

# OXFORD BROOKES UNIVERSITY

## **Non-Natural Foraging Practices of Yellow baboons (*Papio cynocephalus*) in Diani, Kenya:**

### **The Effects of Tourism on Behavior in a Human-Dominated Environment**

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**Abstract:**

As human settlements expand and proximity to non-human primates increases, anthropogenic foraging becomes a source of conflict. In Diani, Kenya a decrease in tourism between 2013 and 2015 has led to decreased amounts of human activity. This study seeks to determine how a decrease in available artificial forage has changed the activity budgets of the local baboon troops. In 2013, Colobus Conservation gathered baseline data on behavior, feeding ecology and distribution of five troops of *Papio cynocephalus* in Diani. During this study I will construct an activity budget, conduct a dietary analysis and determine home range of the same five troops. Additionally, I will conduct a hotspot analysis of *p. cynocephalus* activity in order to create target areas for Colobus Conservation's management plans. By determining changes in each troop's behavior, diet, and distribution I can provide the involved organizations with accurate data regarding human-primate interactions. In the base data set, the baboon troops spent an average of  $40.24 \pm 5.59\%$  of the daytime feeding,  $25.82 \pm 4.66\%$  resting,  $21.75 \pm 2.05\%$  moving,  $8.92 \pm 0.37\%$  socializing and  $3.08 \pm 0.63\%$  other (n=22,944) (Heinicke, 2013). In the current study, the troops spent an average of  $25.54 \pm 7.46\%$  of the observation period feeding,  $23.84 \pm 3.51\%$  resting,  $16.50 \pm 5.64\%$  moving,  $13.54 \pm 1.68\%$  socializing, and  $20.60 \pm 3.94\%$  other (n= 13,884). These results were compared with semi-provisioned and natural-foraging troops at other sites in Kenya and Tanzania. Significant differences between the troops revealed that troops in Diani spent less time feeding and ingested more anthropogenic forage than they had in 2013, revealing activity budgets consistent with semi-provisioned troops elsewhere.

**Key words:** Activity budget · Anthropogenic feeding sites · Anthropogenic Forage · Pest management

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### Introduction:

As human populations around the world continue to expand, land use patterns change to support increased population density. This means more land put aside for housing, for agriculture, and used for natural resources. These actions have increased the frequency and intensity of human-wildlife interactions. Understanding the relationships between human development and changes in the local wildlife forms the basis of all conservation and management policy. The effects that prolonged exposure to human presence have on wildlife are numerous and highly varied. In situations where they don't result in avoidance, they result in habituation. The severity of any effects of human exposure on wildlife varies considerably with the animal itself; its species, age, sex, physical condition, and stage of breeding, but also with the kind of habitat it occupies, whether it is close to other animals, and previous encounters with different types of human activity (Altmann & Alberts, 2003). This exposure could be daily routes through human settlements, peaceful observation, being violently driven off by guards, or being fed by tourists, among myriad others.

In Diani Beach, Kenya, high amounts of tourist traffic have resulted in the construction of large hotels, restaurants, shopping malls, and staff quarters. This construction has fragmented the once uninterrupted coastal forests; increasing the exposure of wildlife, specifically the non-human primates, to anthropogenic food sources. During the construction and early growth in tourism, lax management policies, poor knowledge of human-primate interactions, and tourist hand-feeding led to many species becoming semi-provisioned and eventual pest species. Though they are currently being addressed by local conservation organizations, these changes have had both short and long term consequences for local wildlife (Colobus Conservation; *Pest Management Prescriptions*, 2004). These vary from short term changes in physiology or behavior of

individual animals through to long-term effects such as increased mortality or reduced breeding success of entire populations. Impacts at the ecosystem level include non-intuitive effects on local troops of non-human primates (Else, 1991; Naughton-Treves, 1998).

The present study was undertaken to examine the effects of human activity and accessibility of anthropogenic forage on the activity budgets and ranging patterns of a population of yellow baboons (*Papio cynocephalus*) in Eastern Kenya. Preliminary data was gathered by Stefanie Heinicke and Colobus Conservation in 2013. During the course of this study, baboons were faced with variations in food quality and quantity as consequences of the availability and accessibility of anthropogenic food sources within their home range. Anthropogenic food sources included refuse from hotels, refuse from local settlements, crops from local farms, and hand-feeding from tourists (Heinicke, 2013). Previous studies strongly suggest that anthropogenic forage as a diet enhancer would have a profound effect on the social behaviors and home range size of the local baboon troops (Kamal et al, 1997).

Provisioning situations provide an excellent opportunity to study social and ecological factors that operate in a continuum of environments ranging from various undisturbed habitats through provisioned, semicaptive, and completely captive ones, and these situations can contribute to documentation of limiting factors for populations. However, another important potential of such studies is their possible contribution to management policies that modify or eliminate many of these sites of conflict. (Altmann & Muruthi, 1988; Kamal et al, 1997; Moinde, 2015). For this study, it's not only important to focus on the effects of increases in human population due to tourism, but also the effects of decreases.

Instability in Kenya and its neighbors in the past decade caused security concerns for international tourism. Tourist traffic remained high between 2000 and 2007. However, following the controversial presidential election in 2007 and the national crisis it sparked, tourism revenues and traffic had plummeted 54% by 2008 (Reuters, 2008). While tourism revenue recovered following a negotiated peace, military action by Kenya against Somalia to the north triggered another period of instability in 2011 (Buigut & Amendah, 2016). 2011 saw the first recorded terrorist attacks by Al-Shebab in Nairobi. These attacks increased in frequency, became more violent, and expanded to other major cities, including Mombasa, throughout 2012 and 2013. By 2014, when Kenya grew more stable, many major international sources of tourism revenue had issued travel advisories against non-essential travel to the region. These countries included the U.S.A., Canada, the U.K., Germany, and other EU nations (Buigut & Amendah, 2016).

### **Tourism, Development, and Availability of Anthropogenic Food Sources:**

The frequency with which an animal experiences a particular stimulus will influence its response. If animals repeatedly encounter the same stimulus without experiencing harm, they may habituate or become desensitized to that stimulus and their responses will be reduced. While

this is desirable for commercial wildlife tourism, it is the opposite in urban centers and hotels (Moinde, 2015). Among nonhuman primates, differences in social structure, behavior, and size and use of home range have been attributed to characteristics of food resources (Altmann, 1974; Altmann & Muruthi, 1988). Access to anthropogenic forage has been shown to have severe effects on baboon behavior. It is a stimulus that attracts wild animals into close proximity of human settlements; leading to the habituation of wildlife to human presence and reinforcement of associations between humans and high energy foods (Altmann & Muruthi, 1988; Kamal et al, 1997; Moinde, 2015). In their pursuit of an optimal foraging strategy (OFS), baboons focus foraging efforts on food items which provide the greatest energy intake for the least energy expenditure. Due to their short handling times, high nutrient contents, and easy digestibility, anthropogenic food sources are highly sought after diet enhancers. In all instances where they are available, they represent the OFS (Frothman Quick, 1986).

Limiting factors exist in Diani which both make anthropogenic forage more available in some places and more difficult to access in others. Similarly, factors exist which make natural forage more difficult to access. These factors include, but are not limited to, forest fragmentation, anthropogenic feeding sites (AFS) between fragments, inconsistent refuse management on hotel grounds, inconsistent enforcement of anti-feeding rules, increasing human population size and density, as well as increasing baboon population size and density. These characteristics of Diani's foraging environment could have direct influence on the behavior of *P. cynocephalus* in the area. Socioecological models predict that food resources that are relatively high in abundance, patchily distributed and/or have higher nutrient value compared to other surrounding food resources intensify contest competition compared to food resources that have relatively lower nutrient value and are uniformly distributed (Wrangham, 1980; van Schaik 1989; Isbell, 1991; Sterck et al. 1997). Further, these models also posit that since individuals cannot successfully contest for food resources alone, increased affiliative (e.g., grooming) and coalitionary interactions (e.g., joint attack or defense) are likely to be selected for amongst individuals (Moinde, 2015). According to Janson (1985), if within-group contest competition is strong, higher ranking female's gain better access to high quality resources; thus, the tendency to engage in aggressive interactions is likely to be enhanced. Contest competition is thought to occur when resources are limiting, defendable and worth defending (Quick, 1986).

According to Moinde (2015) higher feeding rates within a specific land use system are an indicator of overall better habitat quality for baboons relative to other land use systems. In habitats with better foraging environments, baboons spent a higher proportion of time feeding with longer duration of bouts and fewer food stops. Feeding rates can be used to provide the most precise assessment of food availability in an area and can be used to indirectly access the energy derived from certain food types (Byrne et al. 1990; Barton et al. 1992; Nakagawa 2000; Moinde, 2015). The combination of these attributes was indicative of higher availability of food resources with larger, highly concentrated food patches (Garber 1986; Iwamoto 1992; Isbell et al 1998; Moinde, 2015). In situations with enhanced levels of contest competition, adult female

aggressive interactions occur outside the context of food as well. These interactions included competing for mates, space, and access to infants and grooming partners, and can enhance the complexity of social relationships more than ecological factors alone (Pruetz 2009). However, findings from this study indicate that, when agonistic behaviors within the context of food competition were not taken into consideration, adult female baboons competed and exhibited agonistic behaviors equally across land use systems. Food, therefore, appears to be the most important resource that influenced differences in aggressive behaviors across the land use systems. The provisioning of wild baboons with anthropogenic forage produces measurable social conflict (Kamal et al, 1997; Moinde, 2015).

### **Activity Budget**

Artificially augmenting the food supply of wildlife can alter other aspects of behavior as well. Provisioned foods allow animals to attain essential nutrients in a shorter amount of time than access to only a natural food source would (Wilson, 1994; Gill, 2002). Provisioned animals are then able to devote more time to other activities. These differences are apparent between populations of the same species. Within the genus *Papio* access to anthropogenic food sources, whether through presence of crops, garbage, or direct feeding, reduced by half the time that the animals in various studies spent feeding and obtaining food. In congruence with Dunbar's argument that resting time represents "slack time more than does socializing time (Dunbar & Shaman, 1984; Dunbar, 1992) troop activity budgets in these scenarios show increases in proportion of daily activity spent socializing and resting.

Previous studies on provisioned primates show a decrease in feeding time associated with provisioning or anthropogenic foraging (in the rhesus. Marriot, 1988; Malik & Southwick, 1988; and in baboons, Forthman-Quick & Demment, 1988, Altmann, & Alberts, 2003). Vervet monkeys (*Cercopithecus aethiops*) in Amboseli under conditions of food enhancement, spent approximately 20% of the time feeding, while wild-foraging vervets spent almost 40% of the time feeding (Brennan et al., 1985). The semi-provisioned vervets spent more time resting and socializing and moved less than did the un-provisioned animals.

Species of the genus *Papio* in the wild typically spend from 40 to 50 % of their time feeding (Bercovitch, 1983; Altmann & Muruthi, 1988). This time is reduced to 10-20 % by foraging from crops or garbage pits (Forthman-Quick & Demment, 1988 ; Muruthi et al., 1991).Olive baboons (*Papio anubis*) in Gilgil, Kenya, fed or foraged approximately 25% of the time if they had access to garbage and planted crops and almost 50% of the time without such access (Altmann & Muruthi,1988; Forthman-Quick, 1984, 1986). The food-enriched Gilgil baboons spent almost twice as much time engaging in resting behaviors slightly more time socializing, and slightly less time moving than did the un-provisioned animals (Forthman-Quick, 1986; Altmann & Muruthi, 1988). In a study of cyclical provisioning of troops of hamadryas baboons

(*Papio hamadryas*) comparative data reveal that the impact of anthropogenic forage, even during low provisioning periods, is not negligible and strongly reduces the need for natural foraging. However, a 30 % increase in feeding time was observed from low provisioning to high provisioning periods. This was coupled with a shift from natural forage to anthropogenic forage, implying a much greater difference in energy intake since the calorie gain per gram is considerably higher for anthropogenic forage (Forthman-Quick & Demment, 1988). The *P. hamadryas* in the study are likely to be overfed during periods of higher provisioning (Boug et al, 1994).

Moinde (2015) reveals that the availability of an anthropogenic food supply resulted in less time spent feeding and more time spent resting among adult females in a group of free ranging baboons regardless of the female's rank within the troop. Socializing time was only slightly increased, and time spent in locomotion was not changed. Changes to activity budgets due to anthropogenic forage affect all members of a troop regardless of social rank and whether major reductions in food availability result in more or less social interaction and competition seem to depend on the amount, distribution, and stability of the food supply (Boug et al, 1994; Kamal et al, 1997; Moinde, 2015)

## **Reproductive Success**

Food enhanced free-ranging baboons experience better body condition than their non-provisioned counterparts (Bercovitch & Strum, 1993). Within the focal troops, access to greater nutritional resources via anthropogenic forage is positively correlated with body condition and negatively correlated with parasitism (Bercovitch & Strum, 1993). In addition, the tempo of reproductive maturation appears to be partly a function of ecological conditions. When foods are clumped or restricted in distribution due to seasonality or location, conditions are conducive to resource monopolization by high-ranking female primates. Differential acquisition fosters rank-related difference in reproductive output (Bercovitch, 1991). Dominant females tend to have a greater reproductive success (Harcourt, 1987; Silk, 1987; Bercovitch, 1991).

Dominant female primates have priority of access to limited food items, often monopolizing critical resources (Whitten 1983; Iwamoto 1987; Barton 1989). Because enhanced nutrition boosts growth rates and improves body condition (Strum 1991), we would expect that rank effects on female reproductive maturation would be most likely to occur under conditions of restricted or seasonal food distribution or availability. (Bercovitch & Strum, 1993) Food provisioning accelerates age at first birth among high-ranking female Japanese macaques, but not among low-ranking females (Sugiyama & Ohsawa, 1982).

In contrast, even when biomass is at its lowest at Gilgil, baboon food items are dispersed and indefensible, yielding a situation that partly ameliorates rank-related effects on age at first birth, yet maintains an accelerated birthrate within the population (Bercovitch & Strum, 1993).

Depending upon resource availability, the onset of puberty has a floor of about 3 years and a ceiling of about 6 years. No baboons have been reported to exceed this age without commencement of menstrual periods. The age at first birth has a floor of about 5 years, but no ceiling effect (Bercovitch & Strum, 1993). In provisioned troops, females reach puberty sooner than in wild-feeding troops. Differences reported between locations in Africa in the effect of rank on the timing of first birth may be the result of differences in habitat characteristics and the potential for resource monopolization by dominant individuals (Bercovitch & Strum, 1993). It is worth noting that, because high rates of reproduction incur a survival cost to females or to their semi-independent previous infant under some conditions (Altmann et al., 1988; Altmann and Alberts, unpubl. data), female reproductive output may be under stabilizing selection in a balance between survival and additional offspring production.

### **Home range**

Foraging environment has a large, pervasive impact on different components of life history in baboons (Strum, 1991; Altmann and Alberts, 2003). However, far from merely experiencing the foraging environment as a fixed, exogenous circumstance, baboons actively improved their foraging environments. *P. Anubis* in Amboseli displayed two strategies.

One group moved into the vicinity of a tourist lodge and made regular visits to its refuse pit. This provided access to a concentrated, abundant, and easily processed and digested food resource. As a consequence, the Lodge Group baboons ingest almost the same calories and protein as the wild foraging baboons, but spend much less time and travel to do so (Muruthi et al., 1991). The results are manifold. Offspring growth rates in Lodge Group are almost double those of wild-foraging animals (9 vs. 5 g/day). Maturation occurs a year earlier; infant survival reaches 90% (approximately 27% higher than in wild-foraging groups); and interbirth intervals are reduced almost 6 months for females whose most recent offspring is still alive, from about 22 months in the wild-feeding groups to 16 months in Lodge Group (Muruthi et al, 1991; Altmann & Alberts, 2003).

The natural-foraging troops actively improved their foraging environments through marked home-range shifts. Following extensive die-offs of Acacia trees, both natural-foraging troops abandoned the home range they had occupied in the central Amboseli basin (Altmann, 1998). In each case, the troops moved 5–6 km west to home ranges that showed little or no overlap with their previous ones (Bronikowski and Altmann, 1996; Alberts and Altmann, 2001; Altmann and Alberts, 2003). The new home ranges contained a relatively high density of *Acacia xanthophloea* trees, which are important food and refuge species for baboons. These shifts yielded similar changes to the troops' life histories as those experienced by the lodge troops. Infant survival increased nearly 40%, from 51% to 70%. Age at maturity for females occurred 5 months earlier,

and inter birth intervals for females with surviving offspring was reduced from 1.8 to 1.6 years (Altmann and Alberts, 2003).

Altmann and Alberts (2003) suggest that these changes may explain observed differences in home ranges and life history parameters from other sites. As foraging conditions change within and between populations, either as a result of troop actions or external stimuli, life-history parameters for those populations change.

In addition, clear differences in activity and ranging patterns were shown to be correlated to the level of provisioning in hamadryas groups (*Papio hamadryas*) along a tourist road in Saudi Arabia (Kamal et al, 1997). When troops were more dependent on natural vegetation due to low tourist traffic along the road, they expanded their home range and increased daily travel outside provisioning sites. During periods when anthropogenic food became more available, home range, daily travel outside of provisioning sites, and speed of locomotion were greatly reduced (Kamal et al, 1997).

### **Baboons as a Pest Species**

Provisioning usually leads to more rapid maturation, to higher rates of survival and reproduction, and, ultimately, to population growth and greater population densities among non-human primates. This growth, combined with the fact that the provisioning comes either directly or indirectly from humans, means that competition and conflict with humans is almost inevitable (Else & Eley, 1985; Else, 1991). Primates that can take advantage of anthropogenic food sources, such as those from the genera *Papio*, *Cercopithecus*, and *Macaca*, quickly become regarded as pests by their human neighbors. These primates are often cited as significant agricultural pests, which cause considerable damage to field and tree crops. Human guarding against these behaviors imposes time and energy costs on local farmers (Hill, 2000; Naughton-Treves, 1997). Within the context of primate foraging strategies, anthropogenic food sources represent high yield items with varying degrees of risk attached. Hotel waste, local waste, and hand-fed items can represent significantly less risk than actively guarded crops or prepared foods. Baboons, due to their cooperative behaviors, ability to learn rapidly, and opportunistic and non-specialized foraging methods, are highly susceptible to being regarded as pests (Else, 1991; Hill, 2000). Studies looking at the behavior of crop-foraging baboons have reported that troop ranging behavior, frequency, and duration of feeding bouts varied according to season and the degree of vigilance practiced by farmers (Maples et al, 1976; Forthman-Quick, 1986; Hill, 2000). Incidences of crop foraging behaviors also varied with baboon proximity to farms and human settlements (Hill, 2000). These conflicts can severely reduce the acceptance of non-human primates and undermine conservation efforts targeting both the pest species and other primate species in the area (Campbell-Smith et al, 2010). Because nonhuman primate species ultimately lose in competition with humans, the apparent benefit to those species that adapt their diets to anthropogenic food sources will usually be misleading and ephemeral (Else, 1991). The resulting conflicts between human and primate rapidly lead to calls for eradication of the animals that are

perceived as dangerous or pests. Removing the offending animals without eliminating the conflict situation often results in movement by adjacent animals into the vacated prime habitats, and the cycle begins again (Moinde, 2015). Thus a solution that may appear to be quick and low-cost can lead to the loss of many animals from their home area, sometimes the loss of an entire population, and can involve considerable financial outlay. As a result, in many situations regarding baboons, lethal solutions are employed. The problems and solutions for conservation of adaptable omnivores such as baboons are different but no less real than those for species for which human encroachment is more immediately and obviously detrimental (Altmann & Muruthi, 1988).

### **My Objectives and Predictions**

This study aims to determine changes to the activity budget, dietary composition, and ranging patterns of five troops of *Papio cynocephalus* in Diani Beach, Kenya between 2013 and 2016. We ask the following questions: 1) has a decrease in tourism between the preliminary study (2013) and this study (2016) led to a decrease in the proportion of anthropogenic forage within each troop's diet? 2) What trends are reflected in changes to each troop's activity budget? And 3) what trends are reflected in changes to the ranging patterns and population density of each troop?

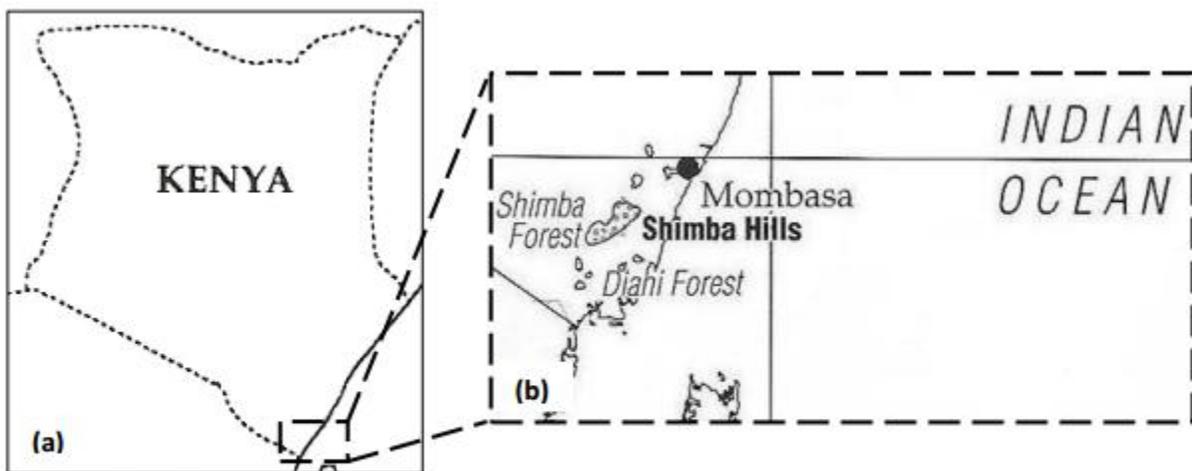
Following decreases in tourist traffic in Diani, this study predicts that the proportion of anthropogenic forage in each troop's diet will decrease and that the proportions of each troops activity budget spent foraging and resting will increase and decrease, respectively. Additionally, this study predicts increased home range size for each troop consistent with loss of access to anthropogenic food sources (Kamal et al, 1997; Altmann & Altmann, 2003; Moinde, 2015)

### **Methods and Materials:**

#### ***Study Site:***

Both studies took place in Diani Beach, Kenya, a small, coastal town in Kwale District located 40 km south of Mombasa (Fig. 1). The study area is located between latitudes 4.16 and 4.21 S and longitudes 39.33 and 39.36 E. Diani Beach has high tourist activity compared to surrounding areas and is characterized by hotels, restaurants, shops, and other attractions situated along one road running North-South; Diani Beach Road. Most farms and local houses are located on the inland (west) side of the road. Staff quarters for each hotel are also on the inland side. The soil in the area is shallow, sedimentary soil comprised mostly of recent corals. Due to this, Diani is a mosaic of coastal rag forest patches which have been developed and degraded to varying extents. In these patches the canopy reaches between 6-10m (Clarke and Robertson, 2000) and undergrowth is usually absent. Common tree species include acacia and bushwillow. However, this is offset by the growth of thick vegetation along the fringes of each patch. Two protected areas called the Kaya Ukunda and the Kaya Diani are exceptions. They are located 0.7km and

0.5km inland from Diani Beach road, respectively. Each has old growth trees that are considerably taller, canopy heights range from 25-35m. The climate is tropical and temperatures remain high during the rainy season. The average temperature in Mombasa is 26.8°C and average rainfall ranges between 900 and 1400 mm (Clark, 2000). However, due to seasonality, 50-70% of the annual rainfall falls during the three wettest months (Clark, 2000). The preliminary study was conducted during the short rains between September and December, 2013 and the follow up study was conducted during the long rains between May and August, 2016. The current major threats to primates in Diani are habitat loss, road deaths, electrocution and snares (Colobus Trust 2011).



**Figure 1.** Map showing (a) the outline of Kenya. Source: Wasser and Lovett 1993 and (b) the location of Diani forest at the southern coast of Kenya between Mombasa and the Tanzanian border. Source: Rodgers et al. 1992.

### ***Study Population:***

Diani beach is home to five troops of yellow baboons (*Papio cynocephalus*). In accordance with previous research the troops are labeled A1, A2, B1, B2, and C. During Heinicke's 2013 study troop size was  $29.6 \pm 10.19$  individuals. During this study, Colobus Conservation's 2015 census data indicated that troop size was  $37.2 \pm 10.38$  individuals. All troops are highly habituated and will tolerate human presence and observation from as close as 2 m.

### ***Data Collection:***

Data were collected from May 16 to July 28, 2016. Troops were followed on a rotating schedule based on proximity to Colobus Conservation. They were followed in the following order: B2, B1, A2, A1, C. Each troop was followed from 6am to 6pm, Monday to Friday. Focal troop was rotated every week. This cycle was repeated twice for a total of 10 days each. Some troops were

followed for an additional 3-5 half days. Researchers used instantaneous focal sampling (Altmann, 1974; Heinicke, 2013). Each individual was followed for 20 minutes with data being collected every minute according to 20 categories of behavior. Focal individuals were chosen semi-randomly to prevent over sampling of highly visible subjects. When the individual was feeding, basic food type was also recorded (provisioned foods, crops, fruits, young leaves, mature leaves, etc). Infants were not included as focal subjects (Heinicke, 2013).

Data was collected by the author and one field guide, Gabriel Matua. Data was collected on the following schedule; troops were located by midday on Monday and followed to their sleeping site. During this time, both GPS and behavioral data were taken. Tuesday morning, the focal troop was picked up at the previous night's sleeping site and followed until 6pm when they selected a new sleeping site. This process was repeated until Friday evening. The data set includes 231.4 hours of observations with a mean of  $2,776.8 \pm 395.69$  minute per troop. The high standard deviation is due to the differences in home ranges between the troops. Some troops spent significant amounts of time on private property that we couldn't access or in remote areas that, for safety concerns, we couldn't follow them into. Efforts were made to keep data sets of comparable size.

This process differs from Heinicke's original study. In the 2013 study, data were collected by Heinicke and four field assistants provided by Colobus Conservation. Similarly to this study, only one field guide was with Heinicke per day. Troops were located at midday and followed to their sleeping site. The following day, the troop was followed from their previous night's sleeping site to that night's sleeping site. On the third day they were followed until midday. This process was repeated five times for each troop. Heinicke's data set includes 382.4 hours of observation with a mean of  $4588 \pm 150.34$  minutes of observation for each troop.

At the beginning of each 20 minute observation period, the GPS location of the focal individual was recorded using a Garmin Etrex 10 handheld GPS. In the 2016 study, an average of 174.4 GPS points was recorded for each troop. In addition, there were averages of 5.2 and 9.0 for Sleeping Sites and Anthropogenic Feeding Sites, respectively, for each troop. In the 2013 study, Heinicke and her guides collected an average of  $262.2 \pm 9.47$  GPS points for each troop.

### ***Data Analysis***

Behavioral data were recoded into five major categories including *Feeding*, *Resting*, *Moving*, *Socializing*, and *Other*. To allow for comparison with previous studies this was done in accordance with other publications (Bronikowski and Altmann, 1996; Dunbar, 1992; Heinicke, 2013; & Hoffman and O'Riain, 2011). The category *Feeding* included all activities that involved consumption of food, food manipulation, and active searching for food items (Heinicke, 2013; Dunbar, 1992). *Moving* refers to any form of directed movement from the focal individual regardless of direction or objective. *Resting* was sitting or lying down with no other form of energy expenditure. *Socializing* refers to physical interactions between the focal individual and

one or more other individuals. This includes allogrooming activities, play, and instances of aggression, among other behaviors. In all instances, it was recorded whether the focal individual was the actor or the recipient of the behavior. *Other* includes behaviors such as self-grooming, and vigilance. Food types were recoded into five categories as well: *Fruit*, *Anthropogenic Forage*, *Seeds/Seed Pods*, *Leaves*, and *Other*. This study includes an additional category, *Grasses*, that was not present in previous publications.

The data was summarized by first calculating relative frequency in proportion form of each category of behavior for each troop and for each category of food item for each troop. Then means across the five troops was calculated with standard deviation (mean  $\pm$  SD). A pairwise analysis of activity budgets and the dietary ecologies was made using a Kruskal-Wallis test with a Mann-Whitney U as a post-hoc test. Using the results from Heinicke 2013, a pairwise comparison was made between the 2013 and 2016 data sets using a chi-square test. Data was analyzed using SPSS with a p-value of less than 0.05 considered significant.

### ***Spatial Analysis***

For the spatial analysis, data points were imported into ArcGIS Explorer and ArcGIS Maps. Home range size was calculated using the “Measure Area” tool and by using the outer most data points in each troop’s ranging pattern. The population density of each troop was calculated by dividing the number of individuals in the troop by the size of that troop’s home range ( $D=N/Km^2$ ).

## **Results**

### ***Activity Budget***

In the base data set, the baboon troops spent an average of  $40.24 \pm 5.59\%$  of the daytime feeding,  $25.82 \pm 4.66\%$  resting,  $21.75 \pm 2.05\%$  moving,  $8.92 \pm 0.37\%$  socializing and  $3.08 \pm 0.63\%$  other ( $n=22,944$ ) (Heinicke, 2013). In the current study, the troops spent an average of  $25.54 \pm 7.46\%$  of the observation period feeding,  $23.84 \pm 3.51\%$  resting,  $16.50 \pm 5.64\%$  moving,  $13.54 \pm 1.68\%$  socializing, and  $20.60 \pm 3.94\%$  other ( $n= 13,884$ ). There were significant differences between the composition of the activity budgets between troops within each dataset and between each dataset (Fig. 2). Significant differences exist between A1 and A2 (Kruskal-Wallis;  $p$ -value=0.014); A1 and B2 (Kruskal-Wallis;  $p$ -value=0.001); A1 and C (Kruskal-Wallis;  $p$ -value=0.024); A2 and C (Kruskal-Wallis;  $p$ -value=0.000); B1 and C (Kruskal-Wallis;  $p$ -value=0.000); and B2 and C (Kruskal-Wallis;  $p$ -value=0.000). Notably, differences were significant for all troops except Troop A2 for Feeding (Chi-square test:  $p=0.196$ ). Differences were also significant between all five troops across both data sets for Other.

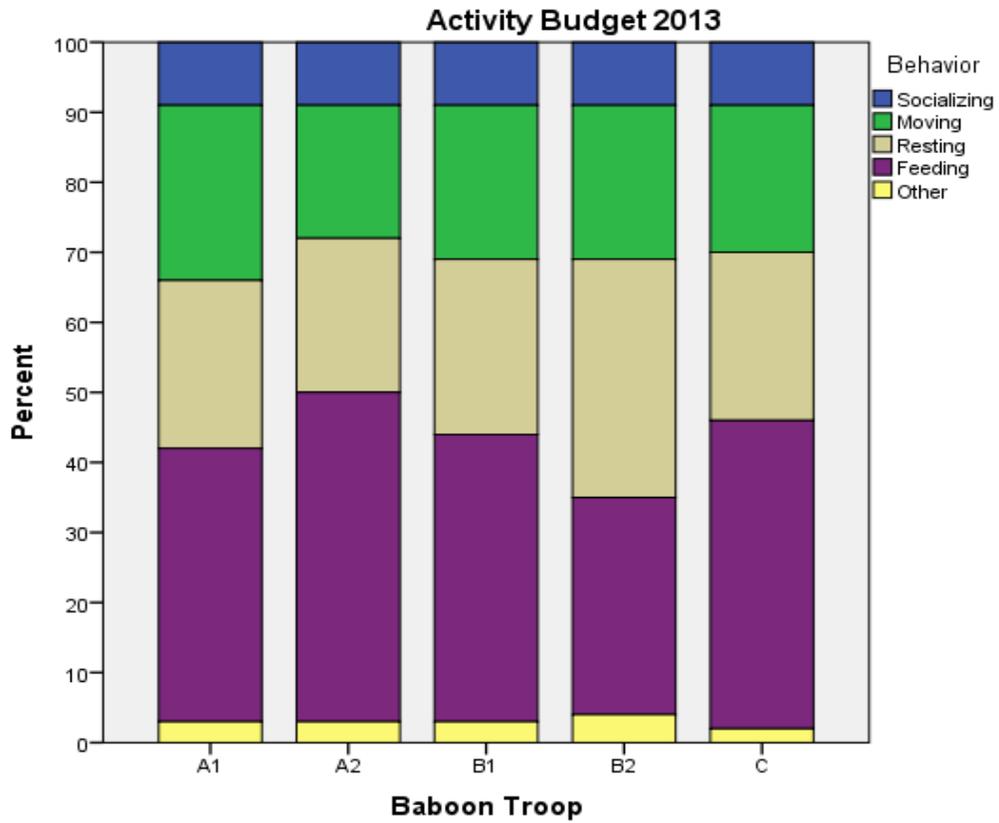


Figure 2. Activity budget of *Papio cynocephalus* in Diani, Kenya, 2013, showing the relative proportion (%) of each behavioral category for the five local troops.

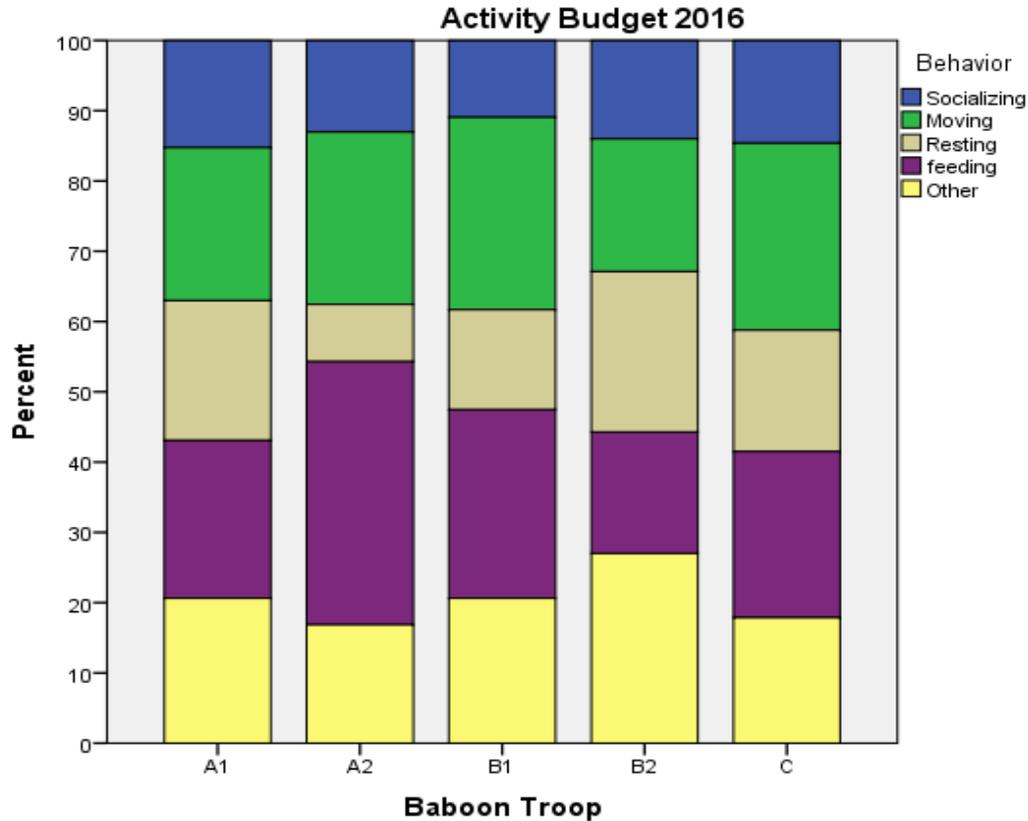


Figure 3. Activity budget of *Papio cynocephalus* in Diani, Kenya, 2016, showing the relative proportion (%) of each behavioral category for the five local troops. Differences were significant across feeding, socializing, and other.

### *Diet*

In the initial study, *Fruit* accounted for the majority of each troop's diet ( $58.68 \pm 9.55\%$ ) with *Anthropogenic Forage* being the second largest proportion ( $15.49 \pm 6.38\%$ ) (Fig. 4). In the 2016 data set, *Grasses* accounted for the largest proportion of each troop's diet ( $29.58 \pm 7.35\%$ ) with *Other* making up the second largest proportion ( $24.13 \pm 12.55\%$ ) (Fig. 5). *Anthropogenic Forage* accounted for  $16.50 \pm 4.03\%$  of each troop's diet. This value does not represent a significant difference across all five troops between each study. However, individual differences between each troop show significant differences. In 2016, troops A1 and B1 doubled the proportion of anthropogenic forage ingested (21.81% and 18.42%, respectively) as compared to the 2013 dataset (10% and 9%, respectively). Conversely, troops B2 and C halved the proportion of anthropogenic forage ingested in 2016 (12.91% and 12.07%, respectively) as compared to 2013 (23% and 21%, respectively). A2 did not exhibit a significant difference between 2013 and 2016.

In Heinicke's study, the diet category *Other* included different plant parts such as buds and roots, but also insects and single records of birds and a suni (*Neotragus moschatus*). These single incidences were not observed in 2016. The category *Other* was comprised mostly of insects.

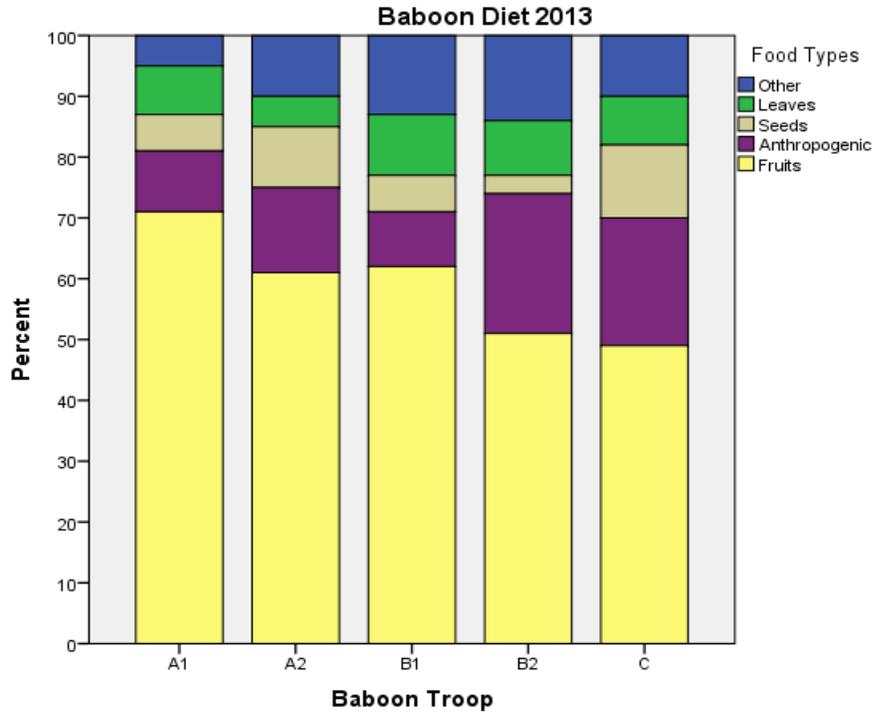


Figure 4. Relative proportion (%) of food types consumed by *Papio cynocephalus* troops in Diani, Kenya in 2013.

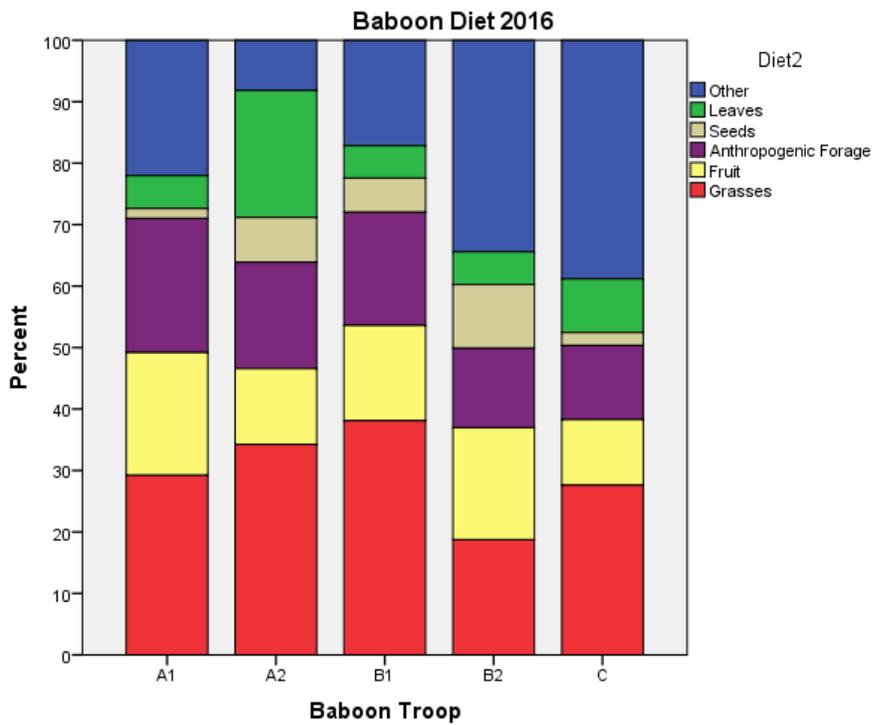


Figure 5. Relative proportion (%) of food types consumed by *Papio cynocephalus* troops in Diani, Kenya in 2016. The additional category of *Grasses* was added.

### ***Home Range:***

Home range analysis of the base data revealed that the home range size of the troops ranged between 0.70 and 1.20km<sup>2</sup>. Analysis of the 2016 data revealed that the range between sizes decreased to 0.740 and 1.111km<sup>2</sup> (Table 1). Baboon density was 29.28 ± 7.50 individuals/km<sup>2</sup> in 2013. Density increased to 39.80 ± 13.84 individuals/km<sup>2</sup> in 2016. A total of 20 sleeping sites were initially observed with each troop using at least two unique sites. That number increased to 26 sleeping sites by 2016 with each troop utilizing at least 4 unique sites. In areas where home ranges overlapped, such as those areas between troops A1 and A2; and between B1 and B2, troops often used the same sleeping sites independently of each other. Heinicke also identified a total of 43 anthropogenic feeding sites. These were mostly garbage piles, but troops also foraged from hotel kitchens, restaurants, and two small farms in the area (Heinicke, 2013). Like the sleeping sites, the AFS are utilized by multiple troops in areas where home ranges overlap. In 2016, 35 AFS were identified. These were also mostly local garbage piles and hotel garbage bins. Feeding with in restaurants was not observed, but garbage from restaurants was disposed of in the same locations as general hotel refuse. Crop foraging was observed to a greater extent than was recorded by Heinicke. All troops exhibited crop foraging behaviors, both near Diani Beach road and along the unnamed back road which runs parallel to it (Appendix 1).

<b>Troop Name</b>	<b>Year</b>	<b>Troop Size</b>	<b>Home Range [Km<sup>2</sup>]</b>	<b>Density [Baboons/ Km<sup>2</sup>]</b>
A1	2013	36	1.17	30.77
A2	2013	33	0.90	36.67
B1	2013	41	1.15	35.65
B2	2013	17	0.70	24.29
C	2013	21	1.10	19.09
A1	2015	45	0.74	60.81
A2	2015	35	1.07	32.74
B1	2015	50	1.11	45.00
B2	2015	24	0.98	24.56
C	2015	32	0.89	35.87

Table 1. Home range and density of *Papio cynocephalus* troops in Diani, Kenya between 2013 and 2016.

## **Discussion**

### ***Behavior***

This study revealed significant differences in the activity budgets and in the composition of diet for the five troops of *P. cynocephalus* in Diani. In comparison to other studies, Heinicke (2013)

found the composition of the activity budgets to be similar to both provisioned and natural-foraging troops at other sites in Kenya and Tanzania with *Feeding* accounting for the largest proportion followed by *Resting* and *Moving*. However, contrary to our predictions, proportion of time spent *Feeding* decreased and accounted for approximately the same proportion as *Resting* and *Other* (see Table 2). Significant differences were discovered in each troop's activity budget between 2013 and 2016. However, with the exception of the category *Other*, all five troops did not show significant differences to proportions of the same activities. The proportion of time spent feeding by each troop in the current study decreased significantly for four out of the five troops. Though differences to the proportion of time each spent *Moving*, *Resting*, or *Socializing* were not found to have significantly increases or decreases, differences were still noted. Significant decreases in proportion of time spent *Feeding* by troops A1, B1, B2, and C suggest that these troops have access to high energy forage (Altmann & Muruthi, 1988; Kamal et al, 1997; Altmann & Altmann, 2003) This is further supported by the universal increase all troops experienced to proportion of *Socializing* behaviors, despite lack of statistical significance. Significant increases were also observed among *Other*. This increase is solely due to increased vigilance activities among troops. These activities interrupt feeding, resting, and socializing and are assumed to be a factor during troop movement. Vigilance behaviors were recorded in the original study, however, they were not as pervasive as have been observed in the current study (Heinicke, 2013).

Reference	Study Area	Troop Name	Troop Size	Activity Budget (%)				
				Feeding	Moving	Resting	Socializing	Other
This Study	Diani, Kenya	A1	45	22.50	21.80	19.90	15.20	20.60
This Study	Diani, Kenya	A2	35	37.40	24.50	8.20	13.00	16.90
This Study	Diani, Kenya	B1	50	26.80	27.40	14.20	10.90	20.60
This Study	Diani, Kenya	B2	24	17.30	18.90	22.90	14.00	27.00
This Study	Diani, Kenya	C	32	23.70	26.60	17.30	14.60	17.90
Heinicke, 2013	Diani, Kenya	A1	36	38.84	25.04	23.91	9.26	2.95
Heinicke, 2013	Diani, Kenya	A2	33	46.26	19.39	22.40	9.30	2.65
Heinicke, 2013	Diani, Kenya	B1	41	41.66	21.61	25.25	8.70	2.78
Heinicke, 2013	Diani, Kenya	B2	17	31.69	21.64	33.95	8.92	3.80
Heinicke, 2013	Diani, Kenya	C	21	43.67	21.44	23.60	8.44	2.85
Bronikowski	Amboseli,	Alto's	64.9 ±	44.8 ±	25.1 ±	20.9 ± 4.9	9.3 ± 2.2	

& Altmann, 1996	Kenya	Group	7.9	9.2	4.5		
Bronikowski & Altmann, 1996	Amboseli, Kenya	Hook's Group	53.4 ± 7.5	48.1 ± 6.1	27.0 ± 5.0	16.3 ± 3.7	8.6 ± 0.9
Bronikowski & Altmann, 1996	Amboseli, Kenya	Lodge Group	48.17 ± 6.9	23.7 ± 1.6	19.2 ± 2.5	43.8 ± 4.0	13.3 ± 1.2
Dunbar, 1992	Gombe, Tanzania		43	25.8	19.4	30.2	10.6
Dunbar, 1992	Ruaha, Tanzania		72	47.4	24.2	16.7	4.5
Dunbar, 1992	Mikumi, Tanzania		120	36.5	26.1	25.0	5.9

**Table 2.** Comparison of activity budgets from previous studies of *P. cynocephalus* in Kenya and Tanzania. The table includes both provisioned and natural foraging troops.

### *Diet*

*Fruit* made up a majority of each troops diet in 2013, accounting for approximately 50-70% of each troop's total food consumption. In during the current study, this proportion decreased to approximately 10-20%. This represents a significant decrease in fruit consumption that may be entirely due to seasonality between the two studies. However, significant increases in consumption of anthropogenic forage in troops A1 and B1, and slight increase in anthropogenic forage consumption in A2 support the assumption that these troops are successfully enhancing their diets by accessing AFS. Significant decreases to AF consumption in troops B2 and C show a lack of access to AFS. This may be due to numerous factors, including; increase in human presence near AFS sufficient enough to guard against baboon foraging, greater regulatory practices concerning refuse disposal, more efficient guarding of crops (although this was not noted as being effective in troop C's home range), or seasonality of crops.

Additionally, approximately 20-40% of the diet of each troop was made up of *Grasses*, a food category unrecorded by Heinicke (2013); thus supporting seasonality as an argument for some of the shifts in diet composition between studies. Proportions of *Grasses* and *Other* food sources ingested increased most in troops B2 and C, which experienced the most significant decreases in access to AFS. It is possible that, in areas where it is available, troops are using *Anthropogenic Forage* to replace *Fruit* during low growth seasons. Thus, in areas where anthropogenic feeding sites are more difficult to access or less numerous, troops rely on *Grasses* and *Other*.

### *Home Range*

The home ranges of troops A1 and C shrank significantly. Size decreased by 36.8% and 19.0%, respectively. In both troops, population density effectively doubled; increasing by 97.6% and 87.9%, respectively. The home ranges of troops A2 and B2 expanded significantly, 18.6% and 39.6%, respectively. In both troops A2 and B2 this coincided with non-significant changes in population density. Density slight decrease for A2 (10.7% decrease) and decreased for B2 (0.27%). Troop B1 did not exhibit significant change to its home range size from 2013 to 2016.

However, population density increased by 26.22%. Analysis revealed different areas of high baboon activity focused at sleeping sites and anthropogenic feeding sites. Many of these areas coincided with overlaps between the home ranges of different troops. These overlaps included three of four abandoned hotels along Diani Beach road; Jardini, African Sea Lodge, and Two Fishes. These hotels were frequently used by both troop A1 and A2. The fourth abandoned hotel, Safari Alliance, was used solely by troop B1. Although these properties were guarded against unauthorized use or were actively used by the local community, the baboons were not chased away from them. Each hotel represents both a safe resting place for the troop using it and, due to refuse left by incidental use and the presence of formerly tended fruiting plants, an anthropogenic feeding site. These sites presented difficulty for defining foraging patterns due to the non-specificity and incongruence of troop feeding preferences. In both studies it can be speculated that home ranges overlapped due to the presence of anthropogenic feeding sites, but it is difficult to ascertain in how specific artificial feeding sites influence the use of the home range (Heinicke, 2013). At many anthropogenic feeding sites there are fruit trees close to artificial feeding sites and while some individuals fed on the provisioned food others fed on the fruits. Individuals feeding on both food sources simultaneously was also observed. This included an individual manipulating one food source with one hand or its mouth while chewing on the other. In these situations priority was given to the food source being chewed on.

Changes to the behavior and life histories of each troop between studies differed greatly. Some troops experienced drastic differences to behaviors that exhibited negligible change in others, making it necessary to examine each troop on a case by case basis. Troop A1 experienced a significant decrease in proportion of time spent exhibiting feeding behaviors coupled with doubling the proportion of anthropogenic forage ingested in the current study as it had in 2013. Home range decreased significantly, compressing its growing population and doubling the population density of the troop. Aggressive behaviors (included under *Socializing* in both studies) increased non-significantly while *Resting* and *Moving* decreased in proportion as well. Troop A1 baboons accessed 15 unique anthropogenic feeding sites within their home range (Appendix 1). This supports the assumption that their home range and activity patterns are concentrated around high energy, anthropogenic feeding sites. Decreased movement patterns, increased population, and increased agonistic behaviors between troop members are also consistent with behaviors of semi-provisioned troops elsewhere (Altmann & Muruthi, 1988; Bronikowski & Altmann, 1996; Dunbar, 1992; Moinde, 2015).

Surprisingly, due to their overlapping home ranges and shared anthropogenic feeding sites, troop A2 did not show the same changes between studies as troop A1. A2 experienced a significant increase in home range size which supported a growth to population that did not influence population density. A2 exhibited non-significant decreases to both proportion of time spent feeding and to proportion of anthropogenic forage ingested, despite accessing 10 unique anthropogenic feeding sites within its home range. A2 predominantly fed on *Grasses*, *Leaves*, and *Other*. Possible explanations include being out competed at all 10 shared anthropogenic

feeding sites by troop A1, but all evidence supports low levels of contest competition within troop A2 consistent with widely dispersed, indefensible food resources (Altmann & Muruthi, 1988; Bronikowski & Altmann, 1996; Dunbar, 1992; Moinde, 2015).

Troops B1 and B2 also share an overlapping home range. Both forage at the refuse containers at Baobab resort. However, while both troops display significantly decreased proportions of *Feeding* behaviors consistent with increased access to anthropogenic forage, only troop B1 displays increased ingestion of that food resource. Troop B1's anthropogenic forage intake doubled between 2013 and 2016 while troop B1's significantly decreased by 56%. Compared to B2, troop B1 has increased access to less disturbed coastal forest as well as to the abandoned Safari Alliance hotel buildings. During observation B1 actively avoided both observers and local people. B2 experienced a significant increase in home range size and exhibited both increased *Moving* and fewer *Resting* behaviors. Combined with the decreased proportion of anthropogenic forage in its diet, this is indicative of a reliance on dispersed, insufficient, and indefensible food resources. The behavioral changes exhibited by B2 are consistent with natural foraging behaviors exhibited by non-provisioned troops elsewhere (Altmann & Muruthi, 1988; Bronikowski & Altmann, 1996; Dunbar, 1992; Moinde, 2015).

Troop C represents a unique foraging ecology in that it has access to a large, constantly replenished hotel waste site adjacent to a fully maintained anthropogenic environment and a protected patch of forest. Troop C's home range is almost exclusively made up of Leisure Golf Course and the nationally protected Kaya Diani. Anthropogenic foraging opportunities include three nearby hotels, a Christian school, multiple restaurants, a maize plantation, and the large, general waste site mentioned above. Troop C exhibited a significant decrease to home range size, as well as significant population increase and significant population density increase. Due to long daily travel lengths between two major sleeping sites, troop C also exhibits increased *Moving* and decreased *Resting* behaviors. This is indicative of heavy provisioning as compared to the other Diani troops and may be a product of their geographic removal from competition with those troops (Altmann & Muruthi, 1988; Bronikowski & Altmann, 1996; Dunbar, 1992; Moinde, 2015).

### **Conclusions:**

It can be argued that decrease in tourism from 2013 onward have had varying effects on the primate populations in Diani.

1. In some areas it has leads to a decrease in available anthropogenic food sources. In order to replace these food sources, troops must increase home range size and revert to a more naturalistic foraging pattern. As the troops range across a wider area, they decrease their proximity to Diani Beach road and the hotels, houses, and staff quarters located along it. They begin spending more time in the forest patches or (in the case of A1 and C) in the large protected forest areas that they have access to. This leads to fewer negative interactions between humans and baboons.

2. This led to multiple hotel closures along Diani Beach road. These hotels are now safe spaces for the troops that have access to them. These hotels provide natural forage for the troops in the shape of vegetation that has taken over the buildings, and semi-natural forage in the form of mango and palm trees that were planted by the hotel and have now grown. The troops can forage here without being molested. While the baboons do not use them as sleeping sites, they do use them as resting sites during the day. Troops travel between hotels and the forest patches along Diani Beach road and travel back to the farms and estates behind those patches by using other man-made dirt roads. There's a paradox of behavior for the troops. They are faced with the choice of having to search for food across a wider area while simultaneously being provided with a safe place to feed and rest that is a little removed from their forest patches. This affects their behavior in a few ways: 1. It creates multiple hotspots of baboon activities, 2. Increases the impact of baboon activities on properties immediately adjacent to abandoned hotels, 3. They typically do not visit the hotels multiple days in a row, preferring other foraging sites.

### **Conservation Implications**

A better understanding of how baboons respond to varying levels of anthropogenic impact on the landscape increases our understanding of primate behavioral adaptations to human-modified habitats. This study demonstrates the plasticity and flexibility of baboon behavior to ecological changes induced by humans. The findings detail implications for the management and conservation of primates in human occupied landscapes. The evidence from this study indicates that anthropogenic modifications of habitats, through different land use systems are indicative of both the direct and indirect roles humans have in influencing baboon feeding and social behaviors. Recognition of sudden decreases in tourism as a potential limit on the foraging ecology and ranging patterns of *P. cynocephalus* allows conservation organizations to implement management practices during specific low points in primate activity. These periods of decreased anthropogenic foraging represent shifts in troop behavior towards natural foraging behaviors. It is possible that low points can be reliably predicted by focusing on both local and national events; such as political instability, travel advisories, and natural tourist low seasons. This is for a few reasons: 1. Low tourist presence means less anthropogenic food sources to focus on and a lower number of primary targets for the initial phases of your program, resources can be concentrated to greater effect 2. Baboons in the area will already be reverting to a more naturalistic foraging method to replace the anthropogenic food sources they lost (preventing access to remaining sources will increase this response) 3. If conservation efforts are not undertaken and baboons may begin to shift the focus of their anthropogenic foraging from the hotels to the local people (in the staff quarters and villages). In times of low tourism the people already enter short term economic depression, during these times the effects of baboon foraging will be felt more poignantly. The problems and solutions for conservation of adaptable omnivores such as baboons are different but no less pressing than for primates facing more immediate human encroachment.

## Acknowledgments:

I would like to thank the Kenyan Wildlife Service and Colobus Conservation, in Diani, Kenya and especially Pamela Cunneyworth, Kelly Martin, and Stefanie Heinicke for help in the conception of the study, research support and logistics. I also thank my field assistant Gabriel Mutua for his help during the data collection. I would also like to thank Oxford-Brookes University, its MSc in Primate Conservation, and my advisor Dr. Catherine Hill for the opportunities provided to complete this research.

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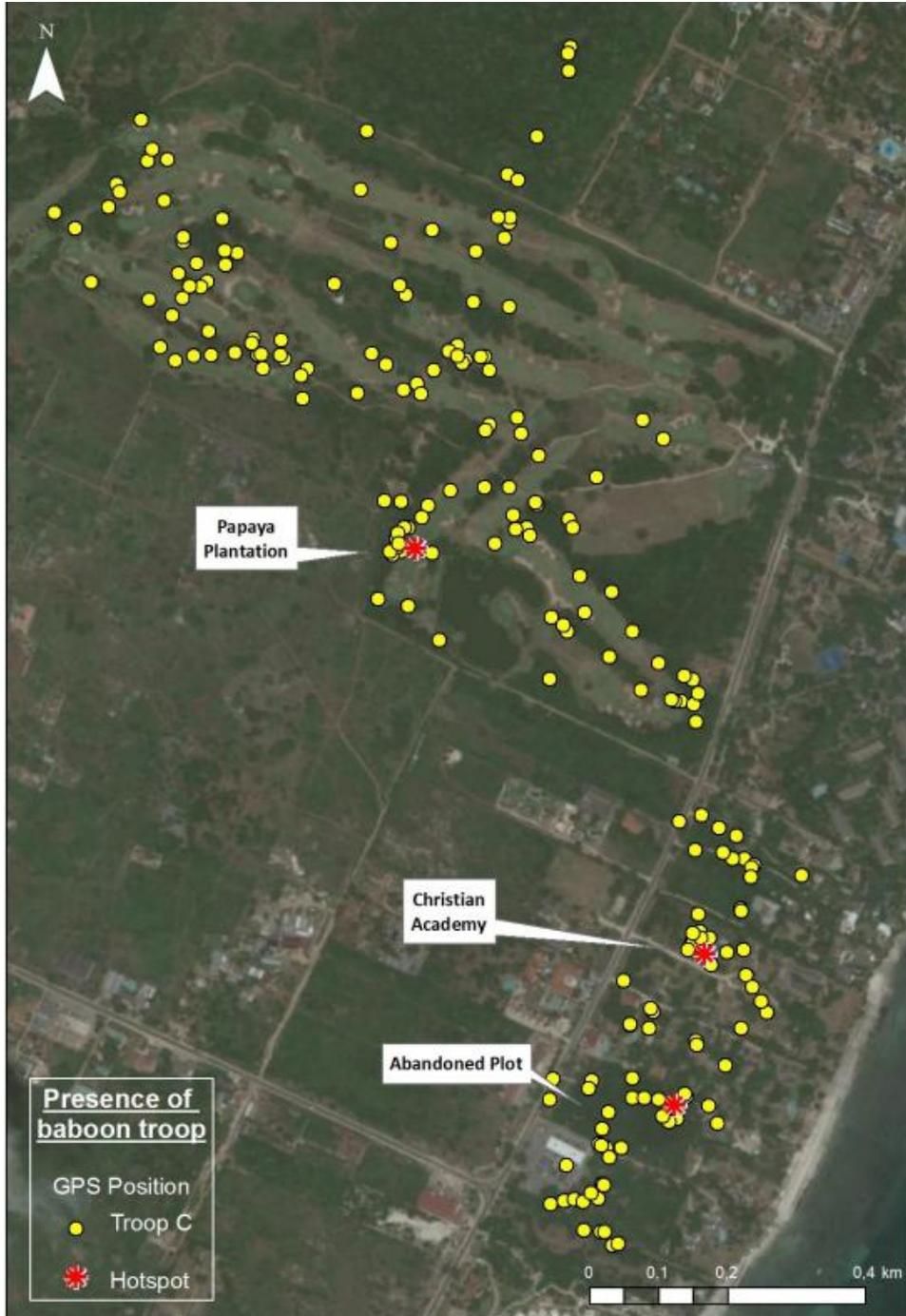
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**Appendix I: 2013**

Maps illustrating the distribution of yellow baboon troops in Diani, Kenya, with hotspots of baboon activity.



**Figure 1: Map (Microsoft Corporation 2010) of the northern part of the study area depicting the recorded GPS positions for troop C with hotspots of baboon activity. The three areas with a hotspot are labelled. All hotspots were significant with  $p < 0.05$ . (Heinicke, 2013).**

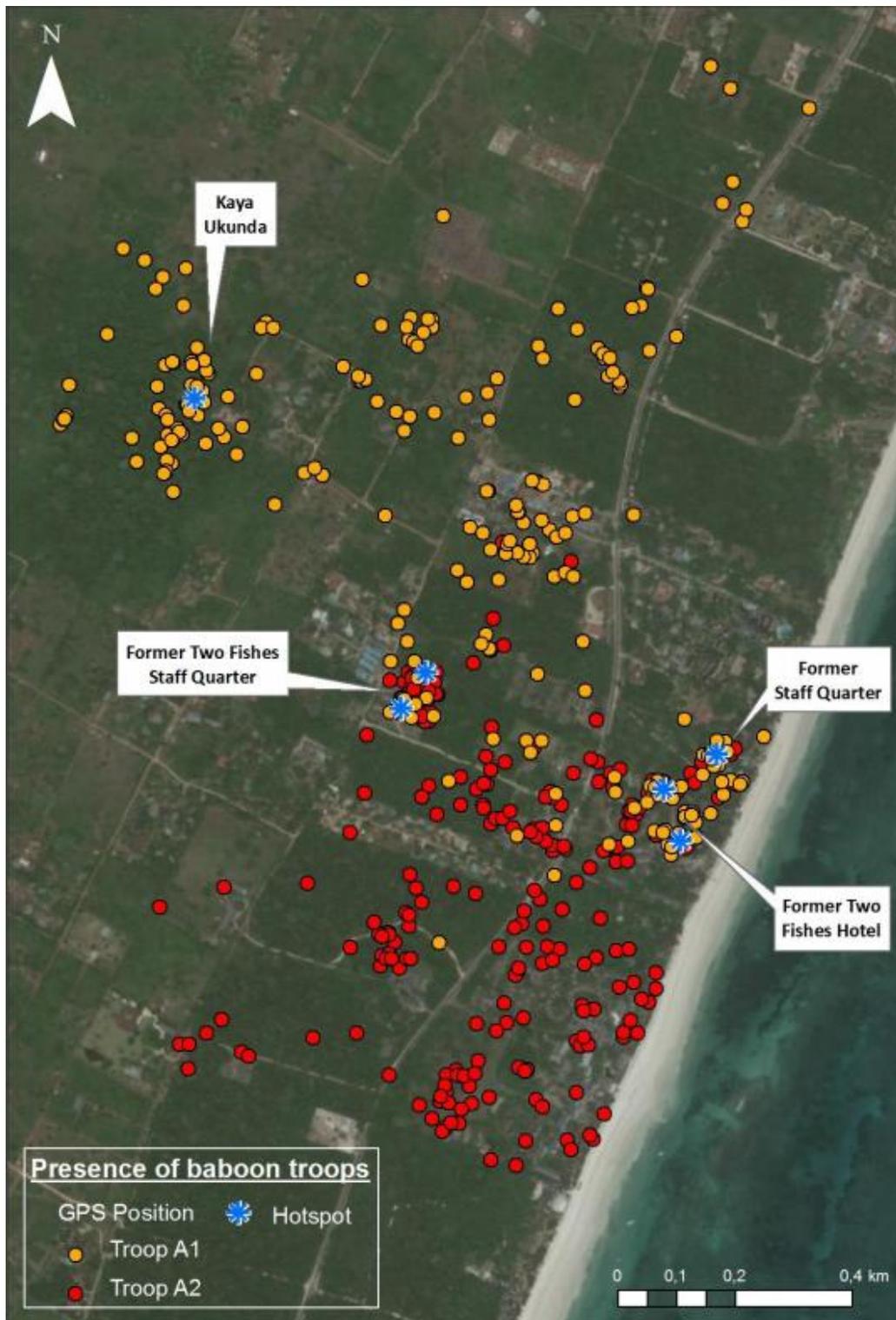


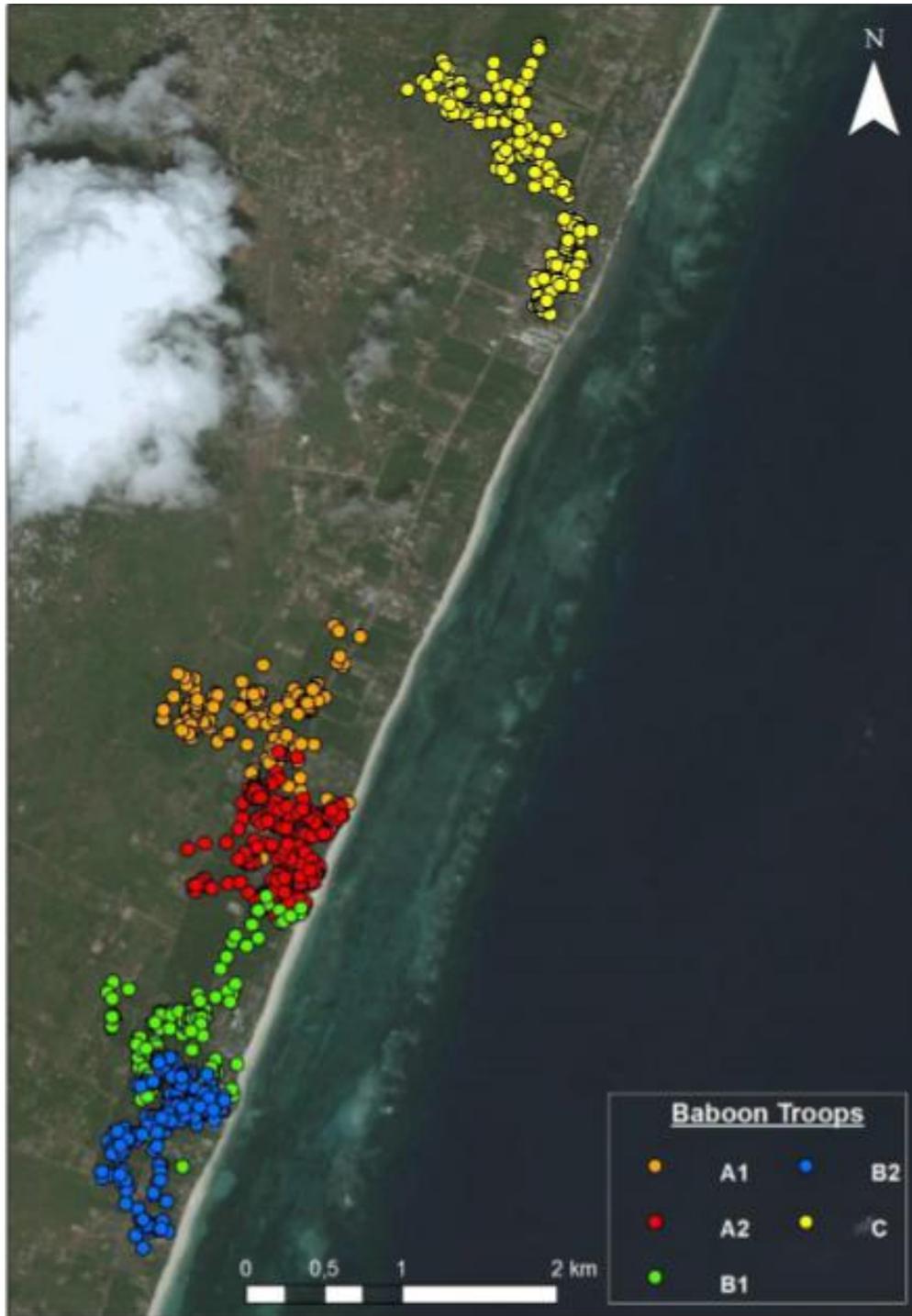
Figure 2: Map (Microsoft Corporation 2010) of the central part of the study area showing the recorded GPS positions for troops A1 and A2 with hotspots of baboon activity. The hotspots can be grouped into four areas as labelled on the map. All hotspots were significant with  $p < 0.05$ . (Heinicke, 2013).



Figure 3: Map (Microsoft Corporation 2010) of the southern part of the study area depicting the recorded GPS positions for troop B1 and B2 with hotspots of baboon activity. The hotspots can be grouped into six areas as labelled on the map. All hotspots were significant with  $p < 0.05$ . (Heinicke, 2013).

**Appendix II: 2016**

Maps illustrating the distribution of yellow baboon troops in Diani, Kenya, with anthropogenic feeding sites.



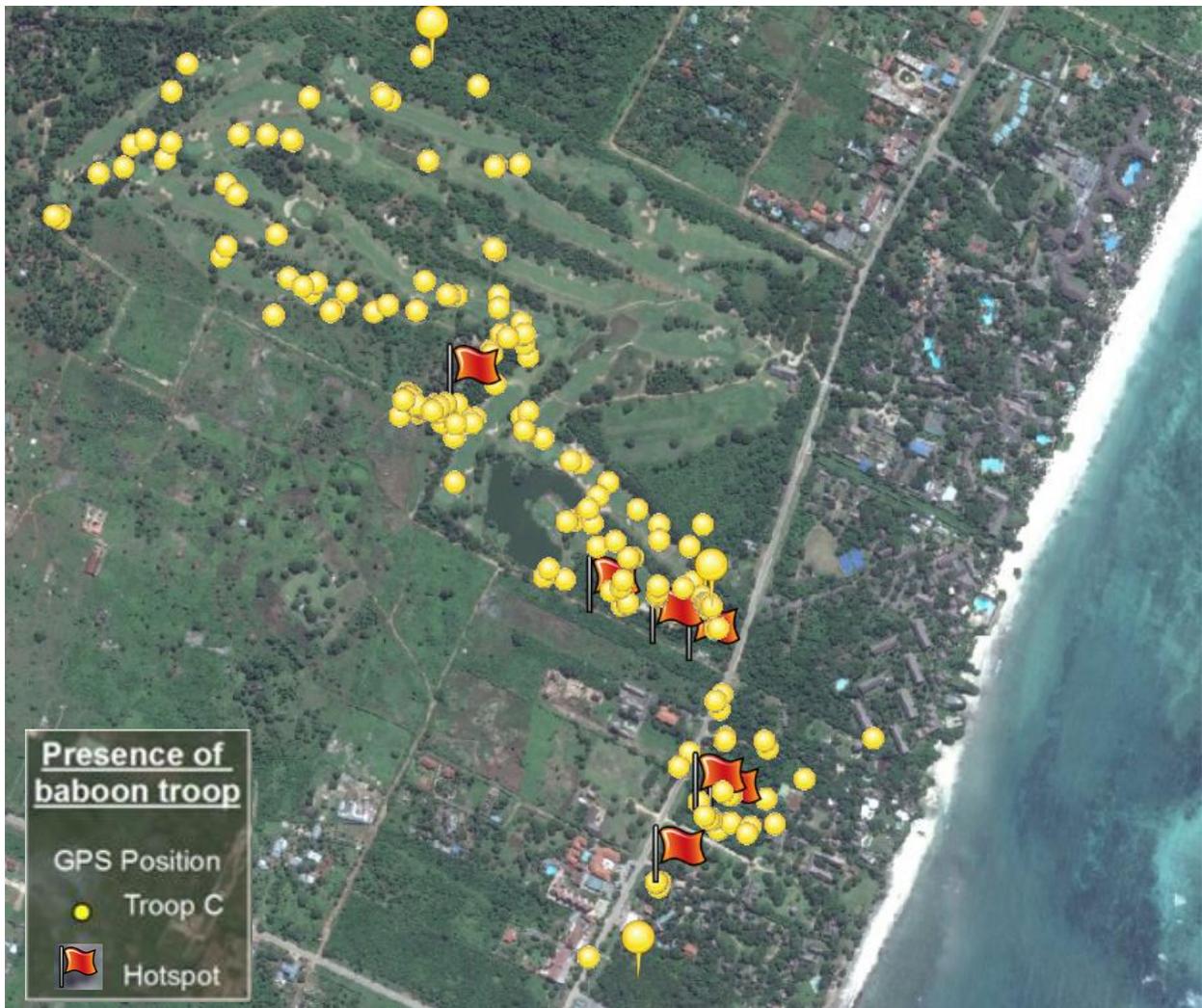


Figure 1: Map (Microsoft Corporation 2010) of the northern part of the study area depicting the recorded GPS positions for troop C with anthropogenic feeding sites.

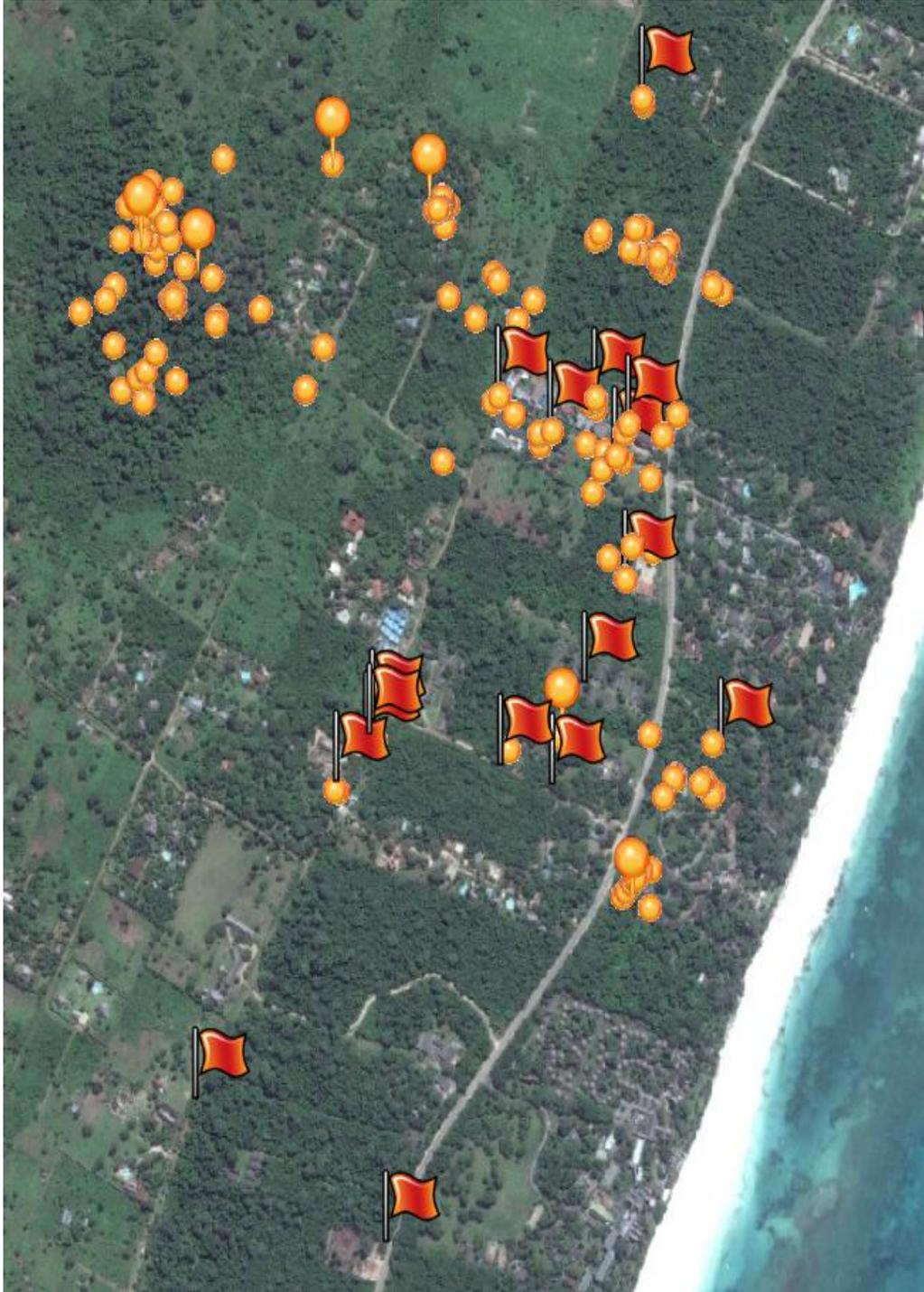


Figure 2: Map (Microsoft Corporation 2010) of the central part of the study area showing the recorded GPS positions for troops A1 with anthropogenic feeding sites.



Figure 3: Map (Microsoft Corporation 2010) of the central part of the study area showing the recorded GPS positions for troops A2 with anthropogenic feeding sites.



Figure 4: Map (Microsoft Corporation 2010) of the central part of the study area showing the recorded GPS positions for troops B1 with anthropogenic feeding sites.



Figure 5: Map (Microsoft Corporation 2010) of the central part of the study area showing the recorded GPS positions for troops B2 with anthropogenic feeding sites.

## Appendix III

**Table 1:** Categories and codes for the recorded behaviour.

Code	Description of Behaviour
A+	Aggression (Actor)
A-	Aggression (Reactor)
C	Contact (individuals touching but not grooming)
FE	Feeding
FO	Foraging (active searching and handling of food)
G+	Grooming (being groomed)
G-	Grooming (grooming another primate)
L	Locomotion (any directed movement)
MA	Mating
MO	Mounting
N	Nursing (mother breast feeding)
O	Other
PL	Playing
PR+	Presenting (being presented to by another primate)
PR-	Presenting (presenting itself to another primate)
R	Resting
SC	Scratching
SG	Self grooming
SU	Suckling (juvenile feeding from mother)
V	Vigilant
Y	Yawn

**Table 2.** Categories and codes for the recorded food types.

Code	Food type
BU	Buds
FL	Flowers
FR	Fruits
G	Grass
I	Insects
M	Mushroom
ML	Mature leaves
O	Other
P	Pods
PF	Provisioned food
R	Roots
S	Seeds
TB	Tree bark
UK	Unknown
YL	Young leaves