The Use of Remote Camera Traps to Estimate Density of Free-ranging Cheetahs in North-Central Namibia

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Remote camera trapping RCT, although successfully used to estimate abundance on other species such as the tiger *Panthera tigris* in India, (Karanth 1995, Karanth & Nichols 1998) and jaguar *Panthera onca* in Bolivia (Wallace *et al*. 2003, Silver *et al*. 2004), has not been fully explored for cheetahs *Acinonyx jubatus*. Apart from Marnewick *et al*. (2008), who investigated the use of the technique for estimating abundance, no other study was found in literature that explored the feasibility of the technique for estimating both abundance and density. This study is therefore the first of its kind, as it addresses the feasibility of using RCT within the CR framework.

Our aim was to develop appropriate sampling design for censusing free-ranging cheetahs using RCT. Two specific objectives were (1) determine free ranging cheetah abundance using RCT and (2) compare density estimates based on effective sampled areas derived using the mean maximum distance moved and the radius of a 95% cheetah minimum convex polygon (MCP).

Materials and methods

Study area

The study was conducted in a 277 km² area in north-central Namibia, within the Cheetah Conservation Fund (CCF) farmland (Fig. 1). Cameras were only placed in CCF's land, the reason for having a gap in the middle of the study area. The area is classified as semi-arid and is described as thornbush savannah vegetation, where bush encroachment is common (Barnard 1998). Open fields and transformed areas are prominent due to previous and current land use practices (Marker 2002). The area harbors a wide variety of species including sympatric carnivores such as the leopard and brown hyena, and numerous ungulate species. (Marker 2002).

Equipment

At each station, two DeerCam (DC-200) heat-and-motion sensor cameras (DeerCam Park Falls, WI, USA), were placed and remained active for 90 consecutive days. All stations except station 19 (circled in Fig. 1) were sampled between the 15th November 2005 and the 12th February 2006, with station 19 being active from the 24th January to the 23rd April 2006. We elected to include the last station on the grounds of the three week overlap plus the fact that the raining season which started in November only ends at end of April. Thus, environmental conditions remained fairly similar throughout the sampling period.
Cameras were mounted on poles or fence lines at cheetah shoulder height (i.e. 75 cm above ground), about 7 meter apart with the road, tree or termite mound in the middle.
Cameras were at a slight angle so as to minimize random exposures due to flash activation. Twenty-four exposure ISO 100 and 200 films were used with Duracell AA batteries. Cameras were checked every other day in case batteries or film needed to be changed, as well as to ensure the cameras were still in good condition (had not been knocked over by animals). Although cheetahs are known to follow roads we deemed that placing cameras at playtrees, that is marking posts, would result on higher CRs. As a result, 10 of the 13 stations were at playtrees and three were next to roads where cheetah tracks were seen on a regular basis.

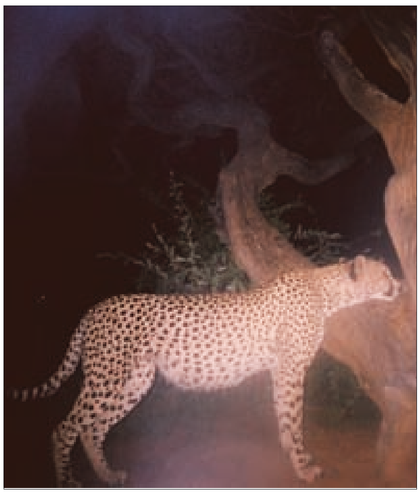
Data analysis

Identifying individuals from photographs was done manually (Kelly *et al.* 1998, Bowland 1994) and the interactive program CAPTURE by Hines (2005, www.mbr-pwrc.usgs.gov) was used to determine cheetah abundance based on a 15 occasion dataset. Gender was determined based on the presence absence of genitals. Capture histories for all stations were collapsed after Karanth & Nichols (2002) recommendation for the rotational sampling approach when not sufficient units are available or large areas are being surveyed. Thus, captures on the first day of each sampling period (e.g. 15 of November and 24 January) were regarded as one. It was felt that environmental conditions remained similar as the wet season in the area is from November through to April. Only adult animals were included in the analysis.

To determine density, two approaches were used for determining the effective sampled area (ESA): (1) the full and half mean maximum distance moved (MMDM and MMDM/2 respectively), and (2) the females (21.15km, n = 10) and all cheetahs (males and females, 19.53 km, n = 30) wet season 95% home range radius (Marker *et al*. 2008). The probability of not detecting a cheetah across the 15 occasions was determined as (1-p') 15, where p' is the probability of capture associated with a model (Jackson *et al.* 2005). The ratio of animals captured to estimated abundance (M_{t+1}/N'), was used as the probability of capturing an individual at risk of capture at least once during the study (Karanth & Nichols 1998).

Results

A trapping effort of 1170 trap nights resulted in 4934 photographs of which only 5% (n = 250) were cheetah pho-



tographs. Cheetahs were captured and recaptured 72 times at 8 of the 13 camera stations (mean ± SD 9 ± 6.09), with a time delay to first detection ranging from 0 to 84 days (23.20 ± 24.52 days). Cheetahs visited stations every 6.87 ± 9.12 days (range 1 to 38 days) with a station being visited by a mean of 3 ± 1.51 different cheetahs. Sixty-three percent of the cheetah photographs were taken during night time indicating a more nocturnal activity pattern

RCT using capture-recapture has two key assumptions that: (1) animals can be identified to the individual level from retrieved photographs and (2) the population in the study area is closed (i.e. no immigration, emigration, death or birth occurs during the sampling period). The first assumption was upheld as out 250 exposures 13 individuals (10 males including a coalition of 2 brothers and a female with 2 cubs). Only a single exposure was discarded as identity could not be ascertained. The second assumption was also upheld as reported by program CAPTURE closure test (z = - 1.59, p = 0.06).

CAPTURE2 has selected the null model (M_o), which assumes no variation on capture probabilities across time as the most appropriate for estimating cheetah abundance. This model estimated an abundance of 11 ± 0.15, 95% CI 10.71 - 11.29, capture probability of 0.34, and a probability of capturing an individual at risk of capture of 1. The heterogeneity model (M_h) was the second best, estimating up to 15 individuals (13 ± 2.00, 95% CI 8.24 – 13.76, p'= 0.29, M_{t+1}/N' = 0.85). The latter assumes individual capture heterogeneity and is preferred because the null model is less robust to violations of its underlying assumption (Karanth & Nichols 1998).

Cheetah density estimates based on the 95% of females and all cheetahs wet season radius, were lower in relation to those estimated using the MMDM approach irrespective of the model (Table 1). Under the MMDM approach up to 2.3 cheetahs per 100 km^2 are estimated while the highest under the radius approach is only 0.47 per 100 km^2. Such differences demonstrate that cautious should be take when selecting a buffer width estimator for cheetah density estimation. Table 1 also shows that all density estimates based on the M_o model are within M_h confidence range, suggesting that estimates do not differ significantly.

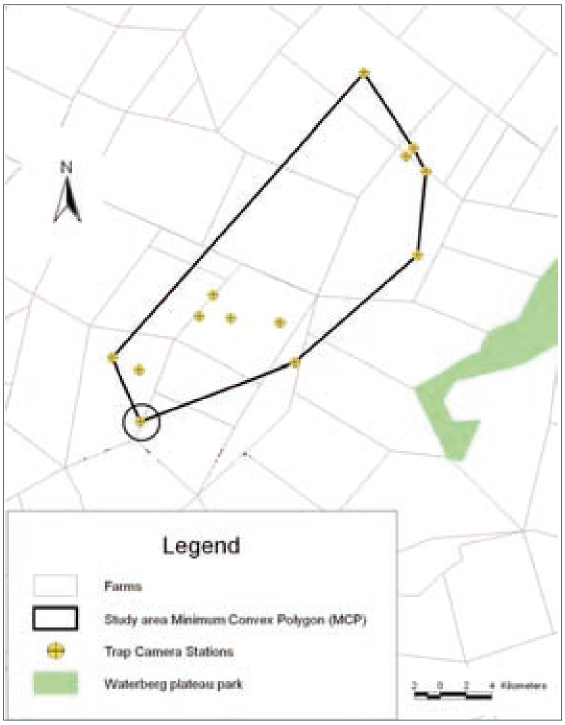


Fig. 1. Distribution of cameras stations, within a 277km2 area on CCF farmlands. The circled station was sampled simultaneously with the other 12 stations for only 20 days. Farms (grey lines) within the study area polygon (MCP) where no camera traps were set were private and not accessible for this research.

Discussion

From a sampling design and effort point of view, the use of playtrees as sampling points proved to be highly successful for different reasons. First, we observed high capture recapture rates as these trees are an integral part of cheetah territory. Second, and related to the previous point, placing trees at playtrees increased the probability of detecting a larger section of the population especially males. Using the same approach, Marnewick *et al.* (2005, 2008) also observed a high males bias capture on their studies. Furthermore, different cheetahs were captured at different stations irrespective of inter-distances, which suggest that playtree proximity should not always be used as a criterion for selecting operating stations. In addition, capture saturation at playtrees is presumed to have been reached as no new individuals were captured after the seventh occasion. However, this changed by the addition of a new playtree where a new cheetah and a previously identified cheetah were captured.

Our data could be analysed in the capture-recapture framework as all underlying assumptions were met. Retrieved photographs were of high quality which enabled an easy visual identification of animals, a detection probability of almost one was observed and the closure assumption was not violated. Karanth and Nichols (2002) suggested the placement of two to three cameras per individual home range. Our effort was higher than this given that an average 95% cheetah home range for the study area is of 269.2 ± 376.2 km^2, an area similar to our sampling area (i.e. 276 km^2). The non-violation of the closure assumption supports the use of a three month period for most carnivores.

Although the 25 threshold number of unique animals was not reached, models capture probabilities were above or just bellow the capture probability threshold of 0.30 for populations of up to 100

(Otis *et al.* 1978). This finding is due to the observed high re-visitation rate of playtrees. Marnewick *et al.* (2005) had a similar visitation rate on their study.

The study results demonstrated the feasibility of using remote camera trapping placed at playtrees in conjunction with the capture-recapture analytical framework for estimating cheetah abundance. Results also show that the 95% radius of a cheetah home range, preferable season specific, should be used as the buffer width for determining the ESA. Consequently, unless distances between stations approximate that of a cheetah home range radius, and cheetahs are actually captured at these stations, the MMDM approach for estimating the ESA should be avoided. Trolle & Kelly (2003) and Soisalo & Cavalcanti (2006) observed and reached a similar conclusion for ocelots and jaguar, and suggested that the MMDM approach (full or half) may only be suitable for small mammals.

Estimated densities based on the 95% HRR had a higher similarity than previously estimates for the study area. For example, using radio telemetry Marker (2002) estimated a density of 2.5 ± 0.73 individuals/1000km^2 (1993 - 2000), while Fabiano (2007) used spoor tracking to calculate a higher overall density of 0.92/100 km (0.86 $\pm$ 0.37 for a 5 year period). Although different, differences may not reflect fluctuations on the actual density but rather may be related to the different techniques used for density determination.

Conclusion and recommendations

We recommend the use of RCT along with the CR method but suggest (1) that cameras which can be set for operation only during specific times be explored and (2) using cheetah home range radius for estimating the effective sampled area. Radius to be used should coincide with the season in which sampling was conducted. Our design is highly effective for capturing the male section of the population. However, further understanding of female movements and habitat selection is necessary to guide further placement of cameras to increase the capture probability for females.

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