Mammals Inventory of the Kihansi River Gorge in Udzungwa Mountains, Tanzania

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Abstract

The Kihansi gorge montane forest in Udzungwa Mountains forms part of the Eastern Arc Mountains (EAM) which contain some of the most biologically diverse and endemic montane ecosystems in all of Africa. The Kihansi river gorge was opened up for hydroelectric development in the late 1990s, attracting hundreds of farming communities whose activities lead to environmental degradation and hence presumed biodiversity loss in the montane forest which is not understood. Using camera traps, an inventory of mammals of the area was conducted for 24 consecutive days. About 14 mammal species were photo captured, indicating diverse assemblage of large and medium size mammals, including the bushbuck, bush pig, yellow baboons, Udzungwa red colobus monkey, black and white colobus monkey, red duiker and grey duiker in the Kihansi gorge montane forest. There is also an array of small mammals including porcupine, bush hyrax, Eastern tree hyrax, giant shrew and bushy-tailed mongooses. Analyses show that the mammalian diversity compares to other EAM montane forests, including adjacent Mwanihana forest. The inventory of mammals in the Kihansi forest indicates the presence of substantial types of species that comprise of the natural history of the greater Udzungwa Mountains. These findings emphasize the need to accord greater protection for the species and habitat of the *Kihansi* gorge.

Key words: Mammals, Montane forest, Kihansi gorge, Eastern Arc Mountains

Introduction

Mammals are major taxa that represent Africa's rich biological heritage. These mammals are a composite of 340 species of rodents, ungulates, carnivores and primates which are presently recorded in the vast Savannah, woodland and forest formations in sub-Saharan Africa (Foley et al. 2014, Estes 2012, Kingdon 1999). Eastern Arc Mountains (EAM) of Eastern Africa are among the Africa's biodiversity hotspots, renowned for their forest mammals (Foley et al. 2014). The mammals are among the diverse and endemic faunal species found in the extensive systems of afromontane forests (Martin and Rovero 2013). Here over 75 species of mammals, birds, amphibians and reptiles have been recorded.

Tanzania's Udzungwa Mountains are the largest block of all the mountain ranges in the Eastern Arc Mountains of Eastern Africa. The forest diversity of mammals is renowned globally, especially for the lesser mammals (rodents, bats and shrews) (Foley et al. 2014). Key to the biodiversity is the rich assemblage of small to medium sized mammals such as shrews, rodents and antelopes that are recorded in the EAM's South Pare, East Usambara, West Usambara, Nguru, Uluguru and Udzungwa Mountains in recent times (Ahumada et al. 2011). The montane and submontane forest habitats of Udzungwa are also known to harbor medium to large mammal species that include Elephant (*Loxodonta africana*), Abbot's duiker (*Cephalophus spadix*), Angolan black-and-

599

white colobus (*Colobus angolensis*), African buffalo (*Syncerus caffer*), and Harvey's duiker (*Cephalophus harveyi*).

The Kihansi river gorge is a subset of the western Udzungwa Mountains. It is a riverine system lined with a narrow strip of montane forest and wetlands along the edges, with remnant mammal species of the EAM. The Kihansi river gorge was opened up for hydroelectric power development in the late 1990s (Myrvoll et al. 2003). The development opened up the gorge's fragile ecosystem to human interference, where the wetlands were among the habitats that endured severe environmental degradation (Gibbs 2003). The Kihansi Spray Toad (*Nectophrynoides asperginis*) population declined drastically to less than 500 animals and has become an indicator of the environmental impacts affecting biodiversity (Channing et al. 2006).

Kihansi Spray Toad (*Nectophrynoides asperginis*) was extirpated and declared extinct in the wild in 2009 (IUCN 2015). This reflected perturbation to the wetlands, but there are increased reports of poaching events suggesting that the impacts have spread to the montane forest also. Periodic (anecdotal) reports of illegal consumptive use of some mammal species indicate significant human impacts on species inhabiting the montane forest (Gibbs 2003). Angolan black-and-white colobus monkey (*Colobus angolensis*) are illegally captured for the live animal trade (Pers. Obs. 2013), while yellow baboons (*Papio cynocephalus*) are regarded vermin and constantly killed in problem animal control (PAC). Furthermore, there are strong indications that small antelopes are illegally killed to supply the local bush meat demand in the upper and lower reaches of the gorge. With the increase in human population in the surrounding villages, increased pressure on the extraction of the animal species in a manner that is unsustainable for the gorge's populations is of concern. Little is known of the impacts on mammal species diversity of the gorge. Therefore the aim of this study was

to carry out baseline surveys which were conducted in wet season of the 2013 to determine the mammalian community of Kihansi montane forest, with objectives of providing 1) real time comprehensive listing of mammal species richness, and 2) a comparison with a similar, but protected EAM site in order to depict human impacts. The study intended to establish the qualitative descriptions and characteristic distribution of mammal species observed and their conservation status relative to the protected Udzungwa MNP Mwanahina Forest.

Materials and Methods
Study area

The Kihansi gorge is a deep and narrow formation, with 4–5 kilometers long and less than half a kilometer wide. It is located on the slopes of the southern Udzungwa mountain escarpment (Figure 1), in south-central Tanzania (approx. 8°34" to 8°37" South latitudes and 35°49" to35°51" East longitudes). The gorge is covered by a narrow strip of montane forest, especially along the main river channel, which is situated about one kilometer at the top of the gorge.

The Kihansi gorge montane forest reaches an elevation of 1,150 meters above mean sea level and receives about 1,500 millimeters of rain annually in a mono-modal pattern (Vandvik et al. 2014). Temperatures are hottest during January and February and coolest during June and July, where the mean daily maximum and minimum temperatures are 25 °C and 13 °C, respectively (Vandvik et al. 2014).

Methods

An area of 9 km^2 in the Kihansi gorge was designated for the surveys using remote, camera (HCO Scoutguard SG565, HCO Outdoor Products, Norcross, GA 30071, USA). The camera-trap photography was used as described by Cutler and Swan (1999). The study was divided into 35 grids of 0.5 km^2 and a digital map produced. The study area was separated by the river, forming 2

sampling sites. Camera-trap placement locations were pre-determined on the digital map and actual points located in the field using Global Positioning System (GPS) (Zimmermann and Rovero 2016). At the locations, camera traps were set next to wildlife trails and other wildlife usage spots (Zimmermann and Rovero 2016).
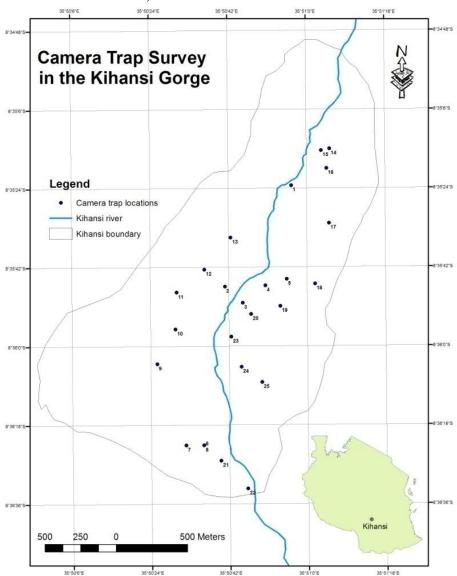

Figure 1: Map of study area, showing the positioning of the cameras in the Kihansi gorge, March-April 2013.

Twenty five (25) camera-traps using HCO Scoutguard SG565 were deployed through two sampling arrays of 14 and 11 camera trap sites simultaneously. Camera placements were non-random, due to restricted accessibility to predetermined sites, but were distributed with variable density of 1–5 cameras/0.5 km^2 (Figure 1). Cameras were set to work continuously without delay between consecutive photos. Sampling took 24 days, in overall search efforts totaling 600 trap days, spanning between March and April, 2013. Each species that was camera-trapped was identified and recorded, and then a comprehensive listing for Kihansi gorge was made.

Analyses

The cumulative numbers of photo-capture events for each species recorded were tallied and an estimate on trap rate made. Trap rates tallied for each species were used to estimate the species gross index of relative abundance (RAI) in the Kihansi gorge Montane forest. RAI was used to analyze species richness using descriptive statistics (Rovero and Spitale 2016).

Results

A total of 14 mammal species were camera-trapped in the Kihansi gorge montane forest in the March-April 2013. All the 14 species were documented in the eastern trap zone and only 9 observed in the western zone (Figure 1). Sampling efforts for each of the zones are summarized in Table 1. In total, 239 images were captured, where 156 were in the eastern zone and 83 in the western, (Table1, Figure 1). These highlighted a total of 137 events of mammal behavioral activity in the forest (over the period); 91 in the eastern and 46 in the western.

Table 1: Sampling efforts summarized by eastern and western zones of the Kihansi gorge montane Forest during March-April 2013

	Zone of Kihansi gorge montane forest	
	Eastern	Western
Number of camera set	14	11
Number of cameras functional	14	11
Camera trap days (24hr periods)	336	264
Mean camera-trap days per camera	24	24
Total number of images recorded	156	83
Total number of events (1-hr interval)	91	46
Total mammal species recorded	14	9

Inventory of mammal species at Kihansi gorge

Table 2 provides a listing of mammal species inventoried. These include three species of primates, four antelopes, four small carnivores and two rodents. Most recorded events were of red duiker, giant rat, yellow baboon, marsh mongoose and Udzungwa red colobus monkey. In general, most mammals were recorded active in the eastern zone of the forest by comparison to the west; perhaps indicating the importance of the area for the ecology of the species. Additional observations of mammal species not from cameras were also made in the course of 4 days of camera-trap placements and displacements, including:
- Udzungwa red colobus *Procolubus gordonorum*
- Black & white colobus *Colobus angolesis*
- Sykes monkey *Cercopithecus mitis*
- Yellow baboon *Papio cynocephalus*
- Red duiker *Cephalophus harveyi*
- Porcupine *Hystrix africaeaustralis*
- Wild cat *Felis silvestris*
- Leopard *Panthera pardus*

602

Observations of the wildcat and leopard were indirectly, through the use of spoors (faeces and carcasses of killed preys). No observation of Sanje Mangabey (*Cercocebus sanjei*) was made despite of the species being known to occur in the area.

These observations indicate that, relatively, the most abundant mammals (by order of descend) are red duiker, giant rat, marsh mongoose, yellow baboon and Udzungwa red colobus in the Kihansi gorge montane forest (Table 3). These species were the ones mostly encountered, and the rates of encounters provide a gross index of their relative abundance in wet season 2013.

Table 2: Species list of mammals observed by camera-trapping in the Kihansi gorge montane forest in wet season 2013. Numbers of recorded events by the camera-traps on each of the species in the east and west of the forest are also presented

Common name	Scientific name	Number of events (images) recorded	
		Eastern	Western
Udzungwa red colobus	*Procolobusgordonorum*	8	0
Black & white colobus	*Colobusangolesis*	1	0
Yellow baboon	*Papio cynocephalus*	5	10
Tree hyrax	*Dendrohyrax arboreus*	5	1
Red duiker	*Cephalophus harveyi*	33	6
Grey duiker	*Silvica pragrimmia*	4	0
Bushbuck	*Tragelaphus scriptus*	0	4
Bush pig	*Potamochoeru slarvatus*	2	1
Suni	*Nesotragus moschatus*	1	0
Marsh mongoose	*Atilaxpaludinosus*	9	8
Bushytailed mongoose	*Bdeogalecrassicauda*	4	1
Giant rat	*Cricetomys gambianus*	14	9
Giant shrew	*Rhynchcyon udzungwesis*	3	0
Wild cat	*Felis silvestris*	1	0
Servaline genet	*Genetta servalina*	1	0
Porcupine	*Hystrix africaeaustralis*	0	6

Table 3: Relative abundance index of mammals' camera- trapped by their occurrence in the east, west and in total at Kihansi gorge montane forest

Common name	Scientific name	Relative abundance index (RAI)		
		East	West	Overall
Udzungwa red colobus	*Procolubus gordonorum*	2.38	0.00	1.33
Black & white colobus	*Colobus angolesis*	0.30	0.00	0.17
Yellow baboon	*Papio cynocephalus*	1.49	3.79	2.50
Tree hyrax	*Dendrohyrax validus*	1.49	0.38	1.00
Red duiker	*Cephalophus harveyi*	9.82	2.27	6.50
Grey duiker	*Silvica pragrimmia*	1.19	0.00	0.67
Bushbuck	*Tragelaphus scriptus*	0.00	1.52	0.67
Bush pig	*Potamochoerus larvatus*	0.60	0.38	0.50
Suni	*Nesotragus moschatus*	0.30	0.00	0.17
Marsh mongoose	*Atilaxpalu dinosus*	2.68	3.03	2.83
Bushy tailed mongoose	*Bdeogale crassicauda*	1.19	0.38	0.83
Giant rat	*Cricetomys gambianus*	4.17	3.41	3.83

		Relative abundance index (RAI)		
Common name	Scientific name	East	West	Overall
Giant shrew	*Rhynchcyon udzungwesis*	0.89	0.00	0.50
Wild cat	*Felis silvestris*	0.30	0.00	0.17
Genet	*Genetta servalina*	0.30	0.00	0.17
Porcupine	*Hystrix africaeaustralis*	0.00	2.27	1.00

Comparative assessment with a similar, adjacent mammal community

A mammalian species profile for two montane forest communities in the Udzungwa Mountain ranges is provided in Table 4. The profile indicates photo captures of at least 32 different mammal species. Photo captures at Kihansi were made on approximately 14 (43.7%) species, constituting less than half of the expected number relative to the Mwanihana forest. The difference was in part compounded by difference in survey efforts in the two sites, where 24 days were deployed at Kihansi vs. 60 days at Mwanihana. Nevertheless, Mwanihana demonstrates a much higher mammal profile, which suggests the probable absence of a number of species at Kihansi.

Table 4: Compared photo capture events of mammals between Kihansi and Mwanihana montane forest habitats (adapted from Rovero et al. 2014)

		Number of events (images) recorded	
Common name	Scientific name	Kihansi	Mwanihana
Red colobus	*Procolubus gordonorum*	8	3
Black & white colobus	*Colobus angolesis*	1	3
Baboon, yellow	*Papio cynocephalus*	15	1
Hyrax, tree	*Dendrohyrax validus*	6	58
Duiker red	*Cephalophus natalensis*	39	NA
Duiker grey	*Silvicapra grimmia*	4	NA
Bushbuck	*Tragelaphus scriptus*	4	2
Bush pig	*Potamochoerus larvetus*	3	24
Suni	*Nesotragus moschatus*	1	165
Mangoose, marsh	*Atilax paludinosus*	17	6
Mangoose	*Bdeogale crassicauda*	5	419
Giant rat	*Cricetomys gambianus*	23	443
Giant shrew	*Rhynchcyon udzungwesis*	3	69
Wild cat	*Felis silvestris*	1	NA
Genet	*Genetta servalina*	1	37
Porcupine	*Hystrix africaeaustralis*	6	NA
Duiker, Harvey	*Cephalophus harveyi*	NA	394
Duiker, Abbotts	*Cephalophus spadex*	NA	52
Sanje mangabey	*Cercocebus sanjei*	NA	129
Sykes monkey	*Cercopithecus mitis*	NA	12
African civet	*Civettictis civetta*	NA	NA
Serval cat	*Leptailurus serval*	NA	NA
Honey badger	*Mellivora capensis*	NA	12
Mongoose, banded	*Mungos mungo*	NA	2
African palm civet	*Nandinia binotata*	NA	9

Common name	Scientific name	Number of events (images) recorded	
		Kihansi	Mwanihana
Leopard	*Panthera pardus*	NA	3
Squirrel, Tanganyika	*Paraxerus vexillarius*	NA	59
Sengi, four-toed	*Petrodromus tetradactylus*	NA	15
Sengi, chequered	*Rhynchocyon cirnei*	NA	1
Rat, cane	*Thryonomys swinderianus*	NA	1
Spotted hyena	*Crocuta crocuta*	NA	NA
African buffalo	*Syncerus caffer*	NA	7
African elephant	*Loxidonta africanus*	NA	9
Human beings	*Homo sapiens*	NA	NA

Discussion

The mammal survey of wet season 2013 has highlighted the presence of mammals, small and large, rare and common, in the Kihansi gorge montane forest. These animals are wide spread within suitable forest cover and terrain, indicating the naturalness state of the montane forest habitat. Identification of fourteen species in the 24 days surveys provides an initial impression of the diversity of the mammal community, but paves way for more intensive sampling efforts in future.

Real-time list of mammals in the Kihansi gorge

Table 3 provides RAI for mammals sighted. Red duikers were by far the most dominant mammals observed, and this may be attributed to the availability of food and perhaps low density of predators such as leopards. Similarly, giant rats also occur in large numbers perhaps due to low density of predators such as the wild cats and serval cats.

The mammal community harbors important tropical forest primates, in particular the Udzungwa red and black and white colobus monkeys. These are indicators of tropical forest health, as they are specialist feeders with restricted diet range (Kingdon 1999). There appears to be a good food base to sustain the small resident population of the forest. Although there are emerging reports of poaching of these primates (Anecdote 2016), levels are likely to be within the population's natural ability to sustain. However, greater protection should be accorded, both for the species and their habitats.

Yellow baboons appear to have a good population in the forest. The species exhibits wide ranging foraging behavior and as such is not expected to be confined within the boundaries of the Kihansi montane forest (Estes 2012). It is very likely that the species has a temporal to semi-permanent residency status in the forest. This needs to be discerned for future monitoring. Baboons can be vermin where they occur in the proximity of humans and suffer from PAC. Kihansi montane forest is currently semi-protected, with wildlife excluded from human activity. However, with the increasing number of farming activity surrounding the forest, the population may be subject to 'population sinks' outside due PAC (Mutagwaba, pers. com., March 2012).

These findings identify the wild cat, genet and leopard as top predators of the ecosystem. These carnivores have the lowest recorded trap rates in the present surveys (see Table 2). Although they all occur as rare and cryptic species, camera-traps are among the best known techniques for their monitoring. The observed rarity in the surveys may suggest the presence of very low numbers of individuals. This may be due to restrictions in population growth imposed by available range size, prey base or human-wildlife conflict (HWC). The forest is small in size, but with substantial numbers of antelopes and rodents and there is little record of HWC around the forest affecting wild cats and leopards (Parson,

pers.com, June 2013). This needs to be discerned for future monitoring.

Comparison of Kihansi mammal listing with the Mwanihana mammal community

The most important finding of the study is the comparative level of Kihansi's mammal community to an adjacent, better understood community of Mwanihana, eastern Udzungwa Mountains (Martin et al. 2015). All species observed at Kihansi are known residents of the Udzungwa Mountains and there are no exotics. This is promising for conservation, as it shows the pristine nature of the forest habitats. This study is first and foremost limited in sampling efforts (a mere 24 days was utilized for the study). The few species observed occur in relatively good abundance, given the sizes of the forest habitats (Table 3).

Only 14 out of 32 known species were observed in Kihansi. However, given the history of the Kihansi gorge, there are indications that some species may have been extirpated by human activities; whether directly through persecution or indirectly through alterations to the immediate environment. Most notable are large mammals, for instance elephants, buffalos and hyenas which are historically known to occur in the area. The loss of these species, in particular elephants, raises the question of the existing degree of population connectivity between the forest and the rest of the Udzungwa Mountain forest habitats. Human settlements and activities surrounding the forest have intensified in recent years and this could be one notable impact on local biodiversity. Buffalos are reported as being poached to local extinction and the bushbuck (next immediate-sized large antelope) and bush pig populations appear to be affected. There are indications of their poaching too (Mutagwaba, pers.com. June 2013).

A number of expected lesser mammals were not observed in the present study in comparison to similar observations at Mwanihana forest. This may be attributed to differences in sampling efforts between the two study sites, rather than presence/absence. Most species missing in the Kihansi inventory are small mammals whose populations in the forest are likely to be limited by habitat sizes, food resources and threats of human activities. As such, to counteract this rarity, increased sampling efforts are likely to discern their presence.

Conclusion

The inventory of mammals in the Kihansi forest indicates the presence of substantial types of species that comprise of the natural history of the greater Udzungwa Mountains. The findings complement ongoing long-term monitoring of tropical forest mammals in the Udzungwas and provide the scope for future expansion into western areas of the mountain range, example Kihansi. Larger mammals (elephant and buffalo) appear to be absent (on permanent scale) and where the most plausible explanation infringes on extirpation through poaching. The few species that remain are likely in decline also. There are similar indications also for the somewhat staggering population of primates. These findings emphasize the need to accord greater protection for species and habitats of the Kihansi gorge. In the immediate attention though, is the need for establishment of an ecological monitoring program that encompasses the mammalian community.

Mwanihana forest through TEAM WORK (www.teamnetwork.org).

References

Ahumada J, Silva CE, Gajapersad K, Hallam C, Hurtado J, Martin E, McWilliam A, Mugerwa B, O'Brien T, Rovero F, Sheil D, Spironello W, Wirnani and Andelman S 2011 Community structure and diversity of tropical forest mammals; data from a global camera trap network. *Philos. Trans. Royal Soc. B: Biol. Sci.* 366: 2703-2711.

Channing A, Finlow-Bates S, Haarklau SE and Hawkes PG 2006 The biology and recent history of the critically endangered Kihansi Spray Toad *Nectophrynoides asperginis* in Tanzania. *J. East Afr. Nat. Hist.* 95 (2): 117–138.

Cutler TL and Swann DE 1999 Using remote photography in wildlife ecology: a review. *Wildl. Soc. Bull.* 27: 571-581.

Estes RD 2012 The behavior guide to African Mammals. The University of California Press, USA.

Foley C, Foley L, Lobora A, De Luc, D, Msuha M, Davenport TRB and Durant S 2014 A field guide to the larger mammals of Tanzania. Princeton University Press, UK.

Gibbs JP 2003 Ecological monitoring protocol for the Lower Kihansi Gorge Ecosystem; A report to the Lower Kihansi Environmental Management Project 2003.

IUCN 2015 IUCN Red List of Threatened Species. Gland Switzerland.

Kingdon J 1999 East African Mammals. Vol. III. Chicago. The University of Chicago Press.

Martin E, Cavada N, Ndibalema V and Rovero F 2015 Modelling fine-scale habitat associations of medium-to-large forest mammals in the Udzungwa Mountains of Tanzania using camera trapping. *Trop. Zool.* 28: 137-151.

Martin E and Rovero F 2013 Assesing tropical forest mammal communities using camera trapping and occupancy analysis: case study from the Udzungwa Mountains of Tanzania. *Proceedings of the 9th TAWIRI Scientific Conferenec, Arusha, Tanzania, 4-6 December 2013.*

Myrvoll F, Hansen SB, Roti JA and Halvorsen A 2003 Monitoring program for an unlined headrace tunnel in unfavourable ground conditions. In *Field Measurements in Geomechanics: Proceedings of the 6th International Symposium Fmgm 2003, Oslo, Norway, 15-18 September 2003.* Taylor & Francis. pp. 245–254.

Rovero F and Spitale D 2016 Presence/absence and species inventory. In: Rovero F and Zimmermann F 2016 *Camera-trapping for wildlife research.* Exeter: Palegic Publishing, UK, pp. 41-67.

Vandvik V, Måren IE, Ndangalasi HJ, Taplin J, Mbago F and Lovett JC 2014 Back to Africa: monitoring post-hydropower restoration to facilitate reintroduction of an extinct-in-the-wild amphibian. *Ecosphere* 5(8):1-16.

Zimmermann F and Rovero F 2016 Field deployment of camera-traps. In: Rovero F and Zimmermann F 2016 *Camera-trapping for wildlife research.* Exeter: Palegic Publishing, UK, pp. 22-32.