KOEDOE - African Protected Area Conservation and Science
ISSN: (Online) 2071-0771, (Print) 0075-6458

Reconnaissance of epigeal ants at the degraded and control sites of Mountain Zebra and Mokala National Parks

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Dates:
Received: 03 May 2018
Accepted: 08 Mar. 2020
Published: 25 May 2020

South African National Parks (SANParks) is implementing rehabilitation projects in parks where acquired lands have degrees of degradation. Such parks need to have empirical data to determine the degree of degradation and the success of the projects. We sampled epigeal ants at degraded and control sites in Mountain Zebra and Mokala National Parks to acquire the empirical data. With the data, our main aims were to: 1) determine the impact of degradation on the ant community; 2) determine if the rehabilitation period influences the difference between the degraded and control sites; and, 3) identify the degradation that affected the ant community the most. The majority of the degraded sites had lower abundance, species richness, Shannon-Wiener Diversity, common- and exclusive-species than their respective control sites. All the degraded sites had a lower abundance of ants compared to their respective controls. The majority of the degraded sites had lower species richness, higher Shannon-Weiner Diversity Index and higher ant species dominance than their respective controls. The rehabilitation periods differently influenced the difference between the degraded and control sites. Degraded sites that had undergone longer rehabilitation times had lower dissimilarity to their respective controls, while a degraded site with shorter rehabilitation period was very different to its control. Ploughing appears to have longer lasting degradation-impact on ant communities than herbicides applications. A site with ploughing degradation was very dissimilar to its control while sites with chemical degradation had lower disparities to their respective controls. Different degradation activities, therefor, affect ant recovery differently.

Conservation implications: Attention should be paid to the type of degradations that are at the lands identified for expanding the conservation areas. Some of these degradations seem persistent and slow to rehabilitate. Variety of organisms (such as ants in this case) should be included when determining the degradation status of a conservation land.

Keywords: disparity; indicator species; rehabilitation age; degradation method; conservation; ecology.

Introduction

Habitat loss is the decline of ecological (or environmental) area (or community) by any action resulting in unfavourable conditions for species to complete their lifecycles (Galvin 2007). Habitat loss is one of the main drivers for the decline of especially endemic species in South Africa as well as globally (International Union for Conservation of Nature (IUCN) 2015). To preserve the indigenous habitats that are within its jurisdiction, the South African National Parks (SANParks) is implementing rehabilitation projects where varying degrees and types of habitat degradation occur (South African National Parks (SANParks) 2016).

A reconnaissance was carried out in two SANParks, Mountain Zebra (MZNP) and Mokala (MoNP), to compare ant diversity and abundance in degraded and undisturbed control areas. Over-grazing, ploughing and eradication of alien species lead to degradation in MZNP, whilst chemical treatment to control woody plant species was the main factor in MoNP.

We chose to use ants as they often respond temporally and spatially to degradation (Gollan et al. 2011). They exhibit relatively low mobility or dispersion within their habitats (Barrow & Parr 2008),

How to cite this article: Sithole, H., Tantsi, N., Bezuidenhout, H., Munyai T.C. & Munyai, L., 2020, 'Reconnaissance of epigeal ants at the degraded and control sites of Mountain Zebra and Mokala National Parks', *Koedoe* 62(1), a1542. https://doi.org/10.4102/koedoe.v62i1.1542

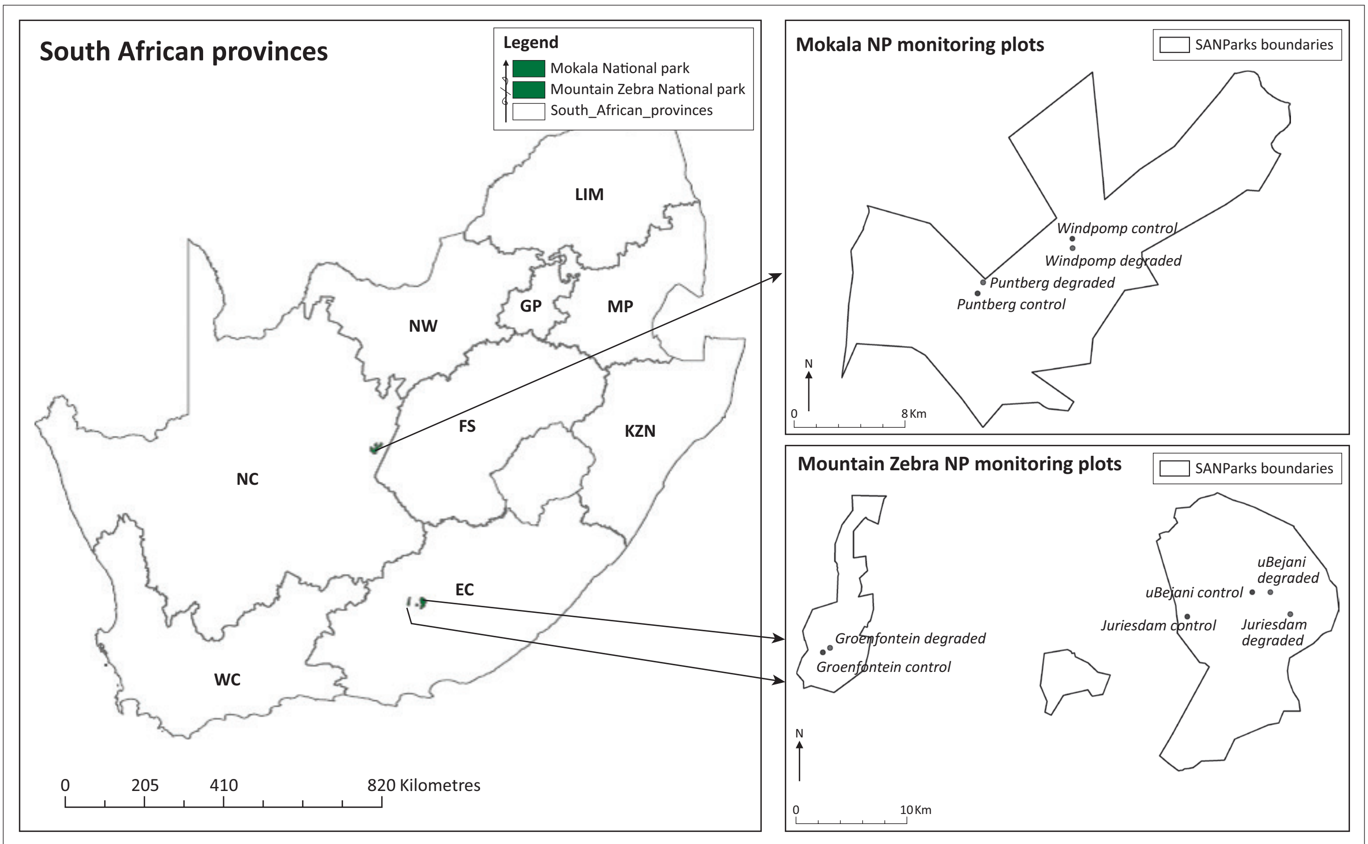
and interact with different organisms at different trophic and symbiotic levels (Agosti, Schultz & Majer 2000; Hölldobler & Wilson 1990). Sampling ants is also relatively cheap (McGeoch et al. 2011).

The main aims for this study are as follows: (1) To determine whether degradation affects the ant communities; this was conducted by comparing ant composition diversity between degraded and control sites of a specific locality. (2) To determine whether rehabilitation periods influence ant communities by comparing the specific biodiversity index disparity between the localities with varying rehabilitation periods. (3) To identify which of these degradation activities impacted most on ant communities by comparing the specific biodiversity index disparity between the localities.

Study area

The MZNP (32.20500° S, 25.45000° E) is situated in the Eastern Cape province of South Africa (Figure 1). Its vegetation consists of a mixture of dwarf shrubs and grasses (Bezuidenhout & Brown 2008). The area receives late summer rain, with the highest rainfall recorded in March and the lowest in June. Average temperature ranges from 0.5 °C to 28.4 °C (Bezuidenhout & Brown 2008). Three localities were selected in this park. The first locality was Groenfontein with the degraded site, at 32.215628° S, 25.119439° E, consisting of bare soil surface and debris left after clearance of the alien plant species *Populus canescens*. The control site for this was at Groenfontein (32.21563° S, 25.11844° E), which had no history of any degradation. Its proximity to the degraded site and similar habitat makes it a valid control site. The second locality was Juriesdam. This degraded site, at 32.18846° S, 25.49268° E, suffered from sheep overgrazing with its undisturbed control site situated at 32.19030° S, 25.40922° E on a similar habitat (Brown & Bezuidenhout 2018; Van der Walt 1980). The third locality was uBejani. The degraded site, at 32.16859° S, 25.47663° E, was formally a ploughed field, and the undisturbed control site was situated at 32.17062° S, 25.46189° E. The proximity and habitat similarity between these sites make the site a valid control site.

The MoNP (29.10350° S, 24.39410° E) is located in the Northern Cape province of South Africa. The dominant vegetation types are Kimberley Thornveld, Vaalbos Rocky Shrubland and Northern Upper Karoo (Bezuidenhout et al. 2015a) (Figure 1). The area receives late summer rain with the highest rainfall recorded in March and the lowest in June. The temperature ranges from −6.61 °C to 39.95 °C (Bezuidenhout et al. 2015a). The two localities that were selected were Windpomp and Puntberg (Figure 1), where bush densification of *Senegalia mellifera* (Swarthaak) was treated chemically (Bezuidenhout, Kraaij & Baard 2015b). The degraded site of Windpomp was located at 29.11187° S, 24.37244° E and the control site was at 29.11069° S, 24.37556° E. The degraded site at Puntberg was situated at 29.13396° S, 24.31461° E with the control site at 29.14880° S, 24.32222° E.



WC, Western Cape; EC, Eastern Cape; NC Northern Cape; FS, Free State; KZN, KwaZulu-Natal; MP, Mpumalanga; GP Gauteng; NW, North West province; LIM, Limpopo; NP, national park.

FIGURE 1: The map showing the localities where ants were sampled from both degraded and control sites in Mountain Zebra and Mokala National Parks.

Methods

Twenty pitfall traps (100 mL plastic cups), each containing 50 mL of 50% propylene glycol–water solution (Adis 1979), were placed at the centre of each site in a grid of 5 × 4 rows (each 10 m apart) for 96 hours. Ants were sampled in November 2015 at the MZNP sites, and in February 2016 for the MoNP sites. Only female workers were then identified to genus level using the keys of Bolton (1994). The morphospecies of the identified specimens from each genus were then given a code based on their external morphological characteristics (viz. body sculptures, body colouring, hair/setae colour, hair/setae shape and petiole shape). All samples were kept at Scientific Services, Kimberley, SANParks, for the future reference.

The biodiversity indices used to determine the composition of ant communities from each site were abundance, species richness, dominant species (i.e. the most abundant) and similarity (Anderson et al. 2008; Dandan & Zhiwei 2007; Spellerberg & Fedor 2003). Sampled ant specimens and the morphospecies were counted to get the ant abundance and ant species richness for each site. The total abundance of all ant species for each site and the relative abundance of each ant species were calculated. The relative abundance of all ant species was ranked in decreasing order to get species that contributed ≥ 75% of the total abundance of each site. The Shannon–Wiener Index and Simpson's Diversity Index were used to calculate the ant diversity per site (Spellerberg & Fedor 2003). Sorenson's Coefficient (Dandan & Zhiwei 2007) was used to determine ant community similarities between the sites of each locality.

The difference between the degraded and control sites of each locality, for each biodiversity index, was compared with its counterparts from other localities. The differences were given a score ranging from 1 (for the least difference) to 5 (for the highest difference) (Roux et al. 2002) for the following indices: abundance, species richness, Shannon–Wiener Diversity Index and Simpson's Diversity Index. The scores for the dominant species were given 0 (where at least three of the five most abundant species at the degraded and control sites were of the same species – regardless of the order of their abundance at top five) or 1 (where at least three of the five most abundant species were different between the degraded and the control sites – regardless of the order of their abundance at top five). The scores for Sorenson's Coefficient Index ranged from 1 (for a locality with the highest Sorenson's Coefficient) to 5 (for the lowest Sorenson's Coefficient). All the scores for each locality were then summed up and compared with other localities.

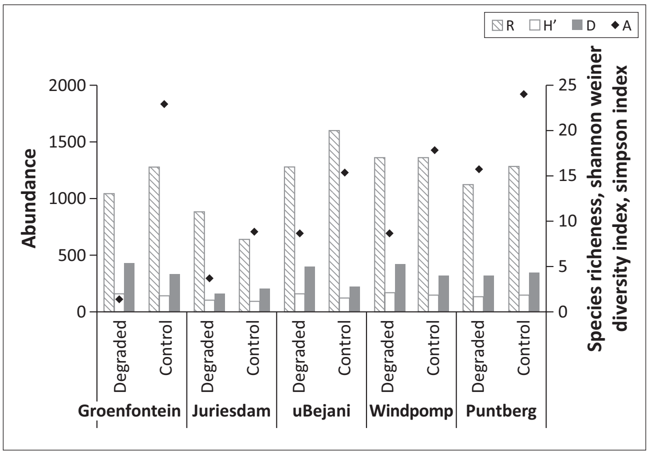
Ethical considerations

This article followed all ethical standards for a research without direct contact with human or animal subjects.

Results and discussion

All the degraded sites had lower abundance values than their controls (Figure 2), with the largest difference at Groenfontein and the least difference at Juriesdam (Figure 2, Table 1).

Species richness was lower at the degraded sites of Groenfontein, uBejani and Puntberg relative to their controls (Figure 2) but was higher at the degraded sites of Juriesdam. The species richness was similar at the degraded and control sites of Windpomp. The degraded and control sites of the uBejani locality had the most dissimilar species richness, whilst the degraded and control sites of the Windpomp locality were least dissimilar (Figure 2, Table 1).



R, species richness; H', Shannon–Weiner diversity index; D, Simpson index; A, abundance.

FIGURE 2: Diversity indices of ants sampled on degraded and control sites from localities at the Mountain Zebra National Park and Mokala National Park.

TABLE 1: Index values from the degraded and control sites of each locality and their disparity rankings relative to other localities.

Locality	Rehabilitation age†	Site	Abundance		Species richness		Shannon Diversity Index		Simpson's Index		Dominant sp. similarity	Sorenson's Coefficient		Overall score
			Value	Rank	Value	Rank	Value	Rank	Value	Rank	Rank	Value	Rank	
Groenfontein	1	Degraded	114	5	13	3	2.03	4	5.39	4	0	0.62	4	20
		Control	1837	-	16	-	1.76	-	4.18	-	-	-	-	-
uBejani	12	Degraded	694	2	16	4	1.97	5	5.05	5	0	0.67	3	19
		Control	1230	-	20	-	1.47	-	2.77	-	-	-	-	-
Windpomp	11	Degraded	685	4	17	1	2.08	3	5.29	3	0	0.71	2	13
		Control	1426	-	17	-	1.81	-	4.10	-	-	-	-	-
Juriesdam	9	Degraded	294	1	11	3	1.20	1	2.08	2	1	0.42	5	13
		Control	708	-	8	-	1.15	-	2.56	-	-	-	-	-
Puntberg	11	Degraded	1256	3	14	2	1.67	2	4.00	1	0	0.73	1	9
		Control	1921	-	16	-	1.82	-	4.37	-	-	-	-	-

†, Number of years since the rehabilitation took place.

The Shannon–Wiener Diversity Index indicated that ant diversity was higher at the degraded sites of Groenfontein, Juriesdam, uBejani and Windpomp, and lowest at Puntberg (Figure 2). The largest Shannon–Wiener Diversity Index difference was at uBejani and the least difference was at Juriesdam (Figure 2, Table 1).

The Simpson's Index showed that Groenfontein, uBejani and Windpomp had higher dominance at the degraded sites, whilst the degraded sites of Juriesdam and Puntberg had lower dominance in relation to their control sites (Figure 2). The uBejani sites had the highest Simpson's Index difference, whilst Puntberg sites had the least Simpson's Index difference (Figure 2, Table 1).

Although the degraded and control sites of most localities had similar dominating ant species (except Juriesdam and Windpomp) (Table 1), most of the ant species contributing ≥75% of the total abundance of the locality were less abundant (and in fewer traps) at the degraded sites (Table 2).

TABLE 2: Species list of ants sampled from each locality with their abundance and indications stating their roles in dissimilarity contributions and exclusivity between the degraded and control sites.

Ant species	Groenfontein		Juriesdam		uBejani		Windpomp		Puntberg	
	Degraded	Control	Degraded	Control	Degraded	Control	Degraded	Control	Degraded	Control
Anoplolepis sp. 1	3	10	41	107	126	679†	10	361†	408†‡	0
Anoplolepis sp. 2	0	0	0	0	0	0	0	0	4	697†
Camponotus sp. 1	6	109†	0	0	0	0	16	11	0	22†
Camponotus sp. 2	0	92†‡	0	0	0	0	0	7‡	0	0
Camponotus sp. 3	0	3‡	0	0	0	0	0	2‡	17	12
Camponotus sp. 4	2‡	0	0	0	0	0	11‡	0	0	9‡
Camponotus sp. 5	0	0	4‡	0	18†	3	1‡	0	0	1‡
Camponotus sp. 6	0	0	0	0	8‡	0	0	0	2	0
Camponotus sp. 7	0	0	0	4‡	1	43†	0	0	0	0
Camponotus sp. 8	0	0	0	0	0	8‡	0	0	0	0
Camponotus sp. 10	0	0	0	0	3‡	0	0	0	0	0
Crematogaster sp. 1	5‡	0	0	0	0	0	10‡	0	0	0
Lepisiota sp. 1	21	283†	3	192†	10	34	10	5	2	5
Lepisiota sp. 2	0	39‡	0	0	0	0	0	0	0	8‡
Lepisiota sp. 3	0	0	2	0	0	0	0	0	0	0
Lepisiota sp. 4	0	0	0	0	0	2‡	0	0	0	0
Leptogynus sp. 1	0	0	0	5‡	0	1‡	0	0	0	0
Meranoplus sp. 1	0	0	0	0	0	0	9	27†	8	37
Messor sp. 1	0	26‡	0	0	58†	2	0	0	0	16‡
Monomorium sp. 1	16	705†	0	0	0	0	82	119†	166	204†
Monomorium sp. 2	3	12	0	0	0	0	2	2	0	0
Monomorium sp. 3	0	2‡	0	0	0	0	0	0	0	0
Monomorium sp. 4	3‡	0	0	0	0	0	0	0	0	0
Monomorium sp. 6	0	0	198	384†	100	262†	0	0	0	0
Monomorium sp. 7	0	0	0	4‡	13‡	0	0	0	0	0
Monomorium sp. 8	0	0	0	0	0	22‡	0	0	0	0
Ocymyrmex sp. 1	8	4	0	0	33†	1	63	48	62†	37
Pheidole sp. 1	0	0	0	0	0	0	113	117†	90†	85
Pheidole sp. 2	39	448†	0	0	0	0	0	1‡	0	0
Pheidole sp. 3	0	0	18‡	0	0	0	0	0	0	0
Pheidole sp. 4	0	0	0	4‡	0	0	0	0	0	0
Pheidole sp. 5	0	0	8‡	0	247†	103	0	0	0	0
Platythyrea sp. 1	0	0	0	0	0	0	29	57†	2‡	0
Tapinoma sp. 1	0	0	12‡	0	5	4	248	573†	431	509†
Technomyrmex sp. 1	0	1‡	0	0	0	4‡	0	9‡	0	0
Technomyrmex sp. 2	0	4‡	0	0	2‡	0	0	0	0	0
Technomyrmex sp. 3	0	0	1‡	0	0	0	0	0	0	0
Tetramorium ser.	1	26	6	8†	57†	42	0	0	0	0
Tetramorium sp. 1	6	73†	1‡	0	7‡	0	25†	21	2	34
Tetramorium sp. 2	1‡	0	0	0	0	1‡	22	53†	14	212†
Tetramorium sp. 3	0	0	0	0	6	10	33†	13	48	33
Tetramorium sp. 4	0	0	0	0	0	2‡	0	0	0	0
Tetramorium sp. 6	0	0	0	0	0	6‡	0	0	0	0
Number of exclusive species	4	7	7	4	5	8	3	4	3	5
Number of common species	10		4		11		14		11	

†, Ant species that contributed ≥ 75% of the abundance in the site. The single dagger is located at the site where the species was more abundant.
‡, Ant species that were exclusively found at one site of the locality.

The low abundance and species richness at the degraded sites suggest that the treatments applied in the habitats were not supportive to ant communities (Table 1). Ant sampling should be included in the methodology used to assess achievement of the aims of rehabilitation interventions. These data and the sampling methodology can also be used in monitoring projects to assess the temporal trends of ant communities to assess rehabilitation actions. Ants are dominant in the terrestrial ecosystems based on their biomass, interactions with other organisms, their roles in the ecosystem and their response to disturbances, as suggested by this study.

We suggest that the lower biodiversity indices from the degraded sites (Figure 2) are driven by the disturbance (or even the diminution) of microhabitats. These disturbances may have altered the effects of driving factors (such as temperature and humidity) to levels beyond the tolerance of some species (Gibb et al. 2015; Hölldobler & Wilson 1990). These changes may have favoured species that are able to adapt to harsher conditions, for instance, *Ocymyrmex* species (Hölldobler & Wilson 1990; Marsh 1985; Sommer et al. 2013). *Ocymyrmex* sp. 1 was more abundant at degraded sites of all the localities, except Juriesdam, where it was not recorded (Table 2). The abundance of *Ocymyrmex* species, where it occurs, could further be used as a general indicator that determines the progress of rehabilitation actions (Table 2). This could be performed by comparing the abundance disparities of Ocymyrmex sp. 1 at a degraded site relative to its control, or by temporally comparing its abundance in a specific degraded site to determine the trend followed by abundance.

The lower ant abundance at all the degraded sites, and the lower species richness at most of the degraded sites (Figure 2), could have affected the important myrmecophile roles at these sites as there could be relatively fewer ants to fulfil their roles in ecosystems in both intraspecific and interspecific symbioses such as competition, mutualism, parasitism and feeding behaviours (Hölldobler & Wilson 1990). Therefore, this could have affected organisms that rely on myrmecophile relationships (positive interactions between ants and other organisms) (Hölldobler & Wilson 1990).

Differences between degraded and control sites suggest that time plays an important role in the rehabilitation process. Sites that had been recently rehabilitated, such as Groenfontein, had the highest overall differences, whilst the ones that had been rehabilitated before, such as Windpomp and Puntberg, had the lowest overall (Table 1) differences. The narrower disparities at Puntberg and Windpomp could be attributed to improved habitat because of longer recovery time (Table 1). This follows data findings of Andersen, Hoffmann and Somes (2003), who also found ants recover better with increasing rehabilitation time. We therefore anticipate that in the future the differences in younger rehabilitated localities would decrease.

In addition to the time of rehabilitation, the type of degradation also influences the recovery (Vasconcelos 1999). uBejani site has the longest rehabilitation time but had the second highest overall differences between its sites (Table 1). We relate this difference to the ploughing that took place at the degraded site. Chan (2001) reported that ploughing disturbs the soil profile and its associated organisms. This again could have had an impact on the ant community by affecting their myrmecophily association with the soil, other arthropods and plant species (Agosti et al. 2000; Hölldobler & Wilson 1990). We anticipate there will be a slower narrowing of differences at uBejani relative to other localities because of the type of degradation it experienced.

The type of degradation can sometimes have no direct impact on ants, as was seen at Puntberg, Juriesdam and Windpomp which have the least disparities between the sites and controls (see overall score in Table 1). The degraded sites at Puntberg and Windpomp experienced chemical degradations, mostly with Tebuthiuron as the active ingredient (Bezuidenhout et al. 2015b) to eradicate woody plant species. As this chemical is systemic and absorbed through the roots (Blaise & Harwood 1991), it may not have been in direct contact with epigeal ants. The chemical may, therefore, had little impact on the ants. We are unsure whether the difference in these localities would remain relatively low because Johnsen and Morto (1989) reported that the concentration of Tebuthiuron and its depth in the soil changes under different rainfall conditions. It may be possible to show this by samplings during different rainfall conditions.

Because this is only a preliminary study conducted during local drought conditions, we recommend further sampling when the rainfall is back to previous averages. We hope also that additional samplings could verify whether the differences still hold for all different sampled degradations.

In conclusion, we suggest that environmental authorities should consider the importance of the degradation types when acquiring lands for expanding conservation areas with consideration for brother organisms. As some of these degradation types seem to be persistent and take longer and more effort to be rehabilitated whilst others need lesser effort. They should also consider including different organisms when determining the degradation condition of the concerned conservation land. Including different organisms when assessing such land would inform the management as to how degraded is that land, in general, and therefore make the decision based on the assessment that would include different avenues.

Acknowledgements

SANParks and Biodiversity Social Projects in SANParks provided funding and manpower for this project.

The following people contributed immensely towards collecting data for this article: Clodene Ackerman, Pulane Daemane, Letlhogonolo Kotsokoane, Abel Matsapula, Phindile

Mbele, Kelebogile Mohudi, Spencely Motloung, Mazwi Mthethwa, Shadi Ndouvhada, Lucky Ramabulana, Bruce Taplin and Nosidima Vumindaba. Laboratory space to identify ant specimen was provided by the Arid Lands Node of the South African Environmental Observation Network (SAEON) in Kimberley. The authors would like to thank the referees who reviewed the article.

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

H.S. was the project leader and responsible for sampling design, project implementation, data analysis and article writing. N.T. was responsible for project implementation, data analyses and article writing. H.B. and T.C.M. were responsible for article writing. L.M. was responsible for sampling.

Funding information

SANParks and Biodiversity Social Projects in SANParks provided funding and manpower for this project.

Data availability statement

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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