Original Research Article

Temporal Utilization Patterns of Constructed Water Pans by Different Mammal Species. A study of Mount Kenya Wildlife Conservancy, Kenya.

ABSTRACT

Climate change induced risks like prolonged dry spells are exacerbating water scarcity especially, in the wildlife conservancies thereby calling for alternative water sources for wildlife. In Mount Kenya Wildlife Conservancy, water pans were constructed to provide water to animals during wet and dry seasons. However, the impacts of these constructed water pans on wildlife in the study area have not been adequately documented. The main objective of this study was to establish patterns of water pans utilization by different mammal species. Observations on the mammals visiting water pans were conducted in the dry season (June 2022) and wet season (October 2022) at two selected water pans in Mount Kenya Wildlife Conservancy. Mammal utilization of water pans was studied using observations at day time and camera trapping for nights. Pearson correlation and t-test were used to analyze data at **alpha=0.05**. Impala had the highest water pan visitations (36.7%) followed by zebra (22.2%) while eland and reedbuck had the lowest (0.7%). Morning (0900hrs-1000hrs) was a period of peak visitation accounting for 59.62% of visitations while dusk recorded the least visitations. There were significant differences in the visitation time between the dry and wet seasons (df =7, t = 2.739, p=0.029) where dry season had high visitations (64.6%) while wet season had 35.4%. Mammals utilized water pans for drinking, wallowing, grazing, socialization, and soil licking. In addition, there was a negative correlation between mammal visitations to the water pans and the time of the day (r= -0.535, p=0.036). In conclusion,constructed water pans are important source of waterfor wildlife. Their location and distribution in protected areas influence the patterns of utilization by different mammal species during both dry and wet seasons.

Keywords: [Temporal, wildlife, utilization patterns, constructed water pans, Mount Kenya Wildlife Conservancy}

Comment: Indicate in the abstract, the materials and methods used in the study

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1. INTRODUCTION

Water availability influences wildlife distribution, density and behavior in various ecosystems (Sungirai&Gwenya, 2016). Globally, water availability controls daily activities and land use patterns of most mammal species (Sutherland *et al*., 2018). Due to impacts of climate change caused by among other factors, the degradation, destruction, and loss of forests, water is a limited resource for use by mammals.

In modern times, many of the protected areas are fenced to protect wildlife and their habitats from the surrounding increasing human encroachments and poaching (Pirie *et al*., 2017; Pekor*et al.*, 2019). These fences reduces the movement of large mammals to suitable habitats, blocks the migratory routes to perennial water sources, restricts animals in an area leading to congregation of animals around available water sources which in turn leads to overgrazing, habitat degradation, increase in predation risks, disease and parasite transmission etc. This leads to dramatic reduction in species numbers hence species population reduction (Tefempa*et al*., 2008; Sutherland *et al*., 2017; Peel & Smit, 2020). On the other hand, climate change resulting from human activities raises temperatures, reduces precipitation, increases evaporation, and reduces the amount of surface water available, resulting in drought events. Severe drought in African protected areas for instance is threatening species to extinction as it reduces the amount of food and water available for the wildlife species (Kiria, 2018; IPCC, 2022). Low-quality forage and water shortage lead to starvation-induced mortalities reducing wildlife populations (Mpakairi, 2019).

Apart from other management interventions such as fire, culling, translocation and fencing, provision of water has been proved important in areas facing water scarcity (Smit *et al*., 2007; Fullman *et al*., 2017). Artificial water points are therefore constructed as management tool in protected areas to provide water to mammal species during the dry season, reduce threats to land degradation, to enhance distribution range (Sungirai&Gwenya, 2016), prevent migration of mammals reducing human wildlife conflicts (Chakuya, 2021), and to increase mammal population and enhance biodiversity (Rispel&Lendelvo, 2016).

Just like any other water sources, utilization of artificial water sources varies according on the species, season and time of the day. Mammals' drinking patterns change in accordance with the distribution of water over different seasons as a result of variations in the availability of surface water (Sutherland *et al*., 2018). The high demand for water by wildlife during the dry season leads to animal concentrations near water sources as ephemeral water sources dry up (Sutherland *et al*., 2018, Trent, 2018). Concentration of mammals around water points increases risks of predation, competition for water resources (Sirot*et al*., 2021), disease transmission, (Webb *et al*., 2022; Titcomb *et al*., 2021), and poor water quality in stagnant water points (Epaphras *et al*., 2008).

Different animal species require different amounts of water. Daily water requirements differ with the animal's size (Hayward & Hayward, 2012), physiological condition of an animal, forage availability (Sungirai&Gwenya, 2016), and ambient air temperature (Surtherland*et al*., 2019; Sirot*et al*., 2016). According to Sungirai&Ngwenya (2016), factors such as distance between foraging areas and water sources, resources availability, presence of alternative water sources, water quality, and the structure of the surrounding vegetation influence animal's selection of water pan to visit. Additionally, predation risk, competition (Sirot*et al*., 2016) and time of day (Sutherland *et al*., 2018; Geenen, 2019) are factors that affect utilization of water points. Location of water points has also been reported to affect mammal visitations to water points. Because animals prefer to use water sources located in places with limited vegetation cover to reduce the risk of predation (Sutherland *et al*., 2018), location has been reported to hinder some animals from visiting water sources to drink (Sungirai&Ngwenya, 2016).

According to Sutherland *et al*. (2018), animals have a behavioral mechanism that allows them to change the timing and duration of their daily activities in order to control the degree of their heat exposure and water loss. Mammal species' daily temporal visitation patterns vary depending on their body size and feeding guild, which generally reflects both their water dependency and risk of predation (Hayward & Hayward, 2012). Temporal utilization of water points is influenced by ambient air temperatures and predation (Sutherland *et al*., 2019). Purely diurnal animals are compelled to change their water utilization patterns to cooler nocturnal times as a result of rising daily temperatures (Valeix*et al*., 2009).

In Australia and North America, the intervention to have artificial water provisioning has been reported to increase wildlife population, alter wildlife distribution and provide water to wildlife species during the dry season (Harris *et al*., 2020); Eliades *et al*., 2022). In Africa water provisioning is an important management technique in maintaining mammal population in most of the protected areas (Tefempa*et al.,* 2008; Perkins, 2020; Chakuya, 2021; Bennit*et* *al*., 2022). Artificial water sources have been reported to be of great importance in maintaining wildlife populations and increasing touristic game viewing in South Africa where many studies have been conducted on the utilization of water points by wildlife (Cain 2012; Hayward & Hayward, 2012; Smith, 2016; Trent, 2016; Purdon, 2017; Sutherland *et al.,* 2018; Veldhius*et al*., 2019). In Zimbabwe, study showed that appropriate planning should be done on water provisioning to cater for the increased water demand by wildlife during the dry season (Sungari &Gwenya, 2016). Elsewhere in Namibia, water provisioning has been observed as an important tool in controlling mammal distribution preventing the loss of biodiversity in times of food and water scarcity (Rispel&Lendelvo, 2016), and in Tanzania, artificial water sources have been observed to be important since it limits migration of wildlife to areas of high poaching and helps in mitigating human-wildlife conflicts. (Epaphras *et al*., 2008; Tefempa*et al*., 2008).

In Kenya, studies previously done in Tsavo East National Park have shown that during the dry season artificial water points provide an alternative water source to wildlife, encourage distribution of mammals into various areas of the park and enhance game viewing for tourist. (Ayeni, 1975; Mwazo, 2012; Ngatia, 2015). However, utilization of water points by wildlife has effects on the surrounding vegetation in the park. Just like in Tsavo National Park, water is a scarce resource for people, livestock and wildlife in Laikipia County (Butynski *et al*., 2014). Artificial water sources therefore have been adopted as the main source of water for both wildlife and livestock in ranches (Spira, 2014).
For instance, Mount Kenya ecosystem is facing enormous pressure from anthropogenic activities by the adjacent community (Nyongesa&Vacik, 2018). The increase in human population and changing land use in the area have led to declining of forest resources and habitat loss (Poletti, 2016). As a result, Mount Kenya Wildlife Conservancy was fully fenced to protect the critically endangered mountain bongo and other wildlife species from poaching and habitat destruction (Fundi, 2013). This fencing however has prevented mammals from accessing natural water source from River Kanyoni which flows alongside the western side of the conservancy. This has left the use of constructed water pans as the main option to provide water to wildlife during both wet and dry seasons. There is however inadequacy of literature focusing on utilization of constructed water pans by mammals and its effects in the conservancy.

General comments: a) The introduction is too big. Please reduce it to one page or utmost 3 paragraphs while keeping to the purpose
b) The aim and specific objectives of the study do not appear in the introduction part.

2. MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Mount Kenya W~~w~~ildlife Conservancy (MKWC) in Nyeri County, Kenya. The conservancy covers an area of 1250 acres and is located at $0^0$02’29” S, $37^0$07’35’’E lying at an ~~alt.~~altitude 2387m above sea level. It is situated approximately 10 Km from Nanyuki town. MKWC is a privately owned, run as a non-profit organization bordering Mount Kenya Forest and was established to conserve rare and endangered species particularly the critically endangered Mountain bongo. It has also an animal orphanage which is located at the center of the conservancy (Figure 1).

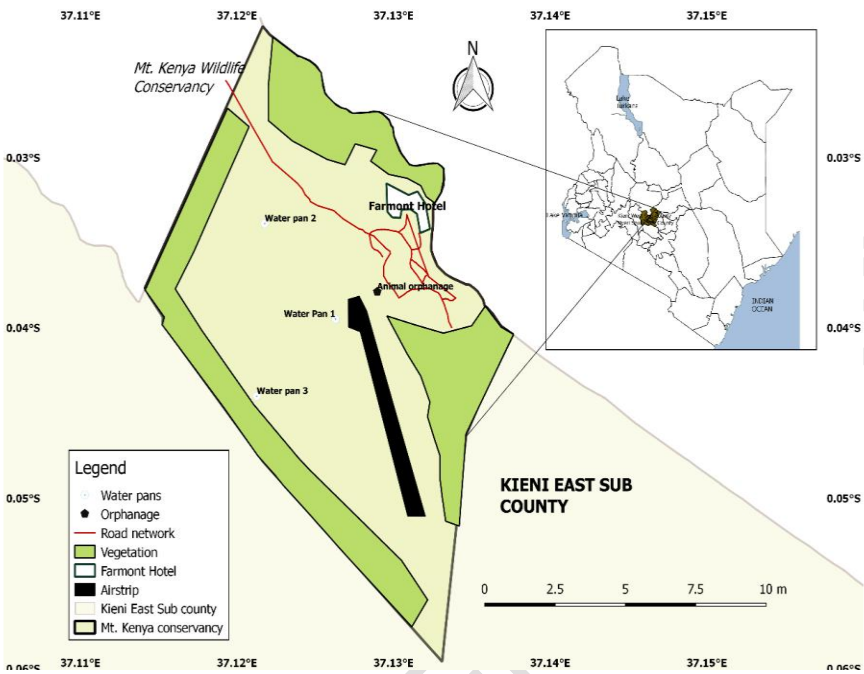

Figure 1:Map showing the location of MKWC and constructed water pans (Author, 2023)

2.2 Sampling

Purposive sampling (provide citation) was done to select the water pans according to their proximity.

2.3 Data Collection

Observations were done from a hide-out overlooking water pans at a distance of 50m and were carried out at the peak of the dry season when animals concentrate around water pans and at the end of the wet season when ephemeral water sources are available in the landscape. At each water pan, observers counted mammals visiting water pans during the day from 0600hrs to 1800hrs, and counts were conducted four times in each season.

Data was collected to determine the pattern of utilization. Observations were carried out during the day, while at night, surveillance wildlife camera traps were placed at strategic locations to capture the visiting animals. Camera traps were set to capture animal movements at night. Images were able to be captured at night using infrared flashes. The cameras were placed at 150cm from the ground at 3m from water pans where they were checked after every 3 days.

Arrival and departure time was taken and used in determining the time spent at constructed water pans by each mammal species. In addition, the frequency of occurrence of species at the water pans was determined by the number of individual species per visit, and the time of peak visits of each mammal species was also determined.

According to the temporal drinking patterns, species were classified as either dawn (0500hrs- 0700hrs), morning (0700hrs- 1100hrs), midday (1100hrs-1300hrs), afternoon (1300hrs-1700hrs), dusk (1700hrs-1900hrs) or nighttime drinkers (1900hrs-0500hrs). The presence of predators at water pans was also recorded as they influence herbivore behavior, therefore affecting water pan utilization patterns.

3. RESULTS AND DISCUSSION (The results should be presented according to the specific objectives which, however, do not appear in the introduction. Harmonize this first)

3.1 Mammal Abundance at Water Pans

A total of 892 visitations from 8 mammal species were recorded at two water pans within MKWC during the study period. These mammal species include Buffalo (*Synceruscaffer*), Common Eland (*Taurotragusoryx*), Impala (*Aepycerosmelampus*), Reedbuck (*Genus redunca*), Warthog (*Phacochoerusafricanus*), deffassa waterbuck (*Kobus ellipsiprymnus*), wildebeest (*Phacochoerus africanus*) and common zebra (*Equusburchelli*). Overall, Impala had the highest abundance at water pans (36.7% of the total visitations recorded), followed by zebra (22.2%) and warthog (16.0%) while Eland (0.5%) and Reedbuck (0.2%) were the least recorded species at water pans. Abundance of species at water pans was determined by their population density in the conservancy. No nighttime species were recorded using camera traps. In addition, the presence of predators was not recorded during this study.

Out of the total observations recorded, 576 (64.6%) were recorded in the dry season (June 2022) and 316 (35.4%) in the wet season (October 2022). Differences in the intensity of water pan use by mammals. Water pan 2 was the most frequently visited (70.2%) while water pan 1 was the least visited (29.8%) (~~as shown in~~ Figure 2). Paired t-test shows that there are no significant differences between wWater pans 1 and 2 (df =7, t = -2.78, p=0.027) in terms of mammal abundance.

Preferences for wWater pan 2 over wWater pan 1 may have been as a result of different factors such as vegetation structure near the water pan. Vegetation around water pan 2 had undergone prescribed burning, providing regrowth of young nutritious vegetation thus attracting many animals. On the other hand, forage quality around Water pan 1 was low since the area had tall grass and the dominant grass species being *Pennisetumschimperi*, is only palatable during the wet season and turns hard and fibrous during the dry season and thus likely to be avoided by grazers (Sargent, 2016). According to Trent (2016), forage affects water pan visitation patterns. This was a perfect explanation of why water pan 2 had high mammal visitations.In addition, the openness of the area around wWater pan 2 enabled the increased vigilance in the area which increased utilization. This supports the findings of the study done in NyaeNyae Conservancy, Namibia which revealed that in order to maximize visibility, animals prefer using water sources that are situated in places with low vegetation cover (Rispel&Lendelvo, 2016). Sutherland *et al*., (2018) also reported that animals avoid environments that make them to risk predation and avoid vegetation types that make them vulnerable for predation.

Previous research has revealed that other factors that influence the decision of an animal to visit a certain water source include resource availability, quality of resources, distance from their selected habitats, (Sungirai&Gwenya, 2016), surrounding vegetation to water point (Sungirai&Ngwenya, 2016), presence of minerals in water (Chamaille-Jammes*et al.,* 2007), competition (Valeix*et al*., 2007), and presence of predators (Kasiringua*et al*., 2017; Sutherland *et al*., 2019).

The overall number of visitations to Water pan 2 was more compared to Water pan 1, indicating that there were variations between the two sites. The difference is more likely to be caused by the availability of forage resources. Therefore, the higher percentage of visitation at Water pan 2 was due to greater mammal abundance in the landscape

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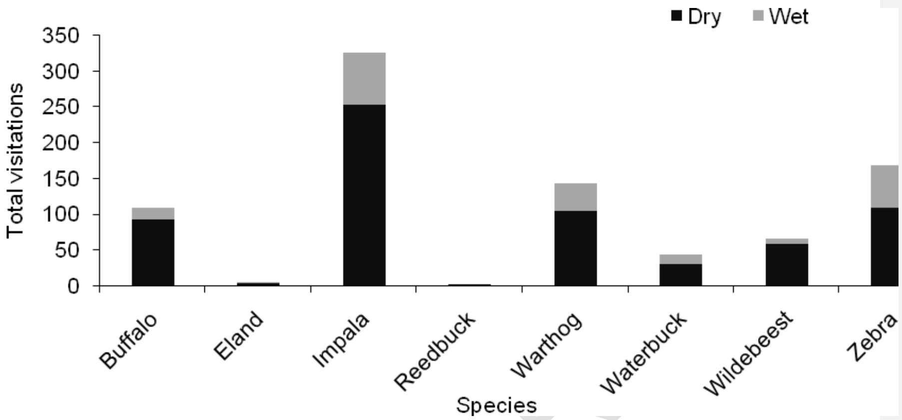

Figure 2: The abundance of individual mammal species at Water pans 1 and 2.

3.2 Frequency of Water Pan Visitations

It was observed that the visitation patterns of mammal species during the day varied according to body size. The most frequently observed species were the Wwarthog and the Iimpala, which together made up more than half of the species recorded (n=105 and n=78, respectively). This concurs with the previous study conducted by Trent, (2018) who reported that small sized species visits water points frequently. Eland and Reedbuck had the least visitations and this is caused by low population density. When considering the influence of seasons on water pan utilization, the dry season had the highest visitations (n=146) comprising 55.51% of the total visitations while the wet season had what??? (n=117).

3.3 Mammal Activities at Water Pans

Drinking (61.22%), drinking/feeding (13.3%), drinking/wallowing (12.55%), and drinking/soil licking (6.84%) were the commonly observed activities by mammals at water pans. Drinking/socialization (3.42%),
Ddrinking/feeding/socialization (1.90%) and drinking/feeding/soil licking (0.76%) were the least observed activities., Drinking was the most commonly observed activity in all mammal species. This corresponds with the previous study done in South Africa by Smith, (2016) who observed that all herbivore species used water points for drinking. Wallowing was only observed in warthogs. Apart from drinking, soil licking was observed in almost (almost? to what extent? be specific and provide %) all mammal species. Drinking/socializing was mostly observed in Impala and Zebra. Impala spent the longest time at water pans socializing and soil licking. Buffaloes spent their time drinking and grazing around water pans while zebra after drinking stayed at water pans socializing. after drinking. In the afternoon when the temperatures are high, some mammals such as warthogs spent more time at water pans wallowing. Wallowing as a behavior is used as a thermoregulatory mechanism that helps with heat loss when the ambient temperatures are high (Trent, 2018). At this time other animals spend less time at water pans to avoid exposure to direct sunlight.

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Mammals were also observed at water pans licking soils. This behavior is known as geophagy (Ajayi *et al*., 2020). Salt licks are used by wildlife for nutritional supplementation (Suberi*et al*., 2022; Mojiol& Lim, 2020). The use of salt licks differs depending on sex, diet and season (King *et al*., 2016). However, overutilization of salt licks by wildlife shows that there is a nutritional deficiency caused by habitat degradation or overpopulation (Suberi*et al*., 2022).

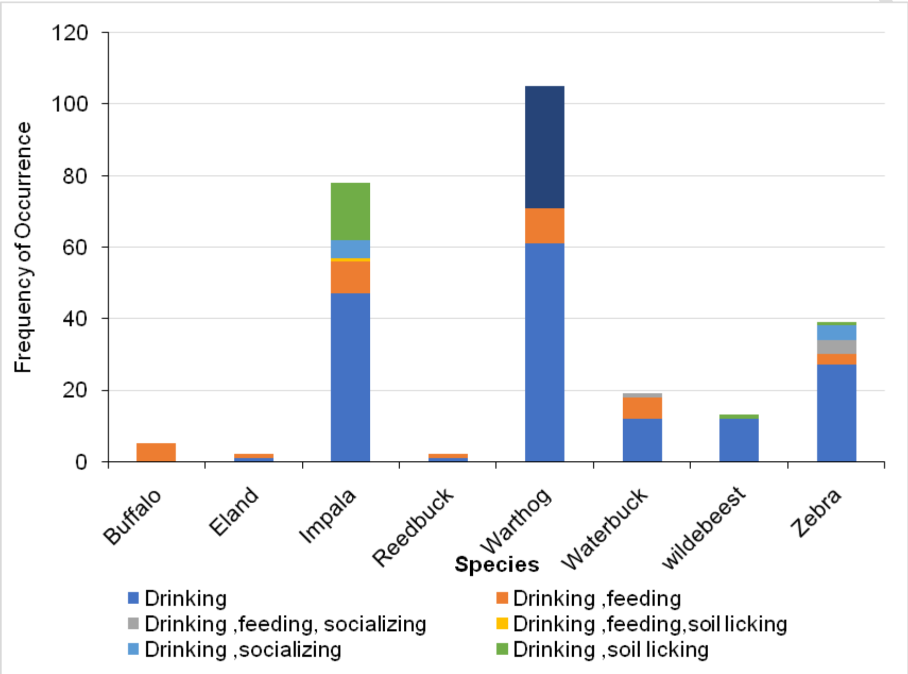

Figure 3: Different activities for each mammal species at water pans in MKWC.

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3.4 Temporal Utilization Patterns

In determining temporal utilization patterns, all species visiting water pans were classified as either dawn (), morning (0700hrs-1100hrs), midday (1100hrs-1300hrs), afternoon (1300hrs-1700hrs), dusk (1700hrs-1900hrs) or nighttime drinkers (1900hrs-0500hrs). In this study, mammals showed strict diurnal water pan visitation patterns (0600hrs-1700hrs), showing different temporal partitioning in their water pan visitations. No nighttime species were captured on camera traps. At both w~~W~~ater pan 1 and w~~W~~ater pan 2, majorities of mammal species were recorded during the morning (0700hrs-1100hrs) and midday (1100hrs-1300hrs) 59.62% and 22.06% respectively. Morning (0900hrs-1000hrs) was a period of peak visitation while dusk (0500hrs to 0600hrs) had the least recorded number of visitations. In addition, no carnivore species were recorded at water pans showing that the presence of carnivores in MKWC has no effects on water pan utilization. Other studies have shown that presence of predators near water sources makes other species to change their drinking time, visiting water points at dusk as a mechanism to prevent (to prevent what???? Please

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get back to the citation and complete the citation!!) (Kasiringua*et al*., 2017; Sutherland *et al*., 2018).

Overall water pan utilization peaked between 0900hrs to 1100hrs differing slightly from the previous research done in Malawi (Genen, 2019) which showed that a peak in water pan utilization was between 1000hrs to 1100hrs. There is no scientific difference here. 10 00hrs falls within your 09 00 hrs to 11 00hrs range! These differ from a study done in Namibia by Kasiringua*et al*., (2017) that showed that peak utilization times were between 1500hrs and 2200hrs. Climatic and environmental factors influence animals' physiological and behavioral responses of species and their water requirements leading to variations in water pan utilization (Trent, 2016). Sutherland *et al*., (2019) and Sirot*et al*., (2016) reported that ambient temperatures influence temporal utilization of water sources where high temperatures reduce the activity of animals during the dry season.

In finding the relationship between mammal visitations to water pans and time of the day, Pearson correlation test shows that there was a negative correlation between mammal visitations to the water pans and the time of the day (r= -0.535, p=0.036) at a 5% confidence level. So what do you infer from this analysis before you relate to Trent (2018)? Trent (2018) in her study in Kruger National Park reported that mammals adjusted their timing and extent of daily activities to prevent heat exposure and water loss. Similarly, in this study visitations peaked around 0900hr to 1100hrs and were low in the afternoon (1300hr to 1700hrs). This may have been caused by high temperatures at this time causing animals to spend long periods in tree shades. This was also reported by Sutherland *et al*., 2018, who noted that animals were active during morning hours (0600hrs to1100hrs) and avoided hottest time of the day which is the afternoon. The peak activity for most herbivores and primates was noted to be during the crepuscular hours.

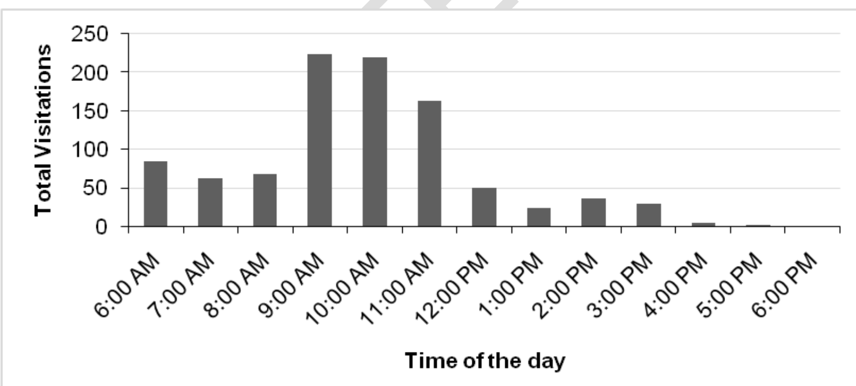

Figure 4: Hourly total visitations for all the species in MKWC

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Buffalo and Reedbuck visited water pans at dawn and morning. Wildebeest visited water pans in the morning. Impala, wildebeest, and zebra visited water pans in the morning, midday, and afternoon. Impala and warthog had widely dispersed visitations across different hours during the day. All 8 mammal species in the conservancy exhibit diurnal water pans visitation patterns. The time of peak visitation for buffalo was (0600hrs), impala (0900hrs-1100hrs), warthog (0900hrs-1000hrs), waterbuck (0800hrs), wildebeest (0600hrs) and zebra (0900hrs)..

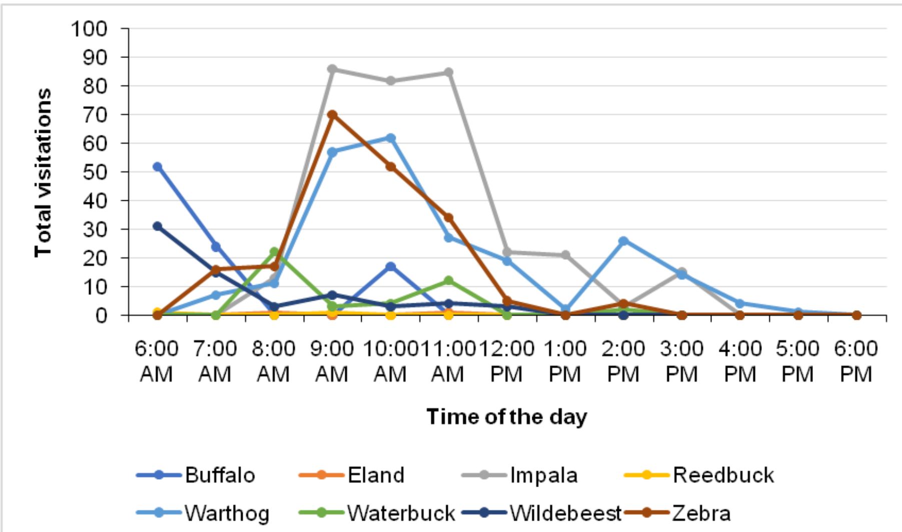

Figure 5:Hourly total visitations for individual mammal species.

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Mammals spent more time at water pans in the morning followed by midday and dawn, with the least at dusk. This could be attributed to climatic and environmental factors since they affect animals' physiological and behavioral responses of species and their water requirements leading to variations in water pan utilization patterns (Sutherland *et al*., 2019)

Figure 6: Time spent at water pans by mammals at different time of the day.

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4. CONCLUSIONS (The conclusion should be presented according to the specific objectives which, however, do not appear in the introduction. Harmonize this first)

Constructed water pans provide an important source of water and are utilized by mammals in the conservancy during both dry and wet seasons. Utilization of water pans differed with time of the day, seasons and between species. Water pans were highly utilized by mammals during the dry season than wet season for drinking, wallowing, grazing, socialization, and soil licking. Therefore, the study shows that artificial water pans provide important source of water in protected areas where natural water sources are absent, inaccessible due to fencing, or during the dry season when water is limited.Water provisioning in areas lacking water during the dry season will increase dispersal ranges in the conservancy reducing mammal concentration around water pans.

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Comments on references
There are many inconsistences in the references

a) **Beconsistent inwriting the initials. Some have space while others do not have**
b) **Put a full stop after the year of publication.**
c) **Etc**
d) **Generally check-out your reference format**
e) **Use appropriate APA format**

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