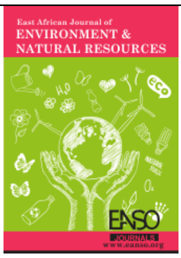

East African Journal of Environment and Natural Resources
eajenr.eanso.org
Volume 7, Issue 1, 2024
Print ISSN: 2707-4234 | Online ISSN: 2707-4242
Title DOI: https://doi.org/10.37284/2707-4242

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Relationships between Anthropogenic Activities and Distribution of Medium to Large Mammal Species Assemblage in Madi Wildlife Corridor: Implication for Biodiversity Conservation in Uganda

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Article DOI: https://doi.org/10.37284/eajenr.7.1.1908

Date Published:

04 May 2024

Keywords:

Wildlife Corridor, Mammal Assemblage, Habitat Types, Poaching Threats.

ABSTRACT

Wildlife corridors between protected areas increase connectivity by integrating populations into single demographic units, thereby increasing gene flows within populations and thus probability of survival. This study assessed the relationship between anthropogenic activities and mammal species assemblage within and around Madi wildlife corridor. The study adopted recce walks along a zig-zag line transect and straight line transect methods of game tracking. Global Position System (GPS) was used to map locations of direct mammal sightings, vocalizations, tracks, dung/droppings, diggings, carcasses, and skeletal remains of mammal species. Similarly, anthropogenic activities such as hunting using bow and arrows, rifles, trapping, tree cutting, charcoal burning, bush burning, cultivation, and settlements that seemed to influence assemblage of the mammals in the area of study were mapped. The result showed that the Madi wildlife corridor still contained diverse mammal species including but not limited to; the African Elephants (Loxodonta Africana sp.), Buffaloes (*Syncerus caffer*) Leopards (Panthera pardus), Spotted Hyena (Crocuta Crocuta), Northern Giraffe (Giraffa Camelopardalis), Uganda kob (Kobus kob thomasi), Hartebeest (*Alcelaphus buselaphus*) and Reedbuck (*Redunca arundinum*), which were comparable to that of the adjacent Murchison Falls National Park (MFNP). The relationship between anthropogenic activities and species assemblage showed a negatively skewed distribution of some of the large mammal species specifically Elephants, Giraffes, and Hippopotamus. The study recommends gazettement of a wildlife corridor between MFNP and East Madi Wildlife Reserve to promote wildlife connectivity between two adjacent ecosystem-protected areas in northern Uganda. As a long-term strategy for wildlife conservation, it is crucial to undertake a systematic assessment and prioritization and demarcation of wildlife corridors and development of a comprehensive action plan for securing them. We further recommend development of a national Wildlife Corridor Regulations to provide a framework for the sustainable conservation of biodiversity.

Article DOI: https://doi.org/10.37284/eajenr.7.1.1908

APA CITATION

Andama, E, Bemigisha, J. & Remigio, T. (2024). Relationships between Anthropogenic Activities and Distribution of Medium to Large Mammal Species Assemblage in Madi Wildlife Corridor: Implication for Biodiversity Conservation in Uganda. *East African Journal of Environment and Natural Resources*, *7*(1), 124-140. https://doi.org/10.37284/eajenr.7.1.1908.

CHICAGO CITATION

Andama, Edward, Jane Bemigisha and Turyahabwe Remigio. 2024. "Relationships between Anthropogenic Activities and Distribution of Medium to Large Mammal Species Assemblage in Madi Wildlife Corridor: Implication for Biodiversity Conservation in Uganda". *East African Journal of Environment and Natural Resources* 7 (1), 124-140. https://doi.org/10.37284/eajenr.7.1.1908.

HARVARD CITATION

Andama, E, Bemigisha, J. & Remigio, T. (2024) "Relationships between Anthropogenic Activities and Distribution of Medium to Large Mammal Species Assemblage in Madi Wildlife Corridor: Implication for Biodiversity Conservation in Uganda", *East African Journal of Environment and Natural Resources*, 7 (1), pp. 124-140. doi: 10.37284/eajenr.7.1.1908.

IEEE CITATION

E., Andama, J., Bemigisha & T., Remigio. "Relationships between Anthropogenic Activities and Distribution of Medium to Large Mammal Species Assemblage in Madi Wildlife Corridor: Implication for Biodiversity Conservation in Uganda", *EAJENR*, vol. 7, no. 1, pp. 124-140, May. 2024. doi: 10.37284/eajenr.7.1.1908

MLA CITATION

Andama, Edward, Jane Bemigisha & Turyahabwe Remigio. "Relationships between Anthropogenic Activities and Distribution of Medium to Large Mammal Species Assemblage in Madi Wildlife Corridor: Implication for Biodiversity Conservation in Uganda". *East African Journal of Environment and Natural Resources*, Vol. 7, no. 1, May 2024, pp. 124-140, doi:10.37284/eajenr.7.1.1908.

INTRODUCTION

Wildlife corridors are strips of habitats or natural land that serve to connect otherwise isolated habitat patches that were once connected in historical times (Saunders & Hobbs, 1991; Ogden, 2015). Since the emergence of conservation biology in the 1970s, the concept of wildlife corridors has been advocated as a means to reconnect fragmented landscapes, protect biodiversity, and maintain population integrity (Ogden, 2015). Wildlife Corridors have been proven to be key for connecting isolated habitats to enable plants and animals to disperse or migrate from one habitat to another. They also play an important role in habit networks which consist of a collection of patches linked by a series of corridors and operate on a range of spatial scales to provide the opportunity to increase connectivity across ecosystems (Vuilleumier & Prělaz-Droux, 2002). The benefits of wildlife corridors include among others increasing additional habitat within the landscape in terms of area and resources available to the populations for breeding and thus increasing populations (Newmark, 1993). Historically, northern Uganda where this study was undertaken used to provide one large extensive wildlife habitat where animals roamed, with minimal human interference (Rwetsiba and Wanyama, 2005). However, as human populations increased with time, the landscape became increasingly fragmented due to settlements and farming activities.

During the Lord's Resistance Army (LRA) civil unrest of more than two decades (1987-2008), the local community in rural areas of northern Uganda who settled within the belt of the "Madi Wildlife Corridor" were moved to Internally Displaced Persons (IDPs) camps. This resulted in "Madi Wildlife Corridor" areas that were previously impoverished of wildlife to regenerate and rebuild wildlife populations (Nampindo et al., 2005). The peace and development prospects for Northern Uganda improved from 2006 when the Government of Uganda signed a cessation of hostilities agreement with the Lord's Resistance Army (LRA) under their leader Kony. This resulted in progressive prospects for long-term peace in the region as a whole. The relative peace enabled the persons living in IDPs to return to their previous villages to resume settled life. The challenge associated with resettlement was how to ensure sustainable utilization of the regenerated rich natural resources and biodiversity that recovered during the insurgency to enhance livelihood and sustainable development of the local community in the region.

Article DOI: https://doi.org/10.37284/eajenr.7.1.1908

"Madi Wildlife Corridor" lies between Murchison Falls National Park (MFNP) and East Madi Wildlife Reserve (EMWR) and consists of the former Aswa-Lolim Game Reserve (ALGR) and Kilak Community Hunting Area (KCHA). This area formed a continuous habitat or corridor that enabled wildlife movements and dispersal between MFNP and EMWR. However, these two previously protected areas (ALGR and KCHA) were degazetted in the 1970s by the Government of Uganda under Idi Amin Dad government and converted to individual and community members for farming. As such there is currently no legal existence of the Madi Wildlife Corridor. According to Lamprey et al. (1999) before degazettement, ALGR and KCHA were rich in wildlife resources and they acted as corridors for wildlife dispersal between MFNP, EMWR, and Zoka Central Forest Reserve (ZCFR). The lack of legal status and protection of the Madi Wildlife Corridor made many opportunistic individuals start settlement activities in the corridor as the communities from IDPs returned to use the land. This increased land degradation activities in the area, posing constraints to the initiation of any conservation programs.

Mammals are the backbone of a thriving ecosystem, playing a crucial role in nutrient cycling, plant recruitment, pollination, and seed dispersal (Doughty et al., 2016). In addition, they fulfill numerous human needs, including clothing, food, and spiritual values. But unfortunately, mammals are facing severe threats such as habitat loss, overexploitation, competition from invasive species, and climate change (Pacific et al., 2017). The extinction of these animals in protected areas can cause unforeseeable harm to the ecosystem, which is why it's crucial to document and monitor mammalian species in and around protected areas, especially focusing on the connecting corridors. This information is used for planning effective conservation and management activities that will safeguard these creatures for generations to come (Nichols & Williams, 2006). Mammals are one of Northern Uganda's most important and elegant tourist attractions.

Mammalian species are indicators and umbrella species of terrestrial ecosystems (Agebo and Tekalign 2022) because they help conserve other species and maintain ecosystem balance (Jorgensen and Ostanza 2005). Particularly, medium and large-sized mammals are good indicators of ecosystem health in savannah woodland communities (Larsen 2016). However, the mammals are under threat from growing human pressure, habitat loss, and migratory route loss. As a result, there is a lack of connectivity among ecological reserves and conservation areas, which is essential for population interactions (Corsa, 2022). Communities in Northern Uganda are culturally known for hunting of the mammal species, reducing their population and threatening to cause the extinction of some species which indirectly reduces the national foreign exchange earnings from tourism activities (UNDP/NEMA/UNEP, 2009). There is currently no comprehensive assessment of the status of mammal species in the Madi Wildlife corridor. This study focused on the assessment of the status of medium to large mammal species and distribution of human activities within the corridor because understanding the distribution and abundance of these mammal species across the range of spatial scales is critical for designing sustainable ecological corridors to support fundamental connections between niches of wildlife species (Harte, 2008). We hypothesized that occurrence and distribution of Madi corridor mammal species were likely to be affected by anthropogenic factors. The results of this study could provide the basis for designing wildlife corridors for restoring and conserving Uganda's rich natural heritage, which is urgently needed to ensure the ecological integrity of Uganda's protected area system and sustainable conservation of biodiversity.

MATERIALS AND METHODS

Study Area

Madi Wildlife Corridor lies on the eastern side of the Albert Nile and is bordered to the South by MFNP, to the North by EMWR, to the West by River Nile (Albert Nile), and to the East by the

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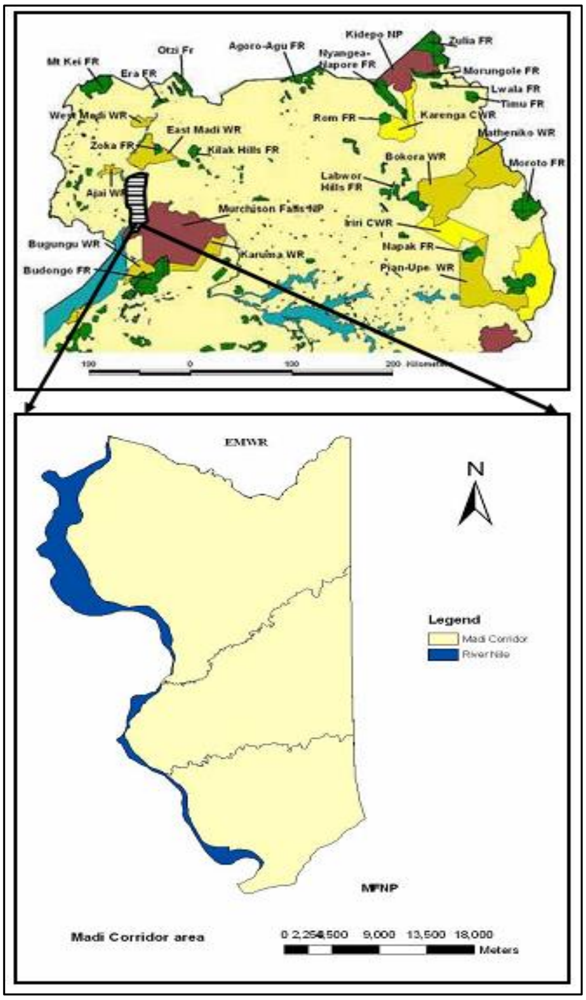
settlement of local communities (Owiunji, 2013). It is located between 2º 26” to 2º 56” N and 31º 30” to 31º 26” E in Nwoya and Amuru districts (figure 1) and within three sub-counties of Purongo, Alero and Amuru (UN-OCHA, 2007). The altitude ranges from about 600 meters above sea level along the shores of the river Nile to about 1005 meters at the top of Ojigo and Banya hills. The area consists of undulating/rolling hills with both woodland vegetation and open grassland. The climate of the region is typically hot and humid (average Relative Humidity of 60%), with a mean minimum temperature of 22^{0}C and a mean maximum of 29^{0}C. High temperatures are recorded during the December-March dry season (Oneka, 1996). The climate of the region is characterized by a bimodal rainfall pattern (White, 1990; Olivier, 1992). Mean annual rainfall in the eco-region ranges between 1000 mm to 1250 mm with the wettest months being March to June and August to November. The remaining months are mainly dry (Oneka, 1996). Geological formations of the area reveal the geology and soil system is underlined by pre-Cambrian rocks, which comprise Cenozoic rocks of Pleistocene to recent (Minai, 2015).

Figure 1: Figure 1: Location of Madi Wildlife Corridor between Murchison Falls National Park (MFNP) and East Madi Wildlife Reserve (EMWR).



Data Collection

Mammal Sampling, Location, and Identification

This study focused on the medium and large-sized mammal communities of the Madi corridor. Medium size mammals are those whose body weight is between 2 and 5 kg, and large-size mammal species are those with over 5 kg body mass (Njoroge et al., 2009). The signs left by the animals such as pugmarks/footprints, dung/dropping/scat, and other signs (scra, scent marks, etc) are reliable indicators of animal presence and have frequently been used for estimating abundance (Bhattarai & Kindlmann 2012). The mammals were surveyed by both direct observation method and indirect using their signs. For direct observations, the group size of the ungulates was recorded with their age and sex composition. Field sampling of mammals was carried out daily for 14 days from 7th-21st January 2009 during the dry season when the vegetation was mostly burnt, and it is easier to detect and identify mammal species with ease from their signs.

Mammal sampling adopted two methods i.e. Recce walks and straight-line transects to obtain animal presence, distribution, and abundance data. The survey route followed approximately zigzag format, starting from the southern part, bordering MFNP to the North (*Figure 2*). Daily distance covered ranged from 8.5 to 21.5 km. The location of the start and end of each transect was recorded using a GPS unit and waypoints were taken at regular intervals of approximately 250 meters along the survey route. Mammal sampling was carried out during the day from dawn (6: 00 am) to about noon when animals were most active.

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The evening census was between 15:00 hours and 18:30 hours. Each time an animal was detected, the perpendicular distance at the point of first detection of the animal was measured using an optical range finder.

Mammal, Identification, and Counting

The number of individuals in the groups in each survey route during each sampling time was counted and the GPS locations of animal sightings were recorded. Fresh spoors consisting of scats, dung, and dung pellets that were easily associated with particular mammal species were used to identify the species using a mammal field guide (Stuart and Stuart, 1997). The signs left by the mammals were observed at regular intervals of 50m distance, by developing the quadrates of 10×10 m to determine the presence or absence. The scats or dung pellets were identified using field guides to mammal signs by Louis (1992), Chris and Tilde (2000, 2008), and Clive (1996). The GPS waypoints for each observation were recorded together with habitat type. Footprints or spoors, hairs, and diggings in soft soil with clear markings which were easy to identify to a particular animal species were recorded. Additional information collected during the survey included skeletal remains (skull and other bones) or carcass remains of the animals and soil excavation signs by the wild animals.

Assessment of Anthropogenic Activities/Disturbance

Common signs of human disturbance recorded included poaching using snares, traps, hunting spears, fireplaces, camp sites, resource extractions, and evidence of animal skins and bones left by poachers at the kill sites. Evidence of freshly used shotgun shells/cartridges along the transect were recorded together with gunshots that were heard during the walks. Other human activities recorded were settlements (huts), farmlands, and community access roads or paths to the newly established homesteads and farms, fishing, logging /canoe-making sites, thatch and broom grass collection, pole collection, collection of firewood, charcoal making, collection of wild rope, fruits, honey, medicinal plants among others. For each encounter of human activity, the type of evidence (including description), and distance to transect and GPS points were recorded.

Data Analysis

The collected data were used to estimate the presence/absence, abundance, and distribution patterns. Correlation and simple regression analysis model was used to investigate the relationship between the relative abundance of mammals and the level of human activities in the study area. We used Simpson's Index $\lambda = \sum \frac{n(n-1)}{N\ (N-1)}$ to measure mammal species dominance. Where n_i = number of individuals or amount of each species (i.e. number of individuals of the ith species) and total number of individuals for the site.

RESULTS

Mammal Assemblage

Eighteen mammal species were sighted during the study (*Table 1*) in the area. Additionally, twelve species were recorded from spoors and skeletal remains (*Table 2.*), giving a total of 30 species recorded in the area. The most common and easily associated forms of animal identification were dung pellets, scats, and footprints. Other animal species that were opportunistically recorded included Python, Goliath heron, Black-headed Gonolek, helmeted guinea fowl, crested francolin, osprey, and African fish Eagle. The abundance in terms of the number of animals sighted or spoors recorded in the transects and their relative species dominance index are presented in *Table 1* and *2*.

The distribution pattern of the large mammal species using both sighting and spoor records is shown in *Figure 1*. Elephants, giraffes, hippopotamus were fewer and mostly restricted to the southwestern part of the study area which was close to both MFNP and the River Nile. Only buffaloes occurred widely (*Figure 3*). The medium-sized mammals such as Bushbuck, Uganda kob, hartebeest, waterbuck, and warthog occurred more widely in the study area (*Figure 4*).

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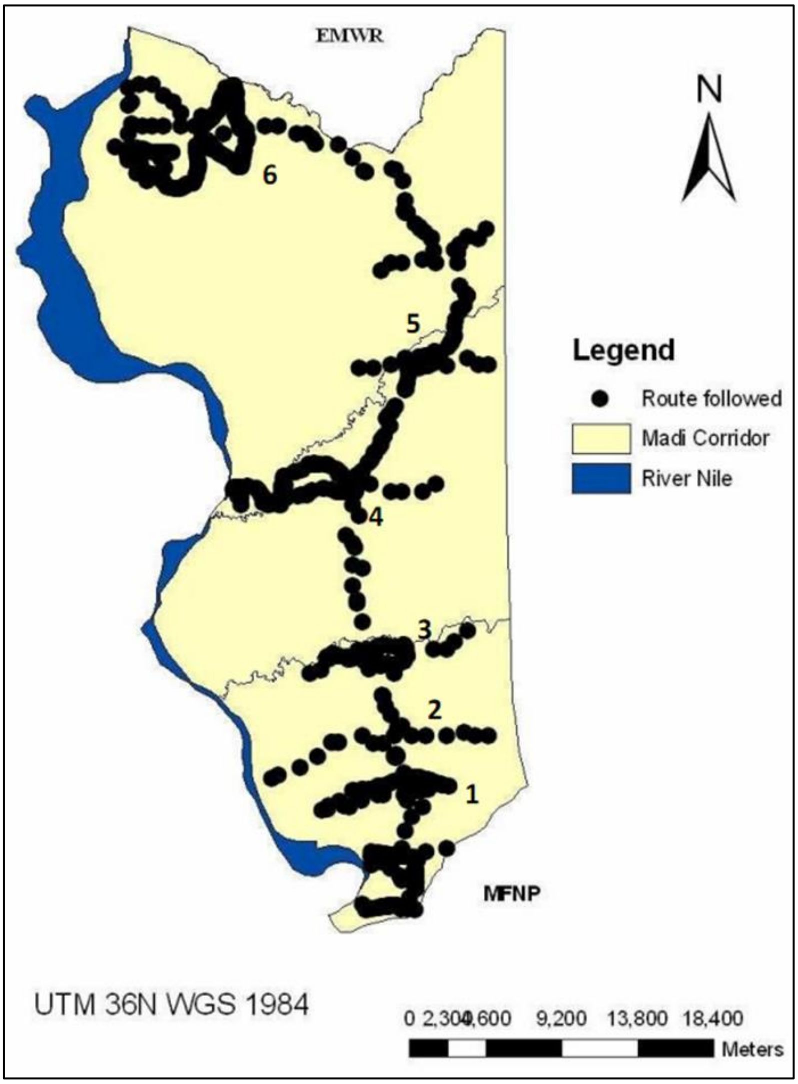
Other species widely distributed were black and white Colobus monkeys, baboons, and vervet monkeys (*Figure 4*.). of the primate species baboons were the most sighted species during the study followed by black and white colobus monkeys (*Table 1*). This suggests that baboons were the most successful species in the area based on the high value of Simpson's Index while the rest of the species had a low value (*Table 1*). It was however noted that the sighting frequency and recording of spoors of these species generally increased from south to north of the study area. Similarly, from the spoor and sighting evidence of species such as duiker, reedbuck, Oribi, and aardvark (*Figure 6*) were fairly uniformly distributed in the area although overall fewer records were made. The distribution of spoors of the carnivore species such as spotted hyena, leopard, side-striped Jackal and serval cat was scanty (*Figure 7*). Leopard spoors were recorded more along riverine forest habitats of river Lakang along the boundary with EMWR and river Omee. Hyena evidence was only recorded near Omee river. The small-sized mammal species, especially the squirrels, crested porcupines; Craw Shay's hare, cane rat, and giant rats were sparsely distributed. Mongoose species (banded, Egyptian, and Slender) were mostly recorded in the open grassland or farmed areas (*Figure 8*). Pangolin evidence was only recorded from the skeletal remains.

Figure 2: Locations of the survey route followed during the study



Sampling sites:

1 = Gotapwoyo

2 = Akwei

3 = Ashwa river

4 = Omee1 River

5 = Omee 2 river

6 = Oforo village

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Table 1: Encounter rate expressed as number of animals sighted per kilometer distance covered (total distance covered was 86.7 km) and Simpson's Index to λ**.**

Common name	Scientific name	Number of animals sighted per kilometer per campsite						Av. sighting per km	Total number sighted	Simpson's Index to λ
		1 (10.4 Km)	2 (13.9 km)	3 (8.5 km)	4 (17.7 km)	5 (21.2 km)	6 (15.0 km)			
African bush elephant	*Loxodonta africana*	1.83	0.00	0.00	0.00	0.00	0.00	0.21	19	0.000601
Common Duiker	*Sylvicapra grimmia*	0.19	0.14	0.12	1.19	0.05	0.00	0.31	27	0.001233
African Buffalo	*Syncerus caffer*	0.09	0.00	0.00	0.00	0.05	0.00	0.02	2	0.000035
Waterbuck	*Kobus ellipsiprymnus*	0.09	0.07	8	0.11	0.14	0.13	0.20	17	0.00477
Warthog	*Phacochoerus africanus*	2.88	0.00	0.00	0.06	0.05	0.07	0.07	6	0.000052
Uganda Kob	*Kobus kob thomasi*	0.18	0.00	0.24	0.45	0.85	1.45	0.61	53	0.004841
Bush buck	*Tragelaphus sylvaticus*	0.09	0.14	0.24	0.23	0.28	0.26	0.22	19	0.000601
African Savanna Hare	*Lepus microtis*	0.09	0.00	0.00	0.00	0.00	0.07	0.02	2	0.000035
Olive Baboon	*Papio anubis*	1.25	0.00	8.00	7.11	2.17	7.13	4.15	360	0.227027
Mongoose (Egyptian)	*Herpestes ichneumon*	0.00	0.07	0.00	0.00	0.00	0.00	0.01	1	00000
Vervet monkey	*Chlorocebus pygerythrus*	0.00	0.288	2.82	5.00	0.19	1.13	0.62	54	0.005027
B&w colobus monkey	*Colobus guereza*	0.00	2.01	4.82	1.41	0.42	4.06	1.89	164	0.046958
Hartebeest	*Alcelaphus buselaphus*	0.00	0.00	0.00	0.00	0.09	0.6	0.13	11	0.000193
Bush pig	*Potamochoerus porcus*	0.00	0.00	0.24	0.17	0.19	0.13	0.13	11	0.000193
Reedbuck	*Redunca arundinum*	0.00	0.00	0.00	0.00	0.05	0.13	0.03	3	0.000011
Ground squirrel	*Xerus erythropus*	0.09	0.00	0.00	0.06	0.00	0.00	0.02	2	0.0000035
Oribi	*Ourebia ourebi*	0.00	0.00	0.24	0.06	0.00	0.13	0.03	3	0.000011
Crested porcupine	*Hystrix cristata*	0.09	0.00	0.00	0.11	0.00	0.00	0.02	1	0000000
Total									755	

Sites: 1 = Gotapwoyo, 2 = Akwei, 3 = Ashwa River, 4 = Omee1 River, 5 =Omee 2 river, 6= Oforo village

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Figure 3: Large mammal species distribution.

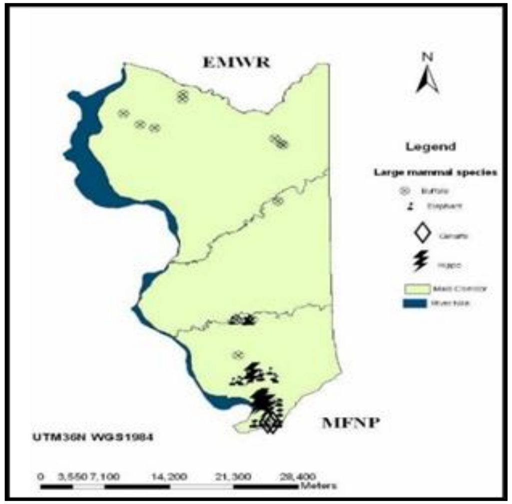

Figure 4: Medium sized mammal species distribution

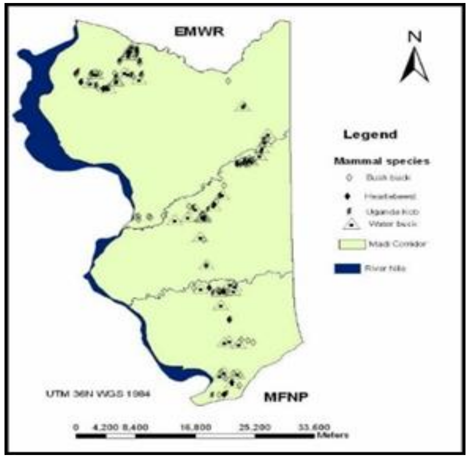

Figure 5: Primate species distribution

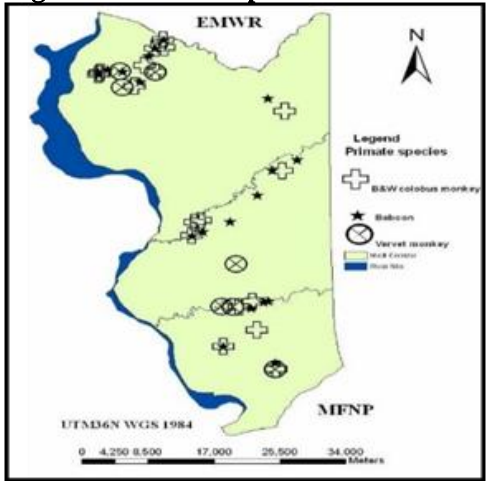

Figure 6: Large mammal species distribution

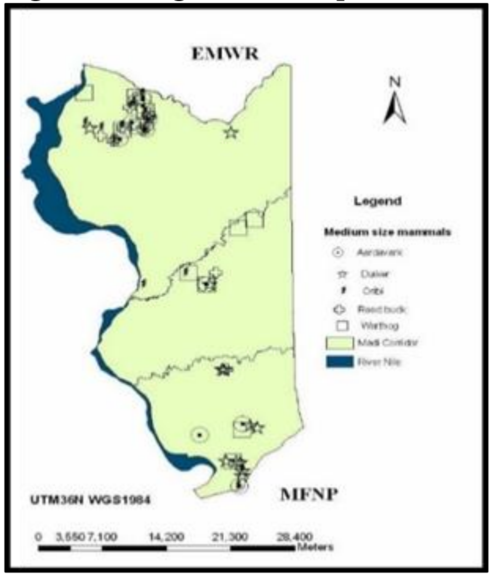

Figure 7: Carnivore species distribution

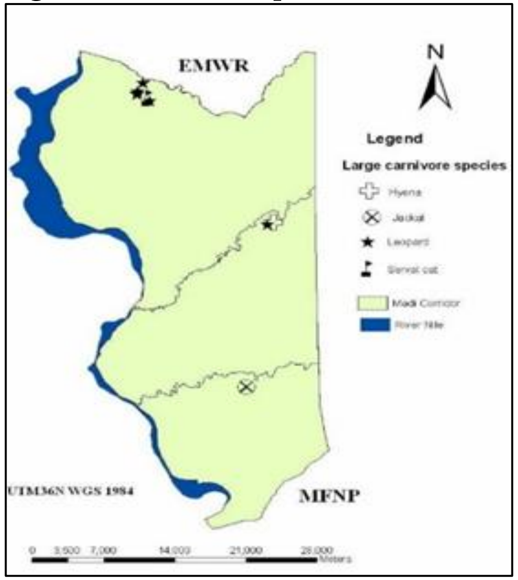

Figure 8: Small mammal species distribution

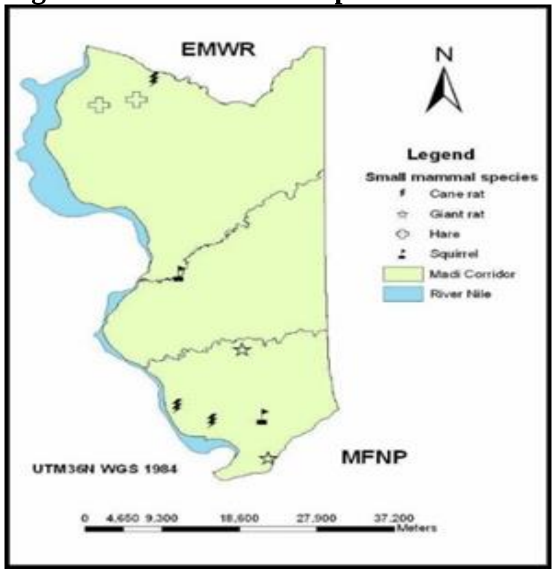

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Table 2: Record of animal evidence from spoors (dung, tracks skeletal and footprint).

s/n	Animal species	Scientific name	Number of sightings per Site						Total
			1	**2**	**3**	**4**	**5**	**6**	
1	African bush elephant	*Loxodonta africana*	18	17	0	0	0	0	35
2	Bush Duiker	*Sylvicapra grimmia*	11	1	4	3	5	2	26
3	Buffalo	*Syncerus caffer*	4	0	5	1	2	5	17
4	Waterbuck	*Kobus ellipsiprymnus*	16	11	15	13	10	30	95
5	Warthog	*Phacochoerus africanus*	1	3	2	3	2	6	17
6	Uganda Kob	*Kobus kob thomasi*	3	0	2	7	27	40	79
7	Bush buck	*Tragelaphus sylvaticus*	18	7	11	22	13	27	98
8	Hippopotamus	*Hippopotamus amphibious*	6	2	0	0	0	0	8
9	Aardvark	*Orycteropus afer*	1	3	0	3	0	8	15
10	Giant rat	*Cricetomys emini*	2	0	1	0	1	0	02
11	Side Striped Jackal	*Canis adustus*	0	0	0	1	0	0	1
12	Serval cat	*Leptailurus serval*	1	0	0	0	0	0	1
13	Oribi	*Ourebia ourebi*	2	0	0	2	1	11	16
14	Hartebeest	*Alcelaphus buselaphus*	2	0	3	0	3	7	15
15	Northern Giraffe	*Giraffa Camelopardalis*	2	0	0	0	0	0	2
16	Cane rat	*Thryonomys swinderianus*	1	2	1	2	5	2	13
17	African Savanna Hare	*Lepus microtis*	2	0	2	0	1	1	6
18	Olive Baboon	*Papio Anubis*	4	3	3	8	6	13	37
19	Bush pig	*Potamochoerus porcus*	0	2	8	28	7	22	67
20	Slender Mongoose	*Galerella sanguinea*	0	1	0	1	2	0	4
21	African Leopard	*Panthera pardus*	0	0	0	0	1	9	10
22	Hyena	*Crocuta Crocuta*	0	0	0	0	1	0	1
23	Reedbuck	*Redunca arundinum*	0	0	1	0	0	13	14
24	Banded mongoose	*Mungos mungo*	0	0	0	0	2	0	2
25	Crested porcupine	*Hystrix cristata*	0	0	0	0	2	1	3
26	Cape Pangolin	*Smutsia temminckii*	0	1	0	0	0	0	0

Sites: 1 = Gotapwoyo, 2 = Akwei, 3 = Ashwa river, 4 = Omee1 River, 5 =Omee 2 river, 6= Oforo village

Distribution of Anthropogenic Activities

The encounter rates and distribution of various human activities taking place in the area are indicated in *Figures 9* and *10 respectively*. The most common activities were trapping wild mammals using wire snares and snap traps, cutting of trees for poles, firewood, and thatch grass collection. Specifically, there was a higher level of wire snare traps in the southern part while there was a higher use of snap traps in the northern areas. Tree cutting, thatch grass collection, and charcoal making were more rampant in the southern part (i.e. sites Gotapwoyo and Akwei) as compared to other sites. The general trend of human activity increased from the southern part towards the northern (*Figure 11*). Human activity signs were common along River Nile probably because of being close to the fishing communities to the west of the River Nile (Madi and Alur tribes) who often crossed the Nile to collect firewood or hunt animals and cultivate crops. Three large fishing villages were recorded along River Nile and four temporary fishing sites were recorded along Aswa and Omee rivers.

The main anthropogenic activities were poaching wild animals using traps (wire snares and large-size antelope snap traps), hunting using bows/arrows, and automatic rifle and fishing. Collection of thatch grass (*Hyparrhenia* species), tree cutting for firewood or poles for housing, and lumbering (sawing timber for sale) very the most commonly encountered activities. Charcoal making and cultivation were more common in the southern part and along the periphery of the study area. Bush burning facilitated hunting of cane rats and this was one of the most rampant activities during the dry season. Evidence of hunting activity included campsites, fireplaces and remains of empty shot gun shell/bullet cartridges and carcasses of mammal species. Settlements were more common in the southern part of the study area.

East African Journal of Environment and Natural Resources, Volume 7, Issue 1, 2024
Article DOI: https://doi.org/10.37284/eajenr.7.1.1908

Figure 9: Encounter rates of human activities recorded in various sites in the study area.

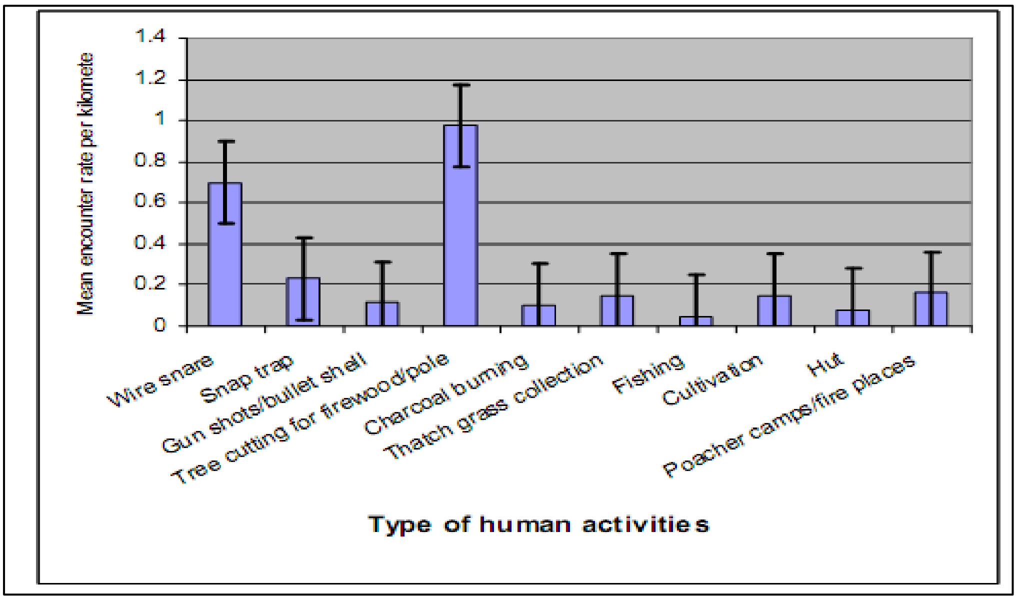

Figure 10: Distribution of human activities in the study area

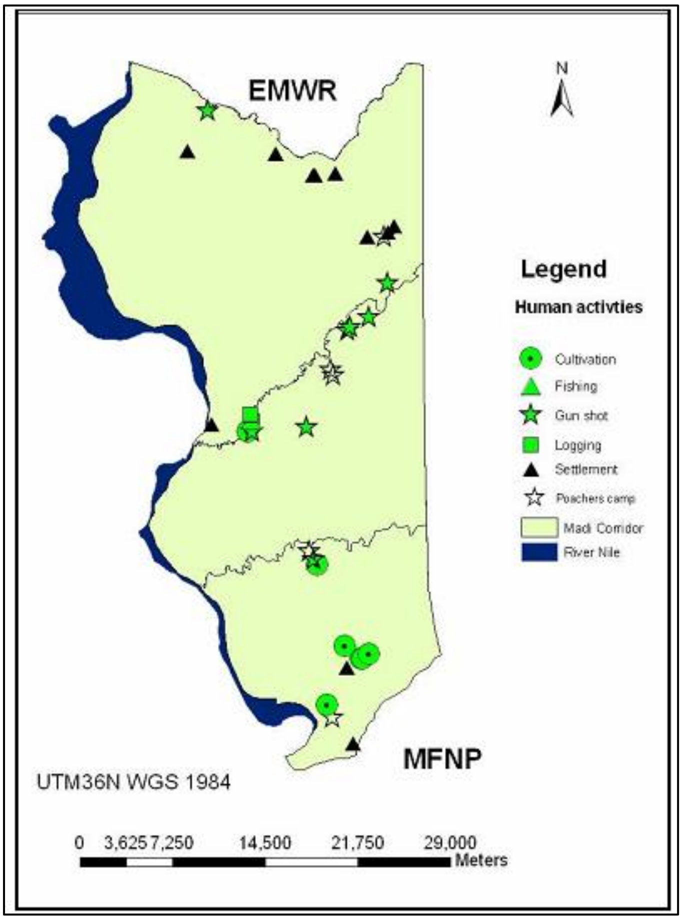

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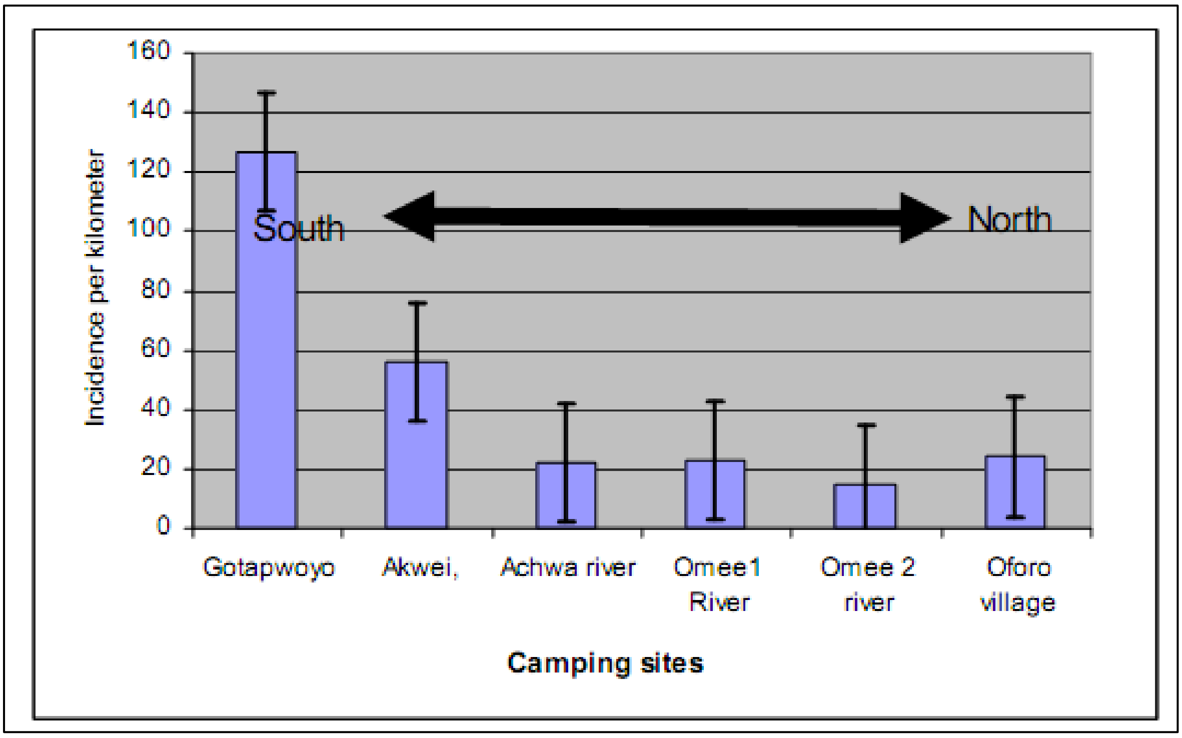
Figure 11: Pattern of human disturbance activities per kilometre along the study sites from south to the north discretion.



Relationship between Anthropogenic Activities and Mammal Distribution

Generally, there was a highly positive correlation between the distribution of elephants and duiker with the occurrence of human activities (*Table 3*). The positive relationship was probably because during the time of this study elephants and giraffes migrated mainly from the nearby MFNP which is adjacent to the degraded part of this study area. While duikers appeared to thrive well and exploited the degraded, more open wooded grassland vegetation. For the rest of the species e.g. waterbuck, Uganda kob, oribi, baboon, bush pigs, hartebeest, and leopard the relations ship was negative. This suggests that these species may be negatively affected by human activities. An assessment of the contribution of human activity to the occurrence of mammal species using simple regression analysis indicates that it contributes to various degrees to the species occurrence (*Table 3*). For example, for elephants, bushbuck, bush pigs, Uganda kob, and duiker the contribution varies from 34% to 75% (*Table 3*). This suggests that various human activities can significantly impact on occurrence of animal species in the area.

Table 3: Spearman's rank correlation (rs) and regression analysis (r^2) tests comparing the incidence of human activity with an index of animal signs in Madi Wildlife corridor

Mammal species	Rs	df	R^2	P
African bush elephant	+0.866	2	0.751	0.02
Bush Buck	-0.057	2	0.353	0.03
Water buck	-0.392	2	0.154	0.05
Uganda Kob	-0.443	2	0.282	0.05
Oribi	-0.148	2	0.061	0.2
Olive Baboon	-0.447	2	0.199	0.04
Bush pig	-0.585	2	0.342	0.01
Hearte-beest	-0.242	2	0.058	NS
African leopard	-0.276	2	0.076	0.03
Duiker	+0.754	2	0.569	0.02

Article DOI: https://doi.org/10.37284/eajenr.7.1.1908

Information from the opportunistic home visits showed evidence of hunting within the study site. Of the eleven homes visited, ten had skins of various wild animal species being used as mats. The skins of Uganda Kob, Waterbuck, and bushbuck were the most common in the homes. Twelve community members were recorded transporting wild mammal carcases from one IDP camp to other sites. These observations confirm that the local community significantly depends on wildlife resources for their livelihoods especially during the dry season period of the year.

DISCUSSION

Mammal Species Assemblage

The large number of small to large mammal species recorded in Madi Wildlife corridor during the study is an indication that the biodiversity of the area is very diverse. Virtually most large mammal species present in the nearby MFNP occurred in Madi Widlife Corridor. An earlier aerial survey (WCS, 2008) of the same area only revealed 3 mammal species. It is expected that as more intensive and specialized ground surveys are undertaken during both dry and wet seasons, new species could probably be recorded. Habitat requirements indicate that the distribution patterns of the mammals are influenced by their feeding habits and water requirements (De Bie, 1991) and other specialized habitat requirements such as open or closed vegetation. Uganda kob, oribi, and hartebeest which are typical grazers often prefer open grassland landscapes.

As noted in this study (table 2) Elephant and bushbuck were commonly recorded in wooded grasslands and more closed wooded habitats. Waterbuck and buffalo were close to swampy sites and near permanent water supply sources. Similarly, amphibious lifestyle and grazing habits restrict hippopotamuses to the vicinity of permanent water along River Nile. The rapid build-up of wildlife populations in the areas within a relatively short period (15 years) suggests the rebounding of wildlife populations naturally if left to recover without human interference. The presence of the nearby wildlife population in MFNP and the existence of migration routes without human interference was another essential factor for the rapid rebuilding of the population. This study established that wildlife corridors such as Madi wildlife corridor have the potential to link various protected areas across Uganda. Lack of legal protection, however, renders such area vulnerable to human abuse through uncontrolled anthropogenic activities that could lead to further fragmentation of the protected areas.

Relationship between Anthropogenic Activities and Mammal Assemblage

This study revealed that human activities negatively influenced the distribution patterns of large mammal species in Madi Wildlife Corridor. A similar observation was made by Mugume et al. (2015) in forest reserves in Western Uganda. In the study area the intensity of human activities increased from south towards the north and this resulted in the skewed distribution of some of the large mammal species such as elephants, giraffes, and hippopotamuses which were limited to the southern parts close to MFNP. The distribution pattern observed indicates that many of these species migrate from the nearby MFNP area. A study in the adjacent MFNP by Ayebare (2011) and Mulondo (2015) showed that elephants, Uganda kob, hartebeest, buffalo and giraffes avoided areas with anthropogenic interference due to oil exploration drilling activities while oribi and warthog showed some level of tolerance behavior towards oil exploration activity. In this study some of the mammal species indeed exhibited negative behavioral responses to anthropogenic activities. For example, Elephants are intelligent mammal species which tend to avoid areas with high hunting and human harassment pressure as observed during this study. Similar behavior for elephants has been reported in Gabon (Barnes et al., 1991). Additionally, access to water availability also determines distribution in water-demanding species such as elephants, hippopotamuses, waterbucks and buffaloes. This consequently dictates their movement patterns and thus distribution. Studies during the wet season may

Article DOI: https://doi.org/10.37284/eajenr.7.1.1908

probably show different distribution patterns for these species as water and green vegetation become more widely available.

Traditional hunting was banned in 1979, and is still illegal under the current wildlife policy (Ministry of Tourism, Wildlife and Antiquities, 2014) except controlled and monitored sports hunting which was re-introduced in 2001. A study done in Kwakuchinja Wildlife Corridor in Tanzania (Njamasi., et al, 2022).) showed that an increased human use of the corridor example for agriculture, livestock keeping, creates significant threats to wildlife and could substantially reduce wildlife use of the corridor. In general, the high hunting levels using automatic rifles could exterminate some of the large mammal population in the area. Other species such as black and white colobus monkeys, vervet monkeys, baboons, duikers, Uganda kob, and bush buck, were fairly widely distributed. However, their relative abundance increased from the south to the northern part. This appears to reflect the level of human disturbance which increases in the reverse direction i.e. from north towards south. The primate species were in particular recorded close to or within riverine forests. These sites act as a refuge, protecting mammal species from poachers and other predators during the dry season. Additionally, the riverine forest contains important fruit tree species such as *Balanitis aethiopium*, *Tamarindus indica*, *Piliostigma thonningii*, various Ficus species, and fruits from climbers such as *Saba comorensis* which these animals depend on during the dry season as observed in this study.

An important issue with the conservation of these mammal species is the wide spread bush burning during the dry season in the area. The open or cleared habitat deprives these animals of shelter and concealment from predators thus exposing them to human predators and other natural predators in the area. The observation suggests that during the dry season riverine forests act as islands of green vegetation and fruits for the survival of the animal species.

This study identified wildlife hunting as an important activity that was widespread in the area. By the time of this study the Madi wildlife corridor lacked legal status and thus protection of the resources there in. The magnitude of poaching recorded from this site appeared extremely high as the surrounding communities considered wildlife as unrestricted, open-access resources where each family, village, clan, or communal society undertakes extractive exploitation opportunities. A variety of weapons both traditional (bows and arrows, spears, snares, traps, and nets) and modern automatic rifles were used for hunting. For timber harvesting, pit sawing was used. Thus, the new and efficient technologies used for hunting in the area tend to have a detrimental impact on reducing wildlife populations. Elephants and hippos were probably the most affected because they were more conspicuous and easily seen. Coupled with their daily rhythms of being close to water, makes them easy to locate and kill by poachers. Buffaloes on the other hand are relatively mobile and sometimes form large herds or even solitary ones which may become aggressive and dangerous to hunters (Kingdon, 1997). While the diurnal primate species were very conspicuous and easy to locate due to their vocalization and feeding habits and thus becoming easy targets.

Although illegal hunting of all forms was banned in Uganda in 1979 (Amos et al. 2020), this was continuing in Madi Corridor as was noted in this study. Generally, all mammal species were targeted by poachers and poaching pressure appeared to have significantly increased with the return of peace in the area and as the community started to return from IDPs to a more settled life. Additional factors leading to the increased hunting pressure in the area could be the availability of a market for bush meat and associated trade routes in the region. Due to the high demand for bush meat in urban centres, the supply could not be satisfied using the traditional wild ungulate species alone and other previously non-target species such as primates (Baboons, Black and white colobus monkeys, and Vervet monkeys) were among main species being hunted. The meat trade had strong cultural and socio-

Article DOI: https://doi.org/10.37284/eajenr.7.1.1908

economic underpinnings on both the supply and demand sides. An earlier study in the region (Kitara, 2007) indicates that bush meat is a luxury food and its additional demand comes largely from an increasingly wealthy urban community market (e.g. in Gulu city and other urban areas across Uganda), who were willing to pay high prices for meat from wild animals. The ready acceptance of game meat amongst the local population is a factor that underlies the seriousness of the problem of poaching in the region. This perhaps explains why the hunters were changing to target the more abundant and easier to locate species such as primates to substitute the previously preferred ungulate species that have become rare and difficult to locate and capture. If such unsustainable hunting continues unabated some of the species may be wiped out as befell the rhinos in MFNP (Oneka, 1996).

As the IDPs return to their original villages, the next emerging threat to wildlife resources is land transformation and degradation, through the opening up of land for crop cultivation, settlements, and livestock grazing. As already noted, human activities negatively influenced the distribution of some large mammal species such as elephants and hippos in Madi Wildlife Corridor. Hunting and evidence of trapping were very common in the study area, which indicates the level of threat to biodiversity conservation in the areas. These human pressures have the potential to strip all wildlife resources in Madi Wildlife Corridor within a short time if the root causes are not urgently addressed. Most protected areas in Uganda are islands that are disconnected. This study is an “eye-opener” for Uganda in relation conservation of wildlife resources based on corridor availability. For example, there are currently only two wildlife corridors that connect important protected areas in Uganda. One is the Kibale corridor at Dura, which covers about 180km and links Kibale National Park with Queen Elizabeth National Park. The other corridor is the Bokora Corridor Game Reserve located in eastern Uganda, which connects Bokora, Upe, Pian, and Matheniko wildlife reserves to Kidepo Valley National Park.

CONCLUSION AND RECOMMENDATIONS

The current study showed that there is significant diversity, distribution, and abundance of medium- and large-sized mammalian species in the Madi Wildlife Corridor. It gives baseline information for further studies on mammalian species in the area. This study demonstrated the importance of Madi Wildlife Corridor as a critical corridor for wildlife movement and habitat connectivity between MFNP, EMWR, and the wider PAs within the northern region ecological landscape. The main threats in Madi wildlife corridor are unsustainable poaching and extraction of wildlife resources, which has impacted mammal species distribution patterns. The high level of poaching was an indication that wildlife was an important resource to the communities surrounding Madi Wildlife Corridor. This provides the basis to initiate wildlife meat production through wildlife ranging, farming in the area. Other potential opportunities are nature-based tourism and sport hunting which all have the potential to be promoted in the area. Because of its position between the two protected areas, Madi Wildlife Corridor has the potential to regain its wildlife population through wildlife dispersal, reproduction, and migrations despite the high hunting pressure. This can only be achieved through establishing a sustainable management system in the area. We recommend collaborative management of wildlife on private/public land within the corridor area. This is consistent with the Uganda Wildlife Statute (1996 the Local Government Act (1997) and other laws and guidelines that may supplement the implementation of such imitative. It is important to undertake a systematic assessment and prioritization of wildlife corridors at the national level, which is important for maintaining and restoring Uganda's rich natural heritage. It is recommended to assess the biodiversity status, prioritize the demarcation of wildlife corridors, and develop an action plan for securing

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wildlife corridors. It is further recommended to develop national Wildlife Corridor Regulations, which will provide a framework necessary for sustainable conservation of biodiversity.

ACKNOWLEDGEMENTS

We thank Uganda Wildlife Authority (UWA) for supporting the survey by providing ranger force. We also acknowledge the cooperation of the Amuru District environment officer, MS. Ajok Dorine, and the Amuru District Local Government that enabled us to undertake the study in the district.

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