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

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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 and a handheld GPS to locate positions. Statistical tests (t-test, Kruskal-Wallis and Pearson's correlation) were employed to determine the association between distance and abundance of animals observed along the gradient. Diversity of mammals along the gradient was determined by a variety of indices using PRIMER 5.0 software. The study revealed that the abundance of animals sighted decreased with distances from the edge of wetland though not statistically significant along the gradient. Flight distances of observed mammals were high indicating higher degree of disturbances related to anthropogenic activities. Indicators of such disturbances in the wetland area included abandoned farms, demolished houses and livestock dung. 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 the wetland is an important refuge area for mammals as both abundance and diversity decreased with increasing distance from the edge of the wetland and increases during the dry season. 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 conservation interventions against anthropogenic disturbances.

INTRODUCTION

Wetlands have been identified as one of the key life support systems. However, it is estimated that half of the world's wetlands have been lost since 1900 (Blumenfeld *et al*., 2009). Wetlands constitute around 1% of Africa's total land area comprising some of the most productive ecosystems in the world (Kabii, 1996; Sielhorst *et al*., 2008). Tanzanian wetlands are considered as 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 (Munishi *et al* 2010, Kilungu and Munishi 2009, Mpemba, 1993; Kabii, 1996; McCartney *et al.* 2007). The swamps of western Tanzania (where Usangu wetlands are found) are believed to be among the wetland areas of highest endemism and of international significance in Africa. Ecologically Usangu wetlands including Ihefu and western wetland are amongst the most valuable ecosystems in Tanzania with tremendous conservation value (McCartney *et*

al. 2007). However, they are not gazetted as a Ramsar site (Franks *et al.* 2004). 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 their degraded state (Mtahiko *et al.* 2006).

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 formerly common in the area. For example, the wetlands were 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). 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 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 be the only individuals remaining in the swamp. The Wildebeest (*Connochaetes taurinus*) has also been extirpated in recent times (SMUWC 2001).

It has been claimed that, throughout the whole area, the original numbers of wildlife were displaced by both people and cattle (SMUWC 2002). Wild mammals are basically gone from nearly one third (1,344 km^2) of the formally known Usangu Game Reserve (Coppolillo *et al.* 2004) which is now gazetted into Ruaha National Park 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) (SMUWC 2001:2002; Franks *et al.* 2004; Mtahiko *et al.* 2006) where the 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*), waterbuck (*Kobus ellipsiprymnus*) and many water birds (Coppolillo *et al.* 2004). 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 (*ibid*).

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 wetlandsbecause animals tend to congregate around wetlands for water, and food (Mpemba 1993). Nonetheless, 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. Also, Said *et al.* (2003) found that livestock and human activities related to water points can negatively affect the distribution and diversity patterns of wildlife. On the other hand, dry lands act as refuge areas for wild mammals in wet seasons (*ibid*). In Usangu a few mammals occur 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). 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).

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 18th, 19th and early 20th centuries and large herds of wild animals were seen roaming around the Usangu plains in the 1950s (SMUWC 2002). For example, it is known that in the 18th Century wild mammals such as impala, zebra, giraffe, elephant, buffalo, eland, hippo, warthog, hyena and silver 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).

The knowledge on population abundance of animals in Usangu associated with changes in the ecosystem is scanty or non-existent. 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. Therefore, this study aimed at assessing the role of Usangu wetlands in supporting mammalian populations of Ruaha National Park including determining species composition of wild mammals in the Usangu wetlands by assessing changes in mammal abundance and diversity along a hydrologic gradient.

Materials and Methods

Study Area

The study was conducted in the Eastern Usangu wetland around the Ihefu swamp (Fig. 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 between about 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.

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. 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.

Data Collection

Primary data collection

Data collection 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 (Table 1).

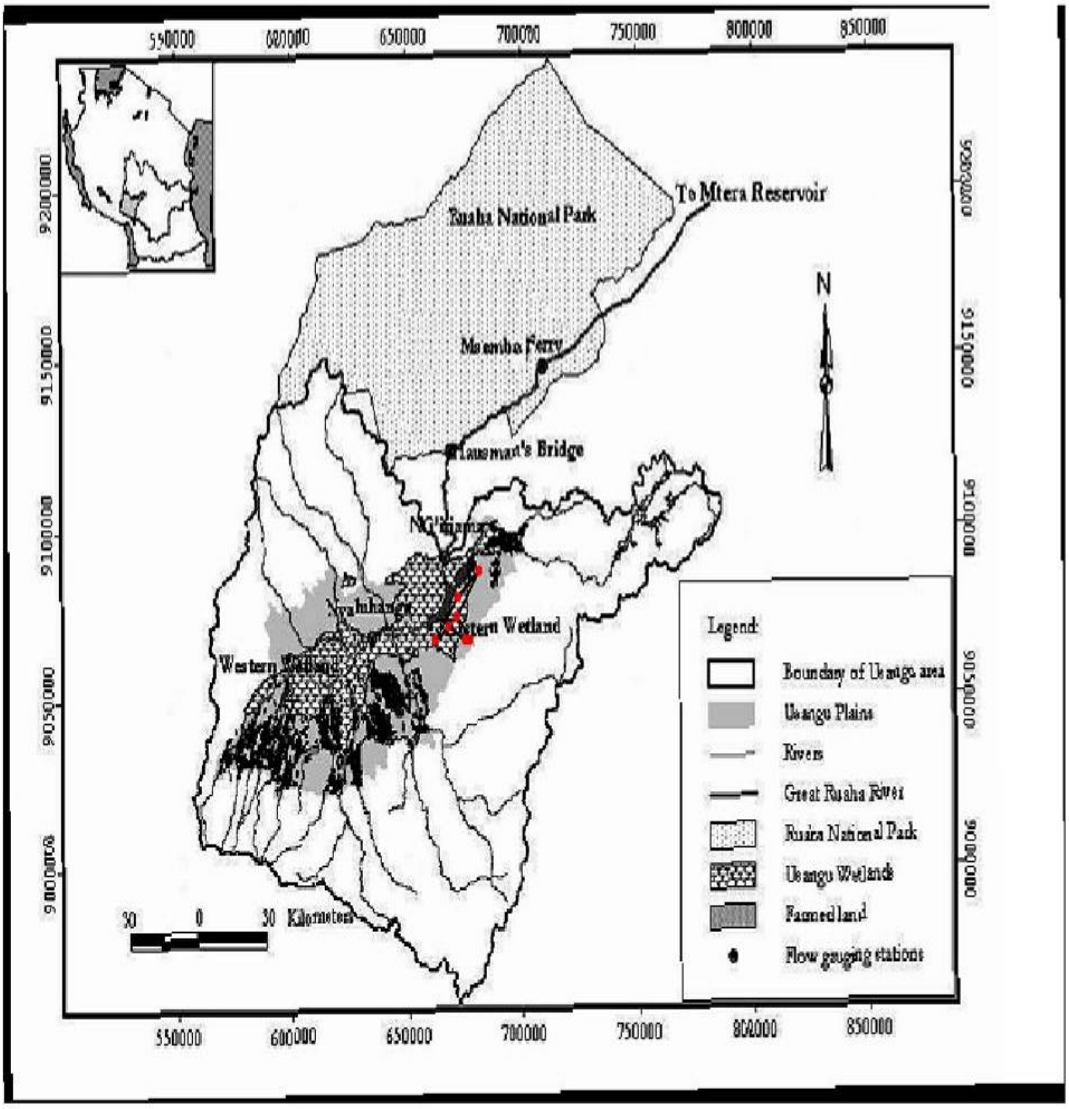

Figure 1: Map of the Usangu plains showing different land uses, the Eastern Usangu wetland (the study site) and the transects denoted by red dots

The total area covered was 7, 971 hectare = 79.71 square kilometres. An open, 4 wheel light duty vehicle was used for data collection with two observers, one on each side and a recorder. An automatic Laser rangefinder was used for measuring perpendicular distances to the observed mammals. Data recorded on a data sheet included, transect number/name, species, number of individuals observed, vegetation type, human activities, odometer readings and distance to animal. Also, park rangers were interviewed in order to track changes in animal abundance and diversity since the park was gazetted into Ruaha National Park.

Table 1: UTM coordinatesfor the sampled areas

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

Data Analysis

DISTANCE 6.0 Program (Thomas, et al., 2009) was used to estimate population abundance of each species. 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 statistics such as chi-square, Pearson's 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.).

Results and Discussion

Mammal Species Composition

A total of 23 mammal species were identified and recorded in all transects (Table 2 & 3). The relative abundance presented in Table 2 was calculated based on density that refers to a quantitative measure of numbers per unit area (Cassey, 1999; Buckland et al., 1993).

Table 2: Mammals species composition and abundance observed in the wetland in the two survey seasons within transect range

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*	Kimbakulanyuki	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 the recorded ones. For example, while only one jackal was observed in one transect, three more jackals were observed out of transect (Table 3). The table shows some of the animals such as warthog that could not be seen on transect during data collection but they exist in Ihefu. It also indicate birds of interest such as the ostrich (*Struthio camelus*) and reptiles such as tortoises (placed in CITES Appendix 2)

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.

Table 3: List of animals observed out of transects in the Usangu flats wetlands Tanzania

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 4 bellow shows the average number of mammal species encountered during daily patrols in and around eastern Usangu wetland yet there were similarities with Table 2. The average was calculated from park ranger's estimates of the animals they usually encounter. Thus, the ranger's reports conform to what was observed in the field using distance sampling method during this study.

Table 4: List of animals that were usually 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 mesomelas*	Mbweha	2	0.018
Buffalo	Bovidae	*Syncerus caffer*	Nyati	10	0.088
Lesser kudu	Bovidae	*Tragelaphus imberbis*	Tandala mdogo	2	0.018

Some of the previously observed mammals 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 the crocodiles and sable antelope. This may probably be attributed to inaccessibility to the swamp by water dependent animals especially crocodiles and hippopotamus.

According to SMUWC (2001), 31 species were observed compared to 23 species (Table 1 and Table 2) 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 the 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).

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

Test statistics for the number of animals observed 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. Given a long history of human disturbance in the wetland, these numbers bring hopes that the restoration plan of the wetland will be successful.

Changes in Wild Mammal 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 (Figure 2).

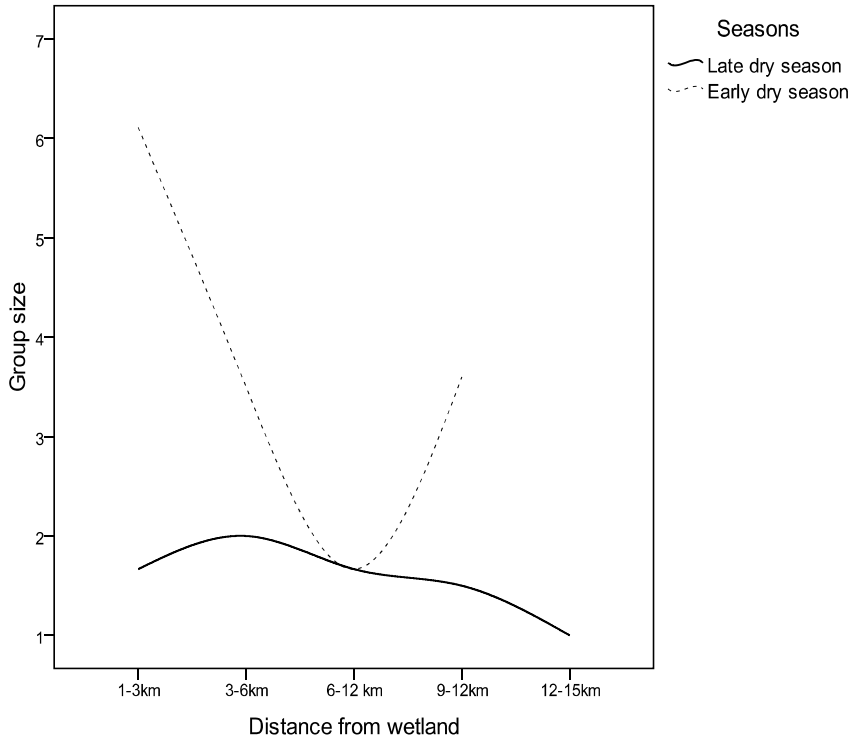

Figure 2: Number of animal along the gradient for the two seasons in the Usangu wetlands Southern Tanzania

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. 2). 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 cattle and goats was seen feeding in the park along Nyamakonge transects. Cow dung were observed everywhere in other transects but homestead and settlements including 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. 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 birds, impala, kudu, bush pig, topi, kudu, zebra, giraffe, hippo, buffalo, elephants, sable antelope, ostriches, 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.

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 2: Mammals diversity along a hydrologic gradient in the Usanngu wetlands Tanzania

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) were compared and the trend show that generally, 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.

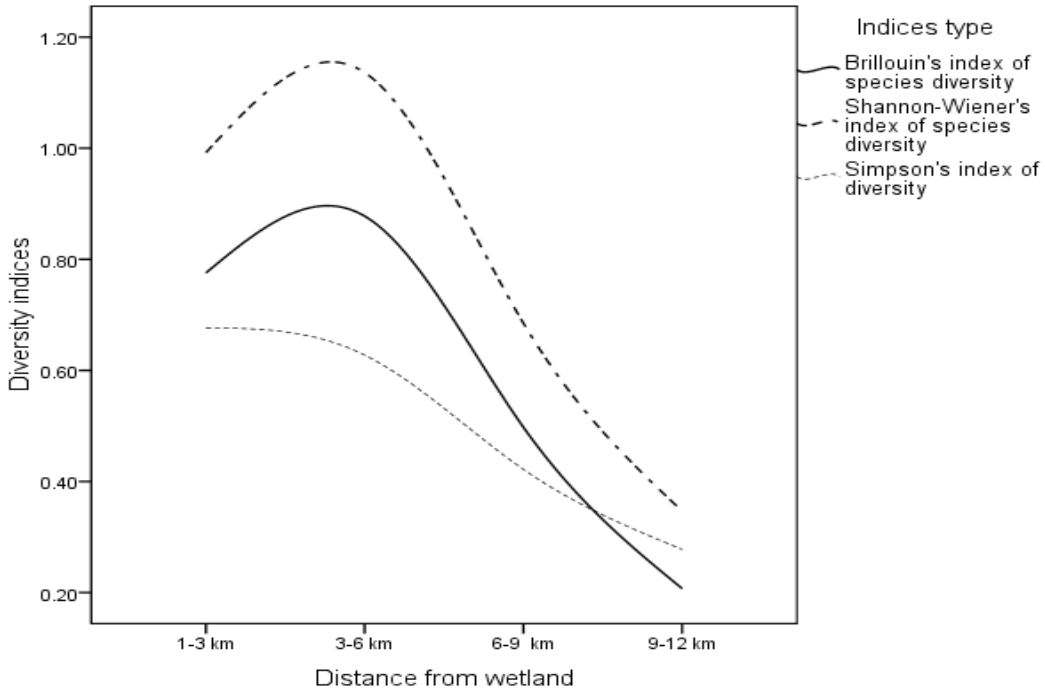

Figure 3: Diversity indices for mammals along the hydrologic gradient in the Usangu Wetlands Tanzania

Due to small sample size, Simpson diversity index was used to represent diversity of mammals in the Usangu because Brillouin's and Shannon-Wiener's indices had much larger values (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 gazettement to Ruaha National Park for restoration in the year 2008.

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 and diversity of mammals decreases as distances increases from the edge of the wetland to the drier inland 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 in wetland ecosystems.

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.

2. 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.

3. A study on animal's flight distance is very important because it can help establish the poaching pressure since eviction of pastoralists from Usangu wetlands.

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

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