# Assessing two detection dog-based sampling strategies targeting cheetah scat in diverse environments of central-east Namibia

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Keywords: cheetah monitoring, detection frequencies, method comparison, Namibia, non-invasive sampling, scat detection dogs, scent marking sites, survey design

## Abstract

Cheetah monitoring can be improved with scat detection dogs that efficiently detect marking sites and scats randomly distributed across the landscape. To assess the scalability and adaptability of this method, we applied walking transects and visual searches, both supported by a detection dog, in four areas with varying cheetah densities, land use types, and habitats in central-east Namibia. We successfully detected cheetahs in all four study areas. Walking transects consistently yielded higher detection frequencies and detected cheetah presence in all areas, while vehicular searches were more time-efficient when marking sites were readily available. We recommend using an adaptive strategy to optimize searches depending on environmental characteristics in a given study area.

## Introduction

Wildlife detection dogs are increasingly used as minimally-invasive survey tools to enhance the detection of wide-ranging species, such as many large carnivores (Grimm-Seyfarth et al. 2021). Their efficiency, compared to human searchers, is particularly evident in scat sample detection (Hofmann et al. 2021). Scat can provide valuable insights into a species' biology, health, and diet, especially when combined with genetic analysis (Schmidt-Küntzel et al. 2017), thereby holding the potential to inform effective conservation initiatives (Campbell-Palmer & Rosell 2011).

The cheetah (*Acinonyx jubatus*) is experiencing severe population declines, demanding immediate conservation efforts supported by accurate demographic data (Durant et al. 2017). However, monitoring the species poses challenges due to their wide-ranging behaviour and low population densities (Melzheimer et al. 2018; Weise et al. 2017). This can result in insufficient detections, impeding accurate inferences from surveys (Strampelli et al. 2022; Verschueren et al., submitted). Increasing the detection of cheetahs can be achieved by monitoring marking sites (Verschueren et al., submitted). Here, territorial male cheetahs will regularly defecate, whereas non-territorial males and females visit primarily for communication purposes without scent-marking (Cornhill & Kerley 2020).

Marking sites are often located by tracking the movement of radio-collared individuals (Melzheimer et al. 2020; Fabiano et al. 2020). However, this relies on capturing territorial males which may prove expensive, risky, and time intensive, in particular in areas with low cheetah presence (Kelly et al. 2012). Minimally-invasive survey methods, such as visual searches for signs of presence, mitigate those challenges, while holding the potential to increase detections (Kelly et al. 2012; Reed et al. 2011). Visual detection of cheetah marking sites may be possible as these sites are often conspicuous landscape features such as large trees, termite mounds, or rocks (Walker et al. 2016; Caro 1994). However, marking sites are not always conspicuous and may go undetected during visual surveys. This can be remedied through the inclusion of walking transects with a scat detection dog in the survey methodology. Scat detection dogs have been proven effective for the detection of marking sites (Becker et al. 2017), as dogs do not rely primarily on visual cues (MacKay et al. 2008). We presented a combined approach of camera trap and scat detection dog surveys in some of our previous work (Verschueren et al., submitted). There we performed walking transects to detect marking sites as well as scats randomly distributed across the landscape that are not associated with marking sites (hereafter 'random scats'), and conducted visual vehicular surveys to identify additional conspicuous marking sites, which we confirmed with a detection dog to find concealed scats. Understanding how these two scat detection dog-based search strategies perform under varying conditions is crucial to inform their deployment on a larger scale to survey cheetahs and other species with similar monitoring challenges.

Here, we deployed a scat detection dog-team to apply our complementary strategy of walking transects and vehicular searches to four study areas in central-east Namibia. The areas encompass a variety of suspected cheetah densities, land use types, and habitats (Atlas of Namibia Team 2022; Durant et al. 2022; Weise et al. 2017). We assess the results to compare the effectiveness of the different components of our strategy relative to the characteristics of each area.

## Materials and Methods

We surveyed four areas in central-east Namibia (Figure 1) characterized by a tree-and-shrub savanna biome and a semi-arid climate with rainfall predominantly occurring in the wet season from October to April (Atlas of Namibia Team 2022). All surveys were conducted during the dry season to maximize the chances of finding scat. Areas 1 and 2 are freehold farmland, where the primary agricultural activity is cattle farming, supplemented by wildlife-based economies (Atlas of Namibia Team 2022). Area 1 is estimated to have the highest cheetah density among our study areas (Weise et al. 2017). Area 2 is a well-researched landscape for cheetahs, likely possessing the second highest cheetah density (Fabiano et al. 2020; Weise et al. 2017). Areas 3 and 4 are communal farmlands designated as communal conservancies (NACSO 2024), with Area 3 situated in the south-western

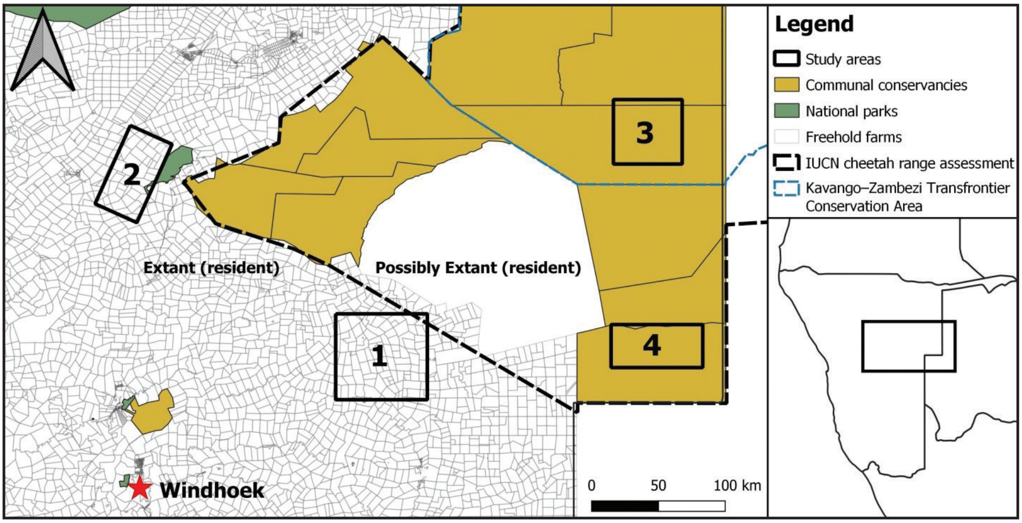


*Figure 1: Overview of the study region in central-east Namibia, depicting the four study areas. The dashed black line indicates the confirmed resident cheetah range (Durant et al. 2022).*

part of the Kavango–Zambezi Transfrontier Conservation Area (KAZA TFCA), and Area 4 bordering Botswana to the east and south. In Areas 3 and 4 cheetahs are possibly resident, albeit with presumably lower density than in Areas 1 and 2 (Durant et al. 2022; Weise et al. 2017). We overlaid each study area with a grid where each cell (sampling unit) measured 16 km x 16 km (256 km²), approximating the minimal home range of cheetahs in comparable ecosystems (Melzheimer et al. 2018; Marker et al. 2008). The surveyed area varied among the study areas, ranging from 2,048 km² in Areas 2 and 4, to 4,096 km² in Area 1 (Table 1).

The scat detection dog and the handler are hereafter referred to as 'dog-team'. The dog (female spayed Belgian Malinois) was trained to indicate cheetah scat by sitting next to it, following the general methodology established in this field (MacKay et al. 2008). The handler Tim Hofmann was a certified dog trainer with expertise in identifying tracks and signs of African mammals. In each area the dog-team conducted both walking transects along roads and vehicular surveys. For road searches, the dog-team systematically searched approximately 16 km (Area 1–3) or 10 km (Area 4) per cell, subject to road availability. For vehicular searches the dog-team drove an average of 30.2 km (Area 3) to 66.9 km (Area 1) per cell to find conspicuous marking sites, which the dog-team subsequently investigated on foot, to confirm the marking site through the presence of scat. We documented survey effort as kilometres driven for vehicular surveys and kilometres walked for transects.

We confirmed cheetah scats by verifying the species identity of the collected samples at the Namibia-based Cheetah Conservation Fund's conservation genetics laboratory (Details of genetic analysis in Wong et al. 2024). We summarized our detection data descriptively by presenting the count of marking trees and random scats found per survey strategy and

*Table 1: Overview of the four study areas within the study region, their environmental characteristics and the sampling design.*

| Study Area | Biome [a] | Vegetation type [a] | Average annual rainfall [mm] [a] | Land use type [a] | Survey period | Survey area [km²] | Cells [#] |
|---|---|---|---|---|---|---|---|
| 1 | Acacia savanna | Central Kalahari | 350–450 | Freehold farmland | May – Sep. 21 | 4,096 | 15.5 [b] |
| 2 | Acacia savanna | Thornbush shrubland | 400–500 | Freehold farmland | Jul. – Oct. 22 | 2,048 | 7.75 [b] |
| 3 | Broad-leafed savanna | Northern Kalahari | 350–400 | Communal farmland | Jul. – Oct. 22 | 2,304 | 9 |
| 4 | Acacia savanna | Central Kalahari | 350–400 | Communal farmland | Aug. 23 | 2,048 | 8 |

[a] According to the Atlas of Namibia Team (2022).

[b] Due to incomplete accessibility of the sampling unit.

study area. Subsequently, we calculated detection frequencies as the number of marking trees per 100 km covered for each strategy and the number of random scats per 100 km for walking transects.

## Results

We found cheetah scat in all four areas through walking transects and in three areas with vehicular searches, both supported by a scat detection dog (Table 2 & Figure 2).

In **Area 1**, we found 9 marking sites and 5 random scats along 248 km of walking transects (16.0 km per cell; detection frequency of 3.6 marking sites and 2.0 random scats per 100 km). During vehicular surveys we discovered 30 marking sites over 1,037 km (66.9 km per cell; 2.9 marking sites/100 km).

In **Area 2**, we identified 2 marking sites along 124 km of walking transects (16.0 km per cell; 1.6 marking sites per 100 km) and found no random scats. During vehicular surveys we discovered 5 marking sites along 423 km (54.6 km per cell; 1.2 marking sites per 100 km).

In **Area 3**, we found 3 random scats along 145 km of walking transects (16.1 km per cell; 2.1 random scats per 100 km), but no marking site. We also found no marking sites along the 272 km vehicular surveys (30.2 km per cell).

In **Area 4**, we covered 80 km of transects (10.0 km per cell) and 320 km of vehicular searches (40.0 km per cell), some of which overlapped for logistical reasons. We detected 1 marking site independently with both methods, resulting in 1.3 marking sites per 100 km for walking transects and 0.3 marking sites per 100 km for vehicular searches. We did not find any random scats while walking transects.

*Table 2: Survey effort in each study area for both sampling methods and their respective results.*

| Study area | Method | Effort [km] | Marking sites [#] | Random scats [#] |
|---|---|---|---|---|
| 1 | Walking transects | 248 | 9 | 5 |
| | Vehicular searches | 1037 | 30 | NA [b] |
| 2 | Walking transects | 124 | 2 | 0 |
| | Vehicular searches | 423 | 5 | NA [b] |
| 3 | Walking transects | 145 | 0 | 3 |
| | Vehicular searches | 272 | 0 | NA [b] |
| 4 | Walking transects | 80 | 1 [a] | 0 |
| | Vehicular searches | 320 | 1 [a] | NA [b] |

[a] The same marking site was identified independently by both methods.

[b] Not applicable, as random scats cannot be detected during vehicular surveys.

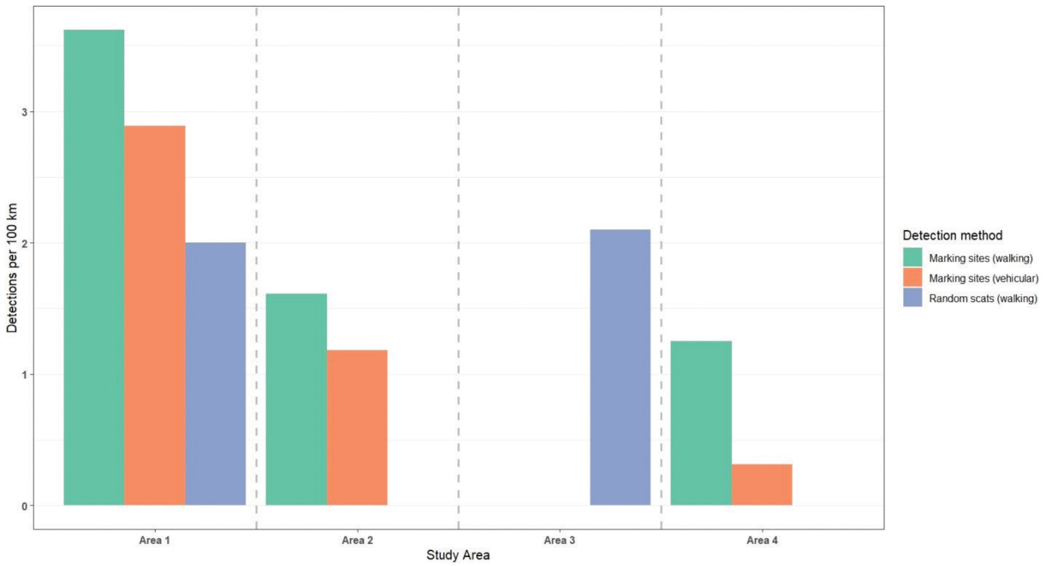


*Figure 2: Marking sites and random scats detected per 100 km for each method in each study area (indicated by dashed vertical lines). Note that no marking sites were detected in area 3 and no random scats in areas 2 and 4.*

## Discussion

We were able to confirm cheetah presence in all four study areas using our complementary strategy of walking transects with a detection dog to find marking sites irrespective of their morphology as well as random scats, and vehicular searches confirmed by a detection dog to find additional conspicuous marking sites. This extends to areas with unknown status of cheetah residence (Durant et al. 2022) and diverse habitat characteristics (Atlas of Namibia Team 2022), highlighting the effectiveness of the scat detection dog as a minimally-invasive survey tool for cheetah monitoring.

As expected, random scats were found only during walking transects, while marking sites were detected with both methods. As such, walking transects alone yielded detections in all study areas, including areas where no marking sites were detected. The detection frequency of marking sites per 100 km was also consistently higher for walking transects than for vehicular searches (Figure 2). We attribute this difference to the capacity of the dog to detect marking sites irrespective of their morphology. However, vehicular searches confirmed with the dog required less effort in terms of time investment, which allowed coverage of larger areas, leading to a higher total number of marking sites detected. As such, in areas where the road network and habitat allow for vehicular searches and the detection of marking sites is the primary study objective, this combination may be considered as the preferred method.

We were not able to confirm marking sites in Area 3, even though we found trees that matched the morphology of marking sites (Walker et al. 2016), albeit in fewer numbers compared to the other areas. Based on our results from these other areas, where we successfully found and confirmed marking sites using the same complementary strategy, we assume that in Area 3 marking sites were rare, rather than not detected. Fewer marking sites could be a reflection of lower cheetah densities reported for this area (Weise et al. 2017). Interestingly, we found an almost identical frequency of random scats in Area 3 compared to Area 1 (2.1 and 2.0, respectively), which had the highest cheetah density of all study areas (Weise et al. 2017; Verschueren et al., submitted). Therefore, another contributing factor may be differences in defecation behaviour associated with an individual's territoriality. Higher proportions of non-territorial males and females may result in an increased detection of random scats on roads relative to the total density of cheetahs (Cornhill & Kerley 2020; Melzheimer et al. 2018; Broomhall et al. 2003). Indeed, cheetahs in Area 3 may be non-resident individuals straying into the study area from the bordering Nyae-Nyae Conservancy, which has stable records of cheetah occurrence (NACSO 2024). In either case, walking transects with a detection dog may be the only way to detect scats under such circumstances.

We found that the variation in detection success for the two methods can be largely attributed to the intrinsic characteristics of each study area. Subsequent analysis of the study areas and the collected scats will help clarify this assumption and assess the extent of the correlation. Furthermore, it is noteworthy that the frequency of detected marking sites in the four study areas corresponded with the density estimates indicated on Figure 3B by Weise et al. (2017) for these areas. Therefore, the frequency of marking sites might serve as a relative abundance index for cheetah population densities, although this warrants further investigation.

We conclude that the combination of walking transects and vehicular searches with a scat detection dog is an effective strategy for detecting cheetah presence through locating marking sites and random scats, irrespective of the characteristics of the study area. Walking transects were consistently more successful, while vehicular searches were more time-efficient when conspicuous marking sites and a sufficient road network were available. The flexibility of this complementary strategy allows for adaptation to the characteristics of each study area and thus promises scalability across a range of target species and their habitats.

## Ethical statement

The fieldwork was conducted under the authority of the Namibian National Commission on Research, Science & Technology, in accordance with Section 21 of the Research Science and Technology Act No. 23 of 2004. Permission was granted to the Cheetah Conservation Fund under the research permit number AN2028011402. The fieldwork was carried out with the consent of the landowners. The training and handling of the detection dog was endorsed by the animal welfare officer of the University of Goettingen.

## Acknowledgements

This project received funding from the Indianapolis Zoo Global Conservation Grant, the Leopold III-Fonds voor Natuuronderzoek en Natuurbehoud, the Deutscher Akademischer Austauschdienst, and the Cheetah Conservation Fund. We would like to express our gratitude to Tresia Shihepo and Benny Munyandi for their supportive laboratory work. We are particularly thankful to the Namibian farmers and local communities for granting us access to the study areas and for their invaluable assistance and hospitality during our fieldwork.

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JOURNAL 71
Namibia Scientific Society
Windhoek, Namibia 2024
ISSN: 1018-7677 ISBN: 978-99945-76-97-5

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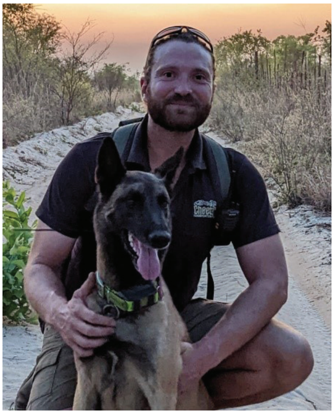

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