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Cows and Colobus (Procolobus kirkii): Resource-Sharing Habits at Jozani National Park

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Abstract

Due to population compression, the Zanzibar red colobus monkeys of Jozani have been forced to explore new food options on the ground. I studied the food preferences of this endangered species in the agricultural land adjacent to Jozani National Park and compared it with the species consumed by local cattle that graze in the same space. This information, along with a preliminary behavioral assessment of the red colobus monkeys when near cattle, provides a first look at the food species eaten by both cows and colobus, in addition to documenting some of the direct and indirect interactions that occur between them. This data may be used to shed light on the previously unknown nature of resource sharing between an endangered species and local livestock.

Introduction

The Zanzibar red colobus monkey (*Procolobus kirkii*) is an endemic sub-species of the sub-family Colobiniae and the family Cercopithecidae. While listed as a critically endangered, over fifty percent of these monkeys live in unprotected areas on the Zanzibar islands (Siex and Struhsaker, 1999a). Still, the most significant and well-studied populations reside in and near Jozani National Park on the island of Unguja. In this area, the monkeys reside in significantly higher densities in Jozani's adjacent agricultural land, known as *shamba*, than in the forested areas: 235 monkeys/km^2 in the forests compared to 550 monkeys/km^2 in the agricultural habitats (Siex and Struhsaker 1999b).

Red colobus are mainly foliovores, and are selective in their food choices, distinguishing preferentially between mature and young leaves, flowers, petioles, buds,

and ripe and unripe fruit in their foraging behavior. They are known to eat a diverse number of species annually, sometimes up to twelve per day (Mturi 1993).

This diet preference, along with higher recorded population densities than all other studied colobines (Siex and Struhsaker 1999b), has created conflict with local farmers near Jozani. Monkeys, especially the red colobus, have historically been considered pest species, and often are shot when seen in agricultural fields. Villagers that have used this tactic often noted that for a while after the group saw one of their own shot, they would avoid that location. But this strategy isn't conducive to the conservation of an endangered species, and during a joint workshop with local community members and representatives of various government offices, the suggestion was brought forth to share with the villagers the profits brought in by red colobus tourism (Juma, 1996). This plan has been revised various times since this first meeting, and now includes crop-damage compensation, community-managed forests, a shop selling local crafts, and four NGOs that deal with everything from beekeeping and micro-credit to enforcement and negotiations of park and community-managed lands (Alloo and Owino, 2000; A. Mwinyi, pers. comm). Community involvement in the park is crucial to the survival of colobus that live and feed outside the groundwater forest area, and for most villagers, a positive attitude toward the colobus is based not on a desire for their conservation, but on the perception of possible economic gains associated with increased colobus-based tourism (Asseid 1997).

More recently, it has been observed that the resident *shamba* groups of colobus at Jozani have been leaving the trees to forage on the ground. Siex (pers. comm.) hypothesizes that this is because the colobus in these areas cannot find enough food on

their frequently-utilized tree species. Siex and Struhsaker noted in 1999(b) that many food trees in Jozani shambas showed "definite sings of colobus overbrowsing", and that today, *Terminalia catappa*, one of the colobus' most utilized trees, are consumed past the point of reproduction (Siex, pers comm.). These circumstances have caused the red colobus in this area to drastically change their "natural behavior", though the dangers of predation while on the ground are much higher than if they were to remain in the canopy (Mturi 1993). It has also forced them to encounter local cattle that villiagers are allowed to graze on park land.

Studies on the diets of the red colobus monkey both in Jozani and elsewhere are many (see, *e.g.*, Kelly ISP 1997, Rogers ISP 1997, Mturi 1993, Siex and Struhsaker 1999b). However, since any significant amount of ground level foraging is a relatively new occurrence, there haven't been any studies on the plant species eaten by colobus specifically when on the ground.

Red colobus are known to form polyspecific associations with other monkeys for activities like eating, resting, allogrooming, and playing (Mturi 1993). Within Jozani, ground-foraging colobus are sometimes seen within a few meters of grazing cows (Warden Ali Mwinyi, pers. comm.) raising the question of whether or not red colobus in this new 'habitat' are capable of forming associations with other species such as cows. By studying the species eaten and interactions between the Zanzibar red colobus monkey in Jozani *shambas* and local grazing cows in the same areas, this study seeks to determine the nature of the relationship that has recently begun to occur between these two species. This information can be added to the existing knowledge about the ecology of the Zanzibar red colobus, and can be utilized in the constantly adapting methodologies for

their conservation, especially in the unique environment that is Jozani. By ascertaining the relationship between this endangered species and village livestock, the results of this study might also be able to head off another potential village/Park conflict before it reaches the extent of that caused by colobus crop-raiding in the past.

Study area

Zanzibar is a semi-autonomous state consisting of two main islands, Unguja and Pemba, and over fourteen smaller islets. This study takes place on Unguja, which lies about forty kilometers off the coast of mainland Tanzania (Zanzibar Forestry 1997). Unguja's original vegetation consisted of coral-rag thicket on the eastern part of the island, and tropical evergreen on the more fertile western side. However, widespread deforestation has left all natural systems on the island highly disturbed (Siex and Struhsaker, 1999b). According to the 1988 census, there were approximately 226 people/ km^2 on Unguja with a growth rate of about 3% per year. About 23.9% of the rural population lives in coral rag areas (Zanzibar Ministry of State Planning, 1991).

Jozani National Park is situated 35 km southeast of Zanzibar municipality on the island of Unguja. This park is part of the Jozani-Chwaka Bay Conservation Area, and was established as the first national park in Zanzibar in 2004. It includes over 15,000 hectares of land spanning ten distinct habitats including mangroves, groundwater forest, and agricultural areas (Habib A. Shaban, pers. comm.). Along with the surrounding community-managed forests, Jozani is host to a large population of endangered Zanzibar red colobus, which attract a large number of tourists each year. The park is so popular that in the year 2000, revenue from admissions fees covered all daily costs for running

the park (Alloo and Owino, 2000). For this project, most observations were limited to the area which is accessible to both monkeys and cattle (see Appendix I for more detail).

Cattle are allowed to graze only on land east of the Town-Makunduchi road within the park boundaries. This area, known officially as "Jozani Farms" is designated as a 'special management area' in the declaration of Jozani-Chwaka Bay National Park, and therefore is regulated in a different manner than the main park lands (Warden A. Mwinyi, pers. comm.). Officially, only residents of the five closest surrounding villages are allowed to graze in these shambas, and arrange care of their livestock with one of four men who have herded cattle on this land since before the park was established. Grazing is regulated through a local NGO called Umoja wa Wenye Mashamba Jozani, or UWEMAJO, which is run by the farmers that own the land used for grazing. Together they address issues such as the enforcement of tethering, village origin of cows grazing in the area, and destruction of the agricultural crops that are also being harvested on these lands (Warden A. Mwinyi, pers comm.). Most rules are not official, though, and many policies, such as removing all livestock from the *shamba* areas at night, are not followed. Numbers of cows grazing within the bounds of the park fluctuate, and reach a high point during the dry season (January to March). Hassan Mohammed, a local herdsman, said that during these months many people bring him their cows, and his herd can reach ten or fifteen animals at a time. At the time of this study, the four main herds ranged from three to seven adult animals, and were comprised of mostly cows and their unweaned young.

Methodology

Cows

Cows were observed 12 November to 26 November 2006 between 6:45 and 18:00 hours. A pilot study determined that each cow should be observed for a focal period of five minutes while it was eating. I recorded the primary component species of each distinct mouthful, or if species was unknown, short description of the plant consumed. Specimens of unknown species were collected for later identification. As most cows were tethered to a tree or bush, it was decided that each cow could only be sampled once per grazing location, as the species availability within reach and subsequent diet preferences when they are forced to remain in the same place would not constitute independent data points. However, if the same cow was encountered on a different day in a new location, species consumed during this observation were included in the analysis. Only adult cows were included in the observations, as their approximated reach into trees was an important variable when comparing with the monkeys. An average cow's "reach" upwards was estimated between 6 and 8ft (1.8- 2.4m) , so the lower end of this scale, 1.8m, was adopted as the standard minimum upwards reach of a cow.

Colobus

Colobus were observed 13 November to 30 November 2006, between 6:00 and 18:45 hours. In the morning a group was located in their sleeping tree, and they were followed for either a morning session of 3-4 hours or for the full day until they again rested in a sleeping tree. A pilot study determined that a five minute focal period was enough to observe multiple eating attempts of the red colobus monkeys, though they eat comparatively slower than the cows. I recorded species, plant part (see Table 1,

Appendix II for description) and amount, and if species was unknown, a short description of the plant consumed. Again, specimens of unknown species were collected for later identification. One consumption item is assumed to be one leaf, bud, or fruit, except in the case of small leaflets which were collected by the monkey in handfuls. In this case, one handful of small leaflets counted as one food item. Additionally, I recorded the height at which the focal animal was eating, and the amount of time spent at or below 1.8m (within cow reach) or above 1.8m (out of cow reach) while feeding. All visible individuals currently eating were observed in a random order. To ensure independence of data points, an individual was not sampled more than once in a fifteen minute stretch, similar to the methods in McGraw (1998). Juveniles were excluded from this study because of their unpredictability; they were likely to stop an eating session before five minutes was up to perform some other activity.

Interactions

Additional behavioral observations were conducted on nine separate occasions to record the types of behaviors performed by a social group of red colobus monkeys. Behavioral activities were divided in to five mutually exclusive groups (Table 2, Appendix II) and the current behavioral state of each visible monkey was recorded at two-minute intervals. For these observations, juveniles were included, though infants and those that spent significant time clinging on mothers were not. Monkeys were observed according to the following criteria: below 1.8m when cows are present (within 5m), below 1.8m when no cows are present, and above 1.8m when no cows were present. In an attempt to control for the daily routine of red colobus, the time of day and duration of each of these three parameters was approximately the same. Additionally, observations

took place on only sunny days, as it is known that activity budgets are correlated to weather conditions (Nowak, 2000). This allowed for direct comparison of the relative time spent engaging in each behavior across the three conditions.

Data analysis

Cow data were analyzed to compute a ranking of the most commonly eaten plants using two systems. First, a species was assigned a ranking based on the number of focal cows that ate that particular species. This was achieved by counting the number of animals that ate *F. virosa*, for example, and repeated for each food species. For each food species, I also computed an average percent consumption when including only focal cows that ate the species under analysis. This was done using the formula:

$$\text{Average \% consumed} = \frac{(\sum \text{\% consumed species})}{\text{total \# of cows that ate species}}$$

Colobus data was divided into focal individuals that fed below and above 1.8m. The species eaten were ranked using the same methods used on cow data. Only focal observations that lasted the full five minutes were included in the analysis of feeding bouts above 1.8m, though observations below this height, being somewhat less common, were analyzed regardless of completion in the same manner as cows to determine average percent consumption and the number of focal individuals that consumed each species.

Time spent in each of the five behavioral states was calculated as the percent of data points in which members of a group were seen occupying each category. Data sets were pooled into below 1.8m-no cows present, above 1.8m-no cows present, and below 1.8m-cows present, and analyzed according to the formula:

$$\text{\% time in behavior} = \frac{100 \times \text{\# behavior instances}}{\text{total \# all behavior instances}}$$

These results were subjected to a χ^2 goodness of fit test comparing the percent of time spent in a particular behavioral state in the three situations mentioned above.

Results

Cows

During 61 focal periods, cattle ate a total of 63 different plant species. Most animals were tethered, and the average length of the rope was 4.7m. Eighteen species of plants were eaten by eight or more cows (at least 13.5% of all focal observations). There were seventeen species that on average each comprised over 15% of total mouthfuls in the session when they were consumed (Table 3, Appendix III).

Colobus

In focal observations, red colobus ate total of 13 plant species, choosing parts such as mature and immature leaves, leaf and flower buds, fruits and roots for their consumption. 85 of the total 151 observations lasted the full five minutes. Of these complete observations, 70 were of monkeys eating above 1.8m. At this height, colobus ate seven species of plants (Table 4, Appendix III). 26 observations took place at or below 1.8m, with an average duration of 200.6 seconds. Eleven species were consumed while monkeys fed at this level.

Interactions

There were no significant differences in the amount of time colobus spent eating, grooming, or sitting/resting under the different conditions ($\chi^2 = 0.50$, 4.11, and 4.05 respectively; DF=2; Figure 3, Appendix III). Colobus spent significantly more time playing when on the ground with cows present than they did above 1.8m with no cows

present (χ^2 = 6.21; DF=1; p<0.05). On the other hand, the monkeys spent significantly less time moving when below 1.8m with cows present than below 1.8m without cows (χ^2 =11.19; DF=1; p<0.005) or above 1.8m without cows present (χ^2 = 4.94; DF=1; p<0.05).

Discussion

Cows

The eighteen species of plants eaten by eight or more cows are probably the most important ones for further scrutiny, though the implications of a species being eaten by a sizable proportion of all cows is somewhat unclear. It could be that cows are seeking out the species particularly, and choose it preferentially over others that may be available in the area. During my observations, I noted that cows that had recently been tied into a new location were quite picky in what they ate, eating all of one available species while examining and then passing over others. Still, cows may not always have the option to preferentially choose their food species when tethered to one location. One group of cows I observed had been fairly choosy when I was collecting data. However, they were not moved for four additional days, and by the third morning, all vegetation below 2m was gone, including the plants that they seemed to have been avoiding on day one. Though most cows were relocated at least once daily, my analysis did not account for how long the focal cow had been tied to its current location. As such, my recorded species are probably a mix of the ones that cows choose first and those they eat when their food supplies within reach were dwindling.

A high number of cows eating a particular species may also indicate that the species is widespread in the study area, and that an increased number of cows consuming

it is a measure of how often that plant occurs in the micro-habitat defined by the radius of a cow's tether. Informal observations showed that many of the frequently consumed plants seemed to be relatively common, but without vegetative sampling, my observations are solely qualitative.

Species were also ranked by average percent consumption. In order to reach a high percentage, two conditions must be met. First, the cow must repeatedly choose to take another bite of the same species. In my observations, this species was sometimes not the most easily obtained, and required digging under vines and bushes to get the next mouthful. Additionally, if the species weren't common at least within the radius of the cow's reach, an individual would not have enough possible mouthfuls available to be able to reach the benchmark 15% consumption. A species that occurred often enough to allow a cow to eat it for at least 15% of five minutes indicates that within a small, very localized area the species was relatively common.

Colobus

During focal observations, colobus ate a total of seven species when above 1.8m and eleven species at or below 1.8m. Additional species were observed to be eaten when on the ground, though these did not occur during focal observations. A complete list of species consumed by colobus can be found in Appendix 4. Four of the species (*Bridelia micrantha, Albizia sp., Terminalia catappa, and Eugenia malaccensis*) consumed above 1.8m were found in the "top ten food species" of other literature on the feeding habits of colobus in agricultural areas (Table 6, Appendix IV), which lends support to the idea that colobus in this study were feeding in a characteristic and somewhat predictable way. Below 1.8m, seven of the eleven recorded species were also in previous literature. It

seems that at this time of year, colobus are eating many of the same species near the ground that are also available higher up, namely, trees. There was not enough data below 1.8m to compare the amounts of species consumed below and above 1.8m, though qualitatively, one can see that the colobus consumed fairly similar percentages of the commonly eaten species. The low quantity of data means that some reported results may not have yet reached a true average value. *E. malaccensis*, for example, was consumed by only one individual below 1.8m. Thus, though it may occupy a large average percent consumption, 100% is not a realistic figure. Additionally, during many observations near ground level, undergrowth was dense and feeding animals in these areas went unrecorded. This likely limited the amount and variety reported, for I recorded only feeding bouts that I could clearly see.

The four species that were eaten both below and above 1.8m comprised a significant amount of the total feedings, however it is interesting to note the absence of *T. catappa* consumption below 1.8m. Though the percentage consumption reported for *T. catappa* in the 'above 1.8m' category might be slightly inflated to do mistaken inclusion of some *E. malaccensis* leaves early on in the study, its consumption is notably absent in lower feedings. This absence is difficult to explain. Large *T. catappa* trees indeed rarely had branches below 1.8m, but smaller trees and saplings did, as cows were able to reach and consume leaves directly from these trees. But though the monkeys commonly consumed other tree species from these heights, they did not feed on low branches of *T. catappa*. Perhaps this was a matter of chance; there were so many more leaves in the higher branches of the trees that colobus rarely had to come to a lower level to feed in the same tree. It also seemed as if most of the *T. catappa* new growth was limited to branch

tips in the crown. As these are the leaves with the most protein (Nowak, 2000), the colobus remained at greater heights than 1.8m to consume them.

Guava (*P.guavaja*) on the other hand, was fed upon almost twice as often below 1.8m as above, and comprised on average 94.53% of consumptions in a focal period. Monkeys were mostly eating unripe fruits, and remained on the lower branches of the tree to peel and eat the fruits after they had been plucked from the branch. Guava fruit, though, is seasonal, and Mturi (1993) found that consumption of unripe fruit is consistently limited by abundance. It is unclear if this study were repeated in a different season without guava fruit or buds, whether one would find monkeys feeding low in these trees. Red colobus diets are known to vary seasonally (Gebo and Chapman, 1995), and the amount of time they spend near the ground foraging is likely to vary as well.

Though not a plant species, I observed colobus coming to the ground to eat what appeared to be average soil. Zanzibar red colobus specifically are known to eat charcoal and exhibit geophagy, and it is hypothesized that charcoal and soil consumption may be eaten as a mineral source and to absorb toxins and other digestion-interfering secondary compounds from their food plants (Struhsaker et al, 1997). Mturi (1991) found the highest amount of digestion-interfering phenolics in young leaves and leaf buds, though these are usually the preferred food of colobus because of their high nutrient content (Mturi 1993). The benefits of this dietary decision may outweigh the costs if the colobus can consume something to absorb these phenolics, such as the charcoal and soil that are found throughout the *shamba* areas. It would be interesting to know if the charcoal-eating behavior is correlated with the amount of phenolics or other harmful secondary compounds in the diet. If this is indeed the case, further study on the local levels of these

compounds in lower plants may provide a link to ascertaining the food choices colobus make when on the ground.

Though I encountered colobus eating plants on the ground outside of my focal observations, the consistent ground feeding about which I had heard rarely materialized. This is probably a result of the season in which this study took place. *T. catappa*, the main food tree in this and other studies (Nowak, 2000; Siex and Struhsaker, 1999b; Mturi, 1993) for colobus living in agricultural lands, sheds all its leaves in July and early August. During this time there is little rain or new growth on the trees in the *shamba,* and colobus food resources are at their scarcest (Habib A. Shaban, pers. comm). This study was conducted during the second half of November, which marks the beginning of *Vuli*, the short rainy season of November and December, in which *P. guajava* begins its three months of fruiting and the Indian almond trees have leafed out once more(Habib A. Shaban, pers comm.). *B. micrantha* and *E. malaccensis* , the other two most common food trees in this study, do not drop their leaves all at one time like *T. catappa*. Still, new growth on these species is also most obvious during *Vuli.*

Comparing cows and colobus by food species

Cows shared five species with colobus in focal observations, four of which are trees. While cows ate a great variety of species, at this time of year the colobus are relying on only a few. Without great food species diversity on the part of the monkeys, the chance of food species overlap is relatively small. When comparing my cows' food species to Nowak's (2000) somewhat more extensive list of colobus food items, I found an additional four species that my cows had also consumed. Since her study was conducted at the same and an adjacent site, it is likely that the colobus I observed were

parts of the same groups as she had seen. Though I did not include them in the diet analysis of colobus in this study, I also recorded nine species of ground plants that I observed colobus eating during activity budget observations, eight of which were also consumed by cows.

Though the number of shared food species between cows and colobus is relatively small, the list does include key colobus food species like *T.catappa, P. guajava*, and *E. malaccensis.* At this time of the year, food for colobus is plentiful in the trees, and they rely heavily upon these trees to make up the bulk of their diets. Cows in this study that fed on trees ate a substantial amount of *T.catappa* and *P. guajava* especially (10.7 and 13.5% respectively). If these percentages are representative of the year-round species composition of a cow's diet, in seasons when traditional colobus food sources are low, one might suspect increased competition for the remaining leaves of trees like *T. catappa* and *P. guavaja*. But one must remember that cows cannot leave the ground, and when they have eaten all the leaves off of lower tree branches, the rest of the leaves in a 40m tree are only available to the colobus. Cows also fed on leaves from trees that had fallen to the ground. *T. catappa* leaves especially seemed easily dislodged by the leaps of traveling colobus. Cows below such movements often ate the fallen foliage, in addition to leaves that had been partially eaten by a monkey before being discarded. The fronds of *C.nucifera* were also sometimes knocked to the ground by colobus, and in fact all cow consumption of this species resulted from colobus actions that caused leaves to fall within reach a tethered animal. In situations like these, it seemed that cows and colobus had been caught in a sort of commensal act; monkeys dislodge foliage during their movements and feedings in the treetops, and nearby cows below benefit from an

increased amount and variety of food objects within their reach. Indeed interactions between cows and colobus that don't require direct contact seemed likely to happen throughout the study area; below every monkey observation, I found cow droppings, and when watching cows, a troop of monkeys passed near the site almost every time.

Iinteractions

Past literature providing activity budgets for red colobus monkeys vary greatly. Often, they are difficult to compare, as there is little standardization of behavioral definitions, and their results span a great range of percentages within which should appear the same behavior. Table 7 (Appendix IV) provides a comparison of this study with other literature.

In this study, three behavioral categories, sit/rest, eating, and grooming, had no significant difference in the amount of time colobus spent performing these activities with or without cows present, above or below 1.8m. This could be interpreted in a number of ways. First, it seems that the monkeys behave similarly at all heights, especially in the case of their two most common behavior states, sit/rest and eating. This is an interesting observation, because one might expect an arboreal monkey to be less comfortable in a new and potentially more predator-filled (Mturi 1993) environment like the ground. The fact that they are not, and instead continue to feed and sit/rest in similar ratios might imply that these particular groups of colobus have already successfully expanded their home ranges to include near-ground levels, and no longer fear it as an unusual habitat.

Along with this expansion, the colobus seemed to accept the addition of grazing cattle to their immediate surroundings. Grooming requires much of an animal's attention,

and thus distracts it from other activities such as watching for predators. That colobus groomed just as frequently in close proximity to a cow as they did high up in the relative safety of a tree suggests that they find little threat from cattle grazing among their group.

Not all aspects of colobus behavior remained unchanged near cows. The monkeys played a significantly higher proportion of the time when on the ground near cows than they did above 1.8m. Often when tourist groups come to see the monkeys, many colobus cease their present activity and began playing with each other or otherwise moving to come lower, and subsequently nearer, to the people watching them from the paths (pers. observation). Perhaps this effect of habituation has been transferred to cows as well. I observed both full-grown and juvenile colobus hanging from branches very near to the heads of cattle, and, twice, chasing one another through and around a grazing cow's legs.

While instances of play increased, movement unrelated to play was significantly less common in the presence of cows than either below or above 1.8m when no cow was present. Perhaps the running, jumping, and chasing associated with play provided ample instances for changing position and location, but when the monkeys did perform an action classified as movement, they were often as brazen as the youngsters playing around the hooves of a large cow. Most notably, one adult female leapt out of a tree, onto the back of a cow, and back into another tree. Cows, for their part, ranged from indifferent and seemingly oblivious to somewhat engaged with the passing troupe of colobines. The individual who had earlier served as a colobus launch pad proceeded to knock at low branches that nearby monkeys shook over her head, and another cow would nudge sitting and playing colobus on the ground as she grazed around them. This

boldness makes regular direct interactions between the two species into a real possibility, especially if during other times of the year monkeys spend even more time on the ground.

Conclusion

Vuli is not the best season for a study designed to watch colobus feeding on the ground. Still, I found food species overlapping between grazing cows and the resident colobines. The fact that these shared species were mostly trees is even more significant, as during this time of year, colobus are relying heavily on just a few tree species for most of their diet, species that are also being consumed by cows. The additional behavioral activity data, though based on only three discrete meetings of colobus groups and cattle, shows that cows and colobus are engaging in a unique type of interaction, one that is probably even more common during other times of the year. By using the 'food species consumed' lists (Appendix 3) as a baseline for further study, it can only be assumed that given the chance for more consistent and prolonged interactions, one might find a profound intersection between the lives of grazing cattle and the *shamba*-dwelling colobus that feed on the ground.

Recommendations

Repeating this study in the months of July and August, when *T.catappa* sheds its leaves, might increase the number and information on species that red colobus eat when on the ground. An organized vegetative survey and identification of the lower plants in Jozani's agricultural lands would be useful to determine if cows' and colobus' food choices of ground plants are preferentially chosen or determined by local availability. Finally, a

more in-depth look at the nature of direct cow and colobus interactions could provide a record of a novel set of behaviors that seems to be unfolding as the pressures exerted on this endangered species change.

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Appendix I: Maps

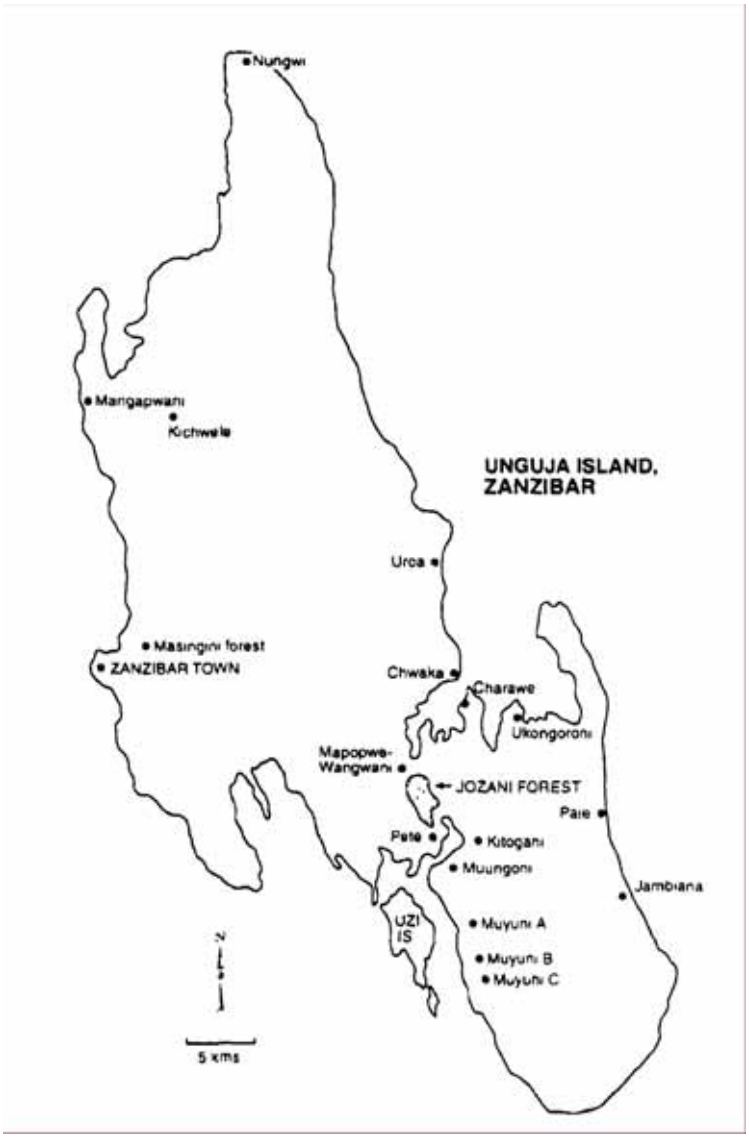
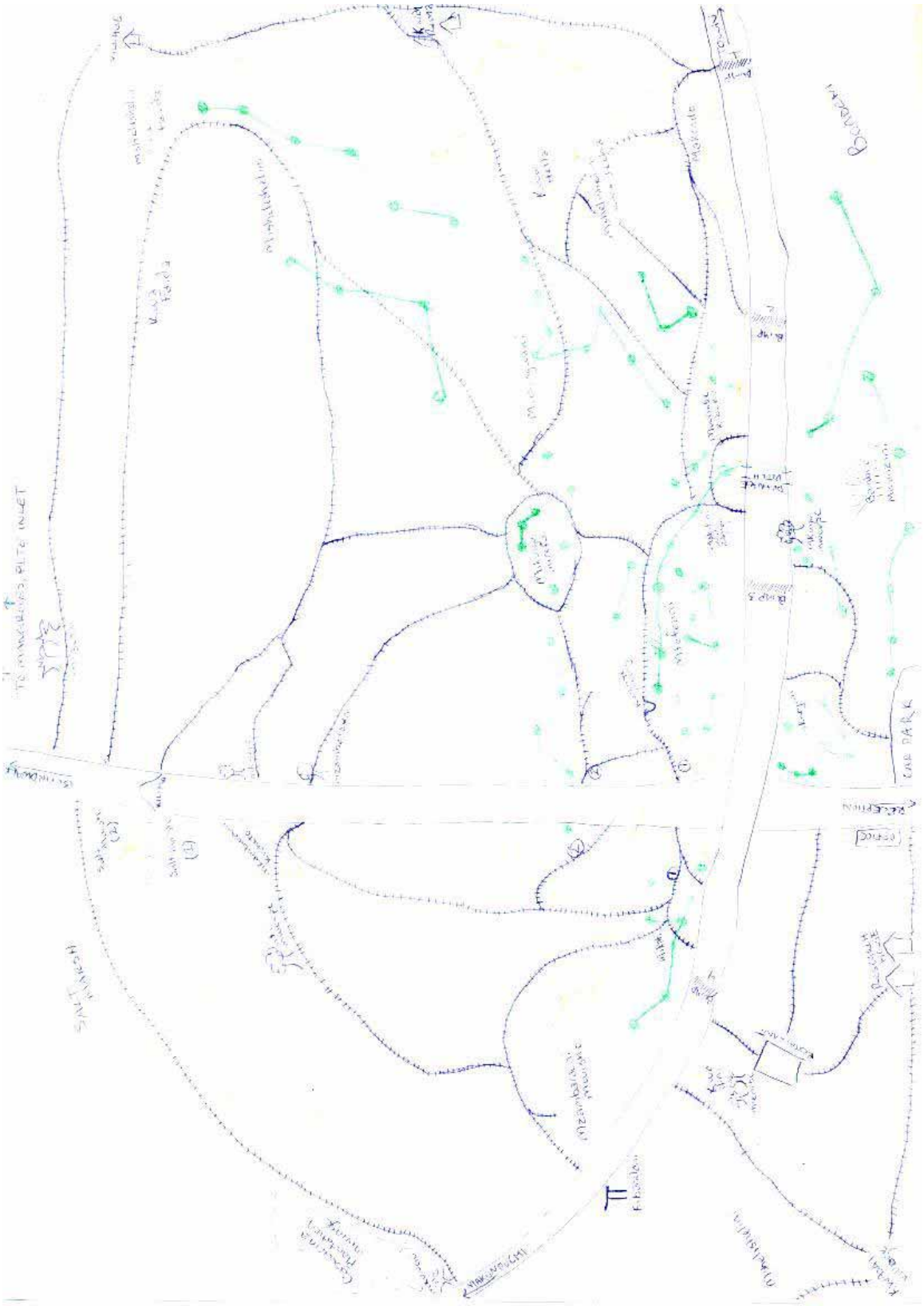


Figure 1. Location of Jozani Chwaka Bay National Park on Unguja, Zanzibar, Tanzania.

Figure 2 (next page). Trail map and illustration of "Jozani farms" study site and adjacent areas. Green dots and lines represent areas of colobus observation; brown lines and dots are cow observation sites. Blue lines are main trails.



Appendix II: Methodologies

Table 1. Definitions used in colobus focal feeding observations.

Complete focal period	One in which the animal ate continuously for the length of the observation, or did not have more than a 15 second lapse between the end of chewing and the collection of the next food item
Leaf	A mature leaf of approximate full-grown size. Can be new or old growth.
Small leaf	leaf of approximately half the size of a full-grown leaf or smaller. In the case of *T. catappa*, a small leaf was always new growth.
Bud/tip	A leaf or flower bud consumed specifically. Often noticeable first as one of the few foods that a colobus eats straight off the plant without plucking. Once bitten one can usually see a different color inside.

Table 2. Behavioral definitions for cow/colobus interaction data.

Eating	Currently in the act of obtaining food (e.g. plucking a leaf or fruit), manipulating it, consuming the food object, or otherwise chewing. Movement related to obtaining food directly was also recorded in this category.
Play	Chasing, pouncing, or hanging from branches to entice another individual all constitute play. Usually two or more individuals, and often performed by juveniles. Running and jumping movements clearly part of play activities are also included.
Grooming	Cleaning of self or another with mouth or hands
Sitting/Resting	Sitting or reclining when not performing an activity of the other categories. Includes sleeping and stationary nursing mothers.
Movement	Running, walking, climbing or leaping with the purpose of reaching a new destination.

Appendix III: Results

Table 3. Plant species eaten by cows

Latin	Kiswahili	#cows that consumed species	Average % consumption
Convolvulus farinosus	Mriba	2	3.53
Cocos nucifera	Mnazi	1	14.29
Unidentified tree 1		4	35.88
Unidentified tree 2		1	13.04
Terminalia catappa	Mkungu	9	10.38
Psidium guajava	Mpera	11	13.49
Eugenia malaccensis	Mtofaa	4	6.30
Senna singeuana	Mkundekunde	8	5.04
Stenotephrum dimidiatum	Pemba grass	23	36.94
Indigotero sp.	Mtuyu	34	16.34
Flovia aestuans	Mweni	4	9.89
	Kiviza	15	10.89
Stachytarpheta indica	Kikwayakwaya	35	12.30
Ficus sur	Mkuyu	1	9.23
Fleurgia viroso	Mkwamba	5	3.32
Hoslundia opposita	Mnunu	10	19.39
Emelia sagittata	Mchaka na mbingu	18	9.97
Panicum pabliglume or *p.trichocladum*		26	10.68
Pentas sp.	Mtui	5	13.56
Indigofera sp.	Ndago	4	40.79
Asystasia gangetica		3	11.27
Sida acuta	Mfagio	4	8.35
Unidentified plant 3		1	17.65
Caylusea abyssinica		6	6.89
Oesimom sp.	Kivumbasi	8	7.23
Euphobia hieta		8	8.58
Unidentified grass1		22	16.44
Tragia furicata		1	5.36
Oxalia corniculata		11	13.92
Cassia tora	Mkundekunde	2	8.78
Phoenix reclinata	Mkindu	8	7.05
Unidentified grass2		2	28.10
Unidentified shrub 1		2	7.59

Sederelosilom inama	Mkandika	1	13.46
	Mdago mwito	10	73.07
Asparagus africanus	Mvuma nyuki	2	2.78
Doclovea viscose	Mbebeta mke	7	6.11
Tacca involucrara	Uwanga jike	2	49.27
Saba comorensis	Mbungo	2	23.52
Flacotia indica	Mgo	3	5.22
Polyspharia polyflora	Mlapaa	2	7.33
Unidentified plant 4		1	1.64
Unidentified plant 5		3	6.51
Unidentified shrub 2		1	2.70
Ampelocissus sp.	Pentagon fruit	3	8.57
Nephrolepsi bisserata		8	25.12
Commelina africana	Kongwa/mpovupovu	6	8.27
Ampelocissus africana	Mzabibu mwitu	4	4.67
Coccinia grandis		2	5.89
Albizia lebec		3	10.10
	Kivumbika fuu	1	28.05
Psychotria sp.		2	15.48
Psychotria sp. (different)		3	20.56
Unidentified plant 6		1	9.57
Commelina betersii	Mpovupovu	14	12.66
Hibiscus surattensis		1	6.09
Aerva lantana	Kinonga	3	14.48
Unidentified plant 7		1	5.41
Calophyllum inophyllum	Mtondo	1	3.92
Cachoros trilocularia		1	5.13
Cachoros tridens		1	17.14
Unidentified plant 8		1	6.38
Anthocleista grandiflora	Mkungu maji	2	16.23

Table 4. Species consumed by red colobus monkeys

Latin	Kiswahili	# monkeys that consumed species **below 1.8m**	Average % consumption **below 1.8m**	# monkeys that consumed species **above 1.8m**	Average % consumption **above 1.8m**
Psidium guajava	Mpera	16	94.53	9	79.78
Eugenia malaccensis	Mtofaa	1	100	6	74.95[A]
Dirt		2	100	-	-
Tamarindus indica	Mkwaju	1	41.67	-	-
Fluergia sp.	Mkwamba	1	58.33	-	-
Ficus sycamorus		1	100	-	-
Cocos nucifero	Mnazi	2	100	-	-
Turea floribunda		1	100	-	-
Bridelia micrantha	Mkati	2	87.5	21	86.28
Albizia sp.		1	100	3	100
Rauvolfia mombasiana	Muwango	1	25	-	-
Terminalia catappa	Mkungu	-	-	38	91.03 [A]
Ampelocissus africana		-	-	1	27.27
Polyspheria paviflora	Mgudi	-	-	1	100

[A] Due to a misidentification error in the first two days of data collection, the value for *T.catappa* may be slightly raised as it might include some *E. malaccensis* leaves as well. Conversely, the focal individuals who consumed these leaves were not attributed to the *E.malaccensis* column.

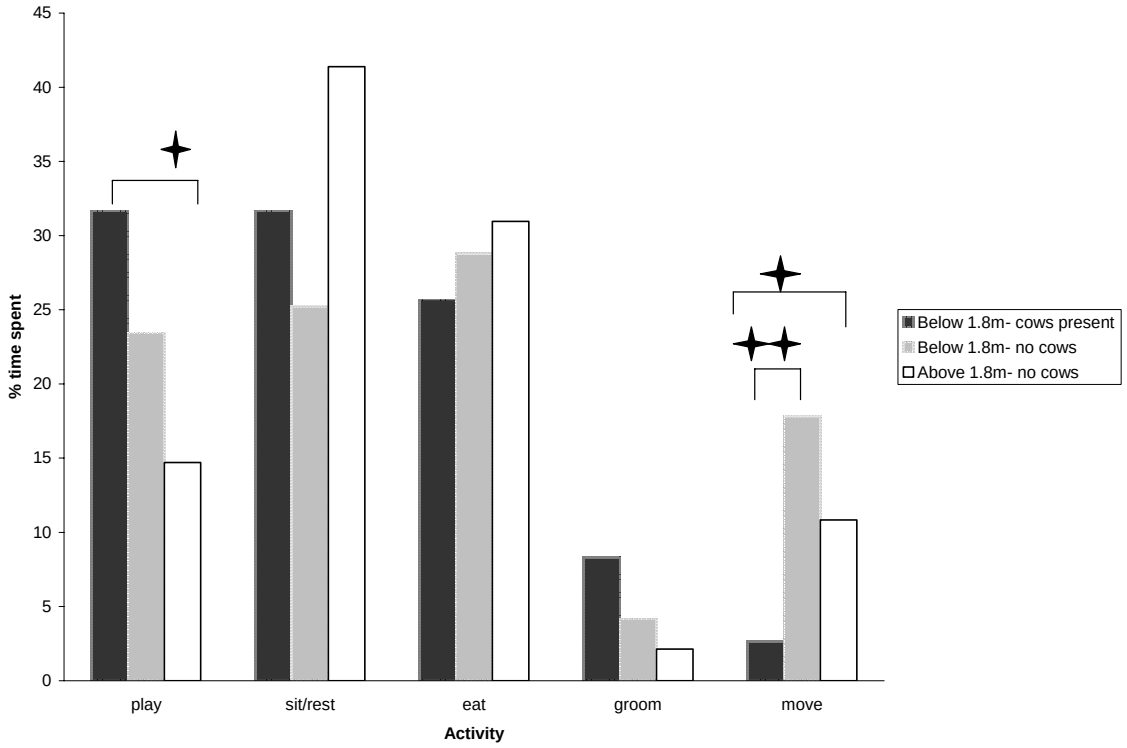


Figure 3. Activity budget for red colobus monkeys in agricultural lands near Jozani National Park. There was a significant difference between the time spent playing with cows present and above 1.8m, and also a significant difference in time spent moving between cows present and each of the other two conditions.
*$p<0.05$
**$p<0.005$

Appendix IV: Discussion

Table 5. Complete list of plant species eaten by colobus during focal observations and behavioral observations

Latin	Kiswahili	English
Terminalia catappa	Mkungu	Indian almond
Psidium guajava	Mpera	Guava
Bridelia micrantha	Mkaati	Bridelia
Tamarindus indica	Mkwaju	Tamarind
Ficus mucosa (F.sycamorus)	Mti mweupe	Sycamore fig
unidentified	Kiviza	
Mollutus sp.	Mchembelele	
Fleurgia sp.	Mkwamba	
Todalia asiatica	Mdaka komba	
Ficus sur	Mkuyu	Cape fig
Eugenia malaccensis	Mtofaa	Zanzibar apple
Cocos nucifera	Mnazi	Coconut
Ampelocissus africana	Mzabibu mwitu	
Rauvolfia mombasiana	Muwango	
Ipomea sp.	Mriba	
Polyspheria paviflora	Mgudi	
Indigotero sp.	Mtuyu	
Fleurgia viroso	Mkwamba	
Cachoros sp.	Mfagio	
Flovia aestuans	Mweni	Stinging nettles
Calophyllum inophyllum	Mtondo	
Turea floribunda	Mtamagoa	

Table 6. Comparisons between literature rankings and species eaten in this study by red colobus. Numbers are rankings in "top ten food species" lists from other sources; Y represents presence but not ranked, numbers in parentheses are the number of animals who consumed that species.

	Above 1.8m	**Below 1.8m**		Nowak (2000)	Derby and Eighmy (1997)	Kelly (1997)	Siex (1995)	Siex and Struhsaker (1999b)	Mturi (1993)
Bridelia micrantha	3 (21)	3 (2)		2	2	Y	1	5	8
Albizia sp.	1 (3)	1 (1)		-	-	Y	8	-	-
Cocos nucifera	-	1 (2)		Y	5	-	5	3	3
Terminalia catappa	2 (38)	-		1	2	-	-	1	1
Tamarindus indica	-	5 (1)		Y	-	-	-	9	-
Eugenia malaccensis	5 (6)	1 (1)		Y	6	-	-	-	-
Psidium guajava	4 (9)	2 (16)		Y	-	-	-	-	-
Ampelocissus africana	6 (1)	-		-	-	-	-	-	-
Polyspheria paviflora	1 (1)	-		-	-	-	-	-	-
Fluergia sp.	-	4 (1)		-	-	-	-	-	-
Ficus sycamorous	-	1 (1)		Y	-	-	-	-	-
Turea floribunda	-	1 (1)		-	-	-	-	-	-
Rauvolfia mombasiana	-	6 (1)		-	-	-	-	-	-
dirt	-	1 (2)		-	-	-	-	-	-

Table 7. Activity budgets from other literature and this study compared. Values listed in percents. Dashes denote unrecorded behaviors.

		Play	Sit/Rest	Eat	Groom	Movement
McGraw 1998		6.3[A B,]	29.9	44.9[A]	-	18.9
Oates 1994		3 [A, B]	55	37	-	5
Derby and Eighmy 1997	Morning	-	10.25	19	-	32.1
	Afternoon	-	7.8	10.8	-	28.6
	Evening	-	0.3	33.8	-	32.5
Chapman 1999	Group 1	5.5 [B]	52.5	30.7 [A]	5.4	2.3
	Group 2	1.2 [B]	59.5	32.9 [A]	8.0	1.4
	Group 3	7.2 [B]	40.7	32.9 [A]	8.0	5.0
Under 1.8m-cows present		31.7	31.7	25.7	8.3	2.7
Under 1.8m-cows absent		23.4	25.2	28.8	4.2	17.8
Over 1.8m-cows absent		14.7	41.4	30.9	2.1	10.8

[A] Categories used in these studies were modified to fit comparison; "social" has become Play, though it also contained other activities. "Feed" and "forage" were combined to become Eat.

[B] Study did not include juveniles under one year of age

Appendix V: Identification of red colobus groups currently residing in Jozani *shamba*

Group name	# monkeys	Range[A]	Distinctive individuals
Group 2	16	Unknown	Female with white eyes; tagged male with a cut ear
Group 3 (tourist group)	72	All shamba areas	Male with injured nose; tagged female with white tag
Group 4	21	Restauraunt to Mkokoni	Male that always squints; male with cut lower lip
Group 5	4?	Reception and research house to coral forest	Male with yellow collar; male with yellow collar and black tag
Group 6	21	Bondeni to Kwa Jecha	Male with one good eye; Female with small eyes
Jozani Village	24	Jozani village to Mbuyu	Male with black nose; female with black nose

[A] For location information, see map in Appendix I.