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The herpetofauna of Meerkat National Park, Northern Cape province, South Africa

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We present the first appraisal of the herpetofauna of Meerkat National Park, a recently established conservation area in the Northern Cape province of South Africa. A baseline list of species of amphibians and reptiles recorded from the park was created using a combination of active searching, night drives and trapping over a nine-day survey in March 2025. We also collated *ad hoc* observations of herpetofauna shared on the community science platform, iNaturalist, to supplement our dataset. Our findings were compared against species expected to occur in the park based on published inferred distribution maps. Our survey resulted in 126 observations from 29 species (6 amphibians and 23 reptiles), increasing the number of known species in the park from 14 to 30 and improving the coverage from 13 to 18 pentads. However, much of the park remains unsurveyed and several expected species were not recorded. Therefore, for a more comprehensive species list, we recommend further sampling of the park.

Conservation implications: Sampling of protected areas is important for generating species lists and building knowledge of population trends that are essential for assisting in species conservation. Our study provides a list of the reptile and amphibian species that currently occur and those that might occur in the newly established Meerkat National Park.

Keywords: amphibians; conservation; distributions; herpetofauna; reptiles; survey.

Introduction

South Africa is home to over 500 species of herpetofauna (>130 species of amphibians, Measey et al. 2019; >400 species of reptiles, Tolley et al. 2023a) of which >50% are endemic or near-endemic to the country (Tolley et al. 2019). Several species are considered to be of conservation concern (Tolley et al. 2023a), with their primary threat being habitat loss via agriculture, mining, urbanisation and other anthropogenic land-use changes (Tolley et al. 2019, 2023a). Ensuring that South African herpetofauna are protected in conservation areas (i.e., national and provincial reserves, etc.) is thus important for maintaining the high diversity, richness and endemism of these animals in the country. However, baseline occurrence data for many herpetofaunal species are sparse in some parts of the country because of limited sampling (Barends et al. 2020; Tolley et al. 2023b), especially in the arid Karoo region in the Northern Cape province (Conradie et al. 2016; Telford et al. 2022).

Meerkat National Park (MNP) is a recently established protected area situated in the Northern Cape province of South Africa (Figure 1) and is more than 135 000 ha in area (South African National Parks [SANParks] 2022). The park is situated roughly 100 km from the towns of Carnarvon to the southeast and Williston to the southwest. Historically, the area consisted of several farms that were primarily used as rangelands for domestic livestock farming. In 2017, the land was acquired by the National Research Foundation (NRF) and South African Radio Astronomy Observatory (SARAO) to support the Square Kilometre Array (SKA) radio telescope project. The area was officially declared a national park in March 2020, managed by SANParks (SANParks 2022).

Various terrestrial fauna and flora occur within the MNP, but considering the limited number of records in public databases, the area appears to have been historically poorly sampled, particularly concerning the herpetofauna. In 2023, SANParks commissioned several surveys to generate baseline species lists of different taxonomic groups in the park. In this study, we report on the results of a nine-day herpetological-focused survey that aimed to provide a foundational species list of the amphibians and reptiles in MNP.

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Note: Additional supporting information may be found in the Online version of this article as Online Appendix 1.

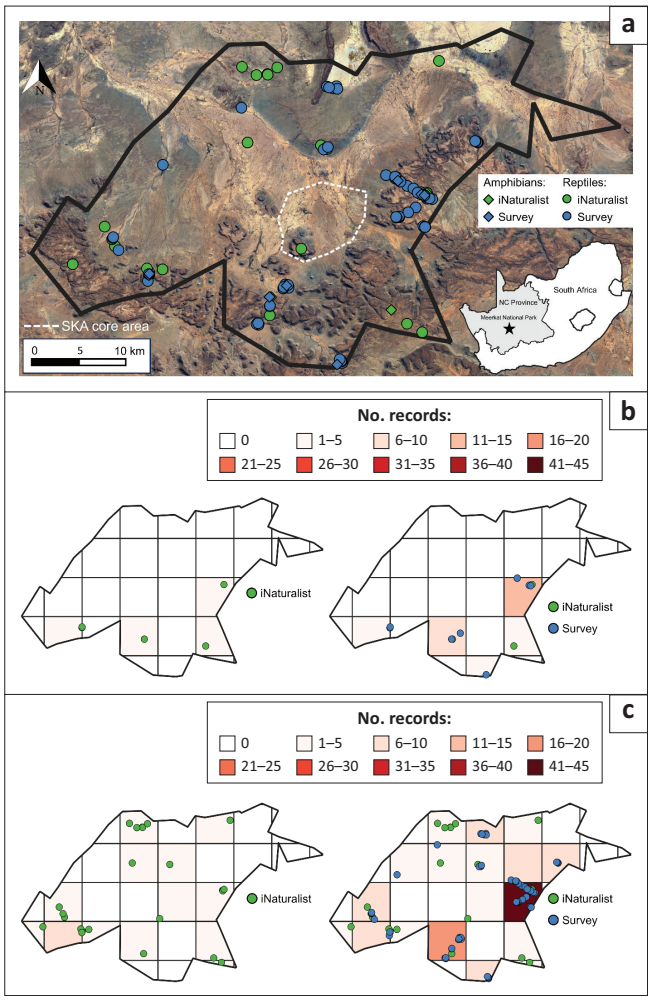

FIGURE 1: Location and boundary of Meerkat National Park, Northern Cape Province, South Africa (a) overlaid on satellite imagery (www.maps.google.com). The dashed line indicates the Square Kilometre Array (SKA) core area. Density of (b) amphibian and (c) reptile species records for MNP. Maps on the left are built from iNaturalist records prior to survey only, and maps on the right are built from iNaturalist records and new survey records.

Research methods and materials

Study area

Meerkat National Park lies within the Nama-Karoo biome, characterised by semi-arid conditions, extreme temperature fluctuations and low, unpredictable rainfall averaging ~220 mm annually (SANParks 2022). Mean annual summer temperature ranges from 16 °C to 33 °C and mean annual winter temperatures range from 2 °C to 22 °C. The park encompasses four major vegetation types: Bushmanland Basin Shrubland, Bushmanland Vloere, Western Upper Karoo and Upper Karoo Hardeveld (SANParks 2022:132) and hosts a variety of low-lying succulents, shrubs and scattered grasses (Mucina & Rutherford 2006; SANParks 2022). The park is approximately 135 425 ha in size and encompasses varied landscapes, including not only flat open plains and low hills but also elevated mountain 'koppies' (hills rising up sharply out of flat terrain), dolerite ridges and rocky outcrops (SANParks 2022). There are a few ephemeral rivers scattered throughout the park, as well as an ephemeral, rainwater-supplied pan situated in the northern parts of the reserve.

Pre-survey data collection and analyses

We downloaded previous records of the herpetofauna in MNP from iNaturalist (www.inaturalist.org). Several researchers surveyed MNP for other taxonomic groups (e.g., birds, plants) in 2023 and 2024 and shared incidental observations of amphibians and reptiles on the platform. In addition, we downloaded species distribution maps from the International Union for Conservation of Nature (IUCN) Red List of threatened species (www.iucnredlist.org). Using the distribution maps, we predicted species occurrence as well as species richness across MNP at the pentad level (5 x 5 min longitude and latitude) in QGIS v.3.36 (QGIS development team 2024).

Coverage

Using the existing iNaturalist records, we produced an intensity estimate of sampling effort in each pentad of MNP by counting the number of points in each pentad in QGIS v3.3.6. We repeated this analysis with our full dataset (see below) to show the change in sampling effort and geographic coverage after our survey.

Sampling

We sampled MNP for amphibians and reptiles over a nine-day targeted survey period from 11 to 19 March 2025 using both active searching and trapping. For active searching, different areas of the park were targeted each day to maximise coverage and habitat diversity. Reptiles were located visually while walking, searching under rocks and other objects, searching in crevices and cracks in rocks and water bodies and streams. Nocturnal searches were also conducted for frogs around waterbodies using headlamps. Herpetofauna were captured by hand (i.e., by nooses, snake hook sticks and tongs or aquarium nets). We also searched for herpetofauna at night by road cruising on tar and dirt roads at <30 km per hour for a minimum of 1 h per night. Animals were either captured for voucher specimens and corresponding DNA samples or were recorded as observations. Voucher specimens were euthanised by contact with 10% benzocaine gel paste placed in the mouth (Rödel & Glos 2019). DNA samples were taken via either a toe or tail clipping or by extracting liver tissue from euthanised specimens. All specimens taken for vouchering were preserved in a 10% formalin solution for 24 h before being transferred to 70% ethanol following the methods of Tolley et al. (2023b). Specimens that were not taken as voucher specimens were released at capture sites. Voucher specimens have been deposited in the herpetological collection at Bayworld Museum in Gqeberha, South Africa, and DNA samples have been deposited in the National Wildlife Biobank in Pretoria, South Africa. The latitude and longitude (±3 m) of each animal caught or observed were recorded using a Garmin 64x handheld GPS receiver.

Trapping was conducted by installing three Y-shaped pitfall and funnel trap arrays. Each trap array included three 10-m drift fence arms positioned around a central pitfall trap

(200 mm diameter and 300 mm depth). Pitfall traps were also present at the terminal end of each arm. In addition, two 1-m-long funnel traps were placed centrally on each side of each drift fence arm (one on each side). Trap arrays were installed on the first day of the survey and kept open for the entire nine-day survey period, during which they were checked twice per day, once in the morning and once in the evening. Specimens trapped were removed and a subset was processed for DNA and vouchering. All individuals were identified to species level based on morphological features (i.e., scalation, patterns, etc.) using field guides (Branch 1998; Du Preez & Carruthers 2018; FitzSimons 1943; Tolley et al. 2023a).

Data analysis

We used a paired *t*-test to compare the numbers of species detected versus those expected in each pentad. Species accumulation curves were derived by plotting the cumulative number of species detected per day for amphibians, reptiles and all herpetofauna together, respectively. In addition, asymptotic species richness estimators (Chao1 and jackknife) were used to estimate species richness based on our sampling effort. The Chao1 estimator uses the frequencies of species observed once and those observed multiple times to estimate the number of undetected species, whereas the jackknife estimator calculates the number of undetected species as being equal to the number of species detected once (Chao & Chiu 2016).

Ethical considerations

Ethical clearance to conduct this study was granted by South African National Parks (Reference No: CRC/2024-2025/MK_Bioblitz/V1) on 26 July 2024.

Results

Expected species before sampling

Based on distribution maps of South African herpetofauna, we estimated that 42 species (7 amphibians and 35 reptiles) potentially occur within MNP (Online Appendix 1: TABLE 1-A1). Estimated species richness across MNP was uniform, with most pentads predicted to have at least 38 species (90% of the total predicted).

Sampling

We recorded 126 individuals from 29 species of herpetofauna, comprising six species of amphibians and 23 species of reptiles in MNP, in addition to gathering 38 previously recorded observations from iNaturalist, resulting in a total of 164 records confirmed for the park (Table 1). Our sampling produced a 232% increase in the number of records for MNP. During our targeted surveys, we recorded all herpetofaunal species previously recorded in MNP except *Dipsina multimaculata*, and we also recorded an additional 15 species not previously confirmed for the park, resulting in a total of 30 confirmed species for MNP (Table 1). Overall, the total dataset included six species of amphibians, one agamid, one cordylid, five geckos, three lacertids, three skinks, eight snakes and three tortoises. In addition, our new records increased the sampling coverage from 13 to 18 pentads (Figure 1), representing an increase in geographic coverage of 38%. Unsurprisingly, we found significantly fewer species per

TABLE 1: Species recorded during surveying and from iNaturalist, marked with an X, with the IUCN threat status indicated.

Family	Species	IUCN status	iNaturalist	This study
Order Anura				
Bufonidae	*Tomopterna tandyi/adiostola*	LC	-	X
	Vandijkophrynus gariepensis	LC	X	X
Pipidae	*Xenopus laevis*	LC	-	X
Pyxicephalidae	*Cacosternum boettgeri*	LC	-	X
	Pyxicephalus adspersus	LC	-	X
Ranidae	*Amietia poyntoni*	LC	X	X
Order Squamata				
Agamidae	*Agama aculeata*	LC	X	X
Cordylidae	*Karusasaurus polyzonus*	LC	X	X
Gekkonidae	*Chondrodactylus angulifer*	LC	X	X
	Chondrodactylus bibronii	LC	X	X
	Pachydactylus latirostris	LC	-	X
	Pachydactylus purcelli	LC	-	X
	Pachydactylus rugosus	LC	-	X
Lacertidae	*Meroles suborbitalis*	LC	X	X
	Pedioplanis lineoocellata	LC	X	X
	Pedioplanis namaquensis	LC	X	X
Scincidae	*Trachylepis occidentalis*	LC	-	X
	Trachylepis sulcata	LC	X	X
	Trachylepis variegata	LC	-	X
Elapidae	*Naja nivea*	LC	-	X
Lamprophiidae	*Boaedon capensis*	LC	-	X
	Boaedon mentalis	LC	-	X
Psammophidae	*Dipsina multimaculatus*	LC	X	-
	Psammophis notostictus	LC	X	X
Typhlopidae	*Rhinotyphlops lalandei*	LC	X	X
Viperidae	*Bitis arietans*	LC	-	X
	Bitis caudalis	LC	-	X
Order Testudine				
Testudinidae	*Chersobius boulengeri*	EN	-	X
	Psammobates tentorius	NT	-	X
	Stigmochelys pardalis	LC	X	X

Note: Dashes indicate species not recorded.

LC, Least Concern; EN, Endangered; NT, Near Threatened; IUCN, International Union for Conservation of Nature.

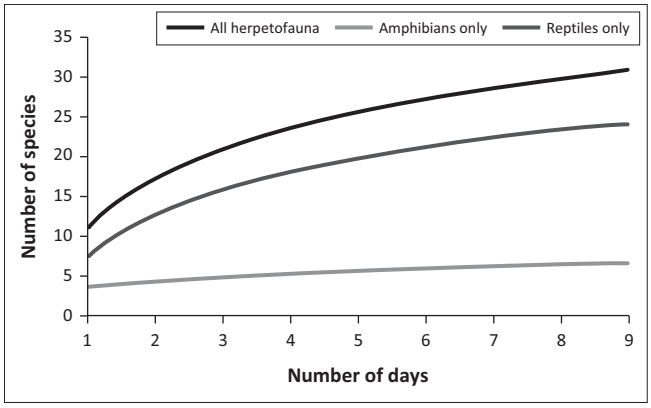

FIGURE 2: Species accumulation curves showing the cumulative numbers of species detected over consecutive days of sampling across Meerkat National Park for amphibians, reptiles and all herpetofauna species separately.

grid cell than those predicted to occur there (Paired *t*-test: $t_{1, 31} = 50.657$; $p \leq 0.001$), with species accumulation curves for reptiles failing to plateau (Figure 2). Based on our sampling effort, the Chao1 estimator's predicted increased sampling would yield up to 33 species (95% CI = 30 – 47, SE = 3.476), whereas the jackknife estimator predicted up to 36 species (95% CI: 32 – 48, SE: 3.719).

Discussion

Based on species occurrence records and inferred distributions, we estimated that at least 40 species of reptiles and amphibians occur in MNP. Our targeted survey confirmed the presence of six of seven species of amphibians and 24 of 35 species of reptiles in MNP, doubling the number of confirmed herpetofauna from 14 to 30 species, as well as providing a 232% increase in the number of herpetofaunal records for the park. Increased sampling is likely to yield more reptile species, as evidenced by species accumulation curves, which did not asymptote, the predicted species list based on IUCN distribution maps, and asymptotic species richness estimators. In addition, while our sampling improved on previous geographic coverage from 13 to 18 (out of 32) pentad grid cells, much of the park remains unsurveyed. Additional surveys targeting those areas could potentially aid in increasing knowledge of the herpetofaunal species richness and diversity in MNP.

Of the species recorded in MNP, small range extensions were recorded for two species. The leopard tortoise, *Stigmochelys pardalis*, was not predicted to occur in the park (Hofmeyr & Baard 2023) but was observed in several pentads to the east and southeast of MNP, approximately 50 km west of the nearest records of native populations. Similarly, the bug-eyed house snake, *Boaedon mentalis*, was predicted to occur only marginally in the western regions of the MNP, but our records confirmed that the species also occurs in the east of the park, outside of its current inferred distribution (Conradie et al. 2023). Furthermore, a new record from iNaturalist (www.inaturalist.org/observations/255269037) from November 2024 was further east of our records, supporting the wider distribution of *B. mentalis*. Taken together, our records and those from iNaturalist allowed us to adjust the distribution polygons for both species (Figure 1-A1). In addition, while not a range extension, our observations of bullfrogs (*Pyxciecephalus adspersus*) are also of interest for the park as the species is rare in the region, and our records in MNP fill in a gap in the occurrence records and confirming that the park offers a suitable refuge for the species given the range of available water sources.

The majority of species recorded in MNP are categorised as Least Concern per the IUCN Red List. Only *Chersobius boulengeri* (Endangered) and *Psammobates tentorius* (Near Threatened) are of conservation concern (see Table 1). Importantly for these species, the park provides an ideal haven with suitable habitat that includes several rocky 'koppies', outcrops and ridges that *C. boulengeri* prefer, and sandy substrate with succulent vegetation suitable for *P. tentorius*. However, our observations of these tortoise species were of deceased individuals. Thus, while we can confirm these species are present in the park, their abundance and welfare are uncertain. Further evidence is required to ascertain the population status of these two species in MNP.

Several species expected in the park were neither detected during our survey nor reported on previous surveys. This is unsurprising given the low detection probabilities of some reptiles (Mazerolle et al. 2007) and the short duration of our survey. Future surveys could assist with detecting additional herpetofaunal species in MNP and would provide a more comprehensive list of species in the park. However, some common species that we expected to be abundant (e.g., *Agama atra*, or *Pachydactylus capensis*) were not recorded despite the multiple sampling approaches used. Moreover, we found no fossorial lizards (e.g., *Acontias* spp., *Scelotes* spp.), no monitor lizards (*Varanus albigularis*), and no terrapins (e.g., *Pelomedusa galeata*). Surprisingly, observations of some typically abundant Karoo species were low. For example, we observed only five individuals of *Pedioplanis lineoocellata*, a species which is typically among the most abundant lizards in the Karoo (KA Tolley pers. obs. 2018). While this might be attributed to a recent drought experienced in the region (SANParks 2022), previous reptile surveys in other parts of the Karoo also under and following drought conditions yielded substantially greater numbers of lacertid observations (Telford et al. 2022). Unfortunately, without data before the drought to contrast against, we cannot provide evidence in support of or against this hypothesis.

Conclusion

Overall, our herpetofaunal-focused survey of MNP provided a substantial increase in the number of records of amphibian and reptile species in the park. However, it is clear that further sampling is required to gain a more complete species list for MNP and to assess trends in population abundances. Additional surveys or long-term surveys are likely to result in additional species detections that can build on the list we produced here. In addition, there are several areas of the park that remain unsampled that could potentially yield additional species. This study therefore provides a provisional list of the species present in MNP, which can act as a solid baseline for further surveys.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

All authors conceptualised the study, conducted the field work and data collection. J.M.B. wrote the original draft of the manuscript and performed the data analysis. W.K.S.-J., W.C., and K.A.T. edited the draft. K.A.T. secured funding and logistical support for the study.

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Data availability

The data that support the findings of this study are not openly available because of reasons of sensitivity and are available from the corresponding author, J.M.B., upon reasonable request.

Disclaimer

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