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 (Broekhuys 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
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 etiolata 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 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 corrr-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, χ² = 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 in a manner that maximised their detection rate.

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.

| Weather condition | 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               |
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 can detect the samples. 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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### 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 | Duration of search (h:min) | Distance (Km) | Temperature (°C) | Humidity (%) | Wind speed Av (m/s) | Wind speed max (m/s) | Scats found |
|-----|-------|------|----------|----------|-----------------------------|---------------|-----------------|--------------|-------------------|-------------------|-------------|
| 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           |
| 22  | 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 (Day 2) | 3:06 2:11                        | 10.0          | 26.2            | 55.6         | 0.9               | 2.5               | 3           |
| 29  | 6     | 2019 | SNR      | Leopard rock | 2:11 11:17                 | 22.5          | 62.1            | 1.5          | 3.1               | 2                 | 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 (Day 2) | 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 (Day 2) | 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             |