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SURVEY OF THE ANGOLAN BLACK-AND-WHITE COLOBUS MONKEY *COLOBUS ANGOLENSIS PALLIATUS* IN THE DIANI FORESTS, KENYA

Abstract: *A subspecies of Angolan black-and-white colobus monkey* Colobus angolensis palliatus *inhabits the coastal forests of southern Kenya and the Eastern Arc Forests of Tanzania. A survey was conducted in the Diani forests, Kenya, to determine the distribution and population size of* C. a. palliatus, *and the effects of deforestation on the population. A total of 165* C. a. palliatus *was counted. Average group size was 6.5 animals. Age and sex ratios were: adult males : adult females = 1:2.2; adult females : young = 1:1.2; adult males : young = 1:2.5. Density was about 14 animals/ km² and biomass was 94 kg/km². Sixty-two percent of*

the groups inhabited forest patches in hotel or residential compounds. Effective population size (N_e) was calculated to be 68.3 individuals, with an inbreeding coefficient (F) of 0.79%. The implication of these results is that the future of C. a. palliatus *in Diani is uncertain. With decreasing habitat, continued fragmentation and isolation of forest patches, limited opportunity for immigration among groups, and small effective population size, this population may be subject to genetic and demographic problems intrinsic to its small size. There is an imminent need for the protection at Diani of this colobus subspecies. Reforestation is recommended, as is the creation of corridors among forest patches.*

Résumé: *Une sous-espèce de colobe angolais noir-et-blanc* Colobus angolensis palliatus *habite les forêts côtières du sud du Kenya et les forêts de l'Arc Oriental de la Tanzanie. Une étude a été menée dans les forêts de Diani afin de déterminer la distribution et la taille des populations de* C. a. palliatus *de même que les effets de la déforestation sur la population. En tout, 165* C. a. palliatus *ont été dénombrés. La taille moyenne du groupe était de 6.5 individus. L'âge et le ratio mâle/femelle ont été évalués comme suit : mâles adultes : femelles adultes = 1 : 2 ; femelles adultes : enfants = 1 : 1 ; mâles adultes : enfants = 1 : 2. La densité de population s'est élevée approximativement à 14 individus/km² et la biomasse à 94 kg/km². Soixante-deux pour cent des groupes habitaient les îlots forestiers au sein des zones hôtelières et résidentielles. La taille de la population active (N_e) a été estimée à 68.3 individus pour un coefficient de consanguinité (F) de 0.79%. De telles résultats impliquent que l'avenir de* C. a. palliatus *à Diani est incertain. Avec un habitat qui rétrécit, une fragmentation et une isolation continues des îlots forestiers, une immigration limitée entre les groupes et une petite taille de la population active, cette population pourrait être sujette à des problèmes démographiques et génétiques intrinsèques à leur petite taille. Le besoin de protéger cette sous-espèce de colobe à Diani est imminent.*

Introduction

Habitat destruction is ranked as the most severe threat to primate species (Butynski, 1997). The creation of patchy habitats leads to the isolation of populations. Species occupying these fragmented habitats are more at risk from catastrophic events. There are eight subspecies of Angolan black-and-white colobus *Colobus angolensis* (Kingdon, 1997). *C. a. palliatus* is found in the forests of Keny's south coast, and at many sites in Tanzania, including the Usambara, Uluguru, Udzungwa and Mahale Mountains in Tanzania. In Kenya, most *C. a. palliates* live in privately owned forest patches. Shimba Hills National Reserve is the only protected area in Kenya where *C. a. palliatus* is present. This Reserve covers an area of 217 km² of which only 95 km² are forested (Bennun & Njoroge, 1999).

Moreno-Black and Maples (1977) conducted the first study of the Diani colobus population in 1973. Since then, the structure of the forest in Diani has changed dramatically. A growing human population and consequent clearing and degradation of the forest threaten the survival of the colobus and other species in Diani. Over 75% of the forest cover in Diani has been lost along with several mammal species such as leopard *Panthera pardus*, lion *Panthera leo*, and elephant *Loxodonta africana* (Moreno-Black & Maples, 1977; Kahumbu, 1997). Deforestation is not the only threat facing the fauna of Diani forests. In 1971 a 10-km road was constructed through the center of the Diani forests. Numerous primates and other animals have been killed or injured while attempting to cross this busy road (Kahumbu, 1997).

Moreno-Black and Maples (1977) conducted a 6-month study of five groups of *C. a. palliatus* in Diani nearly 30 years ago, counted 26 individuals, and found a density of 93 animals/km². Kahumbu (1997) conducted a 1-month survey, counted 234 individuals in 39 groups, and found a density of 24 animals/km². Apart from these two studies, no other research has been conducted on *C. a. palliatus* in Kenya. Due to the rapid decline in the forested area of Diani, it was important that the remaining forests be surveyed. A census and survey of the forests sustaining this *C. a. palliatus* population are the first steps in preserving and managing this increasingly rare subspecies in Kenya.

This paper documents a total count of *C. a. palliatus* inhabiting the private Diani forests and the demography of some groups. The effective population size (N_e) and inbreeding coefficient (F) for the Diani *C. a. palliatus* as a metapopulation are presented.

Study Site

Diani is located on the south coast of Kenya, approximately 30 km south of Mombasa. *C. a. palliatus* inhabit the coral rag lowland forests of Diani and the surrounding kaya forests (kaya forests are sacred communal forests where the local people perform traditional rituals). The census covered forest patches characterized by open canopy with scrubby undergrowth. There are a total of 19 hotels along this strip of approximately 12 km in Diani. The forest patches here are separated by cleared and developed land. The estimated area of the censused forests is 12 km². The five main tree species in these forests are *Combretum schumanni, Stercullia appendiculata, Corpidoptera africana, Trichilia emetica* and *Commiphora zanzibarica*. Other larger mammals in these forest patches include: Sykes's monkeys *Cercopithecus albogularis*, vervet monkeys *Cercopithecus aethiops*, yellow baboons *Papio*

cynocephalus, greater galagoes *Galago garnetti*, senegal galagoes *Galago senegalensis*, bush pigs *Potamochoerus porcus*, sunis *Neotragus moschatus*, red-bellied coast squirrels *Paraxerus palliatus*, and bush squirrels *Paraxerus ochraceus*.

Rainfall is bimodal, with a range of 76–102 mm per year. Long rains occur from April through June, and the short rains from October through November (Moreno-Black & Maples, 1977). Human disturbance included the construction of water mains and power lines through the forests in 1969-1970, and the construction of a 10 km paved road in 1971-1972 (Moreno-Black & Maples, 1977). Trash dumping sites are common throughout the forests. Hunting of animals is not a major threat in Diani forests.

Methodology

A total count of the *C. a. palliatus* population in Diani forests was conducted over 5 weeks from May to June 1997. More than 152 hours were spent in the field, of which 88.2% were observation hours.

Twenty-eight forests were traversed in search of *C. a. palliatus* groups. Most of the censused area covered forests on privately owned land where hotels, restaurants and homes were located. The forests ranged in size from 0.5–2 ha. No attempt was made to measure the size of each forest. The forests were ranked in terms of continuity of the tree canopy, tree height, and proximity to a hotel or a home. Forests were ranked from 1–3; where rank 1 was given to forests over 1.5 ha., with a continuous canopy, tall trees and healthy undergrowth. Rank 2 forests were less than 1.5 ha. with low trees, and were within a hotel or a residential compound. Rank 3 forests had no canopy, and were comprised of bush with dense entangled undergrowth, and may or may not have been within a hotel or residential compound.

Census walks usually followed roads and trails within the forest. Two observers, following each other at about 10 m apart, traversed the forests systematically in north-south or east-west directions, walking at a speed of about 1 km/h, listening and watching for *C. a. palliatus*. Although groups of primates were often heard before being seen, the presence of a troop was always verified visually. When a group was encountered, the observers stood still and all members of the group were counted, aged, and sexed. Individual primates in each group were categorized as juveniles, sub-adults and adults. Adults were individuals with full body size and fully developed black and white pelage. Sub-adults were smaller in size than adults, with fewer white hairs on the face and were independent of their mothers. Juveniles stayed close to their mothers and were smaller in size and covered by white curly hair (Dorst & Dandelot, 1970). Notes on the specific location, food items collected, general behavior, forest condition, presence of other primates and mammals were recorded.

Effective population size (N_e) was determined using the equation:

$$N_e = \frac{4N_m N_f}{N_m + N_f}$$

Where N_m = the number of adult males.

N_f = the number of adult females.

This equation assumes a closed population, random mating, discrete generations, and that all adult males and adult females may reproduce (Falconer, 1982).

The rate of inbreeding was determined using the inbreeding coefficient (F) and the equation:

$$F = \frac{1}{2N_e}$$

Where N_e = the effective population size.

This equation assumes random mating, and no mutation, selection, or migration (Falconer, 1982).

Results and Discussion

A total of 165 *C. a. palliatus* was counted in 25 groups. Three lone males were located. Of the 165 individuals, 15% were adult males, 33% were adult females, 20% were sub-adults, 13% were juveniles, 5% were infants, and 14% were unidentified. The ratio of adult males to adult females was 1:2.2; adult females to young was 1:1.2; adult males to young was 1:2.5. Average group size was 6.5±2.8, with a range of 3-11 individuals (figure 1).

The effective population size (N_e was 68.3 individuals, which is 41% of the metapopulation of 165. The maximum possible N_e for the Diani metapopulation is 108. Thus, the actual N_e lies in the range of 68-108 individuals. Inbreeding coefficient (F) was 0.73%. The minimum rate of inbreeding possible for the Diani *C. a. palliatus* is 0.46%. Thus, the present inbreeding coefficient lies in the range of 0.46 - 0.73%.

Of the 28 forests surveyed, 10 were ranked 1, 15 were ranked 2 and three were ranked 3. Thirty-three percent of *C. a. palliatus* inhabited forests in rank 1, 62% were found in forests of rank 2, and 5% inhabited forests in rank 3.

The density of *C. a. palliatus* in Diani was 13.8 animals/km^2. Biomass estimates are based on an average weight for an adult male of 12 kg, 7.5 kg for an adult female, and 5 kg for a sub-adult (Eley, 1989). A weight of 8.2 kg was assigned to each of the 24 individuals that was not aged. Juveniles and infants were assumed to weigh an average of 2 kg. Based on a censused area of 12 km^2, biomass is estimated to be 94 kg/km^2.

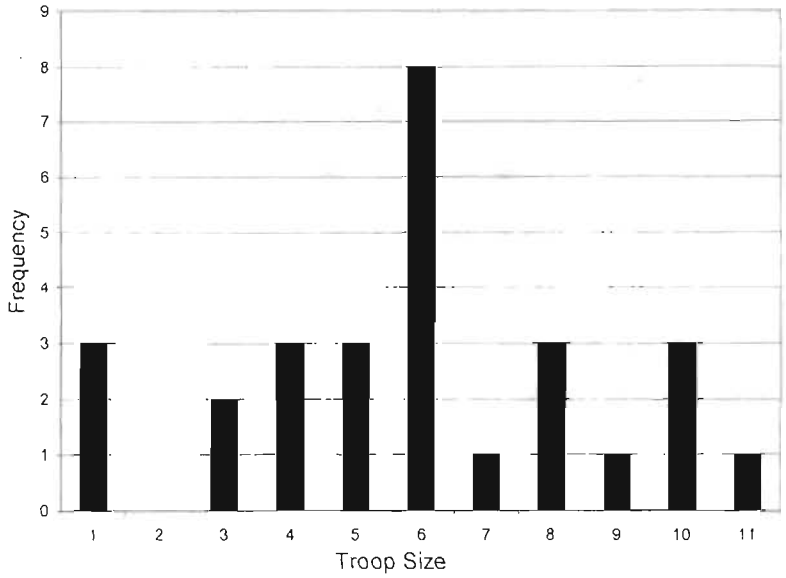

Figure 1. Frequency distribution of Colobus angolensis palliatus *troop sizes in Diani forests, Kenya (1997) (n=28).*

Although the present census surveyed a greater area of forest and encountered groups not included in the 1996 census, fewer *C. a. palliatus* were counted. It is doubtful that the *C. a. palliatus* population decreased dramatically in the 6 months between the two censuses. Both censuses found an average group size of approximately six colobus. The difference in total population count likely arises from double counting of groups by volunteers in the first census (Kahumbu, 1997). There is also the possibility that the present study may have missed one or two groups. Taking these factors into consideration, the estimated current population of the Diani colobus is between 165 and 195 individuals. This figure is arrived at by taking the average of the previous survey (Kahumbu, 1997) and the present survey with some allowance for field technicalities.

Effects of Deforestation

Unlike guereza *Colobus guereza*, *C. angolensis* do not favor areas of secondary and regenerating forests (Groves, 1973; Moreno-Black & Maples, 1977; Dunbar, 1987; Thomas, 1991). Thus, loss of primary forest affects *C. angolensis*. Habitat loss and degradation are the primary threats affecting the *C. a. palliatus* population in Diani, considering that 80% of forest cover was lost within the period 1977–1989 (Kahumbu, 1997). More than half of the censused population (67%) inhabited small forest patches without canopy trees within areas of human activity. These facts have several implications for the future of *C. a. palliatus* in Diani forests.

The effective population size and inbreeding coefficient give indications as to the severity of inbreeding within the Diani metapopulation. Effective population size (N_e) is 68.3 individuals, which is only 27% greater than the minimum of 50 required to avoid a long-term loss of genetic diversity and negative inbreeding effects (Falconer, 1982). Similarly, the inbreeding coefficient (F) of 0.79% signifies high inbreeding. Inbreeding coefficients greater than 1% indicate a short-term loss of genetic diversity and an increase in inbreeding (Falconer, 1982). The values for both N_e and F in Diani *C. a. palliatus* are close to the minimum required to avoid the negative effects of a decrease in genetic diversity and increase in inbreeding. If deforestation continues at the present rate in Diani, effective population size will decrease and inbreeding will increase. The risks from catastrophic events to the Diani *C. a. palliatus* metapopulation due to low effective population and high inbreeding will be greatly increased.

Inbreeding depression and lack of resources are not the only threats to *C. a. palliatus* as a result of deforestation in Diani. *C. a. palliatus* and other primates have a high risk of death from vehicles as they attempt to cross the Diani highway. At the beginning of 1997, 17 *C. a. palliatus* were killed by vehicles in less than 3 months. "Colobus bridges" were erected in 1997 to encourage *C. a. palliatus* and other primates to cross over the busy road (Kahumbu, 1997). *C. a. palliatus* occasionally use these bridges while *C. albogularis* and *C. aethiops* frequently use them. Uncoated electrical wires run through the Diani forests. These wires are a threat to all primates in this area. During the study period, one male *C. a. palliatus* was killed by electrocution. One *C. a. palliatus* troop has a female with a clubbed hand because of electrocution, and other primates have physical defects due to the same. Diani forests are not the only areas along Kenya's south coast where habitat loss is threatening *C. a. palliatus*. Populations in other forests also are threatened by wood poaching, encroachment, clearance for cultivation and subdivision (Robertson & Luke, 1993), and dumping of rubbish.

Conclusion

The establishment of corridors among forest patches is one way to increase immigration opportunities among groups and to reduce inbreeding depression. Trees utilized by *C. a. palliatus* for feeding, traveling, and resting need to be planted in Diani. These would connect the currently isolated forests, allowing for immigration between groups and the expansion of group ranges. Troops in small poor forest patches might be translocated

to better patches or even other forests. Careful monitoring, and active public participation and co-operation are needed to ensure the survival of this black and white colobus subspecies in the private forests of Diani.

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ANTI-PREDATOR BEHAVIOR OF MALE HAMADRYAS BABOONS *PAPIO HAMADRYAS* IN ERITREA

Abstract: *During a 5-month survey of hamadryas baboons* Papio hamadryas *in central and eastern Eritrea, we observed several incidents in which baboons interacted with people or dogs. People and dogs represent the main threat to baboons, as most natural predators have been extirpated during past decades, and because people and baboons live in close proximity. Subadult and adult bachelor males engaged in predator defense of the group and that they also were the first to enter into dangerous areas. Our observations are consistent with those on hamadryas baboons in Ethiopia, but are in contrast to those on Ethiopian olive baboons* Papio anubis.

Résumé : *Lors d'une étude de 5 mois sur les babouins hamadryas* Papio hamadryas *au centre et à l'est de l'Érythrée, nous avons observé plusieurs incidents où les babouins ont interagi avec des gens ou des chiens. Les gens et les chiens représentent la principale menace pour les babouins parce que les prédateurs naturels y ont été extirpés depuis plusieurs décennies et aussi parce que les gens et les babouins vivent en étroite proximité.*