

Impact of weather conditions on cheetah monitoring with scat detection dogs

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Abstract

Knowledge on cheetah population densities across their current range is limited. Therefore, new and efficient assessment tools are needed to gain more knowledge on species distribution, ecology and behaviour. Scat detection dogs have emerged as an efficient and non-invasive method to monitor elusive and vulnerable animal species, like cheetahs, due to the dog's superior olfactory system. However, the success of locating scat using detection dogs can be significantly improved under suitable weather conditions. We examined the impact of temperature, humidity and wind speed on detection rates of scat from cheetahs during a scat detection dog survey in Northern Kenya. We found that average wind speed positively influences the scat detection rate of detection dogs working on leash. Humidity showed no significant influence. Temperature showed a strong negative correlation with humidity and thus was excluded from our model analyses. While it is likely that wind speed is especially invalid for dogs working off leash, this study did not demonstrate this. Wind speed could thus influence the success of monitoring cheetahs or other target species. Our findings help to improve the survey and thus maximise the coverage of study area and the collection of target samples of elusive and rare species.

Introduction

Wildlife monitoring is crucial for effective nature conservation as it provides valuable information on the distribution, abundance and demography of species and local populations (Yoccoz *et al.* 2001). Conservation and management of rare and wide-ranging species requires frequent monitoring using standardised techniques and protocols that are cost and time efficient (Reed *et al.* 2011). Non-invasive sampling is a preferred technique to collect presence data and biological samples. Such data and samples may give insights into species and population trends, population viability, genetic structures and physiological stress (Kelly *et al.* 2012). Results obtained from standardised monitoring schemes can be used as an early warning system in species conservation (Zemanova, 2019). However, it is particularly difficult to collect data of elusive species, which occur in low densities, such as most species at higher trophic levels like top predators (Long *et al.* 2007a).

Various non-invasive monitoring techniques exist to observe free-ranging mammals, such as direct observation (Broekhuis *et al.* 2018), camera traps (Fabiano *et al.* 2018) or spoor surveys based on foot prints or faeces (Kelly *et al.* 2012). The success of spoor surveys strongly relies on species abundance and the availability of a suitable substrate to detect footprints (Kelly *et al.* 2012; Boast *et al.* 2018). Detection dogs have emerged as an alternative non-invasive method to monitor elusive, rare and endangered animal species (Reed *et al.* 2011). This method is based on the dog's superior olfactory system (Becker *et al.* 2017) and has been successfully used for many species, including cheetahs *Acinonyx jubatus* (Becker *et al.* 2017), koalas *Phascolarctos cinereus* (Cristescu *et al.* 2015) and non-human primates (Orkin *et al.* 2016). This method includes the collection of both, presence data and biological samples for subsequent analyses (e.g. population genetics and/or physiology) (Wasser *et al.* 2004; Long *et al.* 2007a; Becker *et al.* 2017).

The populations of cheetahs in Eastern Africa are among the largest remnant populations of this vulnerable carnivore (Becker *et al.* 2017; Marker *et al.* 2018). Kenya's cheetah population is estimated at about 1,200 individuals (Durant *et al.* 2017). The species occurs in low densities (Marker *et al.* 2018). Most of the individuals occur beyond protected areas (Durant *et al.* 2015, 2017). Cheetahs rarely rub against features for territorial and social communication. Thus, the collection of hairs as biological samples is ineffective (Schmidt-Küntzel *et al.* 2018). The use of scat detection dogs for cheetah monitoring improves success rates in

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monitoring schemes (Kelly *et al.* 2012). However, success rates of scat detection with dogs might depend on various abiotic conditions, such as temperature, humidity and wind speed (Smith *et al.* 2003; Wasser *et al.* 2004; Reed *et al.* 2011).

In this study, we examined the influence of temperature, humidity and wind speed on the detection rates of scat from cheetahs, using two dogs during uncontrolled field surveys (field surveys that used natural scat frequencies instead of experimental manipulations) in two national reserves in northern Kenya. The dogs searched on-leash along linear search transects. The dogs were leashed because of the presence of various dangerous animals like sympatric carnivores and large herbivores in our study area. We measured temperature, humidity and wind during each campaign. The results of our study provide data on the best weather conditions suited for scat detection dogs worked on leash and help to improve future cheetah monitoring with scat detection dogs.

Material and methods

Study area

As study area we selected the Buffalo Springs (0.52°N; 37.62°E) and Samburu (0.62°N; 37.53°E) National Reserve in Northern Kenya. The two reserves cover approximately 296 km² and are separated by the Ewaso Nyiro River. The area lies at an altitude of 800–1200 m and is topographically characterised by rugged hills and water courses (Wittemyer, 2001). Rainfall is localised and highly variable in the region with bimodal distribution during the long rains in March–April and short rains in October–November (Wittemyer, 2001; Ogara *et al.* 2010; Ihwagi *et al.* 2011). The distribution of vegetation highly depends on the availability of water. Riverine woodlands along the banks of Ewaso Nyiro River are dominated by *Acacia elatior* and *Hyphaene coriacea*, while the saline soils of low lying pans adjacent to the river are dominated by salt bush, *Salsola droides*. In the dry regions more distant from the river, *Acacia-Commiphora* semiarid scrub woodland and *Acacia* wooded grassland are growing (Wittemyer, 2001).

Data collection

Linear search transects with an average length of 1.96 ± 0.69 km were set in areas where recent cheetah sightings were available (sightings from the past one month before respective campaigns). Cheetah scat detection was performed with a detection dog team, consisting of two detection dogs, a main dog handler and one orienteer (see Becker *et al.* 2017). The orienteer directed the main handler along the predefined transect during searches. The two detection dogs, a male Border Collie Rottweiler mix and a female Belgian Malinois/German Shepherd mix, were locally trained to locate cheetah scat in the field. Each dog had more than three years of training on cheetah scat using both wild samples opportunistically collected in the field and samples from cheetahs in captive facilities. The two dogs worked on leash (with 15 feet long leashes) and alternating. The dog team used a linear search strategy where the detection dogs searched one-way along a linear transect into the wind. The detection dogs searched into the wind to increase their detection rate, which was limited by working them on leash, resulting in reduced freedom to search for scents from multiple directions (Reed *et al.* 2011; Cristescu *et al.* 2015). We employed linear search strategy to optimise the area covered and detection of scat samples from female, juvenile and other non-territorial male (floaters) cheetahs in the study area which do not use scent

Table 1. Correlation coefficients and P values for weather conditions, such as mean temperature (°C), humidity (%) and wind speed (m/s) during uncontrolled field searches using detection dogs in Northern Kenya. Significant P values are given in bold

	Mean temp.	Mean humid.	Mean max. wind	Mean average wind
Mean temp.	1.00	<0.001	0.46	0.80
Mean humid.	−0.75	1.00	0.76	0.38
Mean max. wind	−0.17	−0.07	1.00	<0.001
Mean average wind	−0.06	−0.20	0.79	1.00

marking sites (Becker *et al.* 2017; Schmidt-Küntzel *et al.* 2018). Searches were conducted in June and July of the year 2019 during the morning (06h30 – 10h30). Each dog worked for a maximum of two consecutive days on a transect depending on the condition of the dog, weather and the presence of other wildlife on the transect (please see the Appendix). During the searches, the detection dogs were given six to seven minute breaks after every 15 to 30 minutes. Each detection dog was fitted with a GPS unit (Garmin Alpha TT15 E-collar) to track their search effort (distance and speed) (please see the Appendix). We recorded the number of samples found during each survey. Out of these data, we subsequently calculated the detection rate as the number of scats found per 10 km searched, for each survey (cf. Schmidt-Küntzel *et al.* 2018).

Weather conditions

We recorded temperature (°C), relative humidity (%) and wind speed (meter/second) at the beginning and at the end of each search using a handheld weather station (Ambient Weather Wn-4) (Reed *et al.* 2011). Based on these data, we calculated mean temperature, humidity, wind speed (from average speed) and maximum wind speed for each search (please see the Appendix) (cf. Long *et al.* 2007a).

Statistics

We tested for correlation of all pairs of weather variables using the `rcorr`-function in the R-package `corrplot` v. 0.84 (Wei & Simko, 2017). For variable pairs with a significant Pearson correlation coefficient greater than 0.7, only one biologically reasonable variable was chosen for the model to avoid multicollinearity (Table 1). We then applied a generalised linear mixed effect model (GLMM) as implemented in the `glmer`-function in the R-package `lme4` v. 1.1-21 (Bates *et al.* 2015) to test the effect of humidity and average wind speed on the detection rate. A Poisson distribution was chosen to model the count of detected scat. Therefore, we calculated the scat detection rate per 10 km. We included detection dog as a random effect. All analyses were done in R v. 3.6.1.

Results and discussion

There was a strong positive effect of mean average wind ($P < 0.01$, $\chi^2 = 29.83$) on the dogs' scat detection rate. This result contradicts with previous studies showing no significant influence of wind (speed and direction) on the dogs' detection success (Long *et al.* 2007a; Nussear *et al.* 2008; Leigh & Dominick, 2015; Hoffman *et al.* 2021). The significant effect of mean wind speed during our survey may have resulted from working the dogs on-leash

and along a linear transect into the wind, when they had less freedom to search for scents from multiple directions (Reed *et al.* 2011). According to Reed *et al.* (2011), a non-significant effect of wind speed and direction on detection dogs performance mainly occurs when the dogs are worked off-leash and are able to move freely around the transect line in order to compensate for any effect of wind.

We found no significant effect of mean relative humidity ($P = 0.98$, $\chi^2 = 0.0004$) on the dogs' scat detection rates during the searches. We deduce from the high correlation with humidity (Table 1) that there is no effect of mean temperature on the dogs' scat detection rates. Our results are consistent with results from other studies (Long *et al.* 2007a; Cablk *et al.* 2008; Nussear *et al.* 2008; Leigh & Dominick, 2015) showing no significant variation in dogs' detection rates depending on humidity or temperature.

Although most studies could not demonstrate an effect of weather conditions on detection rates (Long *et al.* 2007a; Nussear *et al.* 2008; Leigh & Dominick, 2015), weather conditions may impact scent detection and influence the time required to search a site (Long *et al.* 2007b). Wind speed and direction for instance affect how the target scent is dispersed, but highly variable wind may disperse scent and make it more difficult for a dog to follow it to its source (Shivik, 2002; Reed *et al.* 2011). This is compatible with our findings that wind speed can influence detection rates of scats when the dogs are worked on-leash. Relative humidity and air temperature may influence the evaporation rate of the target's scent source (Cablk *et al.* 2008), while high temperatures for instance can increase the dogs' rates of panting, which reduces their scenting efficiency (Smith *et al.* 2003). It is therefore important to record environmental variables during surveys and empirically examine the relationships between environmental conditions and detection rates (Reed *et al.* 2011).

Scat detection dogs have been proven to be more effective than spoor-based survey methods in cheetah monitoring (Becker *et al.* 2017). Our results also show that a linear search strategy can be effectively used in scat detection dog surveys to search areas for which cheetahs are known (Gutzwiller, 1990). Most studies recommend working detection dogs off-leash because the dogs can move freely around the handler and search for scents from multiple directions (Reed *et al.* 2011). However, detection dogs ought to be worked on-leash in high risk areas such as national reserves that have high densities of dangerous animals like sympatric carnivores and large herbivores. We would recommend that the handler considers the direction and speed of the wind to ensure maximum detection of the target species. A grid search can also be used to cover relatively smaller areas but with high intensity compared to a linear search strategy (Nussear *et al.* 2008).

We acknowledge that our field surveys used natural scat frequencies instead of controlled experimental manipulations (see Cristescu *et al.* 2015). As a result, the number of samples in the field was not known. Limitation of this study is that this design may result in imperfect detection rates of the target species' scat because the number of samples found is a combination of number samples present and effectiveness of the dogs'. Additionally, species identity of the samples found was not further confirmed by other means such as molecular analysis. Therefore, not all samples found may be attributable to cheetah, and the number of scats detected may thus be overestimated. These two factors may affect the accuracy of the scat detection rate, which may in turn limit its use for the analysis of the effect of weather parameters on the detection of cheetah scats. Nevertheless, we argue that under the assumption that scat density was comparable throughout

our study area or for the various searches, the results of our study are likely to hold true or be confirmed in the future. Another possible limitation of this study is weather variables were only taken at the start and end of the four hour search. This is a long time period during which variables such as wind speed in particular may vary significantly and may not reflect the conditions at the time at which the dog detects the samples. For future studies, we recommend experimental surveys that quantitatively test the effect of weather conditions on scat dog performance during linear or grid search strategies and when the dogs are worked on-leash or off-leash. This information can then be used to design scat detection dog surveys that maximise coverage of the study area and detection of target samples.

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Conflicts of interest. None.

Ethical statement. None.

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Appendix

Table A.1. Transects surveyed for scat by the detection dogs in Buffalo Springs (BSNR) and Samburu National Reserve (SNR) Northern Kenya, in June and July 2019. Temperature, humidity and wind speed are provided as average

Day	Month	Year	Location	Transect	Detection dog			Weather conditions			Scats found
					Duration of search (h:min)	Distance (Km)	Temperature (°C)	Humidity (%)	Wind speed Av (m/s)	Wind speed max (m/s)	
14	6	2019	BSNR	One	2:17	7.5	23.8	60.2	1.7	5.0	3
15	6	2019	BSNR	One (Day 2)	3:19	12.3	24.4	58.8	2.0	4.2	7
18	6	2019	BSNR	Two	3:53	21.3	25.4	53.7	1.8	3.8	5
19	6	2019	BSNR	Five	3:31	10.9	25.9	54.0	1.3	3.7	1
20	6	2019	BSNR	Three	1:17 1:44	6.3	23.5	65.3	0.3	1.7	0
20	6	2019	BSNR	Six	1:44 2:24	6.1	29.6	47.7	2.1	3.3	0
22	6	2019	BSNR	Three (Day 2)	2:24 0:27	9.5	22.9	62.0	1.4	2.6	0
22	6	2019	BSNR	Six (Day 2)	0:27	1.5	29.1	48.0	0.9	2.1	0
23	6	2019	BSNR	Springs	2:26 3:00	11.3	25.5	54.3	0.6	0.8	1
24	6	2019	BSNR	Campsite	3:00	12.6	26.9	52.4	0.5	1.3	0
28	6	2019	SNR	Leopard rock	3:06 2:11	10.0	26.2	55.6	0.9	2.5	3
29	6	2019	SNR	Leopard rock (Day 2)	2:11	11.7	22.5	62.1	1.5	3.1	2
30	6	2019	SNR	Milima	3:37	16.5	25.7	47.8	0.8	3.2	1
2	7	2019	SNR	Airstrip	2:54 2:27	9.6	26.3	56.6	0.9	3.5	0
3	7	2019	SNR	Airstrip (Day 2)	2:27	9.0	23.7	60.3	1.1	4.2	1
4	7	2019	SNR	Kalama	1:33 3:39	6.1	21.4	53.6	1.7	3.8	0
5	7	2019	SNR	Kalama (Day 2)	3:39 0:30	15.6	24.9	50.2	3.1	5.0	4
8	7	2019	SNR	Larsens camp	0:30	5.3	21.6	66.0	0.5	1.5	0
9	7	2019	SNR	Larsens camp (Day 2)	3:12	12.0	26.2	53.7	0.2	2.3	3
10	7	2019	SNR	Samburu Lodge	2:31 3:05	12.3	25.6	55.7	1.8	3.4	1
12	7	2019	SNR	Samburu Lodge (Day 2)	3:05	11.4	26.2	53.9	0.9	1.6	1
13	7	2019	SNR	Corridor	3:52	17.1	24.4	57.2	2.4	4.6	2

Table A.2. Lengths of linear transects and number of days surveyed for scat by the detection dogs in Buffalo Springs (BSNR) and Samburu National Reserve (SNR) Northern Kenya, in June and July 2019

Location	Name of transect	Transect length (km)	N days surveyed
BSNR	One	2.8	Two
BSNR	Two	1.2	One
BSNR	Three	1.5	Two
BSNR	Five	1.3	One
BSNR	Six	1.2	Two
BSNR	Springs	1.2	One
BSNR	Campsite	1.3	One
SNR	Leopard rock	2.9	Two
SNR	Milima	2.2	One
SNR	Airstrip	2.9	Two
SNR	Kalama	3.0	Two
SNR	Larsens camp	2.1	Two
SNR	Samburu Lodge	2.0	Two
SNR	Corridor	2.0	One