Short communications

Density of large predators on commercial farmland in Ghanzi, Botswana

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Accurate estimates of predator densities are important for the conservation management of large predator populations. Predator densities outside of protected areas are often understudied and management decisions are based on assumptions of predator numbers. This study conducted three spoor surveys on commercial farmland in Botswana to estimate large predator densities. Brown hyaenas (*Hyaena brunnea*) were found to occur evenly across both cattle and game farms at higher densities than previously assumed. Cheetahs (*Acinonyx jubatus*) and leopards (*Panthera pardus*) were more commonly located on game ranches, at or below population density assumptions. This study demonstrated the importance but difficulties of conducting predator surveys on farmland, where study animals are often at risk of persecution by landowners, due to the perceived or real threat predators may pose to livestock and stocked game.

Key words: density, farmland, Botswana, cheetah, leopard, brown hyaena.

INTRODUCTION

African large predators exhibit wide-ranging behaviour, often moving outside of protected areas. Due to the limited size and fragmented nature of protected areas in Africa, in conjunction with these large movements and inter-species conflict, the long-term conservation of cheetah (*Acinonyx jubatus*), Africa wild dog (*Lycaon pictus*) and brown hyaena (*Hyaena brunnea*) can be enhanced if their survival in non-protected areas, such as farmland can be improved (Mills 1990; IUCN/SSC 2007). Botswana is an important country for predator conservation; being the core area for the largest population of cheetahs and African wild dogs in the world (IUCN/SSC 2007). Yet information to direct the Botswana National Predator Management Strategy is only available from protected areas, causing assumptions to be made as to predator densities outside of national parks and reserves (Winterbach 2008).

An accurate estimate of predator abundance will facilitate the goal of predator conservation in non-protected areas (Treves & Karanth 2003; Gusset & Burgener 2005). Knowledge of predator densities and population trends are necessary to determine target areas for conservation and human–predator conflict mitigation, to set trophy hunting quotas and to direct predator management policies (McDonald & Yalden 2004). This is the first study to estimate the density of large predators on farmland in Botswana. Three spoor surveys were conducted in Ghanzi, the largest commercial farming area. An area of mixed farm use (containing cattle farms and adjacent game ranches) was compared to an area used primarily for cattle farming and to an area used primarily as game ranches.

MATERIALS AND METHODS

Study area

The spoor surveys were conducted on the Ghanzi commercial farmlands in northwest Botswana (21.70°S; 21.62°E). The area is classified as hardveld with some sandveld sections and vegetation ranges from bush to open tree savanna (Houser *et al.* 2009a). Wild game includes common duiker (*Sylvicapra grimmia*), steenbok (*Raphicerus campestris*) and greater kudu (*Tragelaphus strepsiceros*), whilst game farms contain a mixture of small and large antelopes. A survey on cattle farmland and adjacent game farmland east of Ghanzi town (Fig. 1) was conducted from March to June 2007 (mixed farmland survey). Two subsequent surveys were conducted concurrently west of Ghanzi; one primarily on game farmland and another on cattle farmland from February to July 2008 (Fig. 1). The farms were divided by a mixture of cattle or non-electrified game fencing, enabling the free movement of predators over or under fences.

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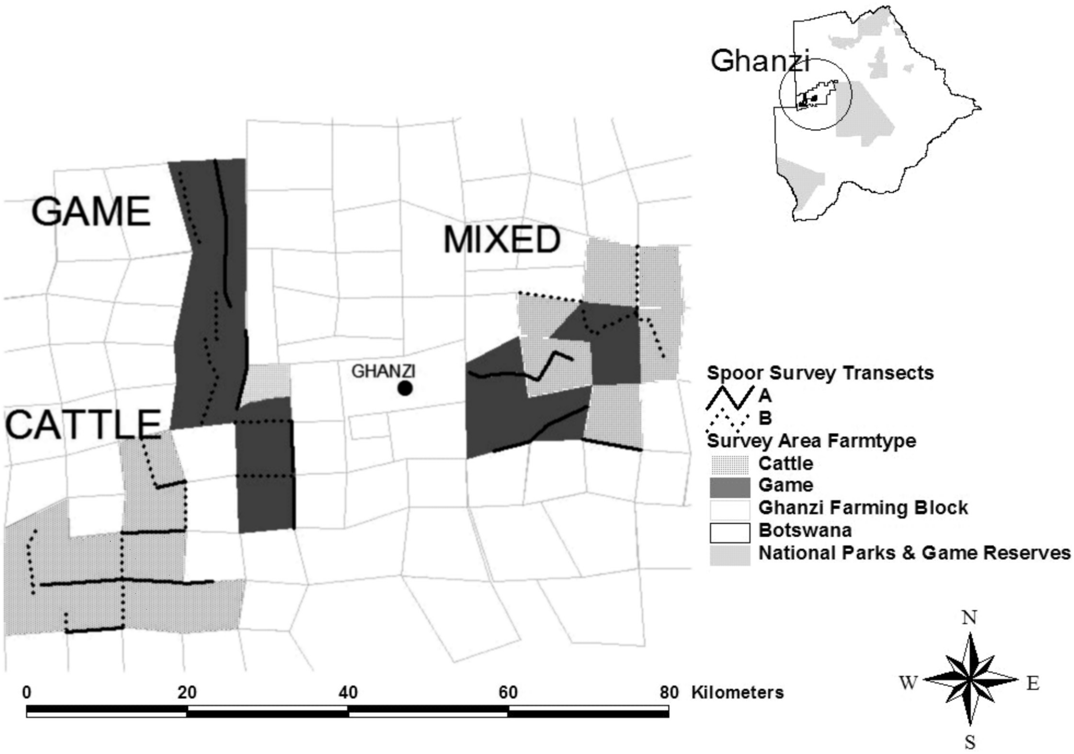

Fig. 1. Location of three spoor surveys for large predators on commercial farmland in Ghanzi, Botswana. The three surveys were conducted on cattle farmland, on game ranches and in an area of adjacent cattle farmland and game ranches (mixed farmland).

Spoor survey methodology

The spoor surveys were conducted upon a fixed route along sand roads, defined as a spoor transect. Two transects were identified in each survey area and were designed to be as linear as possible to reduce the chance of double sampling (Fig. 1). The four transects within the 2008 surveys were sampled an equal number of times, alternating between the cattle and game survey each day. The two transects in the 2007 survey were also sampled equally. A summary of transect length, distance travelled and road penetration (sum of the distance surveyed expressed as a ratio of the sample area) are shown in Table 1.

A San tracker accompanied by a predator biologist located and identified the spoor from a vehicle driven at slow speeds (*c.* 10–13 km/h). The ability of San trackers to reliably and accurately identify and age animal spoor has previously been demonstrated (Stander *et al.* 1997) and trackers were tested on spoor identification before hiring for this study. Any spoor found to belong to a large predator was identified and recorded with the date, GPS location and number of animals. Only fresh spoor (<24 hours old) was used in the analysis and roads disturbed by vehicles or rain in the previous 24 hours were not included. When multiple footprints from the same species were found on the same transect, judgments were made as to whether the spoor belonged to the same or a new individual, with the intention of only recording each individual once per day in accordance with Stander (1998). Spoor were recorded as individual spoor, not as a family group (e.g. five spoor found together were counted as five individual spoor). For maximum visibility, spoor tracking began at sunrise and ended by 11:30.

Statistics

Road penetration, spoor frequency and density were defined and calculated in accordance with Stander (1998). Previous studies with known predator populations have quantified the relationship between spoor density and known species density, resulting in a calibration equation (Stander 1998; Funston *et al.* 2001; Houser *et al.* 2009b;

Table 1. Results of three spoor surveys for large predators on commercial farmland in Ghanzi, Botswana. The three surveys were conducted on cattle farmland, on game ranches and in an area of adjacent cattle farmland and game ranches (mixed farmland). Lion, spotted hyaena and wild dog spoor were not detected.

		Mixed survey	Game survey	Cattle survey	Surveys combined
Total area (game area/cattle area) (km^2)		494.0 (201.1 / 292.9)	408.1 (382.5 / 25.6)	434.9 (0.0 / 434.9)	1337.0
Transect distance (total distance) (km)		70.4 (1026.2)	83.0 (1268.8)	78.4 (1240.1)	231.8 (3535.1)
Road penetration[a]		7.02	4.92	5.55	–
Number of spoor counted	Cheetah	23	13	2	38
	Leopard	1	6	0	7
	Brown hyaena	81	78	98	257
Spoor frequency (km ± S.E.) (CofV[b])	Cheetah	44.62 ± 18.70 (42%)	97.60 ± 23.30 (24%)	620.05 ± 349.70 (56%)	93.03 ± 28.18 (30%)
	Leopard	1026.20[c]	211.47 ± 25.00 (12%)	[d]	505.01 ± 294.31 (58%)
	Brown hyaena	12.67 ± 1.69 (13%)	16.27 ± 2.60 (16%)	12.65 ± 1.90 (15%)	13.76 ± 1.18 (8.6%)
Spoor density (per 100 km) (95% CI)	Cheetah	2.24 (1.20–17.49)	1.02 (0.67–2.14)	0.16[c]	1.07 (0.67–2.78)
	Leopard	0.10[c]	0.47 (0.36–0.68)	[d]	0.20[c]
	Brown hyaena	7.89 (6.23–10.75)	6.15 (4.68–8.96)	7.90 (6.11–11.17)	7.27 (6.22–8.74)
Predator density (per 100 km^2) (95% CI)	Cheetah[e]	0.58 (0.25–5.43)	0.20 (0.09–0.55)	[f]	0.21 (0.08–0.76)
	Leopard[g]	0.05[c]	0.25 (0.19–0.36)	[d]	0.10[c]
	Brown hyaena[e]	2.38 (1.85–3.29)	1.82 (1.36–2.72)	2.38 (1.81–3.42)	2.18 (1.85–2.65)

[a]Sum of the distance surveyed expressed as a ratio of the sample area (1 km surveyed: x km^2 survey area).
[b]Coefficient of variation = standard error/mean × 100.
[c]Insufficient data to calculate standard error (S.E.), 95 % confidence intervals (CI) and/or coefficient of variation (CofV).
[d]ND = spoor not detected.
[e]Using spoor density conversion equation from Funston *et al.* (2010).
[f]Spoor density estimate was too low to apply a cheetah conversion equation.
[g]Using spoor density conversion equation from Stander (1998).

Funston *et al.* 2010). Cheetah and brown hyaena densities were estimated using the Funston *et al.* (2010) calibration believed to be suitable for all large predators on sandy soils. However, this equation is not suitable for low densities, therefore the Stander (1998) equation designed for leopards (*Panthera pardus*), was used to estimate the calibrated leopard density. Differences between surveys, in relation to the total number of spoor counted for each species was calculated using the Pearson's chi-square test with *post hoc* testing of the standardized residuals (*z* scores). Significance was measured at $P = 0.05$.

RESULTS

Predator densities

Spoor from cheetahs, leopards, brown hyaenas and wild dogs were encountered during the spoor surveys. However, the wild dog spoor was detected outside of a specified spoor transect and estimates of density were not possible. Lion (*Panthera leo*) and spotted hyaena (*Crocuta crocuta*) spoor were not detected. After calibration the mean predator densities from the three surveys were 0.21 cheetahs/100 km^2 (range 0.00–0.58), 0.10 leopards/100 km^2 (range 0.00–0.25) and 2.18 brown hyaenas/100 km^2 (range 1.82–2.38). The spoor frequency and spoor density for each species in each survey is shown in Table 1.

Differences between surveys

The number of cheetah spoor detected was significantly higher in the mixed survey *vs* the cattle or game survey. Cheetah spoor were counted 23 times during the mixed farmland survey (*z* score = 3.6), 13 times during the game survey (*z* score = –0.2) compared to only twice in the cattle survey (*z* score = –3.1) ($\chi^2 = 22.64$, d.f. = 2, $P < 0.001$). Similarly, leopard spoor were counted six times during the game survey (*z* score = 2.2), once in the mixed farmland survey (*z* score = –1.6) and were not observed in the cattle survey (z score = –0.7) ($\chi^2 = 7.82$, d.f. = 2, $P < 0.05$). However, the low number of leopard spoor detected violated the assumptions of the chi-square test. In contrast, the number of brown hyaena spoor counted did not differ between surveys (game = 81, cattle = 78, mixed = 98) ($\chi^2 = 3.43$, d.f. = 2, ns).

DISCUSSION

The detected predator densities varied from previously assumed estimates for the Ghanzi farmlands (Winterbach 2002, 2008). Previous estimates had been based on expert opinion in conjunction with limited scientific studies within protected areas however these assumptions had not been tested. The detected brown hyaena density of 2.18 brown hyaenas/100 km^2 (range 1.82–2.38) was similar to brown hyaena populations in the Kgalagadi Transfrontier Park (Funston *et al.* 2001) and the Makgadikgadi pans (Maude 2001). This density is considerably higher than previous estimates of 0.01–0.1/100 km^2 (Winterbach 2002, 2008); however, it is acknowledged that the wide ranging movements of brown hyaenas compared to other carnivores (Houser *et al.* 2009a; Maude 2010), may increase the detectability of spoor, which may not be accounted for by the Funston (2010) calibration factor. Despite this possible over estimation of brown hyaena density, the Ghanzi farmlands still appear to be an important area for their conservation. Detected cheetah densities of 0.21 cheetahs/100 km^2 (range 0.00–0.58) were similar to presumed estimates of 0.15–0.56 cheetahs/100 km^2 (Winterbach 2002, 2008).

The detected leopard density of 0.10 leopards/100 km^2 (range 0.00–0.25) contrasts with local landowners' perceptions who believe leopard are abundant (Kent 2011). Leopards are ranked as the most problematic predator by farmers and are responsible for the majority of government problem animal reports in the Ghanzi district (Selebatso *et al.* 2008). It is likely this high level of conflict may inflate landowners' perceptions of leopard abundance. The detected leopard density was also lower than the assumed estimate of 0.95–1.5 leopards/100 km^2 in the Botswana Predator Management Strategy (Winterbach 2002, 2008). This result indicates that leopard may be at lower densities on Ghanzi farmland than previously thought. However, recent leopard removals from the study area which violated the assumption of a closed population, may have negatively biased the result. Two leopards were known to have been killed in the cattle study area within the three months prior to starting the cattle spoor survey and one leopard was shot in the mixed farmland spoor survey during the study. This highlights the difficulties of working on farmland where study animals may be at risk from human persecution (Gusset *et al.* 2009). Monitoring schemes such as those devised for monitoring predator off-take and trophy size (Anderson & Lindzey 2005; Balme *et al.* 2012), in conjunction with future surveys are needed to determine population trends in this high-conflict species.

Brown hyaenas were found to be equally distributed across all study sites, whilst cheetahs and leopards showed vast contrasts in the number of spoor detected in each survey, with predominately more spoor detected on mixed farmland and/or game ranches than on cattle farmland. These results are most likely attributed to prey availability. Although specific prey counts were not conducted, the absence of stocked game and the presence of feral domestic dogs and poaching in the cattle farming area, resulted in a generally lower observation of wild game. Brown hyaenas are scavengers with a wide range of food sources (Burgener& Gusset 2003) which are likely to be available in all farming areas, whilst cheetahs and leopards may have benefited from the increased prey availability on the game ranches and mixed farmland. Leopard densities were highest on game farmland which would correspond with the expected higher prey availability. However the cheetah density was lower in the game survey than in the mixed farmland survey. It is believed the lower detected densities were due to cheetah persecution in the game ranching area in the previous year. Although no removals occurred during the study, ten cheetahs had been indiscriminately removed from the game area due to human–predator conflict during November 2006 to June 2007. It is therefore possible that the cheetah population had not yet fully recovered to the densities observed on the mixed farmland survey. Future studies will be necessary to establish this population trend. The variable results for cheetahs and leopards emphasize the importance of multiple surveys to establish predator densities. Additionally, future surveys in alternative farming areas will be needed to confirm the land use preference and its cause.

Farmland continues to be an important habitat for the conservation of large predators, in particular the cheetah (Marker *et al*. 2003; Klein 2007). As shown by the cheetah and leopard removals prior to and during the spoor surveys, levels of human–predator conflict remain high on the Ghanzi farmlands and a continued investment into improved livestock management techniques and community education is necessary to enable coexistence with predators. The results also highlight the potential inaccuracies in making assumptions about predator populations and the importance of conducting surveys to determine accurate estimates of predator densities.

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