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Full Length Research Paper

Comparative analysis of diet patterns in baboon groups in pine plantations vs. natural habitats in Zimbabwe's Eastern Highlands

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Bark stripping of pine trees by chacma baboons in plantations of the Eastern Highlands of Zimbabwe has been on the rise leading to the assumption that bark constitutes baboon food. The study investigated diet variation among habituated bark stripping and non-stripping, plantation and non-plantation ranging baboon groups primarily to determine the noteworthy of pine bark in baboon diet. Food resources contributing >0.1% of the observations as well as pine bark were noted by group and season. Feeding observations were done through hourly instantaneous scan sampling which lasted for 5 min. During the scan, data on food items where possibly identified on species level, and part eaten were noted. To determine feeding variation, one way analysis of variance was applied with feeding percentage observations as the dependent variable and baboon groups, seasons, consumed species as well as plant parts as independent. The percentages of feeding observations were compared across baboon groups, seasons, consumed species and plant parts through the generalised linear model using SPSS version 15 (2006). Differences between means were tested using Bonferroni post hoc tests with a 5% level of significance. Feeding observation percentages did not vary significantly ($P > 0.05$, $F = 1.02$; $df = 2$, $N = 960$) across groups and seasons ($P > 0.05$, $F = 1.957$; $df = 2$), food species and plant parts were however, consumed at significantly ($P < 0.05$, $F = 2896.85$, $df = 24$) varying percentages. Bark consumption was lowest with 0.03 ± 0.16%. Pine bark is therefore not a preferred baboon food item. The establishment of plantations provided high quality food in the form of seed for the baboons.

Key words: Baboon groups, bark consumption, consumed species, feeding observations, food items.

INTRODUCTION

Bark stripping of pine trees by various chacma baboons (*Papio ursinus*) in plantations of the Eastern Highlands of Zimbabwe has been on the increase leading to the assumption that bark serves as baboon food. Baboons (*Papio spp.*) are widely regarded as dietary generalists (De Vore and Hall, 1965), consuming a wide range of food items in varying proportions (Whiten et al., 1987). Terborgh (1986) associated the increased dietary diversity with low food resources within their habitats. Preferred foods, for chacma baboons in particular, include fruits, flowers, leaves, seeds, tubers and rhizomes as well as insects, birds and reptiles (Byrne et al., 1993; Altmann, 1998). Chacma baboons are very selective on the type of food species they consume and in particular plant parts (Whiten et al., 1987). They often choose a small component of a plant and forgo the remainder or focus on a single species within a genus (Norton et al., 1987; Altmann, 1998). As such, they are able to feed selectively on the most nutritious parts of the plants available in their habitat each time of the year (Byrne et al., 1993).

Different habitats have characteristic plant species that may attract baboons during various times of the year (Henzi et al., 1997). Baboons thus occupy a broad range of habitats while selectively utilising specific food species within their home ranges (Henzi et al., 1992) and seasons (Alberts et al., 2005). One consequence of this ecological flexibility is that baboons are able to

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opportunistically exploit human habitats such as forest plantations and agricultural land (Hill,1997) thus generating human-wildlife conflict.

Of late, plantation ranging chacma baboons have been observed stripping bark from pine trees (Katsvanga et al., 2006) presumably for consumption. Bark stripping inflicted on the trees impairs growth, reduces the commercial value of the timber and sometimes results in their mortality (Gwenzi et al., 2007). The principal objective of this study was to assess the variation in foraging and diet between baboon groups which utilize plantations and which do not and ascertain whether bark is a significant component of baboon diet.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Mutasa and Nyanga Districts in the Eastern Highlands of Zimbabwe. The specific locations of the troops were Mutsago for the non-plantation group and Nyanga Timbers' Selbourne and Reenen estates for the pine bark stripping and non-stripping groups, respectively (Figure 1). The Mutsago area is a subsistence agricultural community with indigenous woodland patches as well as the alien wattle (*Acacia mearnsii*) and blackwood (*Acacia melanoxylon*) scrubs. The two alien species were once grown on commercial basis at Dunsinane, Selbourne and Reenen estates and later replaced with pines. However, because of their invasive nature, they currently colonise indigenous vegetation sites.

The Eastern Highlands are characteristic of moist afromontane forest. The natural vegetation is characterized by miombo woodlands mainly *Brachystegia spiciformis, Julbernardia globiflora, Cussonia spp.* and *Ficus spp.* with extensive patches of grasslands. However, this natural vegetation has been fragmented by plantation establishments.

The climate is subtropical to temperate, generally cool in summer and cold in winter with frequent frosts. Rainfall is about 1 000 mm/annum and is normally received from late November to early March. Rainfall distribution for the study period is shown in Figure 2.

Study groups

Habituated baboon groups monitored for close to a decade in the Selbourne and Reenen pine plantations were identified as stripping and non-stripping, respectively, depending on bark stripped pines within their home ranges. The Mutsago group was identified as non-plantation as its home range was within woodlands and village settlements, outside plantations. The Mutsago group comprised of 13.8 ± 1.22 (SD) baboons whereas the plantation groups were as large as 74.9 ± 1.26 for the stripping group and 78.3 ± 2.32 for the non-stripping group.

Data collection

Data on foods, including pine bark, consumed by the three baboon groups were collected to determine diet variability among the groups. Special focus was made to determine the inclusion of bark in baboon diet. Ethological observations were used as a means to document food choices among the groups. The groups were monitored from July, 2005 - June, 2006. Each group was located at the sleeping site each morning and followed on foot for the rest of the day until dawn by two observers three times every week. The groups were followed from a close distance (50 - 100 m) so that consumed foods could easily be identified, though, far enough not to interfere with their movements. A pair of binoculars (Nikon Night Working 12 x 40 Optics, Japan) was used to observe food items and plant parts which the baboons ate. Observations were done through hourly instantaneous scan sampling which lasted for 5 min (Altmann, 1974). During the scan, data on food items, where possible identified on species level and part eaten were noted.

Bark consumption was in most cases difficult to capture through hourly instantaneous scan sampling. Therefore, for every site where the baboons would have passed through, fresh lesions on pine trees as well as chewed bark and/or the outer bark strewn on the ground were used as evidence of bark consumption. Every fresh lesion on a tree was equated to bark consumption by an individual baboon.

Phases for data collection were divided into pre-rainy (August to mid November), rainy (November to early March) and post-rainy (March to June) seasons. This was done to assess food variability among seasons.

Data analyses

To ascertain feeding variation, one way analysis of variance was applied with feeding percentage observations as dependent the variable and baboon groups, seasons, consumed species as well as plant parts as independent. The percentages of feeding observations were compared across baboon groups, seasons, consumed species and plant parts through the Generalised Linear Model using SPSS version 15 (2006) . The Univariate analysis of variance function was applied within each independent variable. Differences between means were tested using Bonferroni post hoc tests with a 5% level of significance. The following model was used:

$$Y_i = \quad +A_i+B_i+C_i+(AxB)_i+(AxC)_i+(BxC)_i+e_i$$

Where Y_{ijklm} = the percentage of feeding observations = population mean, A = baboon group, B = season, C = consumed plant or plant part, i^{th} percentage of feeding observations, e = random error.

Differences between means were tested using Bonferroni post hoc tests at 5% level. Only those food items accounting for > 0.1% of the scans, with the exception of bark, were considered for analysis.

RESULTS

Food types constituting > 0.1% of the scans were 23, 20 and 13 for the pre-rainy, rainy and post-rainy seasons, respectively, out of a total of 25. Twenty one food types were recorded for the non-stripping, 15 for the stripping and 13 for the non-plantation groups, respectively. Feeding observation percentages did not vary significantly ($P > 0.05$, F= 1.02; df= 2, N= 960) across the three baboon groups and seasons ($P > 0.05$, F= 1.957; df= 2). Food species were however, consumed at significantly ($P < 0.05$, F = 2896.85, df= 24) varying percentages by the three groups as shown in (Table 1).

The first five predominantly consumed food items comprised of grass species (33.38 ± 0.12), wattle (28.19 ± 0.13), pine (8.55 ± 0.12), *Brachystegia* (4.78 ± 0.12) and insects (4.49 ± 0.13). The least five utilised were

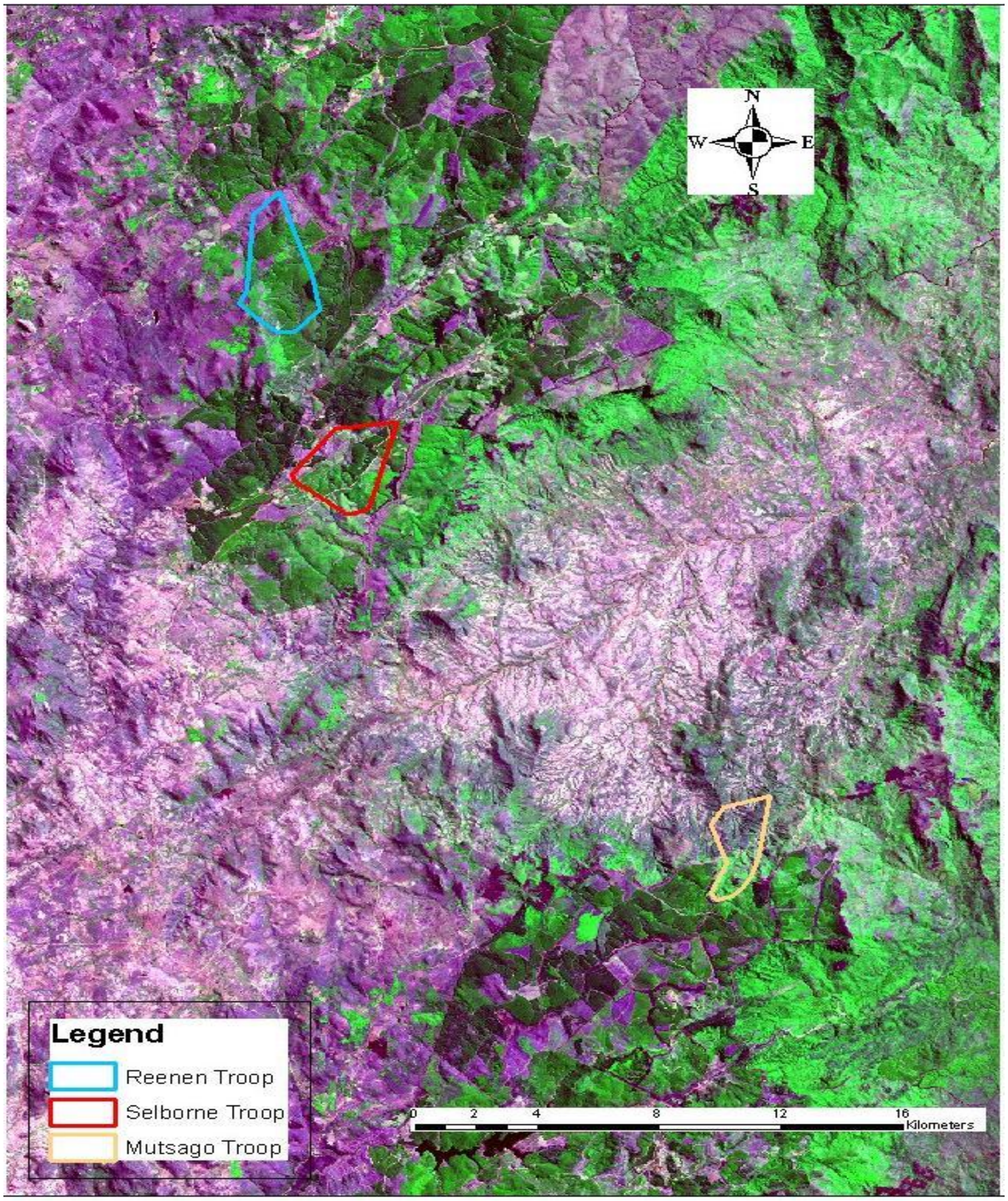

Figure 1. Study site satellite image showing home range convex polygons of the study groups.

Flacourtia (0.037 ± 0.12), reeds (0.083 ± 0.13), yams (0.178 ± 0.13), corms (0.092 ± 0.12) and peaches (0.050 ± 0.13).

The interaction between group and food items showed significantly ($P < 0.05$) varying feeding observation percentages. Plantation groups were characterised by significantly higher percentages of wattle (37.95 ± 0.20 and 30.60 ± 0.23 for the non-stripping and stripping groups respectively while the non-plantation had 9.94 ± 0.26%) and *Cussonia* (3.51 ± 0.18 for the non-stripping and 5.58 ± 0.23 for the stripping groups whereas the stripping did not utilise the species) origin food. The non-stripping group also included a higher percentage of grass (24.96 ± 0.19), aloe (5.29 ± 0.17) and *Vernonia* (5.90 ± 0.19) compared to the stripping with 3.44 ± 0.23 (grass), 1.75 ± 0.23 (aloe) and 1.97 ± 0.21 (*Vernonia*) whilst the non-plantation had less than 1% observations for the three species. The stripping group was also typified by pine (14.77 ± 0.20), insects (8.99 ± 0.21) and mushrooms (3.40 ± 0.21). The non-stripping group however, had lower observed percentages; 7.11 ± 0.19 (pine), 1.09 ± 0.19 (insects) and 0.13 ± 0.21 (mushrooms). The non-plantation group had significantly higher feeding observation percentages of *Brachystegia* (17.26 ± 0.25), grass (54.70 ± 0.27) and maize (5.60 ± 0.26). Besides a higher percentage of grass (22.01 ± 0.21)

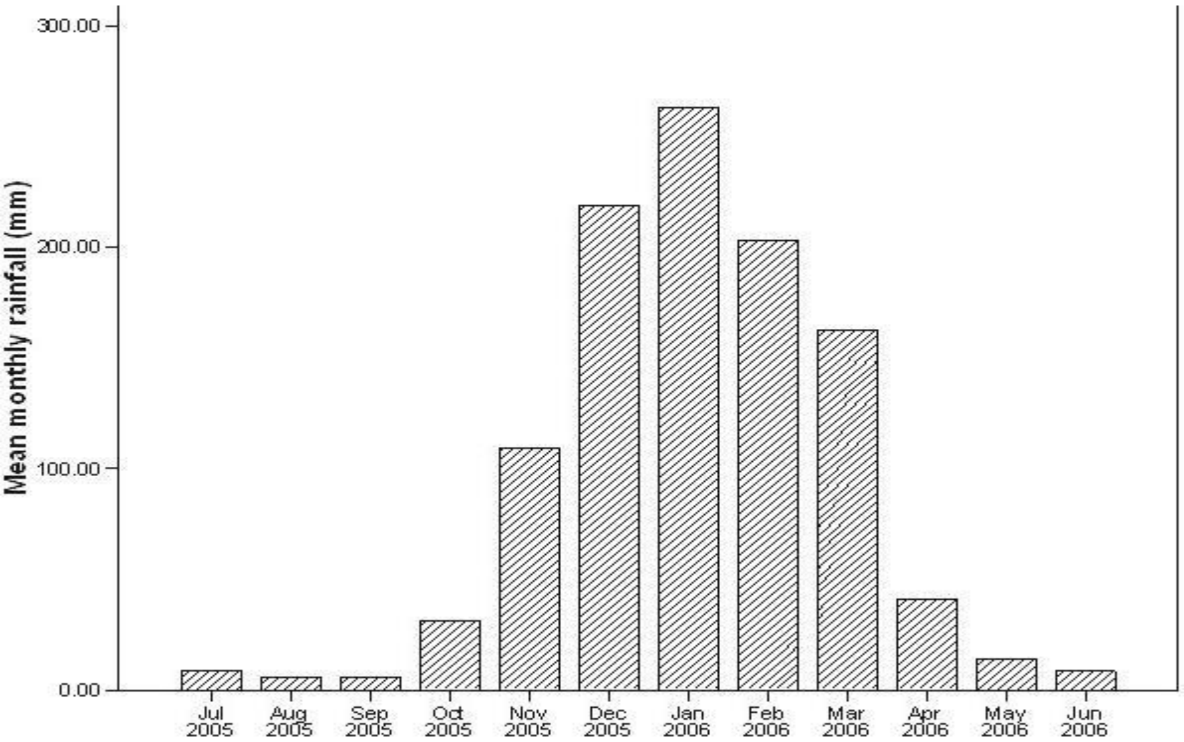

Figure 2. Rainfall received in the study area for the period July 2005 to June 2006.

0.21) observed for the stripping group, the plantation groups exhibited less than 2% for the other food items.

The interaction between season and food items showed significantly (P < 0.05) differing feeding observation percentages. Wattle was invariably utilised throughout the year whereas pine and grass were utilised during both the pre-rainy and rainy seasons. Pine constituted 11.12 ± 0.20% and 9.94 ± 0.02% of the feeding observations for the pre-rainy and rainy seasons respectively whereas grass comprised 21.43 ± 0.21 and 28.39 ± 0.21% respectively for the pre-rainy and rainy seasons. *Brachystegia* and blackwood were exclusively utilised during the pre-rainy season forming 11.82 ± 0.19 and 3.53 ± 0.19% of the feeding observations respectively. The significant (P < 0.05) appearance of maize feeding observations (4.65 ± 0.23%) characterised the rainy season whilst the post rainy season was characterised by the predominance of grass and *Cussonia* at 23.38 ± 0.27 and 9.93 ± 0.26% respectively.

Feeding observations on grass and plant parts showed significant differences (P < 0.05) in terms of preference as shown in Table 2.

Besides grass which constituted 37.21 ± 0.16% of the feeding observations, consumed plant parts were seeds with 41.88 ± 0.17%, leaves; 9.74 ± 0.16, plant stems exhibiting 4.01 ± 0.16. Fruits, subterranean plant parts and maize cobs constituted 2.04 ± 0.53, 2.19 ± 0.17 and 2.30 ± 0.16% of the observations respectively. The lowest feeding observations were noted on bark and resin with 0.03 ± 0.16 and 0.01 ± 0.16% respectively.

Besides consistency in the feeding observations on grass and seed throughout the year, interactions between season and plant part showed significant (P < 0.05) variable feeding observations. The pre-rainy and post-rainy season feeding observations included a significant amount of plant leaves. In addition, during the post-rainy season, the baboons significantly (P < 0.05) included plant stems in their diet. Bark consumption observations appeared during the rainy and post- rainy seasons but was not significantly (P > 0.05) varying across the year.

DISCUSSION

Food items exposed to baboon groups within the broader eastern highlands of Zimbabwe environment were the same during each season. Baboons inhabit pine plantations primarily because of nutritious food availability. According to Clymer (2006), baboons exploit more habitats and resources than other wide specialized primate species. DeVore and Hall (1965) noted that *P. ursinus* diet was extremely variable and eclectic making baboons adaptable and plastic in their foraging behaviour (Altmann, 1998, Alberts et al., 2005).

According to Reed and Bidner (2004), baboons adapt their behavioural and foraging strategies by incorporating

Table 1. Feeding observation percentages by season and baboon group.

Food item	**Season**							
	Pre-rainy			**Rainy**			**Post-rainy**	
	Non-stripping ± SD	**Stripping ± SD**	**Non-plantation ± SD**	**Non-stripping ± SD**	**Stripping ± SD**	**Non-plantation ± SD**	**Non-stripping ± SD**	**Stripping ± SD**
Wattle (seed/leaves)	38.69 ± 1.96	37.06 ± 0.72	3.12 ± 0.19	32.49 ± 0.16	34.10 ± 2.01	16.75 ± 0.13	42.67 ± 1.53	20.65 ± 0.44
Knotgrass	14.03 ± 1.40	-	-	24.43 ± 0.11	-	-	36.43 ± 0.96	10.33 ± 0.10
Aloe spp.	12.96 ± 3.11	-	-	2.11 ± 0.11	-	1.42 ± 0.13	0.79 ± 0.11	5.25 ± 0.24
Pinus spp. (seed)	9.49 ± 0.94	23.88 ± 0.63	-	11.10 ± 0.13	15.95 ± 9.04	2.78 ± 0.13	0.75 ± 0.06	4.49 ± 0.18
Cussonia spp.	7.36 ± 1.10	-	-	1.50 ± 0.06	-	-	1.66 ± 0.09	16.73 ± 0.40
Brachystegia spp. (seed)	3.74 ± 0.42	-	31.72 ± 2.67	-	-	2.80 ± 0.08	-	-
Herbs	3.05 ± 0.19	3.35 ± 0.13	-	0.75 ± 0.13	1.28 ± 0.17	1.40 ± 0.16	0.74 ± 0.09	-
Insects	2.46 ± 0.05	6.73 ± 0.18	1.52 ± 0.15	0.80 ± 0.01	12.48 ± 0.30	4.18 ± 0.85	-	7.75 ± 0.13
Ficus spp.	2.40 ± 0.10	-	-	1.30 ± 0.01	-	-	-	-
Other grass spp.	2.18 ± 0.09	9.90 ± 0.32	52.20 ± 1.65	3.38 ± 0.19	24.58 ± 0.57	57.20 ± 0.84	0.80 ± 0.08	31.56 ± 1.13
Vernonia spp.	0.81 ± 0.07	-	-	1.02 ± 0.13	-	-	-	-
Mushrooms	0.62 ± 0.03	2.70 ± 0.20	-	10.8 ± 0.08	3.22 ± 0.08	-	6.27 ± 0.17	-
Blackwood (seed)	0.40 ± 0.01	10.20 ± 1.48	-	-	-	-	-	-
Corms	0.40 ± 0.01	-	-	0.34 ± 0.11	-	-	-	-
Peaches	0.40 ± 0.01	-	-	-	-	-	-	-
Potatoes	0.40 ± 0.01	-	1.50 ± 0.16	0.30 ± 0.08	-	-	-	-
Gooseberry	0.19 ± 0.01	-	-	-	-	-	0.80 ± 0.08	2.58 ± 0.23
Maize	-	2.08 ± 0.13	-	2.75 ± 0.13	-	11.20 ± 0.74	1.60 ± 0.08	-
Vangueria spp.	-	0.00 ± 0.00	-	1.36 ± 0.09	1.38 ± 0.10	-	6.28 ± 0.11	-
Crickets	-	3.32 ± 0.08	-	0.78 ± 0.13	2.53 ± 0.10	-	0.80 ± 0.08	-
Flacourtia spp.	-	-	-	0.30 ± 0.01	-	-	-	-
Reeds	-	0.66 ± 0.11	-	-	-	-	-	-
Beans	-	-	3.18 ± 0.09	-	-	2.80 ± 0.08	-	-
Uapaca kirkiana	-	-	4.44 ± 0.21	-	-	-	-	-
Yams	-	-	1.42 ± 0.16	-	-	-	-	-
Significance								
Group	NS (F = 0.114; df between groups, within group = 2. 957)							
Season	NS (F = 0.194; df between groups, within group = 2. 957)							
Food item	* (F = 42.946; df between groups, within groups = 24. 935)							
Group × season	NS (F = 1.129; df = 3)							
Group × food item	* (F = 1014.983; df = 48)							
Season × food item	* (F = 168.864; df = 48)							

Significantly different variables ($P < 0.05$) have F values shown in bold with*.

Table 2. Feeding observation percentages of grass and plant parts.

Grass/ plant part	**Season**							
	Pre-rainy			**Rainy**			**Post-rainy**	
	Non-stripping ± SD	**Stripping ± SD**	**Non-plantation ± SD**	**Non-stripping ± SD**	**Stripping ± SD**	**Non-plantation ± SD**	**Non-stripping ± SD**	**Stripping ± SD**
Grass	18.08 ± 0.26	11.94 ± 0.11	53.08 ± 0.82	32.54 ± 2.62	32.94 ± 0.24	60.08 ± 3.74	40.14 ± 1.61	48.85 ± 1.92
Fruit	3.24 ± 0.44	-	4.93 ± 0.83	3.44 ± 0.35	1.24 ± 0.19	-	0.83 ± 0.14	2.66 ± 0.46
Leaves	10.44 ± 0.43	14.40 ± 0.46	1.60 ± 0.82	2.80 ± 0.16	1.22 ± 0.16	21.22 ± 1.66	21.18 ± 0.13	5.04 ± 0.97
Subterranean	8.44 ± 0.11	-	3.60 ± 0.91	2.18 ± 0.19	0.35 ± 0.13	1.50 ± 0.14	-	1.43 ± 0.17
Seed	54.14 ± 1.22	70.40 ± 2.49	36.63 ± 2.14	50.77 ± 2.68	62.92 ± 1.43	4.33 ± 0.25	33.73 ± 1.25	22.17 ± 3.01
Stem	5.70 ± 0.46	0.86 ± 0.35	-	4.20 ± 0.23	1.56 ± 0.11	-	1.64 ± 0.11	18.08 ± 1.88
Bark	-	-	-	-	0.07 ± 0.01	-	-	0.16 ± 0.23
Resin	-	0.02 ± 0.01	-	-	0.03 ± 0.01	-	-	-
Cob	-	2.36 ± 0.17	-	3.40 ± 0.16	-	10.96 ± 1.38	1.70 ± 0.19	-
Significance								
Group	NS (F = 0.327; df between groups, within groups = 2. 351)							
Season	NS (F = 0.640; df between groups, within groups = 2. 351)							
Plant part	* (F = 134.440; df between groups, within groups = 8. 345)							
Group × season	NS (F = 0.296; df = 3)							
Group × plant part	* (F = 1012.71; df = 16)							
Season × plant part	* (F = 715.92; df = 16)							

Significantly different variables (P < 0.05) have F values shown in bold with*.

diverse food categories to meet nutritional demands. However, the plantation environment is normally not species rich as non-commercial plants are removed during weeding.

Wattle and pine seed were observed to constitute a significant proportion of plantation ranging baboon food mainly because of the high nutritional value and abundance especially during the pre-rainy and rainy seasons. The high consumption of the seeds throughout the year is consistent with Altmann and Altmann (1970) and Barton (1989). Consumption of seed and grass by both the plantation and non- plantation groups during the rainy and pre-rainy seasons ensures that carbohydrates and proteins are catered for. This observation concurs with the fallback (grass) and high-return (seeds) hypotheses (Alberts et al., 2005) where both grass and seed have to be consumed in relatively higher proportions. Accordingly, baboons are considered profitable feeders in terms of protein requirements and that the protein fibre ratio is the primary factor determining their food composition (Whiten et al., 1990; Wrangham et al., 1991 and Barton and Whiten, 1994) as well as micronutrients (Gaynor, 1994). The more nutritious maize is consumed during the rainy and post-rainy seasons when it is available. This is in agreement with Byrne et al. (1993); Whiten et al. (1991); Altmann (1998) and Alberts et al. (2005) who reported that baboons feed with great selectivity on particular plant species (Table 1) and parts (Table 2) basing on their particular characteristics (Doran et al., 2002) as well as availability (Alberts et al., 2005). In agreement with Post (1982); Whiten et al. (1991); Byrne et al. (1993) and Altmann (1998) the sparse availability of seed producing species and other nutritious food outside plantations made grass consumption predominant for the non-plantation group.

Seasonality in baboon food productivity has been mentioned in a number of studies. Remis (1997) reported *P. ursinus* to shift their diet when preferred high quality foods were seasonally scarce. In addition, Foley (1987) found that baboons respond to dry-season food scarcities by shifting to foods that are abundant but have low profitability (low ratio of nutrient to harvesting time). The post-rainy season is characterised by grass, leaves and stems mostly for stomach filling. However, in the absence of young leaves which contain high levels of protein (Milton, 1979, 1981), mature leaves rich in carbohydrates (Milton, 1984) are consumed. Grass growing in wetlands, riverine areas and water points is fresh and palatable hence the higher percentage of feeding observations during the pre-rainy and post-rainy seasons which coincide with the dry period.

Although pine bark negligibly contributed to the total baboon food consumption (0.07 - 0.16%) (Table 2), bark consumption was comparatively high during the rainy season compared to the post rainy season. Consumption of bark and resin, in small quantities surprising occurred during the rainy and post-rainy seasons when food items were relatively in abundance in the environment thus failing to justify food shortage prevalent during the pre-rainy and late post-rainy seasons. The findings of this study indicated that bark consumption cannot be a result of the need for macro-nutrients contained in the inner bark as proposed by McIntyre (1972) because of the extremely low observed feeding percentages recorded in this study (Table 2). Furthermore, it is not clear whether the same and few baboons strip different trees per day or several baboons with different conditions strip the pine trees. However, the low consumption rates indicate that pine bark is not a preferred food item for baboons especially considering the high population of pine trees within plantations compared to other species.

Nonetheless, abundant food resources may provide various nutritional components, but lacking other nutritional constituents (Clymer, 2006) possibly obtained from the pine bark. Therefore baboons in need of the lacking elements may exploit pine bark to meet nutritional (Clymer, 2006) or other needs. For example roots and tubers are additional sources of starchy carbohydrates (Reusch, 1999). Seeds are extremely high in protein and fatty acids (Heller et al., 2002). Aloe (succulents) store excess water in the roots leaves and shoots (Sajeva and Constanzo, 1997) provide baboons with an excellent source of water and additional nutrients.

Given the vast array of food resources that *P. ursinus* is known to exploit and the large quantity of food resources that may be available at any given time, it is likely that some factor or combination of factors is driving the bark stripping behaviour by individuals of the baboon groups (Clymer, 2006).

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