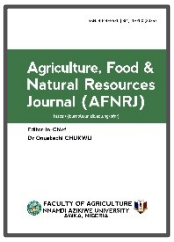
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Original Article

Assessment of forage preferences and dietary composition of African Elephant (*Loxodonta africana*) in Yankari Game Reserve, Nigeria

OPEN ACCESS

Mala MODU* & Deborah Jame JAWAL

Department of Forestry and Wildlife, University of Maiduguri, Maiduguri, Nigeria

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ABSTRACT

The African elephant, Loxodonta africana, is a generalist megaherbivore that utilizes a wide range of plant species. However, habitat loss and fragmentation threaten its food resources and long-term survival. This study assessed the dietary composition, feeding duration, plant parts consumed, and nutritional value of frequently utilized forage species of elephants in Yankari Game Reserve, Bauchi State, Nigeria. Direct observation using focal and scan sampling of feeding behavior was conducted during the late dry season when food availability is most limited and foraging pressure is highest. Observations were done daily during morning [0600–0900 hrs] and evening [1600–1800 hrs] periods for three consecutive weeks to document feeding behavior and plant species consumed. Data was analysed using descriptive statistics. A total of ten plant species were identified in the diet, with leaves constituting a greater proportion of intake than bark. Based on frequency of consumption, four dominant species, Acacia xanthophloea, Ficus thonningii, Combretum imberbe, and Ziziphus mucronata, were selected for proximate and mineral analysis. Ficus thonningii and A. xanthophloea recorded the highest crude protein contents of 15.2% and 13.4%, respectively, indicating higher nutritional value relative to the other species. The findings provide baseline data on elephant forage ecology and nutritional requirements, which are critical for habitat management and conservation planning in the Reserve. The study recommends intensified protection of key forage species and control of illegal activities that threaten elephant forage resources and habitat integrity.

KEYWORDS: *Feeding ecology, Forage species, Nutritional value, Proximate composition, Wildlife conservation*

INTRODUCTION

Forage ecology represents a fundamental animal–environment interaction and underpins several aspects of wildlife ecology, including population dynamics, habitat use, reproductive strategies, and predator–prey relationships (Hohmann *et al.,* 2006). The African elephant, *Loxodonta africana* Blumenbach 1797, is a generalist megaherbivore adapted to diverse habitats through the exploitation of a broad spectrum of plant species. As mixed feeders, elephants are both browsers and grazers, and are physiologically dependent on water, which influences seasonal range shifts in response to variation in forage quality and quantity (Codron *et al.,* 2006). Key morphological and physiological adaptations, such as the prehensile trunk, hypsodont dentition, and a hindgut fermentation system, enable the ingestion and processing of large quantities of low-quality forage necessary to meet the nutritional demands of their massive body size (Sukumar, 2003). However, nutrient assimilation efficiency in elephants is relatively low, making diet selection and forage availability critical determinants of individual fitness and population persistence.

African elephants have high daily nutritional and water requirements, consuming an estimated 5% of their body mass in forage per day (Stephenson, 2007). Their diet is broadly categorized as mixed-feeding and may comprise grasses, bark,

*Corresponding author: malamodu50@unimaid.edu.ng

leaves, roots, fruits, and herbs, with the relative proportions varying according to season and habitat type (White *et al.,* 1993). Foraging is facilitated by morphological specializations: the trunk is used to grasp and manipulate vegetation, while tusks are employed to strip bark and uproot trees, thereby accessing otherwise unavailable plant parts. Reported intake rates are high, with individuals consuming up to 300 kg of forage and 225 L of water daily, and allocating more than two-thirds of their diurnal activity budget to feeding (Stephenson, 2007). Feeding patterns are also spatially constrained by water availability; elephants often undertake long-distance movements to water points, and the seasonal distribution of both food and water strongly influences habitat use and foraging behavior (Stephenson, 2007).

Yankari Game Reserve is a protected area characterized by high tree species richness and structural heterogeneity (Badamasi, 2014). It remains one of the few sites in Nigeria where free-ranging wildlife, including *Loxodonta africana*, can be readily observed (Bergl et al., 2011). The vegetation of Yankari is less uniform and the grass layer is shorter than in southern Nigeria. This structure enables elephants to exploit ground-level forage up to approximately 6 cm in height. Forage processing is facilitated by specialized dentition two to three pairs of large, ridged molars for mastication and the dexterous trunk for selection and manipulation of plant material (Dana, 2018). Dietary diversity is important for meeting nutritional requirements and maintaining population health in elephants. Consequently, documenting the availability of plant species, quantifying elephant feeding preferences, and determining the nutritional composition of key forage species in Yankari Game Reserve are necessary to address existing knowledge gaps and inform strategies for the dietary sustainability of elephants.

MATERIAL AND METHOD

Study Area

The study was conducted in Yankari Game Reserve, located in northeastern Nigeria, Bauchi State, between latitudes $9^{0}40'00''$ N and $10^{0}00'00''$ N and longitudes $10^{0}20'00''$ E and $10^{0}40'00''$ E. The Reserve covers an area of 2,244 km2 and spans Duguri, Pali, and Gwana Districts of Alkaleri Local Government Area (Figure 1). Yankari was designated a Game Reserve by the British colonial administration in 1956, gazetted as a wildlife sanctuary in 1965, and upgraded to National Park status under the Nigerian National Parks Service in 1991 (Arhyel *et al.,* 2019). Management was devolved to the Bauchi State Government in 2006, after which Yankari reverted to its present status as a Game Reserve (Bergl *et al.,* 2011).

The Reserve is a recognized biodiversity hotspot and supports the largest viable population of savannah elephants, *Loxodonta africana*, in Nigeria (Bergl *et al.,* 2011). Vegetation is more heterogeneous and structurally diverse in the southern portion and along the Gaji River catchment compared to northern areas (Walter, 1967 Topography varies from mountainous terrain in the southwest, associated with the Jos Plateau, to predominantly sandy plains in the north (Walter, 1997). During the dry season, the environment becomes patchy and desiccated, with deciduous trees and shrubs shedding leaves as a drought adaptation, while bush burning is a frequent disturbance (Iloeje, 2009). Dominant woody species include *Afzelia spp., Isoberlinia doka, Khaya senegalensis, Vitex doniana, Anogeissus leiocarpus, Tamarindus indica, Detarium microcarpum, Combretum spp., and Pterocarpus erinaceus* (BirdLife International, 2007). Riparian vegetation along the Gaji, Gongola, and Jama'are floodplains is denser and taller than on upland and hilly sites (Abdullahi, 2010).

Data Collection

Direct focal animal sampling was used. feeding observations were conducted during the late dry season. This period was chosen because it coincides with maximum resource limitation in Sudan savanna ecosystems, and is therefore critical for understanding dietary stress and plant species selection by elephants. Observations were carried out daily during morning [06:00–09:00 h] and evening [16:00–18:00 h] periods over three consecutive weeks. These times correspond to peak feeding periods for elephants. Upon encountering an elephant group, one adult individual was randomly selected as the focal animal and observed continuously for up to 20 minutes or until the animal moved out of sight.

For each feeding event, the following variables were recorded: i) number of individual elephants observed feeding, ii) plant species consumed, iii) plant parts utilized, iv) number of plant individuals browsed per species, and v) feeding duration. Feeding duration was measured from the initiation to the cessation of continuous foraging on a plant or plant part (leaves, bark, stem, fruit) by an individual elephant.

Data Analysis

For nutritional assessment, sample feeds were subjected to proximate analysis to determine dry matter, crude protein, crude fibre, ether extract, ash, carbohydrate, and nitrogen-free extract following AOAC (1990) standard methods Descriptive statistics were used to summarize feeding and laboratory data. Results were presented in tables and charts.

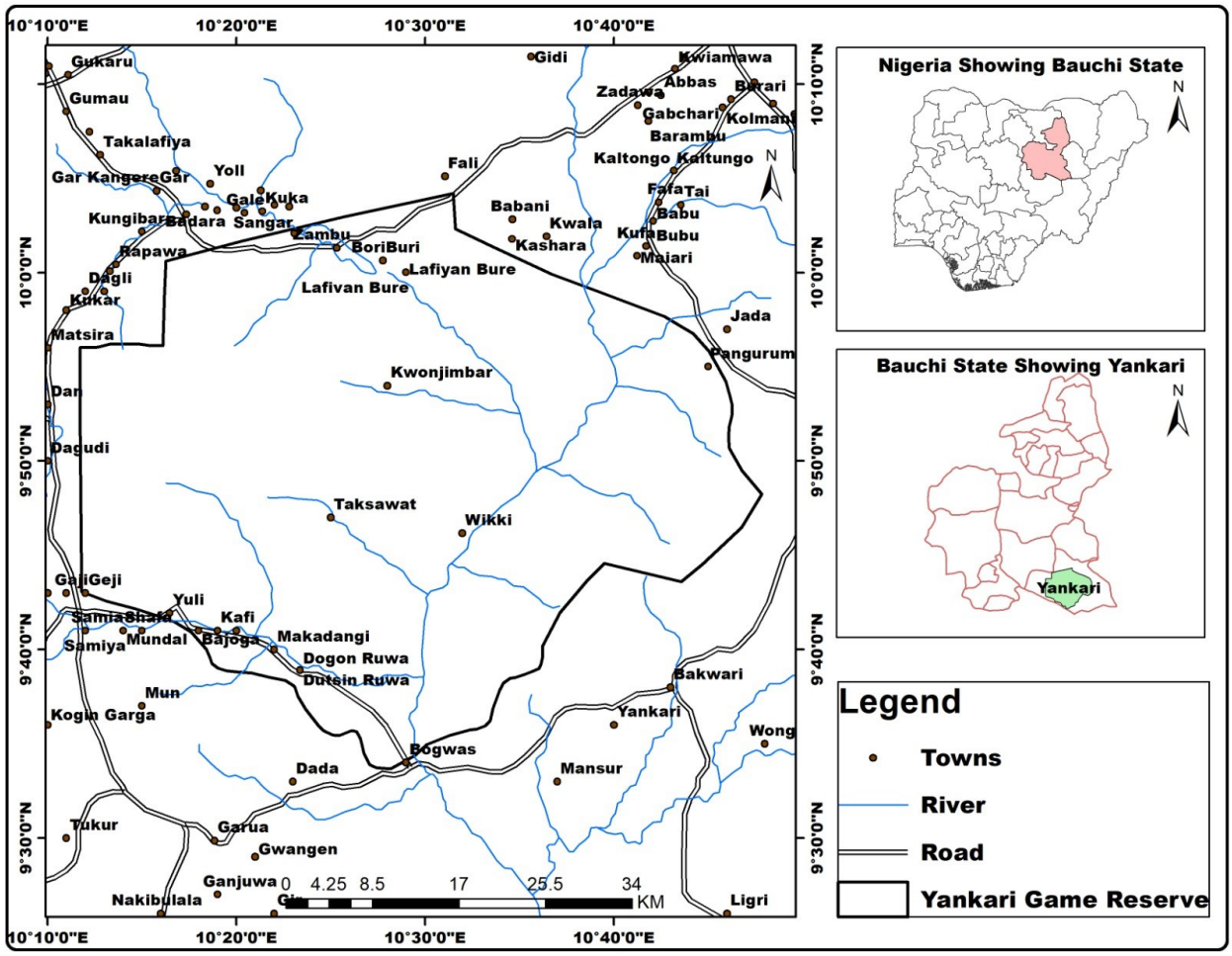


Figure 1: Map of Yankari Game Reserve Nigeria.

RESULTS

Diet Composition and Food Preference of Elephants in Yankari Game Reserve

Elephants in Yankari Game Reserve utilized a diverse range of plant species. During the study period, the following species were observed to coincide the diet of *Loxodonta africana*: *Acacia xanthophloea, Commiphora africana, Terminalia sericea, Combretum imberbe, Diospyros mespiliformis, Ficus thonningii, Grewia bicolor, Ziziphus mucronata, Panicum maximum,* and *Cenchrus ciliaris*. Habitat use was not restricted to a single vegetation type, although some habitats were used more frequently than others, suggesting their relative importance for elephant foraging. Feeding preferences, plant parts utilized, and feeding duration are summarized in Table 1.

Feeding Duration and Schedule

All feeding events were recorded in the morning between 06:00 and 09:00 h, with peak activity occurring between 08:00 and 09:00h. No feeding was recorded during evening observation periods.

The duration of individual feeding bouts ranged from 10 to 45 min, with 45 min representing the maximum continuous feeding duration recorded. The concentration of feeding activity in the cooler morning hours suggests a behavioral adaptation to minimize heat stress and maximize foraging efficiency.

Plant Parts Utilized

Leaves constituted the most frequently consumed plant part by elephants in Yankari Game Reserve (Figure 3). This was followed by twigs and fruits, indicating a varied intake of vegetative and reproductive parts. Bark and small branches were the least utilized, likely reflecting selective foraging preferences.

Table 1: Common plant species consumed by elephants

Food preference	Parts utilized	Feeding duration
Ziziphus mucronata	Leaves and twigs	45 minutes
Cenchrus ciliaris	Leaves and twigs	45 minutes
Acacia xanthophloea	Leaves and small branches	15 minutes
Panicum maximum	Bark and leaves	20 minutes
Ficus thonningii	Bark and leaves	20 minutes
Commiphora africana	Barks and leaves	18 minutes
Terminalia Sericea	Leaves and twigs	20 minutes
Combretum spp	Leaves and twigs	20 minutes
Diospyros mespiliformis	Fruits and leaves	40 minutes
Ficus thonningii	Leaves and twigs	10 minutes
Combretum imberbe	Fruits and leaves	30 minutes
Panicum maximum	Leaves and twigs	16 minutes
Grewia bicolar	Barks and leaves	20 minutes

Source: *Field survey, 2024*

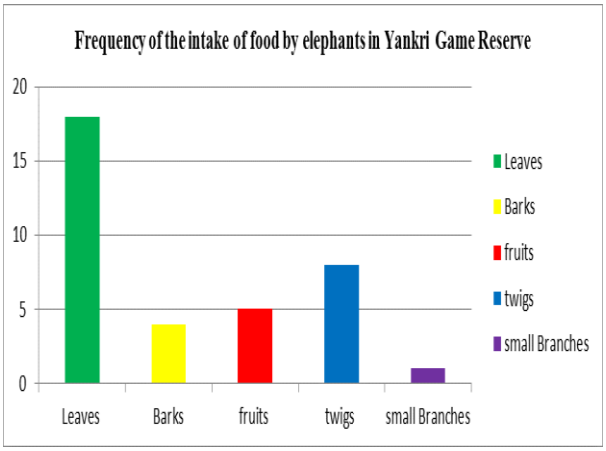


Figure 3: Frequency of plant parts consumed by elephants in Yankari Game Reserve

Elephant Foraging Behavior

Elephants in Yankari Game Reserve exhibited several foraging behaviors (Figure 4). Leaf browsing was the most common, accounting for 23.08% of all observations. Fruit feeding was also frequent, representing 19.23% of observations. Debarking and twig browsing were observed less frequently but remained important components of the foraging repertoire. Grazing and debranching were the least recorded behaviors.

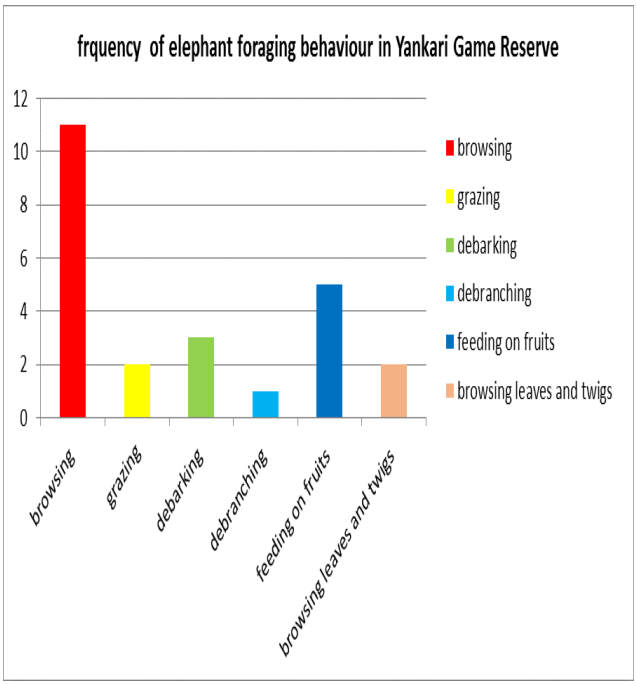


Figure 4: Elephant Foraging Behavior in Yankari Game Reserve

Proximate Composition of Forage Resources

Based on frequency of consumption, four dominant forage species *Acacia xanthophloea, Ficus thonningii, Combretum imberbe,* and *Ziziphus mucronata* were selected for proximate analysis. Table 2 presents the proximate composition of the selected forage species.

Table 2: Proximate composition of forage resources

Sample	Crude protein (%)	Fat/Ether Ext. (%)	Ash (%)	Moisture (%)	Crude Fibre (%)	NFE (%)	Carbohydrate (%)
Acacia xanthophloea	13.4 ± 1.2	2.3 ± 0.5	5.6	6.4 ± 0.5	18.6 ±1.5	40.5	56 ± 2.5
Combretum imberbe	12.1 ± 1.1	2.5 ± 0.4	5.1	6.2 ± 0.4	15.6 ±1.2	40.2	61 ± 21
Ficus thonningii	15.2 ± 1.3	3.65 ± 0.6	6.8	7.85 ± 0.6	20.35±1.8	47.9	49.8 ± 2.8
Ziziphus mucronata	10.2 ± 0.9	2.1 ± 0.3	4.5	5.5 ± 0.3	12.1±1.0	45.5	67.7 ± 2.9

DISCUSSION

During the study period, browsing was the dominant foraging mode observed in African elephants in Yankari Game Reserve. Elephants were observed to feed more on leaves than other plant parts. This agrees with previous studies which reported that elephants prefer leaves during the dry season when herbaceous plants are scarce. Peak feeding activity occurred in the morning hours [06:00–09:00 h], with a secondary peak in the evening [16:00–18:00 h]. This bimodal feeding pattern is typical of elephants and is likely an adaptation to avoid heat stress while maximizing nutrient intake.

Ficus thonningii (15.2% CP) and *Acacia xanthophloea* (13.4% CP) recorded higher crude protein values than *Ziziphus mucronata* (10.2% CP) (Table 2). The elevated protein levels in *F. thonningii* and *A. xanthophloea* are likely to be nutritionally important for elephants in Yankari Game Reserve, as protein is essential for muscle development, immune function, and reproduction. These findings are consistent with the patterns observed by Sukumar (1994) and Sharma et al. (2013), who emphasized the role of *Ficus* and *Acacia* species as high-quality forage and documented lower protein values for *Z. mucronata*. Both studies emphasized the role of dietary protein in meeting the nutritional requirements of large herbivores.

The high reliance of elephants on protein-rich woody species has been reported previously. Ihwagi et al. (2012) noted that Acacia spp. were key dietary items, particularly during the dry season, due to their availability and nutrient content. Similarly, Zyambo (2016) observed that most elephant damage to woody plants in savanna habitats occurred in the dry season, when browse formed a large proportion of the diet. This seasonal shift is likely driven by a decline in forage quality of grasses, which become increasingly fibrous and nutrient-dilute as the dry season progresses. Consequently, elephants increase browse intake, as browse species typically retain higher crude protein than senesced grasses and serve as an important dry-season nutritional reserve. The results of this study support this pattern. *Ficus thonningii* (15.2% CP) and *Acacia xanthophloea* (13.4% CP) were among the most utilized species in Yankari Game Reserve, and their relatively high protein content suggests they function as critical browse resources during periods of low grass quality.

Elephants have been reported to select high-protein forage during periods of nutritional stress, such as the dry season, to meet dietary requirements and maintain body condition (Pellew, 1983). This selective pattern is supported by Pettorelli *et al.* (2005), who emphasized the dietary importance of protein-rich species for elephants.

As hindgut fermenters, elephants rely on crude fiber, including cellulose and lignin, to maintain gut function and provide energy. Symbiotic microbes in the hindgut ferment structural carbohydrates to produce volatile fatty acids, which serve as an important secondary energy source, particularly during periods of low forage quality (Stevens, 1988). In addition to its energetic role, dietary fiber supports gut motility and maintains fermentation efficiency in the hindgut. The relatively high crude fiber content recorded in *Ficus thonningii* (20.35%) and *Acacia xanthophloea* (18.6%) would therefore promote slower passage rate and more efficient nutrient extraction in elephants utilizing these species.

Ash content reflects the mineral fraction of forage and contributes calcium, phosphorus, magnesium, and other elements essential for bone development, metabolic processes, and overall physiological maintenance in elephants. The relatively high ash content recorded in *Ficus thonningii* (6.8%) indicates that it may serve as an important mineral source for elephants in Yankari Game Reserve. This corresponds with observations from Samburu and Buffalo Springs in Kenya, where elephants increased use of nutrient and mineral-rich woody plants during periods of forage scarcity (Ihwagi *et al.,* 2012). Together, the moderate crude fiber and elevated ash values in Ficus and Acacia spp. suggest that these species can contribute to both digestive function and mineral nutrition of elephants.

CONCLUSION AND RECOMMENDATIONS

This study provides baseline data on the dry-season dietary diversity and foraging patterns of African elephants, *Loxodonta africana*, in Yankari Game Reserve. Elephants exhibited selective feeding, with leaves being the most utilized plant part and browse species such as *Ficus thonningii* and *Acacia xanthophloea* being preferentially selected. The higher crude protein and ash content recorded in these two species suggests that nutritional quality influences forage selection during periods of resource scarcity. Peak feeding activity in the morning hours and greater use of browsing over debarking indicate behavioral strategies to maximize nutrient intake under dry-season conditions. For conservation and habitat management in Yankari, protecting and regenerating key browse species, particularly *F. thonningii and A. xanthophloea*, is critical to sustaining elephant populations during the dry

season. Management should prioritize the conservation of riparian and woodland habitats that support key browse species. This study was limited to the dry season; future research should include both wet and dry seasons for a complete assessment of elephant nutritional ecology in Yankari. The study recommends protection and restoration of *Ficus thonningii* and *Acacia xanthophloea* through controlled browsing zones and targeted reforestation to ensure year-round availability. Enforcement against logging and other illegal activities within and around Yankari Game Reserve should be strengthen

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Authors' Contributions

MM & DJL Jointly handled interpretation of data, development of methodology, data analysis, development of the model, literature searches, material support, and review of the manuscript. Both wrote the first draft of the manuscript and approved the final manuscript.

Ethical Statement

Not applicable.

AI Declaration

The authors confirm that Artificial Intelligence (AI) tools were not used in any part of this research, including data generation, analysis, and manuscript preparation.

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