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Somewhere to hide: Home range and habitat selection of cheetahs in an arid, enclosed system

Rebecca J. Welch [a, *], Charlene Bissett [a], Travis W. Perry [a, b], Daniel M. Parker [a]

[a] Wildlife and Reserve Management Research Group, Department of Zoology and Entomology, Rhodes University, Grahamstown, PO Box 94, Grahamstown, 6140, South Africa
[b] Department of Biology, Furman University, Greenville, SC, 29613, USA

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ABSTRACT

The decline in cheetah (*Acinonyx jubatus*) numbers during the last century has been severe, and fenced reserves may pose as a conservation option for the continued survival of this species. Understanding the use of space within these systems, however, is imperative for their management. Home range (95% Kernel Utilization Distributions) and use of space (Resource selection function models) for cheetahs reintroduced into a small (284 km^2), arid, fenced national park was analysed. On average male home range size (139.94 km^2) was smaller than female home range size (170.29 km^2). Cheetahs did not use the space randomly and variables which aid hunting strategies appear to be important. Despite the chemical contraception of females and absence of competitively superior predators, differences in space use between male and female cheetahs were still observed. The factors that have been used to previously describe these differences were not present in this system, and this could therefore indicate the importance of additional factors such as the availability of prey and that perhaps the evolutionary history of the species results in a form of instinctual behaviour. The study demonstrates the adaptability of the species and if managed appropriately enclosed reserves can act as a population source for cheetahs.

1. Introduction

The conservation of large carnivores is a high profile wildlife management issue worldwide (Gittleman et al., 2001). Low densities and wide ranging behaviours mean that effective conservation is challenging (Karanth et al., 2004; Balme et al., 2009). The cheetah (*Acinonyx jubatus*) is currently listed as vulnerable on the IUCN red list. The extant population is estimated at approximately 7500 adult animals (Durant et al., 2008), and habitat loss and fragmentation have contributed to the worldwide reduction in numbers (Kelly, 2001). In southern Africa, conflict with livestock farmers is the main threat to cheetah persistence (Purchase et al., 2007). With approximately 76% reduction in their historic distribution (Ray et al., 2005) and an increasing human population, loss of habitat and fragmentation are only likely to increase. Outside of protected areas, cheetahs have been observed to have large home ranges, which increase their contact with human populations and settlements, further escalating the potential for conflict (Marker et al., 2008). Consequently, the establishment of fenced protected areas may present one of the greatest tools for the continuing survival of cheetahs (Marnewick et al., 2009). However, such enclosed systems require careful management because certain natural processes such as emigration, immigration and outbreeding cannot normally take place (Caughley, 1994).

Historically, cheetahs were recorded with a wide distribution, from Africa across to southern Asia, occurring over a range of habitats (Caro, 1994; Sunquist and Sunquist, 2002). Many studies have described the habitat selection of cheetahs in East and southern Africa (eg. Caro, 1994; Laurenson, 1994; Durant, 1998; Bissett and Bernard, 2007), with earlier ones reporting that cheetahs were savanna specialists, requiring the wide open spaces to chase down prey at high speed (Caro, 1994; Laurenson, 1994). More recently, however, studies have indicated that cheetahs are extremely adaptable, utilising a wide range of habitats and denser vegetation for successfully rearing cubs (Durant, 1998; Bissett and Bernard, 2007; Mills and Mills, 2013). Thus, identifying important habitats and resource use by cheetahs, in enclosed systems in particular, is imperative for their conservation and management (Milakovic et al., 2012). Extrapolating data from different systems to inform management is problematic and risky as behaviour can vary dramatically across different habitats (Mills, 1991).

* Corresponding author.
E-mail address: welchrebecca83@gmail.com (R.J. Welch).

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Few studies have examined the home range and resource selection of cheetahs within small (<300 km^2), enclosed protected areas (but see Bissett and Bernard, 2007; Cristescu et al., 2013). Male and female cheetahs are known to prefer different habitats, with females generally selecting thicker areas for increased cub survival and reduced kleptoparasitism (Durant, 1998; Bissett and Bernard, 2007; Mills and Mills, 2013). However, the relatively common practice of chemical contraception of female cheetahs in enclosed reserves (Bertschinger et al., 2002), and therefore the absence of cubs, may reduce the necessity for female cheetahs to seek out thicker habitats. In addition, in the absence of any competitively dominant species such as lions (*Panthera leo*), cheetah space use may be altered, as the risk of kleptoparasitism is removed, or at least markedly reduced. Thus, the objective of our study was to examine habitat and resource selection for cheetahs in an arid, enclosed system. Because all female cheetahs were contracepted and superior predators were absent at our study site, we hypothesized that male and female home range sizes and space use in relation to environmental variables (e.g. vegetation type, elevation and degree of slope) would be similar.

2. Materials and methods

2.1. Study site

Mountain Zebra National Park (hereafter MZNP, 32°18′S, 25°24′E.) is a South African National Park (SANParks) situated in the Eastern Cape. The park is approximately 284 km^2, situated in the Nama-Karoo biome and characterised by an arid climate (Mucina et al., 2006). The southern section of the park is mountainous with altitudinal peaks of up to 1960 m, whereas the northern section is composed of lower lying areas ranging from 1000 m to 1500 m.

In 2007, four cheetahs (two adult females and a coalition of two adult males) were re-introduced into the park. The population quickly increased to over 30 individuals in 2010 (C. Bissett, pers obs.). After this rapid increase, SANParks management successfully relocated most of the individuals to Monate Lodge, Pidwa and Kapama reserves in Limpopo, South Africa by 2011. Our study was conducted between January 2011 and June 2012 when seven individuals (three adult males and four adult females) remained. These seven cheetahs were the focus of our assessment. At the time of our study, cheetahs were the only apex predators present in the park. The seven cheetahs were immobilized and fitted with VHF/GSM collars (Africa Wildlife tracking, Rietondale, South Africa) by a SANParks veterinarian and conservation staff for routine post-release monitoring and management purposes in November and December 2010. In addition, all female cheetahs were chemically contracepted with Deslorelin (Suprelorin®, Peptech Animal Health, Sydney) by a SANParks veterinarian prior to the commencement of our study and implants were effective until December 2012.

2.2. Home range estimations

GPS locations were recorded by the collars four times per day, at 0500 h, 0700 h, 1700 h and 1900 h, over the study period (January 2011–June 2012). GPS locations were rarified to one per day (the first fix of the day) for the home range analyses to eliminate autocorrelation, as the intervals between recordings were unequal (De Solla et al., 1999). Home range and core area estimates were calculated using 95% and 50% kernel probability contours (Worton, 1989; Seaman and Powell, 1996). Bandwidth recommendations include using the reference bandwidth h_{ref} (Hemson et al., 2005), however, this value often over-smoothes data and exaggerates home range estimates, therefore 70% proportions of the h_{ref} value were used to calculate bandwidth values (as recommended by Bertrand et al., 1996). Home ranges were subsequently clipped to the park boundary in those cases where kernel utilization distributions exceeded the park boundary. Home range analyses were conducted using Home range tools in ArcMap v. 9.3 (ESRI, Redlands, California).

2.3. Home range overlap

Home range overlap between each pair-wise combination of all individual cheetahs was calculated. A percentage overlap for two individuals (A and B) was calculated, using the equation as adapted from Poole (1995):

$$\%\,\text{Overlap} = 100 \times 2AB/(A+B)$$

Where A and B signify home range areas and AB represents the area common to both animals (Poole, 1995; Cristescu et al., 2013).

2.4. Environmental data

A functional vegetation map was created by dividing the park into six categories of vegetative cover. Existing, botanically categorized vegetation maps were used in combination with 1: 10,000 aerial photographs and ground truthed data. Aerial photographs were enlarged to 1: 3000 and the vegetation classified on a categorical scale of 1–6, representing the density of the vegetation (Fig. 1). Category 1 (1.64% of the total park area) represented open, bare ground with minimal vegetation and included areas of bare rock. Category 2 (49.97%) was defined as old cultivated lands and short grassland. Vegetation in this category did not exceed 30 cm in height and no woody bushclumps were present. Category 3 (16.36%) consisted of tall grass, shrubs and small bushclumps. Vegetation in this category did not exceed a height of 70 cm and there were no more than 2–3 bushes in an area of 10 m^2. Category 4 (20.85%) represented areas with more (4–6) bushclumps and individual bushclumps could occupy areas as large as 10 m^2. The height of vegetation ranged from approximately 0.7 m–1 m. Category 5 (8.95%) consisted of dense bushclumps interspersed with open areas. The height of vegetation in this category ranged from approximately 1 to 1.5 m, with up to 10 bushes within an area of 10 m^2. Category 6 (2.21%) was very dense (often riverine) bush, with very few open areas and exceeded 1.5 m in height.

In addition to the vegetation map, a digitalized elevation model (DEM) was created in ArcMap 9.3 using a contour shapefile. Elevation values (m.a.s.l.) were extracted from the DEM for each cheetah location. This DEM layer was also used to create a slope (°) layer. A solar-gain raster layer was created using 'solar radiation' (MJ) in spatial analyst tools in ArcMap 9.3, and Euclidean distance (m) to drainage lines was measured using the 'near' feature in the analysis toolbox. Percentage rock cover was visually assessed within the soil types ($n = 8$) of MZNP (SANParks, unpublished data). The park was already delineated into eight different soil types. To relate substrate to a more ecologically relevant parameter for cheetahs, percentage rock cover was calculated for each of the existing soil types. Within each of the soil types, five random points were generated using Hawth's tools in ArcMap 9.3 (Beyer, 2005), and a 50 m transect established at each point. A 1 m^2 quadrat was used to subjectively measure rock cover at 10 m intervals along each transect by the same observer (CB), starting at 0 m. The quadrat was divided into 64 quadrants and the number of quadrants with rocks present were counted at each 10 m intersect. The percentage rock cover was established in each quadrat by calculating the percentage of the 64 quadrants with rocks present and an overall percentage rock cover established for each soil type. Five transects were sufficient for establishing overall % rock cover for all soil types (Friedman ANOVA, $\chi^2 < 9.52$, $df = 4$, $P > 0.05$) with the exception of category 8 where 10