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## Activity Patterns of Black-and-White Colobus Monkey (*Colobus guereza caudatus*) in Rau Forest Reserve, Tanzania

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### Research Article

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#### ABSTRACT

This study on black-and-white colobus monkey (*Colobus guereza caudatus*) was conducted in Rau Forest Reserve, Moshi, Tanzania investigating overall activities and activity across age and sex groups. We used scan sampling to record overall activities. We used focal animal sampling to record activities across age and sex groups. Black-and-white colobus monkeys in Rau Forest Reserve spent much time resting (57.7%), followed by feeding (27.7%) and less time on moving (10.8%) and social activities contribute only (3.8%). Across age groups, adults spent 60.7% of their time resting while juveniles and infants spent only 50% and 46.1% respectively. Furthermore, adults spent 21% of their time feeding, followed by juveniles 27.9% and infants 16.9%. Movements were more similar across ages (10.5-13.1%). Time engaged in social activities varied strongly among ages (adults 7.8%, juveniles 10.8%, and infants 23.8%). Sexes differed slightly in their activities, most notably with females spending almost twice as much time in social activities as males (8.0% vs. 4.3%). This difference seems to be dictated by the availability of social partners. Resting time in colobus monkeys is a strategy for energy conservation, although socialization is also particularly important for infants. The study provides baseline information for the conservation of black-and-white colobus monkey in Rau Forest Reserve since little is known and the species is locally threatened.

### INTRODUCTION

Primates' activities can be determined by habitat types in which they are living<sup>[1-4]</sup>. This is influenced by the availability of food, water, cover, and other environmental factors<sup>[1,3,5]</sup>. Because primates live in a variety of habitats, their activity depends on group size, site, time and individual variation<sup>[4,6,7]</sup>. Some groups (age groups) tend to spend much time feeding while other groups spend more time grooming, playing and moving<sup>[6]</sup>. Mountain forest colobus monkeys spend up to twice as much time feeding and six times moving, but less time resting, compared to colobus monkey in coastal areas<sup>[2,4]</sup>. Feeding activities tend to increase from morning to evening, major movements tend to occur in the late afternoon and resting tends to remain constant throughout the day<sup>[7]</sup>. Sexes differ in activity. For example females spend much time grooming and moving while aggression is much more common in males than females<sup>[2,6,7]</sup>. Infants tend to use more time playing and less time grooming than adults<sup>[6]</sup>. Adult colobus monkeys defend the territory<sup>[6]</sup>.

Variation in activities is related to the strategies employed by primates to budget their energy<sup>[4,8-12]</sup>. Similarly to activity of black-and-white colobus monkeys, energy conservation strategies differ from one group to another, even at a single site<sup>[7,13,14]</sup>. Also energy management can vary from one season to another and even between sexes<sup>[2,7,10]</sup>. The diversity in activities of black-and-white colobus monkey might be due to energy conservation<sup>[4,10]</sup>. For example, black-and-white colobus monkey tend to move short distance and spend much of their time resting and feeding on available abundant food materials<sup>[4,6,15]</sup>. Results obtained

from various studies show that activities like grooming, vigilance, greeting, and playing take less time of black-and-white colobus monkey as compared to resting and feeding<sup>[2,4,6]</sup>. Activities can also be influenced by the number of individuals present in the group of primates<sup>[8,13]</sup>. Individual vigilance declines with group size<sup>[13]</sup>. Other scholars argue about the behavioral thermoregulation in colobus monkey, that they spend much of their time resting hence remain inactive for much time of the day. However, this needs much study to have it revealed<sup>[6]</sup>.

Habitat loss is the primary threat facing species worldwide<sup>[16-22]</sup>. This loss of habitats is a result of habitat destruction mainly influenced by human activities and other inevitable factors such as climate change<sup>[23]</sup>. One of the habitats which has been degraded by humans is tropical forests, with a loss of 1.1% annually<sup>[24]</sup>, or 9.4 million hectares per year<sup>[25]</sup>, accompanied by fragmentation of remaining forest<sup>[25,26]</sup>. The rate results to fragmented habitat hence confined the habitat connectivity<sup>[27-30]</sup>. Despite all evidence of habitat loss, the black and white colobus is the least concerned (LC) by IUCN<sup>[8,29]</sup>. Numerous species of primates inhabit lower quality forest habitats but are capable of surviving; therefore research will expand the understanding on their behavioral ecology<sup>[25]</sup>. The studies in primate behavior including black-and-white colobus monkeys in different forest fragments can help to give information related to time spent in looking for food and habitat quality<sup>[25,31,32]</sup>. In high quality habitat, individuals should spend less time travelling and foraging compared to lower quality habitat whereby its affects the normal activity pattern<sup>[25,33-45]</sup>, therefore in this case we decided to analyses the activity pattern of Rau Forest Reserve.

## MATERIALS AND METHODS

### Study area

Rau Forest Reserve (3° 23' S and 37° 22' E) is 3 km SE of Moshi in the Kilimanjaro region of Tanzania. It covers an area of 25 km<sup>2</sup><sup>[46-50]</sup> from 730 to 765 m elevation<sup>[46,48,49]</sup>. Annual rainfall is approximately 870 mm with temperatures of 26 °C in February and 21 °C in July<sup>[47,49]</sup>. Rau Forest Reserve is mainly dominated by ground water forest but Rodgers<sup>[47]</sup> classified the reserve vegetation into natural ground forest, swamp forest and woodland forest. The reserve has diverse bird life and several large mammal species including black-and-white colobus monkey, blue monkey and Kirk's dik-dik<sup>[50]</sup>. The soils of the Rau Forest Reserve are volcanic in origin with alluvial sand and loam rich in gleysols and fluvisols<sup>[47,49]</sup>.

### Data collection

This study involved both focal sampling and scan sampling; however a reconnaissance survey was conducted in the study area before the implementation of those methods. During the reconnaissance survey, we selected a groups that was already habituated by human activities, influenced by the road passing through the reserve and tourism activities. Abraham Eustace and one research assistant were involved in data collection. We collected activity data for 14 days from morning (7:00-8:00h) to evening (15:00-17:00h) in June, 2014<sup>[7,25]</sup>. Focal observation and recording were done for 5 minutes at 15 minute intervals throughout the day<sup>[6,7]</sup>. After spotting a monkey, we waited five seconds before starting recording to avoid over-representing eye-catching activities like moving<sup>[7]</sup>. The focal adult individual was selected opportunistically<sup>[51]</sup>. If the focal adult individual was lost before the end of the day, another adult individual was selected and observation and recording were conducted as long as possible<sup>[51]</sup>. Upon sighting of individual, the first activity held for 5 seconds was recorded<sup>[52]</sup>. If the individual was involved in more than one activity for example during social interaction, recording was done into sequence of those behaviors occurred during 5 seconds<sup>[53]</sup>. Group activity was recorded every 15 minutes by scan sampling to determine activity which was done by at least 50% of the group members<sup>[54]</sup>.

Five activity categories were recorded as modified from Mekonnen<sup>[52]</sup>, feeding, moving, resting, and social. Feeding involved ingestion and masticating of plant or prey, put into remarks parts and species name. Moving referred to the activity which leads to the changing of spatial location either by walking, running or jumping. Resting includes all activities which the individual was physically inactive either sleeping or sitting. Social includes grooming, playing, mating, aggression and greeting. Others include any activity which did not fit into the above categories, such as drinking, defecating and urinating.

For differentiating age categories, we classified adults to include all monkeys that have attained reproductive maturity and full body size<sup>[6]</sup>. Juveniles included individuals smaller than adults but not carried by their mothers, while infants were carried by their mothers at least occasionally<sup>[6]</sup>. To differentiate sex wasn't difficult since the group of black-and-white colobus monkey is dominated by a single male. Despite to the differences in body morphology and genital materials, only males of black-and-white colobus monkey possess a large continuous line of white hairs across the perineum<sup>[6]</sup>.

### Data analysis

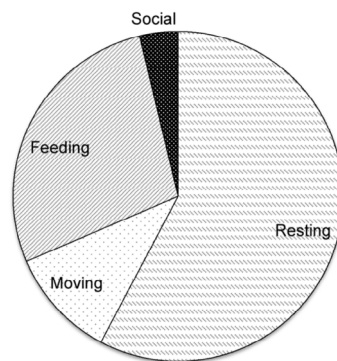
To represent the overall activities of the colobus monkey the ratios of the number of records were transformed into percentages<sup>[2,4,7]</sup>. We used SPSS 21 and MedCalc version 12.5.0.0. Chi-square tests and Single factor ANOVA (=0.05) were used to test the overall daily activity and in time spent per each of the activities observed across age groups. Furthermore, student t-test was used for comparison of time spent on the activities across the sex groups<sup>[4]</sup>. Kolmogorov-Smirnov test was used to test for normality<sup>[55]</sup>. Spearman's rank correlation coefficient ( $r_s$ ) was used to test the relationship between activities conducted at different periods of the day<sup>[10]</sup>.

## RESULTS

A total of 3,338 activity observations were collected from both focal animal sampling and scan sampling from one group with mean of  $9.86 \pm 1.77$  with 8 to 12 individuals. We conducted a mean of  $25.36 \pm 0.75$  scans per day with a total of 360 scans. Other activities like defecation and urination did occur outside of sampling time; they were recorded but not involved in the analysis. Therefore our results do not have the behavior category named “others”. Monkeys foraged most heavily on *Ficus sycomorus* (flowers), *Ficus exasperata* (leaves and fruits), *Delonix regia* (leaves) and lianas (leaves) as it were observed when recording feeding activities.

### Overall activity

Black-and-white colobus monkeys spent much of their time resting (57.7%) and feeding (27.7%) while less time was spent on moving (10.8%) and social activities (3.8%) but the difference between these activities was not vary,  $\chi^2 = 4.35$ ,  $P = 0.98$  (**Figure 1**). The social activities observed were grooming and aggression, which were done by adults, and playing by infants. Socially, grooming was mostly recorded within the group while aggression was both intra- and inter-group (**Figure 1**). Social activities were less observed compared to other behaviors i.e. Resting and feeding (**Table 1**).

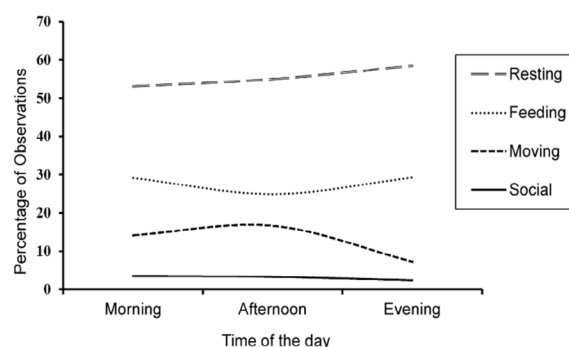


**Figure 1.** Overall activity for black-and-white colobus monkey (*Colobus guereza caudatus*) in Rau Forest Reserve (n = 360).

**Table 1.** Comparison of activity (% of time) of black-and-white colobus monkeys (*Colobus guereza*) groups with other studies in Africa. Compared results modified from Teichroeb [7].

| Study Area             | Source      | Group Size | Resting | Feeding | Moving | Social | Other |
|------------------------|-------------|------------|---------|---------|--------|--------|-------|
| Kibale Forest, Uganda  | Oates [15]  | 9          | 57      | 20      | 5      | 11     | 7     |
| Ituri Forest, DRC      | Bocian [56] | 8-10       | 44      | 26      | 24     | 5      | 1     |
| Kakamega Forest, Kenya | Fashing [6] | 10-13      | 63      | 28      | 2      | 7      | -     |
|                        |             | 5-8        | 64      | 23      | 3      | 10     | -     |
| Rau Forest, Tanzania   | This study  | 8-12       | 58      | 28      | 10     | 4      | -     |

Daily activity varied from morning to evening although the variation was not statistically significant ( $F_{(2,9)} = 1.18$ ,  $P = 0.35$ ). Resting was high at all times of day while feeding tended to be high in morning and evening and slightly lower during the afternoon. Movements of the group were higher in the morning and afternoon, becoming lower in the evening. There was a significant negative relationship between feeding and moving from morning to evening daily (Spearman's rho:  $r_s = -0.88$ ,  $P = 0.02$ ) while social activities were fairly constant and less observed throughout the day (**Figure 2**).

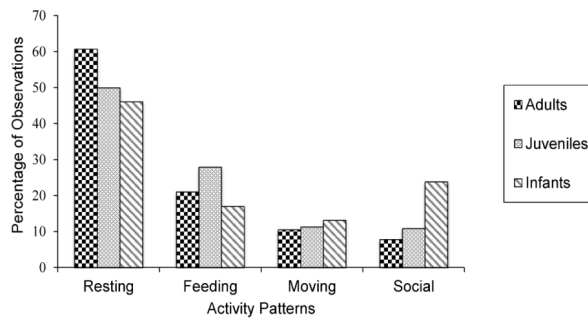


**Figure 2.** Temporal activity of *Colobus guereza caudatus* in Rau Forest Reserve throughout the day.

### Activity across age groups

Adults spent about 60% of their time resting while juveniles and infants spent only 50% and 46% respectively (**Figure 3**) ( $F_{(2,18)} = 2.04$ ,  $P = 0.16$ ). Feeding varied with adults spending 21%, juveniles 27.9% and infants 16.9% of their time taking food ( $F_{(2,18)} = 5.09$ ,  $P < 0.05$ ). Moving didn't vary across age groups with adults spending 10.5%, juveniles 11.3% and infants 13.1%

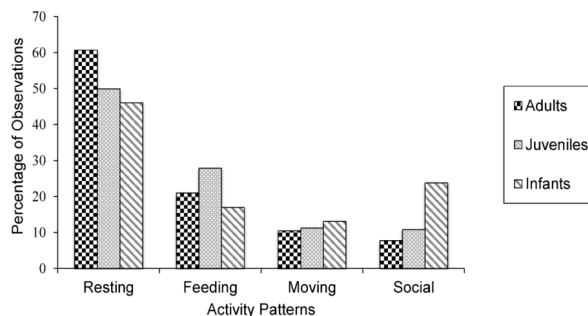
of their time in this activity ( $F(2,18) = 0.57, P = 0.57$ ). There was a difference in time spent in social activities across age groups with adults spending 7.8%, juveniles 10.8% and infants 23.8% of their time ( $F(2,18) = 7.80, P < 0.01$ ).



**Figure 3.** Comparison of time spent on different activities (resting, feeding, moving and social) across age groups (adults, juveniles and infants) for *Colobus guereza caudatus* in Rau Forest Reserve.

### Activity across sex groups

There was no difference between sexes in resting in males and females t-test: ( $t_{(1,11)} = 0.24, P = 0.81$ ) (Figure 4), feeding (males 19.2% and females 21.1%, ( $t_{(1,11)} = -1.05, P = 0.31$ ) and moving (males 14.4% and females 18.1%;  $t_{(1,11)} = 1.81, P = 0.09$ ). The only significant difference was observed in social activities (males spent 4.3% and females 8.0%,  $t_{(1,11)} = -6.06, P < 0.01$ ). Social activities mostly recorded in males involved aggression and vocalization while females' was grooming.



**Figure 3.** Comparison of time spent on different activities (resting, feeding, moving and social) across age groups (adults, juveniles and infants) for *Colobus guereza caudatus* in Rau Forest Reserve.

## DISCUSSION

### Overall activity

Similar to other studies on activity of black-and-white colobus, *Colobus guereza* in Rau Forest spent much time resting and feeding (Table 1). Compared to other studies in Uganda and Kenya, monkeys at Rau spent a similar amount of time resting and feeding, although they moved more. Monkeys at Ituri Forest, DRC, rested less and moved more than even Rau monkeys [6,11,15,52-56]. As argued by other authors, high resting might be due to behavioral thermoregulation with colobus resting under shaded tree canopies during afternoon and in sunny canopies in the morning and evening [6,10,11,15]. Also much time in resting might be needed to assist food digestion as colobus monkeys feed on cellulose-rich food materials requiring long gut passage times [10,51,57-60].

Monkeys in Rau Forest spent more time resting and feeding than moving or engaged in social activities (Figure 1). This variation in activity can also be due to energy conservation strategies [4,8-12]. As a result of energy conservation, colobus monkeys tend to move short distances and spend much time resting while feeding on the abundant food available [4,6,15]. Difference in activity with other studies (Table 1) might be due to variations in habitats, from coastal forests to montane forests [2,7,61]. Data collection techniques also lead to differences in activity from one study to another. Some researchers recorded the first behavior which lasts over 5 seconds while others recorded the behavior held by 5 seconds after spotting the focal animal and others record behavior instantaneously [2,6,7,62]. These differences in data collection methods may impact findings [7,13,58].

Activities of monkeys in Rau Forest varied but not significantly over the course of the day (Figure 2). Resting tend to be at high in all times of the day but peak in the evening. Feeding tended to be higher in the morning and evening, suggesting that colobus monkeys feed more at cooler times of day. Movements were negatively correlated with feeding, peaking in the afternoon and less in the morning and evening, suggesting that black-and-white colobus monkey move less when they are feeding. The results for daily patterns of resting and feeding activities are consistent with other published studies of colobus monkeys daily activity [7,15,56].

### Activity Across age groups

Activity by age groups did not vary significantly (Figure 3). Adults spent more of their time resting than juveniles and infants. While resting, males were often vigilant, while females were associating with infants [6,62]. Also, as animal become older they

become less active and rest more <sup>[62]</sup>. Juveniles were observed spending more time feeding than adults and infants as similarly observed by Fashing <sup>[6]</sup> in one group of colobus monkey at Kakamega Forest. Movements across the age groups tend to be more or less similar probably because colobus monkeys move as a group <sup>[29,63-65]</sup>. Infants spend much of the time in social activities, probably due to their involvement in a wide range of activities including playing, which is common at other ages <sup>[6]</sup>. Infants spent time in playing while adults are resting <sup>[62]</sup>. The results of feeding and moving across age groups do conform to the results published by Fashing <sup>[6]</sup> in two groups of black-and-white colobus monkeys in Kakamega Forest, Grimes <sup>[62]</sup> in Entebe Botanical Gardens, and O'Dwyer <sup>[44]</sup> in Diani Forest.

### Activity across sex groups

Sexes differed in activity at Rau Forest: males spent more time as also noted by Fashing <sup>[2]</sup>; Wijten <sup>[4]</sup>; Fashing <sup>[6]</sup>; Teichroeb <sup>[7]</sup>; O'Dwyer <sup>[44]</sup>. Resting in males was accompanied with other activities such as vigilance, which is less practiced by females <sup>[6,62]</sup>. As described by Fashing <sup>[51]</sup>, body size has a positive relationship with resting time in African colobines, as males are larger than females and rest more. Feeding, moving and social activities were more observed in females than in males (**Figure 4**) similar with other studies <sup>[2,4,6,44,62]</sup>. Females feed more so as to cover their increased nutritional requirements resulted from suckling infants <sup>[7]</sup>. As much they need more food hence they more search for it <sup>[3]</sup>. Social activities in females are influenced by the availability of social partners as most groups of colobus monkeys are dominated by single male <sup>[7,29,40,41,66-68]</sup>. In this study four incidences of aggression were observed (only one during sampling time). Three incidences involved focal male chasing males from another group, in another the male was chasing a blue monkey, and another involved a male chasing an owl. One incidence of aggression, observed during sampling time, involved the group being chased by a male from another group after the focal group entered another group's home range. Incidences of aggression in *C. guereza* are rarely seen and if they occur, mostly involve males <sup>[6,43,62,69]</sup>. This is an indication that competition in colobus monkeys is mostly over access to females and not for food <sup>[6]</sup>.

### Feeding habits and competition on colobus monkeys in rau forest reserve

Although determining the feeding habits and competition wasn't a major focus of this study, it was observed that colobus monkeys in Rau forest feed on leaves, flowers and fruits. This was recognized when recording feeding activities. Generally, black-and-white colobus monkeys in this area mainly feed on leaves and fruits, as is typical for colobus <sup>[29,43,44,62,70]</sup>. The trees used in Rau Forest Reserve included *Ficus sycomorus* (flowers/fruits), *Ficus exasperata* (leaves and fruits), *Delonix regia* (leaves) and lianas (leaves). From 72 tree species identified by O'Dwyer <sup>[44]</sup>, *Ficus sycomorus*, *Ficus exasperata* and *Delonix regia* are among the tree species utilized by six troops of black-and-white colobus monkeys as food materials. Fashing <sup>[43]</sup> mentioned about colobus monkeys spending more time feeding on *Ficus exasperata* from 32 tree species in Kakamega Forest, Kenya. Among 42 trees species present in Diani Forest, *Delonix regia* is more highly consumed by black-and-white colobus monkeys than other trees <sup>[29]</sup>. Lianas are a common food component for monkeys including the black-and-white colobus monkeys <sup>[71,72]</sup>.

## CONCLUSIONS AND RECOMMENDATIONS

Overall activity of black-and-white colobus monkey do vary, as they spend much time (more than 50% of their time) in resting and feeding while spending less time in social activities like grooming. These variations do occur also between age and sex groups. Adults rest more than juveniles and infants while juveniles feed more than adults and infants. However, infants spend much of the time in social activities especially playing. Regarding activity across sex groups, males rest more than adult females and females socialize (grooming) more than males. The variations in overall activity are due to energy conservation strategies and more time for digesting cellulose food materials hence more resting time. Body size tends to be factor for much resting time across age and sex groups. Availability of social partners was the factor for females to socialize much than males while the involvement of infants into a wide range of social activities was the factor for infants to be involved much in social activities than adults and juveniles. This study on behavioral ecology of black-and-white colobus monkey in Rau Forest Reserve provides baseline information for the conservation of the species since little has been documented in the area. The results will be used for planning conservation strategies as black-and-white colobus monkeys are locally threatened.

Our results from Rau forest are based on a single group studied for a short period. It would be useful to study additional groups, and to compare activity across seasons. These studies will help to determine whether the population in isolated Rau forest can be sustained.

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