The leopard population on Düsternbrook game farm: A pilot study

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Introduction

The leopard (*Panthera pardus*) is a large, primarily nocturnal felid that is adapted to survive in a range of habitats, with a distribution over much of Africa, the Middle East, and Asia (Alderton 1998). Although its wide distribution means the leopard is not globally endangered, regional populations and subspecies are currently at risk from habitat loss and persecution on farmlands that suffer from livestock depredation (Alderton 1998; Marker & Dickman 2005). To support management strategies that can reduce the conflict between leopards and humans, more research is needed to better understand leopard ecology at a smaller scale and to develop methods for the continued monitoring of local populations.

One effective, yet low cost method of studying leopards is to undertake a track count survey, which involves identifying animal tracks from transects along river beds, game trails and dirt roads, and recording the observed locations for analysis (Gese 2001; Henschel & Ray 2003). From this type of data, leopard presence and distribution can be determined, and estimates of relative abundance made (Henschel & Ray 2003). To estimate absolute abundance and population density, some kind of individual identification must be made. In some cases, it is possible to identify the tracks of individuals from careful measurements, although this requires a large number of tracks to be collected from each animal (Riordan 1998; Gese 2001). This method requires a great deal of experience, as variation in substrate type can distort the appearance of tracks, unless track plates are used to record the prints with consistently quality and accuracy (Gese 2001; Henschel & Ray 2003).

A more accurate and reliable method of identifying individuals in a population can be to use remote camera traps, which have been widely used for carnivore surveys. Camera traps are able to operate almost continuously and are largely non-invasive, which can be valuable when surveying elusive nocturnal species that may be difficult to detect otherwise (Henschel & Ray 2003; Silveria *et al.* 2003). The cameras can be set throughout the survey area in locations where the animal is most likely to walk past, such as tracks, game trails, and river beds (Henschel & Ray 2003), and do not rely on a suitable substrate being present, as is the case for tracks. A further advantage of camera trapping is that the photographs provide a permanent record that can be assessed repeatedly. The photographs can be studied to compare the variations between animals and identify individuals by their pelt characteristics, which are unique to each leopard (Gese 2001). This approach has been used in a number of studies to research jaguar (Silver 2004; Maffei *et al.* 2002; Wallace *et al.* 2003; Harmsen *et al.* 2009); tiger (Karanth 1995; Karanth & Nichols 1998); snow leopard (Jackson 1996; Jackson *et al.* 2006); cheetah (Marker *et al.* 2008); ocelot (Trolle & Kéry 2003) and leopard (Henschel & Ray 2003; Wang & Macdonald 2009). Even with species that are essentially unmarked, it may still be possible to identify individuals in the short term from features such as whisker patterns, ear notches, parasites and tags, as has been shown by studies on cougars (Kelly *et al.* 2008), lions (Ogutu *et al.* 2006) and bobcats (Heilbrun *et al.* 2003). This data can then be used to provide estimates of relative or actual abundance, population density, and home range size (Gese 2001; Henschel & Ray 2003).

Unlike track identification, there is a large set up cost involved to purchase enough equipment for a full and extensive camera trap survey. An example given by Henschel & Ray (2003) recommends placing camera traps at even intervals that are no more than 2 km apart. In an area 100 km^2 in size, this would require 25 camera trap stations to cover the whole area (Henschel & Ray 2003). With limited resources, time and equipment, it can be useful to combine data from a number of sources and methods, such as leopard tracks and camera trap captures, to provide a more complete dataset for analysis.

If the collected data also include information on their location (e.g. from GPS), further analyses can be made using geographical information systems (GIS). This type of software provides a visual representation of data, and is used for creating digital maps and making spatial analyses. Such methods have been used for studies of distribution, habitat use, and home range size, and can be used as an effective tool for disseminating information to non-specialists for making management decisions and educating local people.

The aim of this study was to provide an estimate of the distribution, abundance and population density of leopard on the farm from a combined track identification and remote camera trap survey, and GIS spatial analysis.

Methods

Study area
This study was made within Düsternbrook Guest Farm (22°16′ S, 16°54′ E), a 12,000 ha (120 km^2) private game farm in the north-central uplands of Namibia. The region is classified as semi-arid, with vegetation dominated by

thornbush savannah. The farm was previously managed for cattle production, before later being converted to a game farm, with new animals introduced/reintroduced. The farm now supports a wide variety of species, including large populations of ungulates (oryx; wildebeest; kudu; impala etc), and predators such as leopard; cheetah and brown hyena. This study was made during the months of July and August 2011, which is the dry season in Namibia. Although heavy rains earlier in the year had lead to streams and dams withholding water in larger quantities and for longer than usual, a negligible amount of precipitation occurred during the survey period.

Equipment
Three remote camera traps were used in the survey (2 x Reconyx RC55 Rapidfire; 1 x Reconyx PC800 Hyperfire Pro), which are triggered by motion sensors and have an infra-red LED flash for taking night photographs at 3.1 mp resolution. Camera stations were set up along tracks and game trails in locations with thick bush vegetation on both sides, creating a natural funnel for large animals to pass through. The cameras were fixed to trees close to the trail, deployed either singularly or in pairs. They were attached to the trees with bungee cord at a height of approximately 1 m, set with a slight downward angle facing towards the centre of the trail. The cameras were set up for continuous 24 hour operation and with the default capture settings (3 photographs per motion-sensed event, 1 second interval, and no quiet period). Tracks, direct leopard sightings, and camera station locations were recorded with a unique ID on a Garmin ETrex handheld GPS (accuracy 4-6 m).

Sampling method
An initial scoping survey was made by dividing the survey area into a 1 x 1 arc minutes grid of 20 cells (Fig. 1). In each of these survey cells, track identification transects were made by walking along 4x4 trails, dry stream beds, and game trails, excluding animal enclosures and campsites. When a track set (defined as more than two paw prints) was identified as leopard, the GPS location was recorded with a unique ID. Track sets that could be observed throughout the length of the transect were recorded with multiple GPS points, at approximately every 50-100m along the transect. The track identification surveys were repeated in each grid cell on multiple occasions, with a number of days (3-10) between surveys. In each of the survey grid cells, 1-2 camera stations were also deployed. As there was a limited number of camera traps available, the cameras were moved to another station location after 1-6 camera trap nights (mean = 3).

The results of the scoping survey were used to direct further camera trapping in locations where leopard tracks had been sighted. The additional camera stations were placed over 1 km away from the previous stations, and on trails where camera traps had not yet been deployed. In total, 35 camera trap stations were deployed in the survey area over the period from 4^{th} July to 28^{th} August.

GIS mapping

Mapping was done using GRASS GIS 6.4.0 (open source). A base map of the farm was created by manually digitizing features from existing mapping and Google Earth imagery, including major 4x4 trails, water bodies, game fences, and enclosures (Fig. 1). The camera trap and leopard track GPS locations were plotted on the map to provide a visual representation of the collected data for analysis. Minimum convex polygons of the survey area and leopard distribution were created manually by joining the outermost data points.

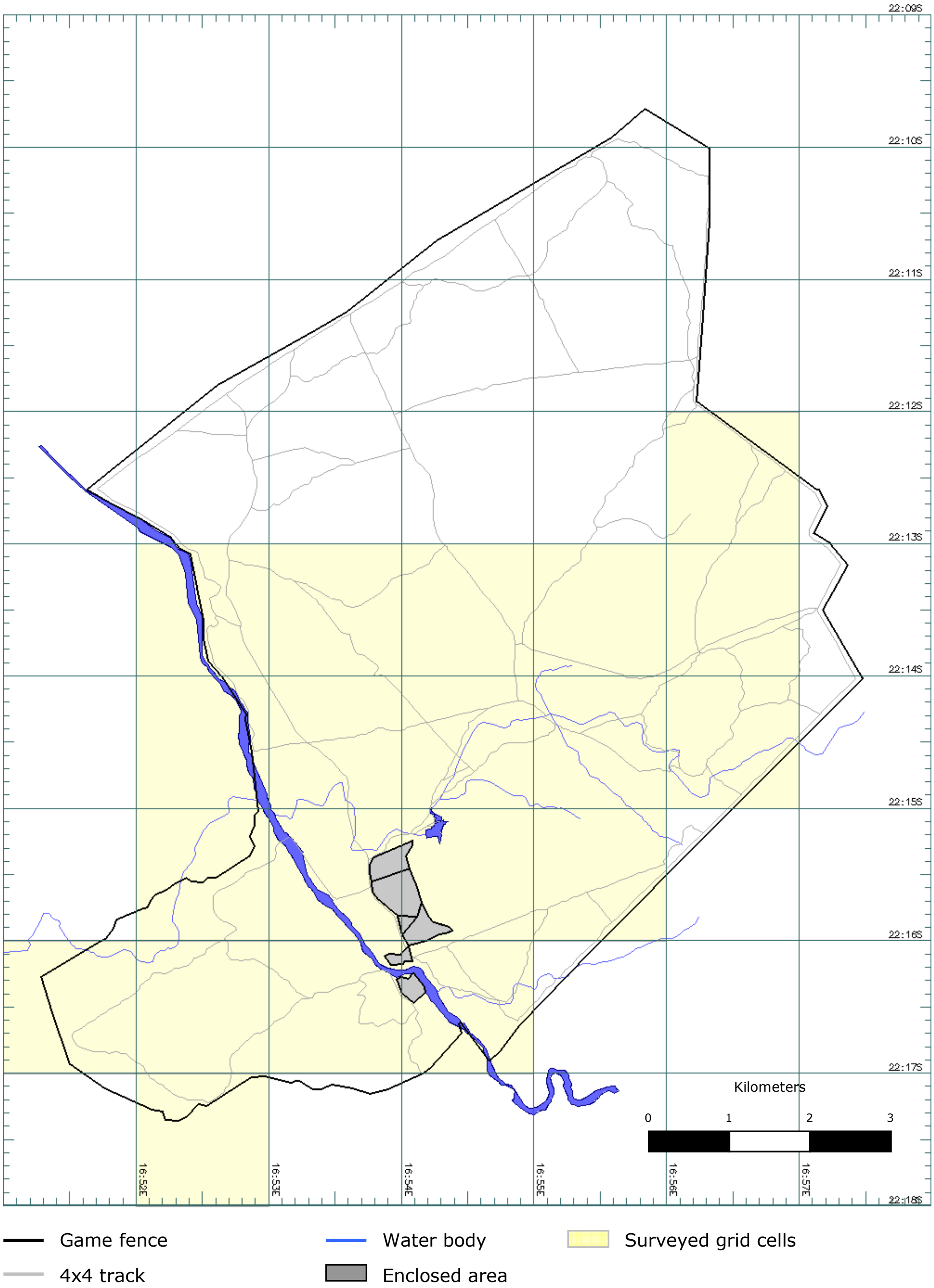

Figure 1. Base map of the main Düsternbrook game farm and scoping survey grid

Results

Leopard surveys
The minimum convex polygon (MCP) over the survey locations covered an area of 46 km^2 (4,600 ha). All of the major 4x4 tracks within the MCP were surveyed for leopard prints on multiple occasions. Leopard tracks were found on 18 out of 50 survey days (36% of days), and there was one direct leopard sighting recorded. In total, 141 GPS locations were recorded as having leopard tracks present.

The remote camera traps were set up at 35 stations throughout the survey area, for a total duration of 106 camera trap nights. Camera trap nights at each station averaged 3 nights, with a range of 1-6 nights. Twelve leopard captures were made by the camera traps in total, from nine of the 35 stations (three cameras with two separate captures). This produces a capture ratio of 8.83 nights per leopard capture. On a number of occasions, camera traps were placed in locations where leopard tracks were frequently found, but failed to photograph a leopard during the time period it was installed (Fig. 2). Also, some of the leopard captures were made in locations where no tracks were visible.

Leopard distribution
GPS locations from camera traps, track sets, and direct sightings were collated together for analysis. This data was then plotted as points on the farm base map in the GIS (Fig. 2). Evidence of leopards was found throughout much of the survey area, with leopards covering an area with an MCP of 25 km^2. Leopards were never found within the northern boundary of the survey area, despite camera traps being placed along all major trails in this region, and a number of track surveys being made. The largest number of camera trap captures and tracks were found in the central and eastern regions of the survey area.

Leopard abundance and density
Successful camera trap captures were studied in detail to identify individuals from features such as rosette patterns, rosette size, gender, and build. Four out of the 12 leopard captures were poorly lit, out of focus, or were affected by motion blur, and had to be discarded from analysis. From the remaining eight photographs, only two could be identified as being the same animal, with noticeable differences between individuals in the other images. As such, a minimum of seven individual leopards were identified from the camera trapping survey, with a population density of 0.15 km^{-1} (15/100 km) in the 46 km^2 study area. Applying this density value to the whole 120 km^2 farm area estimated the total leopard population at approximately 18 individuals.

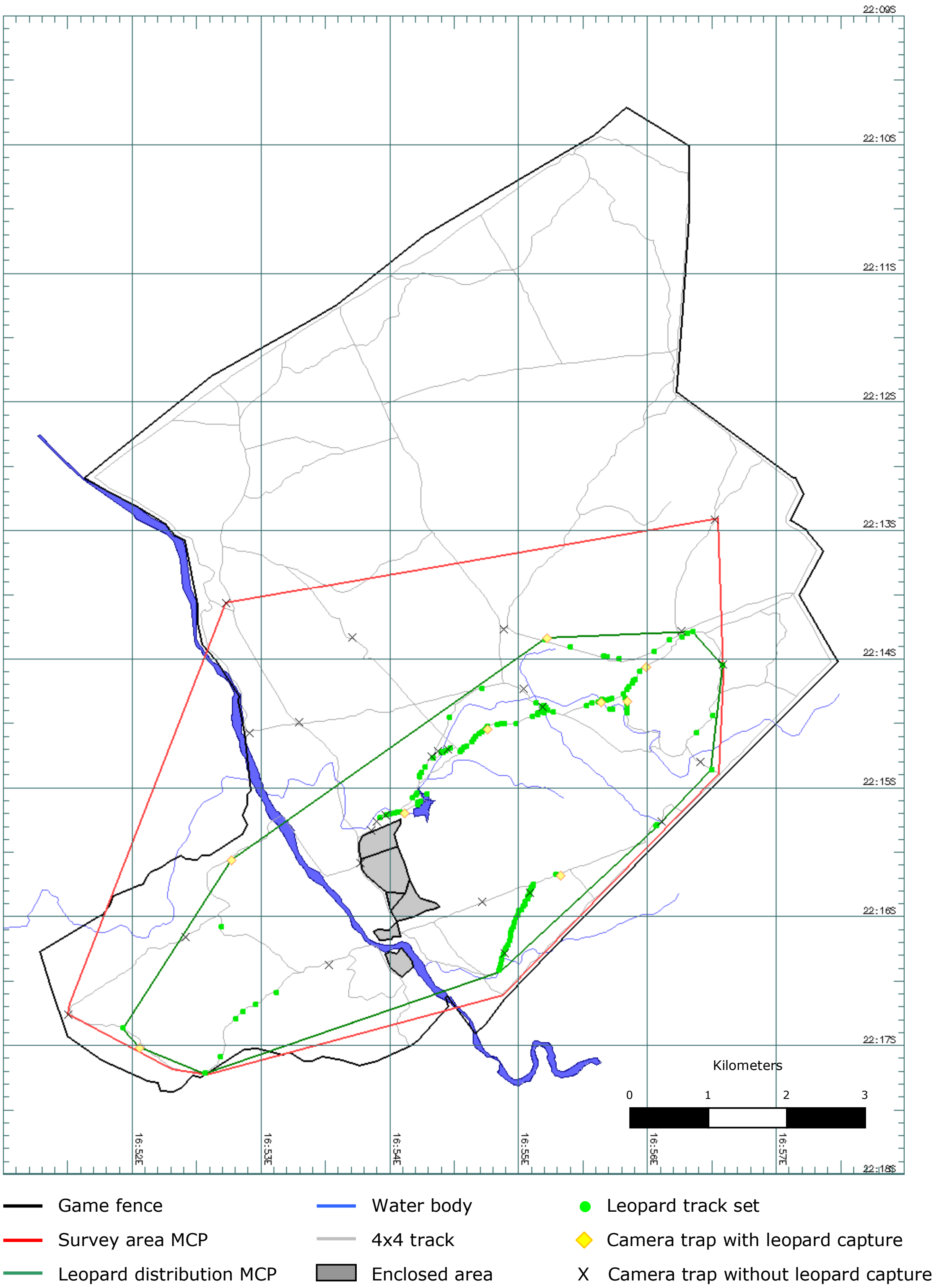

Figure 2. Leopard distribution map, with camera trap and track GPS locations

Discussion and further work

This study demonstrates the value of collecting data from multiple survey methods, as camera traps provided leopard distribution data where tracks could not be found, and likewise, tracks in locations where camera captures did not occur. In the case of track identification, the substrate type, vegetation coverage and traffic (both vehicles and game) varied along and between transects, which can directly affect the detection of tracks. The camera traps are not limited by such factors, but may require more time than the 3 nights average to make a capture, as leopards will not use the same paths every night.

Different individuals were identified within close proximity of one another, and in some cases, at the same camera trap station. This suggests that overlap occurs with the leopard home ranges on the farm. In a similar part of Namibia north of the study area, Marker & Dickman (2005) found leopards to be using large home ranges with a high amount of overlap. Where leopards face high amount of persecution, they may modify their behaviour to include home range increases and overlap (Tuyttens *et al*. 2000 in Marker & Dickman 2005). Whilst overlap was found in this study, a previous study on a radio collared leopard on the farm found it to be using a core home range of 11.5 km^2 (J. Vaatz, pers. com.), which is relatively small for a leopard (Henschel & Ray 2003). Although the leopards are now protected on this farm, this may not be the case with other farms in the region, which could be a factor influencing the home ranges overlap observed here.

The estimated density value of 0.15 km^{-1} and subsequent population value of 18 individuals is quite high for the area of the farm (120 km^2). Leopard density is usually positively correlated with prey biomass and availability (Henschel & Ray 2003). As such, the numerous reintroduced game animals combined with the lack of leopard persecution on this farm is likely to be the cause of the high population density here. The high density estimate is also supported by the ratio of 8.83 trap nights per leopard capture. A study by Carbone *et al.* (2001) found this ratio to be negatively correlated with population density for tigers. A value of 8.83 is towards the lower end of the model results, and relates to approximately 13-15 individuals per 100 km.

Further work could continue the camera trap and track surveys, to collect more data to refine the population estimates made here. The method could also be greatly improved with a larger number of camera traps, which could be deployed for a longer period (e.g. 7-10 days). This would allow for more capture and recapture data to be collected, which could then be used to revise and improve the results of the pilot study, to make a more accurate estimate of leopard distribution, abundance and population density.

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