Journal of Arid Environments 124 (2016) 304–309

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

An oasis in the desert: The potential of water sources as camera trap sites in arid environments for surveying a carnivore guild

Sarah Edwards [a, b, *], Alan C. Gange [b], Ingrid Wiesel [a, c]

[a] Brown Hyena Research Project, P.O. Box 739, Lüderitz, Namibia
[b] School of Biological Sciences, Royal Holloway, University of London, Egham Hill, Egham, Surrey, TW20 0EX, UK
[c] Centre for Wildlife Management, University of Pretoria, Pretoria, South Africa

ARTICLE INFO

Article history:
Received 22 July 2015
Received in revised form
4 September 2015
Accepted 14 September 2015
Available online xxx

Keywords:
Camera trap
Carnivore
Detection probability
Multiple species
Namibia
Survey design

ABSTRACT

Discussions regarding the importance of accounting for detection probability have long been present in ecological literature. Various studies have demonstrated the influence of survey design on detection probabilities, and whilst the placement of camera traps along roads is a commonly used survey design, it has shown to be biased towards certain species. In arid environments, water sources have the potential to be efficient sites for camera trap placement. We compared the influence of a water source camera trap survey design on the detection probabilities of a guild of seven carnivore species, in comparison detection probabilities from camera traps along roads, on arid, commercial farmland in southern Namibia. Results showed detection probabilities for all species to be higher at water, with the water source design producing shorter latencies of detections and higher naive occupancy estimates for most species. However, for species with unique markings, the water source design produced lower proportions of images suitable for individual identification. As detection probabilities of all species were influenced in a positive manner, we suggest placing camera traps at water sources in arid environments to be an effective survey design. However, for surveys requiring individual identification, placing camera traps along roads may be more suitable.

1. Introduction

Within the field of ecology, the issue of imperfect and varying detection probability remains a central theme of discussion (Sollmann et al., 2013), particularly pertaining to the use of relative abundance indices. Whilst statistically sound methods have been developed for those species with unique natural markings (Karanth and Nichols, 1998), relative abundance indices are still frequently used for those species without such markings, which often comprise the majority of species detected during a survey (Carbone et al., 2008). The use of relative abundance comparisons across species, space and time is particularly controversial, as such comparisons rely on the assumption of constant probability of detection (Kellner and Swihart, 2014). However, detection probability has been shown to vary with a number of factors including local density, seasonal or behavioural patterns, amount of area surveyed (Bailey et al., 2004), and survey design (Sollmann et al., 2013), meaning the assumption is unlikely to hold true (O'Connell et al., 2012), but is rarely accounted for (Kellner and Swihart, 2014). This issue has most recently been highlighted by Hayward et al. (2015) as one of the key problems facing the debate regarding the conservation use of dingoes *Canis dingo* in Australia. Hayward et al. (2015) suggest that conflicting results regarding the species' role in mesopredator suppression may be a merely an artefact of sampling methods used and failure to account for detection probability.

A number of previous studies have highlighted the importance of accounting for detection probability in multi-species surveys, by demonstrating how survey design can be biased towards particular species. Weckel et al. (2006) found both paca *Agouti paca* and armadillo *Dasypus novincinctus* had higher detection probabilities away from forest trails in Belize, whilst Harmsen et al. (2010) found off-trail camera traps failed to detect puma *Puma concolor*, ocelots *Leopardus pardalis* and white-lipped peccary *Tayassu pecari*, which were detected by trail traps in Belize. Even within a single guild, differential responses to survey design have been shown, for example Bischof et al. (2014) found species-specific differences in

* Corresponding author. School of Biological Sciences, Royal Holloway, University of London, Egham Hill, Egham, Surrey, TW20 0EX, UK.
E-mail address: hyenaconflict@gmail.com (S. Edwards).

http://dx.doi.org/10.1016/j.jaridenv.2015.09.009
0140-1963/

site-specific factors influencing detectability when surveying snow leopards *Panthera uncia*, stone marten *Martes foina* and red fox *Vulpes vulpes*. Additionally, in a study of puma and jaguar *Panthera onca*, two relatively similar species, Harmsen et al. (2010) showed camera traps placed on trails were biased towards puma captures, warning comparisons between relative abundances of the two species are likely to be invalid. In such circumstances, without accounting for the variation in detection probability, it may be difficult to tell if the variation seen between species capture rates is due to differences in abundance or detection probabilities (Foster and Harmsen, 2012).

Survey designs seek to maximise detection probabilities which in turn confers the benefits of higher precision estimates of abundance parameters (White et al., 1982; Karanth and Nichols, 2002; Lukacs and Burnham, 2005), and a decrease in the number of survey days, or sampling periods needed to obtain reliable data (Mackenzie and Royle, 2005; Rovero et al., 2010). However, when there is variation in the influence of the survey design on detection probabilities between species, selecting a single survey design can be problematic. Nevertheless, such an approach is likely to be the most cost effective method of surveying multiple species in a single area. Mann et al. (2014) examined the influence of camera trap placement on the detection probabilities of a range of mammals in the Little Karoo and found detection probabilities in relation to distance from roads to show extensive variation between species, suggesting camera traps placed on roads are effective for surveying carnivores, but not their prey, in an arid environment.

Many previous carnivore surveys have focused survey efforts on roads and trails, either when using camera traps (e.g. Rios-Uzeda et al., 2007), or sign surveys (e.g. Melville et al., 2006). Such an approach has been suggested to be particularly effective as roads and trails often act as natural funnels through vegetation, directing animal movement through an area (Kelly et al., 2012). Other studies have successfully used baits and lures to increase carnivore detection probabilities (Dillon and Kelly, 2007), for example Thorn et al. (2009) found a fish lure significantly increased encounter rate for brown hyenas *Hyaena brunnea*, whilst du Preez et al. (2014) found bait to significantly increase capture rate for leopards *Panthera pardus*. Previous studies have also used camera traps to produce suitable images for individual identification, for example Ngoprasert et al. (2012) used baits to encourage both Asiatic black bears *Ursus thibetanus* and sun bears *Helarctos malayanus* to expose the chest area to camera trap to show the chest markings needed for individual recognition, usually not seen when bears walk past camera traps.

The use of baits in surveys is however, debated, with concerns being raised regarding violations of the geographic closure assumption of capture–recapture surveys if the bait causes permanent immigration or emigration onto and off the trapping grid, as well as differences in individual levels of habituation through time (Balme et al., 2014). Gerber et al. (2011) examined the effects of baited camera traps on Malagasy civet *Fossa fossana* and found baits not to affect immigration or emigration, abundance or density estimates, but did increase precision of these estimates. However, for large African carnivores, the use of baits has also been suggested to raise ethical concerns as it potentially increases individual vulnerability to trophy hunting, which often uses baits (Balme et al., 2014).

Permanent water sources in an arid environment are rare and attractive to a number of species, therefore it may be considered a natural bait, without the problems associated with more traditional baits introduced into the environment for the duration of a survey only. A recent study by Edwards et al. (2015) showed evidence of temporal, rather than spatial partitioning to be the main mechanism promoting the avoidance of dominant competitors within a carnivore guild at water sources in an arid environment. In contrast, a large body of literature exists suggesting the preferential use of roads by apex predators and the avoidance of them by mesopredators in the presence of apex predators (Hayward and Marlow, 2014). Therefore, in arid environments, water sources have the potential to represent ideal locations for camera trap placement for carnivore surveys, yet the influence of such camera trap placement so far remains untested with regard to its influence on detection probabilities for multiple guild members.

This study examined the influence of camera trap placement on detection probabilities for a guild of eleven carnivore species across two commercial farmlands in southern Namibia, to investigate the potential of this survey design for multiple carnivore species. Detection probabilities produced by camera traps placed at water sources were compared to those produced by cameras placed along roads. Latency until first detection, naive occupancy estimates and species inventories produced by the two camera trap survey designs were also compared. As water is likely to be attractive to numerous carnivore species, and there being no vegetation funnel that may force carnivores to move through the site along roads, it was hypothesised the water source camera trap design would produce higher detection probabilities and naive occupancy estimates as well as shorter latencies until first detection, and a higher diversity of carnivore species inventoried. Additionally, as identifying individuals for species with unique natural markings is a fundamental aspect of density estimation, the proportion of photos where individual identification could be made was compared between the two survey designs. Here is was hypothesised the road camera trap survey design would produce higher proportions of photos for individual identification as animals are more likely to pass perpendicularly in front of road camera traps, whereas at water animals may approach from any angle.

2. Methods

2.1. Study site

The study was conducted across two neighbouring commercial farmlands; Tsirub and Klein Aus Vista (KAV), bordering the Tsau// Khaeb (Sperrgebiet) National Park, Karas region, southern Namibia. A full description of study sites can be found in Edwards et al. (2015).

2.2. Methodology

Two camera trap survey designs were compared, one with camera traps located at water sources, and another with camera traps placed along unfenced farm roads. A total of 12 Scoutguard SG560 V (HCO Outdoors, Norcross, GA, USA)camera traps were placed at water points (Tsirub $n = 7$, KAV $n = 5$), eleven being artificial water troughs and one being a permanent, natural spring on KAV. Scoutguards were programmed to take one photo per trigger, with a minute delay between triggers and set to be active 24 h per day. A full description of camera traps placed at water sources can be found in Edwards et al. (2015). A total of nine Reconyx HC600 (Reconyx Inc, Holeman, Wisconsin, USA) camera traps (Tsirub $n = 5$, KAV $n = 4$) were placed along farm roads connecting the water sources monitored by the water point camera traps, with the mean distance from water source camera traps to the nearest road camera trap being 1.79 km (range 0.45–4.27 km). Reconyx camera traps were programmed to be active 24 h a day, to take five photos at a time with no delay between triggers and at medium sensitivity. All camera traps within each survey design were spaced 3.5–4 km apart, a distance which was considered to be spatially independent. Camera traps from the road survey design