Received: 6 November 2018 | Revised: 30 March 2019 | Accepted: 28 April 2019

DOI: 10.1111/aje.12638

NOTE AND RECORD

African Journal of Ecology WILEY

Large mammals and wetland utilisation: A case study in Yankari Game Reserve, Nigeria

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1 | INTRODUCTION

The African plain harbours high abundance and diversity of mammals, most of which are confined to protected areas (PAs) due to anthropogenic threats (Craigie et al., 2010; Dirzo et al., 2014; Estes, 1999; Kingdon, 1997). Also, PAs face problems of hunting, logging and livestock grazing, conflict of interest and poor management (Caro, 2001; Dharmaratne, Sang, & Walling, 2000; Gardner et al., 2009; Geldmann et al., 2015; Geldmann et al., 2015; Hall, Harris, Medjibe, & Ashton, 2003; Pressey, 1994; Salum, Eustace, Malata, & Mbangwa, 2017; Thuiller, 2007), consequently disrupting conservation goals, effective monitoring and understanding of habitat utilisation dynamics of mammals.

Although wetlands are important habitats for sustaining animal populations, there is a widespread trend of increasing degradation of these habitats (Fynn, Chase, & Röder, 2014) and dearth of information pertaining to wetland utilisation in most PAs. While this is integral for effective conservation practice, few studies focus on this area in Africa (Arzamendia, Cassini, & Vila, 2006; Kumar, Mudappa, & Raman, 2010; Rahman et al., 2017). Here, we investigated the wetland utilisation dynamics of large mammals in Yankari Game Reserve (YGR). The objective was to determine abundance, density and diversity of large mammals and whether these variables were associated with wetland size and time of day.

2 | METHODOLOGY

Ten wetlands (Mu'azu Lamido, Mawulgo, Mawulgo Annex, Crocodile Zone, Magama, Baba Ilori, Salt Lick B, Tupper-Carry, Kangiwa and Guruntum) were surveyed between April and June 2009 in YGR. The reserve is 2,244.10 km^2 at an altitude of 160–750 m a.s.l. and located between latitudes 9°35′–10°05′N and longitudes 10°10′–10°50′E in the Sudan Savannah south-central zone of Bauchi State, Nigeria. The reserve is bisected by the River Gaji with flood plains at 300- to 630-m intervals along its bank making about 10% of the entire reserve area. The Gaji is bordered by gallery and riparian forests, and the other areas of reserve are woodland savannah (Crick & Marshall, 1981; Geerling, 1973). The area experiences wet and dry seasons with annual rainfall averages of 900–1,000 mm and mean annual temperatures of 12–36°C.

Point count (PC) was carried out from marked positions in the wetlands during morning (06:00–10:00 hours) and evening (15:00–18:00 hours) with counts repeated multiple times (n > 32) to avoid bias in data collection (Sutherland, 2008). Ten minutes was spent in each wetland to record species of mammal seen or heard, and distance from observer using binoculars and telescope. Motion-sensor cameras (MSC) (Wildview) were mounted at vantage positions in wetlands (Andrew, Todd, & Laurie, 2008) to record mammals in the early morning (01:00–06:00 hours), afternoon (11:00–15:00 hours) and late evening (18:00–24:00 hours). Cameras were mounted on trees 1.70 m aboveground with 45- to 90-degree lens view and 30 m clear visualisation in north or south direction to avoid poor image quality from sun rays. Cameras were retrieved every 48 hr for data download and battery replacement. Size (km^2) and distance (m), that is from each other, of wetlands were determined using a GPS device.

Data were analysed using the SPSS package (version 12, 2002). Density and diversity of mammals were estimated using Distance

Software version 5.1.0 (Thomas et al., 2010) and Shannon–Weiner diversity index, respectively. Independent-sample *t* test was used to test differences between morning and evening abundance and Kruskal–Wallis tests for differences between early morning, afternoon and late evening abundance of mammals. The relationship between wetland size and abundance, density and diversity was determined with Wilcoxon's test.

3 | RESULTS AND DISCUSSION

Together, fourteen species of mammal in eight families were recorded in wetlands: PC detected 2,224 individuals of twelve species and six families during 640 days, and MSC detected 166 individuals of twelve species and eight families during 160 days. Both methods detected 10 (71.4%) species in common and two species (16.6%) exclusively (Table 1).

Wetland size was positively correlated with abundance (Wilcoxon test $Z = -2.803$, $p = 0.005$; Figure 1a); but negatively with density (Wilcoxon test $Z = -2.293$, $p = 0.022$; Figure 1b) and diversity (Wilcoxon test $Z = -2.497$, $p = 0.013$; Figure 1c). Further, abundance of mammals differed by time of day, for example morning and evening (independent-sample *t* test, $t = 1.585$ $p = 0.027$; Figure 1d); and early morning, afternoon and late evening (Kruskal–Wallis, $X^2=6.359$, $p = 0.042$; Figure 1e). Diversity varied across time of day (Wilcoxon test $Z = -3.920$, $p < 0.001$). Larger wetlands

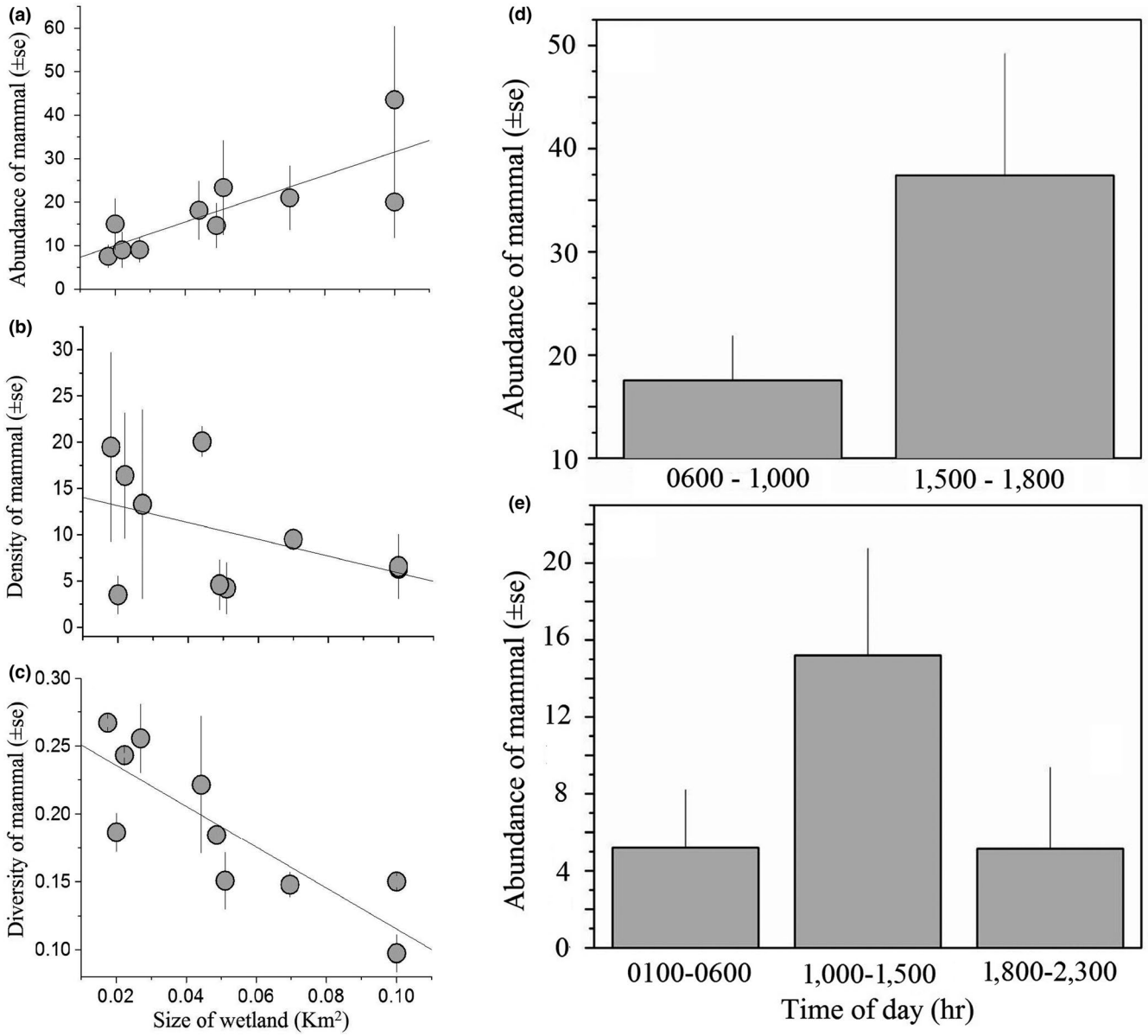

FIGURE 1 The relationship between the size of wetlands and (a) abundance, (b) density and (c) diversity; and abundance of large mammals by the period of the day (d) morning and evening, (e) early morning, afternoon and late evening in the wetlands of Yankari Game Reserve

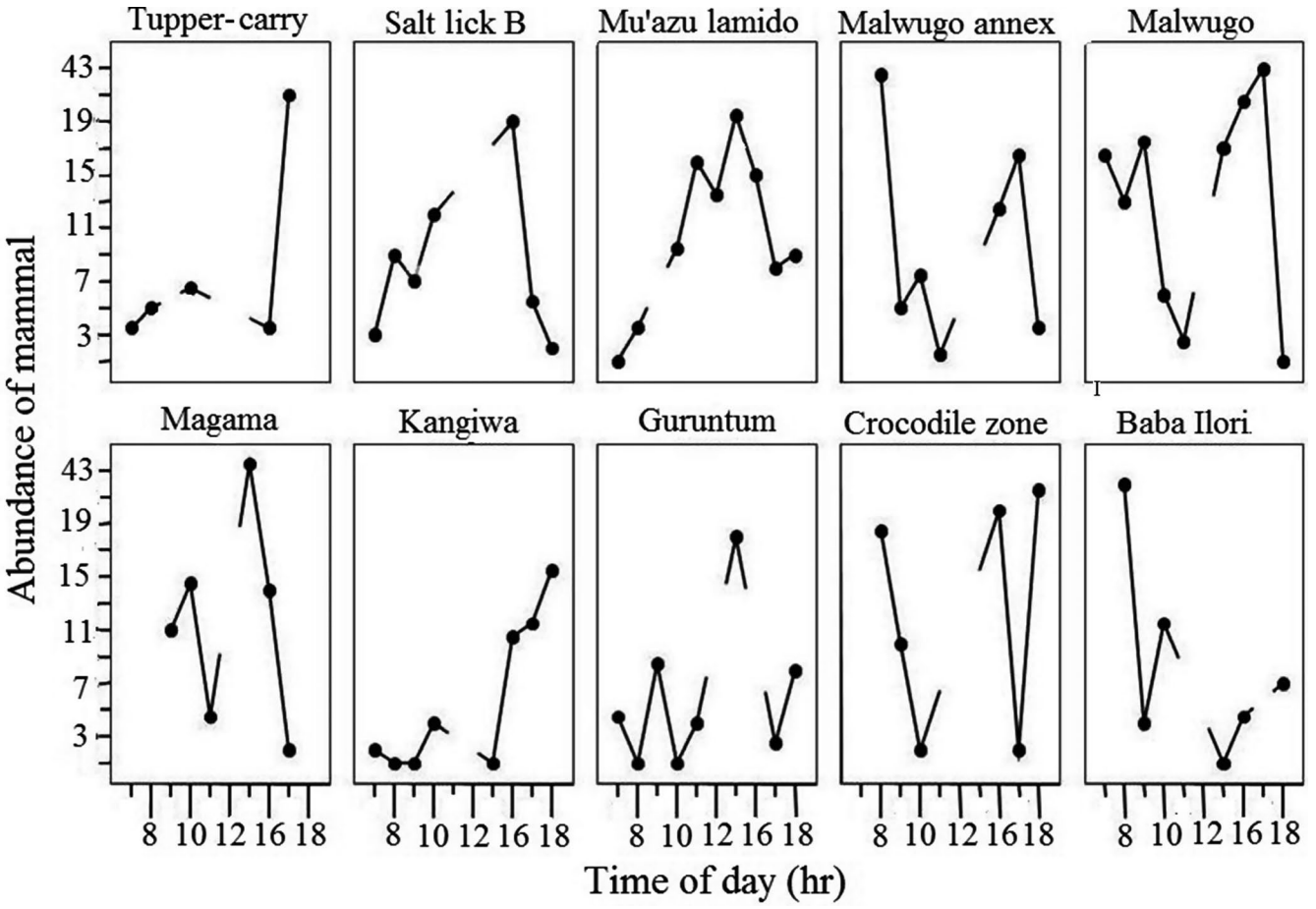

FIGURE 2 The peak abundance of large mammals per hour of the day across wetlands in Yankari Game Reserve

had higher abundance of mammals, but not density and diversity (Figure 2a). Wetland location and quality of resources may drive this trend across the wetland (He & Legendre, 1996; Van Horne, 1983). Large wetlands may provide space for species concurrence and drive overlap in resource use while minimising competition (Bjørneraas et al., 2012; Fryxell & Sinclair, 1988; Mduma, Sinclair, & Hilborn, 1999; Rosenzweig, 1981). The difference in abundance and diversity of mammals by time of day is not surprising. Increasing heat of the day poses dehydration problems to mammals leading to more frequent visits to and utilisation of wetlands across time of day (Figure 2).

Water, food and cover are important factors influencing distribution of animals (Afolayan, Milligan, & Salami, 1983), and wetlands offer these basic necessities. Threat of dehydration, starvation and mortality in the dry season can cause movements from upland areas of dried and depleted forage to wetland buffer zone (Fynn et al., 2014; Girma, Mamo, & Ersado, 2012; Jenkins, Corti, Fanning, & Roettcher, 2002; Macandza, Owen-Smith, & Cain, 2012; Owen-Smith, 2002; Stacie, Erek, Nabil, Dhaval, & Bruce, 2010; Yaba, Mekonen, Bekele, & Malcolm, 2011), suggesting that wetlands are important for sustaining herbivore nutrition over the dry seasons (Bukombe et al., 2017; Grant & Scholes, 2006; Hopcraft, Olff, & Sinclair, 2010; Parrini & Owen-Smith, 2009) and influencing their assemblages across wetlands. Wetlands also enable mammals to achieve thermoregulation via bathing pools and mud wallows.

Our results provided information on the abundance, density and diversity of large mammals in the wetlands in YGR, and the associated effect of wetland size and time of day on wetland visit and utilisation establishing the usefulness of wetlands to large mammals in the reserve.

ACKNOWLEDGEMENTS

We are grateful to Dr A. P. Leventis for financial support. We thank the Bauchi State Government for permission to conduct this study in YGR. We also thank the General Manager and management of YGR for their support. Haladu Idi drove our field vehicle. This is contribution no. 144 from the A. P. Leventis Ornithological Research Institute.

TABLE 1 Presence (checked), absence (unchecked) and total count for point count (PC) and motion-sensor camera (MSC) records for species of large mammals on wetland sites in Yankari Game Reserve, Nigeria

Common name	Species	Mu'Azu Lamido	Mawulgo	Mawulgo Annex	Crocodile Zone	Magama	Baba Ilori	Salt Lick B	Tupper-Carry	Kangiwa	Guruntum	PC	MSC	Occurrence (%)
Olive baboon	*Papio anubis*	√	√	√	√	√	√	√	√	√	√	651	43	28.45
African buffalo	*Syncerus caffer*		√		√							121	9	5.00
Bushbuck	*Tragelaphus scriptus*	√	√	√	√	√		√	√	√	√	68	11	3.30
African elephant	*Loxodonta africana*			√							√	60	26	3.50
Hippopotamus	*Hippopotamus amphibious*	√	√	√		√	√	√	√		√	24	13	1.90
Lion	*Panthera leo*				√					√		[a]	3	0.10
Patas monkey	*Erythrocebus patas*	√										33	1	1.40
Red-flanked duiker	*Cephalophus rufilatus*			√								1	[a]	0.04
Roan antelope	*Hippotragus equinus*	√		√	√	√		√	√			33	[a]	1.40
Tantalus monkey	*Chlorocebus tantalus*	√	√	√	√	√	√	√	√	√	√	482	2	20.30
Common warthog	*Phacochoerus africanas*		√	√	√	√	√	√	√	√	√	97	14	4.60
Waterbuck	*Kobus ellipsiprymnus*	√	√	√	√	√	√	√	√	√	√	555	34	24.60
Western Hartebeest	*Alcelaphus buselaphus*	√	√			√	√	√				99	9	4.50
African civet	*Civettictis civetta*		√									[a]	1	0.04

[a]Species exclusively recorded for the two survey methods.

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How to cite this article: Omotoriogun TC, Tende T, Adeiza ZO, et al. Large mammals and wetland utilisation: A case study in Yankari Game Reserve, Nigeria. *Afr J Ecol*. 2019;00:1–6. https://doi.org/10.1111/aje.12638