Baboon Foraging Behaviour: The Influence of Natural Food Availability and Anthropogenic Dump Food

A study into baboon feeding behaviour based on seasonal varieties in Alldays, South Africa

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Abstract

The growing concern for conservation due to the increase in human-wildlife conflict (HWC) in human-modified areas (HMAs) such as farms, villages, and dumps is attributed to the reduction of wildlife habitats and the subsequent rise in confrontations. For example, high frequency of foraging by Chacma baboons (*Papio ursinis*) in human-modified areas (HMAs) negatively impacts livelihoods and creates a general sense of unsafety, leading to reduced tolerance for wildlife and sometimes resulting in lethal measures of retaliation. Despite the extensive and regular occurrence of HMA foraging by various baboon species across Africa, there are limited quantitative accounts of HMA primate behaviour or effective deterrents. This study, conducted in the Limpopo region of South Africa at a local dump in Alldays, aimed to understand the frequency of HMA foraging by the *Lahla* baboon troop and its potential correlation to the availability of natural and HMA food across seasons. Systematic behavioural observations and vegetation transects were used to gather data. Results revealed that time spent foraging at the dump by the *Lahla* troop was significantly higher during the dry season (Mar-Sep) compared to the wet season (Oct-Feb). Our food availability model showed higher energy availability in natural vegetation during the wet season and low energy availability during the dry season, while the dump remained a relatively stable energy source throughout the year. Current and previous research reveals a noticeable preference among baboons for foraging in natural areas versus human-modified areas (HMA) when both food options are abundant. Further investigations should be conducted to uncover the contributing factors such as flavour, nutrition, foraging costs, predation risk, and avoidance of human interaction. These studies will yield fresh perspectives and provide avenues for mitigating human-baboon conflict, a component of the broader issue of human-wildlife conflict, thereby promoting wildlife conservation efforts.

Key words: Human-wildlife conflict (HWC), chacma baboon (*Papio ursinis*), food preference, human modified area (HMA), HMA foraging, seasonal food availability, natural food constant (Ec)

Contents

1. Introduction

1.1 Human wildlife conflict (HWC)

Conflict between wild animals and humans has existed since the beginning of human civilization, often stemming from their natural competition for resources such as food and living space[1]. In recent decades, the expansion of human populations and modification of natural habitats have intensified the impacts of human-wildlife conflict (HWC), as degraded habitats drive wildlife towards human settlements[2,3]. As a result, human communities experience economic losses, food shortages, and safety risks, as they try to mitigate the growing problem[1,4]. Especially in less developed countries HWC presents a significant issue, with high concentrations of wildlife, extensive land degradation, and limited resources for HWC mitigation[4,5].

On the other hand, escalating human-wildlife conflict has resulted in a significant increase in wildlife fatalities and threatens the survival of multiple species.[1,5]. Common methods of deterring wildlife, such as traps, poisoning, and firearms, are causing harm to wildlife populations[1,6]. However, increased awareness of wildlife conservation and the development of wildlife-friendly deterrents, such as physical barriers and scaring devices, are showing promise[1,6]. Although these new deterrents may not be effective for highly adaptable species like baboons, which continue to be involved in dangerous conflict and face a potential risk in the future[6,7].

1.2 Human baboon conflict

There are six taxa of baboon (*Papio*) species widespread over the African continent and the Arabian Peninsula, inhabiting tropical rainforests, highlands, deserts, and savanna's (*Fig. 1*)[8–11]. The geographic variety of the non-hominoid *Papio* genus can be accredited to their ''generalist'' features, such as high flexibility in climate tolerance and an opportunistic omnivorous diet, but also a complex and variable social organization with a high degree of behavioural plasticity attribute to their widespread reproductive success[12–14]. The Chacma Baboon (*Papio ursinus*), a species native to southern Africa (*Fig. 1*), subsists on a naturally diverse range of food items including fruits, seeds, grasses, fungi, arthropods, nematodes, grubs, rodents, birds, small antelopes, and other nutritionally valuable substances[15,16]. An excellent example of the latter is the consumption of human-derived food found in garbage wastes, consisting of high-quality processed food and drinks, and cultivated fruit and vegetable[14,17].

Naturally, the continuous availability of high-quality food sources in garbage wastes, but also in crop farms and villages, attract generalist primates such as baboons, especially when natural food is scarce[14]. Unfortunately, baboon's movement towards human-modified areas (HMA) amplifies human-primate conflict as well[18,19]. Moreover, global urbanization and the expansion of anthropogenic land use fragmentates and reduces all primate's natural environments, also drawing baboons closer to human populated areas, overall resulting in a more ''intimate'' co-existence[20,21].

Habitat overlap between humans and baboons increases the number and severity of human-baboon conflict in southern Africa[18,19]. From the human's perspective, these conflicts arise from unwanted crop foraging, property break-ins, and aggressive baboon behaviour[19,22]. These actions result in economic losses, property damage, physical injuries and a general hazardous sentiment among the co-existing human population[19,22]. This detrimental presence of baboons often elicits negative responses from humans, including physically abusive behaviour with the use of harmful objects (e.g., rocks, glass, heavy, and hard objects) and instigation of domestic dog attacks. Additionally, human-induced lethal injuries caused by gun-shooting, poisoning, and snare-trapping are regularly inflicted upon these baboons[19,22]. Aside from human encounters, baboons possess several defenses against predators, including the protective presence of their large and vigilant group, aggressive disposition, and sharp teeth[23,24]. Nevertheless, African lions occasionally ambush baboon troops and African leopards frequently hunt these baboons at night, also influencing their foraging behaviour[23–25]. The frequency of baboon foraging in HMAs generally increases their exposure to anthropogenic threats, while reducing the risk of predation from large carnivores like lions and leopards, who usually avoid HMAs[17,19,22].

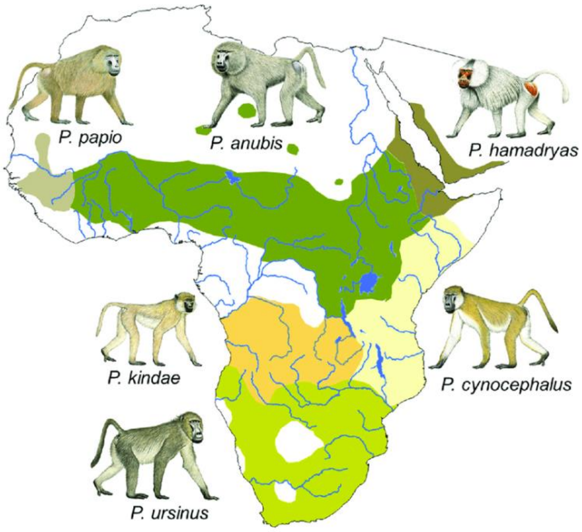

Figure 1; Geographic distribution in Africa and Arabian Peninsula of all six taxa from the Papio genus, including: P.papio, P.anubis, P.hamadryas, P.cunocephalus, P.kindae and P.ursinus[26] *.*

1.3 Baboon food preference

Baboons are omnivores with a highly diverse diet and can adopt both human-provisioned and natural-provisioned lifestyles. On average, an adult baboon ingests approximately 4000 Kilojoule (Kj) or 1000 Calories (kcal) per day in energy expenditure[14–16,27]. When compared to human-provisioned food, foraging for natural resources generally yields lower energy per unit of energetic effort, especially during times of scarcity, leading to a demanding "hard-work" lifestyle (*Fig. 2)*[17]. Human-provisioned food, in contrast, is higher in energy and requires less foraging effort, allowing for a more relaxed "lazy" lifestyle with reduced travel (*Fig. 2*)[17]. Food preferences and foraging behaviour in baboons are influenced by multiple factors, including flavour, food composition, foraging costs, and the presence of humans or natural predators [25,28–33].

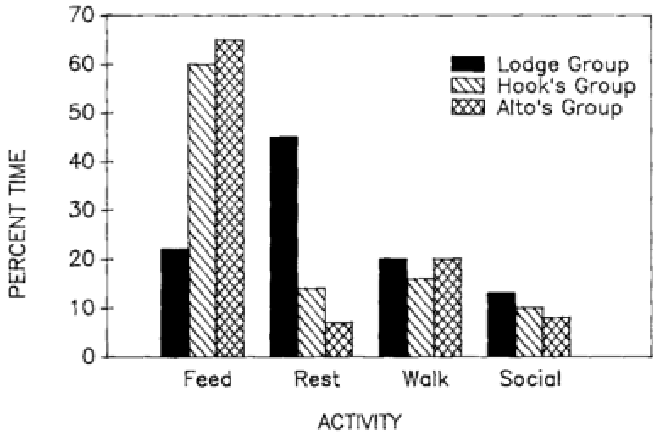

Figure 2: Human-provisioned baboons (Lodge Group) spend less time feeding and more time resting and being social compared to natural-provisioned baboon groups (Hook's & Alto's Group). An equal amount of time walking is observed between all groups, but human-provisioned baboon Lodge group walks slower and therefore smaller distances [17].

The growth of natural vegetation in the Alldays region of South Africa's Limpopo area increases significantly when the dry season (April to September) transitions into the wet season (October-March)[34,35]. Research findings suggest that baboons utilize HMAs less frequently during the wet season compared to the dry season as seen in *figure 3*, by roughly comparing summer and winter to the wet and the dry season[14,34]. This indicates that baboon foraging shifts towards natural food sources when they are more readily available[14,19]. However, research shows limited understanding of baboon food preferences and foraging frequencies in HMAs or natural food sources, particularly in relation to seasonal fluctuations in food availability.

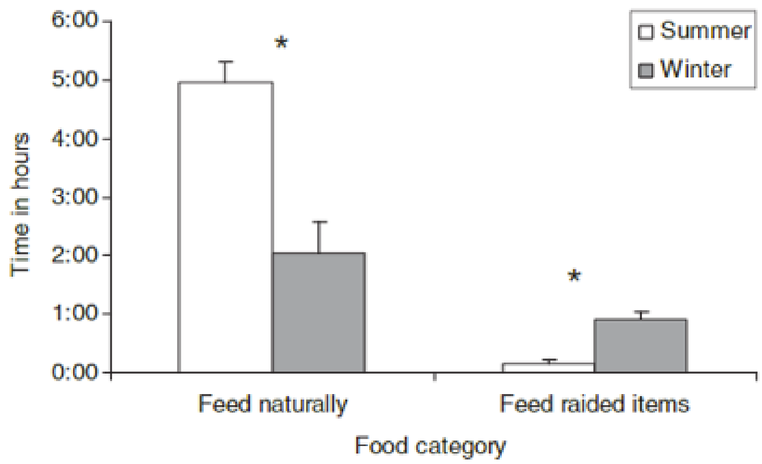

Figure 3: Number of hours per day spent feeding on natural and human provisioned items in the wet season and the dry season are shown in the graph. Natural feeding takes up around 5 hours per day in wet season, while during the dry season this decreases to only 2 hours. Vice versa, time spent foraging HMA's rarely occurs in wet season (maximally 10 minutes per day on average), while in dry season, foraging time increases to almost one hour per day on average. These results indicate significant seasonal differences of the Baboon's feeding pattern, supporting the idea that Baboons have a preference for natural food[14].

The objective of this study is to gain a deeper understanding of the factors that motivate baboons to forage in HMAs and eventually contribute to human-baboon conflict mitigation. Specifically, the study aims to examine the differences in time spent dump-foraging by a habituated baboon troop in Alldays, South Africa, during the wet season and the dry season, which represent periods of low and high natural food availability, respectively. To understand the impact of food availability on baboon foraging behaviour in HMAs, this study will estimate and compare monthly energy availability (measured in Kj) of both the dump and surrounding vegetation within the home range of a habituated baboon troop, data was collected from December 2019 till December 2022.

Based on previous research by *Doorn et al*. and *L. Findlay*[14,19], we hypothesize that baboons in Alldays will forage the local dump less during the wet season when natural vegetation is abundant, and more during the dry season when natural food availability is limited. Our study aims to either confirm or disprove this hypothesis, and to debate other variables that influence baboon food preference.

2. Material and methods

2.1 Study site

The present study was conducted in the Northern province of Limpopo, South Africa, at the local dump site in the village of Alldays (population: 3000) (*Fig. 5*)[36]. The area experiences a semi-arid climate, with warm and wet summers (average daily temperature: 19°C to 30°C) from October to March and cooler, dry winters (average daily temperature: 8°C to 22°C) from April to September (*Fig. 4*)[37,38]. The dominant vegetation in Alldays is deciduous and includes species such as acacias, baobabs, thornbushes, and tall grasses, which rely on the wet season for water[39]. As a result, vegetation primarily grows in the summer (wet season), making the winter (dry season) a difficult period for baboons and other fauna in terms of natural food availability[14,40,41]. The terrestrial biome is identified as savanna, specifically Musina Mopane Bushveld, which is characterized by undulating plains with some hills, and vegetation ranging from open woodland to moderate closed scrubland[42].

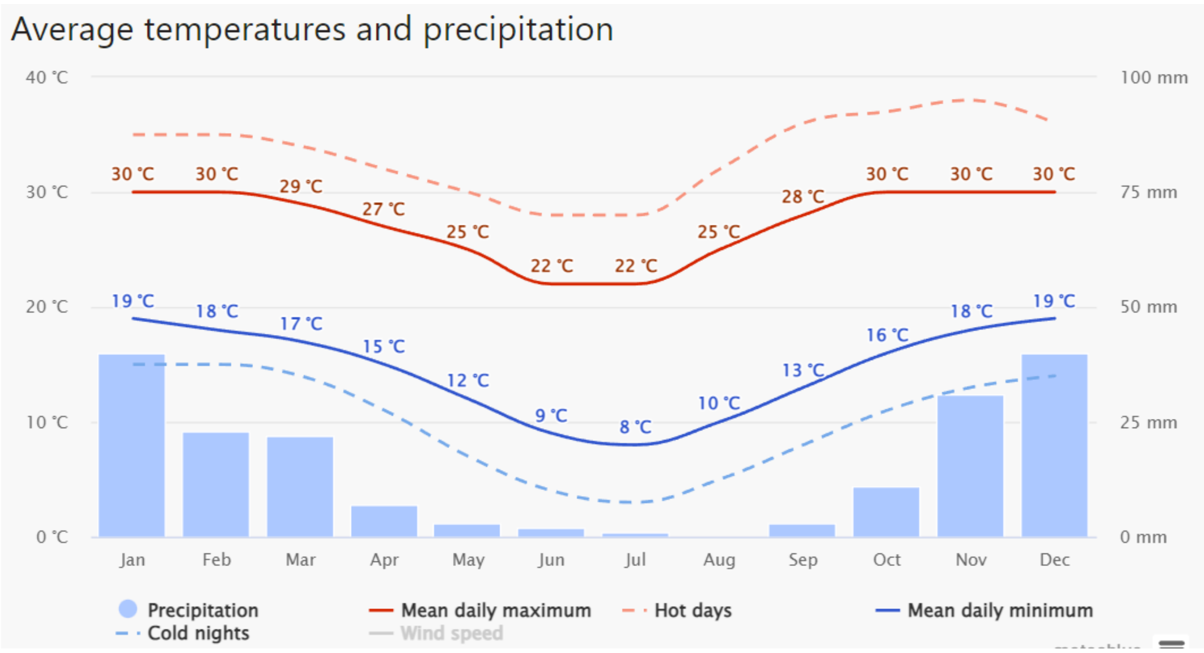

Figure 4: Simulated historical climate & weather data for Alldays, illustrating relatively high rainfall and high temperatures in summer (Oct – Mar), interchanged by low rainfall and lower temperatures (Apr – Sep) [37].

The study is divided into three sections:

- The first section aims to determine the monthly average daily time spent by baboons at the dump.
- The second section seeks to estimate the monthly variation in food energy availability at the dump and its surrounding natural vegetation.
- The third section presents a visual comparison of the results from the first two sections to investigate potential correlations.

2.2 Baboon dump time

Study group – Baboons (Lahla troop)

Three baboon troops live near the village of Alldays in South Africa, that frequently visit the local dump to feed (*Fig. 5A & 5B*). The number of individuals in the different troops vary approximately from 50-55, 20-30, and 7-25 individuals in between December 2019 till February 2023. For the purpose of this research, the smallest troop (*Lahla* troop) was picked as they visit the dump more frequently than the other groups and were more susceptible to habituation (*App. A*). The habituation process started on the 25th of June 2019, performed by trained field assistants following standard processes and techniques described by *Williamson and Feistner*[43].

Data collection

Lahla troop was fully habituated after six months. Data collection started in December 2019 and is still ongoing (February 2023). However, partially due to the COVID-19 pandemic and logistical issues, there are several hiatuses in the timeline varying from 1-6 months (*App. A*). The objective of this research is to systematically assess *Lahla's* daily time spent at the dump and their behaviour in both the dump and natural environment for a minimum of three days per week. Observations were made from 6:00 AM to 6:00 PM, when baboons are most active and foraging, as they typically return to one of their sleeping sites outside of this time frame[17].

Scan samples of *Lahla* troop were obtained at 30-minute intervals for a maximum of 5 minutes. During each sample, the behaviour of all visible individuals, was recorded, along with information on location, weather, and general information in accordance with the protocol described by Altman (*App. B*)[44]. Upon obtaining familiarity with the individuals, baboons were identified by sex and age: adult male, adult female, subadult male, subadult female, juvenile. Juvenile sex was difficult to determine, so data was collected on their age level only. Four dominant behavioural activities were recorded through scan sampling, as they account for over 95% of baboon time budget[45]. Data was collected from a distance of 5 to 10 meters, based on the group's movement, with data collection starting either from front to back or left to right to avoid double-counting of an individual in a single scan. Data was recorded using Microsoft Excel spreadsheets on a portable iPad (Apple Mini5 64 SG).

Average daily time spent at the dump by the baboons during different months of the year was calculated based on the scan data *(App. C & Eq. 1)*. Subsequently, a normal distribution was created by the arcsine square root transformation followed by a one-way ANOVA to test significance of monthly variations.

Average daily time spent at dump per month = Ad
Daily time spent at dump = Dt
Days visited dump per month = Dm

$$Ad = (Dt_1 + Dt_2 + Dt_3 + Etc..) : Dm$$

Equation 1

2.3 Dump food vs. Natural vegetation

2.3.1 Dump food

Study group – Trash bag content

The total dump area contains 41.7 km^2 and 840 m circumference, within this area there are designated locations for different purposes such as; trash bag deposits, glass collections, plastic bottle collections, trash burning piles and unused open areas (*Fig. 5A*). The total surface area where trash bags are dumped was determined on location and the surface estimated ~7.5 km^2 using Google Earth. Within this area, the amount of trash bags will be estimated (*Eq. 2*) and the average energetic value per trash bag will be calculated (*Eq. 3*) and used to estimate the monthly energetic food availability at the dump (*Eq. 4*).

Figure 5: (A): Red lined locations include the areas including trash bags with food content (7.5 km^2). 'Other' contains empty space, glass collections, plastic collections, trash burning pile[48]. (B): Habituated baboon ''Monica'' resting at the local dump[59].

Data collection

From December 2019 till October 2021, daily trash bag influx (Di) at the dump was registered by the local dump guards regularly (1-7 days per month) in order to determine the average daily trash bag influx per month (Ai) (*App. D)*. Based on anecdotal evidence from researchers and dump employees, the size of the dump does not change significantly over time (2 years). Therefore, trash bag food efflux is assumed equal to Di over time due to baboon feeding, trash burning, natural decay. Ai can be calculated from the sum of Di, divided by the number of days that trash bag influx was counted (Dc) (*Eq. 2*).

Average amount of daily trash bag influx per month = Ai
Daily trash bag influx per month = Di
Days trash bag influx counted per month = Dc

Ai = (Di1 + Di1 +Di3 + Etc..) : Dc

Equation 2

To assess average energy availability per trash bag (Aet) in Kilojoule (Kj), 20 trash bags were randomly picked twice a month, dissected, and the contents subsequently classified and weighed per food category (680 trash bags in total, from January 2020 till October 2021, (*App. E)*). The average energetic value of the food category per gram (Ev-food) is based on the composition of macronutrients (Carbohydrates – 1760 kJ per 100 grams, Proteins – 1720 kJ per 100 grams, Fats – 4000 kJ per 100 grams)[46,47] (*Tab. 1*).

Food category	Estimated energy (Kj) per g [24]	Average energy (Kj) per trash bag
Bread	10.4	595.92
Chips (Crisps)	21.61	20.94
Cooked food (Pasta)	5.11	607.55
Leftover fruit (Apple)	2.2	270.47
Leftover vegetable (Zucchini)	0.75	164.39
Milk (Whole)	2.72	91.37
Sauce (Mayonnaise)	11.96	159.54
Soda (Coke)	1.8	31.15
Uncooked foods (Pasta)	14.17	294.09
Animal derived food (meat)	12	177.95
Garden waste	1	0
Total	-	**2413.38**

Table 1: Estimated energy (Kj) per gram of food category was multiplied with the average weight (g) per food category present in a trash bag to calculate the average energy (Kj) per trash bag.

The Ev-food is multiplied by the average food category presence in grams per trash bag (Ap-food), and added up to estimate an average energetic value per trash bag (Aet) (*Eq. 2*).

Average energy available per trash bag (Kj) = Aet
Average estimated energy (Kj) per gram food = Ev-food
Average weight (g) food per trash bag = Ap-food

Aet = (Ev-bread * Ap-bread) + Ev-chips * Ap-chips) + (Ev-leftover fruit * Av-leftover fruit) + (Etc..)

Equation 3

Subsequently, average energetic value per trash bag is multiplied by average daily influx per month, which is then multiplied by the number of days in the month (N-month) in order to estimate the total monthly average energy available at the dump (Te) (*Eq. 4*).

Te = (Aet * Ai) * N-month

Equation 4

Finally, the monthly influx of trash bags was statistically analysed to determine the variability, which was measured using the coefficient of variation (CV). Student's t-Distribution Test was then performed to assess the significance of the CV. This analysis helps to understand the degree of variability in the influx of trash bags and the energy associated with it.

2.3.2 Natural vegetation

Study group – Vegetation cohort

A large variety of natural vegetation grows within the home range of the *Lahla* troop (±700 km^2). As baboons do not feed on all available biomass, only vegetation they feed on was selected in 10 transects of 10*50m (0.5 km^2) that are randomly located within the estimated home range of the *Lahla* troop based on their sleeping sites and daily observed locations (*Fig. 6 & App. F)*. Collectively, the transects include 121 trees that are estimated to contain a substantial amount of natural energy (Kj) for the *Lahla* troop, based on the criteria that: 1. Tree stem >= 10 cm diameter 2. Being a regular part of the baboon's diet (*Fig. 6 & App. F, G*).

To estimate the energy available for the baboons in these transects, the number of leaves and fruits of a chosen branch will be counted monthly per tree, and then extrapolated to the size of the total tree. The wet weight of the leaves and fruits are measured with a kitchen scale (10 samples were weighed to calculate the average. If the weight was insufficient, additional samples were included to ensure an accurate measurement) and the energy (Kj-g-leaf & Kj-g-fruit) it contains is estimated from the literature.

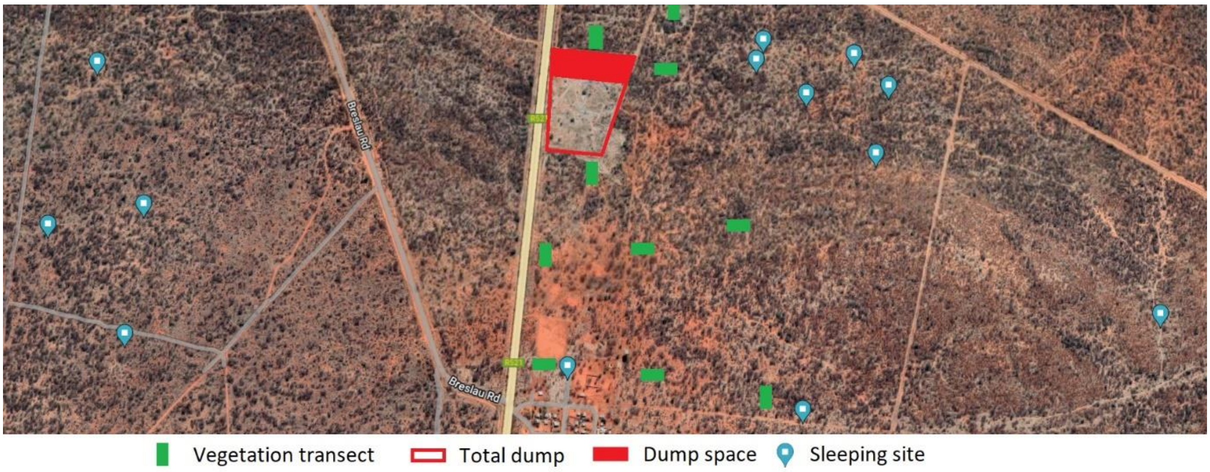

*Figure 6: This figure shows the total estimated home range of the Lahla troop. The total dump area contains 41.7 km^2, while the actual dump space containing trash is 7.5km^2. There are 10 randomly placed vegetation transects (10*50m = 0.5 km^2) in the baboon's home range area of a total ±700km^2. Sleeping sites vary and are used by different troops over time*[48]*.*

Data collection

From December 2019 till October 2021 vegetation transects in the estimated home range of the *Lahla* troop were visited once every month, and the leaves and fruits per tree species (Pb-tree) were estimated, bloom percentage was calculated based on the highest amount measured in the past two years (*App. G*).

The full bloom energy in Kj per tree species (Fbe-tree) is calculated by the average weight of a leaf and fruit per tree species (Wl-tree & Wf-tree), multiplied by the estimated number of leaves and fruits per tree species at full bloom (Nl-Fb & Nf-Fb), then multiplied by the energy in Kj per gram of fruit and leaf per tree species (El-tree & Ef-tree) *(Tab. 2 & Eq. 5)*.

100% bloom energy (Kj) per tree species = Fbe-tree
Average weight leaf per tree species = Wl-tree
Average weight fruit per tree species = Wf-tree
Number of leaves at full bloom per tree species = Nl-Fb
Number of fruits at full bloom per tree species = Nf-Fb
Energy (Kj) per gram of leaf per tree species = El-tree
Energy (Kj) per gram of fruit per tree species = Ef-tree

Fbe-tree = ((Wl-tree * Nl-Fb) * El-tree) + ((Wf-tree * Nf-Fb) * Ef-tree)

Equation 5

Subsequently, we find the estimated energetic value per tree species per month (Me-tree) by multiplying Pb-tree with Fbe-tree *(Eq. 6)*.

Me-tree = Pb-tree * Fbe-tree

Equation 6

Me-tree is then multiplied by the amount of that tree species present in all of the transects (N-tree) and added up to the total energy of all the transected trees per month (Tte-month). Then, Tte-month will be multiplied by 1.5 to simulate 7.5km^2 instead of 5km^2 (from the transects), to compare with the total dump area. Finally, Tte-month will be added to an estimated constant availability of energy in the vegetation (Ec), based on yearly available food (e.g.: insects, tree bark, animal rests, shrubs), which will give is the total estimated natural energy available (Tne-month). Due to a lack of data, three different hypothetical values will be given to Ec (Million Kilojoule (MKJ): 0.005MKj, 5MKj, 10MKj), to respectively produce a low, middle, and high value scenario. The low scenario was conceived as an alternative to zero, as zero is considered unrealistic. The middle scenario was designed to examine the outcomes if natural energy approximates dump energy. The high scenario was executed to evaluate the results if natural energy consistently surpasses dump energy.

Number of trees per species = N-tree
Total energy of all transected trees per month = Tte-month
Total estimated natural energy available (Kj) per month per 7500m^2 = Tne-month

Tte-month = (Me-tree1 * N-tree1) + (Me-tree2 * N-tree2) + (Me-tree3 * N-tree3) + (Etc..)

Tne-month = Tte-month + Ec

Equation 7

Tree species	Latin name	El-tree[49]	Ef-tree[49–52]	N-tree
Common corkwood	*Comniphora pyracanthoides*	20.3	20.01	8
Knob thorn	*Lannea schweinfurthii*	20.3	19.50	7
Marula	*Acacia nigrescens*	20.3	27.03	6
Purplepod clusterleaf	*Sclerocarya birrea*	20.3	18.62	2
Red bushwillow	*Acacia robusta*	20.3	20.33	2
Rough-leaved corkwood	*Terminalia prunoides*	20.3	20.01	29
Velvet-leaved corkwood	*Combretum apiculatum*	20.3	20.01	33
Worm-bark false-thorn	*Comniphora edulis*	20.3	20	6
Stink wood	*Boscia albitrunca*	20.3	20	2
Stink shepherd's tree	*Cassia abbreviata*	NA	12.05	3
Sjambokpod	*Boscia foetida*	20.3	13.47	3
Shepherd's tree	*Ocotea bullata*	NA	12.05	14
False marula	*Commiphora mollis*	20.3	20.01	5
Narrow-pod robust thorn	*Albizia anthelmintica*	20.3	19.50	1
				121

Table 2: List of substantially edible trees present at the 10 transects in the Lahla's troop estimated home size range. Substantial edibility was based on: 1. Being a regular part of the baboon's diet (ref). 2. Large enough size to provide a significant amount of energetic feed (Tree diameter => 10cm). El-tree could not be found in literature specifically per tree species, an average El-tree was used. Ef-tree could be found in most cases, otherwise data from the same genus was used.

2.4 Correlation analysis

The third results section will include a graphic comparison by combining the graphs (Excel-2019) resulted from: 1. Food energy available at the dump per month 2. Food energy available in the home-range vegetation per month 3. Average daily time spent at the dump per month. A statistical correlation between time spent at the dump by the baboons and food availability in the dump and nature will be calculated by Pearson's correlation test, followed by Two-tailed ANOVA to test significance.

3 Results

3.1 Average time spent at dump per month

The highest average daily time spent at the dump is seen in the dry season (August = 06:00 h), while the least time spent per month on average is seen in wet season (April ±00:30 h), only 1/12th of August *(figure 7)*. This correlates with the theory that baboons spent more time at HMAs in the dry season than in wet season[14]. Moreover, the start of the wet season (Oct) goes paired with a considerable drop in average daily dump time (Aug - Oct), while the start of the dry season initiates a substantial increasing trend in average daily dump time (Apr)[34]. These seasonal phenomena are concurrent with significant vegetation growth (wet season) and decline (dry season), indicating a possible correlation between daily dump time and vegetation biomass.

The statistical analysis shows the data to be significant (P 6E-09 < P 0.05), meaning the mean time spent by baboons in the dump differs significantly between the different months (*App. H*).

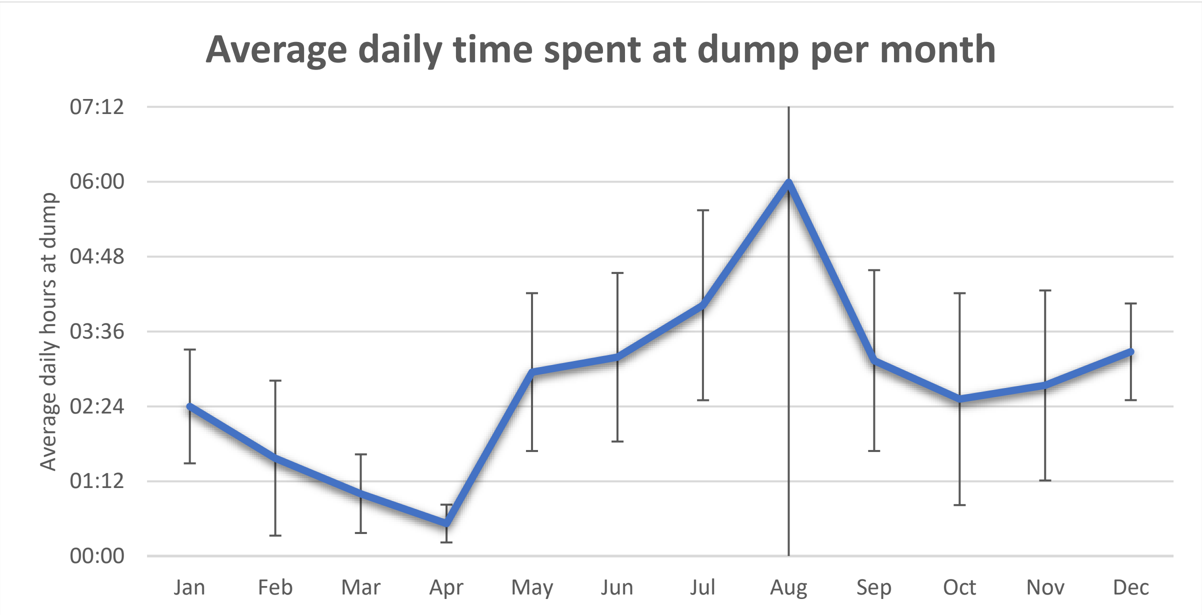

Figure 7: Average daily dump time spent by Lahla troop per month is significant (P-value 6E-09 < 0.05)

3.2 Food availability dump per month

Average daily trash bag influx per month was calculated and monthly standard deviation shown in *table 3*, where a relatively high standard deviation is given on the average daily influx over all of the months, indicates weak statistical significance. However, 10 out of 12 months (Feb - Nov) have similar average daily trash bag influx varying from 40-60 per day on average, comparable to the total average of 54.3 trash bag influx per day, which indicates a constant influx of trash bags monthly, and thus constant influx of energy (Kj).

When analyzing the monthly influx of trash bags, the coefficient of variation (CV) was calculated to be 37.7% with a significance of 8.0 E-15. This result indicates a moderate level of variability in the monthly trash bag influx, but the significance of 8.0 E-15 suggests that this variability is statistically significant and not likely due to random error. However, it's worth noting that a CV of 37.7% is still relatively high.

When excluding December and January from the analysis, the CV decreased to 14.9% with a significance of 5.2 E-17. This suggests that the outliers in those months were contributing significantly to the overall variability in the data. The decrease in CV and increase in significance indicate that the remaining data points are more consistent and the variability in the monthly influx of trash bags is largely due to the outliers in December and January, and that the remaining months may have a more stable influx pattern. Demonstrating a significant discrepancy, the low sample size in December could account for the difference, whereas a robust sample size in January warrants further examination in the discussion section.

Month	*Days Counted*	*Bags*	*Daily average*	*std def*
Jan	23	456	19.83	17.90
Feb	34	1519	44.68	56.99
Mar	29	1586	54.69	75.45
Apr	18	992	55.11	54.08
May	13	716	55.08	37.56
Jun	28	1572	56.14	61.71
Jul	34	2076	61.06	58.55
Aug	33	1236	37.45	41.77
Sep	34	1658	48.76	54.80
Oct	33	2104	63.76	73.16
Nov	14	650	46.43	41.73
Dec	5	543	108.60	81.57
Total	298	15108	54.30	-

Table 3: Registered trash bag influx per day, monthly average influx and the standard deviation is shown in the table from December 2019 till February 2021 (15 months, App. D). Data collection in December was minimal due to COVID-19 and logistical issues.

The average energy per trash bag (2413.38Kj) was multiplied by the trash bag influx per month to calculate the estimated energy availability at the dump per month (*figure 8* (*Eq. 2,3,4*). Most months, except for January (1.4 MKj) and December (8 MKj), show a stable influx energy influx (3-5 MKj) (*Tab. 3 & Fig. 8*). In general, databases of dump trash influx do so on a yearly basis, indicating a constant influx on a monthly basis, which we will assume for the Alldays dump as well[53]. Taking into consideration the fact that an average baboon consumes around 4000 Kj per day and the Lahla troop consists of 7 to 25 members over a two-year period, the total energy consumption from the dump as a food source can be estimated to range between 0.85 MKj and 3 MKj per month. This highlights the dump as a reliable and ample source of food energy that remains available for most of the year.[27].

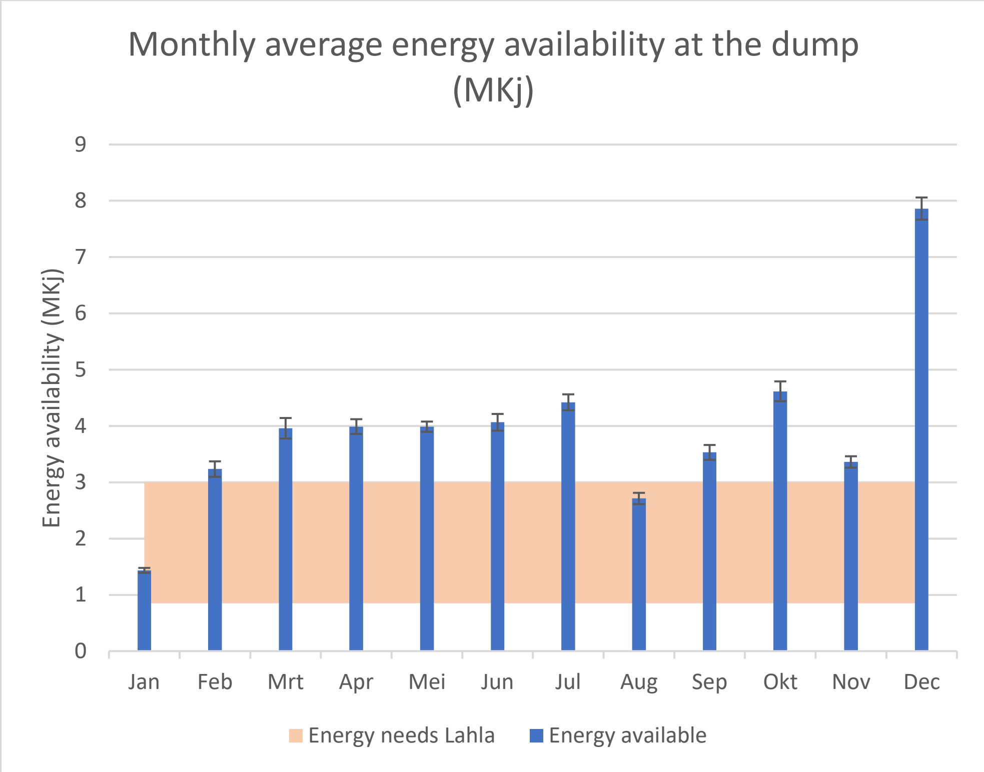

Figure 8: Total daily energy available at dump per month. CV is 37,7% (significant: P= 0.05 > 8.0 E-15), excluding outliers January and December, CV is 14.9% (Significant P=0 .05 > 5.2 E-17).

3.2.1 Food availability vegetation per month

To calculate the energy generated from natural vegetation, energy values for its plants and fruits were obtained from literature. The ensuing results are presented in *table 5 (Eq. 6)*.

Tree species	Latin name	Nl-Fb	Wl-tree	El-tree[24]	Nf-Fb	Wf-tree	Ef-tree[9,23,25]	Fbe-tree (Kj)	N-tree
Common corkwood	*Comniphora pyracanthoides*	230,340	0.09	20.3	2340	0.1239	20.083	414964	8
Knob thorn	*Lannea schweinfurthii*	290,400	0.02	20.3	200	1.0045	19.497	131841	7
Marula	*Acacia nigrescens*	2,985	0.14	20.3	400	0.3833	27.03	12561	6
Purplepod clusterleaf	*Sclerocarya birrea*	178,158	0.04	20.3	864	0.2796	18.619	142074	2
Red bushwillow	*Acacia robusta*	7,872	0.32	20.3	1000	0.3612	20.334	59120	2
Rough-leaved corkwood	*Terminalia prunoides*	22,960	0.09	20.3	2340	0.7604	20.083	76518	29
Velvet-leaved corkwood	*Combretum apiculatum*	148,680	0.05	20.3	2340	0.5028	20.083	161259	33
Worm-bark false-thorn	*Comniphora edulis*	64,584	0.13	20.3	1000	0.26	20	175637	6
Stink wood	*Boscia albitrunca*	44,217	0.13	20.3	100	1.5	20	119689	2
Stink shepherd's tree	*Cassia abbreviata*	NA	NA	NA	1000	0.22	12.05	2651	3
Sjambokpod	*Boscia foetida*	12,246	6.67	20.3	1000	0.5	13.467	1664108	3

Shepherd's tree	*Ocotea bullata*	NA	NA	NA	1000	0.5	12.05	6025	14
False marula	*Commiphora mollis*	22,960	0.09	20.3	2340	0.7604	20.083	76518	5
Narrow-pod robust thorn	*Albizia anthelmintica*	118,248	0.05	20.3	2340	0.1239	19.497	125674	1
									121

Table 4: A list of the trees present in the transects and information of their parts that include the baboons diet. Abbreviations: Number of leaves at full bloom per tree species (Nl-Fb), Average weight leaf per tree species (Wl-tree), Energy (Kj) per gram of leaf per tree species (El-tree), Number of fruit at full bloom per tree species (Nf-Fb), Average weight fruit per tree species (Wf-tree), Energy (Kj) per gram of fruit per tree species (Ef-tree), 100% bloom energy (Kj) per tree species(Fbe-tree), number of trees (N-tree).

To illustrate the seasonal availability of biomass energy, three scenarios of monthly natural energy availability (Tne-month in MKj) in the transects (per 7.5 km^2) are illustrated in *figure 9,* using a different Ec for each prediction. In all scenarios, biomass energy availability strongly decreases in March, simultaneous with the start of the dry season. This decrease continues to a minimal biomass energy level in June, July, August and September, concurrent with the dry season. In October, a major increase in biomass energy is observed, simultaneous with the start of the wet season, this increase reaches its peak in December, January and February, or mid wet season. These seasonal patterns in biomass growth follow the same trend as the monthly rainfall, which is expected by the normal pattern of biomass growth in South-Africa[34,42]. Because the three different Ec values do not affect the trend of the biomass estimations, the only difference is the amount of energy available throughout the year, and the presence of energy in general during the dry season. However, *figure 9* does illustrate that the energy requirements of the Lahla troop are consistently fulfilled or surpassed in the high and middle scenarios. While in the low scenario during the dry season, these needs are not met.

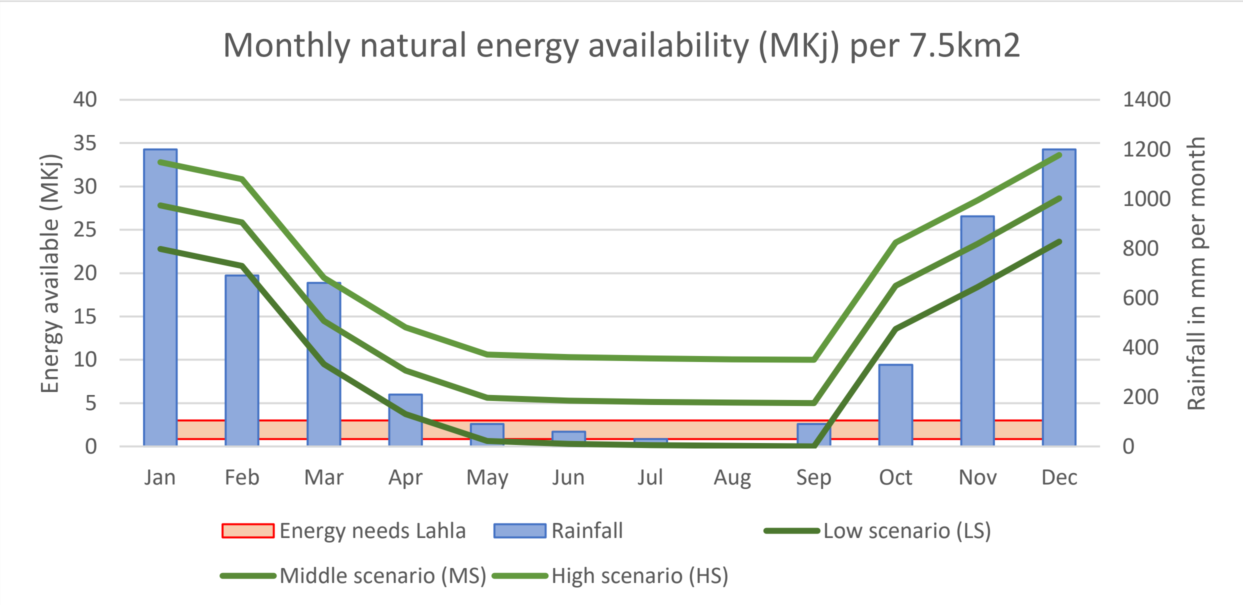

Figure 9: Calculated estimation of the monthly natural vegetation energy (MKj) available for the baboons in all measured transects (7.5 km^2) with three different values for Ec, creating three different natural energy scenarios (LS, MS, HS). A depiction of the average monthly precipitation in Alldays is presented based on the past 30 years of data[37].

3.3 Correlation analysis

The energy availability (MKj) at the dump and in the natural vegetation (per 7.5km^2) are visualized in *Figure 10*, while also including average monthly time (h) spent at the dump by the *Lahla* troop. The amount of energy available at the dump mostly remains relatively low and stable (±4 MKj). Contrarily, natural vegetation shows high energy availability peaks during the wet season in all three scenarios (14-33MKj, October – March), with none-to-minimal energy available in the dry season (±0,005-10MKj, April – September). The time spent at the dump by *Lahla* troop follows the opposite trend compared to natural energy availability, with most time spent at the dump during the dry season when there is minimal natural food availability, and least time spent at the dump during the wet season, when plenty of natural food is available.

These results are confirmed by statistical analysis, as a negative correlation **(Pearson's correlation: -0.29)** is found between the average time spent at the dump and food availability in nature, with a significant p-value **(Two-tailed test: 0.003)**. This suggests that an increase in food availability in nature leads to a decrease in time spent at the dump and vice versa.

Regarding the relationship between the average time spent at the dump and food availability at the dump, there is a positive correlation **(Pearson's correlation: 0.032)**, but with a weak relationship. The p-value **(Two-tailed test: 7.1E-09)** indicates that the correlation is statistically significant, however, the low magnitude of the coefficient suggests that it may not have a substantial impact.

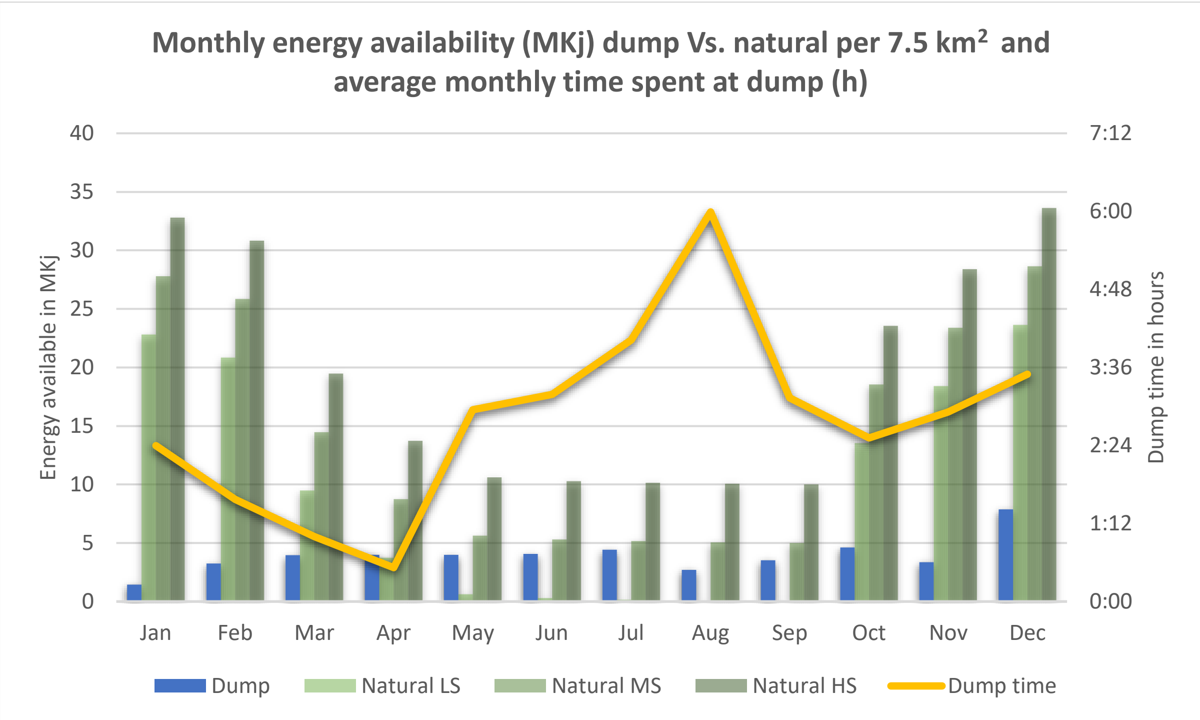

Figure 10: Monthly energy availability (MKj) at the dump and natural vegetation (LS, MS, HS) per 7.5 km^2 are shown in the graph, with the average time (h) spent at the dump per month added.

4 Conclusion and discussion

This report contributes to the development of knowledge on baboon food preference by measuring monthly time spent in HMA's by baboons and utilizing models of food availability in HMA's and natural vegetation over different seasons. Here I present a summary of the main research themes and assessments of the methodology to suggest recommendations for future research.

In context of the baboon foraging behaviour study, there are some factors we should keep in mind when evaluating our experiment:

- Due to their relatively small size and decrease in numbers (25 to 7 baboons in two years), *Lahla* troop may be less representable in their foraging behaviour, as they face increased competition from larger troops and thus have to resort to exploring alternative food sources, such as a dump. The potential risks associated with accessing a dump could be worth it for smaller troops, as it may provide them with a reliable and abundant source of food.
- The dump provides a single location with limited food resources, the home range of baboons in natural vegetation is much larger (±100 times greater) and may increase and change with variation of the baboon's behaviour. As a result, natural vegetation will always be able to offer more food, but possibly at higher costs in terms of foraging or predation risk[23,32,54].
- This experiment does not include important factors that affect baboon food preferences and therefore foraging behaviour, such as nutritional components of food, energy foraging costs and predation risks[29–32,54,55].

Also, the energy availability model has some aspects to consider when analysing the results:

- The dump energy model contains two strong outliers in the dataset: January and December. While December's deviation may be attributed to its small sample size (only 5 datapoints, compared to 25 on average), the reason for January's discrepancy is uncertain. Local residents suggest that it may be related to decreased post-holiday spending, leading to less food waste disposal at the dump.
- Literature did not provide energy values per gram for all individual tree species, so common values were sometimes utilized instead for the natural energy model.
- The natural energy model lacks a precise representation of the constant availability (Ec) of natural food sources (e.g.: insects, grasses, tree bark, shrubs)[18]. To account for this uncertainty, the analysis includes three different constant values representing low, middle, and high scenarios for constant energy availability in the natural environment, as different values for this variable can impact conclusions.

Our results show no clear correlation between the time spent at the dump and the amount of food available at the dump site. The energy supply from the dump is consistent, but comparatively low (3-5 MKj), and does not appear to significantly affect the foraging behaviour of the baboons. However, a significant inverse relationship between the time baboons spend at dump sites and the availability of natural food in all three natural constant scenarios (LS, MS, HS) was found, consistent with previous research (*Fig. 10)*[14,19]. Starting from the wet season (September-October), the baboons' time at the dump was reduced by half as natural food sources increased exponentially. In May, a significant increase in baboon dump time was observed, which coincided with a decline in natural food sources. This supports the idea that baboons prefer natural food foraging when they are abundant and readily available, and their interest in dump foraging decreases accordingly[14,17,19]. With three different natural energy scenarios, varying interpretations of the results are produced:

Low constant scenario (LS)

The low constant scenario suggests that baboons prefer natural foraging over dump foraging when it is available. However, during times of limited natural food availability, they resort to dump food. The observed trend of decreased HMA food utilization during abundant natural food periods aligns with prior research and supports the validity of the low constant scenario[6,19].

Middle constant scenario (MS)

In the middle constant scenario, baboons have ready access to both natural and dump food. Natural food is consistently available throughout the year, even in the dry season, while dump sites remain a steady source of calories. During periods of abundant natural vegetation, like the wet season, baboons tend to prefer natural foraging over dump foraging, possibly due to the presence of seasonal food options like fruits and leaves with a more favorable nutritional composition and lower foraging energy costs[31,32,54]. This scenario demonstrates the possibility of equal availability of food sources, with utilization determined by factors like nutritional or taste preference and foraging ease.

High constant scenario (HS)

Baboons tend to prioritize anthropogenic food sources, such as dumps, over consistently high availabilities of natural food, such as insects and tree bark, in the high constant scenario (HS). This preference may be driven by factors like taste preference and nutritional composition. However, baboons may still show a preference for seasonal natural food that is abundant during the wet season due to its more favorable composition[28,31,32,54]. Our analysis suggests that the high constant scenario is unlikely in nature, as previous research has indicated that baboons resort to anthropogenic food sources only when natural food is scarce. The idea that they would prioritize anthropogenic food over abundant natural food seems unlikely.

Overall, we can conclude that there most likely is a preference for natural food foraging based on the negative correlation between dump time foraging and natural food availability. There are many variables that could influence this behaviour, as it is a complex interplay of ecological factors, for example:

- **Nutritional food composition**: The nutritional composition of food sources plays a critical role in the health and behaviour of baboons. Anthropogenic food sources, such as dumps, tend to contain high levels of fat and energy, but also harmful additives and chemicals. In contrast, natural food sources offer a balanced blend of essential vitamins and minerals, but often lack concentrated fat and energy[28,56]. These differences impact the baboons' health and dietary preferences, as they have a documented preference for sweet food and aversion to salt. The nutritional composition also affects the taste and flavour of the food, which can influence the baboons' food choices[29,31].
- **Foraging costs**: The energy required to obtain food plays a significant role in determining baboon foraging behaviour[32,54]. Anthropogenic food sources, like the dump, are generally more accessible and result in lower energy costs compared to food found in natural environments. Research suggests that baboons relying on HMA food sources tend to travel less distance and at a slower pace compared to baboons foraging in natural environments, where obtaining food requires greater energy expenditure through increased travel and foraging effort[30,32,54].
- **Risk**: Baboons have a tendency to alter their living areas in response to potential predator threats[23]. In Human Modified Areas (HMAs), baboons experience increased danger from humans, leading to potential conflict. However, the presence of wild predators, such as leopards, is reduced[33,57]. In contrast, in natural environments, baboons are exempt from human threats, yet their vulnerability to predation from leopards and lions is heightened[23,24].

Future experiments could categorize these important factors for baboon’s foraging behaviour. For example, by providing baboons with dump food, seasonal natural food, and constant natural food available without the need to forage, and observe baboon preference (based on flavour or nutritional components). From there on, environmental impact could be tested by making the three food types available in different environments, and observe if there is a change in preference (based on predation risk or human threat). Moreover, for the same food types, variable difficulties in foraging could be included in the experiment in order to see the impact of this. Also, calculating and including a more precise model on constantly available natural food could be an improvement for future analyses.

Because data is still being collected, it could be of great assistance to answer these questions in order to understand more of the nature of baboon foraging at HMA's. So, we can hopefully find out how to mitigate baboon-human conflict and improve overall wildlife conservation in the near future, which will be of vital importance to maintain global biodiversity.

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6 Appendix

*Appendix A: Lahla's troop population count over the period they were studied (Dec-19 till Feb-23), NR is not recorded due to Covid-19 or logistical issues. * = males moved to a different troop with juveniles.*

Months	Adult male	Adult female	Subadult male	Adolescent female	Juvenile	Infant	Total
Dec 19	2	7	1	0	10	2	22
Jan 20	2	7	1	0	10	2	22
Feb 20	2	7	1	0	10	4	24
Mar 20	2	7	1	0	10	4	24
Apr 20	2	7	1	0	10	4	24
May 20	2	7	1	0	10	5	25
Jun 20	2	6	1	1	9	5	24
Jul 20	2	6	1	2	8	6	25
Aug 20	2	6	1	2	8	6	25
Sep 20	2	6	1	2	6	6	23
Oct 20	2	5	1	2	5	3	18
Nov 20	2	5	1	2	5	3	18
Dec 20	2	5	1	2	5	3	18
Jan 21	1	7	1	0	5	3	17
Feb 21	0	7	1	0	5	3	16
Mar 21	0	6	1	0	5	4	16
Apr 21	0	6	1	0	5	4	16
May 21	0	5	1	0	5	4	15
Jun 21	0	5	1	0	5	4	15
Jul 21	0	5	1	0	5	4	15
Aug 21	0	5	1	0	5	4	15
Sep 21	0	5	1	0	5	5	16
Oct 21	0	5	1	0	5	5	16
Nov 21	0	5	1	0	5	5	16
Dec 21	NR	NR	NR	NR	NR	NR	NR
Jan 22*	0	5	0	0	0	3	8
Feb 22- May-22	NR	NR	NR	NR	NR	NR	NR
Jun 22	0	5	1	0	1	3	10
Jul 22	0	5	1	0	1	3	10

Aug 22	0	5	1	0	1	3	10
Sep 22	0	4	1	0	1	0	6
Oct 22	0	4	1	0	1	1	7
Nov 22	0	4	1	0	1	1	7
Dec 22	0	4	1	0	1	1	7
Jan 23	0	4	1	0	1	1	7

Appendix B: Ethogram for data collection during scan sampling.

Category	**Sub-category**	**Description**
Date		Date of data collection
Number of observers		Number of people following the group
Time		Time when each scan stared
Environmental		
Weather		Clear sky
		Mostly clear sky
		Mostly cloudy
		Cloudy (Overcast)
		Misty
		Light rain
		Heavy rain
Wind		Calm
		Breeze
		Windy
		Very windy
Habitat		Natural
		Human modified (dump)
Activity		
Feeding	Foraging	Actively searching for foods while stationary or moving in small distances, processing and handling of food items by hand or mouth
	Cheek pouch feeding	Collecting and temporarily storing foods in the cheek pouch, most often chewing.
	Feeding	Holding, licking or chewing and swallowing food items, but not while moving; drinking water or any liquid Further recordings- Types of food, name of plant species and parts of plants being eating (natural food), categories of dumped foods, approximate quantity eaten
Moving	Walking	Move at a regular pace by lifting and setting down hands and foots
	Running	Very fast movement by lifting and setting down hands and foots swiftly
	Climbing	Ascending or sliding from one tree branch to another
Resting	Resting sitting	Sitting stationary
	Resting standing	Standing stationary
	Resting lying	Sleeping or lying down, eyes may be closed

	Resting huddle	Sitting very closely with one another, often performed by at least two individuals
Grooming	Groom other/groom given	Manipulating, nibbling or licking fur of other group members Further recordings- individual Identity and age-sex of partner
	Being groomed/groom received	Manipulating, nibbling or licking fur by any other group members Further recordings- individual Identity and age-sex of partner
Others		
Distance from nearest neighbour		Estimated distance to the nearest neighbour (at 1 metre intervals for 0-10m) and name of individual
Location of the activity	Ground	On the ground
	Man-height later	Between the ground and 2m above the ground
	Lower canopy	2-5m above the ground
	Mid canopy	5-10m above the ground
	Upper canopy	10m or more above the ground

Appendix C: Daily time (h) spent at the dump by Lahla troop per month (Dec-19 till Dec-22).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
03:30:00	00:50:00	02:15:00	00:25:00	04:00:00	04:20:00	03:50:00	03:20:00	04:40:00	03:30:00	04:50:00	03:50:00
01:15:00	01:20:00	01:00:00	00:30:00	02:30:00	01:50:00	05:10:00	02:35:00	05:40:00	02:45:00	02:30:00	04:15:00
01:10:00	02:35:00	01:10:00	00:10:00	05:15:00	02:55:00	05:35:00	04:00:00	03:00:00	04:20:00	04:30:00	03:40:00
02:15:00	01:05:00	01:05:00	01:00:00	03:00:00	03:25:00	03:35:00	05:15:00	03:30:00	01:50:00	01:30:00	03:30:00
02:10:00	01:15:00	00:00:00		03:30:00	03:40:00	04:45:00	03:20:00	05:35:00	04:10:00	01:20:00	03:00:00
03:45:00	05:05:00	01:00:00		02:30:00	01:55:00	03:15:00	02:20:00	01:55:00	05:45:00	02:05:00	01:40:00
02:00:00	02:20:00	00:00:00		03:50:00	03:50:00	02:45:00	05:05:00	04:30:00	02:05:00	02:05:00	03:00:00
03:30:00	00:50:00	01:05:00		03:45:00	04:10:00	02:50:00	05:00:00	03:40:00	05:15:00	01:30:00	02:00:00
02:00:00	01:10:00	00:50:00		01:15:00	04:20:00	04:10:00	06:20:00	03:10:00	02:40:00	00:35:00	02:00:00
	00:00:00	01:35:00		02:30:00	03:00:00	04:10:00	05:35:00	02:55:00	02:00:00	00:00:00	07:30:00
	01:25:00			04:10:00	01:30:00	02:50:00	04:45:00	03:40:00	03:05:00	03:00:00	03:00:00
	00:55:00			00:35:00	06:10:00	05:05:00	03:00:00	01:30:00	01:30:00	05:20:00	04:30:00
				01:30:00	01:15:00	02:45:00	03:35:00	04:00:00	00:15:00	03:30:00	
					03:20:00	02:40:00	00:00:00	02:25:00	01:50:00	02:40:00	

					03:20:00	02:45:00	01:40:00	02:10:00	00:00:00	04:20:00	
					01:44:00	06:15:00	02:10:00	06:40:00	05:15:00	04:00:00	
					02:10:00	08:05:00	04:15:00	02:55:00	02:20:00	02:00:00	
					03:05:00	02:30:00	02:50:00	00:50:00	03:30:00	00:30:00	
					01:45:00	05:20:00	00:00:00	02:00:00	03:10:00	03:30:00	
					06:00:00	01:50:00	06:00:00	01:40:00	02:40:00	03:30:00	
						03:45:00	03:35:00	03:35:00	01:00:00	03:30:00	
						03:40:00	00:45:00	01:55:00	05:30:00	04:30:00	
						02:00:00	03:35:00	02:45:00	00:00:00	00:30:00	
						03:30:00	01:15:00	03:20:00	00:00:00	02:30:00	
						04:00:00	01:00:00	02:00:00	01:00:00	05:30:00	
						04:30:00	08:00:00	04:30:00	02:15:00	07:00:00	
						08:00:00	03:30:00	05:00:00	02:45:00	02:00:00	
						03:30:00	03:00:00	00:30:00	00:00:00		
						03:30:00		02:00:00			
								02:00:00			

Appendix D: Trash bag influx count per day (Jan-20 till Oct-21).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6	5	260	93	36	9	3	41	152	9	78	132
16	6	86	16	12	60	12	85	36	27	46	121
11	13	356	28	69	72	11	61	132	27	9	65
17	5	27	30	8	125	204	142	11	85	62	222
8	8	11	24	135	5	16	2	3	242	54	3
12	16	17	12	28	150	10	9	260	3	26	
31	53	16	16	96	6	41	14	129	55	48	
84	27	31	93	64	25	159	6	35	32	85	
17	18	35	30	59	19	60	5	24	13	10	
12	179	22	13	99	3	206	13	82	27	30	
11	131	88	35	26	84	129	66	110	235	14	
12	68	94	10	30	33	49	44	15	8	20	
25	30	14	28	54	37	85	17	11	202	7	
7	272	12	78		179	62	195	19	101	161	
13	9	39	33		5	5	11	75	121		
18	14	33	98		98	7	23	22	70		
9	13	70	202		10	23	13	48	16		
13	82	71	153		19	147	2	24	96		

5	31	64	3	67	5	62	19
42	31	19	9	59	6	4	14
42	1	34	249	91	28	8	16
7	33	33	12	24	25	10	4
38	8	24	71	24	77	10	191
	10	27	20	160	27	9	129
	50	40	31	44	47	56	175
	40	21	130	11	13	87	34
	70	21	53	83	32	49	108
	24	2	55	110	10	23	5
	16	19		10	69	21	6
	17			13	37	60	7
	96			23	6	11	3
	107			63	46	21	15
	11			59	59	9	9
	25			6		30	

Appendix E: Fraction of full dataset as an example: Measured weight (g) per food category per 20 trash bags from the dump twice a month.

Food type	Nutritional value/g	January	January2	February	February2	March	March2
Bread	10.4	797.68	1030.64	1056.64	417.56	589.16	312.52
Chips	21.61	0	0	0	0	0	0
Cooked food	5.11	235.06	16.863	425.9185	321.1635	45.7345	886.8405
Leftover fruits	2.2	1102.53	25.08	134.53	16.72	0	58.41
Leftover vegetables	0.75	415.5	103.3875	22.125	100.3125	1.0125	79.8
Milk/ milk product	2.72	102.136	28.152	549.44	367.2	2.72	157.624
Sauces	11.96	0	0	155.48	627.9	29.9	119.6
Soft drinks/juice	1.8	75.33	27	12.78	9	0	0
Dry foods/biscuits/dry pasta/dry rice/flour	14.17	36.842	699.998	519.3305	19.838	29.757	87.854
Animal derived food	12	0	0	0	0	28.8	96
Garden waste e.g. sugarcane	1	0	0	0	0	0	0
Water	0	0	0	0	0	0	0
Total Kj/bag		2765.078	1931.1205	2876.244	1879.694	727.084	1798.6485

Appendix F: Edible vegetation from the selected transect.[50,51,58]

SPECIES	*Latin*	Fruits	Seeds	Bark	Leaves	Buds	Flower	Roots
Marula	*Sclerocarya birrea*	Y	Y	Y	Y	Y	Y	N
Shepherds Tree	*Boscia albitrunca*	Y	N	Y	N	Y	Y	N
Sandpaper Raisin	*Grewia flavascens*	Y	Y	Y	N	Y	Y	N
Common Corkwood	*Commiphora pyracanthoides*	Y	Y	N	Y	Y	N	Y
Velvet Raisin	*Grewia flava*	Y	Y	N	Y	Y	N	N
White Raisin	*Grewia bicolor*	Y	Y	Y	Y	Y	Y	N
Knob Thorn	*Acacia nigrescens*	Y	Y	Y	Y	N	Y	N

Glossy-Leaved Corkwood	*Commiphora schimperi*	Y	Y	N	N	Y	N	N
Red Bushwillow	*Combretum apiculatum*	Y	Y	Y	Y	Y	N	N
Baobab	*Adansonia digitata*	Y	N	Y	Y	Y	Y	N
Purple-Pod Clusterleaf	*Terminalia prunoides*	Y	Y	Y	Y	N	Y	N
Sicklebush	*Dichrostachys cinerea*	Y	Y	N	Y	N	N	N
Velvet-Leaved Corkwood	*Commiphora mollis*	Y	Y	Y	Y	Y	N	N
Mallow Raisin	*Grewia villosa*	N	Y	N	N	N	N	N
Worm-Bark False-Thorn	*Albizia anthelmintica*	Y	Y	N	Y	Y	N	N
Rough-Leaved Corkwood	*Commiphora edulis*	Y	Y	N	Y	Y	N	N
Poisin-Grub Corkwood	*Commiphora africana*	Y	N	N	Y	Y	N	N
Sweet Thorn	*Acacia karoo*	N	N	N	Y	N	N	N
Zig-Zag Clusterleaf	*Terminalia stuhlmanni*	N	N	N	Y	Y	Y	N
Copperstem Corkwood	*Commiphora harveyi*	Y	Y	Y	Y	N	N	N
Knobwood	*Zanthoxylum capense*	N	N	N	Y	N	N	N
Flame Thorn	*Senegalia ataxacantha*	N	N	N	Y	N	N	N
Four-Leaved Bush Willow	*Combretum adenogonium*	N	N	N	Y	N	N	N
Silver Clusterleaf	*Terminalia sericea*	N	Y	N	N	N	N	N
Star Chestnut	*Sterculia rogersii*	Y	N	N	N	N	N	N

Appendix G: Percentage of bloom per month per tree species relative to their measured Nl-Fb & Nf-Fb.

% bloom	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Nl-Fb	Nf-Fb
Common corkwood	0.8	0.775	0.478571	0.0321429	0.0035714	0	0	0	0	0.19642857	0.41875	0.8125	230,340	2340
Knob thorn	0.760714	0.657142857	0.542857	0.525	0.175	0.075	0.04285714	0.010714	0	0.26428571	0.471429	0.72857143	290,400	200
Marula	0.866667	0.872222222	0.8	0.4611111	0.0625	0.00625	0.00625	0	0	0.33125	0.7625	0.84444444	2985	400
Purplepod clusterleaf	0.7	0.8	0.775	0.55	0.5	0.375	0.2	0.1	0	0.7	0.75	0.7	178,158	864
Red bushwillow	0.75	0.85	0.675	0.55	0.2	0.1	0.025	0.025	0	0.275	0.25	0.75	7,872	1000
Rough-leaved corkwood	0.875862	0.868965517	0.284483	0.08	0	0	0	0	0	0.54137931	0.698276	0.84482759	22,960	2340
Vervet-leaved corkwood	0.695455	0.478787879	0.168182	0.0075758	0.0015152	0	0	0	0	0.60909091	0.757576	0.78484848	148,680	2340
Worm-bark false-thorn	0.72	0.79	0.58	0.87	0.04	0	0	0	0	0.37	0.52	0.74	64,584	1000
Stink wood	0.8	0.7	0.5	0.2	0.05	0.01	0	0	0	0.2	0.5	0.8	44217	100
Stink shepherd's tree	0.760714	0.657142857	0.542857	0.525	0.175	0.075	0.04285714	0.010714	0	0.26428571	0.471429	0.75	0	1000
Sjambokpod	0.875862	0.868965517	0.284483	0.08	0	0	0	0	0	0.54137931	0.698276	0.9	12246	1000

Shepherd's tree	0.8	0.7	0.5	0.2	0.05	0.01	0	0	0	0.2	0.5	0.8	0	1000
False marula	0.875862	0.868965517	0.284483	0.08	0	0	0	0	0	0.54137931	0.698276	0.84482759	22,960	2,340
Narrow-pod robust thorn	0.875862	0.868965517	0.284483	0.08	0	0	0	0	0	0.54137931	0.698276	0.95	118248	2340

Appendix H: One-way Anova on ''Daily time spent dump''

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Jan	9	2.84464	0.316071	0.004627
Feb	12	2.851179	0.237598	0.012512
Mrt	10	1.820006	0.182001	0.010423
Apr	4	0.565988	0.141497	0.002525
Mei	13	4.533083	0.348699	0.008451
Jun	20	7.310271	0.365514	0.00723
Jul	29	12.06101	0.415897	0.006961
Aug	28	10.4402	0.372864	0.016262
Sep	30	10.80098	0.360033	0.008896
Okt	27	8.29133	0.307086	0.021272
Nov	16	5.183144	0.323947	0.016253
Dec	7	2.628291	0.37547	0.002987

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.803084	11	0.073008	6.342615	6.3E-09	1.83853
Within Groups	2.221556	193	0.011511			
Total	3.02464	204				