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Impacts of Constructed Water Pans on Mammal Distribution and Abundance. A Case of Mt. Kenya Wildlife Conservancy, Kenya

Kiria Edwin [a*], Mmula Beldine [a], Mutuma Evans [a], Samuel N. Mahiga [b] and Robert Aruho [b]

[a] Chuka University, P.O Box 109-60400, Chuka, Kenya.
[b] Mt. Kenya Wildlife Conservancy, Kenya.

Authors' contributions

This work was carried out in collaboration among all authors. Author KE designed the study and wrote the first draft of the manuscript. Authors MB and SNM managed the analyses of the study. Author MB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To assess the impacts of constructed water pan utilization on wildlife distribution and abundance in Mount Kenya Wildlife Conservancy.
Study Design: Ecological survey design.
Place and Duration of Study: The study was conducted in the dry season (June 2022) and wet season (October 2022) at Mount Kenya Wildlife Conservancy, Kenya.
Methodology: Systematic sampling using belt transects was used in collecting data on mammals' distribution and abundance.
Results: Distribution patterns differed with species between seasons. For the dry season, results show that eland(r=-0.516, p=0.295), impala(r=-0.714, p=0.111), warthog(r=-0.754,p=0.08),

**Corresponding author: E-mail: ekiria@chuka.ac.ke;*

waterbuck(r=-0.986,p=0.0003), and zebra(r=-0.657,p=0.156) had a strong negative correlation with distance from water pans. During the wet season, impala (r = -0.49, p=0.329), wildebeest (r = -0.26, p=0.623), and waterbuck (r = -0.71, p=0.111) showed a negative correlation, while warthog (r = 0.60,p=0.208) and zebra (r = 0.26, p=0.62)showed a positive correlation with increased distance from water.

Conclusion: many mammals concentrated near the constructed water pans during the dry season due to the presence of forage and drinking water but dispersed out when ephemeral water sources and forage availability increased during the wet season.

Keywords: Mammal distribution; abundance; water pan utilization; Mt. Kenya.

1. INTRODUCTION

Water availability influences wildlife distribution, density and behavior in various ecosystems [1]. Globally, water availability controls daily activities and land use patterns of most mammal species [2]. Water for mammal utilization is a limiting resource as a result of increase in climate change caused by the degradation, destruction, and loss of forests [3].

Climate change 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 example is threatening species to extinction as it reduces the amount of food and water available for the wildlife species [4]. Low-quality forage and water shortage lead to starvation-induced mortalities reducing wildlife populations [5].

Natural ecosystems majorly rely on water for proper functioning and sustenance [6]. Globally, artificial water provisioning has been used as a management tool in Australia, North America, and Africa to increase wildlife populations [7] alter wildlife distribution and provide water to wildlife species during the dry season [8,9].

In Australia and North America research has been conducted on the effects of artificial water provisioning on birds [10] carnivores, invasive species [11] and rodents [12]. In Africa, most research has been done on mainly on African large mammalian herbivore [13] Sutherland *et al*., [2] Geenen, [14] Kasiringua, [15] Perkins [16]. Some studies have been done on carnivores Krag *et al*, [17] birds Abdu *et al*., [18].

In most of parks and game reserves in Africa, artificial water points (AWS) has become one of the main management interventions [19]. Water may not be the only factor affecting mammals' distribution and abundance, there are others like vegetation quality and quantity, predation, seasons, competition and disturbance [20,21]. Water availability influences the abundance and distribution of large herbivores in arid and semi-arid areas Sungirai & Ngwenya, [1] Eliandes *et al.,* 2022; Komba, [22]. It also affects both daily and seasonal migration of wildlife (Stoldt *et al.,* 2020). However, scarcity of this essential resource threatens the existence and persistence of biodiversity.

Prolonged drought in African protected areas exacerbated by climate change is threatening species to extinction as it reduces the amount of food and water available for the wildlife species in protected areas [4]. Low-quality forage and water shortage lead to starvation-induced mortalities of mammals [5]. For example, in Hwange National Park, Zimbabwe, animal mortality was reported to be caused by depletion of forage quality and quantity [23]. From the census report, effects of drought on wildlife in Kenya's protected areas had led to the death of wildlife species, migration, and human-wildlife conflicts. The most affected mammal species were grazers such as wildebeest, common grazers, elephants, gravy's zebras, and buffaloes [24].

The drying of available water sources in protected areas has led to the seasonal migration of wildlife species to areas of water availability within the parks or even outside the protected areas [25]. In Mexico, drought had led to water scarcity causing human-wildlife conflicts. Wildlife moved out of the protected areas to the villages in search of water which led to hunting of the game animals. It was recommended that water be provided to animals in protected areas to mitigate human-wildlife conflicts. Similarly, in Tanzania, climate change was reported affected water availability in protected areas leading to migration of wildlife in search of water which led to their killing [26]. Elsewhere, in Amboseli and Tsavo National Parks, Kenya there has been an increase in the incidents of human-wildlife conflicts caused by severe droughts as animals move out of the protected areas [24].

As a management practice, water pans are constructed in protected areas to provide water to wildlife reducing mortality during the dry season (Eliandes *et al*., 2022, Chakuya *et al.,* [27] reduce habitat degradation and alter herbivore distribution [1]. In Botswana and Zimbabwe, the well-distribution of artificial water sources within the protected areas has been mentioned to prevent animals from migrating to areas of high poaching and reduce human-wildlife conflicts [28] Chakuya, [27] respectively). It has also been observed to increase species diversity and abundance thus maintaining the wildlife population especially water-dependent species in Nyae Nyae conservancy, Namibia [6]. However, high density of water points affects both the vegetation and herbivores leading to a reduction of biodiversity in areas in close proximity to the artificial water sources [14].

AWS increase the reliance of mammals on water making them to be sedentary thus altering the distribution and abundance of mammals in an ecosystem [29]. Provision of water for wildlife makes animals concentrate near available water sources (Veldhius *et al*., 2019), affecting the distribution of species and increasing predator abundance which decreases the density of prey species (Valeix *et al* [30] Sirot *et al*., [19]. It also leads to habitat degradation due to overgrazing and trampling [1,14].In Kruger National Park, South Africa artificial water sources have been reported to cause decline in rare antelope species [31].

The extent of water dependence in mammals is determined by factors such as feeding guilds, digestive physiology, thermoregulatory mechanism, body size and the loss of water through feaces and urine [32,33,34]. Differences in water requirements cause animals to be distributed differently around water points and the distance mammal species if found from water source during dry season shows their water dependence level (Schmied *et al*., 2023. The water-dependent species are usually observed mostly around the water source while the water-independent species are usually found away from the water source during the dry season. In terms of feeding guilds, grazers such as buffaloes are water-dependent since they feed on grass which has low moisture content compared to browsers such as elands and giraffes that are less water-dependent, as they feed on leaves that have high moisture content [14,6].

Body size affects the distribution patterns of mammals around artificial water sources (Kasiringua, 2010). Small sized species such as impala and warthogs are usually confined in areas close to water points while medium sized species such as wildebeest and zebra are distributed further compared to impala. This is because large sized species have large home ranges therefore not found in close proximity to the water sources [15].

Further, mobility has also been mentioned to influence the distribution of mammals around water points. Different species respond differently in relation to distance from water sources. Some species such as buffalos, elands and kudus can walk long distances from water points to foraging areas whereas small species like impalas and warthogs have been reported to feed closer to water points [15]. In Namibia, wildebeest travelled longer distances than gemsbok to and back from potential water sources in wet and dry season. Less dependence on surface water reduces the costs associated with the drinking. Water independent species are able to forage in additional areas away from water sources reducing the energy cost associated with the animal moving from foraging to drinking areas (Veldhius *et al*., 2019), there is a reduction in competition with other species for resources and reduced the predation risks (Veldhius *et al*., 2019; Louw *et al*., [35].

Constructed water pans in Mount Kenya Wildlife Conservancy provides water to wildlife during both dry and wet season. However, utilization of these water points have defined effects on mammal species distribution and abundance as well as on surrounding vegetation composition, diversity and abundance in a manner that has not been well understood. These effects have not been documented for Mount Kenya Wildlife Conservancy yet this information is important in planning and management of wildlife conservancies in the face of increased human activities and climate change, increasing water scarcity and the need for alternative water supply systems for the wildlife. Therefore, this study seeks to establish the patterns of utilization of the constructed water pans, their effects on wildlife distribution and abundance including on the surrounding vegetation in Mount Kenya Wildlife Conservancy.

2. MATERIALS AND METHODS

The study was conducted in Mount Kenya wildlife Conservancy 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.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. The climate of Mount Kenya ecosystem significantly changes with the altitude, forming different belts of communities. Mount Kenya experiences equatorial mountain climate with very cold nights and very hot during the day [36]. The mean annual rainfall ranges from 2,300mm on the windward side to 900mm on the Leeward side [37]. Vegetation within the conservancy consists of open glades of shrub, herbs and grass.

The wildlife population in the study area includes ungulates such as Cape buffalo (*Syncerus caffer*), bushbuck (*Tragelaphus scriptus*), deffassa Water Buck (*Kobus ellipsiprymnus*), the common zebra (*Equus burchelli*), Suni (*Neotragus moschatus*) and the common duiker (*Sylvicapra grimmia altivallis*). Primates include Mount Kenya guereza (*Colobus guereza kikuyuensis)* being the most common, and olive baboon (*Papio anubis*). Carnivores within the area includes leopard (*Panthera pardus*), spotted hyena (*Crocuta crocuta*), serval cat (*Felis serval*), black backed jackal (*Canis mesomelas*) and the genet (*Genetta tigrina*).

Some of the bird species found within the study area include, crowned eagle (*Stephanoaetus coronatus*), hartlaub's turaco (*Turaco hartlaubi*), scaly francolin (*Francolinus squamatus*), silvery cheeked-hornbill (*Ceratogymna brevis*), the harmercop (*Scopus umbretta*), olive pigeon (*Colomba arquatrix*), crowned hornbill (*Tockus alboterminatus*) and the giant kingfisher (*Megaceryle maxima*).

2.1 Sampling

In determining distribution and abundance of mammal species in relation to water pans belt transects were used. Mammal sampling was carried out using 6 belt transects of width 50m each per water pan up to a distance of 300m. Data was collected in two water pans during dry and wet seasons on spatial distribution of mammals from water pans. Visual counts of mammals were done by walking along transects lines (300m) recording the presence and abundance of different mammal species within belt transects. In total,12 belt transects and 6 line transects were used in studying mammals for the two water pans in each season.

2.2 Data Collection

Mammal species were counted in belt transects from each water pan using direct observations and this was repeated four times in each season (start, mid-season and end). First, points were marked using ribbons in different directions at a distance of 50m, 100m, 150m, 250m, and 300m intervals from each water pan to form circular belt transects. Researcher recorded changes in species distribution by walking along transects lines recording the presence and abundance of different species within each belt transect. Changes in species distribution were assessed the morning (0600hrs), noon (1300hrs), and evening (1800hrs) with the aid of binoculars. Individual species numbers for each water pan were then recorded in specially designed data sheets.

In finding mammals' distribution and abundance, individual mammal species and their cumulative totals at various distances from water pans were determined. In order to evaluate the relationship between species abundance and distribution from the water pans, Spearman's rank correlation was used. The difference in means between seasons and water pans was further tested by an independent sample t-test.

3. RESULTS AND DISCUSSION

Mammal species distribution and abundance were determined at various distances from water pans in MKWC. A total of 7 species were observed at different distances from water pans. Overall, the abundance of different mammal species varied with distance from water pans. At 50m, impala had the highest abundance (33.7%), followed by zebra (21.1%) and waterbuck (13.9%). Buffalo and warthog had 10.9% each, wildebeest (5.4%) while eland (4%). At 100m, zebra and wildebeest had 30.3% each, followed by impala and warthog (12.9%), then waterbuck (11.8%) and eland had the lowest (1.8%). At 150m, wildebeest had 28.2%, waterbuck (26.8%), zebra (25.4%), while impala and warthog had (9.9%). At 200m, zebra had the highest abundance (37.8%), followed by wildebeest (34.7%) and warthog (11.9%). Waterbuck had (8.3%) while impala (7.3%). At 250m wildebeest had the highest (25%), impala (23.3%), zebra (18.3%), warthog (15%), waterbuck (13.3%), and eland (5%). At 300m, zebra had the highest abundance (37.0%), wildebeest (28.4%), warthog (19.1%), impala (10.5%) and waterbuck (4.9%) (Fig.1). Buffalo was recorded close to the water pans (50m) but the data was not enough to show significant changes in abundance and distribution. Buffaloes were recorded at a distance of 50mbut were mainly observed at distances further from water pans (>300m) even though they are water dependent. In addition, eland was observed at distances 50m, 100m, and 250m from the water pans and this was during the dry season. Impala, zebra, and warthog were evenly distributed in the landscape with impala and zebra having the highest abundance in areas near water pans (50m) as shown in the (Fig. 1).

In determining the differences in mammal abundance between water pans, the overall mean abundance for species was highest in areas around Water pan 2 compared to Water pan 1. Distance 50m had the highest concentration of mammals followed by 100m. However, 150m had the lowest mean abundance (Fig. 2).

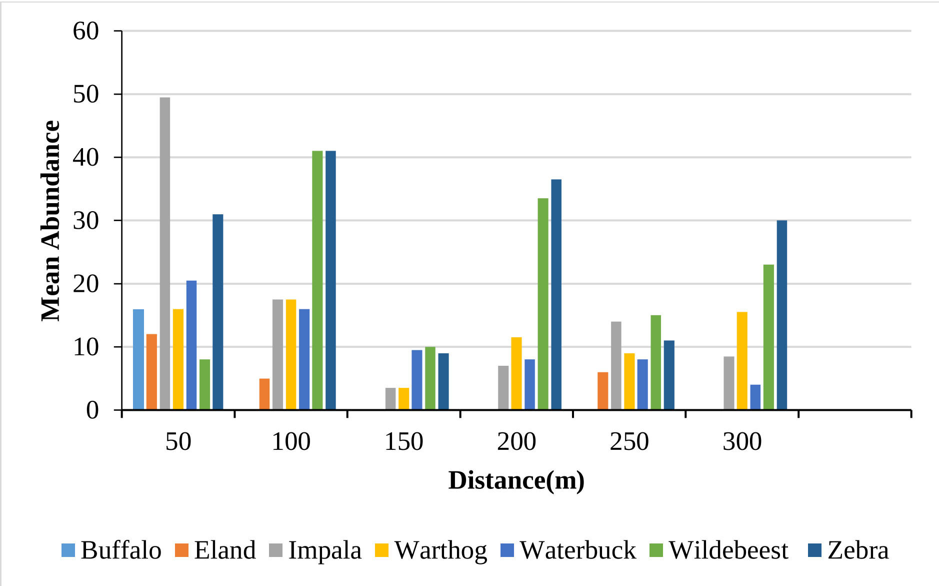

Fig. 1. Mean abundance of individual species in relation to distance from water pans

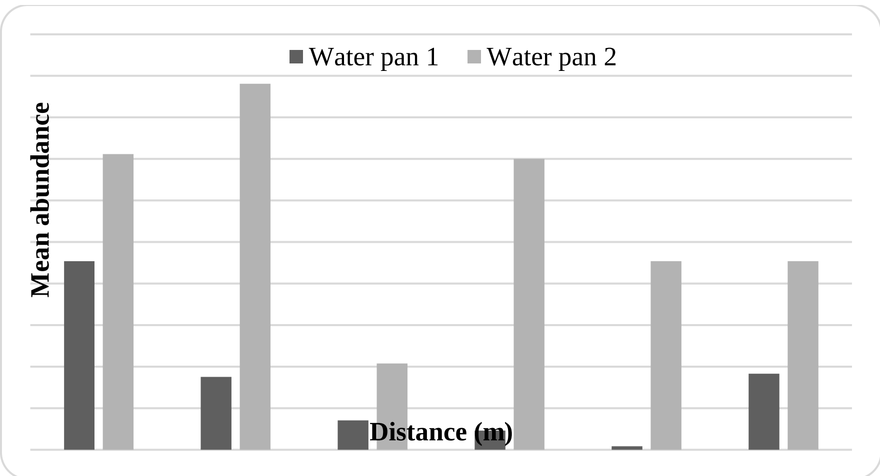

Fig. 2. Abundance of mammal species in relation to distance from each water pan

Spearman's non-parametric correlation was conducted on data from water pans and from both seasons to assess the relationship between mammal abundance and distance to water pans at α=0.05. For the dry season, results show that eland, impala, warthog, waterbuck, and zebra had a strong negative correlation with distance from water pans (r = -0.516, r=-0.714, r = -0.754, r=-0.986 and r= -0.657 respectively) showing that they stayed close to water pans during this period of water scarcity while wildebeest had a weak positive correlation (r= 0.143). Waterbuck is the only species whose abundance significantly decreased with an increase in distance from water pans (p= 0.05) (Table 1).

During the wet season, impala, wildebeest, and waterbuck showed a negative correlation (r= -0.486, r = -0.257 and r = -0.714 respectively) meaning that they remained near water pans, while warthog and zebra showed a positive correlation (r= 0.6 and r= 0.257 respectively) with distance from water pans showing that the dispersed into the area since the ephemeral water sources were full (Table 2).

The mean abundance between the dry and wet seasons was not significantly different (t = 0.346, df =5, p=0.743) at a significant level of α=0.05for the mammal species as tested by independent sample t-test.

Water availability vary both spatially and temporally, which has an impact on species distribution and habitat utilization Epaphras *et al*., [38] Kasiringua, 2019). According to Trent [39] seasons affect availability of forage and water affecting the distance the species has to cover to access the resources influencing the distribution of mammal species.

Different mammal species showed different distribution patterns in relation to distance from water pans between seasons in the conservancy. In the dry season, more mammals were observed than during the wet season within 50 meters of water pans; this could be because these places are rich in food and water [20]. Mammal distribution patterns inside the conservancy were affected by the concentration at water pans throughout the dry season. During the dry season, the amount of water available on the surface decreases, causing high concentrations of mammals near water sources [2]. During the wet season, animals disperse showing that water availability does not only influence distribution but also affects the functionality of the ecosystem [1].

Overall mammal abundance decreased with increasing distance from water pans showing that mammal species in the conservancy are water dependent except for eland that is water-independent and the water pans are important source of water for wildlife species during the dry season when water is limited.

Grazers alter their distribution and remain near water sources. When natural water sources are dry during the dry season, there are fewer water points, increasing the distance to travel [13]. This increase in distance increases the risk of predation, the cost of energy spent during traveling from foraging areas to water points [13]. low quality of the available water and competition [40]. Therefore, well-distributed water points will prevent animals from migrating [28,27] reduces diversity loss, and help in maintaining ecological balance Rispel & Lendelvo, [6] Smith *et al*., 2020).

From the study buffaloes were observed further way from water points. The findings agree with the study done in Kruger National Park, South Africa which showed that buffalo and waterbuck were found far away from water points during the dry season [41]. Areas further from water points are important during the dry season since they act as buffer forage areas available for stronger mobile species that can move long distances between water and forage resources [41].

Table 1. Spearman's rank correlation showing the relationship between mammal abundance and distance from water pans during the dry season

Species	r	P
Eland	-0.516	0.295
Impala	-0.714	0.1107
Warthog	-0.754	0.084
Waterbuck	-0.986	0.0003*
Wildebeest	0.143	0.787
Zebra	-0.657	0.156

(Correlation is significant at p< 0.05).*

Table 2. Spearman's rank correlation showing the relationship between mammal abundance and distance from water pans during the wet season at (p=0.05)

Species	r	P
Impala	-0.486	0.329
Warthog	0.600	0.208
Waterbuck	-0.714	0.111
Wildebeest	-0.257	0.623
Zebra	0.257	0.623

Based on previous studies, mobility has been reported to influence the distribution of species around water sources. Some of the species that have been noted to travel large distances from water sources to feeding areas are buffalo, roan antelope, and kudu [15,30] Rispel & Lendelvo, [6] This study however agrees with the previous finding in regard to buffalo. Buffalos being mobile water-dependent species were found further from water pans compared to other mammals like impala, warthog, and zebras that are non-mobile water-dependent species and thus prefer to remain near water sources. According Kasiringua *et al.* [15] buffaloes are reported to be evenly distributed over the landscape, demonstrating that their proximity to water sources does not affect them during wet or dry seasons. Water-dependent species thus require to drink water frequently in order to supplement the low water content in the grass [6].

Different mammal species have different water requirements causing differences in distributions around water pans. Water requirements in animals differ with body size (Kasiringua, 2019). In this study, large–sized species e.g. buffalo and zebra were more evenly distributed in the landscape than small-sized mammals (warthog and impala). Zebra (grazer) and impala (mixed feeder) were associated with water pans. This agrees with the previous studies that have shown that zebra and impala are water-dependent and therefore found near water pans. In addition, large-sized species have larger home ranges compared to small-sized species enabling them to satisfy their requirements [31] Kasiringua, 2019).

Elands are water independent therefore they were found further from water points. However, during the dry season, elands were observed at water pans. This is because in the dry season, few leaves remain and they get less water being forced to visit water pans. Water-independent species occupy areas far away from water points and this enhances their survival due to reduced competition and predation pressure [6,14].

Wildebeest are typically water-dependent species and thus they concentrate in areas with high water availability. From the study, the abundance of wildebeest was high near water pans. From a study that was done in Namibia by Rispel & Lendelvo [6] a homogenous distribution of water points led to a homogeneous distribution of wildebeest.

4. CONCLUSION

In terms of mammal distribution and abundance, many mammals concentrated near the constructed water pans during the dry season due to the presence of forage and drinking water but dispersed out when ephemeral water sources and forage availability increased during the wet season. Therefore, construction of water pans in protected areas can be a management tool for influencing wildlife distribution and abundance.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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