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Short Communication

Analysis of the abundance and spatial distribution of the common hippopotamus, (*Hippopotamus amphibius*) in the Manjirenji Dam, Zimbabwe, to inform conservation and detect human–wildlife conflict hot spots

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Introduction

The population of the common hippo (*Hippopotamus amphibius*) has decreased drastically over the last decades (Jablonski, 2004) and its distribution becoming patchy and uneven (Lewison & Oliver, 2008a,b). This is largely attributed to loss of grazing habitats or daytime retreats due to deleterious activities such as river siltation, water extraction, water pollution, shoreline cultivation and riparian deforestation (Zisadza *et al.*, 2010) as well as unregulated hunting for meat, hide and ivory from its canine and incisor teeth (Eltringham, 1999). Severe constriction of habitat quality and quantity can result in competition for natural resources between wild animals and resident human communities and can lead to human–wildlife conflict (Ertiban, 2016).

Reductions in the size and abundance of suitable hippo pools due to anthropogenic driven activities such as river sand mining, gold panning and siltation rife in the Chiredzi River, in Zimbabwe, force hippos to migrate towards the more permanent water at Manjirenji Dam (Zisadza *et al.*, 2010). In recent years, partly due to extreme variations in rainfall and temperature, and the increase in irrigable land in the Mkwasine sugar estates (Mazvimavi, 2010), the lake levels in Manjirenji Dam have been fluctuating widely (Svubure *et al.*, 2010; Zimbabwe National Water Authority, 2014). This has presented a dilemma for the common hippo, that is as the dam wall acts as a barrier and there is a lack of suitable habitats in the upstream section of the Chiredzi River. During periods of extreme low water levels, there is a large muddy drawdown zone which is devoid of palatable short grass in both the Manjirenji Dam and Chiredzi River. Although a hippo can survive in muddy wallows, it must have permanent access to water in the dry season because of complex skin physiology (Lewison & Oliver, 2008a). As an obligate grazer, short-grass grazing specialist and a prototypical mega herbivore (Dudley, 1998), hippos may increase distance travelled from a pool as it forages in drought periods (Jablonski, 2004; Lewison, 2007).

When hippos move into the crop fields of adjacent villages, there is an increased likelihood of fatal encounters between human and hippos (Lewison, 2007). Villages adjacent to the catchment of the Manjirenji Dam have reported destruction of crops (*pers. com*). However, the anecdotal reports of human–hippo conflicts from communal areas in the catchment of the Manjirenji Dam do not provide scientific data to inform the Parks Management, and may impede the development of effective conflict mitigation plans. Therefore, the goals of this study were to determine the spatial distribution of hippos in the Manjirenji Dam and estimate their abundance to inform conservation and detect potential human–wildlife conflict spots around the Dam.

Material and methods

This study was carried out at Manjirenji Dam which is 2,020 ha in extent, with a 17-km shore length and located in the arid south-eastern part of Zimbabwe. The dam was built solely to provide irrigation water for the Mkwasine sugarcane estates, although multiple uses have evolved (ZINWA, 2014). We established ten shallow and seven deep water sites to more evenly sample the entire Manjirenji Dam (Fig. 1), although logistical constraints

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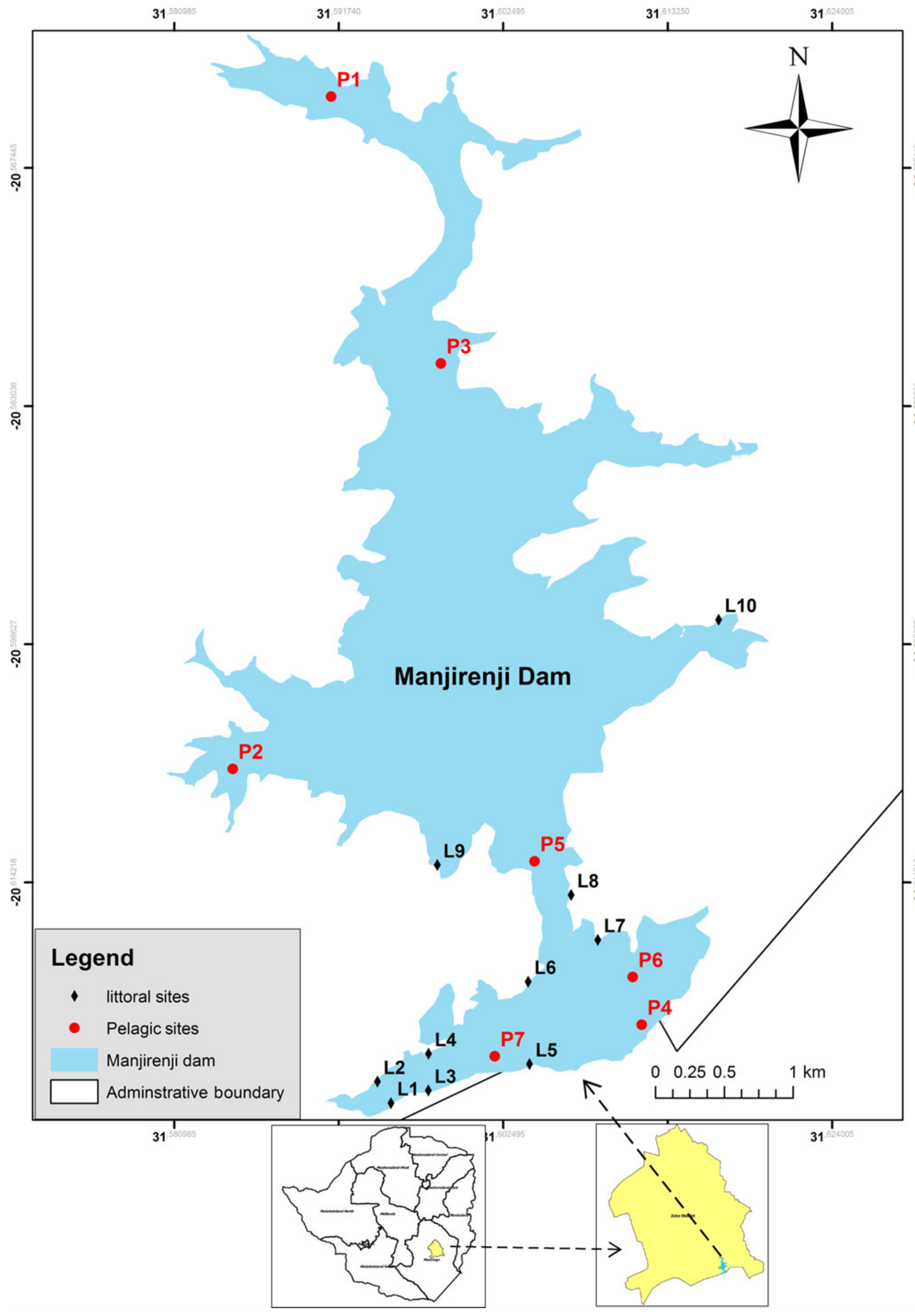

Fig 1 Location of the sampling sites in the Manjirenji Dam

limited the number of deep water sites. We sampled each site once a month from August 2013 to April 2014. At each site, we recorded the total number of hippos observed and logged the sighting positions of the nearest fixed sampling site into a Garmin Geographic Positioning System (GPS) 60 receiver unit. Due to safety concerns, we used a motorboat to navigate the dam and sample the hippo population. Motorized boat surveys result in double counting of hippos as they retreat upon hearing the sound of the outboard engine; thus, in this study, we switched off the boat engine upon sighting hippos to minimize the noise. We visually assessed grazing intensity in a 2-km radius off each site. Visual estimates of grazing intensity were done off boat at each site in the drawdown zone to determine and identify the feeding tracks of the hippo at each sampling occasion using the Jardine's general reconnaissance method (Jardine, 1908; Jardine & Anderson, 1919), modified for short grasses (Holecheck & Galt, 2000) as summarized in Table 1. To avoid bias, the team was divided into two groups, one for assessing grazing intensity, whilst the second group was recording the number of hippos sighted at each sampling site. The base map for Manjirenji Dam was overlaid with the collected hippo sightings to determine spatial relationships of hippos in the Manjirenji Dam. We do not disregard the shortcomings in the Jardine's qualitative method of categorizing grazing intensity, with regard to forage availability estimates as it is based on estimates of the ground cover of each species rather than on direct measurements of the volume or weight of the forage productivity or yield and neglect the sward height (Jardine, 1908; Jardine & Anderson, 1919). However, the Jardine's method is functional in modified forms for quick estimation of grazing intensity (Holecheck & Galt, 2000) hence its application in this study.

We recorded the total number of hippos at each site for each month and used the data to calculate spatiotemporal differences using ANOVA ($P < 0.05$). To understand hippo spatial distribution and conduct a hot spot analysis, we computed the Getis-Ord Gi* statistic (Z) (Getis & Ord, 1992) using algorithms in ArcGIS 10.1 (Scott & Warmerdam, 2005), using the fixed distance band under the conceptualization of spatial relationships and the Manhattan distance method (Mitchell, 2005).

Results and discussion

We recorded a combined total of 177 hippos in the seventeen sites sampled over the study period in the Manjirenji Dam. Hot spot analysis for hippo sightings detected two significantly high hot spots with GiZ score, that is $Z > 2.58$ at site P1, located near the entrance of the main tributary, Chiredzi River and site P3, located near the communal areas at (Fig. 2). Presence of a large cohort of hippos near the Chiredzi River entrance is attributed to the dwindling number and size of suitable pool habitats upstream, a finding supported by visible siltation and sand mining scars in the Chiredzi River bed. Viljoen & Biggs (1998) report that hippo populations are regulated by both aquatic and terrestrial factors, that is the availability of daytime retreats and foraging areas. We found no other evidence of hot spots ($Z < -2.58$) and no statistically significant spatiotemporal differences (ANOVA, $P > 0.05$; $F = 0.9116$, df = 8) in hippo abundances in sampled sites. This reflects no evidence that human–hippo conflict may fluctuate with seasonality in Manjirenji Dam. However, the short duration of the sampling period has potential to underestimate human–wildlife conflicts (Zisadza *et al.*, 2010).

Table 1 Qualitative characteristics of grazing intensity used to categorize peripheral land in the drawdown zone of the Manjirenji Dam adapted from Holecheck & Galt, 2000

Qualitative grazing intensity category	Use of forage by weight%	Qualitative indicators of grazing intensity
Light to nonuse	0–30	Only choice plants show use. No use of poor forage plants
Conservative	31–40	Choice forage plants have abundant seed stalks
Moderate	41–50	Most accessible range shows use. Key areas show patchy appearances, with one half to two-thirds of primary forage plants showing use. Grazing is noticeable in a 1–1.5 mile radius.
Heavy	51–60	Nearly all primary forage plants show grazing in all key areas. Palatable shrubs show hedging. Key areas show lack of seed stalks. Grazing is noticeable in areas over 1.5 miles from water.
Severe	61+	Key areas show a mowed or clipped appearance (no stubble height) Shrubs are severely hedged. There is evidence of livestock trailing to forage. Areas over 1.5 miles from water lack stubble height.

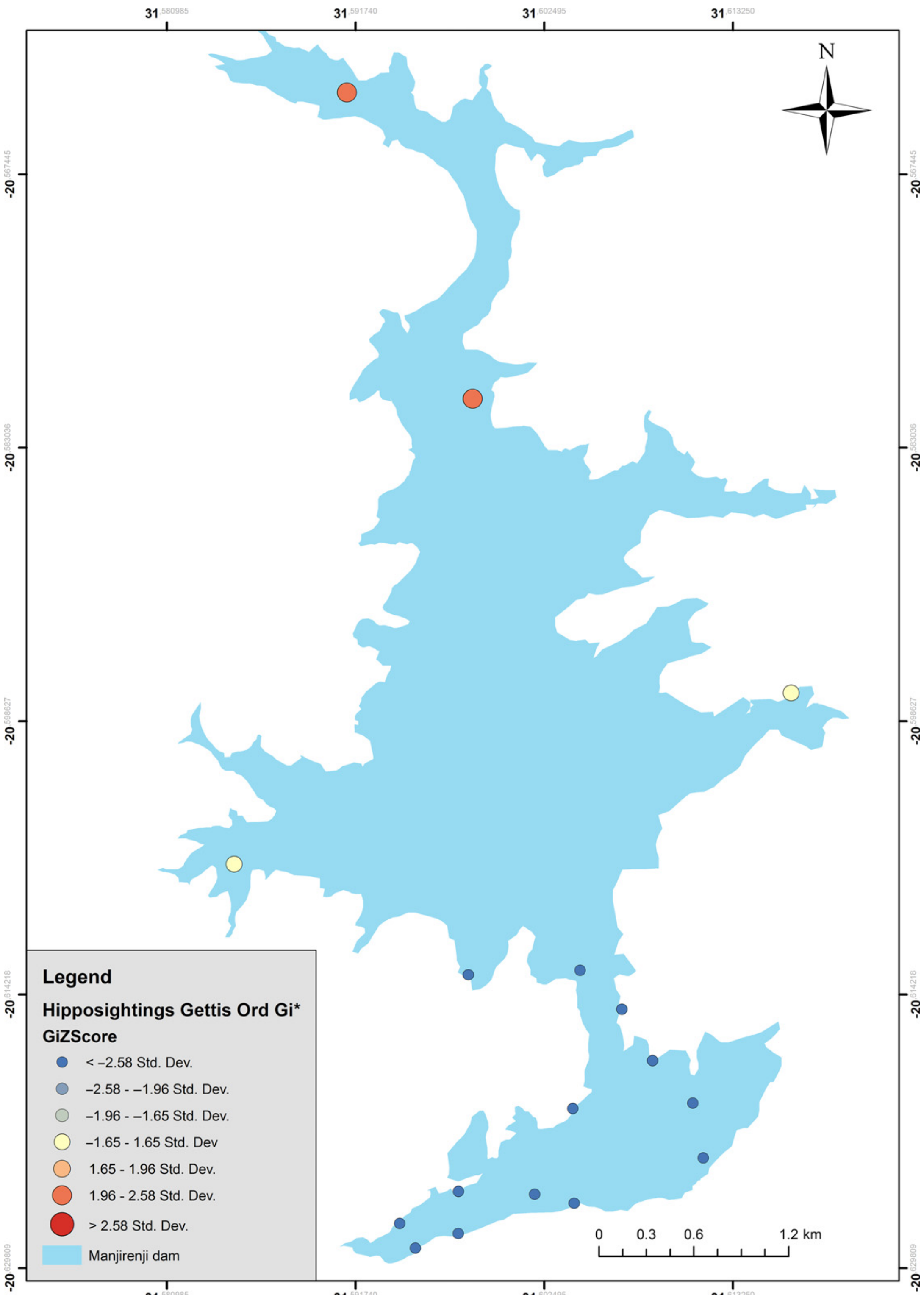

Fig 2 Hippo sightings Gertis Ord categories for each sampling site in the Manjirenji Dam

Table 2 Grazing intensity of hippos in the drawdown zone of the Manjirenji Dam. LI, Light; MD, Moderate; SV, Severe; HV, Heavy and CN, Conservative grazing intensities

Grazing intensity									
Site	August	September	October	Nov	December	January	February	March	April
L1	MD	MD	LI	LI	LI	LI	LI	LI	LI
L2	MD	MD	CN	LI	LI	LI	LI	LI	LI
L3	MD	MD	LI	LI	LI	LI	LI	LI	LI
L4	CN	CN	MD	LI	LI	MD	LI	LI	LI
L5	LI	LI	MD	LI	LI	LI	LI	LI	LI
L6	LI	LI	LI	LI	CN	CN	LI	MD	MD
L7	CN	CN	LI	MD	CN	CN	CN	LI	LI
L8	CN	CN	CN	LI	LI	LI	LI	LI	LI
L9	LI	LI	LI	LI	LI	LI	LI	MD	MD
L10	HV	HV	LI	MD	MD	MD	MD	MD	MD
P1	SV	SV	SV	MD	MD	MD	MD	MD	SV
P2	SV	SV	MD	MD	MD	MD	MD	MD	SV
P3	HV	HV	MD	SV	CN	CN	MD	SV	SV
P4	CN	CN	MD	LI	LI	LI	MD	MD	MD
P5	LI	LI	LI	LI	LI	LI	LI	LI	LI
P6	LI	LI	LI	LI	LI	LI	LI	LI	LI
P7	LI	LI	LI	LI	LI	LI	LI	LI	LI

Grazing intensity was heavy to severe at sites P1, P2, P3 and L10, which are located either near the Chiredzi River, a tributary to the Manjirenji Dam, or near adjacent communities, particularly in the dry months of August and September (Table 2). This corroborates with the presence of significantly large hippo hot spots at sites P1 and P3. High grazing intensity sites were located near field crops belonging to adjacent communities, which suggests that the availability of alternative forage in the form of field crops may influence hippo grazing and distribution; it is possible that small cohorts/groups can indicate poor distribution and poor habitat quality for the hippos (Timbuka, 2012). However, large cohorts of hippos can be merely an indication of crowding together brought about by lack of water space (Atwell, 1963; Ertiban, 2016). We found some evidence for this assertion as sites with least significant hippo hot spots occurred near nonvegetated, rocky shorelines and on the dam wall and had low occurrence or even absence of feed tracks.

A combination of environmental factors such as low rainfall, reduced lake levels and human-induced threats is likely to have negative effects on local hippo populations (Smuts & Whyte, 1981; Eltringham, 1999; Lewison, 2007). The observed dynamics of the Manjirenji Dam which has been subjected to wide, severe and extreme water level fluctuations over the last decades (ZINWA, 2014) has created patches of nonvegetated littoral muddy pedestal or contour terraces due to constant nutrient erosion and reduced water residence time and a pronounced drawdown zone (Kolding & Zwitten, 2012). The poor littoral vegetation and the rock fill wall of the dam reduce available forage in and around the dam that may cause hippos to forage at P1, P2, P3 and L10 adjacent to community villages.

Hippo migration or movement into surrounding communal areas potentially creates human–wildlife conflict with villagers (McCarthy, Ellery & Bloem, 1998). Although anecdotal reports from wildlife officials indicate hippos have been consistently persecuted by villagers, villagers report of human fatalities. Similar human–hippo conflicts (HHC) have been reported in Kenya and Mozambique (Kanga, Ogutu & Piepho, 2012), also linked to land-use initiatives around wetlands. This study is the first record of the abundance of the hippo and its distribution in the Manjirenji Dam in Zimbabwe. We recommend that future hippo studies should further investigate hippo population structure and sex ratio as suggested by Zisadza *et al.* (2010) and aim to correlate the water quality, forage quality and hippo intradam movements with human–hippo conflict in Manjirenji Dam communities. Prudent water extraction management by the dam authorities can maintain viable retreats for hippos which are known to have a profound effect on the biodiversity of aquatic ecosystems (Timbuka, 2012). To balance ecological goals and socio-economic well-being of local communities and curtail threats to endangered hippos, a multifaceted approach of hot spot analysis, hippo corridor migration assessment, drawdown grazing intensity and human community dynamics around dams needs consideration.

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