SEASONAL AVAILABILITY AND NUTRIENT CONTENTS OF MONA MONKEY (*CERCOPITHECUS MONA*, SCHREBER, 1774) PLANT DIETS IN LEKKI CONSERVATION CENTRE, NIGERIA

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ABSTRACT: The mona monkey is the only non-human primate in Lekki Conservation Centre, a privately owned Strict Nature Reserve located in a peri-urban part of Lagos, Nigeria. The reserve is becoming a forest island due to rapid urbanization around it. This study determined the seasonal availability of the plant foods utilized by the monkey during the dry and rainy seasons of 2011 and 2012. The nutrients and fibre fractions contents of the plant foods utilized in 2011 were determined using standard procedures. The plant parts consumed by the monkeys were determined by observing the feeding behavior of several troops for a total period of 33 days, and opportunistic collection of discarded portions. The nutrients determined were crude protein (CP), ether extracts (EE), crude fibre (CF), ash, and nitrogen free extracts (NFE) while the fibre fractions were neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), hemicellulose (HC), and cellulose (CS). The monkeys utilized different parts of 17 plant species from 11 Families. Based on the parts of plants accessed as food, fruits constituted 59 %. This was followed by nuts and seeds, 9 % each. During the dry season, *Mangifera indica* (whole tender fruits) had the highest CP value of 22.31 %. The highest NDF was found in the fruits of *Anthocleista vogelii*. In the rainy season, the highest CP and NDF values of 6.56 % and 66.40 % were respectively found in the seed of *Mussaenda polita*. Using CP as basis of the diets in the reserve to meet the monkeys' need, 11.52 ± 0.95 found in fruits (n =6) more than meets the recommended value of 6.4 – 8.0 % by the National Research Council.

KEY WORDS: Mona monkey, food seasonality, nutrient content, fibre fraction content

The mona monkey (*Cercopithecus mona* Schreber, 1774) is an arboreal non-human primate that depend on the forest ecosystem for food and other needs (Ejidike & Okosodo, 2007). They obtain macronutrients (carbohydrates, proteins, and lipids), micronutirents (minerals and vitamins) and water for their metabolism, growth and reproduction through foods sourced from their environments. These macronutrients supply energy and help in the building of new tissues; while micronutrients are needed in small amounts for physiological processes (Leonard, 2000; Lambert, 2007).

Seasonality which results in the alternation of dry and wet seasons in rain forests causes variation in the availability of reproductive and vegetative parts of plants thereby resulting in abundance or scarcity of food for consumers such as primates (van Schaik & Brockman, 2005). Changes in the availability of preferred foods affect the activity levels, reproductive, social, and ranging behavior of many primate species (Matsuda, 2007). Besides the temporal variation, food availability also varies with space (geographic location). Consequently, food could be abundant in one area during one season and in critical short supply in another

area during other seasons. Diet selection in wildlife is driven by the quantity and quality of available food as well as the nutritional needs of the animal (Yarrow, 2009). So when animals are faced with variations in food quantity and quality at different times and places, they tend to adjust their diets to meet their nutrient requirements (Rothman et al., 2008). Seasonal fluctuations in the availability of various foods and the nutritional composition of the same food affect nutrient intake and influence density and distribution of primate populations (Worman & Chapman, 2005; Rothman et al., 2008).

The availability of a particular food may influence whether or not it would be consumed independent of its nutritional content. Hence, seemingly attractive foods may not be consumed due to some anti-nutritional factors (Ganas et al., 2008). It therefore becomes imperative that the analysis of the quality and anti-quality components of wild food plants that a particular primate selects, its net gain from eating them, and the factors underlying its pattern of food selection be explored to gain a better understanding of the behavioural patterns of primate species (Milton, 2006). Insufficient knowledge of these intricacies has misled many primatologists to view primates as being capable of altering their dietary behaviour. It has been suggested that proximate analysis of the food consumed by primates could also help to fill these knowledge gaps.

The Lekki Conservation Centre (LCC) is a 78 hectare Strict Nature Reserve surrounded by urban sprawl developments that have made it an insular forest. It a unique ecosystem that has both swamp forest and coastal savanna grassland. It harbours only one non-human primate species, the mona monkey. However, there is a dearth of information on the availability and nutritional content of the food resources mona monkeys in the Reserve access for their diets. This study determined the seasonal availability and nutritional content of the plant diet of mona monkeys in the Reserve with a view to ascertaining the adequacy of such diets for their long term conservation on the facility.

MATERIALS AND METHODS

Study Area. The study was conducted in Lekki Conservation Centre, a Strict Nature Reserve that is located on latitude 6° 26′ N and longitude 3° 32′ E (Fig. 1). The Reserve has two vegetation types: a dominant mangrove swamp forest and a secondary savanna. The common trees in the fresh water marshes include *Alstonia boonei*, *Elaeis guineensis, Ficus spp., Raphia hookeri,* and *Xylopia aethiopica* (Osinubi, 2007). The Mona monkeys are naturally occurring in these marsh/swampy coastal forest and sandy coastal savanna grassland.

Data Collection. All-animal observation method as described in National Research Council (2003) was used to determine the food plants mona monkeys fed on during January – March (representing dry season), and June - September (representing rainy season) in 2011 and 2012. All the five troops in the Reserve were observed, at one time or the other, as they were encountered during the observation period of 33 days. The two board walks on the swamp forest area and foot path leading to the savanna were used alternately to trail the monkeys. Monkeys were observed on both sides of the trails as they foraged, until they were out of sight. Observation was from 6:30 – 10:30 hours. Once a troop was encountered, the monkeys were observed until they were out of sight. The trees they foraged on and the parts consumed were recorded. Binocular (Boots™) was used in viewing distant troops. Opportunistic collection of food remnants at ground level as suggested by Rothman et al. (2011) was carried to identify what they ate at the top of the tree canopies. Insects and other arthropods that were

consumed did not form part of the study. Foods the monkeys sourced by raiding nearby communities and staff canteen, and those provided by visitors were included in the study. These were termed composite foods. The food samples collected in 2011 were used for nutrient and fibre fraction analyses.

All food plants were identified by the field staff of the Nigerian Conservation Foundation. Based on the parts utilized food plants were grouped into fruits, seeds, flowers, leaves, exudates, and nuts following the method of Crissey et al. (2003). The number in each food groups was summed, divided by the total number of all the parts consumed and subsequently expressed as percentage.

Laboratory analyses for nutrients and fibre fraction contents. The nutrients and fibre fraction analyses were conducted in the Department of Animal Science Laboratory, University of Ibadan, Nigeria. The nutrient contents of the collected plant parts the monkeys consumed as food (Table 2) were determined by analyzing for crude protein (CP), ether extract (EE), crude fibre (CF), and ash using the AOAC (1990) method. Nitrogen free extract (NFE) was determined by difference. It was estimated by subtracting the sum of the other food components (crude protein, ether extract, crude fibre and ash) from 100. Fibre fractions made up of acid detergent fibre (ADF), neutral detergent fibre (NDF), and neutral detergent lignin (ADL) were determined using the method described by van Soest et al. (1991). Hemicellulose and cellulose were determined by difference (Rothman et al., 2007; Sommer et al., 2011). Hemicellulose (HC) was determined by subtracting the value of ADF from that of NDF, while that of cellulose (CS) was estimated by subtracting ADL value from that of ADF. The analyses were conducted at the Animal Science Laboratory of the Department of Animal Science, University of Ibadan, Nigeria.

Data Analyses. Tables and pie chart were used to summarize data on seasonal availability, proximate, fibre fraction compositions and parts of the food plants consumed by mona monkeys. The method used by Milton (1999) where the nutrient contents of individual food plants were pooled into groups of food types (here fruits and nut) and their mean and standard deviation determined was used. We determined statistically the relationships between the nutrients and fibre fraction values using correlation and regression analysis with Statistical Package for Social Science (SPSS, version 16.0, Chicago, IL, USA).

RESULTS

Seasonal availability of food plants. In each season ten different plant species were used as food by the mona monkeys. Three plant species were available in both seasons (Table 1).

Plant parts and other foods consumed by mona monkeys. The monkeys utilized 17 plant species from 11 Families (Table 2). Three species of these plants were from the Euphorbiaceae Family while Anacardiaceae, Arecaceae, Chrysobalanaceae, and Annonaceae Families had two species. The proportion of the plant parts and other composite foods (bread and sausage roll) is shown on Fig. 2. Fruits constituted the bulk of the diet (59 %). Nuts and seeds made up 9 % each, of the diet.

Nutrient and fibre fraction compositions of dry season's food plants of mona monkeys. The tender fruits of *M. indica* had the highest CP (22.31%) while ripe fruits of *T. catappa* had the lowest CP of 6.13% (Table 3). *A. vogelii* fruits had the highest EE content of 23.00%. The ripe fruits of *T. catappa* had the lowest value of 10.20%. The ripe fruits of *T. catappa* had the highest NFE value of

68.87%. This was followed by the fruits of *F. ingens* (65.20 %). *H. crepitans* seeds had the highest CF and Ash values of 17.00% and 9.40% respectively.

The fibre fraction values of the food plants of the mona monkeys during the dry season is shown on Table 4. *A. vogelii* fruits had the highest NDF and HC contents of 71.40% and 27.58% respectively. *F. ingens* fruits had the highest ADF value of 49.00%, while the least ADF of 27.12% was found in *H. crepitans*. *T. catappa* (ripe) had the highest CS value of 32.76%, while the least CS of 4.60% was found in *C. nucifera*.

Nutrient and fibre fraction composition of rainy season's food plants of mona monkeys. The nutrient composition of analysed rainy season's food plants of mona monkeys is shown on Table 5. *M. polita* seeds had the highest CP, EE and Ash contents of 6.56%, 31.80%, and 9.00% respectively. This was followed by *X. aethiopica* seeds with respective CP and EE values of 1.33% and 24.60%. The highest CF of 26.60% was found in *X. aethiopica* seeds, while the highest NFE of 71.28% was found in ripe fruits of *T. catappa*, followed by 69.02% found in unripe fruits of *T. catappa*.

Fibre fraction values of the rainy season's food plants are shown on Table 6. *M. polita* seeds had the highest NDF value of 66.40%. This was followed by the seeds of *X. aethiopica* (61.52%) which also had the highest ADF and CS contents of 43.19% and 25.75% respectively.

The pooled nutrients and fibre fractions contents of mona monkeys' food plants. The mean of the pooled nutrient values of the food plant parts consumed by mona monkeys is shown on Table 7. There were only two food groups: fruits (n=6) and nut (n=1). The fruit group had higher CP, EE, and CF values over nut. The nut had higher values than the fruit group only for Ash and NFE. Table 8 shows the mean fibre fraction values of the food plant parts of mona monkeys. The NDF, ADF, and CS values were higher in fruit group, while ADL and HC were higher in nut.

Correlation between nutrients and fibre fraction contents of mona monkeys' food plants. The correlation between the nutrients contents of mona monkeys' food plants is shown on Table 9. There was a high and significant negative correlation between EE and NFE (r =-.71, P= 0.011). A positive and significant correlation was found between EE and NDF with r=.67 and P=0.018; and between NDF and ADF (r=.61, P=0 .032).

DISCUSSION

This study showed the mona monkey utilized a variety of plant parts, the most of which were fruits. The species is known to be frugivorous (National Research Council, 2003; Matsuda, 2007; Kingdon et al, 2013). The occurrence of ten different species of food plants in each season, with only three species overlapping both seasons implied the monkeys had an expanded choice of foods. *Alchornea cordifolia* and *Terminalia catappa* were two food plants that fruited more than once a year, and as such occurred in both seasons. Although *Elaeis guineensis* occurred in both seasons, it had extended fruiting period and the fruits were available to the monkeys throughout the year. This was because the fruits stay on the plant until it is harvested by man or preyed upon by animals. *Elaeis guineensis* and *Mangifera indica* fruits seem to be staples for the mona monkeys. Earlier studies in Nigeria showed these two plant species as components of the mona monkey diet (Ejidike & Salawu, 2009; Nwufoh, 2011). Matsuda (2007) identified *Elaeis guineensis* fruits as part of the food plants mona monkeys in Lama Forest, Republic of Bénin consumed. Other monkeys also consumed similar

diets. Long-tailed macaques monkeys (*Macaca fascicularis*) in Kuala Selangor, Malaysia were reported to consume *Elaeis guineensis*, *Mangifera indica*, and *Terminalia catappa* (Kassim et al., 2017). A difference was observed between what the mona monkeys accessed as food in this study with that listed by Akinyemi and Kayode (2012) for savanna primates such as baboon and tantalus monkey.

As an arboreal animal, often jumping from one tree top to the other, and ranging over long distances in search of food, a ready source of energy as commonly found in the simple sugars of fruits would be the first preference (Lambert, 2007). They also consumed seeds and flowers, which were similar to what Matsuda (2007) reported. Apart from food plants, snacks which were offered by visitors did constitute part of the monkeys' diet.

All the plant parts the mona monkeys utilized as foods had high NFE values. These meant the mona diets were high in carbohydrate contents, needed to support the active arboreal life of the animal. During the dry season, the crude protein content of 6.13% for *T. catappa* fruit was lower than the 9.86 ±0.20 reported by Kassim et al. (2017) for the same plant. The value they obtained was however, not expressed on seasonal basis. Ash and NFE contents were higher in nut than fruits. The CF content for fruits was higher than that of nut. Fruits are known to add bulk to the dietary content of foods. Of the fibre fraction components, the highest NDF values were found in seeds.

The very high and significant negative correlation ($P<0.05$) between EE and NFE was due to the fact that NFE was determined by difference. Thus higher values of other nutrients, affected the NFE values. A very high and significant positive correlation ($P<0.05$) between EE and NDF meant that diets high in EE had high NDF contents.

Since the mona monkey is a monogastric animal, it accessed the parts of the food plants it could easily digest. As an arboreal it consumed large numbers of fruits for ready supply of energy to meet their active lives. Their diet was also rich in protein. The protein content of the fruit group quite exceeded the amount recommended by National Research Council. The Lekki Conservation Centre has the variety of food plants that can sustain the mona monkeys.

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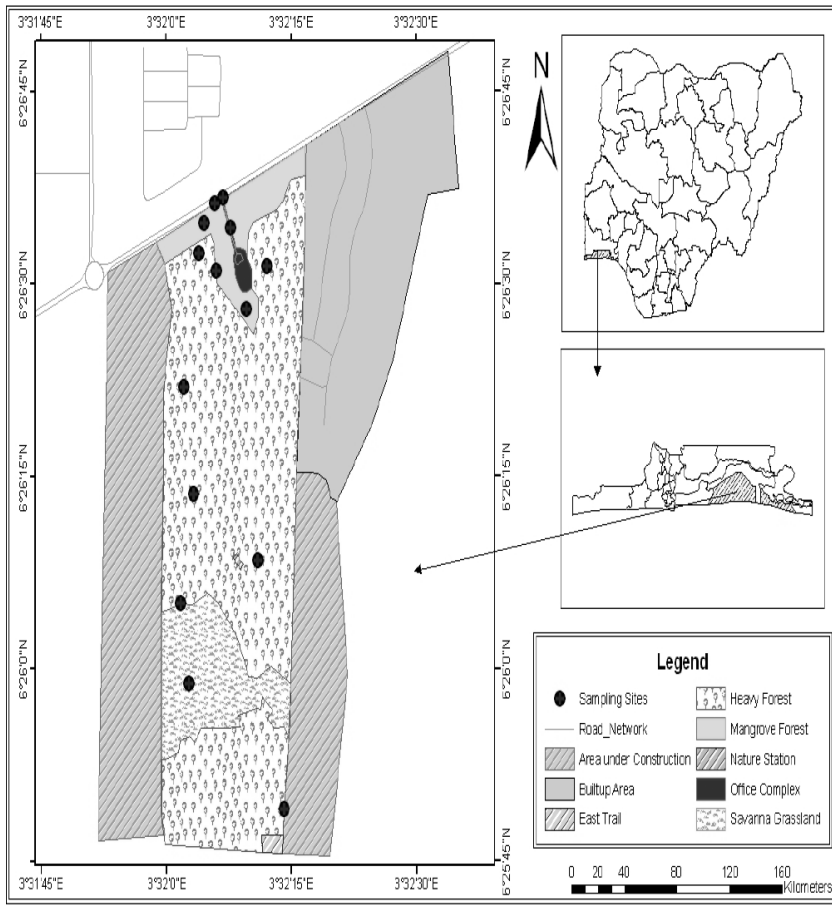

Figure 1. Map of Lekki Conservation Centre.

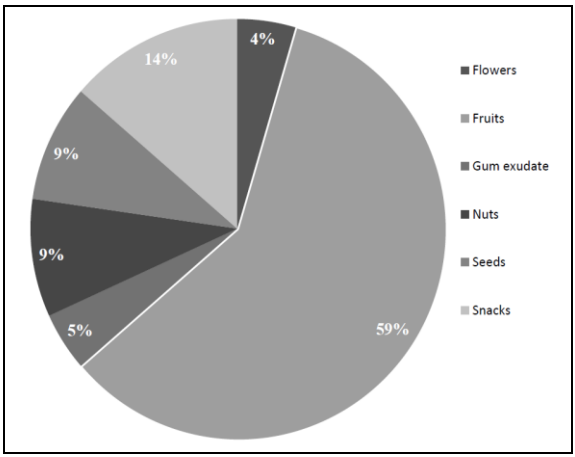

Figure 2. Plant parts and other products mona monkeys in LCC accessed as food.

Table 1. Dry and rainy seasons' plant foods of mona monkeys.

Dry season foods	Rainy season foods
Alchornea cordifolia	*Alchornea cordifolia*
Anacardium occidentale	*Chrysobalanus ellipticus*
Anthocleista vogelii	*Elaeis guineensis*
Chrysobalanus icaco	*Murraya paniculata*
Cocos nucifera	*Mussaenda polita*
Elaeis guineensis	*Polyathia longifolia*
Ficus ingens	*Raphia hookeri*
Hura crepitans	*Terminalia catappa*
Mangifera indica	*Vitex doniana*
Terminalia catappa	*Xylopia aethiopica*

Table 2. Species, family, common names of plant foods and parts consumed by mona monkeys.

Species	Family	Common Name	Parts Consumed
Alchornea cordifolia	Euphorbiaceae	Christmas bush	Fruit
Anacardium occidentale	Anacardiaceae	Cashew	Fruit, gum exudates
Anthocleista vogelii	Gentianaceae	Cabbage tree	Fruit, flower
Chrysobalanus ellipticus	Chrysobalanaceae	Pigeon plum	Fruit
Chrysobalanus icaco	Chrysobalanaceae	Cocoplum	Fruit
Cocos nucifera	Euphorbiaceae	Coconut	Nut
Elaeis guineensis	Arecaceae	Oil palm	Fruit, nut
Ficus ingens	Moraceae	Fig	Fruit
Hura crepitans	Euphorbiaceae	Sand box	Seed
Mangifera indica	Anacardiaceae	Mango	Fruit, tender seed
Murraya paniculata	Rutaceae	Orange Jasmine	Fruit
Mussaenda polita	Rubiaceae	-	Seed
Polyathia longifolia	Annonaceae	Masquerade tree	Fruit
Raphia hookeri	Arecaceae	Raphia palm	Fruit
Terminalia catappa	Combretaceae	Indian almond	Fruit
Vitex doniana	Verbanaceae	Black plum	Fruit
Xylopia aethiopia	Annonaceae	Negro pepper	Seed

Table 3. Nutrient composition of mona monkeys' foods during the dry season.

Xylopia aethiopica	DM	CP	EE	CF	Ash	NFE
Xylopia aethiopica	76.80	11.38	19.56	12.60	3.20	53.26
Xylopia aethiopica	81.43	10.50	23.00	9.00	2.60	54.90
Cocos nucifera	93.67	10.90	18.00	9.40	6.00	55.70
Ficus ingens	85.66	7.00	18.60	5.00	4.20	65.20
Hura crepitans	76.91	11.34	11.00	17.00	9.40	51.26
Mangifera indica	81.31	22.31	14.50	4.40	5.00	53.79
Terminalia catappa (Ripe)	75.45	6.13	10.20	6.40	8.40	68.87

DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fibre, NFE = Nitrogen free extract

Table 4. Fibre fraction content of mona monkeys' foods during the dry season.

Food sample	NDF	ADF	ADL	HC	CS
Alchornea cordifolia	58.60	38.86	29.15	19.74	9.71
Anthocleista vogelii	71.40	43.82	19.19	27.58	24.63
Cocos nucifera	56.40	31.20	26.6	25.20	4.60
Ficus ingens	61.70	49.00	30.41	12.70	18.59
Hura crepitans	44.64	27.12	7.53	17.52	19.59
Mangifera indica	49.20	37.20	20.43	12.00	16.77
Terminalia catappa (Ripe)	66.10	48.70	15.94	17.40	32.76

NDF = Neutral Detergent Fibre; ADF = Acid Detergent Fibre; ADL = Acid Detergent Lignin, HC = Hemicellulose and CS = Cellulose

Table 5. Nutrient composition of mona monkeys' foods during the rainy season.

Food sample	DM	CP	EE	CF	Ash	NFE
Mussaenda polita	78.19	6.56	31.80	11.80	9.00	40.84
Terminalia catappa (Ripe)	82.31	0.44	11.50	9.07	7.71	71.28
Terminalia catappa (Unripe)	84.13	0.88	12.50	12.55	5.05	69.02
Xylopia aethiopica	92.49	1.33	24.60	26.80	0.10	47.17

DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fibre, NFE = Nitrogen free extract

Table 6. Fibre fraction content of mona monkeys' foods during the rainy season.

Food sample	NDF	ADF	ADL	HC	CS
Mussaenda polita	66.40	41.00	17.40	25.40	23.60
Terminalia catappa (Ripe)	60.35	42.99	29.24	17.36	13.75
Terminalia catappa (Unripe)	59.51	17.11	12.39	42.40	4.72
Xylopia aethiopica	61.52	43.19	17.44	18.33	25.75

NDF = Neutral Detergent Fibre; ADF = Acid Detergent Fibre; ADL = Acid Detergent Lignin, HC = Hemicellulose and CS = Cellulose

Table 7. Mean and SEM of pooled nutrient content of food plant parts accessed by mona monkey.

Food group	DM	CP	EE	CF	Ash	NFE
Fruits (n=6)	80.05 ± 0.57	11.52 ± 0.95	19.75 ± 1.21	9.97 ± 0.80	5.57 ± 0.49	53.21 ± 1.30
Nut (n=1)	93.67	10.90	18.00	9.40	6.00	55.70

SEM= Standard Error of Mean, DM = Dry matter, CP = Crude protein, EE = Ether extract, CF = Crude fibre, NFE = Nitrogen free extract

Table 8. Mean and SEM of pooled fibre fraction content of food plant parts accessed by mona monkeys.

Food group	NDF	ADF	ADL	HC	CS
Fruits (n=6)	58.66 ± 1.70	39.5 ± 1.23	20.69 ± 1.40	17.82 ± 2.30	20.34 ± 3.17
Nut (n=1)	56.40	31.20	26.60	25.20	4.60

Table 9. Correlation between nutrients and fibre fraction contents of mona monkeys' food plants.

Correlated nutrients	R	P	Inference
EE and NFE	-.71*	.011	Very high negative correlation and sig. at $P<0.05$.
EE and NDF	.67*	.018	Very high positive correlation and sig. at $P<0.05$.
NDF and ADF	.47^	.081	Average positive correlation and sig. at $P<0.10$.
ADF and ADL	.61*	.032	Average positive correlation and sig. at $P<0.05$.

*. Correlation is significant at the 0.05 level; ^. Correlation is significant at 0.10 level. Definition of abbreviations is shown on Tables 2 and 3