Seasonality and nutrient composition of the plant diets of mona monkeys (*Cercopithecus mona*) in University of Lagos, Nigeria

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Abstract

This study was conducted during the dry and rainy seasons of 2011 and 2012 in the University of Lagos. The aim was to determine the seasonal availability and nutrient contents of mona monkeys' plant diets. Visual observation of feeding behaviour and opportunistic collection of discarded portions were used to determine seasonality of the food plants. Portions of the food plants consumed were subjected to proximate analyses for crude protein (CP), ether extracts (EE), crude fibre (CF), Ash, and nitrogen free extracts (NFE) contents, and fibre fraction analyses for neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL) using standard procedures. The nutrient values for consumed plant parts as fruits, leaves, seeds and nuts, and tubers were pooled and used for descriptive statistics. Mona monkeys utilized 30 plant species as foods, of which 37 % and 48 % were available during the dry and rainy seasons respectively. Dry season food plants, *Albizia lebbeck* and *Brassica oleracea* had the highest CP values of 37.19% and 29.53% respectively. *Dioscorea alata* (raw) had the least CP value of 0.88%. *Musa paradisiaca* had the highest ADF value of 45.00%. *Brassica oleracea* had the highest ADL content of 30.46%. The rainy season food with the highest CP of 37.19% was *Albizia lebbeck*. Ripe *Terminalia catappa* had the highest NDF of 76.20%. Seeds ($n = 4$) had the highest CP value of 29.5 ± 2.55%. Fruits ($n = 10$) had the highest CF of 11.09 ± 0.63%. Leaves ($n = 3$) had the highest Ash of 10.07 ± 0.40%. The plant diets utilized by mona monkeys met the 6.4-8.0% protein recommended by National Research Council for adult primates in captivity. The nutrient values of the foods in this study could serve as guide for feeding mona monkeys and sympatric species in captivity.

Keywords: Mona monkeys; seasonality of foods; nutrient composition; fibre fraction content.

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Introduction

The mona monkey (*Cercopithecus mona*) is one of the remnant large mammals that still exist in the University of Lagos since its establishment over five decades ago. Asiwaju (1987) had reported the existence of two other larger mammals such as antelopes and deers in the pre-University of Lagos forests. These two mammals are now extirpated.

Most primates are arboreal and depend on the forest and the forest ecosystem for food and other needs (Ejidike and Okosodo, 2007). In the rainforest, primates must locate nutrient sources necessary for their metabolic maintenance (Sayer and Wegge, 1992). Seasonality affects many aspects of primate lives (van Schaik and Brockman, 2005). For example, changes in the availability of preferred foods have great effects on the activity levels, reproductive, social, and ranging behaviour of many primate species (Matsuda, 2007). However, changes during dry and wet seasons in rain forests causes variation in the availability of plant reproductive and vegetative parts thereby inducing either abundance or scarcity of food for consumers (Gautier-Hion, 1980; van Schaik *et al* 1993).

One major factor that influences wild animals' production, growth, reproduction and survival is nutrition. Growth, reproduction and survival of wildlife are critical parameters in their population dynamics assessment, ecology and management (Rode *et al* 2006). Nutrients, especially energy giving types, provide quantifiable limits within which an animal and a population must operate (Lambert, 2007). For instance, the protein requirements of any species of non-human primates has been expressed in relation its metabolizable energy needs (National Research Council, 2003).

The mona monkey like any other animal must obtain nutrients (carbohydrates, proteins, lipids – fats and oils, minerals, vitamins) and water for their metabolism, growth and reproduction through foods sourced from their environments (Oates, 1987; Waterman and Kool, 1994; Lambert, 2007). Carbohydrates, proteins and lipids are required in large quantities for the energy for growth and maintenance are referred to as macronutirents while minerals and vitamins are needed in small quantities for physiological processes are referred to as micronutrients (Leonard, 2000). How much of these macronutrients are present in the wild diets of free ranging mona

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monkeys is unknown. Understanding the food-types, their seasonal availability and nutritional composition could assist in determining the habitat management strategies that will enhance the food quality of the mona monkeys, and other sympatric species in their natural habitats (Chapman *et al* 2003). Fibre contents in the diets of free-ranging non-human primates can serve as guides for captive species (National Research Council, 2003). Thus the determination of the macronutrient and fibre contents of free ranging non-human primate diets could help in the selection, formulation and provision of required foods to their kin in captivity.

In an urban environment where human activities have eroded the wildlife habitats and their food resources, resilient populations must adapt and subsist on what is available. However, all non-human primates appear to show species-specific dietary pattern, even though they be at home in different habitats (Milton, 2006). Analysis of the quality and anti-quality components of wild food plants a particular primate selects, its net gain from eating them, and the factors underlying its pattern of food selection are under-explored for many primate species (Milton, 2006). This lack of information makes many primatologists to assume primates as capable of altering their dietary behaviour. In Nigeria, few studies have been carried out on the nutrient composition of wildlife food plants and perhaps less on the fibre fraction contents. This study determined the seasonal availability, and nutrient composition offood plants accessed by mona monkeys in their fragmented urban habitat, the University of Lagos, Nigeria.

Materials and methods

Study area

The study was conducted in the University of Lagos Main Campus. The map (Figure 1) of the study-area was created from coordinates recorded during field observations and sample collected. University of Lagos lies on 6° 31 0″ North and 3° 23 10″ East and occupies a total land of 802 acres. The mona monkeys inhabit 11.95 hectares of the fragmented vegetation in the northern part of the university.

Collection of food samples

Focal-animal observation for few animals and all-animal observation for a group of animals as described in Altmann (1974) and National Research Council (2003) were used to determine the food plants the mona monkeys utilized. Observation studies were conducted during the months of January-March (dry season) and June-October (rainy season) of 2011 and 2012. At 0700-1100 hours on observation days, troops of monkeys were followed via paths and trails as they foraged till they got out of sight. Foraging activities on distant trees were observed with the aid of binocular. When an individual or troop was/were sighted feeding, 5-10 minutes was used to scan what food it/they was/were feeding on and the parts consumed were collected. These were used to determine what the monkeys consumed during the dry or rainy seasons, and nutrient analyses of the diets. Unknown plants were taken to the University of Lagos Herbarium for identification. The study was limited to opportunistic collection of discarded food plants as described by Rothman *et al* (2011). Food items sourced from class rooms, dump sites, food canteens or thrown to them by people were also identified.

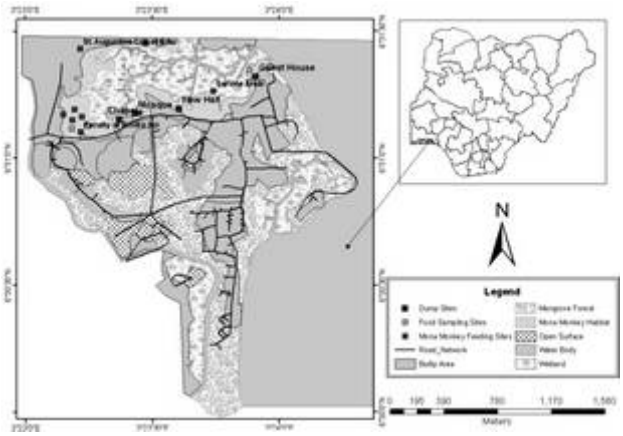


Figure 1. Map of study area.

The method used by Crissey *et al* (2003) to categorize callitrichids (marmosets) diets into fruits, vegetables and starchy vegetables was modified to group the mona monkey's food plants into include seeds, and composite foods. Plant parts the monkeys utilized as part of their diet were grouped into fruits, seeds, flowers, leaves, exudates, tubers, and nuts.

Nutrient composition analyses

Proximate analyses (crude protein -CP), ether extracts -EE, crude fibre -CF, and Ash) of the food samples were carried out on dry matter basis using the AOAC (1990) method. Fibre fractions of the food samples were analysed using the methods described by Goering and van Soest (1970), van Soest *et al* (1991). The analysed fibre fractions were neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin (ADL). Hemicellulose (HC) and cellulose (C) were determined by difference.

Determination of dry matter

Dry matter (DM) values were obtained by oven drying weighed portions at 100^{0}C to a constant weight. The change in weight divided by the initial weight and expressed in percent constituted the DM value.

Determination of crude protein

The crude protein content of the mona monkeys' food samples was determined by the Kjeldahl digestion method. 0.5/1g of the sample was weighed into a Kjeldahl flask and one capsule of selenium oxide (SeO_2)

was added as catalyst. 10 mls sulphuric acid (H_2SO_4) was added and heated for 1-3 hours in a fume cupboard until a clear colour was obtained. The digested sample was washed with distilled water into a conical flask, and made up to the mark of the flask. 10 mls was pipetted out and put into the distiller. The released ammonium was collected into 1 ml boric acid, changing the colour to light purple. This was titrated with Sodium hydroxide to determine the nitrogen content of the sample. The 6.25 factor was used to estimate crude protein in the samples by multiplying the amount of nitrogen, because many plants and animal proteins are known to contain on average 16% nitrogen (van Soest, 1994; Rothman *et al* 2008).

Determination of ether extract (EE)

Ether extract (crude fat) made of fat, oils, some waxes, pigments and other substances that are soluble in ether was determined using the soxhlet extraction method. Food sample was weighed and placed in an extraction thimble which was then immersed in petroleum ether and boiled. The sample was refluxed with the ether severally. The ether was distilled, leaving the crude oil in the flask. The EE was expressed in percentage of weight changes between refluxed product and the distillate divided by weight of refluxed product.

Determination of crude fibre (CF)

The weighed food sample was digested using 10 ml H_2SO_4 acid. The content was washed with hot distilled water and filtered by suction. The residue was transferred to a digestion flask, 20 mls of NaOH was added and boiled for about 30 minutes and rinsed with hot distilled water, then dried to constant weight and ignited to burn off all organic matter, leaving the ash. The change in weight represents crude fibre.

Determination of ash

Ash content was determined by putting 1g of dried food plant sample into in a pre-weighed porcelain dish and burning it in a muffle furnace at 550-600^{o}C overnight. After burning, porcelain dish was cooled in a desiccator and weighed. The sample weight differential before and after burning divided by its initial weight, expressed in percentage represented the value of Ash.

Determination of nitrogen free extract (NFE)

This was not determined analytically but by difference. It was estimated by subtracting the sum of the other food components (crude protein, ether extract, crude fibre and ash) from 100.

% NFE = 100- (CP + EE + CF + Ash).

Gross energy (GE)

Gross energy is the total energy content of a food, which may be released after combustion in a bomb calorimeter (Rothman *et al* 2011). It is limited as an indicator of the available energy of a food item, since not all the energy is digestible by the consumer, some are voided as faeces. However, some primate studies used gross energy as a measure of energy (Ganas *et al* 2008). It was determined by calculation using the Atwater factor (Stewart, 1992). The CP and NFE values of food samples were multiplied by the Atwater factor of 4.0, while the EE values were multiplied by Artwater factor of 9.0. The products were summed up as GE.

Thus GE = (CP x 4.0) + (NFE x 4.0) + (EE x 9.0).

Determination of fibre fractions:

Neutral detergent fibre analysis

100 ml neutral detergent solution (pH 7) was added to 1 g of sample. Sodium sulphate and some drops of n-octanol was added and boiled, refluxing for 60 minutes from onset boiling. It was filtered with boiling water, and dried at 105^{o}C for 8 hrs, cooled and weighed. The change in weight divided by the initial weight and multiplied by 100 gave the NDF value.

Acid detergent fibre analysis

100 ml of acid detergent solution at room temperature and some drops of n-octanol were added to 1 g of sample. It was boiled and refluxed for 60 minutes from onset of boiling, filtered with boiling water, dried at 105 for 8 hours, cooled and weighed. The ADF value is expressed in percentage of the change in weight after digestion in acid detergent solution divided by the initial weight.

Acid detergent lignin analysis

100 ml of concentrated $H_2SO_4$was used to hydrolyse 1 g of sample and the residue burnt to ash at 550^{o}C, cooled and weighed. The change in weight divided by the initial weight and multiplied by 100 gave the ADL value.

Hemicelluse and cellulose determination

These were determined by difference (Rothman *et al* 2007; Sommer *et al* 2011). The amount of hemicellulose (HC) in the foods was determined by subtracting the value of ADF from that of NDF, while that of cellulose (CS) were estimated by subtracting ADL value from that of ADF.

Data analyses

Descriptive statistics as Tables, bar and pie charts were used to present the data on food plant types, seasonality and nutrient composition of the mona monkeys' diet. Microsoft Office Excel 2007 was used to express the nutrient compositions of the food plants and the parts consumed in bar and pie charts respectively. Mean and standard deviation was determined for pooled values of the food plant parts using the method of Milton (1999).

Results

Seasonal availability of food plants

The food plants accessed by mona monkeys during the dry and rainy seasons are shown on Table I. A total of 30 plant species were recorded as component of the mona monkeys diet, of which 53.33 % were wild as they were consumed by monkeys only while the rest were human food sources. The wild food plants included *Alchornea cordifolia*, *Avicennia germinans*, *Paullinia pinnata*, and *Pithecellobium dulce.* In all, 37 % food plants were accessed during the dry season while 48 % were utilized during the rainy season, and 15 % occurred in both seasons. Peculiar food plants consumed by the monkeys during the dry season only were *Daucus carota*, *Elaeis guineensis*, *Mangifera indica*, and *Paullinia pinnata*. Those found only during the rainy season included *Alchornea cordifolia*, *Avicennia germinans*, *Blighia sapida*, and *Mussaenda polita*. *Carica papaya*, *Dioscorea alata*, *Musa paradisiaca*, *Musa sapientum*, and *Terminalia catappa* were found during both seasons.

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

	Dry season food plants	Rainy season food plants
Avicennia germinans	*Alchornea cordifolia*	*Ipomoea cairica*
Brassica oleracea	*Anthocleista djalonensis*	*Manihot esculenta*
Carica papaya	*Anthocleista vogelli*	*Musa paradisiaca*
Daucus carota	*Antocarpus altilis*	*Musa sapientum*
Dioscorea alata	*Avicennia germinans*	*Mussaenda polita*
Elaeis guineensis	*Blighia sapida*	*Phaseolus vulgaris*
Ficus congensis	*Brassica oleracea*	*Pithecellobium dulce*
Mangifera indica	*Carica papaya*	*Raphia hookeeri*
Musa paradisiaca	*Citrullus lanatus*	*Senna siamea*
Musa sapientum	*Colocasia esculenta*	*Terminalia catappa*
Paullinia pinnata	*Dioscorea alata*	*Zea mays*
Terminalia catappa	*Ficus ingens*	

Food plant parts and other foods consumed by mona monkeys

The plant parts and composite foods utilized by mona monkeys as part of their diet is shown on Figure 2. Fruits formed 56% of the monkeys' diet. This was followed by seeds (15%), composite foods and tubers (8% each). Other plant parts were flowers and (5% each), and exudates (3%). Composite foods consisted of cooked or processed foods such as jollof rice, biscuits, bread and pastries. They were accessed from classrooms, dump sites, or through provisioning by people in food canteens.

Nutrient and fibre fraction composition of dry season's food plants of mona monkeys

The proximate values of the dry season's food plants of the mona monkeys is shown on Figure 3. The seeds of *Albizia lebbeck* had the highest CP value of 37.19%. It was followed by *Brassica oleracea* with a CP value of 29.53%, and *Avicennia germinans* (15.75%). Among the fruits, unripe *Terminalia catappa* had the highest CP content of 12.69%, followed by ripe *Terminalia catappa* (8.75%), and *Mangifera indica* (7.00%). *Dioscorea alata* (raw) had the least CP value of 0.88%. *Artocarpus artilis* and *Brassica oleracea* had the highest EE values of 22.20% and 22.00% respectively. *Artocarpus altilis* and unripe *Terminalia catappa* had the highest CF values of 21.40% and 21.10% respectively. *Brassica oleracea* had the highest Ash value of 11.20%. The highest NFE value of 75.96% was found in *Dioscorea alata*, followed by *Musa paradisiaca* (71.59%), while *Albizia lebbeck* had the lowest NFE value of 33.81% followed by *Brassica oleracea* (34.07%).

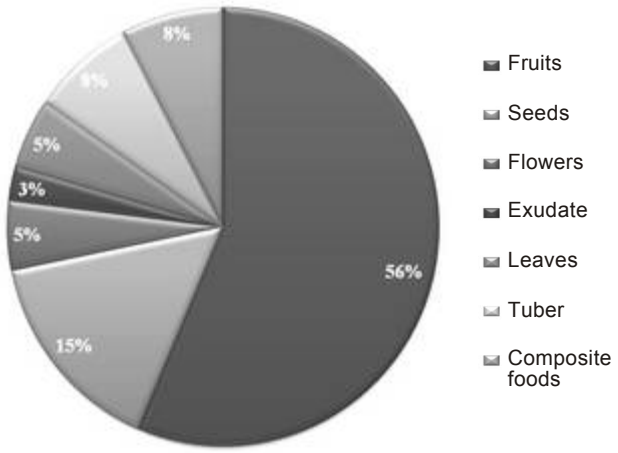


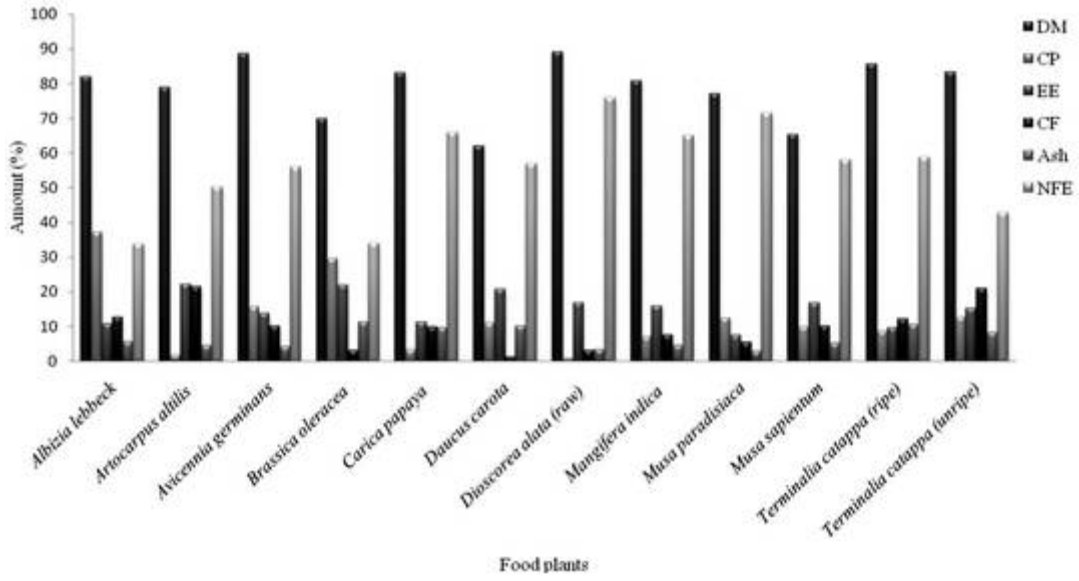
Figure 2. Plant parts and composite foods consumed by mona monkeys in University of Lagos.

The fibre fraction values of the dry season's food plants of the mona monkeys is shown on Figure 4. *Daucus carota* had the highest NDF, HC and CS values of 72.10 %, 30.06% and 27.46% respectively. *Musa paradisiaca* had the highest ADF value of 45.00% while *Brassica oleracea* had the highest ADL content of 30.46%. The least NDF, ADF, ADL, and CS content of 13.70%, 6.00%, 1.61%, and 4.39% respectively was from *Dioscorea alata* (raw) while the least HC value of 2.69% was found in *Artocarpus altilis*.

Nutrient and fibre fraction composition of rainy seasons food plants of mona monkeys

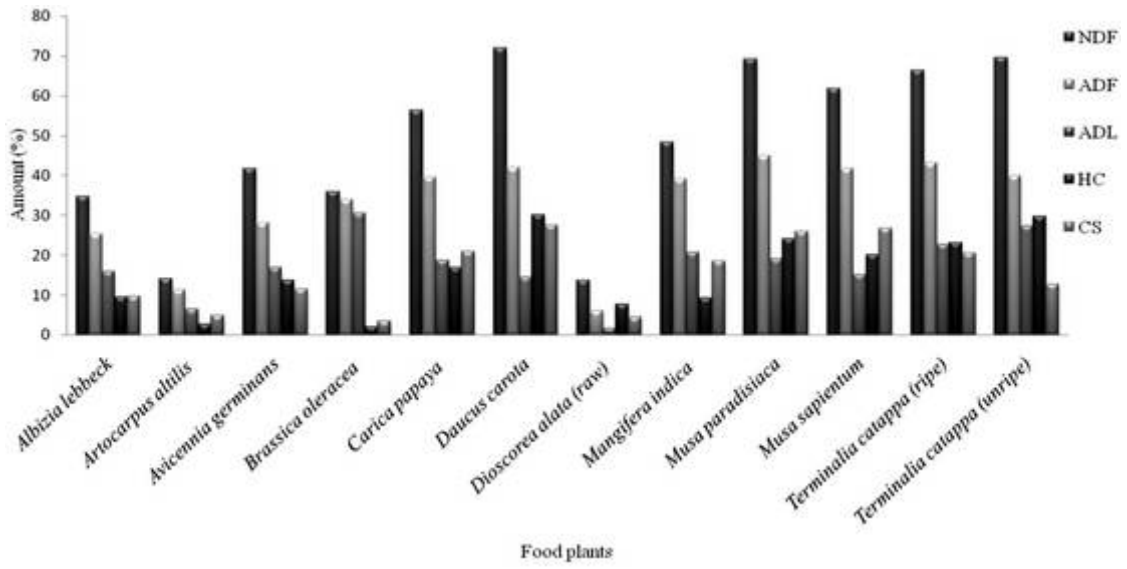
Figure 5 shows the proximate values of the rainy seasons food plants of *C. mona*. *Albizia lebbeck, Phytocellobium dulce* and *Brassica oleracea* had the highest CP values of 37.19%, 27.86% and 25.96% respectively. Unripe *Terminalia catappa* had a CP value of 6.13%. *Artocarpus altilis* and *Terminalia catappa* (ripe) had the lowest CP value both of 2.63%. *Phytocellobium dulce* had the highest EE value of 20.46%, while *Albizia lebbeck* had the lowest EE value of 10.80%. The highest NFE value

Figure 3. Proximate composition of dry season's food plants accessed by mona monkeys in University of Lagos.



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

Figure 4. Fibre fraction values of dry season's food plants of mona monkeys in University of Lagos.



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

of 73.57% was from *Artocarpus altilis*. *Albizia lebbeck* had the lowest NFE content of 33.81%.

The fibre fraction content of mona monkeys' foods during the rainy season is shown on Figure 6. *Terminalia catappa* (ripe) had the highest NDF, ADF, ADL and CS values of 76.20%, 62.60%, 36.61% and 25.99% respectively. *Pithocellobium dulce* had the highest HC content of 31.80%. The least NDF, ADF and ADL values respectively of 14.60%, 3.60% and 1.60% were found in *Artocarpus altilis*. The lowest HC and CS values of 7.40% and 0.46% were found respectively in *Brassica oleracea* and *Terminalia catappa* (unripe).

The mean of the nutrient contents of the food groups consumed by *C. mona* is presented on Table 2. Seeds (n = 4) had the highest CP value of 29.5 ± 2.55%. This was followed by leaves (n = 3) with a CP content of 22.14 ± 3.30%. Leaves also had the highest EE content of 19.93 ± 0.87%. The highest CF of 11.09 ± 0.63% was found in fruits. Leaves had the highest Ash value of 10.07 ± 0.40%. The highest NFE of 69.21 ± 1.59%

was from tubers (*n* = 4). The least GE (cal/g) of 398.06 ± 9.05 was from fruits.

The mean fibre fraction contents of the food groups *C. mona* consumed is shown on Table 3. As a group, tubers had the least fibre fraction values. This was followed by seed. Leaves had the highest NDF, ADF and ADL values of 52.25 ± 6.13, 39.1 ± 1.52 and 26.5 ± 3.51 respectively.

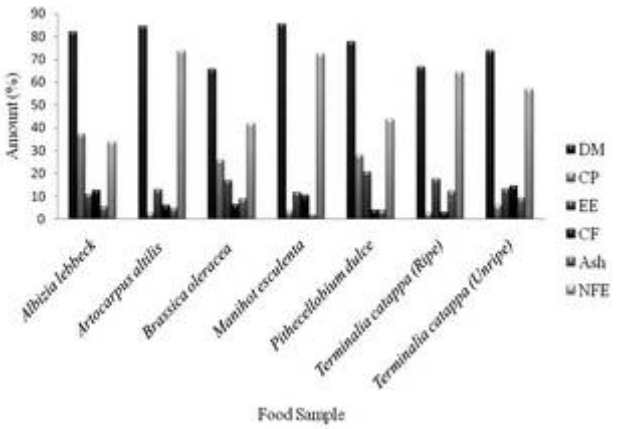


Figure 5. Proximate values of rainy season's food plants of mona monkeys in University of Lagos.

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

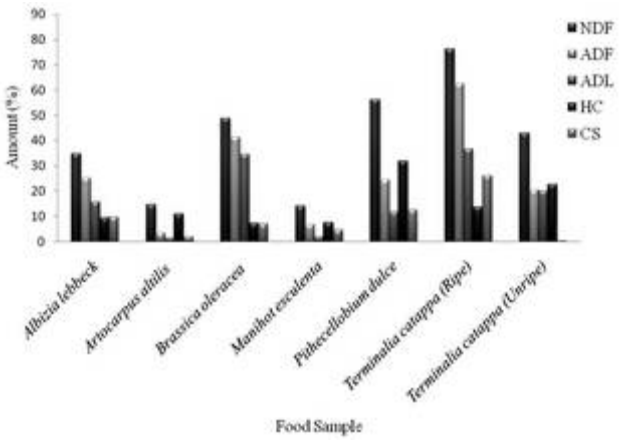


Fig. 6: Fibre fraction content of mona monkeys' food plants during the rainy season in University of Lagos.

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

Table 2. Mean and SEM of nutrient content of mona monkeys' pooled food plant parts in University of Lagos.

Food parts	DM	CP	EE	CF	Ash	NFE	GE (cal/g)
Fruits (n=10)	77.88 ± 0.72	6.75 ± 0.41	14.24 ± 0.42	11.09 ± 0.63	7.2 ± 0.32	60.73 ± 0.94	398.06 ± 9.05
Leaves (*n*=3)	65.8 ± 1.32	22.14 ± 3.30	19.93 ± 0.87	3.57 ± 0.86	10.07 ± 0.40	44.29 ± 3.86	445.13 ± 10.42
Seeds (*n*=4)	82.63 ± 1.13	29.5 ± 2.55	13.97 ± 1.14	9.80 ± 1.04	4.88 ± 0.22	41.86 ± 2.63	411.13 ± 21.19
Tubers (*n*=4)	85.38 ± 0.67	5.9 ± 1.11	13.84 ± 0.54	8.48 ± 0.92	2.58 ± 0.19	69.21 ± 1.59	425 ± 11.20

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

Table 3. Mean and SEM of fibre fraction content of mona monkeys' pooled food plant parts in University of Lagos.

Food parts	NDF	ADF	ADL	HC	CS
Fruits (*n*=10)	51.98 ± 2.23	34.67 ± 1.77	19.81 ±1.00	17.31 ± 0.16	14.86 ± 0.77
Leaves (*n* =3)	52.25 ± 6.13	39.1 ± 1.52	26.5 ± 3.51	13.15 ± 4.61	12.60 ± 1.99
Seeds (*n* =4)	41.9 ± 2.53	25.85 ± 0.41	15.05 ± 0.56	16.05 ± 2.12	10.80 ± 0.15
Tubers (*n* =4)	23.33 ± 5.53	23.52 ± 5.01	8.68 ± 2.01	0.19 ± 0.52	14.84 ± 3.00

SEM = Standard Error of Mean, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent lignin, HC = Hemicellulose, and CS = Cellulose.

Discussion

There were more wild (those plants/parts that were used exclusively by the monkeys) food plants during the rainy season than dry season. The 15% that occurred in both seasons means that they occurred throughout the year. Fleming *et al* (1987) reported that in wetter forests, seasonal peaks and troughs of fruit abundance as well as flowers and new leaves tend to be correlated with rainfall. In some other cases, fruiting peaks tend to occur at the end of the raining season or the beginning of the dry seasons (Fleming *et al* 1987). In a study in Lama Forest, Republic of Bénin, Matsuda (2007) reported that mona monkeys fed on fewer food species in the major dry season. This corroborates the seasonality of food plants accessed by *C. mona*. *Terminalia catappa* was the only wild food plant occurring in both seasons, and mona monkeys foraged on both its ripe and unripe fruits. This plant could be the key resource in reducing human-monkey competition for food. Fruits formed more than half of the diet of *C. mona*. This was followed by seeds. Matsuda (2007) reported the most important foods for *C. mona* as fruits, legume seeds and arils. The National Research Council (2003) listed leaves as the major food *C. mona* consumes when fruits are scarce. Access to human foods, including composite ones, during both seasons could be due to the monkeys' close proximity to human habitation. Consumption of composite foods could be an adaptive foraging strategy that might have contributed to the monkeys' persistence in the study location despite the degradation in terms of wild food plant resources. *Macaca fascicularis* (a species of macaques) accessed human foods found in many religious temples or shrines in Bali, Indonesia (Wolfe and Fuentes, 2007).

Elaeis guineensis, *Mangifera indica*, *Musa sapientum* and *Terminalia catappa* observed as mona monkey's food plants, were also reported by Kassim *et al* (2017) as part of the diet of long-tailed macaques monkey (*Macaca fascicularis*) in Kuala Selangor, Malaysia. *Elaeis guineensis*, *Mangifera indica*, and *Musa sapientum* were listed by Ejidike and Salawu (2009) as part of the diet of mona monkeys in Okomu National Park, Nigeria. The diet of mona monkeys in Awka, Nigeria included *Carica papaya*, *Elaeis guineensis*, *Mangifera indica*, and *Musa sapientum* (Nwufor, 2011). Matsuda (2007) identified *Elaeis guineensis*, *Ficusex aspirate Mussaenda elegans* and *Paullinia pinnata* as part of the food plants mona monkeys consumed.

In Nigeria, few studies have been conducted to determine the feeding ecology of the mona monkeys (Ejidike and Salawu, 2009; Ejidike e*t al* 2010; Nwufoh, 2011). This study seems to be the first attempt in assessing the nutritional content of mona monkey's food plants, especially the wild ones such as *Albizia lebbeck*, *Artocarpus altilis*, *Pithecellobium dulce*, and *Terminalia catappa*. Fruits constituted 56% of the food plants consumed by the mona monkeys implied that the animal preferred nonstructural carbohydrates. Fruits are high in nonstructural carbohydrates and low in protein (Milton, 1984; Lambert, 2007). The CP content of fruits was 6.75±0.41% (n=10). This was similar to what Milton (1999) reported as the average crude protein content of 7.0±1.10 %, for 7 Venezualan fruits eaten by red howler monkeys (*Alouatta seniculus*) and 6.30±0.50% for 8 species of wild fruits eaten by gorillas (*Gorilla gorilla dieli*) in Cameroon.

The CP content of dry season *Terminalia catappa* was higher than that of rainy season. Perhaps the rains could be the cause of the differences. The high CP of 12.69% found in unripe *Terminalia catappa* during the dry season was higher than 9.86±0.02 reported by Kassim *et al* (2017) as the CP *Terminalia catappa* consumed by macaque monkeys. However, the CP value of dry season's ripe *Terminalia catappa* (8.75%) obtained in this study was close to their value, even though they did not indicate the season nor the maturity state of the *Terminalia catappa* fruits they analysed. The low CP values of food plants like *Artocarpus artilis*, *Dioscorea alata* and *Manihot esculenta* could have been compensated for through the intake of seeds of *Pithocellobium dulce*, *Albizia lebbeck* and *Avicennia genminans* which had higher CP. The high crude fibre in fruits implied that they are good sources of dietary fibre.

National Research Council (2003) does not have estimates for the nutrient requirements for *C. mona*. The estimated crude protein requirements (in dietary dry matter) of primate model species, adult macaque and squirrel monkey (Family Cercopithecidae), fed purified or semi-purified diets for maintenance were 8% and 8-21% respectively (National Research Council 2003). If these values were used as standard for the *C. mona* (also of the Family Cercopithecidae), 75% of the dry season food plants had CP values within and above the 8-21% range. Seeds and leaves had CP values above 21%. Leaves, insects and other anima matter are major sources of dietary protein in primate diets (Lambert, 2007). However, fruits and tubers had CP values that were lower than the 8% threshold. On the whole, the CP of each of the food plant groups met the recommended National Research Council (2003) value of 6.4-8.0% protein required by captive adult primates. The NDF and ADF estimated as adequate (dry matter basis) for post-weaning non human primates was 10-30% and 5-15% respectively (National Research Council, 2003). Only *Artocarpus artilis*, *Dioscorea alata* (raw) had NDF and ADF values within these ranges. The NDF content of *Artocarpus artilis* was a little higher than 31.5% found in the wild diet of *Cercopithecus ascanius* (red-tailed monkey) but lower than the value of 36.0% found in the diet of *Procolobus badius* (Western red colobus) (National Research Council, 2003). All the food plants (except *Artocarpus artilis* and *Dioscorea alata*) had NDF values that were close to 61.8% found in the diets of *Prebytis entellus* (gray langurs). The high

fibre fraction content of the *C. mona* implies that it can tolerate fibrous materials.

In conclusion, the results obtained from this study could be useful as guide to zoo keepers in formulating food rations for different primates in captivity. It is also useful in selecting natural unprocessed plant food for such categories of animals. The crude protein content of the foods meets the values recommended by the National Research Council for primates in captivity. The presence of the mona monkeys in the food resource degraded habitat could be due to the availability of foods consumed by humans that the animals accessed.

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References

Altmann, J. 1974. Observational study of behavior: sampling methods. *Behaviour*, *49:* 227-265.

Asiwaju, A. I. 1987. Localised Impact. In: Aderibigbe, A. B. and Gbadamosi, T. G. O. (eds.) *A History of the University of Lagos, 1962-1987*, University of Lagos Press, Lagos, pp. 153-168.

Association of Official Analytical Chemists (AOAC). 1990. *Official Methods of Analysis (15th Edition),* Washington DC, USA, 83pp.

Chapman, C. A., Chapman, L. J., Rode, K. D., Hauck, E. M., and McDowell, L. R. 2003. Variation in the nutritional value of primate foods: among trees, time periods, and areas. *International Journal of Primatology, 23:* 313-330.

Ejidike, B. N., Durojaye, G. and Bello, M. A. 2010. Behaviour and troop size of mona monkey (*Cercopithecus mona*) in Okomu National Park, Edo State, Nigeria. *Applied Tropical Agriculture*, *15:* 170-173.

Ejidike, B. N. and Okosodo, F. E. 2007. Food and feeding habits of the thicke-tailed galago (*Otelemur crassicaudatus*) in Okomu National Park, Edo State. *Journal of Fisheries International*, *2:* 231-233.

Ejidike, B. N. and Salawu, A. 2009. Food and feeding habits of mona monkey *Cercopithecus mona* in Ayede/Isan forest reserve, Ekiti State. *Journal of Research in Forestry, Wildlife and Environment*, *1(1):* 56-59.

Fleming, T. H., Breitwisch, R., and Whitesides, G. H. 1987. Patterns of tropical vertebrate frugivore diversity. *Annual Review of Ecological Systems, 18:* 91-109.

Ganas, J., Ortmann, S. and Robbins, M. M. 2008. Food Preference of Wild Mountain Gorillas, *American Journal of Primatology*, *70:* 927-938.

Gautier-Hion, A. 1980. Seasonal variations of diet related to species and sex in a community of Cercopithecus monkeys. *Journal of Animal Ecology*, *49:* 237-269.

Goering, H. K., and van Soest, P. J. 1970. *Forage Fibre Analyses (apparatus, reagents, and some applications).* Agricultural Handbook No. 379. Agricultural Research Services. United States Department of Agriculture, Washington, D.C., USA, 20pp.

Kassim, A., Hambali, K., and Amir, A. 2017. Nutritional composition of fruits selected by long-tailed macaques (*Macaca fascicularis*) in Kuala Selangor, Malaysia. *Tropical Life Sciences Research*, *28(1):* 91-101.

Lambert, J. E. 2007. Primate Nutritional Ecology. In: Campbell, C. J., Fuentes, A. Mackinnon, K. C., Panger, M. and Bearder, S. K. (eds.) *Primates in Perspective*. Oxford University Press, New York, pp. 482-495.

Leonard, W. R. 2000. Human nutritional evolution. In: Stinson, S., Bogin, B., Huss-Ashmore, R., and O'Rourke, D. (eds.) *Human Biology: An Evolutionary and Biocultural Approach*. Wiley-Liss, New York, pp. 295-343.

Matsuda, R. G. 2007. Behaviour and Ecology of the Mona Monkey in the Seasonally Dry Lama Forest, Republic of Benin. PhD Dissertation submitted to the Graduate School of the City University of New York. 351pp.

Milton, K.1984. The Role of food-processing factors in primate food choice. In: Rodham, P. and Cant J. (eds.) *Adaptation for Foraging in Nonhuman Primates*. Columbia University Press, New York, pp. 249-279.

Milton, K. 1999. Nutritional characteristics of wild primate foods: Do the diets of our close relatives have lessons for us? *Nutrition*, *15(6):* 488-498.

Milton, K. 2006. Analyzing nutritional ecology: Picking up the pace: Nutritional ecology as an Essential research tool in primatology. In: Hohmann, G., Robbins, M. M. and Boesch, C. (eds.) *Feeding Ecology in Apes and Other Primates: Ecological, Physiological and Behavioural Aspects*. Cambridge University Press, Cambridge, pp. 381-396.

National Research Council. 2003. *Nutrient Requirements of Non-human Primates (2nd Edition)*. The National Academic Press, Washington, D.C., 306pp.

Nwufoh, E. I. 2011. Ecology and conservation of mona monkeys (*Cercopithecus mona*) in Awka capital city of Anambra State, Nigeria. Report submitted to Primate Conservation Inc. 12pp.

Oates, J. F. 1987. Food distrition and foraging behaviour. In: Smuts, B. B., Cheney, D. L., Seifarth, R. M., Wranghan, R. W. and Struhsaker, T. T. (eds.), *Primate Societies*. University of Chicago Press, Chicago, pp. 197- 209.

Rode, K. D., Chapman, C. C., McDowell, L. R. and Stickler, C. 2006. Nutritional correlates of population density across habitats and logging intensities in redtail monkeys (*Cercopithecus ascanius*), *Biotropica*, *38(5):* 625-634.

Rothman, J. M., Chapman, C. A. and Pell, A. N. 2008. Fiber-bound nitrogen in gorilla diets: Implications for

estimating dietary protein intake by primates. *American Journal of Primatology, 70:* 690-694.

Rothman, J. M., Chapman, C. A. and van Soest, P. J. 2011. Methods in primate nutritional ecology: A user's guide. *International Journal of Primatology,* DOI.10.1007/s 10764-011-9568-x

Rothman, J. M., Plumptre, A. J., Dierenfield, E. S. and Pell, A. N. 2007. Nutritional composition of the diet of the gorilla (*Gorilla beringei*): A comparison between two montane habitats. *Journal of Tropical Ecology, 23:* 673-682.

Sayer, J. A. and Wegge, P. 1992. *Biological Conservation issues in Forest Management*. In: Jill, M., Blackhouse, M. A., Sayer, J. A. and Wegge, P. (Eds.) The IUCN Forest Conservation Programme Proceedings of Workshop held at the IUCN General Assembly, Perth, Australia, 30th November-1st December, 1991, 244pp.

Sommer, V., Bauer, J., Fowler, A. and Ortmann, S. 2011. Patriarchal chimpanzees, matriarchal Bonobos: Potential ecological causes of a pan dichotomy. In: Sommer, V. and Ross C. (Eds.), *Primates of Gashaka: Socioecology and Conservation in Nigeria's Biodiversity Hotspot*. Springer, New York, pp. 417-449.

Stewart, J. 1992. *Use of Atwater Factors in USDA's Nutrinet Databank.* In: Proceedings of the 17th National Nutrient Databank Conference Celebrating the First 100 Years of Food Composition Data, 1892-1992. June 7-10, 1992, Baltimore, Maryland, USA, 311pp.

van Schaik, C. P., Terborgh, J. W., and Wright, J. 1993. The phenology of tropical forests: Adaptive significance and consequences for primary consumers. *Annual Review of Ecological Systems, 24:* 353-377.

van Schaik, C. P. and Brockman, D. K. 2005. Seasonality in primate ecology, reproduction, and life history: An overview. In Brockman, D. K.., and van Schaik, C. P. (eds.) *Seasonality in Primates: Studies of Living and extinct Human and Non-human Primates*. Cambridge University Press, New York, pp. 3-12.

van Soest, P. J. 1994. *Nutritional Ecology of the Ruminant*. Cornell University Press, Ithaca, New York, 476pp.

van Soest, P. J., Robertson, J. B. and Lewis, B. A. 1991. Methods for dietary fibre, neutral detergent fibre, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, *74:* 3583-3597.

Waterman, P. G. and Kool, K. M. 1994. Colobine food selection and plant chemistry. In: Davies, A. G. and Oates, J. E. (Eds.) *Colobine monkey: Their ecology, behaviour, and evolution*. Cambridge University Press, Cambridge, pp. 251-284.

Wolfe, L. D. and Fuentes, A. 2007. Ethnoprimatology: Conxtualizing human and non-human primate interactions. In: Campbell, C. J., Fuentes, A., Mackinnon, K. C., Panger, M. and Bearder, S. K. (Eds.) *Primates in Perspective*. Oxford University Press, New York, 691-701.

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