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SHORT COMMUNICATION

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Seasonal movement behaviour of large male elephant in Hwange National Park, Zimbabwe

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Abstract

A great challenge for African conservationists is human–wildlife conflict outside the boundaries of protected areas (PAs). This is particularly true when considering large mobile species, such as elephants, that often disperse from PAs into community land. In Zimbabwe's Hwange National Park, studies on elephant dispersal have focused on breeding herds. Here, we analyse the movements of five older, large males fitted with GPS collars. We found some dispersal outside Hwange, but large males were largely restricted to the Park, especially during the late dry season when water was scarce. Our findings may be useful to regional conservation decision makers.

Abstrait

Gérer les conflits entre l'homme et la faune à l'extérieur des zones protégées (ZP) constitue un défi majeur pour les autorités africaines chargées de protéger l'environnement Cette situation est particulièrement manifeste lorsqu'on a affaire aux grands mammifères mobiles, tels que les éléphants qui s'échappent souvent des zones protégées pour se hisser sur les terres communautaires. Dans le parc national de Hwange au Zimbabwe, les études sur la dispersion des éléphants se sont concentrées sur les troupeaux reproducteurs. Dans notre étude, nous analysons les mouvements de cinq grands mâles âgés équipés de colliers GPS. Nous avons constaté quelques sorties en dehors de Hwange, mais les grands mâles étaient largement limités au parc, notamment en fin de saison sèche, lorsque l'eau était rare. Nos résultats peuvent être utiles aux décideurs de la région en matière de conservation.

1 | INTRODUCTION

African savannah elephant (*Loxodonta africana*) populations have declined across much of Africa over the past few decades (Wittemyer et al., 2014). Habitat loss and illegal hunting have largely driven this decline (Schlossberg et al., 2020), and continent-wide, elephant populations are decreasing by 8% per annum (Chase et al., 2016). The pattern does not hold for southern Africa, however, where savannah elephant (hereafter elephant) densities remain relatively high, although these are mostly restricted to Protected Areas (Wittemyer et al., 2014). Relatively large elephant populations now occupy wildlife areas across northern Botswana (Chobe-Kwando region), through to western Zimbabwe (Hwange-Kazuma region), and efforts to facilitate elephant dispersal are underway (Huang et al., 2022). These regions are part of the Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA).

In some parts of the KAZA TFCA, such as Hwange National Park in Zimbabwe, elephant densities are at historically high levels (Ferry et al., 2021). When Hwange was designated as a National Park almost 100 years ago, elephant dispersed widely across the region, as water availability was seasonal (Davison, 1967). Year-round artificial water supply, and increased human settlement outside of Hwange has now restricted elephant to the Park, and densities are now >2 animals per km^2 (Dunham, 2015); higher than ~1 elephant km^2 in the mid-1980s, when culling was stopped (Ferry et al., 2021).

Elevated elephant densities in Hwange NP have altered vegetation structure (Ferry et al., 2021), and there are concerns about the indirect ecosystem effects of these changes. Moreover, the fencing of the perimeter of Hwange NP is not effective in restricting movement into communal areas, as most of it has been damaged. Consequently, elephants can move outside of the Park, bringing them into conflict with poor villagers (Guerbois et al., 2012). The challenges of elephant management in Hwange are similar across the KAZA TFCA, and conservation scientists working to facilitate dispersal of elephants across the transfrontier area require data on animal movement. They may also require data on the intensity of habitat use by elephants in large Protected Areas (PA) like Hwange, given the likelihood of vegetation change as elephant densities increase.

Within Hwange NP, some work has been done on female elephant habitat use and movement outside of the Park (Chamaillé-Jammes et al., 2013; Tshipa et al., 2017), but practically no work has been done on adult male elephant dispersal, excepting one study that collared one male elephant (Mlambo et al., 2021). This is an omission as problem elephants tend to be males, in particular older bulls (Chiyo et al., 2011).

Our study sought to address this bias for Hwange NP. Specifically, we tracked five older male elephants in Hwange NP for up to 22 months, with the purpose of (a) recording dispersal events outside of the Park, (b) estimating seasonal home ranges, and the possible role of artificial water in determining these and (c) exploring the effect of season on male elephant behaviour.

2 | MATERIALS AND METHODS

2.1 | Study site

Hwange NP is a 14,650 km^2 site in north-western Zimbabwe. Rainfall ranges from 300 to 800 mm per annum, mostly over the rain or wet season, from start December to end March (Dzinotizei et al., 2019). There is a cool dry season (April–July), that we term the early dry (ED) and a late dry season (August–November). The LD is a resource restricted period, and borehole-pumped waterholes are the principal source of surface water over this season. Details on the vegetation types in Hwange NP may be sourced from Arraut et al. (2018). Reliable rainfall data were not available during our study.

2.2 | Location data

Five large male elephants were immobilised on foot, and fitted with GPS (IM-SAT) collars in August and November 2018. All field work was conducted within Hwange NP. Collars were provided by *African Wildlife Tracking* (https://awt.co.za) and configured to record location data every hour. The shoulder height of tagged males ranged from 309 to 344 cm, ageing the animals at 40–60 years (see Shrader et al., 2006).

Two animals died ~6 months after tags were placed, and the damaged collars were not re-fitted. Hourly location data were derived for ~19 months for 1 remaining collar, and ~22 months for the other 2 collars. We could not remove collars after 24 months as intended (in 2020) because of the pandemic, so collars were set to record location at less regular intervals, and all three collars were removed in August 2021. Further details on the field work are provided in the Supporting Information.

2.3 | Data analysis

From the GPS location data, we were interested to know how much time male elephants spent outside of the Park, and when this occurred. We used a shapefile of Hwange NP boundaries to separate animal location data within, and outside of the Park, and used the date and time stamps for each location data point (estimated as latitude and longitude) to infer male dispersal over season and diel. The Geographic Information System (GIS) software used was ArcGIS, licenced to University of Leeds. See the Supporting Information for day/night times.

We also wanted to know the effect of surface water on elephant movement during the LD season. Thus, we subsampled elephant

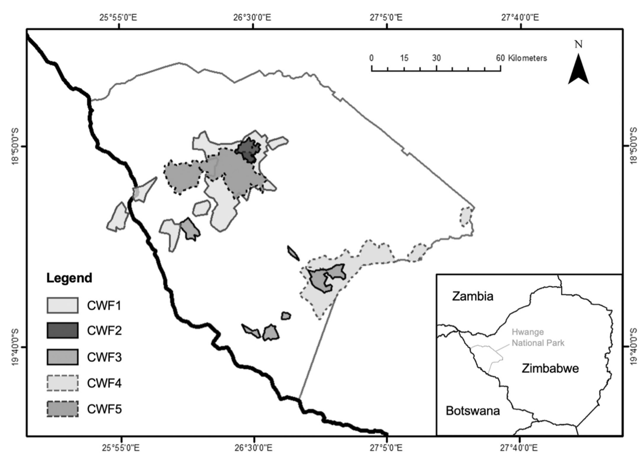

FIGURE 1 Map of Zimbabwe's Hwange National Park showing the 90% k-LoCoH home ranges of five male elephants tracked with GPS collars. Elephants are referenced using GPS collar IDs (CWF1-5). The data used in this study span ~22 months for CWF1 and CWF4, ~19 months for CWF5, and ~6 months for CWF2 and CWF3. See Supporting Information for details of collar IDs.

TABLE 1 The proportion of time that all male elephants spent outside of Hwange NP over the study period and for season and diel.

Season	Diel period	GPS fixes inside of National Park	GPS fixes outside of National Park	Percent outside (%)
Early Dry	Day	6509	492	7.0
	Night	6494	446	6.4
	All	13,003	938	6.7
Late Dry	Day	8811	110	1.2
	Night	8688	211	2.4
	All	17,499	321	1.8
Wet	Day	9628	139	1.4
	Night	9462	255	2.6
	All	19,090	394	2.0

Note: Data are based on all GPS fixes (for all five collars), and across years.

location over the LD (across years) and calculated distance to water in metres (using the *near* tool in ArcGIS). Surface water location in Hwange NP over the LD was taken from known artificial waterholes and permanent pans (see Supporting Information). We further estimated the effect of diel on elephant water visitation, where a 'visit to water' was taken as an elephant location within 1 km distance to the closest water point (see Chamaille-Jammes et al., 2013).

Further, we required the seasonal home ranges of male elephants in Hwange NP, and possible extension of those ranges outside of the Park. To construct home ranges, we used the utilisation distribution, based on the kernel method and the minimum convex polygon approach provided through the R package AdehabitatHR (Calenge, 2006). We also used the local convex hull approach through the R package LoCoH (Getz et al., 2007). Analyses were done via the R computing language platform (R Development Core Team, 2022). The effects of season were pooled across years, and we mapped the differences between seasonal home ranges (see Supporting Information).

Finally, we wanted to know the effect of season on male elephant movement behaviour. We postulated that a marked reduction in daily movement over the dry season may indicate physiological stress due to restricted access to water. Thus, we determined animal movement speed using the R package AdehabitatLT (Calenge, 2011), where speed was estimated as mean distance moved (between locations) per hour. Elephant location data from outside Hwange NP were omitted because individual elephant behaviour may change when outside of a PA (Jachowski et al., 2013).

3 | RESULTS AND DISCUSSION

Based on all location data, large male elephants in Hwange NP appear to spend much of their time within the National Park (Figure 1; Table 1). For all study animals, and across years the LD season was when animals were most restricted to the Park (Table 1). This may be because much of the available surface water in the region is within Hwange NP (over the dry season). Previous

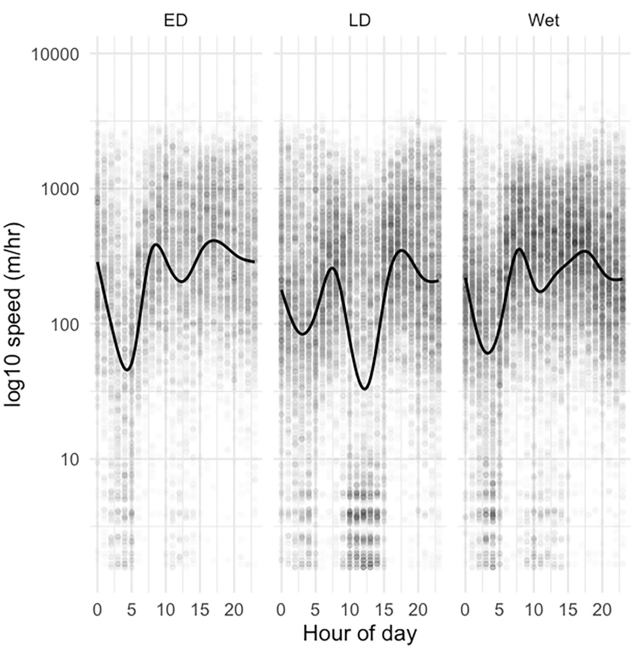

FIGURE 2 Movement speed by hour of day in the early dry (ED), late dry (LD) and wet seasons in five adult male elephants in Hwange National Park. Raw data are plotted and fitted lines are based on generalised additive model smoothing. Data are across 2 years. The ED season plot excludes two of the five elephants as their GPS data spanned <6 months and did not cover an ED season. Movement speed here is log10 transformed metres per hour.

studies on female elephants in Hwange NP also found that animals were restricted to the Park over the dry season (Tshipa et al., 2017). We found that male elephants tended to disperse widely within the Park after the rains had arrived, and there was some movement outside of the Park over the wet season, and into the early dry (Figure S1). Similar to collared females in Hwange NP (Tshipa et al., 2017), wet season male excursions were principally into Botswana, or neighbouring Forestry Commission land (Figure S1). We observed minor excursions made by some males into communal lands over the LD season (Figure S1). The mean distance dispersed outside the Park by all male elephants here over

TABLE 2 The home range sizes (km^2) of male elephants in Hwange NP.

	k-LoCoH		KDE$_{(href)}$		MCP	
	50%	90%	50%	90%	50%	90%
CWF1						
Wet	126	577	310	1675	391	2121
ED	75	626	482	2429	951	2353
LD	42	196	78	362	90	490
Year-round	124	1099	237	1927	490	2857
CWF2						
Wet	6	47	22	84	23	78
LD	8	54	23	79	26	70
Year-round	14	69	27	92	30	79
CWF3						
Wet	15	103	512	1911	1009	1146
LD	10	85	35	267	26	199
Year-round	24	221	310	1862	588	2568
CWF4						
Wet	157	925	493	2364	864	2573
ED	11	81	20	110	34	139
LD	21	129	34	183	49	191
Year-round	59	674	133	1125	309	1304
CWF5						
Wet	64	311	161	662	236	809
ED	47	309	167	834	562	799
LD	21	209	86	466	94	1047
Year-round	99	569	173	776	347	1200

Note: Data are shown for each study animal across seasons and years. Seasons are; wet, early dry (ED) season, late dry (LD) season. Shown here are core 50% and 90% home ranges. Details on the methods used to estimate home ranges are provided in the Supplementary Material.

the wet season was 2924 m ± 193 (SE), 6984 m ± 117 (SE) over the ED and 1173 m ± 40 (SE) over the LD.

Of all male elephant location data outside of Hwange NP, many of these were recorded at night (Figure S2). This suggests avoidance of people, as has been documented elsewhere (see Ihwagi et al., 2018).

Surface water seems to have some influence on male elephant movement in Hwange NP, although we only had data on permanent water for the LD season (known artificial waterholes, and a few permanent pans). Mean distance to surface water in the LD (all animals, across years) was 5271 m ± 4093 (SE), and waterhole visitation peaked at night time (Figure S3). The distance to water values for males here are not dissimilar to those of female elephants in Hwange NP (Valls-Fox et al., 2018).

Regarding the home ranges of male elephants, we note a pattern of restricted ranges over the LD, with dispersing range expansion following the rains (Table 2, Figure S1). These findings are again similar to female elephants in Hwange NP (Mlambo et al., 2021; Tshipa et al., 2017). Wet season dispersal events for male elephants may be a strategy to move away from forage depleted areas around waterholes (e.g. Valls-Fox et al., 2018), although we had no data on vegetation structure. Movements may have been related to musth, but we had no data on musth events for our collared bulls. Paternity success is skewed towards male elephants >35 years of age (Hollister-Smith et al., 2007), and it may be that our study animals dispersed in search of females in oestrus.

Season and time-of-day did appear to affect male elephant behaviour in Hwange NP, as measured by movement speed (Figure 2). Data for all animals across years show that movement (m/hr) peaked in the early morning and early evening hours, with rest periods evident before sunrise over both the wet and ED seasons. Rest periods were more common at midday during the LD season (Figure 2), with animals likely taking to the shade. Evaporative cooling is obligatory in African elephants where air temperatures exceed 12°C (Dunkin et al., 2013), and it does seem that male elephants here adapt their behaviour during the LD to reduce water loss. Access to increased water after the rains may explain why male elephants elevated their day time activity during the wet season (Figure 2). A study on female elephants in Hwange NP also found movement speed to be greater in the wet than dry season (Mlambo et al., 2021). The dry season tethering of elephants to surface water observed here may in part be explained by the thermoregulatory requirements of these large bodied animals (Dunkin et al., 2013).

While our study was restricted by sample size (n = 5), our work on large male elephants does contribute to the literature of elephant movement ecology in Hwange NP, which has skewed toward breeding herds. Home range and movement behaviour of male elephants across seasons appear similar to females in Hwange NP (Mlambo et al., 2021), although female elephants appear to disperse further in the wet season (Tshipa et al., 2017). Notably, our study was restricted to older males (40+ years), and we recommend research on the movement behaviour of young male elephants in Hwange NP.

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CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

All animal location data available upon reasonable request.

PERMITS

Field research permit through Zimbabwe DNPWM (023 1CII 0218) and Animal Ethics Permit through Liverpool John Moores University (LT 2018 2).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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