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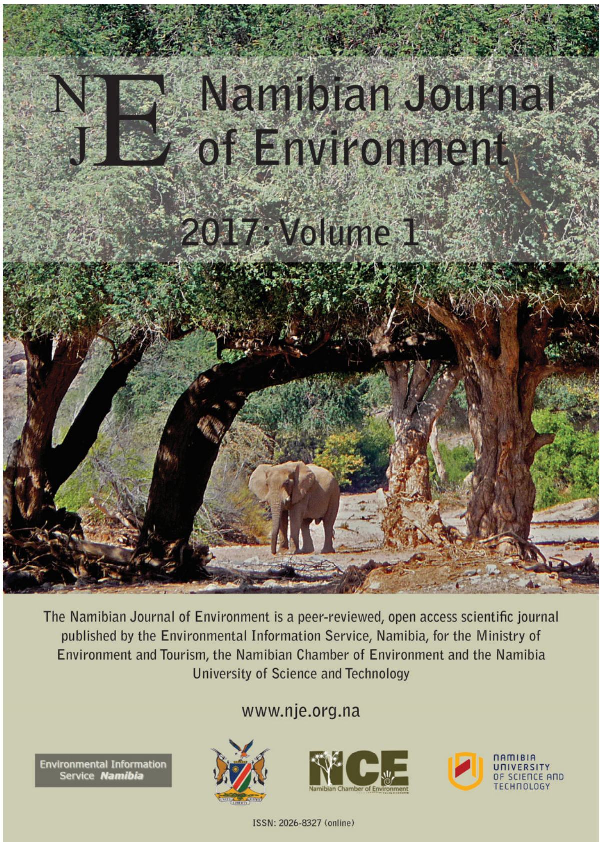

SECTION B: OPEN ARTICLES

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Can camera traps count game?

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Abstract

Game counts provide essential information for the management of wildlife populations. On Ongava Game Reserve, two methods are used annually to count animals: a helicopter aerial count and a 72-hour waterhole count. During the extended waterhole count, observers remain in place for the duration of the count, and are required to record details of all animals seen. In this study we assessed whether camera traps could assist in the count process, firstly by easing the vigilance burden of observers in the nocturnal periods, and secondly by improving the accuracy of the overall count. We found that camera traps not only can substitute for human observers for nocturnal counts, they record more events and hence count more animals. We also found that traps record cryptic and small species that are often missed by observers. Ongava now uses camera traps as the primary counting method from midnight to dawn. In contrast, we found that camera traps cannot substitute for observers for diurnal observations when animal group sizes of more than ten animals are present. Even with extended trap arrays, the field of view and complexity of individual movements in large groups compromises the ability of offline counters to track animals, and they underestimate group sizes. However, there remain a number of advantages of running a camera census in parallel with observers – sightings can be checked and verified, and traps have a consistent mode of operation, minimising inter-observer bias. Images of marked animals can be reviewed offline for further analysis. We believe that the additional information recorded by camera traps provides important population data for both prey and predator species, allowing the development of an integrated ecosystem management strategy.

Keywords: camera trap, game count, Namibia, nocturnal animals, waterhole

Introduction

One of the essential tools for wildlife managers is the 'game count' and regular, repeatable animal counts provide an important foundation for population management (Bothma 2002). There are several options for undertaking counts, and the selection of the most appropriate depends on the habitat, terrain and species composition of the area in question (Bothma 2002). However, most count methods have associated errors or biases that need to be considered when interpreting the results (Elphick 2008). On Ongava Game Reserve, two annual game counts are undertaken. A new-moon helicopter count is followed by a full-moon 72-hour continuous waterhole count. The data from these counts are analysed across years to assess population trends, and are also compared to provide an estimate of population sizes.

Waterhole counts require observers to remain at the location and to record the details of all visits by animals to the waterhole. When these count periods are extended over multiple days, observer performance can be compromised, especially during nocturnal periods.

In recent years the use of automated camera traps has become ubiquitous in wildlife biology. Researchers are using camera traps to search for rare and endangered species, to compute occupancy, density and structure of extant populations, and even to monitor dynamic parameters such as behaviour and movement (O'Connell et al. 2011). While there is a significant core of literature that discusses the limitations of the use of camera traps in wildlife research (reviewed in Burton et al. 2015), there are few studies that assess the use of camera traps in census work. In this study we explore how camera traps might be used during game counts.

We tested camera traps in two 72-hour waterhole game count scenarios. First, we assessed whether traps would be a sufficient substitute for observers for nocturnal observations. Then we configured arrays of traps to record all animal movement during daylight hours, and compared off-line counts from the image records for selected waterholes with sightings recorded by observers.

Methods

Ongava Game Reserve, a 300 km² private reserve bordering Etosha National Park in the north of Namibia, uses a conventional methodology for extended waterhole counts. Two or three people are deployed to each waterhole for the duration of the 72-hour period at full moon. For waterholes close to dwellings or with permanent hides, the observers remain in the same place for the duration of the count. At remote waterholes, hides are erected for diurnal observation, but the observers use vehicles to move closer to the waterhole for nocturnal observation. Observers record the date, time, species, total count and age/sex structure for each wildlife sighting.

For nocturnal trials, camera traps are mounted on nearby supports (typically trees) and are focused on the edges of each waterhole. In most cases, two cameras within 5 m of the waterhole are sufficient to provide complete coverage. When either the area of water is large, or there are no convenient local mounting points, we deploy up to three additional cameras on nearby trees.

For diurnal trials, we supplement the nocturnal placements to achieve a wider view. The trap models we use typically have a 45-degree field of vision, so we designed 'panorama rigs', configured to hold up to four cameras and calibrated to provide a wide view with a 5-degree visual field overlap between adjacent cameras (see Figure 1 Inset). In order to provide additional views, and where there is no convenient natural structure, we mount our rigs on poles (Figure 1). Poles with cement bases are placed close to typical approach trails. To allow animals to habituate to the equipment, we deploy these poles at least two weeks before counting trials, and then attach the rigs without cameras for the final week.

For all trials, we start recording data several days before the observer count. This allows us to confirm that our placements are accurate and that all cameras are configured correctly. Typically, we use Reconyx RC-500 traps for core monitoring at each waterhole, supplemented by Reconyx RC-55, Bushnell HD and Bushnell E-series traps for more peripheral monitoring. All these traps use infrared for nocturnal imaging. For the diurnal trials we also include some Bushnell Aggressor and Cuddeback C-1 traps. All traps are configured to record three or ten images per trigger with either a 1-

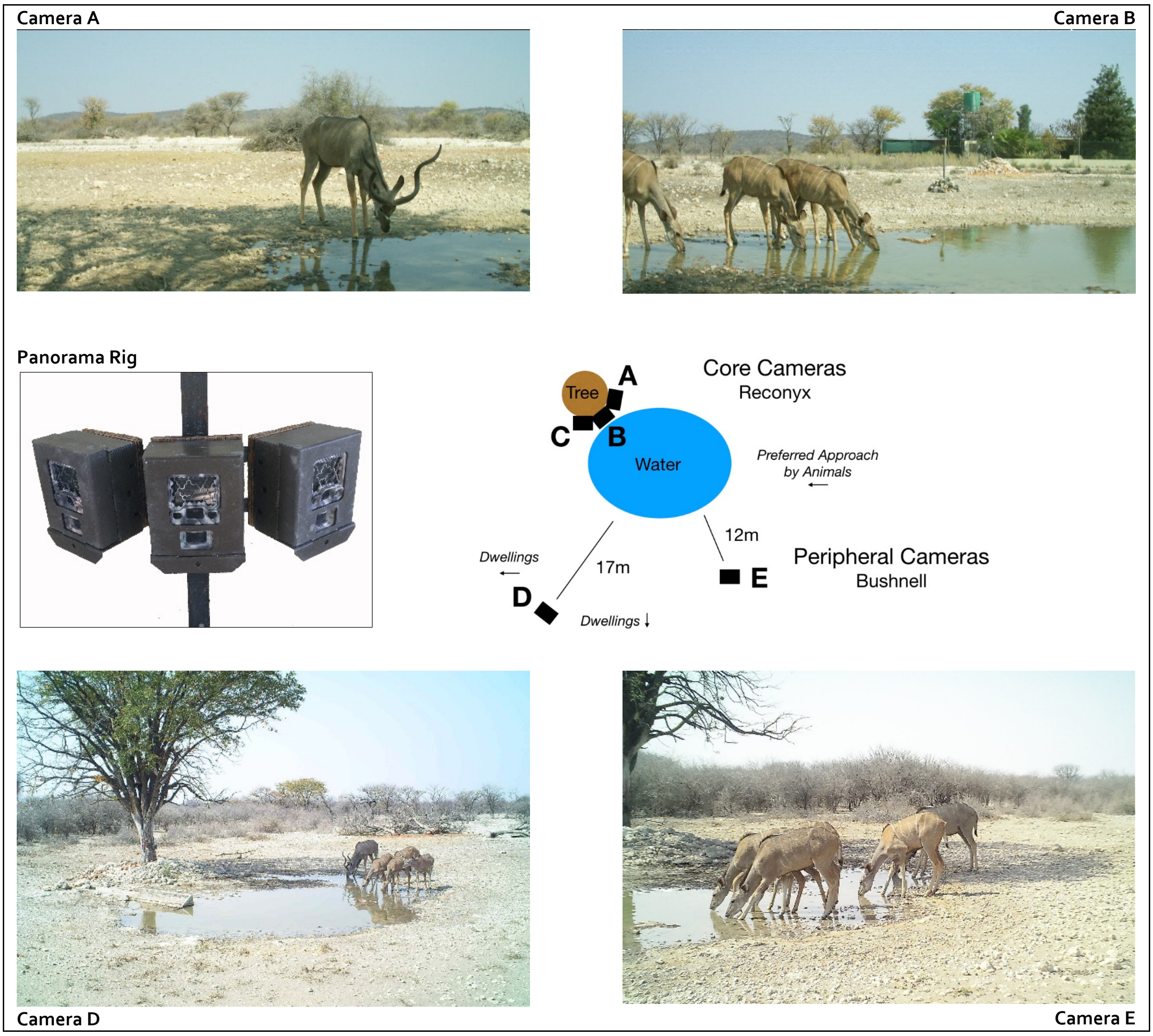

***Figure 1**: Examples of views from multiple cameras. Schematic shows the layout of cameras around a waterhole. A, B and C are core cameras used for nocturnal monitoring, D and E are peripheral cameras that are added for diurnal monitoring. These cameras are typically set back from the waterhole to provide a greater field of view. Images are of the same small group of five kudu (*Tragelaphus strepsiceros*) taken at the same time by each of the cameras. Note that the core cameras are placed at a distance that does not provide a field of vision that is wide enough to see the entire group. However, these cameras need to be that close to trigger for cryptic and smaller species. Offline analysis uses a synchronised multi-camera view to assist the operator in recording observations.*
Inset. An example of a 3-camera 'panorama rig', that provides a calibrated field of vision of 125 degrees with 5 degree overlaps between cameras.

second (core monitoring) or 3-second (peripheral monitoring) delay. The cameras are set to re-prime as fast as possible to ensure we record as many images as possible per observation.

Results

Noctural

In our first nocturnal trials in 2012 and 2013, up to 26 traps were deployed across 9 (2012) or 8 (2013) of 11 waterholes. When compared to the nocturnal records made by observers, the camera traps recorded additional animals at night (2012: n=301, 2013: n=264). This increase in number of animals recorded was more pronounced for remote waterholes that are not lit (n=6). In addition, camera traps recorded more nocturnal observations at waterholes that have associated wallows or secondary reservoirs. Camera traps were particularly effective at recording cryptic and small nocturnal species that were missed by observers (Figure 2). Across the trials, a range of mammalian herbivores was also observed drinking nocturnally (oryx (gemsbok), *Oryx gazella gazella*, springbok, *Antidorcas marsupialis*, Angolan giraffe, *Giraffa giraffa angolensis*, Hartmann's mountain zebra, *Equus zebra hartmannae*, common duiker, *Sylvicapra grimmia*).

On Ongava, typically one-tenth of all animals counted are recorded from nocturnal observations (e.g. 2016: 9.2%, 2017: 10.3%), with about 40% of these occurring in the period from midnight to dawn. After our initial nocturnal trials, management was able to sufficiently trust the data from camera traps to allow observers to stand down and rest, at least between midnight and dawn. These data make a small but significant contribution to the overall count - for example, in total 287 animals were counted from camera trap images in the three midnight to dawn periods across the 72-hour count in October 2017 (32% carnivores), constituting about 4% of the total 72-hour animal count.

Figure 2: *Examples of cryptic and smaller nocturnal species recorded by camera traps. From left to right, top to bottom: aardwolf,* Protelis cristatus*; brown hyaena,* Parahyaena brunnea*; Cape fox,* Vulpes chama*; caracal,* Caracal caracal*; cheetah,* Acinonyx jubatus*; civet,* Civettictis civetta*; honey badger,* Mellivora capensis*; leopard,* Panthera pardus*; porcupine,* Hystrix africaeaustralis*; serval,* Leptailurus serval*; spotted hyaena,* Crocuta crocuta*; African wild cat,* Felis sylvestris lybica*.*

Diurnal

In 2016 we performed a comprehensive camera trapping exercise in parallel with the 72-hour count, deploying 63 camera traps across 12 waterholes (n=3-7 traps per waterhole, see Figure 1 for a typical configuration). For selected waterholes we performed an offline 'count', using images from the trap arrays. Table 1 shows the results for two of these waterholes, one remote, the other near dwellings and lit at night.

For each waterhole, our offline camera trap counts recorded more observations and counted more animals than the human observers. However, this effect was only pronounced during the nocturnal period, and had greater impact at the non-lit waterhole (see accuracy and number of observations missed). It is important to note that the camera traps also missed some observations at one of the waterholes. This arose due to a core camera failure, emphasising that consistent coverage of the field of view is critical for accurate counts.

The traps were able to replicate the diurnal count in most cases, however group size played an important role in determining trap performance. We found that for group sizes above about 14 animals (12-17 across species) offline counters were unable to track the movements of animals in and out of the field of vision of the camera traps, even when using panorama configured arrays. Their estimates were often less than half of those of the human observers. This effect was exacerbated when animals were disturbed during drinking, such that counters were not able to determine which animals were drinking for the first time, or revisiting. Human observers were much better at counting group sizes for larger groups.

To estimate the impact of this, in Table 2 we show the 2016 observer group size counts for the five herbivore species on Ongava that are typically found in groups or herds.
#
Applying a conservative group resolution cut-off of ten animals indicates that camera traps would significantly underestimate population counts for these species in about 25% of all observations. Note that all of the larger group observations for these species were diurnal.

Table 1: *Comparison of observer and camera trap counts during a 72-hour waterhole count. *Consolidated count across all traps, most observations seen on multiple traps. ** Excludes midnight–dawn period when observers were not active, accuracy is the proportion of correct observations expressed as a percentage.*

Period 10:00 14/9/16 to 10:00 17/9/16			
A. Remote Waterhole		Observers	Camera Traps
	#	2	5
Observations*	Total	30	77
	Diurnal	22	23
	Dusk-Midnight	8	19
	Midnight-Dawn	not active	35
	Missed**	16	4 (did not drink)
	Accuracy**	50%	88%
Animals*	Total	100	168
	Diurnal	87	82
	Dusk-Midnight	13	27
	Midnight-Dawn	not active	59
B. Lit Waterhole (near dwellings)		Observers	Camera Traps
	#	2	4
Observations*	Total	76	113
	Diurnal	43	50
	Dusk-Midnight	33	37
	Midnight-Dawn	not active	26
	Missed**	26	18
	Accuracy**	69%	89%
Animals*	Total	205	251
	Diurnal	157	173
	Dusk-Midnight	48	45
	Midnight-Dawn	not active	33

Table 2: *Number of observations by group size of Black-faced Impala,* Aepyceros melampus petersi; *Blue Wildebeest,* Connochaetes taurinus; *Springbok,* Antidorcas marsupialis; *Waterbuck,* Kobus ellipsiprymnus; *Kudu,* Tragelaphus strepsiceros.

	Group Size					
Species	1-9	10-19	20-29	30-39	40-49	>50
Black-faced Impala	153	32	14	6	4	5
Blue Wildebeest	5	3	0	1	2	1
Springbok	51	8	2	0	0	0
Waterbuck	41	2	1	0	0	0
Kudu	106	11	1	0	0	0

Discussion

In this extended study of waterhole counts, we show that camera traps not only can substitute for human observers for nocturnal counts, in fact they record more events and hence count more animals. We also note that traps record cryptic and small species that are often missed by observers. Others have also found camera traps to perform better than more conventional counting methods (e.g. spoor counts, Dupuis-Desormeaux et al. 2016). The management decision to use camera traps as the primary counting method from midnight to dawn relieves the observers and their subsequent vigilance improves. This methodology is now implemented routinely for most waterholes on Ongava.

In contrast, we find that camera traps cannot substitute for observers for diurnal observations, at least not when animal group sizes of more than ten animals are expected. One reason for this is that camera traps typically trigger in response to movement a maximum of 10-15 m from the trap (closer for smaller animals), hence the first images of larger groups are too close to the cameras and extend beyond the field of view. Conversely, if the camera is placed too far from the waterhole, movements will not trigger the camera. We are currently working on methods to activate the cameras using an external synchronised trigger.

However, there remain a number of advantages of running a camera census in parallel with observers – for example, counts can be checked and verified. Camera traps have a consistent mode of operation, and therefore inter-observer reliability is less of an issue, especially across waterholes (Kaufman & Rosenthal 2009). In addition, images of marked animals (either natural marks, such as spots and stripes, or artificial marks, such as tags) can be reviewed offline. This is important from two points of view. Firstly, we use mark-recapture methods to analyse carnivore populations, and, secondly, identification of marked animals allows us to estimate drinking intervals for each of the herbivore species. We typically run the camera trap census for several days before and after the 72-hour period, allowing us to gather additional information about species counts, and also to assess whether the presence of human observers influences the count statistics. (The effect is nowhere near as significant as the disruption in herbivore drinking patterns created by a pride of lions residing at a waterhole for 72-hours!)

There is a significant overhead to processing the data that come from large camera trap surveys (Scotson et al. 2017), in addition to the substantial initial purchase costs. In the 2016 extended study described above, the 63 camera traps generated more than 1,000,000 images in a 14-day period that incorporated the 72-hour count period. While we have developed in-house software to assist with this processing, an experienced operator will still take 4-5 hours to perform the offline count for just the 72-hour period from a typical waterhole. Researchers are currently developing methodologies and software to standardise data collection, storage and analysis (e.g. Niedballa et al. 2016).

We report that about 10% of all animals recorded are counted at night, and typically 30% of those species are carnivores. Given that the focus of animal census work tends to be on the larger herbivore species, is this part of the count important in the context of managing populations? We believe that it is. In order to manage animals in fenced reserves it is important to have information about both prey and predator species so that the management policies can aim to balance the ecosystem for the primary herbivores and carnivores.

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References

Bothma J du P (ed; 2002) *Game Ranch Management*. Van Schaik, Pretoria, South Africa.

Burton AC, Neilson E, Moreira D, Ladle A, Steenweg R, Fisher JI, Bayne E, Boutin S (2015) Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. *Journal of Applied Ecology* 52: 675–685.

Dupuis-Desormeaux M, Davidson Z, Mwololo M, Kisio E, MacDonald SE (2016) Comparing motion capture cameras versus human observer monitoring of mammal movement through fence gaps: a case study from Kenya. *African Journal of Ecology* 42: 154–161.

Elphick CS (2008) How you count counts: the importance of methods research in applied ecology. *Journal of Applied Ecology* 45: 1313–1320.

Kaufman AB, Rosenthal R (2009) Can you believe my eyes? The importance of interobserver reliability statistics in observations of animal behaviour. *Animal Behaviour* 78:1487–1491.

Niedballa J, Sollmann R, Courtiol A, Wilting A (2016) camtrapR: an R package for efficient camera trap data management. *Methods in Ecology and Evolution* 7: 1457–1462.

O'Connell AF, Nichols JD, Karanth KU (eds; 2011). *Camera Traps in Animal Ecology: Methods and Analyses*. Springer, New York, USA.

Scotson L, Johnston LR, Iannarilli F, Wearn OR, Mohd-Azlan J, Wong WM, et al. (2017) Best practices and software for the management and sharing of camera trap data for small and large scales studies. *Remote Sensing in Ecology and Conservation* 3: 158–172.