ABUNDANCE AND DIVERSITY OF WILD MAMMALS ALONG A HYDROLOGIC GRADIENT IN THE USANGU WETLANDS, TANZANIA

BY

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN WILDLIFE MANAGEMENT OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

2011

ABSTRACT

This study was conducted in the Eastern Usangu wetland in Mbeya and Iringa regions to examine the composition, abundance and diversity of mammals along a hydrological gradient. Data were collected in two seasons using distance sampling method along transects using a GPS to locate positions. Kruskal-Wallis, Pearson's correlation and t-tests were employed to test the association of distance and number of animals observed along the gradient. Diversity of mammals along the gradient was determined by a number of indices using PRIMER 5.0 software. The study revealed that animal sightings decreased with distances from the edge of wetland though not significant different along the gradient. Also, flight distance of observed mammals was high indicating higher degree of poaching, and probably disturbances. Human activities such as abandoned farms, demolished houses and fresh livestock dung, were rampant in the wetlands. There was a statistically significant difference in the number of observed mammals in the two seasons, where species richness and abundance were higher in the late dry season. These results indicate that wetlands are important refuge areas for mammals as both abundance and diversity decreased with distance from the edge of the wetland. This study recommends a continuous monitoring of birds and mammals populations such as topi to help in determining the changes in abundance and diversity over time in Usangu wetlands as a result of intervention from anthropogenic disturbances.

DECLARATION

I, ROSE PETER KICHELERI, do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

Rose Peter Kicheleri — 14/10/2011 — Date

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The above declaration is confirmed

24.10.2011

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ACKNOWLEDGEMENTS

Firstly, I thank my heavenly Father for giving me strength during my entire Masters Degree study programme. I also, wish to express my sincere gratitude to my supervisors, Dr. Ndibalema, V.G. and Prof. Munishi, P.K.T. whose invaluable guidance has made the completion of this study possible. I also wish to acknowledge the NUFU-TZ 2007/10229 project for funding this masters program. My sincere, thanks are also extended to Advancing Conservation in a Social Context (ACSC): Working in a world of trade-offs (www.tradeoffs.org) project with the help from Prof. Songorwa, A.N. whose timely financial support helped me to finish the second phase of my field work. In addition, I would like to express my gratitude to Tanzania National Park Authority and all staff in Ruaha National Park at Ikoga ranger post in Usangu for their hospitality during data collection. Thanks are also due to Mr. Uhagile, L., Uhagile C., Nditi, M. and Kamwela, G. for their enduring assistance in the field.

Last but not least, I am grateful to my Husband Charles E. Mkumbwa, the entire staff of the Department of Wildlife Management and Faculty of Forestry and Nature Conservation and my postgraduate colleagues whose support made my academic prospective fruitful.

TABLE OF CONTENT

LIST OF TABLES

LIST FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ACSC: Advancing Conservation in a Social Context

CITES: Convention on International Trade in Endangered Species

GRR: Great Ruaha River

IUCN: International Union for Conservation of Nature

MNRT: Ministry of Natural Resources and Tourism

NUFU: Norwegian Programme for Development, Research and Education

RIPARWIN: Raising Irrigation Productivity and Releasing Water for Intersectional Needs

SMUWC: Sustainable Management of Usangu Wetlands and it's Catchment

UNIDO: United Nations Industrial Development Organization

UTM: Universal Transverse Mercator

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Wetlands have been identified as one of the key life support systems on this planet (Blumenfeld *et al.*, 2009). However, it is estimated that half of the world's wetlands have been lost since 1900 (*ibid*). In Africa, wetlands constitute around 1% of Africa's total land area excluding coral reefs and some of the smaller seasonal wetlands (Kabii, 1996). In addition, African wetlands comprise some of the most productive ecosystems in the world, providing services of great values to societies and they host a great diversity of species (Kabii, 1996; Sielhorst *et al.*, 2008). Tanzanian wetlands are considered to be potential 'bread baskets' and as important resources. This is due to the high diversity of biota in wetlands, provision of a source of food through agriculture, hunting and other livelihood activities (Mpemba, 1993; Kabii, 1996; McCartney *et al.*, 2007). The swamps of western Tanzania (where Usangu swamp is found) are believed to be among the wetland areas of highest endemism and of international significance in Africa.

Usangu area has recently become the focus of considerable national and international interest, because of its wetlands (MNRT, 2001). Ecologically, Usangu wetlands including Ihefu and western wetlands are amongst the most valuable ecosystems in Tanzania (McCartney *et al.*, 2007). It is, however, not gazetted as a Ramsar site (Franks *et al.*, 2004). Demand for water in the Usangu Basin is driven by a number of competing uses including domestic supplies, irrigated agriculture, livestock,

fishery, maintenance of the Usangu/Ruaha ecosystem, Ruaha National Park and major hydroelectric power plant downstream such as Kidatu and Mtera Dams. As a result of a number of factors including growing population, the water resources of the basin became increasingly stressed, and downstream flows decreased significantly especially during the dry season. Increase in human population and associated activities have had a marked effect in and around Usangu wetlands with possible negative effects on wildlife (Mtahiko *et al.*, 2006), and hence tourism in Ruaha National Park. Moyer (2000) reports that hunting of mammals and habitat destruction has resulted in extirpation and near total population crash of most mammal species previously common in the area. The changes brought by increased population and associated activities in Usangu catchment, including the eastern (Ihefu) and western wetlands date back to the 1950s when human population was low and the natural environment relatively undisturbed (SMUWC, 2002; Franks *et al.*, 2004).

In 1950s, pastoral Maasai followed by the Sukuma in the 1960s immigrated and settled in Usangu in large numbers (Walsh, 2007). Initially, their settlement in Usangu led to local political conflicts. However, an environmental impact due their transhumance nature was not an issue until 1990s (*ibid*). In 1992 the Great Ruaha River (GRR) started to dry in each dry season. The drying up of the river led to low reservoir levels at Mtera and Kidatu and national power cuts in 1992-93 followed by severe power cuts in 2006-2008 (Walsh, 2007). The misuse of water by upstream users mainly pastoralists was blamed. However, some researchers (Franks *et al.*, 2004; Tenga, *et al.*, 2008; SMUWC, 2001) disagree to this point arguing that

abstraction of water for small scale and large scale irrigation was to share blame for the woes of Usangu wetlands which is the immediate source of water for the GRR.

It is reported that the changes to the Usangu wetlands including Ihefu wetland have led to large physical changes, including replacement of the original vegetation of *Acacia* woodland by a mix of cultivated land and thorny bushlands (SMUWC, 2002). The western wetland with grassland has also been affected, with invasions of thorn trees and bushes, and changes in grass species. Changes can also be seen in the Ihefu swamp which has no clear channels and has more weedy vegetation, and fewer types of fish. It has been claimed that, throughout the whole area, the original numbers of wildlife were displaced by both people and cattle (SMUWC, 2002). Settlements and cultivation had intensified. These changes, coupled with livelihood activities in and around the Usangu wetlands were claimed to have caused the drying up of the Great Ruaha River (GRR) (*ibid*). Thus, the drying up of the GRR since 1993 (Mtahiko *et al.*, 2006) was useful in focusing the attention of stakeholders on the extent of the problem and in stimulating appropriate action (Franks *et al.*, 2004; SMUWC, 2001).

1.2 Problem Statement and Justification

Given the hydrologic impacts on the Usangu ecosystem and the increasing resource use pressure on the wetlands one would expect changes in abundance and diversity of mammals as distance increases from the edge of the wetlands. This is because animals tend to congregate around wetlands for water, and food (Mpemba, 1993). But, reports (SMUWC, 2002) suggest that there have been no estimates of numbers of wild mammals in the Usangu area. Circumstantial evidence however, indicates

that the Usangu wetlands supported a wide range of savannah species during the 19th and early 20th centuries and large herds of wild mammals were seen roaming around the Usangu plains in the 1950s (SMUWC, 2002).

Wetlands are known to be good repositories of wildlife all year around. In this case changes that have occurred in the Usangu ecosystem may have influenced changes in animal abundance. There are claims that the recent drying of the GRR has reduced the dry season habitat by nearly 60% for species that are heavily dependent on water including buffalo (*Syncerus caffer*), and waterbuck (*Kobus ellipsiprymnus*). The local distribution of African buffalo along the GRR appears to have decreased by about 42%, with no buffalo record in aerial surveys along the lower 92 km of the GRR in 2004 (Coppolillo *et al.*, 2004). The knowledge on population abundance of animals in Usangu associated with ecosystem changes is scanty. Little is known about how the hydrologic gradient in the Usangu area influences animal abundance and diversity. In addition, there is little or no baseline information that can be used as a basis for monitoring wildlife populations in response to the eviction of pastoralists and fishermen from the Usangu wetlands.

1.3 Objectives

1.3.1 Overall Objective

The main objective of this study was to assess the role of Usangu wetlands in supporting mammalian populations of Ruaha National Park.

1.3.2 Specific Objectives

The specific objectives of the study were to:

i. determine species composition of wild mammals in the Usangu wetlands along a hydrologic gradient.

ii. assess changes in mammal abundance along a hydrologic gradient.

iii. determine changes in mammalian diversity along a hydrologic gradient.

1.3.3 Research Questions

i. What species of wild mammals are currently found in the Usangu wetlands?

ii. How is the abundance and composition of wild mammals influenced by the wetland?

iii. How is the diversity of wild mammals influenced by the wetland?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Connection of Terrestrial and Aquatic Habitats

The interconnection between terrestrial and aquatic habitats is very important in the maintenance of wetland viability. Thus, attempts to preserve biodiversity associated with wetlands need to recognize the importance of such interconnections and consider the wetland habitat as part of a larger landscape (Burke and Gibbons, 1995). For example, Velund (2009) found that the density of puku antelope (*Kobus vardoni*) in Kilombero valley flood plain decrease as you move away from the water sources. On the other hand, dry lands act as refuge areas for wild mammals in wet seasons (*ibid*). Therefore, an effective management of animal species in wetlands can be greatly improved when there is accurate knowledge of population abundance and dynamics (Cassey, 1999).

2.2 Threats to Mammals in Wetlands

Many wetlands are rich in wildlife populations which provide important recreational attractions for tourists, food resources and commercial products. Unfortunately, human activities are responsible for species decline causing some mammals to become endangered and others threatened with extinction (Kamukala and Crafter, 1993). For example, Said *et al.* (2003) found that livestock and human activities related to water points can negatively affect the distribution and diversity patterns of wildlife. Therefore, without proper conservation many species may disappear (Kamukala and Crafter, 1993). Threats that are facing wetlands in Tanzania include overgrazing and over-cultivation by pastoralists and farmers respectively. Other

threats include establishment of new human settlements, livestock grazing, hunting and killing of wildlife, introduction of alien species, illegal fishing activities, cutting of vegetation for fuel, development activities such as dam construction, coastal development and mining activities, housing and commercial activities and pollution by domestic sewage, industrial affluent and agrochemicals (Kamukala and Crafter, 1993).

2.3 Importance of the Usangu Wetlands

Usangu wetlands in the Rungwa–Ruaha landscape have tremendous conservation values. They have been designated as Important Bird Area by Birdlife International, but their designation as a Wetland of International Importance is on hold due to its degraded state (Mtahiko *et al.*, 2006). The wetland was a home to hundreds of thousands of breeding water birds, including the globally threatened Wattled crane (*Bugeranus carunculatus*) and the only population of topi (*Damaliscus lunatus*) in central Tanzania (Moyer, 2000 in Mtahiko *et al.*, 2006). Nevertheless, due to changes that have occurred wild mammals are basically gone from nearly one third (1344 km^2) of the Usangu Game Reserve (Coppolillo *et al.*, 2004).

2.4 Current State of Wild Mammals in Usangu Wetlands

It is known that in the 18^{th} Century wild mammals such as impala, zebra, giraffe, elephant, buffalo, eland, hippo, warthog, hyena and silver backed jackal were numerous in Usangu wetlands (SMUWC, 2002). On the other hand, waterbuck, mountain and bohor reedbuck, impala, topi, zebra, hippopotamus, rhinoceros, giraffe, lion, hyena, jackals and crocodile were described as abundant while kudu, eland,

sable antelope, roan antelope and wildebeest were occasionally seen between Madibira and the Ruaha River (SMUWC, 2002). The Nyasa blue wildebeest, (*Connochaetes taurinus Johnstoni)* is also of interest as it is quite possible that it once occurred in Usangu, although it does not feature in recent findings (SMUWC, 2002).

According to SMUWC, (2001), no species of large mammal is believed to be endemic to the Usangu area. Although, an isolated subspecies of topi, also known as Usangu Topi (*Damaliscus korrigum eurus)* has been described. However, no assessment of its status in light of current understanding of the normal variation of the species has been undertaken. According to IUCN (1996, cited in SMUWC, 2001), several wild mammal species found in Usangu (or which are known to have occurred there within historic times) are regarded as threatened. Such species include the black rhinoceros (*Diceros bicornis)* - classified as critically endangered and has been locally extinct within the Usangu area for some time due to poaching - the African Elephant (*Loxodonta africana*) classified as endangered following extensive poaching for ivory - the lion and cheetah both regarded as vulnerable. Species in the lower risk category include waterbuck, Common Eland (*Taurotragus oryx*), topi, and Nyasa wildebeest. The single group of six hippopotamus (*Hippopotamus amphibious*) detected during the SMUWC surveys in 2001 may well be the only individuals remaining in the swamp. The Wildebeest (*Connochaetes taurinus*) has also been extirpated in recent times (SMUWC, 2001).

There is serious pressure on almost the entire large mammal populations of the Usangu area. It is known that formerly Usangu plains supported wild mammal populations, which have almost completely disappeared. Today the whole Usangu except for the northern end is virtually devoid of mammals and before the eviction of pastoralist, Usangu was used throughout for cultivation and livestock keeping. A few mammals occurred during the wet season but are almost completely absent during the dry season, presumably due to pressure from human activities especially poaching and competition from livestock. Thus, it has been said that wild mammals in the Usangu area are maintained by the populations from Ruaha National Park in a source-sink relationship (SMUWC, 2002).

According to SMUWC (2002), mammals have almost been eliminated from the seasonal wetlands and their numbers are severely reduced in the adjacent miombo. The major threats to wild mammals stem from human activities especially poaching, in the northern miombo woodland and competition from livestock in the grasslands.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Site Location

This study was conducted in the Eastern Usangu wetland around the Ihefu swamp (Appendix 1). The eastern wetland covers approximately 1,400 km^2 (Coppolillo *et al.*, 2006). The Ihefu swamp covers an area of about 82 km^2 during the rain season and 27 km^2 during exceptionally dry years (Mtahiko *et al.*, 2006). The wetland is found at an elevation lying between 1000 and 1100 m.a.s.l. with mean rainfall of about 720 mm per year and mean potential evaporation of about 1700 mm per year. About 90% of the rain falls between January and April and the dry season extends from May to November (SMUWC, 2002). All downstream flows from Ihefu are channelled through the Great Ruaha River.

3.2 Sampling Design

Distance sampling method (Buckland *et al.*, 1993) was used in this study. Distance sampling is a widely used method for estimating the size or density of biological population (Thomas *et al.*, 2009). Both late dry season (November 2009) and early dry season (June 2010) data were collected. The sample study area covered was 79.71km^2 (Appendix 2). Transects were established systematically using a GPS with a random starting point in a predetermined compass direction radiating from the edge of the wetland towards dryland. Transect average length was 11 km with subsequent 1 km length subtransects separated from each other by 2 km in order to avoid double counting. Transects were run alternately i.e., from the edge of wetland to the dry land and vice versa inorder to capture the presence of mammals that could

not be observed from one direction of data collection. Also, the transect width was bound to 1 km on each side of the transect line. Furthermore, an interview with the park rangers was conducted to reveal the state of wild mammals found around Ihefu since its gazettement into Ruaha National Park in the year 2008.

3.3 Data Collection

3.3.1 Primary Data Collection

Field work was carried out during the late dry season in November, 2009 and early dry season in June 2010. Four transects namely: Madawi-Ikoga (South East), Matwegamwanu (South East), Nyamakonge (North East) and Nyumbanitu (South West) were established using Garmin GPS with the respective UTM coordinates (Appendix 2). The total area covered was 7, 971 hectare = 79.71 square kilometres (Appendix 3). An open, four wheel light duty vehicle was used for data collection with two observers one on each side of the vehicle and a recorder. An automatic Laser Rangefinder was used for measuring perpendicular distances to the observed mammals. Data were recorded on a data sheet covering transect number/name, species, number of individuals observed, vegetation type, human activities, odometer readings and distance to animal (Appendix 4). Also, park rangers were interviewed (Appendix 5). In order to track changes in animal abundance and diversity since the park was gazetted into Ruaha National Park.

3.4 Data Analysis

DISTANCE 6.0 Program (Thomas, *et al.*, 2009) was used to estimate population abundance of each species. Unfortunately, the program was unable to run

successfully due to small sample size. Instead, MS Excel and SPSS Version 17.1 were used to analyse data using a combination of different statistical analyses such as chi-square, Pearsons correlation and t-tests. Diversity of mammals along the gradient was determined by a variety of indices i.e., the Simpson's Index (D), Shannon-Wiener index (H') and Brillouin's diversity index (H) using the software package PRIMER 5.0 (Plymouth Marine Laboratory, U.K.). The Simpson index was obtained as follows:

$$D = \sum_{i=1}^{S} p_i^2 . \quad \text{.....(i)}$$

Where D = Simpson's index of diversity, S= species richness and pi = n/N (proportion of a given species relative to the total of each species).

The Shannon Wiener index is shown below:

$$H = -\sum_{i=1}^{S} p_i \ln p_i \quad \text{.....(ii)}$$

Where H =Shannon-Wiener index, S = number of species, p_i = the fraction of individuals belonging to the i^{th} species and 'ln' = log to the base 'e' (which is called natural logarithms). In this case, 'e' has an approximate value of 2.718.

Brillouin's index is given by:

$$\text{..... } H = 1/X \text{ Log}\left(\frac{X}{x_1!x_2! \ldots x_n!}\right) \quad \text{.....(iii)}$$

Where H =Brillouin's index, X = total number of individuals in the entire collection x_1 = the number of individuals of species 1, x_2 is the number of individuals of species 2 and x_n is the number of individuals of the n^{th} species.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Composition

A total of 23 mammal species were identified and recorded in all transects (Table 1 and Table 2). The relative abundance presented in Table 1 was calculated based on density that refers to a quantitative measure of numbers per unit area (Cassey, 1999; Buckland *et al.*, 1993).

Table 1: Mammals species composition and abundance observed in the two survey seasons

SN	Common name	Family name	Scientific name	Swahili name	No	Relative abundance
1	Bushbuck	Bovidae	*Tragelaphus scriptus*	Bongo	1	0.015
2	Jackal	Canidae	*Canis mesomelas*	Mbweha	1	0.015
3	African clawless otter	Mustelidae	*Aonyx capensis*	Fisi maji	1	0.015
4	Reedbuck	Bovidae	*Redunca redunca*	Tohe	1	0.015
5	Bush pig	Suidae	*Potamochoerus larvatus*	Nguruwe pori	1	0.015
6	Wildcat	Felidae	*Felis silvestris lybica*	Pakapori	1	0.015
7	Brown hare	Leporidae	*Lepus capensis*	Sungura	2	0.010
8	Lesser kudu	Bovidae	*Tragelaphus imberbis*	Tandala mdogo	1	0.015
9	Slender mangoose	Herpestidae	*Herpestes sanguine*	Nguchiro	3	0.014
10	Duiker	Bovidae	*Sylvicapra grimmia*	Nsya	3	0.014

11	Bush squirrels	Sciuridae	*Paraxerus sp*	Kicheche	4	0.018
12	Banded mongoose	Herpestidae	*Mungos mungo*	Nguchiro	4	0.018
13	Honey badger	Mustelidae	*Mellivora capensis*	Kimbakulan yuki	4	0.018
14	Zorilla	Mustelidae	*Ictonyx striatus*	Kicheche	6	0.027
15	Dikdik	Bovidae	*Rhynchotragus kirkii*	Dikidiki	13	0.059
16	Impala	Bovidae	*Aepyceros melampus*	Swalapala	16	0.073
17	Vervet Monkeys	Cercopithecidae	*Cercopithecus aethiops*	Tumbili	17	0.078
18	*Mouse			Panya	35	0.160
19	Topi	Bovidae	*Damaliscus lunatus*	Nyamera	95	0.434

*Note: There are more than one species of mouse in Usangu (SMUWC, 2001). Due to the method used and their mobility it was impossible to note the species types.

The Ihefu wetland seems to have many other mammalian species apart from recorded. For example, while only one jackal was observed in one transect, three more jackals were observed out of transect (Table 2). The table shows some of the animals such as warthog that could not be seen on transect during data collection but do exist in Ihefu. It also indicate birds of interest such as the ostrich (*Struthio camelus*) and reptiles such as tortoises placed on CITES Appendix 2 because they are regarded threatened by live animal export trade (SMUWC, 2001). During the second field work about three tortoise's carcases were recorded and mortality might have been caused by prescribed burning while in the first field work about two carcases were spotted whose mortality was suspected to be caused by poachers. This shows that fire and poachers pose threat to small animals in conservation areas.

Table 2: List of animals observed out of transects

Common name	Family name	Scientific name	Swahili name	Number
Impala	Bovidae	*Aepyceros melampus*	Swalapala	6
Civet cat	Viverridae	*Civetticus civetta*	Paka pori	1
Dikdik	Neotraginae	*Rhynchotragus kirkii*	Digidigi	7
Warthog	Suidae	*Phacochoerus africanus*	Ngiri	7
Leopard Tortoise	Testudinidae	*Geochelone pardalis*	Kobe	8
Zorilla	Mustelidae	*Ictonyx striatus*	Kicheche	2
Topi	Bovidae	*Damaliscus lunatus*	Nyemela	40
Ostriches	Struthionidae	*Struthio camelus*	Mbuni	38
Jackal	Canidae	*Canis mesomelas*	Mbweha	3
Reedbuck	Bovidae	*Redunca redunca*	Tohe	1

Although Table 3 shows the average number of mammal species encountered during daily patrols in and around eastern Usangu wetland, yet there were similarities with those recorded in Table 1. Their average was calculated from park ranger's mammals estimates recorded in every encounter. Thus, the ranger's reports conform to what was observed in the field using distance sampling method during this study.

Table 3: List of animals that were previously seen during patrols by the rangers

Common name	Family name	Scientific Name	Swahili name	Average group size	Relative abundance
Sable antelope	Bovidae	*Hippotragus niger*	Palahala	8	0.070
Topi	Bovidae	*Damaliscus lunatus*	Nyamela	10	0.088
Dikdik	Neotraginae	*Rhynchotragus kirkii*	Dikidiki	2	0.018
Hippopotamus	Hippopotamidae	*Hippopotamus amphibious*	Kiboko	8	0.070
Crocodiles	Crocodylidae	*Crocodylus niloticus*	Mamba	4	0.035
Impala	Bovidae	*Aepyceros melampus*	Swalapala	6	0.053
Ostrich	Struthionidae	*Struthio camelus*	Mbuni	3	0.027
Greater Kudu	Bovidae	*Tragelaphus strepsiceros*	Tandala mkubwa	8	0.070
Duiker	Bovidae	*Sylvicapra grimmia*	Nsya	3	0.027
Wild dog	Canidae	*Lycaon pictus*	Mbwa mwitu	1	0.009
Hare	Leporidae	*Lepus capensis*	Sungura	2	0.018
Waterbuck	Bovidae	*Kobus ellipsiprymnus*	Kuro	3	0.027
Vervet monkeys	Cercopithecidae	*Cercopithecus aethiops*	Tumbili	11	0.096
Slender mongoose	Herpestidae	*Herpestes sanguinea*	Nguchiro	7	0.061
Zorilla	Mustelidae	*Ictonyx striatus*	Kicheche	8	0.070
African Clawless Otter	Mustelidae	*Aonyx capensis*	Fisi maji	7	0.061
Civet cats	Viverridae	*Civetticus civetta*	Paka pori	1	0.009
Warthog	Suidae	*Phacochoerus africanus*	Ngiri	5	0.044
Bushbuck	Bovidae	*Tragelaphus scriptus*	Bongo	2	0.018
Bush pig	Suidae	*Potamochoerus larvatus*	Nguruwe pori	6	0.053
Reedbuck	Bovidae	*Redunca redunca*	Tohe	2	0.018
Jackal	Canidae	*Canis*	Mbweha	2	0.018

		mesomelas			
Buffalo	Bovidae	*Syncerus caffer*	Nyati	10	0.088
Lesser kudu	Bovidae	*Tragelaphus imberbis*	Tandala mdogo	2	0.018

Some of the previously observed mammals (Table 3) including sable antelope, hippopotamus, crocodiles and warthogs were not seen in the current survey. Nevertheless, signs of these animals including droppings and footprints were observed except for sable antelope and crocodiles. This may probably be attributed to inaccessibility to the swamp area by water dependent mammals.

According to SMUWC (2001), 31 species were observed (Appendix 6) compared to 23 species recorded in this study. Nonetheless, small mammals such as ground squirrels, hare, otter and lesser kudu that were observed in this study are gone missing in the SMUWC list. While SMUWC (2001) report uncovered the subspecies of topi (Usangu Topi) *Damaliscus korrigum eurus* which is known to be endemic to Usangu, four groups of topi were established in this study comprising of 95 individuals in total. Whereas six individuals of hippopotamus are known to survive in the Ihefu wetland, more that 150 hippopotamus were recorded by the rangers (A. Shirima Pers. Comm.). In support of the rangers report signs of hippopotamus were observed in the Nyumbanitu (SW) transect during this study. Furthermore, signs of lion zebras, and warthogs were observed in the Madawi-Ikoga transect (SE).

4.2 Temporal Differences in Composition and Abundance of Mammal Species in the Ihefu Wetland

Test statistics for the number of observed mammals (Table 4) show significant difference in the two seasons ($P < 0.05$). The mean group size for the first season was 2 while the second season was 4.

Table 4: The number of mammals observed in the two seasons in the Usangu Wetlands

Season	Transect No	Species	Group size	Season	Transect No	Species	Group size
1	1	Duiker	3	2	1	Mouse	12
		Velvet monkey	7			Zorilla	3
		Dikdik	3			Honey badger	1
		Ground squirrel	4			Monkeys	2
	2	Bushbuck	2			Wild cat	1
		Hare	1			Lesser kudu	2
		Banded mangoose	1			Topi	35
	3	Velvet monkey	5			Monkeys	4
		Banded Mangoose	3		2	Topi	30
		Polecat/zorilla	6			Mouse	7
		Dikdik	2			Honey badger	2
		Mouse	2			Slender mangoose	3
	4	Hare	1			Wild pig	1
						Dikdik	2
					3		
						Mouse	17
						Dikdik	8
						Honey badger	1
						Zorilla	1
					4	Topi	20
						Impala	16
						Jackal fox	1
						Otter	1
						Reedbuck	1

4.3 Changes in Wild Mammals Populations along the Hydrologic Gradient

The number of animals observed decreased with increasing distance from the edge of the wetland. The highest number of animals in both seasons was at a distance of 1-3 km from the edge of the wetland decreasing to minimum (Fig. 1).

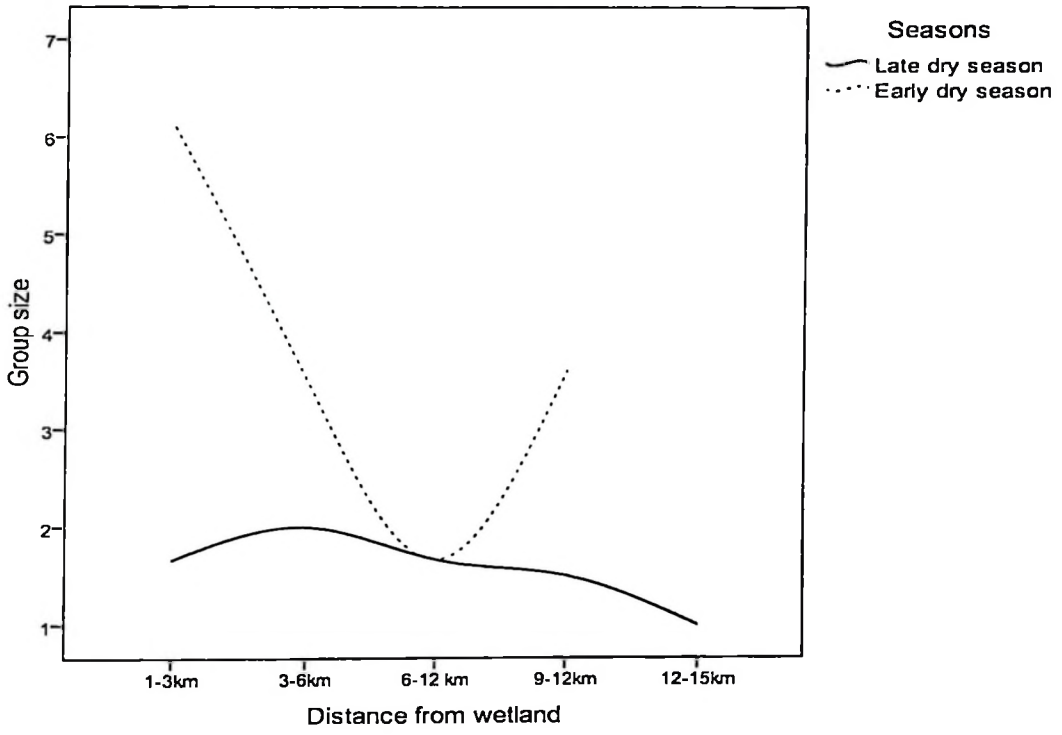

Figure 1: Number of animal along the gradient for the two seasons in the Usangu wetlands Southern Tanzania

Based on Chi-square test ($P > 0.05$) and Pearson's correlation ($P > 0.05$) the difference in numbers of animals along the gradient was not significant. The non significant test obtained could be attributed to the lower sample size. However, highest number of animals at a distance of 3-6 km decreased to a minimum at 12-15 km (Fig. 1). This could be attributed to sufficient pasture far from the wetland where animals do not

have to move to the wetland during the early dry season except for water. During the day mammal find shade under the trees while early in the morning they move in the wetland for water (Personal observation). Thus water is an indispensable resource to Usangu animals.

Moreover, the level of water increased to about 1.5 km long away from the wetland accessed only during the late dry season and could not be accessed by the truck during the second field visit. This support early observation by SMUWC (2001) that, few mammals occur during the wet season but are almost completely absent during the dry season because they hide in un-accessed part of the swamp. Therefore, mammals tend to come out of the swamp during the rains and concentrate in the swamp during the dry season. Furthermore, park rangers' interview revealed that most animals tend to concentrate in the Ihefu swamp during the dry season while in the rain season they reside on the drier parts of the wetland. But, having few animals in the dry seasons and many in the wet seasons could explain the importance of the linkage of the wetlands and terrestrial land. Studies elsewhere (Velund, 2009; Jenkins *et al,*. 2002; Jenkins *et al.*, 2003) support the above findings that wildlife species using floodplains need dry land as refuge when the wetlands flood.

Nevertheless, it was obvious that the original numbers of wildlife were displaced by both people and cattle SMUWC (2002). For example, a herd of about 80 cattle and goats was seen feeding in the park along Nyamakonge transects. Cow dungs were observed everywhere in other transect while in all transects homestead and settlements and water abstraction ridges could still be seen.

Also, nine years after SMUWC work in 2002 it was obvious that the original vegetation of *Acacia* woodland was replaced by a mix of cultivated land and thorny bush lands. Still, whistling Acacia (*Acacia depranolobium*) was observed

According to Roodt (2005) whistling Acacia show the presence of browsers where ants living in the galls offer symbiotic relation between ants and plants. Thus, plants provide cover and food to the ants, while ants protect the plants from severe browsing by attacking the browsers if they feed for too long on the same tree. Past observation (SMUWC, 2001) show that Usangu had an abundant number of animals. Warlsh (1998) also noted of abundant wildlife in Usangu in 1980s although they were in a great hunting pressure.

Park rangers are optimistic that many animals including, impala, kudu, bush pig, topi, kudu, zebra, giraffe, hippo, buffalo, elephants, sable antelope, and lesser kudu will return to the wetland. All these animals were locally extinct before the eviction of the pastoralists. SMUWC (2002) report suggested that in the past mammals like elephant, hyena, buffalo, and zebra used to migrate from the Ruaha National Park to Usangu especially for water during the dry season in a source sink relationship.

4.4 Diversity along the Gradient

Species diversity is an index that incorporates the number of different species in an area (species richness) and also their relative abundance (Harrison, *et al.*, 2004). The diversity concept is of central importance in ecological theory and practice. Species diversity is also important in conservation management. They are frequently used as

indicators of the 'well-being' of ecological systems. Diversity is also widely used in environmental monitoring. Results obtained for the diversity of mammals in the Usangu wetland are indicated in Table 5.

Table 5: Mammals diversity along the gradient

Distance (km)	S	N	HB	H'	D
1	2	2	0.347	0.693	1
2	6	56	0.658	0.768	0.349
3	9	56	1.321	1.514	0.680
4	8	39	1.510	1.755	0.823
5	4	7	0.863	1.277	0.809
6	2	8	0.259	0.377	0.25
7	1	1	0	0	0
8	3	6	0.683	1.011	0.733
9	5	19	0.811	1.043	0.532
10	3	4	0.621	1.039	0.833
11	1	2	0	0	0
12	1	2	0	0	0

Where S = No. of species, N = No. of individuals, HB = Brillouin's index of species diversity, H' = Shannon-Wiener's index of species diversity and D = Simpson's index of diversity

Three diversity indices (Table 5) in this study were compared and the trend show that diversity decreased with increasing distance from the edge of the wetland (Figure 2). This may be due to the fact that wetlands act as an important source of water for

animals thus, making most animals to be found near the wetland than far away especially during the dry season.

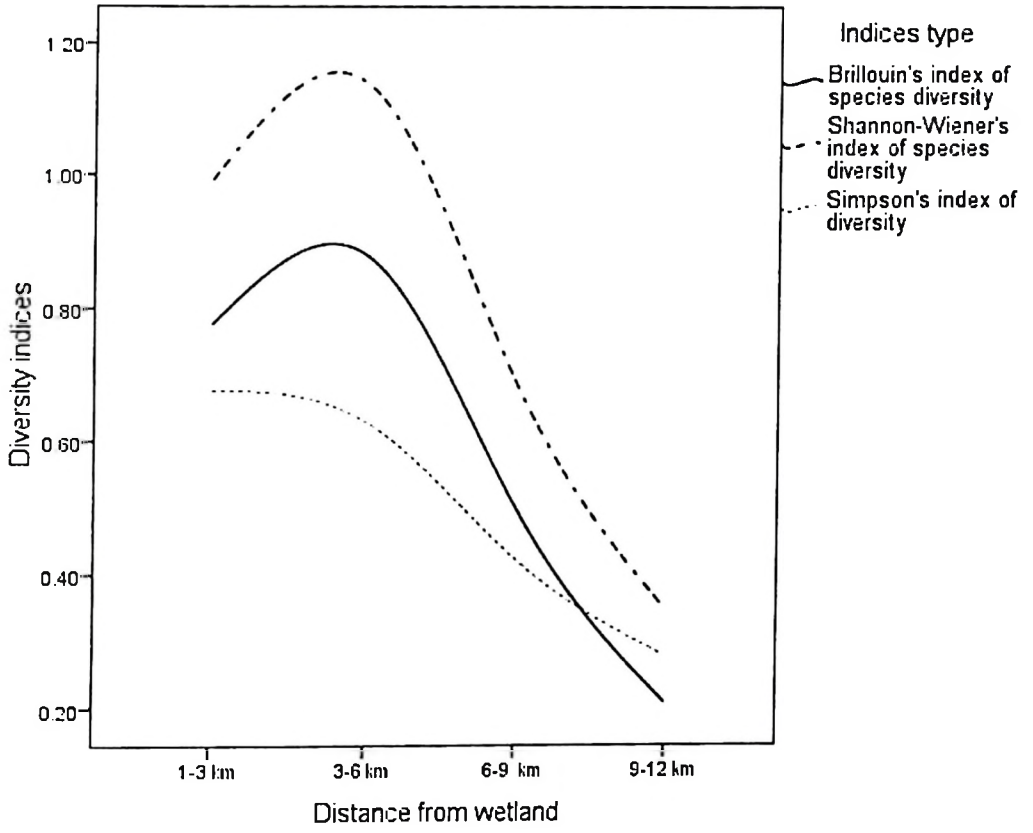

Figure 2: Diversity indices along the gradient

Due to small sample size, the study used Simpson diversity index to represent diversity of mammals in the Usangu because Brillouin's and Shannon-Wiener's indices had much larger values compared to Simpson index (Table 5). According to Smith and Grassle (1977) when the sample size is small many diversity indices do not behave well except for the Simpson diversity index. . This support Smith and Grassle findings but also, eastern Usangu has been severely degraded for a long time before gazettment to Ruaha National Park for restoration in the year 2008.

4.5 Limitations of the Study

1. The method of data collection required a 4WD vehicle for easy accessibility and tracking mammal's movement due to high flight distance , it is likely that some mammals were running away before were observed. This study suggests the use of combination of methods such as dung counts in the subsequent studies.

2. Rainfall disrupted the timing of data collection in the respective seasons because I had to wait until the ground was firm enough for the field vehicle to pass after the rain season. This means, animals that could have been present while it was raining might have been missed.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

A total of twenty three species were observed in the wetland. The most abundant species were mouse, velvet monkeys *(Cercopithecus aethiops)*, impala *(Aepyceros melampus)*, topi *(Damaliscus lunatus)*, and dikdik *(Rhynchotragus kirkii)*. This study shows that generally the abundance of mammals and diversity decreases as distances increases from the edge of the wetland to the drier land i.e., along the hydrologic gradient. This justifies the importance of wetland for the survival of wild animals apart from social, economic and livelihood activities. Thus, the link between the wetlands and terrestrial lands need to be well maintained for sustainable conservation of wildlife.

5.2 Recommendations

1. A long term monitoring of all birds and topi in the wetland is needed. For example, the number of topi has been very low (SMUWC, 2001; WCS, 2006) but this study has observed a significant increase in topi. Also, long term monitoring is needed in order to understand the influence of the pastoralist eviction and determine whether it yielded the desired intention of restoring the wetland from livestock and human impacts.

2. A study on animal's flight distance is very important because it can be established in future if the poaching pressure has decreased since eviction of pastoralists from Usangu.

3. Indirect observation methods for large and small mammals should be used in subsequent studies.

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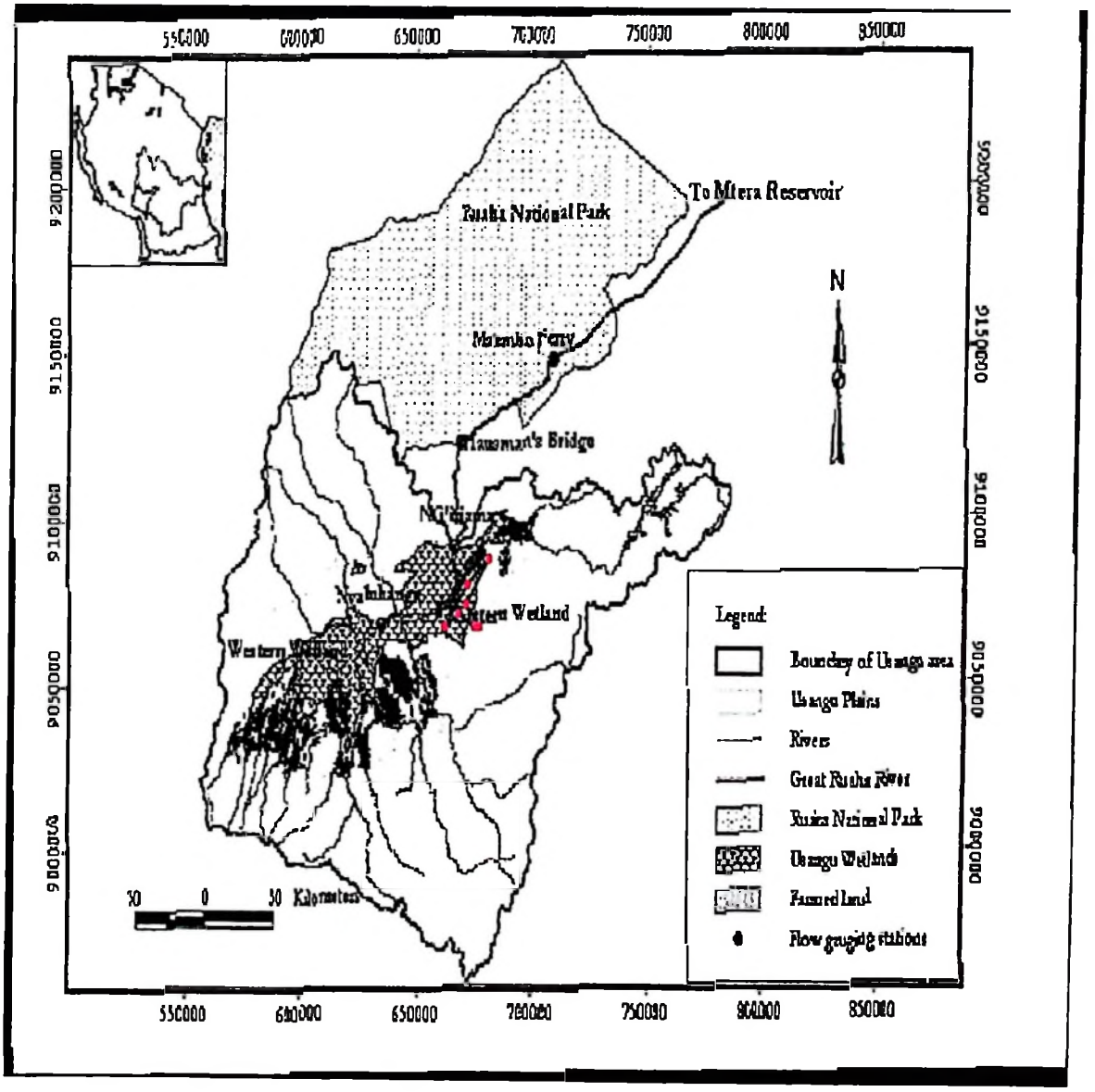
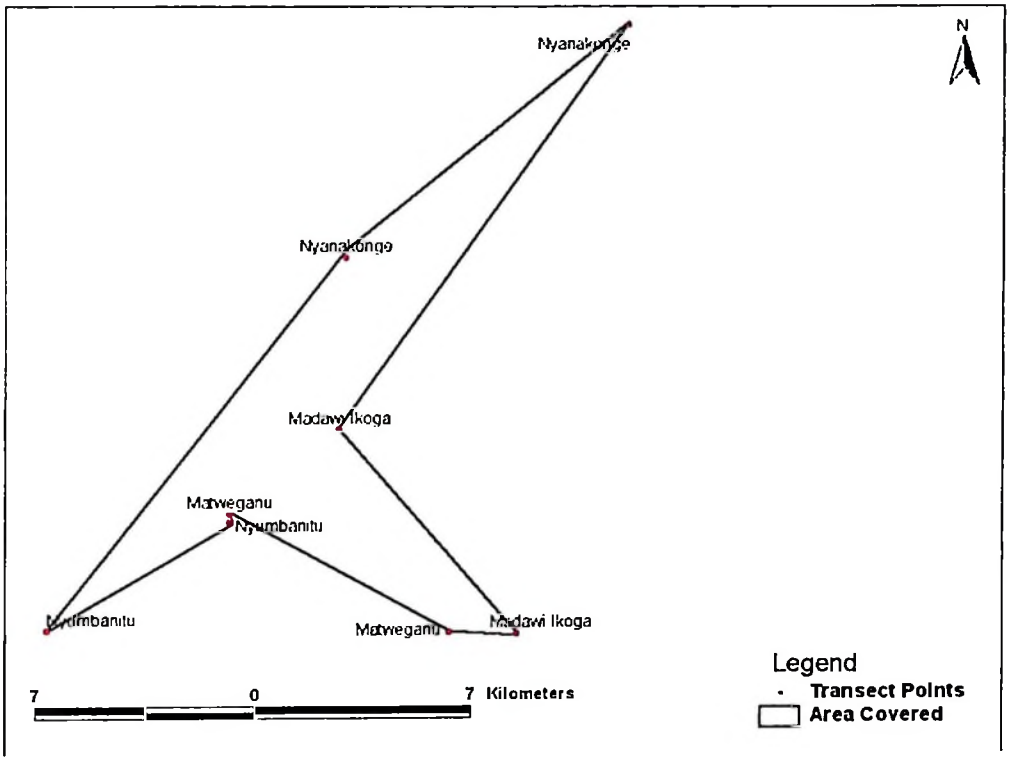
APPENDICES

Appendix 1: Map of the Usangu plains showing different land uses, the Eastern Usangu wetland (the study site) and the transects denoted by red dots



Source: Modified from Kashaigili (2008)

Appendix 2: Area covered and transects surveyed



Appendix 3: UTM coordinates

SN	Eastings	Northings	Names of transects
1	672894	9073828	Madawi Ikoga
2	678708	9067036	Madawi Ikoga
3	669391	9070758	Nyumbanitu
4	663589	9067157	Nyumbanitu
5	669391	9071025	Matwegawanu
6	676491	9067106	Matwegawanu
7	673089	9079534	Nyamakonge
8	682306	9087242	Nyanakonge

Appendix 2: Data sheet

Time	GPS 1	GPS 2	Species	No of individuals	Distant to animal	Angle to animal	Angle of road	Odometer reading	Behaviour
Young (M/F)	Adults (M/F)	Distant from wetland	Rain	% Grass	% Cloud	% Trees	% Shrubs	% Greenness	Human activities

Appendix 3: Rangers interview guide

1. What is your name?
2. What is your job position
3. How long have you been working at Usangu plain especially the eastern part?
4. What changes regarding mammals have you seen since the wetlands were taken by Tanzania National Park Authority?
5. Which mammals do you encounter on your daily patrols?
6. How big are the groups of mammals you encounter?
7. At what distant from the water are they usually found?
8. Which animal were not seen at the beginning but you can see them now and why?
9. Do mammals found in Usangu migrate? If yes from where to where?
10. Do you believe in the future the eastern Usangu wetland will have the mammals that it had before, if yes, why?
11. What other challenges do you face?

Appendix 4: Large mammals known to occur in Usangu

SN	Order/family	English name	*Scientific name*	Swahili name
	Order Primates			
	Family Cercopithecidae	Monkeys		
1		Monkey, Vervet	*Cercopithecus aethiops*	Tumbili
2		Baboon, yellow	*Papio cynocephalus*	Nyani
	Order Carnivora			
	Family Canidae	Jackals, Foxes		
3		Jackal, Black-backed	*Canis mesomelas*	Mbweha
	Mustelidae	Mustelids		
4		Zorilla	*Ictonyx striatus*	Kicheche
	Herpestidae	Mongooses		
5		Slender Mongoose	*Herpestes sanguinea*	Nguchiro
	Hyaenidae	Hyaena		
6		Hyaena, Spotted	*Crocuta crocuta*	Fisi
	Felidae	Cats		
7		Cheetah	*Acinonyx jubatus*	Duma
8		Lion	*Panthera leo*	Simba
9		Leopard	*Panthera pardus*	Chui
	Order Proboscidea			
10	Elephantidae	African Elephant	*Loxodonta africana*	Tembo or Ndovu
	Order Perissodactyla	Odd-toed Ungulates		
11	Equidae	Plains Zebra	*Equus burchelli*	Pudamilia
12	Rhinocerotidae	Black Rhinoceros	*Diceros bicornis*	Kifaru
	Order Tubulidentata			
13	Orycteropodidae	Aardvark	*Orycteropus afer*	Muhanga
	Order Artiodactyla	Even-toed Ungulates		
	Suidae Pigs			
14		Warthog	*Phacochoerus africanus*	Ngiri
15		Bush pig	*Potamochoerus larvatus*	Nguruwe
16	Hippopotamidae	Hippopotamus	*Hippopotamus amphibius*	Kiboko
17	Giraffidae	Giraffe	*Girafa camelopardalis*	Twiga
	Bovidae	Horned Ungulates		

SN	Order/family	English name	*Scientific name*	Swahili name
	Alcelaphinae			
18		hartebeest	*Alcelaphus buselaphus*	Kongoni
19		Wildebeest	*Connochaeates taurinus*	
20		Topi	*Damaliscus lunatus*	Nyamera
	Antelopinae			
21		Impala	*Aepyceros melampus*	Swalapala
	Bovinae			
22		Guffalo	*Cyncerus caffer*	Nyati
23		Eland	*Tragelaphus oryx*	Pofu
24		Bushbuck	*Tragelaphus scriptus*	Bongo
25		Kudu, Greater	*Tragelaphus strepsiceros*	Tandala mkubwa
	Cephalophinae			
26		Duiker	*Sylvicapra grimmia*	Nsya
	Hippotraginae			
27		Roan Antelope	*Hippotragus equinus*	Korongo
28		Sable Antelope	*Hippotragus niger*	Palahala
	Neotraginae			
29		Dikdik	*Rhynchotragus kirkii*	Dikidiki
	Reduncinae			
30		Waterbuck	*Kobus ellipsiprymnus*	Kuru
31		Reedbuck, Bohor	*Redunca redunca*	Tohe

Source: SMUWC, (2001)