting and leaf shedding of tree species were recorded on a phenology data sheet (appendix I). Data on flowering, leafing, fruiting and leaf fall were collected at the space of 4 weeks interval using binoculars. It was done for 3 months (June, July and August) due to time limit for the research.

Data on weather information was recorded from the weather station of Gashaka Biodiversity Project (GBP) located at Kwano field station.

Statistical Analysis

The diversity of tree species along the 8km transect was determined using Shannon-Wiener's Diversity Index as described by Adekunle *et al.* (2013).

$$H' = -\sum_{i=1}^{N} P_i \ln (P_i) \quad (1)$$

Where H' = Shannon- Wiener's Diversity Index

N = the total number of all individual tree species within the transect

P_i = the proportion of a species to the total number of individual tree species in the 8km transect.

i= the proportion of the species relative to the total number of species (P_i)

Descriptive statistics including percentages, graphs, charts, tables were used to present the data on leafing, flowering, fruiting and leaf shading periods.

Analysis of Variance (ANOVA) of the Mixed Effect Model was used to compare if there were differences within the months in leafing, flowering, fruiting and leaf shedding. The linear statistical model was:

$$Y_{ij}= \mu+ T_j + \varepsilon_{ij} \quad (2)$$

Where:

Y_{ij}= individual mean

μ= general mean

T_j= effects of the treatments (leafing, flowering, fruiting and leaf shedding)

ε_{ij}= experimental error

Replicates: June, July and August.

RESULTS

Tree Species Diversity Index

Shannon-Wiener's Diversity Index for the chimpanzees' forest habitat, Kwano was 4.115.This means that the chimpanzee forest habitat Kwano is highly diverse of tree species. Euphorbiaceae family (17.42%) was the highest among the diverse tree species observed in Kwano forest followed by Combretaceae (9.80%) and third by Caesalpinoideae (8.65%). Capparidaceae, Lecythidaceae, Calophyllaceae, Melianthaceae, Celtidaceae, Celastraceae, Maesaceae, Burseraceae, Rutaceae, and Dracaeroaceae each with 0.12% were the least families observed. The diversity of the tree species also serve as a better home and source of food for the chimps, with this, the chimpanzees will be available for researchers, tourists and students as well as Park staff which could translate to more income generation for the host communities through business boosting and increase in the demand for labour.

Checklist of the Tree Species

Checklists of the tree species occurring on the transect are presented in appendix II. The results shows that 867 individual tree species consisting of 127 species from 45 families and with 4 unidentified tree species found on this transect indicated that *Anogeissus leiocarpus* (7.04%) is the highest in the number of the tree species, *Trichilia martineani* (6.34%) and *Crossopteryx febrifuga* (5.65%). From the total number, 191of the tree species were found to be dead.

The Periodic Occurrences of Life Changes of the Tree Species

The phenological studies of the tree species recorded within the period of study (June, July, and August) were leafing, flowering, fruiting and leaf shedding.

Leafingof tree species

There was only one (1) tree species *(Spathodatha campanulata)* observed to be leafing in the month of June (0.12%), as for the months of July and August, no single tree species was observed to be leafing.

Flowering of tree species

Table 1 shows the trend in the total number of tree species flowering. The result had a gradual decrease from June (3.92%), July (2.19%) to August (1.73%), while the total number of tree species not flowering was on the increase.

The result recorded in June indicated that *Piliostigma thonningii* (0.46%) was the highest tree species flowering, *Bridelia ferruginea* (0.35%), *Trichilia martineani*, *Anogeissus leiocarpus*, *Lanneaacida*, *Terminalia avicennioides*, *Macaranga schweifurthii* and *Bridelialutea* (0.23%) each, for July, *Piliostigma thonningii* (0.58%) was the highest, *Terminalia avicennioides, Lanneaacida, Anogeissus leiocarpus* each (0.23%), *Ficus lutea, Cola gigantea, Malacantha alnifola, Bridelia ferruginea, Trichilia martinea, Khaya senegalensis, Crossopteryx febrifuga,* and *Erythroxylume marginatum* (0.12%) each, and August, *Piliostigma thonningii* (0.46%) was the highest followed by *Lannea acida* (0.23%), *Vitex doniana, Ficus lutea, Cola gigantea*, *Malacantha alnifola, Trichilia martineani*, *Khaya senegalensis, Crossopteryx febrifuga*, and *Garcinia smeathmannii* (0.12%) each.

Table 1: Flowering of Tree Species

Month	Frequency of Tree Species Flowering	Percentage of Tree Species Flowering	Frequency of Tree Species not Flowering	Percentage of Tree Species not Flowering	Total Frequency of Tree Species	Total Percentage of Tree Species
June	34	3.92	833	96.06	867	100
July	19	2.19	848	97.81	867	100
August	15	1.73	852	98.27	867	100

Source: Field Survey (2022)

Fruiting of tree species

Table 2 shows a recorded increase in the total number of tree species fruiting within the three months of study. In June 3.92% of them were observed to be fruiting, 7.27% in July and 7.96% in August.

Tree species observed to be fruiting in June were; *Bridelia ferruginea* and *Crossopteryx febrifuga* (0.58%) each, *Trichiia martineani, Anogeissus leiocarpus*, *Bridelia lutea* and *Vitex doniana* (0.46%) each, and *Terminalia avicennioides* and *Cola hispida* (0.35%) each. The result for July indicated that *Bridelia ferruginea has the highest* (0.69%), *Crossopteryx febrifuga* (0.58%), *Piliostigma thonningii, Vitex doniana* and *Trichilia martineani* (0.46%) each. In August, *Bridelia ferruginea* and *Piliostigma thonningii* has the highest *(0.81%)* each, Crossopteryx febrifuga (0.69%), and *Terminalia avicennioide* (0.58%) each.

Leaf shedding of tree species

The result indicated that no single tree species was shedding leaves throughout the period of study.

Table 2: Fruiting of Tree Species

Month	Frequency of Tree Species Fruiting	Percentage of Tree Species Fruiting	Frequency of Tree Species not Fruiting	Percentage of Tree Species not Fruiting	Total Frequency of Tree Species	Total Percentage of Tree Species
June	34	3.92	833	96.08	867	100
July	63	7.27	804	92.73	867	100
August	69	7.96	798	92.04	867	100

Source: Field Survey (2022)

Summary of Tree Species phenology Results

The results of the phenology shown in figure 3 shows that in June, 0.12% of the tree species were observed to be leafing, flowering and fruiting were 3.92% each while none was shedding leaves. In July no single tree species was observed leafing, 2.19% were seen to be flowering, 7.27%

were fruiting none was observed to be shedding leaves. In August, none was seen leafing or shedding leaves, 1.73% of the tree species were flowering and 7.96% were fruiting.

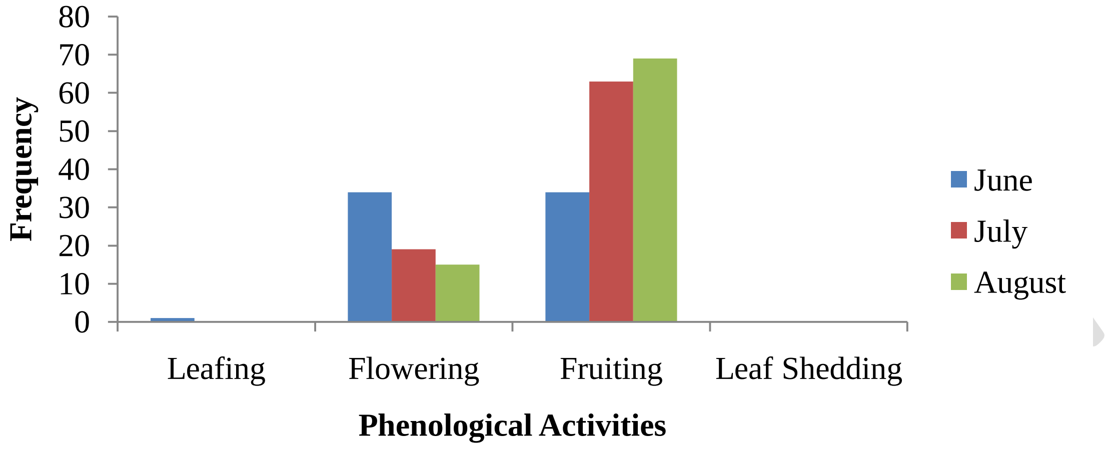

Figure 3: Chart of the Summary of Tree Species Phenological Data

Checklist of the Tree Species

Checklists of the tree species occurring on the transect are presented in appendix II. The results shows that 867 individual tree species consisting of 127 species from 45 families and with 4 unidentified tree species found on this transect indicated that *Anogeissus leiocarpus* (7.04%) is the highest in the number of the tree species, *Trichilia martineani* (6.34%) and *Crossopteryx febrifuga* (5.65%). From the total number, 191of the tree species were found to be dead.

The Result of Weather Observations

Figure 4 shows that the weather information of the study area for the period of study, which reveals that the maximum temperatures were 30°C, 31°C and 32°C for the months of June, July and August respectively, while the minimum temperatures were 22°C, 22°C and 23°C for June, July and August each respectively. Records of rainfall in the period of study were 164mm, 246mm and 226mm for June, July and August respectively. While relative humidity were 87%, 84% and 85% for June, July and August respectively.

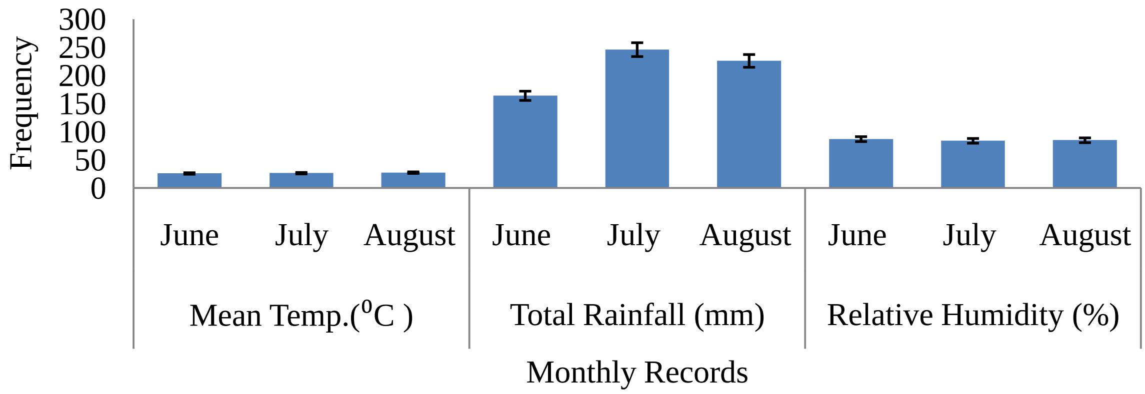

Figure 4: Chart of Weather Records for the Period of Study

NB: The error bars are indicating the degree of variability of the plotted values (or measured values) from the actual or real values.

Comparison of Phenological Records among the Months of Study

The records of observations on tree species leafing during the study shows that only 0.12% of them were observed leafing and when subjected to Analysis of Variance, it revealed non-existence of significant difference in the 3 months of observation ($P > 0.05$).

On the records of tree species flowering, the results showed that 3.92% of them were seen to be flowering in the month of June, 2.19% in July and 1.73% in August. The analysis revealed the existence of significant differences among the 3 months ($P < 0.05$).

As for the records of tree species fruiting, the results showed that 3.92% of them were seen to be fruiting in June, 7.27% in July and 7.96% in August. The analysis revealed the existence of significant differences among the 3 months ($P < 0.05$).

No single tree species was observed to be shedding leaves throughout the study period, so nothing to test.

DISCUSSION

Tree Species Diversity

The Shannon-Wiener's Diversity Index for the tree species in the chimpanzees' forest habitat Kwano agrees with Gaines *et al.* (1999) who reported that the Shannon-Wiener's Diversity Index ranges from 1.5 to 3.5 and rarely reaches 4.5. It indicates that the tree species in the Kwano forest are very much diverse; this is of great importance to the chimpanzees who feed on a wide variety of fruit trees. This agrees with National Biodiversity Strategy and Action Plan (2003) who reported that forest tree species in Nigeria are particularly diverse, and many of these have commercial importance. Elobeid (2000) also reported that tree species contribute to environmental stability and sustainability through conservation of ecological processes that link the continuity of life and humans, and conservation of biodiversity and genetic resources which both animal and other plants depend on. The diversity of the tree species also serve as a better home and source of food for the chimpanzees. This will make the chimpanzees available for researchers and tourists, students as well as park staff meaning more income generation for the host communities through business boosting and increase in the demand for labour. USAID (2008) reported that diverse older tree crop strains may hold a key to human food security as environmental conditions change due to global warming and anthropogenic activities, their inherent genetic characteristics of disease resistance and drought tolerance may become necessary to recapture. The result of tree species diversity is an indication of interspersion of vegetation in the study area conforms to Sankaran *et al.*(2005) and Russell-Smith *et al.*(2012) that Taraba State has a vast array of diverse indigenous biodiversity including woody species. TRIP Ltd (2014) also reported that Taraba State is made up of three major ecological zones that are typified by the co-existence of woody plants with the relative proportions of being influenced predominantly by water availability, fire, nutrients, herbivores and people. This in turn makes the area a good habitat for animals and also rich in food resources for primates and particularly for the chimpanzees. This is in line with the findings of Anderson *et al.* (2002) that ecosystems with interspersion of vegetation are richer in terms of food provision and cover for wild animals.

The Periodic Occurrences of Life Changes of the Tree Species

Leafing of tree species

There was only one tree species observed to be leafing within the three months of study from June through July to August. There was non- significant difference in leafing among the three months which was in line with Howe *et al.* (2003) Linkosalo *et al*. (2006) and Caffarra and Donnelly (2010) who reported that leafing always comes up during the dry seasons of the year in most tropical forests. It also agrees with Polgar and Primack (2011) who reported that leafing-out of tree species signals the transition from winter to spring and onset of the growing season in temperate as well as tropical forests. Almost all the tree species in the chimpanzee's forest habitat were on their leaves at the commencement of this study. This is important to the chimpanzees because they make their nests on leafy fig trees and also uses it as food. This was what Ammann *et al*. (2003) reported, that chimpanzees every night and often also during the day, build their nests (sleeping platform) from leafy twigs, typically in trees; Peterson and Ammann (2003) observed that chimpanzees spend between 57-71% of foraging time on ripe fruits, 18-21% on leaves and 11-23% on other plant parts, in particular terrestrial herbs. The availability of leaves on the tree species implies a better home and source of food for the chimpanzees thereby making them available for researchers, tourists, students and conservators and hence more income generation for the local communities. The study on leaf-out phenology is also very important for monitoring how these tree species can be affected by climatic changes, this is in line with Polgar and Primack (2011) who reported that understanding the mechanisms and controls regulating leaf-out, how these mechanisms differ among species and how the timing of leaf-out in plant species, populations, and communities will be affected by climatic changes, would be helpful in the management and conservation of natural areas and in forecasting future changes in the carbon budgets of ecosystems.

Flowering tree species

The total number of tree species observed to be flowering during this study period was reducing steadily from June through July to August. There was the existence of significant differences in flowering within the three months of study, this agrees with Buba (2013) who reported that flowering of the tree species in this forest is minimal during the wet months (June-October) and maximum during the dry months (November-May). This could be as a result of increase in moisture and reduction in dryness which is in line with Fitter and Fitter, (2002) who stated that flowering in tree species is sensitive to temperature, as higher temperatures increases flowering and vice versa with lower temperatures. The availability of flowers on the tree species can help predict when the tree species will be producing fruits which are sources of food for the chimpanzees; this is due to the fact that the flowering cycle in tree species is proceeded by the fruiting cycle. This agrees with Zhoner and Renner (2014) who reported that understanding, and hence being able to predict plant phenological events such as flowering is essential for forestry and agriculture and is the basis for forecasting how this process can change with a changing climate.

Fruiting tree species

There was a steady increase in the total number of tree species fruiting from June, July and August. This implies that fruits which are sources of food for the chimpanzees will be available and will steadily be increasing until it gets to the peak and finally out of season. There was existence of significant differences in fruiting within the three months. Buba (2013) reported that there is always an increase in the availability of fruits in this forest from

January-June and a reduction in July- October; chimpanzees in the Kwano forest are always visible when fruits are available which serves as food sources to them. NEMA (2010) reported that tree species provide edible fruits for both mankind and animals. The increase in fruit production also implies survival of the tree species which has many other functions to play as far as human survival is concern. The presence of the chimpanzees in the Kwano forest implies that the local people can generate more income from the conservation activities of researchers, tourists and conservationists through business patronage, employment and so on.

Leaf shedding tree species

No single tree species was observed shedding its leaves within the study period. This finding agrees with Buba (2013) who reported that trees in this forest (Kwano) shed their leaves moderately in February, March and April with the least in June, July and August. This is important to the chimpanzees that make their nests on leafy fig trees and also uses it as food. There is a steady increase in the number of tree species dying in this forest on a yearly basis (according to phenological records in GBP field station Kwano) which is a course for concern because this poses a lot of threat to biodiversity conservation.

The results of leafing, flowering, fruiting and leaf shedding can be used as an example to that of agricultural crops which assist agriculturalists understand the timing of leafing, flowering, fruiting and leaf shedding of their economic crops which corroborate Loomis and Connor (1992) report that phenology is of great interest in agriculture, where the timing of flower and fruit production can be critical in determining crop yield.

Weather Observations (Mean Temperature, Total Rainfall and Relative Humidity)

The weather results showed that there was no major change in minimum and maximum temperature which tallies with the phenological results of flowering. The increase fruiting in trees between the months of June, July and August might not be unconnected to the slight increase in the total amount of rainfall within the same period and could therefore be said that increase in precipitation enhances fruiting in trees. This finding agrees with Bowers and Dimmitt (1994). These results are slightly higher than Buba’s (2013) results in rainfall records while slightly lower in temperature and relative humidity records. These variations might not be unconnected to the impact of climate change on the study area and there is the possibility of further variation in the near future which could further impact the biodiversity of the Park. These changes are very detrimental to the chimpanzee habitat as increase in temperature will lead to global warming and distortion of the lifecycle forms of the trees. This can cause a lot of trees to suffer from water shortages as a result of decrease in rainfall thereby leading to the decrease in their production, with this, the chimpanzees will be forced to relocate and so depriving the local communities and others of the benefits derived because of their availability in the Kwano forest.

CONCLUSION

The results of phenological study are indications that tree species do not flower well in the wet months of the year likewise leafing. Most if not all the tree species do not leaf out in the months of June, July and August, which therefore means that the tree species were already on their leaves during the wet months which is an advantage to the chimpanzees which make their nests only on leafy figs. Leafing, flowering and fruiting in the Kwano chimpanzees' forest habitat at this period of study provided a conducive habitat and food availability for the reproduction of the chimpanzees and will make them readily available for research and tourism.

The results from tree species diversity is an indication that the chimpanzee forest habitat Kwano is highly diverse of tree species which makes food availability for the chimps and other animal species living within this forest abundant.

The existence of conservation activities in the Kwano forest could go a long way to enhance the economic status of the enclave and buffer zone communities.

RECOMMENDATIONS

With regards to the findings of this research, the following recommendations were made:

- The park management and conservation projects operating within the park should sponsor more phenological researches on a wider scope within the Park, in order to build a phenological data base.
- More Rangers should be employed (with more preference to youths from the park enclaves) and posted to the Filinga range and other ranges of the park to enable them cover the large and rough terrain of the park so as to increase the intensity of patrols most especially within the chimpanzee forest habitat, Kwano for better conservation results. The park management and conservation projects operating within the park should be organizing sensitization programs to enlighten the local communities on the benefits they could derive from regular conservation Projects.

- The park management and conservation projects operating within the park should liaise with the traditional rulers/ local leaders into their management plans for better conservation activities.
- To keep GGNP area intact as a watershed is thus clearly of extreme economic value and should be considered a matter of high national priority.

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Appendix I: Phenology Data Sheet

Date:...............................

Species Name	June				July				August			
	Leafing	**Flowering**	**Fruiting**	**Leaf Shedding**	**Leafing**	**Flowering**	**Fruiting**	**Leaf Shedding**	**Leafing**	**Flowering**	**Fruiting**	**Leaf Shedding**

Appendix II: Phenology Checklist of Tree Species

Family	Species name	English name	Fulani	Hausa	Frequency	Percentage (%)
Fabaceae	*Afzelia africana*	Mahogany bean, mahogany		Kawo	1	0.12
	Burkea africana	Wild seringa		Karya	1	0.12
	Dichrostachys cinerea	Sickle bush	Burlehi	Dundu	1	0.12
	Pterocarpus erinaceus	African rosewood	Iyamhi	Madubiya	6	0.69
Mimosoideae	*Albizia intermedia*				2	0.23
	Albizia zygia				4	0.46
	Parkia bicolor	Bicolor parkia	Wang	Dorowa	9	1.04
	Parkia biglobosa	Locust bean tree	Nareje		6	0.69
	Piptadeniastrum africanum				2	0.23
Euphorbiaceae	*Alcornea cordifolia*	Christmas bush			1	0.12
	Anthostema aubruanum				1	0.12
	Bridelia atroviridis	Rare forest			19	2.19
	Bridelia ferruginea		Mbori	Dargaza	28	3.23
	Bridelia lutea		Murumburum		9	1.04
	Bridelia macrantha	Bridelia, coast goldleaf	Burumburum		10	1.15
	Bridelia speciosa		Burumburum		19	2.19
	Hymenocardia acida		Ngaluwaje, samataje	Janyaro	19	2.19
	Macaranga barteri				2	0.23
	Macaranga schweinfurthii		Dalamhi		10	1.15
	Spondianthus preussii				1	0.12
	Uapaca guineensis	Red cedar		Wawan kurmi	13	1.50
Sapotaceae	*Aningeria altissima*				1	0.12
	Chrysophyllum subnudum	Adasema			3	0.35
	Synsepalum dulcificum	Miracle fruit			4	0.46
	Synsepalum glycydorum				1	0.12
	Synsepalum stipulatum				4	0.46
	Tiegherella heckelii				1	0.12
Annonaceae	*Annona senegalensis*	Wild custard apple		Gwanda daji	6	0.69

Cont'd.Phenology Checklist of Tree species

	Anonidium mannii				1	0.12
	Hexalobus monopetalus var. parvifolius			Gondan kurmi	7	0.81
	Xylopia staudi	African pepper			2	0.23
Combretaceae	*Anogeissus leiocarpus*	Axlewood	Kojoli	Marke	61	7.04
	Combretum molle	Velvet bush, velvet leaf willow		Wuyan damo	1	0.12
	Terminalia avicennioides		Kulahi	Bauche	20	2.31
	Terminalia glaucescens		Kulahi	Bauche	3	0.35
Caesalpinoideae	*Anthonota crassifolia*				5	0.58
	Anthonotha lamprophyllum				3	0.35
	Brachystegia eurycoma		Wambo		15	1.73
	Daniellia oliveri	West African copal, African copaiba balsam tree	Karlahi	Magie, Maje	7	0.81
	Dialium guineense	Black velvet, velvet tamarind	Kom	Samiyan biri	6	0.69
	Erythrophleum suaveolens	Sasswood, poison wood tree		Gwaska	13	1.50
	Piliostigma thonningii	Camel foot	Barkehi	Kargo	23	2.65
	Volganga africana				3	0.35
Moraceae	*Antiaris toxicaria*	Ark cloth tree,false iroko,upas tree			1	0.12
	Ficus exasperate	Sandpaper tree			1	0.12
	Ficus lutea	Giant-leafed fig	Durumihi	Farin gamji	12	1.34
	Ficus mucoso				1	0.12
	Ficus sur	Bush fig	Ibbal	Baure	5	0.58
	Ficus trchopoda	Swamp fig			1	0.12
	Ficus vallis-choude	Fig tree	Ibbal danejum, Rima bechi	Farin baure	9	1.04
	Ficus vogeliana				1	0.12
	Treculia obovoidea				1	0.12
Rutaceae	*Araliopsis tobouensis*				1	0.12

Cont'd.Phenology Checklist of Tree Species

Sapindaceae	*Blighia sapida*	Akee apple			12	1.34
Bombaceae	*Bombax costatum*	Red-flowered silk cotton tree		Gurjiya	3	0.35
Burseraceae	*Canarium schweinfurthii*	African elemi		Atile	1	0.12
Bombacaceae	*Ceiba pentandra*	Silk cotton tree, Kapok	Bantahi	Rimi	2	0.23
Ulmaceae	*Celtis afracana*	White stinkwood			2	0.23
	Celtis zenkeri				1	0.12
Lamiaceae	*Vitex doniana*	Black plum, West African plum	Ngalbije	Dinya	22	2.54
Sterculiaceae	*Coffia canephoria*				6	0.69
	Cola gigantean	Giant cola	Kukahi		30	3.46
	Cola hispida				4	0.46
	Cola millenii	Monkey cola			11	1.27
Rubiaceae	*Crossopteryx febrifuga*	African bark	Rima joga	Kashin awaki	49	5.65
	Erythroxylum emarginatum	African coca tree, common coca tree		Gwaska	4	0.46
	Sarcocephalus latifolius	African peach, pin cushion tree	Bakurahi	Tafisia	5	0.58
	Clerodendrum tomentallum	Bleeding glory, Bagflower			1	.012
	Rothmanna hispida				1	0.12
Araliacae	*Cussonia arborea*	Octopus cabbage tree	Jumbali		14	1.61
	Polyscias fulva	Parasol tree			1	0.12
Ebenaceae	*Diospyros mespiliformis*	West African ebony, Jackal berry	Balehi Nyamnyam		2	0.23
Malvaceae	*Dombeya buettneri*				3	0.35
	Sterculia oblonga	Yellow sterculia	Bodahi		29	3.34
	Sterculia rhinopetala				2	0.23
	Sterculia tragacantha	African tragacantha			2	0.23
Dracaenaceae	*Dracaena arborea*	Tree dracaena	Lera		1	0.12

Cont'd. Phenology Checklist of Tree Species

Putranjivaceae	*Drypetes floribunda*				2	0.23
Meliaceae	*Ekerbergia senegalensis*		Red karehi		11	1.27
	Entandrophargma candollei				1	0.12
	Khaya senegalensis	African mahogany	Dalehi	Madachi,Mahoga	16	1.85
	Lovoa trichilioides	African walnut			1	0.12
	Pseudocedrela kotschyi	Dry zone cedar	Wada wurohi		1	0.12
	Trichilia martineani		Kobahi		55	6.34
	Trichilia splendid		Kobahi		8	0.92
Arecaceae	*Elaeis guineensis*	Oil palm		Kwara	4	0.46
	Phoenix reclinata	Wild date palm	Bali darle		1	0.12
Papilionoideae	*Erythrina sigmoidea*				4	0.46
Guttiferae	*Garcinia afzelii*	Bitter cola	Bura lainde		2	0.23
	Garcinia smeathmannii				2	0.23
	Psorospermum febrifugum	Christmas berry	Sawalki		1	0.12
Clusiaceae	*Harungana madagascarensis*				1	0.12
	Symphonia globulifera		Chabbole lainde		1	0.12
Salicaceae	*Homalium dalzielii*		Mahbelko lainde		6	0.69
Bignoniaceae	*Kigelia africana*	Sausage tree			2	0.23
	Markhamia lutea	Nile tulip tree			1	0.12
	Markhamia tomentosa				5	0.58
	Spathodea campanulata	African tuliptree			4	0.46
	Sterospermum kunthianum	Pink jacaranda	Golombe		3	0.35
Anacardiaceae	*Lannea acida*		Muratuta		19	2.19
	Lannea avvic				1	0.12
	Lannea barteri				1	0.12
	Lannea kestingii				3	0.35
	Lannea nigritana	Wodier wood			2	0.23
	Pseudospondias microcarpa	African grape	Mugum		19	2.19

Cont'd.Phenology Checklist of Tree Species

Strephonemataceae	*Strephonema manii*		Kom		32	3.69
Ochnaceae	*Lophira lanceolata*	Red iron wood	Sakto, Pirohi	Jatau, Namijin kadanya	2	0.23
	Ochna schweifurthiana	Brick-red ochna			15	1.73
Maesaceae	*Maesa lanceolata*	False assegai			1	0.12
Celastraceae	*Maytenus senegalensis*	Confetti tree	Yayehi		1	0.12
Dipterocarpaceae	*Monotes kerstingii*		Naude	Towon biri	3	0.35
	Monotes polyandra		Naude	Towon biri	2	0.23
Pandanaceae	*Pandanus candelabrum*	Screw pine	Butol tigon	Ananan daji	2	0.23
Myristicaceae	*Pycnanthus angolensis*	African nutmeg			2	0.23
Olacaceae	*Strombosia pustulata*		Ciwo lainde		7	0.81
Myrtaceae	*Syzygium guineense*	Water berry, Rose apple, Bicoloured waterberry	Sumsum		1	0.12
	Syzygium guineense var. macrocarpum		Buneji	Cika kondo	1	0.12
Apocynaceae	*Tabernaemontana pachysiphon*	Pinwheel flower			2	0.23
Celtidaceae	*Trema orientalis*	Trema, Pigeon wood			1	0.12
Melianthaceae	*Bersama abyssinica*	Winged bersama		Loko	1	0.12
Calophyllaceae	*Calophyllum pentasa*				1	0.12
?	*Malcantha alnifola*				16	1.85
Lecythidaceae	*Napoleonaea talbati*				1	0.12
Capparidaceae	*Crateva adansonii*	Garlic pear tree, Obtuse leaf crateva			1	0.12
?	*Monodora mystica*				1	0.12
?	*Mychinia sp.*				1	0.12
?	*Endodesmia pentadesma*				1	0.12
Total					**867**	**100.00**

Source: Field Survey, 2022