Tanzania Journal of Science and Technology

ISSN 2507-783X (print) and eISSN 2591-6742 (electronic)

Journal homepage: https://journals.out.ac.tz/index.php/tjst

Comparison of abundance and diversity of small mammals between the Wooded Grassland and Primary Forest in Pande Game Reserve, Tanzania

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Abstract:

Species diversity and trap success (abundance) between the two sites were assessed. Animals were sampled using four types of traps; Bucket pitfalls, Sherman, Tomahawk and Snap traps. A total of 103 animals comprising of 18 species in 8 families were captured; 73 of them from the Wooded Grassland and 30 from the Primary Forest. Species richness in the Wooded Grassland was 14 species and in the Primary Forest (11species). Using the Welch's t-test, species diversity between the Wooded Grassland (H'= 0.78) and that of the Primary Forest (H'= 0.71) did not differ significantly. The Sørensen Coefficient (CCs) value of 0.56 indicates a low similarity in the species inhabiting the two study sites. Small mammals species which disappeared for many years in the past could now be found inhabiting the Game Reserve. Most of it is still a secondary forest but it will recover into a primary forest in the near future if efforts to curb illegal tree harvesting and wild fires continue to be taken seriously.

Keywords: *Abundance; Diversity; Small Mammals; Pande Game Reserve*

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1. Introduction

Small mammals comprise mammalian species with adult weight of less than 5.0 kg (Husband & Stevens, 1998). In Africa they include several Orders, namely Chiroptera, Rodentia, Insectivora, Carnivora, Lagomorpha, Hyracoidea, Primates and Pholidota (Camargo *et al.*, 2018; Magige, 2013).

Small mammals form an important component of ecosystems due to their abundance as almost three out of four mammals fall under this category (Webala, Muriuki, Lala, & Bett, 2006). They are an important source of food to a large array of predators and birds of prey. Rodents for example, have been shown to contribute significantly to the survival of one of the most endangered canids in the world, the African species of wolf (*Canis simensis*) (Amori & Luiselli, 2011; Webala *et al.,* 2006).

Most small mammals are not specific to any particular habitat due to their ability to utilize almost all habitats in the continents (Amori & Luiselli, 2011; Gebresilassie, Bekele, & Belay, 2004; Kok, Parker, & Barker, 2012; Webala et al., 2006). In general, small mammals are abundant at the ecotone (transition zone between two habitats) than at the middle of homogenous areas (Manson & Stiles, 1998; Stevens & Husband, 1998). Small mammals are highly adaptive as they occur in all continents of the world except Antarctica and their population sizes tend to increase toward the equatorial region (Meserve, Kelt, & Previtali, 2011) .

Small mammals are also sensitive to environmental perturbations such as the expansion of land for pasture, settlement farming, forest degradation and tourism development (Magige and Senzota, 2006; Webala *et al.,* 2006). Seasonal variations affect the spatial distribution and abundance of fauna, including small mammals (Meserve *et al.* 2011). Rainfall promotes growth of vegetation, which provides food for small mammals that consequently increase their rate of reproduction.

Generally, small mammals such as rodents and insectivores are highly mobile. Their diversity is not only directly influenced by altitude and vegetation types, but also strongly correlated to human disturbance (Magige, 2013; Webala *et al.,* 2006). Expansion of human population causes the conversion of natural vegetation into farmlands which in turn makes habitats for wild fauna more fragmented, reducing home ranges and diversity of some animal species (Webala *et al.,* 2006). Amongst the small mammals, rodents are more studied mainly because of their economic importance as crop destroyers and vectors of pathogenic organisms that cause disease epidemics in human populations. Also they are most diverse in terms of species (Kiwia, 2006; Magige, 2013).

The objective of this study was to determine the diversity and abundance of small mammals in the Wooded Grassland and Primary Forest in Pande Game Reserve. In Pande Game Reserve there is only one study in the past that have dealt with the diversity and abundance of small mammals (Kiwia, 2006). Therefore, there was a need to study the small mammals in detail particularly in the Reserve to facilitate formulation of sound conservation strategies within and even outside the local selected area. This study can also be used to provide important knowledge for gauging habitat destruction and other perturbations in protected areas elsewhere. Furthermore, the results of this study will be useful for further ecological studies such as the relationship between the

small mammals and their predators (Gomez-Villafane, Exposito, Martin, Picca, & Busch, 2012).

2. Material and methods

2.1 Description of the study area

Pande Game Reserve is an Eastern African Coastal Forest in Kinondoni District, Dar es Salaam, Tanzania. It is located approximately 25 km northwest of the Dar es Salaam City (Fig.1) and 16 km inland from the Indian Ocean (6^o 40' 32"S - 6^o 44' 10"S; 39^o 04' 10"E - 39^o 05' 40"E) (Masongo, 1984). The reserve lies on the edge of the city and is surrounded by five villages, Msumi, Msakuzi, Mabwe Pande, Mpiji Magoe and Mbopo. The Game Reserve was gazetted in 1990 having previously been a Forest Reserve. It covers 1,226 ha with an altitude ranging between 80 – 126 metres above sea level encompassing disturbed forest, thicket, grassland and woodland. Data were collected in Pande Game Reserve during the wet season (April and May).

2.2 Climate

Rainfall pattern is bimodal with a period of short rains between October and December and a more prolonged rainy season between March and May. The Forest receives a mean annual rainfall of about 1200 mm per annum (Doggart, 2003) The mean daily air temperature is 26^oC, with a seasonal variation of 4^oC and a daily range of 8^oC. The highest air temperature is 31^oC during the dry seasons (Doggart, 2003).

2.3 Sampling Procedures

Small mammals were sampled from demarcated transect lines in the two study sites (Wooded grassland and the Primary Forest) as in (Vieira, 1998). In the Wooded grassland, we placed parallel traps from North to South, 15 m apart in 8 × 8 grids (trapping area: 1.10 ha), whereas in primary forests we placed traps 15m apart along 2 transect lines that were 15m apart (trapping area: 0.65 ha). Four types of traps were employed to sample small mammals in this study: Medium sized Sherman traps (23×9.5×8 cm), Tomahawk live traps of size (59×15×15 cm), Snap traps and bucket pitfall traps with drift fence (Vieira, 1998). All these traps have been used with success by several researchers.

In each habitat transects lines were set and trapped for seven consecutive days before being shifted to other transects within the same habitats for another seven days, thus the total trapping effort was 14 days in each habitat. Sampling was conducted using a combination of all types of traps in each trap line comprising 103 traps (50 Sherman traps, 50 snap traps and 3 Tomahawk traps). Each snap trap was tied on a branch or tussock grass by a string in order to prevent it from being carried away by predators. Untargeted live trapped animals were released into the field.

All traps were set on the ground at 5m interval and red plastic straps were tied on branches or tall grass over each trap station for ease of location. For the large and heavier species such as *Cricetomys gambianus* and *Petrodromus tetradactylus*, Tomahawk live traps were set along their trails. Traps were checked twice daily, immediately after sunrise (0630-0730hrs) and in the evening (1730-1830-hrs). Traps were baited daily with a mixture of freshly fried coconut pieces smeared with peanut butter and small fish *(Restrineobola argentea)*. Global Positioning System (GPS) was used to record the location and altitudes of the sampling sites (Kiwia, 2006).

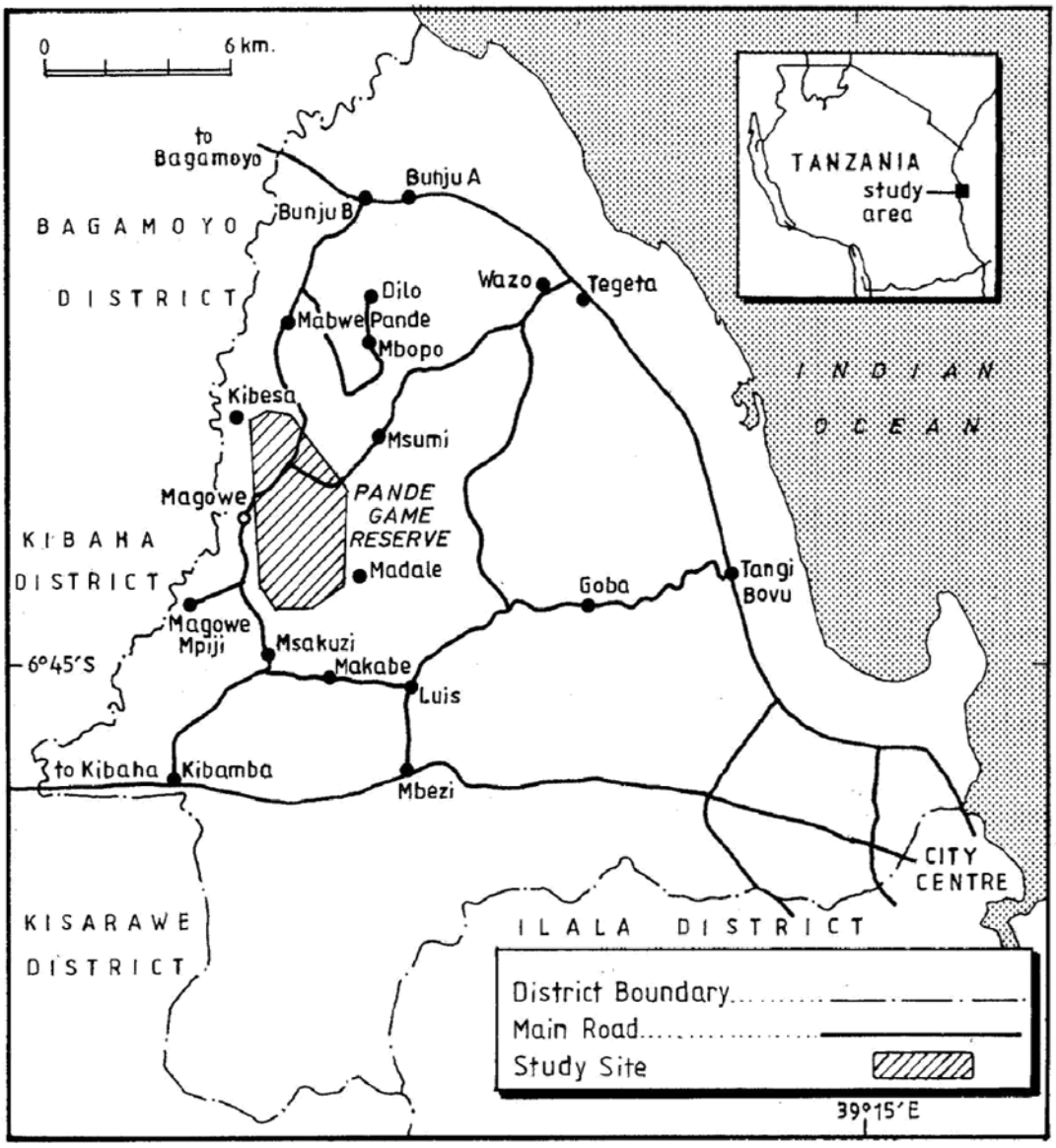

Figure 1: Map showing the location of Pande Game Reserve in relation to Dar es Salaam City Centre, Tanzania.

Standard museum records were taken for all captured animals. These included; species name, head and body length (HB), tail length (TL), hind foot length (claws inclusive) (HF), ear length (EL), sex and body mass (BW). Live captured animals were identified, sexed, weighed and marked on tails using a waterproof marker pen before being released into the field. Body mass was taken by weighing the animal in a cotton bag of known weight; the animal weight was then taken to be the difference between the weight of the bag and that of both the bag and the animal. A spring balance with 0.001-gm accuracy was used.

Small mammals collected either for further identification or as voucher specimens were labeled and fixed in 10% formalin for 24 hours and then preserved in 70% alcohol and taken to the museum of the Department of Zoology and Wildlife Conservation at the University of Dar es salaam. The research permit for conducting this study was offered by Ministry of Natural Resources and Tourism, Tanzania

2.4 Data Analysis

2.4.1 Species richness

Using identification guide, species richness was compiled from the list of caught animals, casual encounters, animal signs and information gathered from the local people (Decher, 1999; Kingdon, 2003). The Fishers Exact Test (Kiwia, 2006; Zar, 2010) was used to compare species richness between the two study sites.

2.4.2 Species Diversity

Vegan package in R statistical software was used to compute Shannon diversity index *(H')* (Shannon, 1949; Zar, 2010). The following formula was used to calculate the species diversity in the two study sites;

$$H'=-\sum(p_i)\,(\ln p_i)$$

Where H' is the diversity index and p_i is the proportion of species i in the total number of animals captured. The difference in species diversity between the two study sites was calculated using the Welch's t-test.

2.4.3 Trap Successes

Trap success, usually expressed as the number of animals caught per 100 trap nights was used to determine the relative abundance of species caught in the two areas. Trap success *(TS)* was calculated using the formula:

$$TS(\%) = \frac{Tc}{Tn\ X\ 100}$$

Where Tc= Total catch= the total number of individuals of species i caught and Tn= Trap nights = a product of the number of traps used and trapping effort (trapping effort = number of days of trapping or effective trapping nights). A trap in use for a 24 –hour period from sunrise to sunset is referred to as a trap night. Mann-Whitney U-Test was used to compare the overall trap successes for all individuals captured in the two habitats, whereas the Fisher's Exact Test was used to compare the Trap successes by species in the two habitats.

2.4.4 Coefficient of Community similarity

Sørensen Coefficient (CCs) was used to determine the similarity of small mammal species between the Primary Forest and Wooded Grassland based on binary (present-absent) data (Magige & Senzota, 2006; Wolda, 1981; Zar, 1996). The coefficient was calculated as follows

$$CCs = \frac{2c}{s1+s2}$$

Where s_1 and s_2 = the number of species encountered in the Study site 1and 2

respectively and *c* = the number of species common to both study sites (Kiwia, 2006; Wolda, 1981). The value of *CCs* ranges from 0 (when all species found in the two habitats are not similar) to 1.0 (when all species found in both habitats are similar).

3. Results

3.1 Species richness

A total of 103 small mammals were captured belonging to 18 species and 8 families (Table 1). The Wooded Grassland comprised of 14 species from 7 families whereas in the Primary Forest the number of species was 11 from 7 families. The number of species did not differ significantly between the two study sites (Fishers exact test *P*= 1.00; *df*=1).

3.2 Trap success

In the Wooded Grassland, *Cricetomys gambianus* had the highest trap success of 11.91% followed by *Lemniscomys rosalia* (1.57%), *Crocidura* species (0.93%), *Gerbilliscus nigricauda* (0.86%), *Acomys ignitus* (0.79%) and *Mastomys natalensis* (0.71%) (Table 2). In the Primary Forest the most common species was *C. gambianus*, which had the highest trap success of 9.52%, followed by *Crocidura sp.* (0.79%), *Grammomys dolichurus* (0.43%), *Petrodromus tetradactylus* (0.40%), *Beamys hindei* (0.29) *and Rhynchocyon petersi* (0.27%) (Table 3). Since the trapping regime was the same in the two sites, the raw data on the number of individuals captured in the sites were compared using the Mann Whitney U-Test (The assumptions of parametric tests were not met). The Wooded Grassland was found to harbour significantly more small mammal individuals than the Primary Forest (U=3.50, P=0.02, n1&n2=6).

3.3 Species diversity

Using the Shannon –Wiener index of species diversity H' in the Wooded Grassland was 0.76 and in the Primary Forest 1.09. The two diversities were found not to differ significantly (t = 0.07; df= 1).

3.4 Coefficient of community similarity

The 14 species encountered in the Wooded Grassland against 11 species in the Primary Forest and 7 species common to both habitats resulted into a Sørensen Coefficient (CCs) value of 0.56, indicating a low similarity of the species inhabiting the two study sites.

4. Discussion

4.1 Species richness

The difference in small mammal species richness was not significant between the Wooded Grassland (14 species) and Primary Forest (11 species). This is possibly because the Primary Forest had not reached its final stage of succession after having been severely degraded in the recent past (Doggart, 2003) therefore, some species could utilize both habitats for food and shelter. (Dickman, Greenville, Tamayo, & Wardle, 2011) also showed similar results, that species richness of small mammals was the same in Primary Forest and Wooded Grassland of Coastal Forests of Australia.

Results shows that some species are habitat specialists *(e.g. Beamys hindei* and *Acomys ignitus)* while others are generalists (e.g. *Cricetomys gambianus* and *Crocidura* sp.) as also suggested by other researchers (Magige & Senzota, 2006; Rubio, Ávila-Flores, & Suzán, 2014). Although small mammals are usually found in most habitats, normally species are mostly found in their preferred microhabitats and alteration of such microhabitats may lead to the decrease in species richness in a particular area

(Bateman, Kutt, Vanderduys, & Kemp, 2010; Rubio et al., 2014). Species with various food habits were represented in the checklist. Some were insectivores *(Crocidura sp),* omnivores (*multimammate rats*) seed and grass eaters (*Lemniscomys rosalia* and *Acomys ignites).*

Table 1: A checklist of common small mammal species in a wooded grassland and primary forest in Pande Game Reserve, Tanzania

Family	Species	WGL	PF	Common name
Erinaceidae	*Atelerix albiventris**	+	+	Four-toed Hedgehog
Cricetidae	*Beamys hindei*	0	+	Lesser pouched rats
	Cricetomys gambianus	+	+	African giant pouched rat
Herpestidae	*Mungos mungo*	+	+	Banded mongoose
	Herpestes sanguineus	+	+	Slender mongoose
Macroscelididae	*Petrodromus tetradactylus*	+	+	Four –toed elephant shrew
	Rhynchocyon petersi	0	+	Black & rufous elephant shrew
Muridae	*Acomys ignites*	+	0	E. African spiny mouse
	Grammomys dolichurus	0	+	Common thicket rat
	Lemniscomys rosalia	+	0	Stripped grass mouse
	Mastomys natalensis	+	0	Natal multimammate rat
	Mus minutoides	+	0	Pygmy mouse
	Rattus rattus	+	0	Black rat
	Gerbilliscus nigricauda	+	0	Black tailed gerbil
Sciuridae	*Paraxerus paliatus**	+	+	Red- bellied coast squirrel
	*Heliosciurus rufobrachium**	0	+	Red legged sun squirrel
Soricidae	*Crocidura sp.*	+	+	Shrew species
Thryonomidae	*Thryonomys gregarianus*	+	0	Lesser cane rat
Total 8	**18**	**14**	**11**	

WGL=Wooded Grassland, PF=Primary Forest, * = mammals seen but not caught.

Table 2: Trap successes for the trappable small mammals in the wooded grassland - Pande Game Reserve, Tanzania

Species	Number of animals	Trapping effort	Number of traps	Trap nights	Trap success (%)
Acomys ignitus	11	14	100	1400	0.79
Cricetomys gambianus	5	14	3	42	11.91
Crocidura sp	13	14	100	1400	0.93
Lemniscomys rosalia	22	14	100	1400	1.57
Mastomys natalensis	10	14	100	1400	0.71
Gerbilliscus nigricauda	12	14	100	1400	0.86
Total	**73**				

Table 3: Trap successes for the trappable small mammals in the primary forest Pande Game Reserve, Tanzania

Species	Number of animals	Trapping effort	Number of traps	Trap nights	Trap success (%)
Beamys hindei	4	14	100	1400	0.29
Cricetomys gambianus	4	14	3	42	9.52
Crocidura sp	11	14	100	1400	0.79
Grammomys dolichurus	6	14	100	1400	0.43
Petrodromus tetradactylus	3	14	53	742	0.40
Rhynchocyon petersi	2	14	53	742	0.27
Total	**30**				

(*Gerbilliscus* sp) were also represented in the catch. The presence of all these groups suggests that the study method and materials used for this study were probably proper for sampling small mammals in an area.

4.2 Species diversity

The species diversity in the Wooded Grassland (*H'*= 0.76) and in the Primary Forest (*H'*= 1.09) were not significantly different. This is possibly because the Primary Forest was at transition stage, thus some species were migrating between the two habitats in search of resources.

The observed low diversity of small mammals in this study may be due to the time of study (in the mid of rainy season). Several similar studies (Caro, 2002; Doggart, 2003; Kerley, 1992; Kiwia, 2006; Magige, 2013) also observed an increase in species diversity with increasing resource availability and the peak in diversity occurred at high levels of plant productivity, usually during the end of the wet season.

4.3 Abundance (Trap success)

Trap successes in the two study sites were not significantly different, but using the raw data the number of individuals captured in the Wooded Grassland was found to be significantly higher than in the Primary Forest. This significance difference between the habitats could partly be contributed by the presence of numerous microhabitats in the Wooded Grassland that could support a larger number of individuals than that in the Primary Forest. This observation supports earlier findings by (Kiwia, 2006; Magige & Senzota, 2006; Stevens & Husband, 1998) who showed grasslands with dense cover to support a higher number of individual small mammals than tree covered areas. Seed

abundance and numerous microhabitats are essentials for high abundance and distribution of granivorous rodents in the wooded grassland (Dickman *et al.*, 2011; Walsh, Woods, & Hoffman, 2016).

Cricetomys gambianus had the highest trap successes in both habitats with trap successes of 11.91% in the Wooded Grassland and 9.52% in the Primary Forest. This is probably due to their adaptability to live in various vegetation mosaics as reported by (Ivanter & Makarov, 2002; Manson & Stiles, 1998). A study on small mammals done by (Kiwia, 2006) in Pande and Zaraninge coastal forests also found the species to have highest trap successes in the two areas. Comparing trap successes of *Cricetomys gambianus* (11.91%) in this study and that of Zaraninge Forest (5.46%). (Kiwia, 2006) showed the difference not to be significant different (Fishers exact test; p= 0.49; df=1) possibly due to the fact that these forests share the same climatic conditions and vegetation structure.

Studies of various species of small mammals conducted in other areas of Tanzania such as Udzungwa National Park (*Lemniscomys species* (40%) *Mus minuitoides* (19%) *Crocidura* species (37%) (Njau, 1999), Western Serengeti (*Crocidura species* (12%) *Lemniscomys* species (12.1%) (F. Magige, 2003) and Mikumi National Park (*Crocidura* = 29.7%) (Venance, 2008) shows higher trap successes than values obtained in Pande Game Reserve. This is possibly because the Parks are larger in size and have more resources for the small mammals including the higher level of protection provided by Tanzania National Parks.

Habitats should be protected and conserved to sustain the generation of small mammals. Generally Tanzania is facing major challenge in conserving its partially protected areas (such as Game Reserves) due to unauthorized resource use activities (Wilfred, 2018). All small mammals are r-

selected species of which, when established in a particular habitat, their populations may crash rapidly if their habitats are destroyed or invaded by more competitive species (Kok *et al.,* 2012; Sangiwa & Magige, 2019). Pande Game Reserve is recovering from its long history of fragmentation. At the moment most of small mammals habitats in the reserve still is secondary forest but will recover into a primary forest in the near future if efforts to curb illegal tree harvesting and wild fires continue to be taken seriously.

4.4 Conclusion

In this study, comparison was done on the diversity of small mammals between the Wooded Grassland and Primary Forest in Pande Game Reserve. Both species richness and diversity were found not to be significantly different in the two study sites. The Primary Forest is in transition stage of recovering from the past severe destruction. A total of 18 species within 8 families were documented.

Using the raw data, the number of individual small mammals captured in the Wooded Grassland was significantly higher than in the Primary Forest. *Cricetomys gambianus* appears to be the most common species in both habitats because the species relies on both forested habitats for seeds and shelter and farmland that surrounds both study sites where it raids cultivated crops especially grains which are cached in burrows for the dry season food supply.

Seven species were only found in the Wooded Grassland and three species only in the Primary Forest. On the other hand seven species were generalists thus the community similarity of the small mammals between the study sites was low. The observed similarity suggests that migration of the species between the Primary Forest and Wooded Grassland was minimal.

With the above list of small mammals encountered, some untargeted species were also caught. These included birds such as Yellow necked francolin (*Francolinus leucoscepus*), reptiles e.g. short necked skink (*Mabuya brevicollis*), frogs, beetles, millipedes and cockroaches.

The present study was conducted in only one season; it is possible that longer periods of trapping could have resulted into more species. Future studies should be of extended period to cover wet and dry seasons as well as survey a larger area of the Game Reserve. Further studies should be carried out in Pande Game Reserve in order to find the relationships between the various species as well as prey-predator relationships. This will enhance formulation of better conservation strategies for the small mammals and associated habitats.

5. Acknowledgements

I am grateful to Dr. Hudson Yared Kiwia (University of Dar es salaam), Professor Ole Seehausen (Institute of Ecology and Evolution, University of Bern-Switzerland) for their supervision and financial support and Mr. Mfaume for field assistance. Finally, I wish to thank three anonymous reviewers for their constructive comments and suggestions on an earlier draft of this paper.

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