

Monkeying Around

Spatial Differences in Riverine Habitat Utilization by Vervets, Sykes, and Baboons

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Acknowledgements:

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Abstract

The purpose of this study was to examine where in five vertical locations (river, bank, ground, trunk, and canopy) and at what times vervet monkeys, sykes monkeys and baboons utilized the habitat of the Simba River at Ndarakwai Ranch in the West Kilimanjaro district of Northern Tanzania. The study attempted to use this information, particularly in regards to eating behavior, to see if these sympatric species use vertical special or time of day to partition the resources along the river, and if close proximity to other primates affected vertical location. The study was conducted within 25m of a 2.8km section of the Simba River between April 11 and April 29, 2009. Groups of primates were encountered during walking transects of the river and data points containing species, time, location, and behavior of each individual were collected using scans. Data points (n=3279) were analyzed using descriptive statistics. Results indicated that primates do utilize different vertical levels of the habitat with sykes remaining predominantly in the canopy, baboons on the ground, and vervets utilizing both substantially, but spending more time on the ground. Differences by time of day were slight. Eating behavior by vertical level followed the overall trend. When grouped with other primates, sykes and baboons did not greatly change their location, but vervets moved to the ground in the presence of sykes and to the canopy in response to baboons. Overall, the hypothesis that these primates use different vertical levels to share the habitat was supported by the study and emphasizes the need to conserve all parts of the habitat (as opposed to focusing on fruit trees) for wildlife management.

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Introduction:

Across the world, there are 185 known species of primates. Of these, 51 species exist in Africa. These include primates of the families Loriscidae, such as bush babies and pottos, Cercopithecidae, including monkeys and baboons, and Hominoidea, including humans and great apes (Estes, 1992). Tanzania specifically is home to many species of primates such as the savanna baboon (*Papio cynocephalus*), black and white colobus monkey (*Colobus guereza*), vervet monkey (*Cercopithecus aethiops*), and blue/sykes monkeys (*Cercopithecus mitus*). Many of these species exist sympatrically with overlapping troop home ranges.

Among many species of primates, including those in Tanzania, some remarkably high levels of overlap in diet can occur, even with species utilizing the same habitat. Although “complete competitors cannot coexist” according to many resource partitioning theories, primates often use and compete for the same resources (Waser, 1987). Competition between primates, particularly for food, can include excluding other species from using the resource (such as through aggression) or simply exhausting the resource before the other group can utilize it (such as through eating a limited food source). Many studies on niche partitioning in primates have relied only on measuring the food eaten or home ranges used by different species. Because of the overlap between species in both food type and home range, many of these studies have been unable to draw significant conclusions. As Waser, a primate ecologist, notes, “the location from which food items are taken has rarely been a subject of study.” Differences in vertical location (ground, canopy, trunk, etc.), that food is taken could be an overlooked key component in how primates partition resources. Another possibility is that resources shared between primates are not actually in a short supply (Waser, 1987). If a limiting factor of the number of primates that can be in a certain area (carrying capacity) is something other than food, like predation or space, partitioning food resources might not even be necessary.

While multiple species of primates share the same habitats around the world, an excellent place to study primate resource partitioning is Ndarakwai Ranch in Northern Tanzania. There, three primates (sykes monkeys, vervet monkeys, and olive baboons) exist sympatrically, all utilizing the same sections of a riverine habitat within a savanna ecosystem. All three species are year-round residents of the ranch. The sykes and vervet troops along the river remain there for large sections of time and baboon troops move between the riverine and other habitats over the course of the day (Ole-Kuya, 2009). The river is seasonal and, after normal rainy seasons, can support a variety of distinctive fruiting plants including figs. These fig fruits are a “keystone” fruit, being a major source of food for each of the primate

species along the river. Along all sections of the river in Ndarakwai, fig trees fruit multiple times a year, including in the rainy season in April (Ole-Kuya, 2009). Because all the three primate species use this small section of river and share this same food source during the same seasons, they are an excellent sample population to study primate resource partitioning.

In November of 2004, Brian Miller, a former SIT student, conducted a study on resource partitioning of the same three primate species (vervet monkeys, sykes monkeys, and baboons) along the Simba River in southern Ndarakwai. He used focal scans to create behavioral time budgets for each of the three species. He also compared their use of the river in each of three horizontal sections (along the river's length) and by the location of more than 50% of the troop in the trees or on the ground (i.e. vertical locations). He did not find any significant differences in their use of the river by time of day or section use, but he did find significant differences between species in the time spent on ground versus trees. The majority (>50% per sighting) of baboons in a troop were located on the ground, the majority of sykes in a troop were located in the trees, and the majority of vervets were found in the trees in half of the scans and on the ground in the other half. Although the measurements of the location of the majority of the troop were not very precise and were taken down as meta-data in Miller's study, it points to a difference between the species in their use of vertical space in the riverine habitat.

Each of the primate species has its own distinctive traits, though many aspects of their feeding ecology and range of behaviors are similar. Vervets, sometimes called savanna monkeys, are commonly found throughout savanna ecosystems in northern and southern Africa. This species is one of the few guenons that leaves the woodlands to forage in the grasslands and is often associated with riverine habitats. Vervets live in groups of multiple females, males, sub-adults, and juveniles, in some studies averaging 11 troop members (Estes, 1999); although in one study of riverine troops at Ndarakwai, 29 vervets composed a single troop (Saville, 2005). Like many similar African monkeys, their peak activity times are in the morning and late afternoon but vary greatly depending on the habitat. Their diet is wide ranging including: "fruits, seeds, seedpods, new leaves, buds, sap, flowers, herbs and grasses, along with invertebrates and some small vertebrates" (Estes, 1999). During the rainy season, when I conducted the study, they usually eat insects, herbs, and grasses (Estes, 1999) .

In Miller's study, sykes monkeys (*Cercopithecus mitis*) were the second most observed species of primate using Ndarakwai's river during the day (2004). Also called blue monkeys, sykes are the only forest guenon that also moves outside of the lowland forest habitat and lives in eastern and southern Africa. Socially, sykes live in troops with related

females and one resident male. While troop size can vary greatly (Estes, 1999), one study of sykes monkeys conducted along the Simba River in Ndarakwai found a troop of approximately 16 individuals. The same troop spent 42.9% of their time feeding in the AM and 36% feeding in the PM (Welikonich 2005). Other studies in African forests have found troops moving in the early mornings and late afternoons, with a resting peak between 1 and 2 pm. They are “highly arboreal” and avoid “strong sunlight” (Estes, 1999). They generally sleep in tall trees and often remain in a single fruiting tree from morning to dark (Estes, 1999). In terms of diet, sykes monkeys are omnivorous generalists feeding on “fruit, foliage, insects, and other invertebrates.” In some studies in Uganda, they concentrated on one or two types of food at one time (Estes, 1999). In a study conducted on sykes monkeys along the Simba River at Ndarakwai in April 2005, sykes monkeys spent 34% of their time utilizing *Ficus* species along the river (Welikonich, 2005).

Savanna baboons (*Papio cynocephalus*) were the third and most transient species found in Miller’s 2004 study (Miller, 2004). Another study conducted on the baboons at Ndarakwai ranch determined that the baboons utilizing the river may be a hybrid between olive baboons (*P. cynocephalus anubis*) and yellow baboons (*P. cynocephalus cynocephalus*) (Pevos, 2004). Of all the primates in Africa, baboons are the most widespread and are found in a variety of habitats, mostly limited by water. They live in family groups (anywhere from 8 to 200 individuals) of females and offspring with multiple males that emigrate to other (non-family) troops. Baboons are diurnal, but aside from this, the daily activities of troops are highly unpredictable (Estes, 1999). According to one study conducted on the time budgets of a baboon troop at Ndarakwai, they spent the majority of their time resting (36.8%), foraging (33%) and traveling (20%; Schroepfer, 2004). When Miller conducted his study on resource partitioning between vervets, sykes, and baboons, he observed that when groups of the three species were in close proximity to one another “baboons tended to displace the other two species” (Miller, 2004). Baboons have a very wide omnivorous diet, able to forage equally well in trees and on the ground. Their food sources include: “tubers, bulbs, roots, leaves, buds, flowers, fruits, seeds, shoots, twigs, bark, sap, aquatic plants, mushrooms and lichens” along with, “invertebrates and vertebrate prey such as lizards, young birds, eggs, rodents, and even young antelope” (Estes, 1999).

While Miller’s 2004 study provided solid ground for looking at resource partitioning of primate species at Ndarakwai, the methods and focus of this study have been altered to more clearly tease apart the ways in which these primates may partition resources. How do the sympatric species of primates differently utilize the habitat along the Simba River?

Any time the primate species are in the riverine system, they are making use of the habitat. Even if they are only resting on the ground, there is a possibility that the presence of large, tall trees there allow the troop as a whole to be more vigilant or have an escape from predators. Troops moving through might just be going the shortest way from point A to point B and/or could be allowing members to drink, eat, or make use of the shade along the way. It would be difficult if not impossible to describe a situation in which a troop would be within 25m of the river (the study site) and distinctly not utilizing it.

In order to highlight the resource utilization strategies of these 3 primate species, my study focused on the differences in the vertical space (canopy, ground, etc.) in which individuals of different species are situated, the time of day spent performing different behaviors (particularly eating) at these locations, and the effects of the presence of nearby troops on vertical location. Measuring these variables will allow me to relate eating behaviors to time, physical location in a vertical plane, and proximity to other primates. This will provide a closer look into the different ways the primates utilize and/or partition the river resources.

My hypothesis was that vervets, sykes, and baboons would utilize different vertical levels in order to partition the resources of the Simba River. I predicted that there would be strong differences between the vertical locations of the primate species, especially for eating. I also predicted that there would be slight differences in the frequency and vertical levels of eating by time of day, but that all species would have a resting period during the hottest hours. I predicted that the vertical levels for obtaining food for sykes monkeys would be higher than that of vervets and baboons, since the literature characterizes sykes as spending more time in the trees, and there were many fruiting trees in the study site. I also predicted that close proximity to troops of other primate species would exaggerate these differences, with the species separating themselves more strictly into distinct vertical spaces. Overall, I predicted that this scanning method would more closely reveal systems of resource partitioning between the primates.

I expected this study to highlight the important food resources (in terms of the use of foods in different vertical planes) for all three primate species and how they might be coping as the number of individuals in each species is increasing. The results of this study were designed to be applicable to management for the tourism activities that take place on Ndarakwai Ranch.

Study Site:

Ndarakwai ranch is over 11,000 acres in size and is part of the West Kilimanjaro basin system. Surrounded by national parks and other conservation areas, Ndarakwai is an important migrational route for many animals like elephants (Ndarakwai Ranch," 2009). My study site was a 2.8km section of the Simba River on the southernmost part of Ndarakwai Ranch in Northern Tanzania.

Ndarakwai and the Simba River are not isolated sections of nature, unaffected by human contact. During World War I, the area was German controlled and trenches can still be seen around the ranch. After that period, the ranch was a British colonial ranch until Tanzania's independence in 1961. In 1975, the land was nationalized, and from that point until Peter Jones, the current owner of the ranch acquired the land, it was used for grazing and tree cutting by nearby Maasai bomas, and some hunting by other nearby villages. In 1994, Jones began the process of converting the ranch into a private conservation and tourist area ("Ndarakwai," 2009).

Even today the land is greatly affected by the surrounding people. At the eastern end of the river is a lodge where tourists reside, complete with kitchens, a open bar and eating area, and upscale tents (personal observation; see Fig. 1). Many properties upstream from the Simba river divert water for irrigation, and in recent years the once constantly flowing river has become seasonal (Ole-Kuya, 2009). Rafiki farm at the downstream section of my study site, now owned by Jones, also uses the river for irrigation (Miller, 2004). When the rains come, the river flow increases and the many fig trees on the banks of the river fruit. Currently, a nearby Maasai boma is cutting trees and considering farming in an area just outside the ranch and visible from my study site. Throughout the study period, I observed Maasai women and children collecting water, and frequently saw cattle on the southern side of the river. (personal observation). Although there has been an overall vegetation increase since Miller conducted his study in 2004, erosion has recently become a problem in part due to these activities, particularly cutting down trees (Ole-Kuya, 2009).

The weather in Northern Tanzania, like the rest of East Africa is determined in large part by its location in the Intertropical Convergence Zone (ITCZ). The ITCZ causes the formation of wet and dry seasons in Eastern Africa even though rainfall can be variable year to year. Rainfall is also modified by physical landforms like Mount Kilimanjaro, which lies to the west of the ranch (Gichohi, 1996). The water flow in the Simba River is affected by this seasonality. During my study period, the river was dry from April 11-13, but was flowing

from April 14-15 and April 21-29 (Note: April 16-20, I did not visit the river due to illness; personal observation).

The same section of the Simba River that Miller used in 2004 was used for this study. Although I was not able to collect data to compare to his study (see methods and limitations), this site allowed me to clearly see the vertical sections of the riverine habitat the primates used. The study site frame extended to 25m on either side of the river. It included a small section of the ground on either side of the river, but was still close enough to be considered part of the riverine system.

Fig. 1 maps out the study site, the Simba River, the location of primate groups observed along its length, and large fig trees, landmarks, and human use areas. The study site extended from the tourist lodge (tourists stayed between April 11-14 and April 24-27 during my study period) until the last river crossing point before Rafiki Farm. The northern side of the river is parallel to a dirt road used at night for anti-poaching patrols and during the day for tourist walking safaris (personal observation). Over the study period I observed mongoose, warthog, waterbuck, giraffe, zebra, elephants, and many birds, utilizing the riverine habitat within the study site. Based on personal observations and discussions with Kristin Meseck, another SIT student studying baboons near the river, I estimated that there were two baboon troops, two troops of sykes monkeys and two to three troops of vervet monkeys that periodically used this habitat during the study period (Meseck, 2009).

The vegetation on both sides of the river for all sections was dominated by fig trees during my visit, although other fruit trees, including *Vangulea*, *Presure*, and *Acacia Malifera* were also present. In contrast to November 2004, Ole-Kuya, a manager at the ranch noted that more fruit should be present for the monkey troops to eat. An increase in both baboons and sykes monkeys has also occurred (Ole-Kuya, 2009).

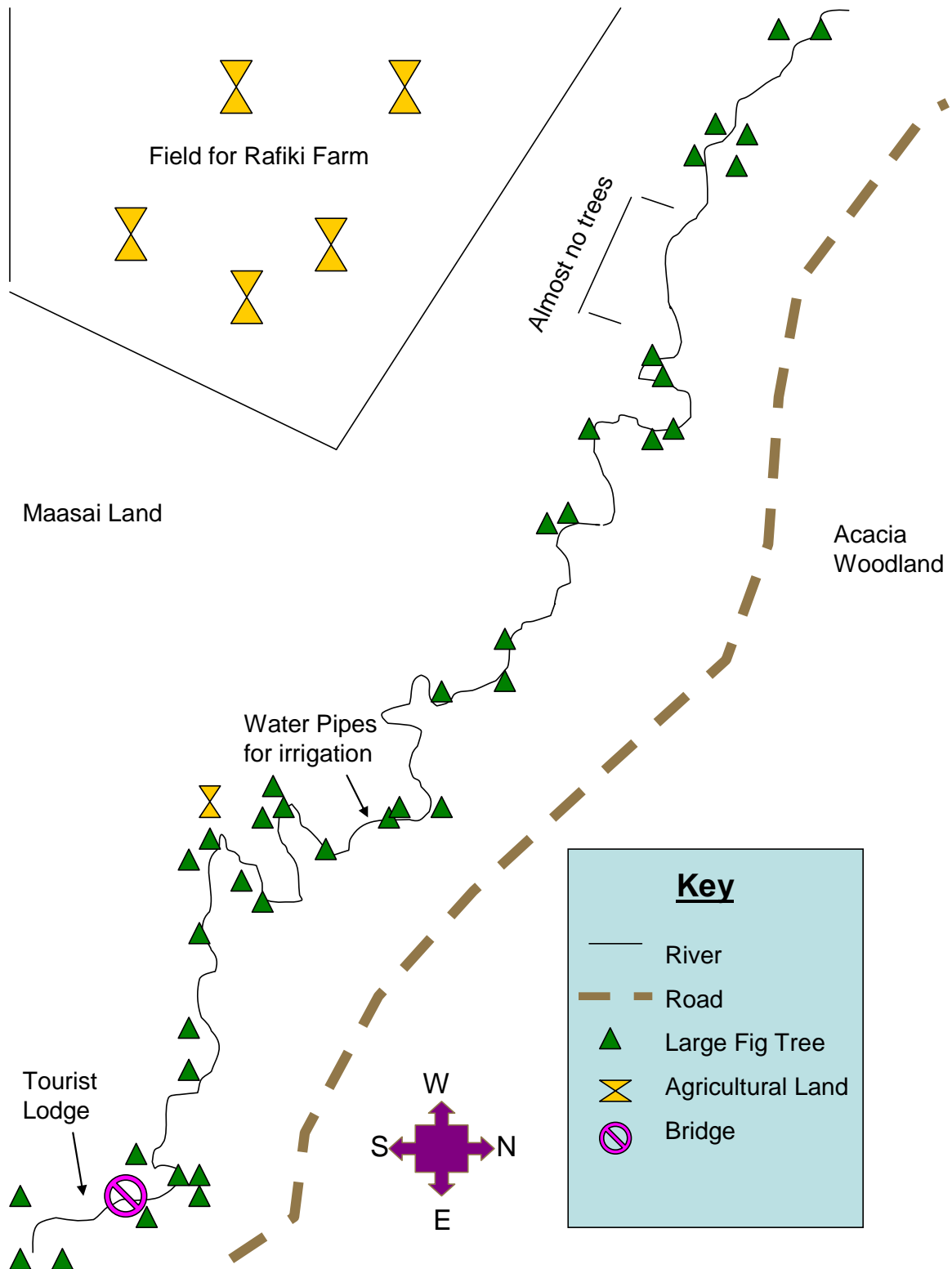


Fig 1—Map of the study site on the Simba River at Ndarakwai Ranch. Map is adapted from Miller’s (2004) map of the Simba River line and large fig trees. Total length of study site in this map is 2.8km (Miller 2004). Map checking and all additional information collected by Sondra Lavigne during April 11-30, 2009. Map created 7 May 2009 using Microsoft Power Point.

Methods:

To test my predictions, I spent 13 days collecting data on the vertical place and behavior of primates, two days conducting key informant interviews, and one day reconstructing a map of the river and testing my methods. Overall, I collected 3279 data points which included species, time, location, and behavior (1461 on vervets, 480 on sykes, and 1338 on baboons). My study site and the methods for encountering groups of primates are adapted from Miller's (2004) study, although the types of scans, time period, and intermixed scan methods were constructed specifically to test my hypotheses. I conducted walking belt transects of the river during each time period, conducting scans on primates' vertical locations and behavior.

I collected data along the river from 7-10AM and 3-6 PM each day. These were times that the monkeys were awake and active, with the break being in the hottest point of the day. Due to guard availability, I was not able to collect data at the same times as Miller, and thus was not able to compare my results to his study. I walked parallel to the river and collected data on any group of primates (more than 3 without a larger troop of the same species within sight) within 25 meters of the river. I walked from one end of the study site to the other and then walked back along the other side of the river during each of my two time periods. I would continue to make loops around the river until the end of my data collection period occurred. Typically this was between two and three lengths of my study site. I alternated the end and side of the river that I started on each morning and afternoon to reduce biases due to physical area and to record data on each side for each time period.

When I encountered a group of primates within 25m of the river, I used focal scanning to record data. I used a four minute scanning period (2 minutes for scanning and 2 for meta-data) conducted five times per encounter. During each scan, I recorded the species, vertical location, and behavior of each individual primate. I did not distinguish between individuals of different ages or sexes and like Miller (2004), wanted to compare *across* species instead. The vertical locations are defined as follows (see Appendix B for a visual depiction of these sections):

1. River: the flat section on the rocks, fallen logs, or ground where water flowed (or would have flowed for the days the river was dry).
2. Bank: on the sloped section between the river and flat ground
3. Ground: on the flat ground on either side of the river
4. Trunk: on the trunk, central branches of the tree
5. Canopy: on the leafy branches of trees.

In the scan for each individual I also paired their location with their behavior. The behavior categories were as follows:

- i. Move: walking, jumping, running or climbing
- ii. Eat: foraging, eating or chewing
- iii. Rest: sleeping, sitting, or lying down (inactivity)
- iv. Vigilance: focusing intently on me or other animals/movement/alertness
- v. Groom: combing through another individuals fur or being combed
- vi. Play: social interaction involving movement or mock fighting
- vii. Aggression: fighting, threat displays
- viii. Other: any other activity that does not fit into these categories

Although I intended to also note what species and part of the plant primates were eating from, it was impossible to note this due to visibility restrictions and lack of identification tools (see Limitations and Recommendations).

I conducted scans from left to right and then from right to left for all visible individuals within 25m of the river at the time of the scan. If any the range of individuals in troops of different species overlapped or were less than five meters of one another, they were considered “intermixed”. Intermixed scans recorded both species as one “group” and all individuals of both species were included in the same scan. I used a two minute meta data period in between scans to write down the time, placement of troop along the river, presence of other animals, and the distance (in meters) between the center of the observed primate troop and any other visible troop. I then scanned again, repeating for a total of five scans. If the troop moved out of my 25m range completely, I stopped conducting scans and moved on. See sample data collection sheet (Appendix C) for more information on my scanning methods

Descriptive statistics were used to analyze the differences between the behaviors, vertical locations, times of day used, foraging time and place, and intermixed groups versus those alone. Aside from eating, the behaviors (initially collected to compare to Miller’s [2004] study, were used to categorize differences between the species that might inform their location, eating habits, and reactions when intermixed. They were not directly analyzed to test hypotheses. As stated previously, data for species and part of plant eaten was not collected, and thus not included in analysis.

Results

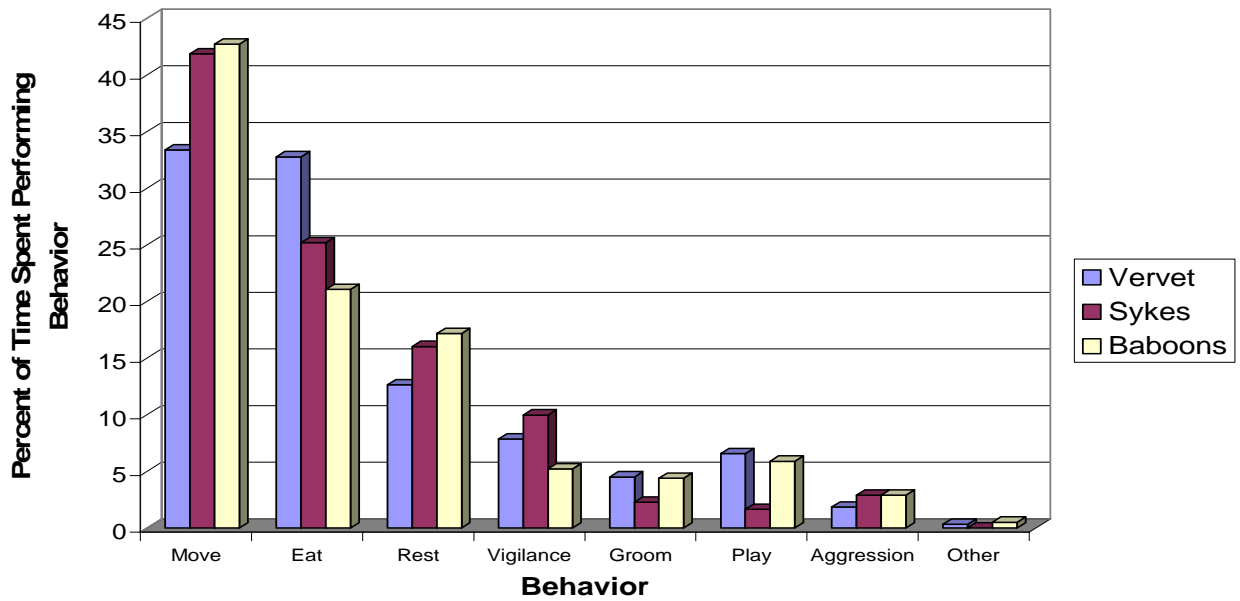


Fig. 2- Behavioral time budgets of Ndarakwai primates [n=1461 for vervets, n=480 for sykes, n=1338 for baboons]. Data collected by Sondra Lavigne at Ndarakwai Ranch in northern Tanzania in April 2009 between 7-10AM and 3-6PM.

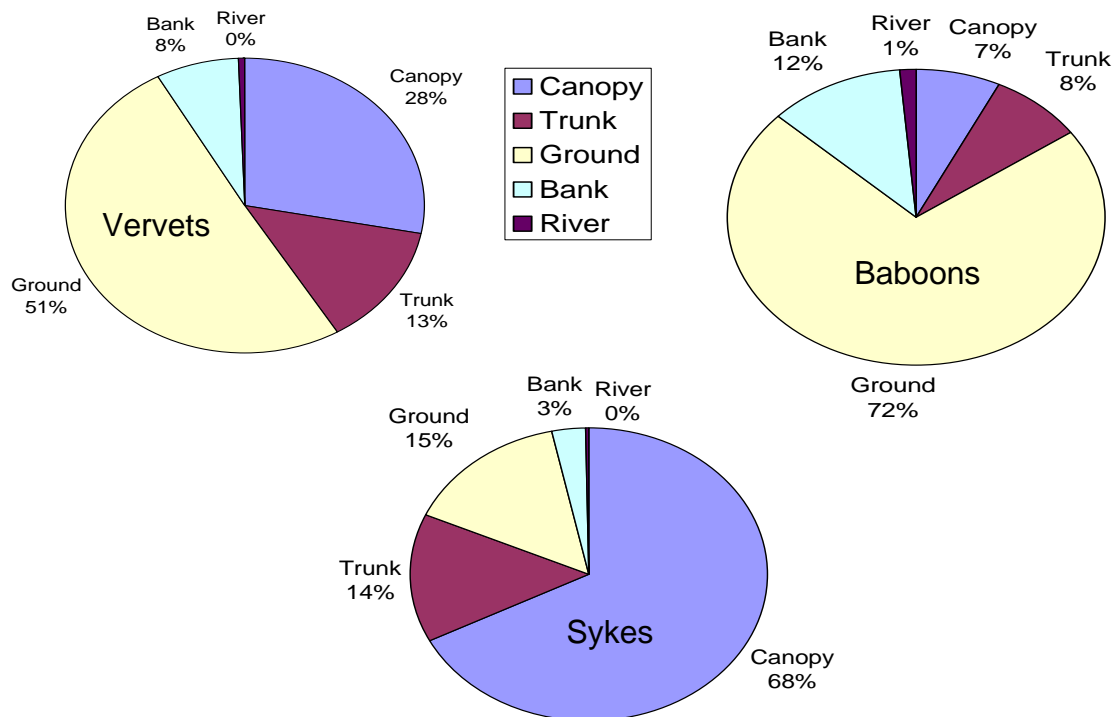


Fig 3.—The percentage of time that each of the three primate species (vervet monkeys, sykes monkeys, and olive baboons) spent at each of five vertical locations [n=1461 for vervets, n=480 for sykes, n=1338 for baboons]. Data collected by Sondra Lavigne at Ndarakwai Ranch in northern Tanzania in April 2009 between 7-10AM and 3-6PM.

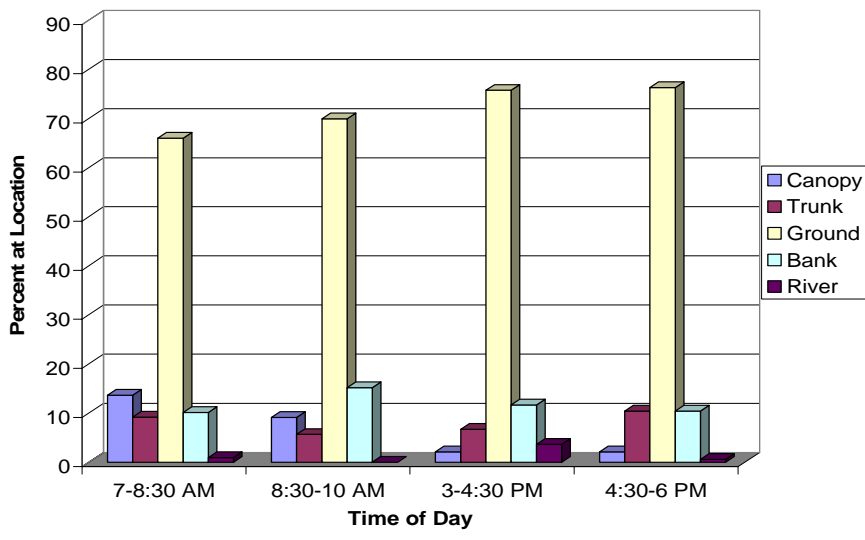
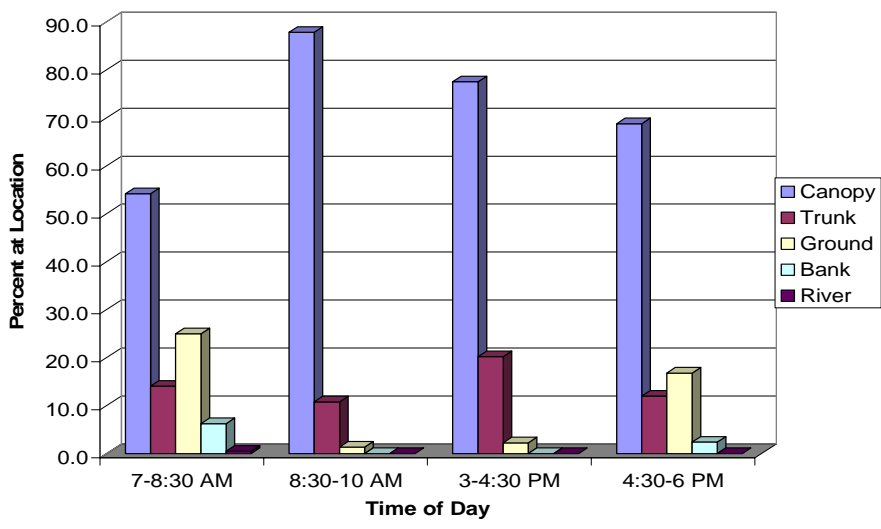
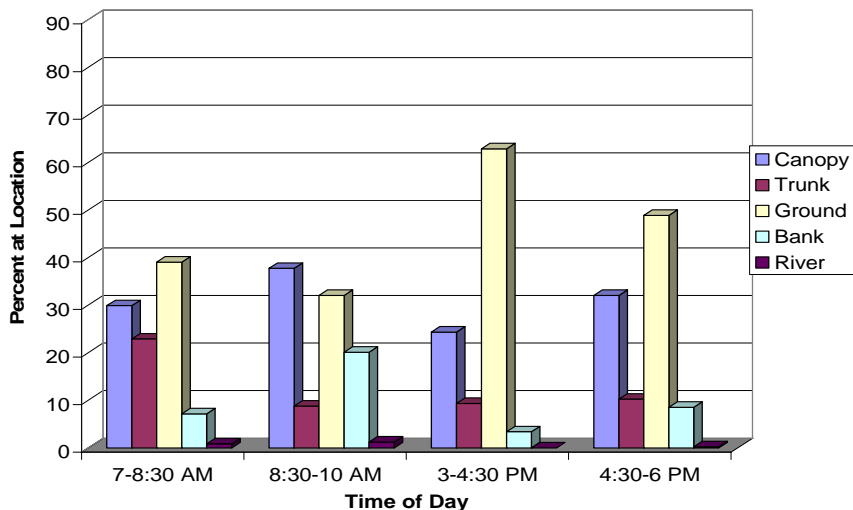


Fig. 4—The percent of time primates spent in the five vertical locations in four equal time periods [n=1461 for vervets, n=480 for sykes, n=1338 for baboons]. Data collected by Sondra Lavigne at Ndarakwai Ranch in northern Tanzania in April 2009 between 7-10AM and 3-6PM.

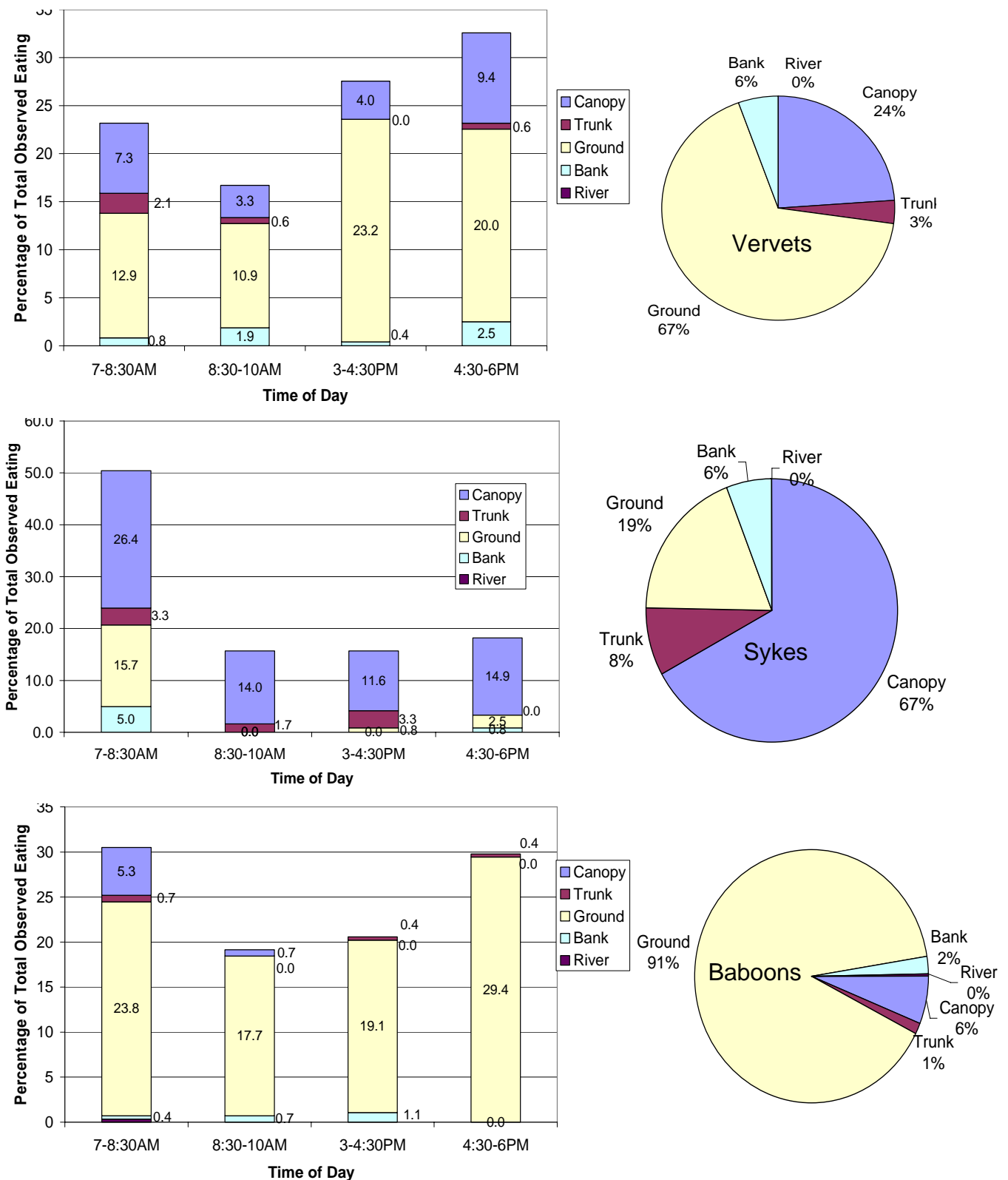


Fig. 5—The eating habits of the vervets, sykes, and baboons respectively. The bar graphs on the left depict the percentage of eating events occurring in different time periods at different vertical levels. The pie graphs on the right depict the overall percent of time eating at different locations [n=479 for vervets, n=121 for sykes, n=282 for baboons]. Data collected by Sondra Lavigne at Ndarakwai Ranch in northern Tanzania in April 2009 between 7-10AM and 3-6PM.

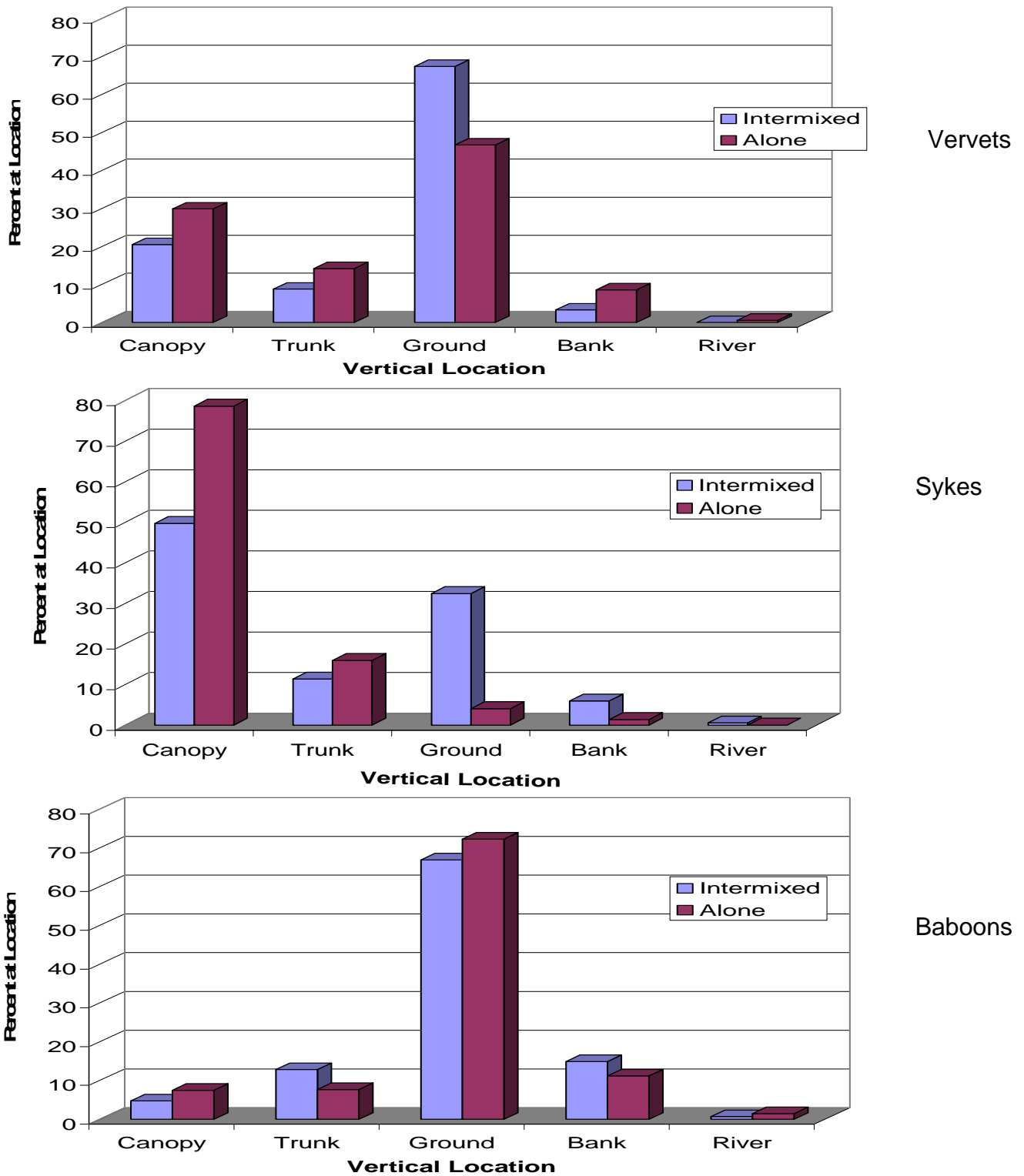


Fig 6—The location of each primate when observed as intermixed (multiple primate species) or separate groups [Vervets intermixed n=273, Vervets alone n=1188, Sykes Intermixed n=185 Sykes alone n=295, Baboons intermixed n=148, Baboons alone n=1190]. Data collected by Sondra Lavigne at Ndarakwai Ranch in northern Tanzania in April 2009 between 7-10AM and 3-6PM.

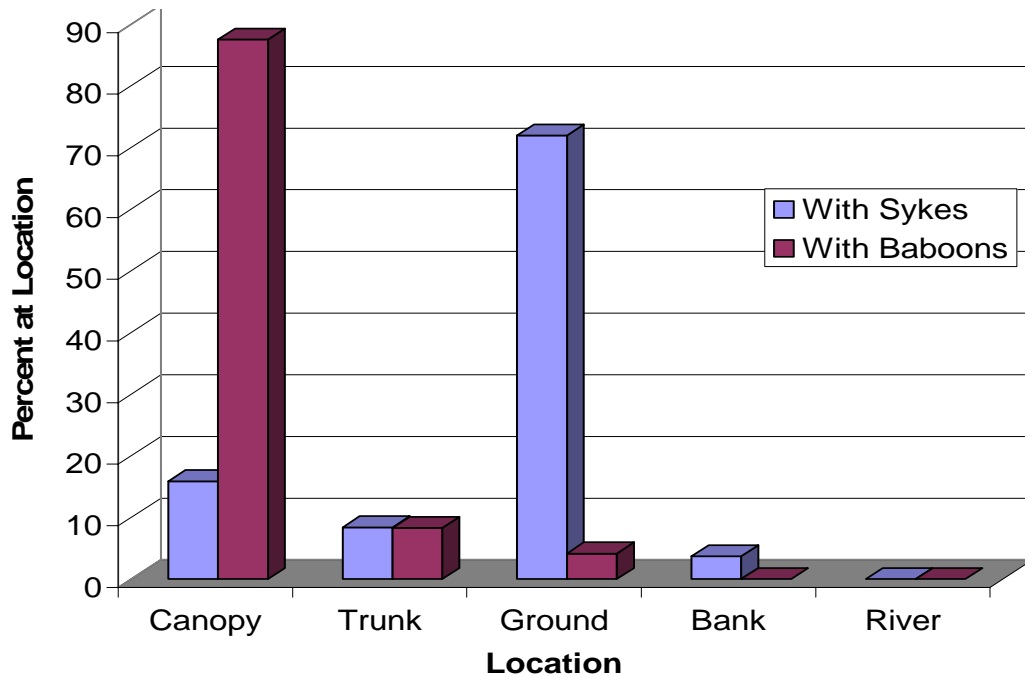


Fig. 7—Vervet distribution among five vertical levels while intermixed with sykes monkeys or baboons [With baboons n=24, With sykes n=214]. Data collected by Sondra Lavigne at Ndarakwai Ranch in northern Tanzania in April 2009 between 7-10AM and 3-6PM.

Data points of species, time, vertical location, and behavior were separated into behavioral time budgets (Fig. 2), overall location profiles (Fig. 3), location by time of day (Fig. 4), eating habits (Fig. 5) intermixed versus non-intermixed locations (Fig. 6) and vervet location based on type of mixed group (Fig. 7), to test hypotheses. Although behavior time budgets do not directly address the hypotheses they provide a basis for the discussion. Additional charts concerning pairing of behaviors with vertical location are found in Appendix D, but were excluded from results and discussion because they did not reflect on hypotheses. Personal observations linking differences in vertical level usage to anti-predator behavior are expanded upon in the discussion, but are not represented graphically here.

Discussion

Vertical Location—Overall

The results from this study provide evidence for my hypothesis: that baboons, vervet monkeys, and sykes monkeys, utilize different vertical levels in order to partition the resources along the Simba River at Ndarakwai Ranch. In my results for physical location, vervets were the most generalist, located on the ground 51% (745/1461), and in the canopy 28% (409/1461) of the time (Fig. 3). In accordance to Estes' (author of The Safari Companion) characterization of sykes as "highly arboreal" (1999), they were observed in the canopy 68% (326/480) of the time and on the ground only 15% (72/480, Fig. 3). Although baboons were characterized by Estes as foraging equally well on the ground and in the trees (1999), this study found that during the study period, baboons utilizing the river habitat spent 72% (963/1338), the vast majority of their time, located on the ground and 12% (161/1338) on the bank (Fig. 3). In terms of foraging specifically, their preference for the ground was even greater (Fig. 5, also discussed below).

My observations for all the primates, though they show distinct differences, probably underestimate the number in the canopy, as they were much harder to see there than any other vertical level. Sykes' fur in particular blended in with the canopy well and they were extremely shy compared to the other primates, making canopy observations even more difficult, most likely skewing their results to lower vertical levels (personal observation). As the trunk, bank, and river levels contained a smaller amount of space and fewer food resources (compared to fruits and leaves of the canopy and the grass and insects on the ground), they were used less by the smaller primates, although the banks were still utilized by the baboons, primarily for non-food activities including moving and resting (see Appendix D). Primates were generally only located in the river when crossing banks (moving), resting on rocks or logs, or drinking (see Appendix D).

Vertical Location by Time of Day

There were only slight differences between the locations for each primate based on the time of day. Due to afternoon rains, inconsistent guard arrival times, and the presence of many elephants, my start and end times were inconsistent for each session and so all times

were standardized by calculating the percent (not frequency) of locations for each time period.

Vervets were observed in a mix of different levels at each time period (Fig. 4). Entire troops tended to remain mostly on the ground or mostly in the canopy, trunk, or bank (closer to the center of the river), though occasionally a large troop would be spread out between all levels (personal observation). In the 4:30-6PM observation period, there was a spike in time spent on the ground which also corresponded to a spike in the proportion eating on the ground (Fig. 4; Fig. 5).

Sykes spent most of their time in the canopy across all observation periods, but spent a larger proportion at lower vertical levels early in the morning. Typically only a few individuals were observed on the ground at a time, with the majority remaining in the trees, often being vigilant (personal observation). These early morning times at lower vertical levels correspond to a spike in eating on the ground in this observation period (Fig. 5), as well as observations of intermixed groups with sykes (which corresponds to an increase in ground located sykes) in this observation period (Fig. 6). This overlap in increased ground eating and a higher level of intermixed groups with sykes in the early morning made determining why the sykes monkeys remained on the ground in the morning difficult. They possibly moved to the ground to eat more often in the morning, or possibly I observed them located and eating on the ground more often in the morning because they were often seen at this time located with other primates.

Baboons were the most consistent in their location across the time periods. Aside from a small spike in canopy time in the 7-8:30AM observation period, they consistently spent between 65% and 75% of their time on the ground (Fig. 4, n=1338). This small spike in morning canopy observations probably corresponds with the troop waking. Baboons on the ranch often went up into a few large trees to sleep at night, and although they were always awake when I observed them, some of the early morning observations probably occurred soon after the troop woke (personal observation).

Partitioning of Food Resources

Results for the times and locations that each of the three primates were observed eating highlighted the ways that they partition their food resources despite eating many of the same foods. Each primate's eating habits corresponded closely to the amount of time they spend in each vertical level. Since the majority of the food for all three primates was taken

from the canopy and the ground, these are the major foci of this discussion. Vervets, generalists in terms of vertical location compared to the other primates, eat 67% (321/479) of the time on the ground and 24% (115/479) in the canopy, numbers that correlate the 51% (745/1461) and 28% (409/1461) that they spend overall in these levels respectively (Fig 5; Fig. 3). Sykes prefer to both eat (67%; 81/121) and overall remain (68%; 326/480) in the canopy, only eating on and overall remaining on the ground 19% (23/121) and 15% (72/480) respectively (Fig 5; Fig. 3). For baboons, the difference between their overall location percentages and the location of eating were the largest. While they spent 72% (963/1338) of their overall time on the ground and 7% (96/1338) in the canopy, they ate on the ground 91% (254/282) of the time, only eating 6% (17/282) of their food in the canopy (Fig 3; Fig. 5). The grass shoots and other food (fallen figs, insects, tubers, etc.) that they obtained from the ground was probably preferred and possibly more nutritious than the leaves and fig fruits that they could obtain from the canopy. When baboons were present in the canopy, they were often playing, moving, or sometimes being chased by other baboons (personal observation).

The primates also partitioned their food resources based on eating by the time of day and the location of the food taken at each time of day. Vervets were observed eating food in the canopy twice as much in the 7-8:30AM and 4:30-6PM time periods than in the middle observation periods (Fig. 5). The 8:30-10AM time period was the period in which vervets ate the least (Fig. 5). It was probably one of the hotter portions of my observation period, and might have influenced their eating frequencies. Overall, however, throughout the day they mostly ate on the ground with a few eating in the canopy.

Sykes monkeys had a stronger pattern based on the time of day. Over 50% of the observed eating took place in the 7-8:30AM time period (Fig 5, n=121). During this time period, the vast majority of ground eating, 18 data points out of 23, took place (Fig. 5). Eating on the bank and canopy were also higher in this than any other time period. As stated before, this could be caused by their tendency to be more intermixed with other species in the morning, according to the data collected over the study period. The early morning might also facilitate eating more often and eating at lower vertical levels because of the lower temperature, or because humans that might disturb them were not as active during these periods. Sykes were often found within the lodge where rocks were thrown at them or where they were chased for stealing food from kitchens or making their way into tents (personal observation). This might have made them more vigilant at all times of day but may have also led them to eat, especially on the ground where they are vulnerable, when humans were the least active. In each time period though, eating follows the overall trend with sykes: the

percentage eating in the canopy was much higher than the percentage eating in any other location.

Baboons had spikes of eating in the 7-8:30AM and 4:30-6PM time periods, the cooler parts of the day (Fig. 5). In the 7-8:30AM time period, most of the canopy eating occurred (Fig. 5). In the other three time periods, very little, if any eating above the ground level occurred. This possibly occurred because in the early morning, baboons would come down from their sleeping trees. This canopy eating may have been opportunistic eating before the troop began to move for the day. During the observation period, baboons often moved along the river eating grass shoots and other food items they found on the ground on either side of the river, generally ignoring the ripe fig fruits the other primates were eating (personal observation).

Intermixing Between Species

I also hypothesized that close interactions between multiple species would amplify the differences in vertical levels that the primates generally exhibit. The data between the intermixed species versus non-intermixed groups yielded results that supported my predictions for some species and refuted it for others.

For baboons, my prediction was not supported; however, it was also not reversed. Baboons appeared to stay at almost the same vertical level regardless of the presence of other primates. Given that baboons are the largest and most aggressive (see Fig. 2) of all of the three primate species with large powerful canines, they have little reason to change their position in response to the other species. When they were observed with either of the other primates, there was an increase in the number of baboons located on trunks and a slight decrease in those found on the ground (Fig. 6). Many of the trunk data points were of juvenile baboons chasing vervet monkeys into the canopy on multiple occasions; however, this was probably a form of play for the baboons and not aggression, since no adults were observed performing this action. (personal observation).

The reaction of sykes monkeys to the other primates yielded results contrary to my prediction. When intermixed, sykes spent a larger proportion of their time at lower vertical levels than when alone (Fig. 6). This may relate to a low sample size for sykes as a whole, but might also be related to increased levels of vigilance when sykes were with other primates. Sykes spent a larger proportion of their time being vigilant (Fig. 2) than the other primates and were much quicker to hide or run when I approached (personal observation). While

sykes were still predominantly in the canopy during intermixed group observations, the shift to ground locations when intermixed could be linked to the increased safety of eating nutritious shoots and insects on the ground while another primate troop helped increase vigilance to the mixed group as a whole.

Vervets, the species that spends a sizeable proportion of its time in both the canopy and the ground, provided the most interesting results in terms of resource partitioning by vertical space in mixed species groups. While only small differences in location were observed between vervets in intermixed groups and those alone (Fig. 6), when data points were grouped into vervets and sykes and vervets and baboons, a clear distinction between vervet locations in the presence of each other species occurs (Fig. 7). The results supported my prediction that changes in vertical location would be exaggerated when two species come into contact with one another. As stated before, vervet monkeys split their time between the canopy and the ground more than the other primates. When intermixed with baboons, 87.5% (21/24) of vervets on average were observed in the canopy and only 4.2% (1/24) were observed on the ground (Fig. 7). When intermixed with sykes monkeys, only 15.9% (34/214) were observed in the canopy with a majority of 72.0% (154/214) on average located on the ground (Fig. 7).

Although this was a small sample size (n=238), it is evidence for the idea that vervets avoid conflict during direct interactions with other primates by moving to a different vertical level. Baboons and sykes monkeys, who, during this study period, tended to remain on the ground and in the canopy respectively, generally did not interact on the same vertical levels, and thus have little reason to move in response to each other. Vervets, which frequently used both the canopy and the ground overlapped with both. Being smaller and slightly less aggressive than the other two primates (Fig. 2) it makes sense that vervets were the ones to be displaced out of their vertical locations.

Other Trends Observed

The other main trend that I observed in respect to the different ways these three primate species use the resources of the river was their anti-predator responses. Each of the species reacted very differently to my presence when I came too close. Vervet monkeys that were on the ground generally moved up into the canopy when frightened of me and remained there until I left (personal observation). The open ground on either side of the river gave them a place to forage on the ground with the protection of the river trees close by. Sykes monkeys

used the canopy from the trees growing on the banks of the river as a highway to escape, moving along the river's length while hidden within the upper leaves, distancing themselves from me substantially (personal observation). Because the river was one of the few places where a long line of trees allowed them to do this, the riverine system probably provided them with extra protection. When they reached a section where they could not move from tree to tree, they generally jumped down into the river to run away less conspicuously than they would be on the ground (personal observation). Baboons generally moved up and down the river along its banks away from me. They also tended to move to the opposite side of the river and still remain on the ground (personal observation). By keeping the river between themselves and me (a potential "predator" or aggressor) they were likely attempting to increase their safety levels.

Each of these three ant-predator strategies highlighted the primates' different uses for the river habitat. Vervets made use of the open ground and the large trees, sykes took advantage mostly of the connected canopies, and baboons used the ground and the banks.

Limitations

- Sykes monkeys were hard to see and might have sometimes been missed because of their preference for staying in the canopy and their shy nature. Baboons were often sighted, but sometimes moved out of the study site before data could be collected.
- It was harder to observe primates in the canopy than those on the ground. Because of this, my data is probably somewhat skewed towards the lower vertical levels.
- Less individual data points were collected on sykes than vervets or baboons because they tended to remain in smaller troops and hid more effectively. While I collected a similar amount of individual data points on baboons as vervets, they were derived from a few sightings of many baboons. More groups of vervets or sykes occurred.
- Kristin Meseck was studying a troop of baboons that frequently used the river during this period. Sometimes we interfered with each other's studies by inadvertently scaring the baboons into another area while trying to observe them.
- Due to the numerous elephants we needed a guard at all times and a guard was not always available for me individually. The schedules (and late arrivals) of the Ndarakwai guards also limited my observation hours.
- Hundreds of elephants moved into Ndarakwai because the rain fell on the reserve instead of all around it. Normally in late April, the elephants disperse. I often could not go out or had to miss observing large sections of the river in order to avoid getting charged by elephants.
- Tourists not only limited the number of guards, but their presence kept me from visiting the river at certain hours of the day (when they would leave for walks).
- I contracted an eye infection, (most likely from the grass pollen and allergies) during my study. Overall, I missed five days of data collection.
- I initially wanted to track what types and parts of trees the primates were eating from as well as the levels. This was extremely difficult and abandoned due to visibility issues and a lack of a knowledgeable guard every day or tree book for identification.

Recommendations

- If a knowledgeable guard and tree identification book could be used to identify species, a study of the feeding ecology of either vervet monkeys or baboons would be useful. This type of study has already been conducted by Welikonich in the year 2005 on sykes monkeys on the river.
- Conducting a repeat study to determine the differences in feeding levels between the wet and the dry season would be useful. There appeared to be abundant food, particularly in the form of grasses for the baboons and vervets during my study. Food might be a more limiting factor in dryer seasons with less grass and less fruit forcing more visible resource competition.

Conclusion

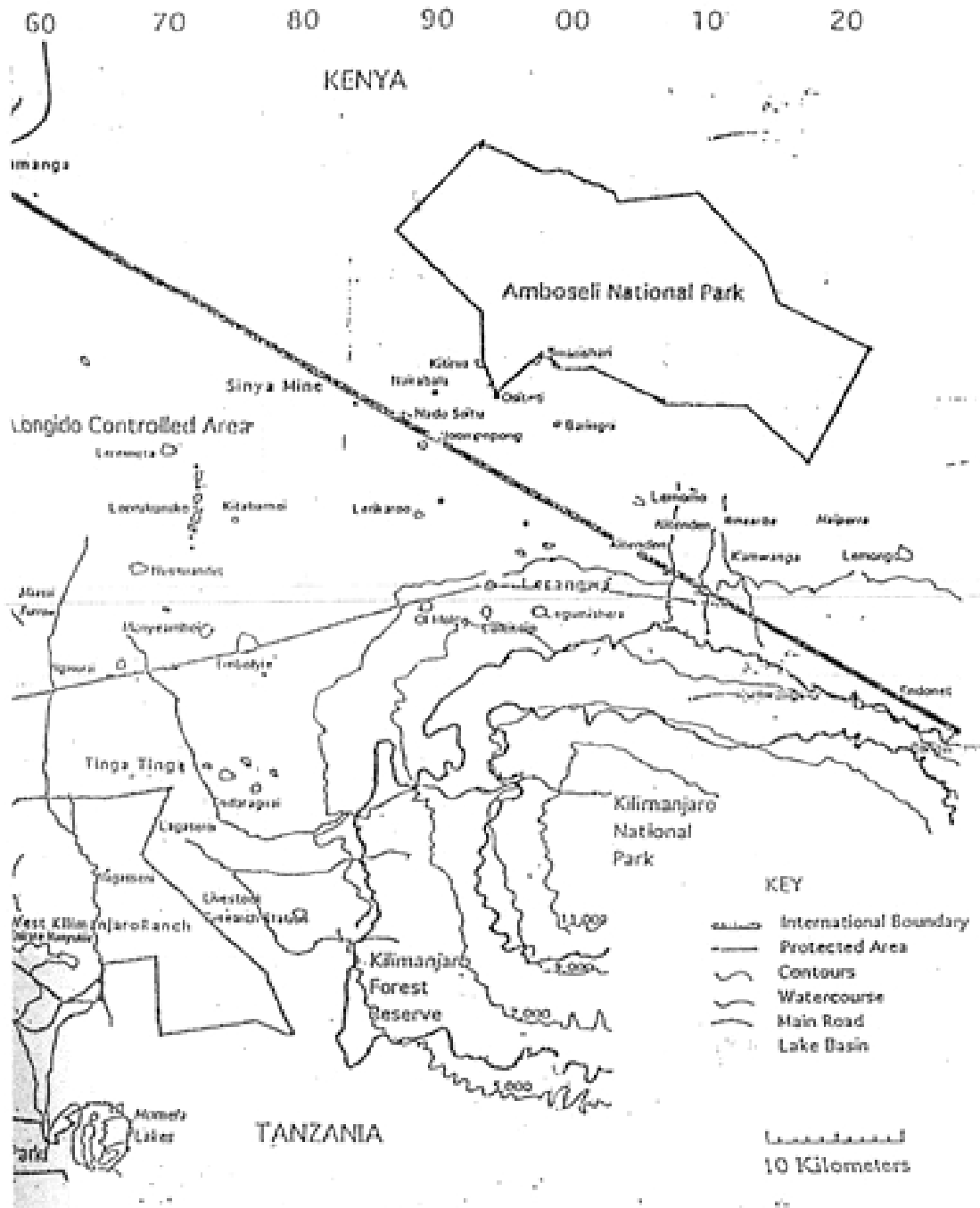
This study supported the hypothesis that vervets, baboons, and sykes along the Simba River at Ndarakwai Ranch in Tanzania utilize different vertical levels in order to partition resources. The trends exhibited in both the eating behavior of all three primates and the change in location of vervets in response to the other two primate species showed that the utilization of different vertical levels may be an important way in which these primates partition their food resources during the rainy season in April. While these primate species overlap in the types of foods they eat, where (vertically) they obtain most of their food differs greatly and could help partition the abundant resources in the river habitat during the study period. As each species use different levels of the habitat for their activities, managing the river system as a whole (particularly the grasses that the vervets and baboons eat and not just the charismatic fruit trees), is important for increasing the number of primates. The encroachment of cattle around the river and the cutting down of trees nearby also may affect the primates' use of different aspects of the habitat, particularly the ground if the grass is grazed or excessive runoff occurs.

. While Miller (2004) found few strong differences between the primates' activity budgets based on time of day or horizontal space, and other studies of their diets (Estes, 1999) returned with similar results for the types of food eaten, the vertical levels in which the primates used the river revealed large differences between species. Although this study is limited in terms of the scope of the study site and the time allotted for data collection, it points to the importance of little-investigated variables in determining strategies for resource partitioning and for studying primates as a whole. Investigating ecological phenomenon in a three-dimensional manner is important to accurately learn about the natural world.

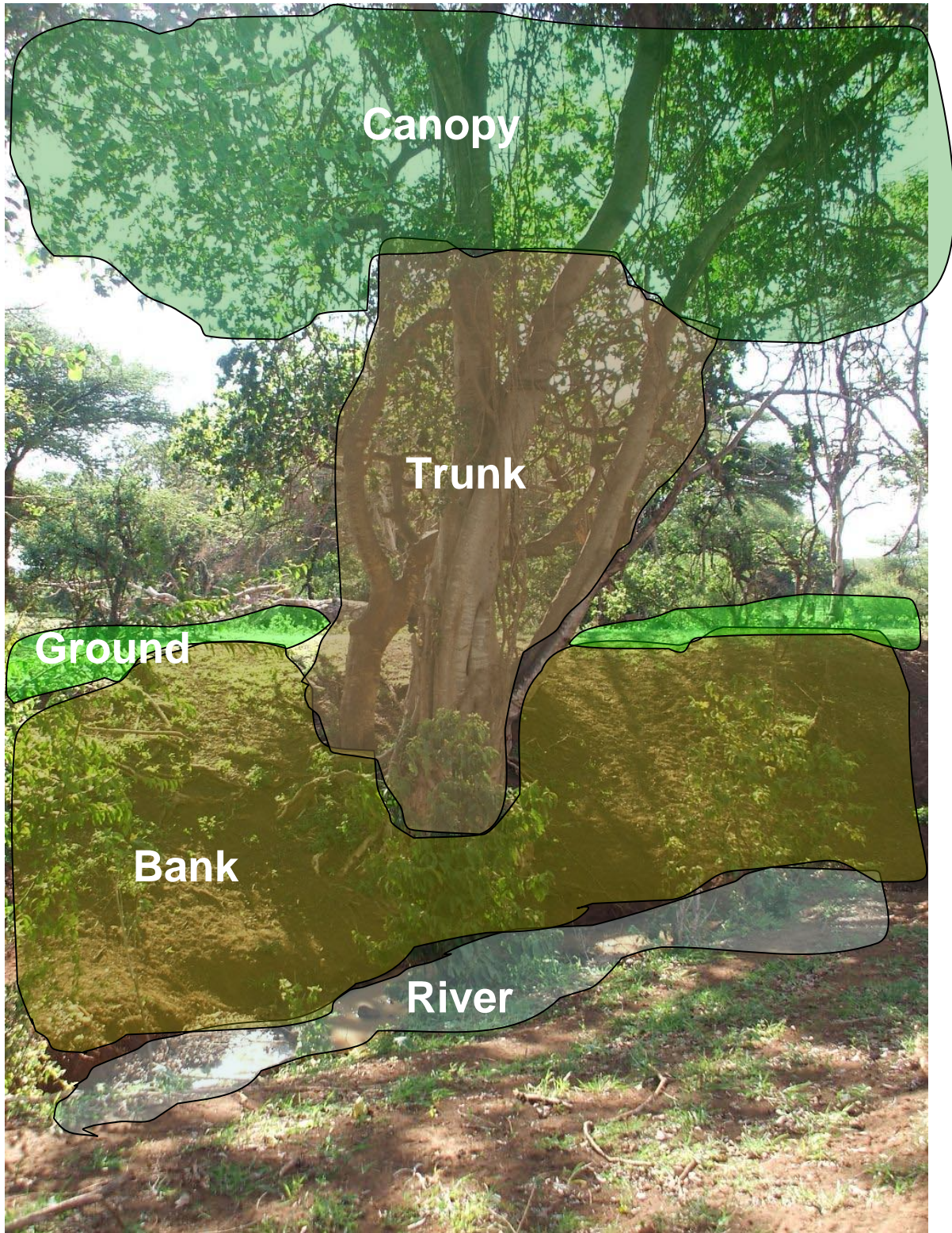
Works Cited

- Estes, Richard. 1992. The Behavior Guide to African Mammals. University of California Press, London, England. Pp. 449-56.
- Estes, Richard. 1999. The Safari Companion. Chelsea Green Publishing Company, White River Junction, VT. Pp. 396-408.
- Gichohi, H. 1996. "Savanna Ecosystems". East African Ecosystems and Their Conservation. Oxford University Press, England. Pp. 273-98.
- Meseck, Kristin. Personal Communication. April 2009.
- Miller, Brian. 2004. Riverine Habitat and Resource Partitioning of Three Sympatric Primate Species at Ndarakwai Reserve, Tanzania. School for International Training, Arusha, Tanzania.
- "Ndarakwai Ranch" 20 Mar. 2009. <http://www.ndarakwai.com>.
- Ole-Kuya, Thomas. Personal communication. 18 Mar. 2009.
- Pevos, Jennifer. 2004. What Species are they Anyways?: A study of baboons at Ndarakwai Game Reserve. School for International Training, Arusha, Tanzania.
- Saville, Lauren. 2005. Grooming and Aggression: What's the Connection? A study of a Troop of Vervet Monkeys at Ndarakwai Ranch. School for International Training, Arusha, Tanzania.
- Schroepfer, Kara. 2004. Time Budgets in a Troop of Olive Baboons (*Papio anubis*) at Ndarakwai Reserve, West Kilimanjaro, Tanzania. School for International Training, Arusha, Tanzania.
- Waser, Peter. "Interactions among Primate Species." Primate Societies. University of Chicago Press. Chicago, IL. Pp. 212-215.
- Welikonich, Ashley. 2005. Activity Budget of a Troop of Blue Monkeys (*Cercopithecus mitis*) at Ndarakwai Ranch with Respect to Vegetation Use. School for International Training, Arusha, Tanzania.

Appendix A—Maps of The West Kilimanjaro Basin



Appendix B—Visual Definitions of Vertical Locations



Appendix C—Sample Data Collection Sheet

Scan 1

Time: 9:07AM

Individual 1: Vervet, Eat, Canopy

Individual 2: ‘ ’, Rest, Ground

Individual 3: ‘ ’’, Feed, Ground

Individual 4: ‘ ’, Play, Trunk

Individual 5: ‘ ‘ ‘ ‘, Play, Trunk

Individual 6: Sykes, Vigilance, Canopy

Individual 7: ‘ ’, Eat, Canopy

Meta Data: Vervets and Sykes intermixed located 15m from me, all on south side of the river, sunny, mongoose at termite mound on other side of river within study site,

Scan 2 (etc.)

Note: I had one letter abbreviations for each activity and location. (E=Eat, C=Canopy, etc.)

Appendix D—Additional Data Collected on Primates

Total Behaviors and Locations

Vervet Total Behaviors and Locations

	Move	Eat	Rest	Vigilance	Groom	Play	Aggression	Other	Total
Canopy	151	115	44	36	5	45	13	2	411
Trunk	51	16	48	24	38	11	5	0	193
Ground	237	321	72	43	19	35	9	3	739
Bank	44	27	19	12	4	5	0	0	111
River	5	0	2	0	0	0	0	0	7
Total	488	479	185	115	66	96	27	5	1461

Sykes Total Behaviors and Locations

	Move	Eat	Rest	Vigilance	Groom	Play	Aggression	Other	Totals
Canopy	137	81	48	37	5	4	12	0	324
Trunk	31	10	12	5	4	4	2	0	68
Ground	28	23	14	5	2	0	0	0	72
Bank	4	7	3	1	0	0	0	0	15
River	1	0	0	0	0	0	0	0	1
Total	201	121	77	48	11	8	14	0	480

Baboons Total Behaviors and Locations

	Move	Eat	Rest	Vigilance	Groom	Play	Aggression	Other	Total
Canopy	54	17	6	11	0	4	4	0	96
Trunk	29	4	20	14	5	37	1	0	110
Ground	409	254	162	36	37	31	27	3	959
Bank	76	6	33	9	17	5	7	2	155
River	4	1	9	0	0	2	0	2	18
Total	572	282	230	70	59	79	39	7	1338

Note— Data collected by Sondra Lavigne at Ndarakwai Ranch in northern Tanzania in April 2009 from 7-10AM and 3-6PM..

