SEASONALITY OF OLIVE BABOONS' FOOD AND THE IMPORTANCE OF PLANT PHENOLOGY TO WILDLIFE FEED AVAILABILITY IN KAINJI LAKE NATIONAL PARK, NIGERIA

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Abstract: Olive baboons (*Papio anubis*) are referred to as savanna dwelling species. Kainji Lake National Park (KLNP) is an example of a savanna ecosystem characterized by seasonality in plant productivity. Wild animals in such habitat have the challenge of finding enough food across the seasons. This study therefore centered on the seasonality of olive baboons' food and the role of plant phenology on the food availability in KLNP. Direct observation method was used to elicit data on food plant species consumed by olive baboons in KLNP during the dry and wet seasons, for a period of 24 months. Data were analyzed using descriptive statistics and ANOVA at $\alpha_{0.05}$. Sixteen food plant species (*Dioscorea rotundata, Cochlospermum tinctorium, Swartzia madagascariensis, Isoberlina doka, etc.*) belonging to 12 families were identified during dry season while nine food plant species (*Piliostigma thonningii, Grewia molle, Tamarindus indica, etc.*) belonging to 8 families were identified in the wet season. There were more variety of food plants for olive baboons in the dry season (64%) than in wet season (36%). Proximate composition of the food plants indicated a relative stability in the nutritional composition (crude protein) of food plants despite the seasonal variation in food availability. The phenological pattern of food plant species made more food variety available for olive baboons in dry season and provided year round availability of food resources in the park. KLNP offered a rich habitat for the conservation of olive baboons in Nigeria.
Keywords: Food, Kainji Lake National Park, mutualism, plant phenology, seasonality

Introduction

Kainji Lake National Park (KLNP) is a typical example of a savanna ecosystem characterized by scattered drought resistant trees and shrubs with attendant variability in annual rainfall (Solbrig, 1996). There is a consequent and significant seasonality of plant productivity in savannas occasioned by rainfall seasonality. Seasonality usually entails 'the occurrence of certain obvious biotic events, or groups of events, within a definite limited period, or periods of the astronomic (solar or calendar) year (Lieth, 1974). Wild animals dwelling in such seasonal habitats are therefore confronted with the herculean task of finding enough food and water across the season, even as the situation gets exacerbated in the drier months (Alberts *et al.*, 2005). Availability of forage resources is not always regular throughout the year which may be a setback to wildlife population. For instance, no fruit is available for several months in the year (Hanya *et al*., 2004). Frugivores primates such as olive baboons (*Papio anubis*) will therefore have to settle for variable diets due to fluctuating resource availability (Dew, 2003). (Chapman and Chapman, 1990) gave credence to this by identifying seasonality as one of the probable factors contributing to diet variability in primates.

Plant phenology is also affected is also affected by periodic fluctuations in rainfall, temperature and photoperiod (Leith, 1974). Plant phenological pattern, to a large extent determines the temporal and spatial variation in the availability of plants resources and by extension; olive baboons' diet with far reaching implications for primate social structure and reproductive performance (van Shaik *et al.*, 1993; van Shaik and Brockman, 2005). An understanding of the phonological pattern of olive baboons' plant foods in KLNP is therefore pivotal to primate ecology and conservation.

Primates are considered a very suitable taxon for effects of seasonality and are sometimes referred to as important ecological interactors (Hanya *et al*., 2011; Dew, 2003). They display high level of flexibility in their distribution and diet. Several primate species inhabit tropical and subtropical regions typified by varying degree of seasonality (Myers *et al.* 2000 and Mandl, 2018). Olive baboons in particular have a broad distribution across Africa (Grooves, 2001). Although olive baboons are described as savanna dwelling species, they also inhabit moist ever green forests (Cawthon, 2006). They consume an array of food types with a complementary skill of being able to extract food from the ground, in trees and underground (Cawthon, 2006). This study therefore focused on the seasonality of olive baboons' diet in KLNP and the role of plant phenological pattern on olive baboons' food availability.

Materials and Methods

Study area

This research was conducted in Kainji Lake National Park. The Park was established in 1979 by the merger of two former non- contiguous game reserves (Borgu and Zugurma) into one enitity. It covers a total area of 5,340.82 km^2. The two sectors (Borgu and Zugurma) of KLNP lie approximately between latitudes 9^0 40'N and 10^0 30'N and longitudes 3^0 30'E and 5^0 50'E respectively (Aremu *et. al*., 2000). KLNP is situated in the boundary between the North and South of Guinea Savanna. Riparian Forests also occur on the banks of larger water courses. Generally, the vegetation is described as Northern Guinea Savanna which has formations of mosaic of plant communities contrasting in structure. The topography of the park is gently undulating with general decrease in elevation from West to East. Some areas are hilly with the highest elevation of about 300 – 350 m above sea level (Ayeni, 2007). The park is drained by a network of rivers and streams, all of which empty into rivers Oli, Timo and Doro while the drainage in Zugurma sector consists of rivers Manyara and Ruwa Zorugi. The park has a yearly circle of dry and wet season based on Northern Savanna climate. The wet season begins from April to October while the dry season is from November to early April with a short harmattan period between mid-December and February. The annual rainfall ranges from 975 to 1220 mm (Ayeni, 2007). KLNP has about 59 plant families. The dominant tree species include; *Burkea africana, Detarium microcarpum, Afzelia africana, Isoberlina tomentosa, Acacia spp.*, etc. There are over 66 species of large mammals represented by about 13 artiodactyls, 10 carnivores and 5 primate species. The area is also rich in bats, birds and insects (Ayeni, 2007). In addition, there are also 62 species of fish belonging to 20 families and 28 species of reptiles and amphibians. Examples of the animal species in the park include Roan antelope (*Hippotragus equinus*), Olive baboon (*Papio anubis*), Patas monkey (*Erythrocebus patas*) Buffalo (*Syncerus caffer*), Senegal (*Kobus kob*), Hippopotamus (*Hippopotamus amphibus*), etc. (Ayeni, 2007).

Method of data collection

Direct observation method was adopted in eliciting information on the feeding activities of olive baboons in the study area while they foraged during the dry and wet seasons for a period of 24 months. This was achieved through the following procedures:

i. **Trailing system:** This involved following behind tracing (through the foot prints and fresh feacal droppings) of the animals especially in the evening from drinking sites (water holes such as rivers and streams) to their sleeping sites. Often times, olive baboons retire from water points in the evening to their sleeping sites. However it is worthy of note to state that considerable and appropriate distances were kept away from the animals depending on the visibility and vegetation cover. The minimum distance kept was 5 m. This was to avoid the study animals from being agitated and to ensure that the observers were not attacked by the study animals.

ii. **Auditory clues:** Olive baboons` feeding sites were identified by trailing their vocalization such as long, alarm calls, warning barks and other forms of vocal communications they made right from the sleeping sites before departure for foraging in the morning. There vocalizations were traced from 05:00 h. The study was conducted for a period of 24 months covering wet and dry seasons.

Food samples collection

Terrestrial food samples eaten by Olive baboon were collected with the aid of machetes and plant pruners. Poles were used to extract arboreal foods. Opportunistic collection of food samples was also carried out whereby food samples were picked from fallen fruits or branches dropped by animals. An average of 500 g wet weight for each sample was collected as recommended by Rothman *et al.* (2011). The samples were weighed immediately after collection and labeled appropriately. They were thereafter air dried prior to transportation in a sealed plastic bag to the laboratory for nutritional analysis. The essence of the drying was to inhibit enzymatic activity so as to prevent chemical shift and preserve the samples' nutritional attributes (Rothman *et al.*, 2011).

Nutritional composition of food samples

Proximate composition of the plant part eaten by olive baboons in the study area was determined using the methods of Association of Analytical Chemist (AOAC, 2005).

Data analysis

Descriptive statistics such as frequencies, percentages and pie chart were used to present results of plant species consumed proportion of plant parts consumed and result of proximate analysis. Analysis of variance was used to establish significant differences among nutrient composition of various plant species consumed by olive baboons. The level of significance was at $P \leq 0.05$.

Results and Discussion

Out of all the food plant species recorded during the study period, sixteen of them belonging to twelve families were identified during the dry season while nine food plant species belonging to eight families were identified in wet season (Table 1). There was marked variation between food plants available for olive baboons (*Papio anubis*) in the dry season and the wet season. This phenomenon is typical of savanna vegetation. Unlike in the tropical forest with no clear cut rainfall seasonality, there is great variability of rainfall in savanna across the year with consequent considerable seasonality of plant productivity orchestrated by seasonality of rainfall. Tropical savannas are different from forests in having less rainfall which is strongly seasonal and often very unpredictable even within seasons (Bourliere and Hadley 1983; Solbrig, 1996).

Table 1: Plant species consumed by olive baboons in KLNP on Seasonal basis

S/N	Dry season		Wet season	
	Plant species	**Family**	**Plant species**	**Family**
1	*Dioscorea rotundata*	Dioscoreaceae	*Piliostigma thonningii*	Fabaceae
2	*Cochlospermum tinctorium*	Cochlospermaceae	*Grewia molle*	Malvaceae
3	*Swartzia madagascariensis*	Fabaceae	*Tamarindus indica*	Fabaceae
4	*Isoberlina doka*	Fabaceae	*Strychnus spinosa*	Strcychnaceae
5	*Kigelia africana*	Bignoniaceae	*Spondias mombin*	Anacardiaceae
6	*Ficus sycomorous*	Moraceae	*Discorea rotundata*	Dioscoreaceae
7	*Grewia molle*	Malvaceae	*Nauclea latifola*	Rubiaceae
8	*Piliostigma thonningii*	Fabaceae	*Oncoba spinosa*	Salicaceae
9	*Vitelaria paradoxa*	Sapotaceae	*Adansonia digitata*	Bombacaceae
10	*Icacina trichantha*	Icacinaceae		
11	*Vitex chrysocarpa*	Lamiaceae		
12	*Afzelia africana*	Fabaceae		
13	*Xamenia americana*	Olacaceae		
14	*Detarium microcarpum*	Caesalpiniacea		
15	*Parkia biglobosa*	Fabaceae		
16	*Gardenia sotoemesis*	Rubiaceae		

Furthermore on the account of the broad geographic range of olive baboons, it is envisaged that their habitat will vary in the amount and seasonality of rainfall which could account for seasonal variation in resource availability (Janson and Verdolin, 2005). By implication, getting adequate food and water is a challenge associated with animals living in seasonal environments. However by evolution and over time, animals in savanna habitat develop adaptations to cope with these seasonal changes. For instance, a look into the result of comparison of proximate composition of olive baboon diet between dry and wet season in the study area indicated that there was generally a slight difference between the seasons (Tables 2 and 3). In other words, regardless of variation in the number of available plant species between the two seasons, the nutritional composition of Olive baboon diet hardly varied. In fact, crude protein had the same mean values for both dry and wet seasons (Tables 2 and 3). There was a relative stability of Olive baboon diet across seasons despite seasonal pattern in food availability. In the same vein, baboons in Amboseli National Park, Kenya achieved stability in their diet, notwithstanding their food types showing seasonality and different temporal pattern of availability (Alberts *et al.*, 2005).

Table 2: Proximate composition of plant species eaten by olive baboons in Dry season in Kainji Lake National Park

Plant species	%CP	%CF	%ASH	%EE	%DM	%NFE
D. rotundata	4.99^{h}	14.67^{e}	5.29^{c}	0.48^{jk}	32.9^{i}	74.58^{e}
C. tinctorium	2.29^{j}	51.16^{a}	3.14^{i}	0.18^{k}	91.33^{ab}	43.23^{m}
S. madagascariensis	22.30^{b}	18.59^{c}	6.40^{b}	5.54^{d}	91.59^{ab}	47.18^{k}
I. doka	26.98^{a}	11.23^{g}	7.39^{a}	8.19^{b}	34.38^{hi}	46.22^{l}
K. africana	18.09^{c}	6.28^{k}	4.94^{d}	4.28^{f}	32.66^{i}	66.42^{h}
F. sycomorous	13.43^{e}	8.16^{i}	4.56^{e}	7.23^{c}	54.61^{f}	66.63^{h}
G. molle	11.97^{f}	7.63^{j}	4.08^{f}	7.04^{c}	36.52^{h}	69.29^{g}
P. thonningii	17.62^{c}	19.35^{b}	5.07^{d}	4.62^{e}	92.76^{a}	53.34^{j}
V. paradoxa	8.41^{g}	15.33^{d}	3.42^{h}	2.27^{h}	93.29^{a}	70.57^{f}
I. trichantha	2.34^{j}	2.01^{n}	3.89^{g}	0.41^{jk}	33.73^{i}	91.36^{a}
V. chrysocarpa	5.39^{h}	10.04^{h}	1.91^{l}	22.92^{a}	36.94^{h}	59.74^{i}
A. africana	1.93^{j}	3.65^{m}	2.55^{k}	0.67^{j}	89.95^{b}	91.21^{a}
X. americana	3.79^{i}	3.37^{m}	2.90^{j}	4.66^{e}	62.06^{e}	85.29^{c}
D. microcarpum	2.09^{j}	11.89^{f}	3.20^{i}	0.55^{j}	71.91^{c}	82.27^{d}
P. biglobosa	16.74^{d}	5.95^{k}	4.19^{f}	3.73^{g}	67.49^{d}	69.39^{g}
G. sotoemesis	3.81^{i}	4.58^{l}	3.28^{hi}	1.33^{i}	38.79^{g}	87.00^{b}
Means	10.14	12.12	4.14	4.63	60.06	68.98

abc means within the same column with different superscripts differs significantly ($P \leq 0.05$)
CP: Crude Protein; C.F: Crude Fibre; ASH: Ash Content; EE: Ether Extract; DM: Dry Matter; NFE: Nitrogen Free Extract

Table 3: Proximate composition of plant species eaten by olive baboons in Wet season in Kainji Lake National Park

Plant species	%CP	%CF	%ASH	%EE	%DM	%NFE
Piliostigma thonningii	4.36^{i}	10.93^{c}	3.40^{i}	2.08^{f}	89.06^{a}	68.07^{a}
Grewia molle	6.07^{g}	13.36^{b}	20.56^{a}	1.08^{g}	79.50^{c}	38.44^{c}
Tamarindus indica	16.06^{a}	17.19^{a}	5.44^{f}	2.24^{e}	74.98^{d}	34.06^{d}
Strychnus spinosa	11.31^{e}	7.14^{e}	3.95^{h}	2.95^{c}	30.16^{h}	4.81^{h}
Spondias mombin	9.93^{f}	6.00^{f}	5.01^{g}	3.23^{b}	63.59^{f}	39.43^{c}
Discorea rotundata	12.48^{c}	2.94^{g}	6.65^{e}	1.03^{g}	29.31^{h}	6.33^{g}
Nauclea latifola	4.94^{h}	6.36^{f}	11.52^{b}	2.58^{d}	33.46^{g}	8.07^{f}
Oncoba spinosa	14.06^{b}	8.46^{d}	11.06^{c}	2.29^{e}	65.63^{e}	29.77^{e}
Adansonia digitata	12.09^{d}	6.03^{f}	7.68^{d}	3.62^{a}	86.98^{b}	57.58^{b}
Means	10.14	8.71	8.36	2.34	61.41	31.84

***abc** means within the same column with different superscripts differs significantly ($P \leq 0.05$)*
CP: Crude Protein; C.F: Crude Fibre; ASH: Ash Content; EE: Ether Extract; DM: Dry Matter; NFE: Nitrogen Free Extract

The ability of baboons to stabilize their diet even when found in seasonal habitats ranging from deserts to savannas has been implicated in their success of being able to reproduce throughout the year. As found in most vertebrates, the bulk of primate species exhibit reproductive seasonality that indicates the seasonality of their habitat. There are however two exceptions to the rule of seasonal reproduction: humans and baboons which imply that they are able to reproduce throughout the year in seasonal environments (Alberts *et al.*, 2005).

The result of the study (Table 1) also agrees with Adeola *et al*. (2014) that there was seasonal variation between the food plants available to Olive baboons in the dry season and wet season in the study area. They reported seven (7) and ten (10) plant species to be available for baboon in the wet and dry seasons respectively. Similarly, Akosim *et al*. (2010) in their study of feeding behavior of baboons in Hong Hills, Adamawa State found out that nine (9) forage plants were available and eaten by Olive baboon in the wet season while another seven (7) forage plants were available and eaten by baboons in the dry season.

The phenological pattern observed in KLNP has implications on food availability for olive baboons in KLNP. It made more variety of food to be available in the dry season, contrary to the assumption that there is often food shortage in the dry season than wet season (Fig. 1). This is contrary to the findings of Akosim *et al*. (2010) who found more plants to be available for baboons in the wet season than in the dry season in Hong hills but agrees with the findings of Adeola *et al*. (2014) in the same KLNP that Olive baboons had more variety of food plants in the dry season than in the wet season. This can possibly be explained by the concept of plant phenology.

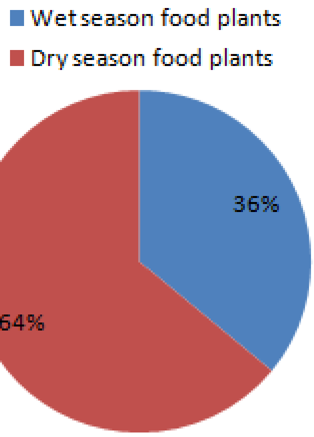

Fig. 1: Proportion of food plant species available to olive baboons between dry and wet season in KLNP

Phenology has to do with the study of periodic biological events in the animal and plant world as influenced by the environment, especially temperature changes driven by weather and climate (Dube *et al*., 1984). Silva expressed the view that climatic factors appear to be more important than phylogenetic history in determining the reproductive period i.e. the seasonal timing of flowering and fruiting of plants in savannas. Phenology is the art of observing life cycle phase of plants and animal in their temporal occurrence throughout the year. Or better still, the calendar of events in the life history of plants (Leith, 1970; Abu-Asab *et al*., 2001).

Our observation on the field was that most of Olive baboon food plant species followed a particular reproductive phenological rhythm in which production of fruits began late in wet season, transcended into the dry season and ripened often time in the harmattan period of the dry season. The seasonal timing of flowering and fruiting is directly associated with resource availability to animals and consequently has effects on herbivory, pollination and seed dispersal (Mduma *et al.*, 2007; Stevenson *et al.*, 2009; van Schaik *et al.*, 1993). The importance of plant phenological pattern observed in KLPN made more variety of food plant species to be available for olive baboons in the dry season than in wet season in contrary to the general view of food shortage in dry season.

This phenological pattern has ecological implication on other sympatric animals that share the same habitat with olive baboons having frugivory tendency. Such animals will have these fruits as fallback foods when the landscape becomes deciduous and other palatable resources have been depleted. Fallback foods are resources animals consume when their preferred foods are unavailable. They are critical for a population's survival although they may not be the preferred food items (Marshall and Wrangham, 1994; Marshall *et al*., 2009).

The phenological pattern in KLNP also facilitated year round availability of food resources for olive baboons. In other words, the temporal distribution of food resources between dry and wet season was fairly spread. It is of essence that food resource availability be as temporally even as possible across seasons. With this occurrence, the study animals had guaranteed food items irrespective of the season. This is quite essential for the wellbeing of free ranging animals. Wild animals such as olive baboons in KLNP that are predominantly frugivorous in their diet (Odebiyi and Alarape, 2017) can be adversely affected by a sharp decline in fruit production with far reaching implications on their management and conservation (Camargo *et al.*, 2013; Kannan and James, 1999). The year round availability of food resources for olive baboons in KLNP makes the park an ideal and suitable habitat for olive baboons (Table 1). Erratic supply or sudden decline in fruit availability have drastic effect on vertebrate frugivores like olive baboons. For instance, elsewhere in Barro Colorado Island Panama, a community wide scarcity of fruits brought about a plummeting of frugivorous vertebrate populations (Wright *et al.,* 1999). The year round availability of food resources occasioned by the plant phenological pattern would have a consequential effect on reproductive, population and conservation of olive baboons in the park. Extended period of sufficient food resources is unarguably complementary to the reproductive performance of living organisms. This explains why most female mammals synchronize their pregnancy and nursing of infants with the time of abundant forage resources. For instance, Verhulst *et al.* (1997) and Husby *et al.* (2009) reported that some avian sp can double-brood within a year if food resources are adequate.

From all the aforementioned, it is evident that olive baboons benefited from the interaction with their food plant species. However, in ecology, when relationship between different organisms is positive for both parties, such interaction is said to be mutual. While olive baboons in KLNP derived food and survived on the nutrient from the fruit bearing plants, they reciprocated by acting as the plants' agent of seed dispersal thereby preventing seedlings competition, seed predation and ultimately sustaining the plant diversity and ecosystem function of the park. The place of olive baboons and other frugivores in the natural ecosystem cannot be downplayed. Frugivores facilitate the rejuvenation of degraded vegetation. An unusual decimation of olive baboon population in KLNP can be very devastating for nature conservation. Galetti and Dirzo (2013) reported that plant conservation has suffered set back owing to decimation of wildlife species in tropical ecosystem with repercussion on seed dispersal and seedling establishment. This is far reaching on large-bodied seed dispersers that are often the target of hunters (Dirzo *et al.*, 2014). Mutualistic interactions can be closely interrelated whereby the decimation of a particular species can have ripple effects on other species that interact with it.

Conclusion

There was seasonal variation in availability of food plant species for olive baboons in KLNP. Nevertheless, olive baboons had a relatively stable diet across the seasons. The phenological pattern of food plant species in the park made more food variety to available for olive baboons in the dry season and year round availability of food resources. KLNP offered a rich habitat for the conservation of olive baboons in Nigeria. Success achieved in the conservation of olive baboons in KLNP should be consolidated through effective park protection, regular monitoring and evaluation of the park's biodiversity.

Conflict of Interest

Authors declare that there is no conflict of interest reported on this work.

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