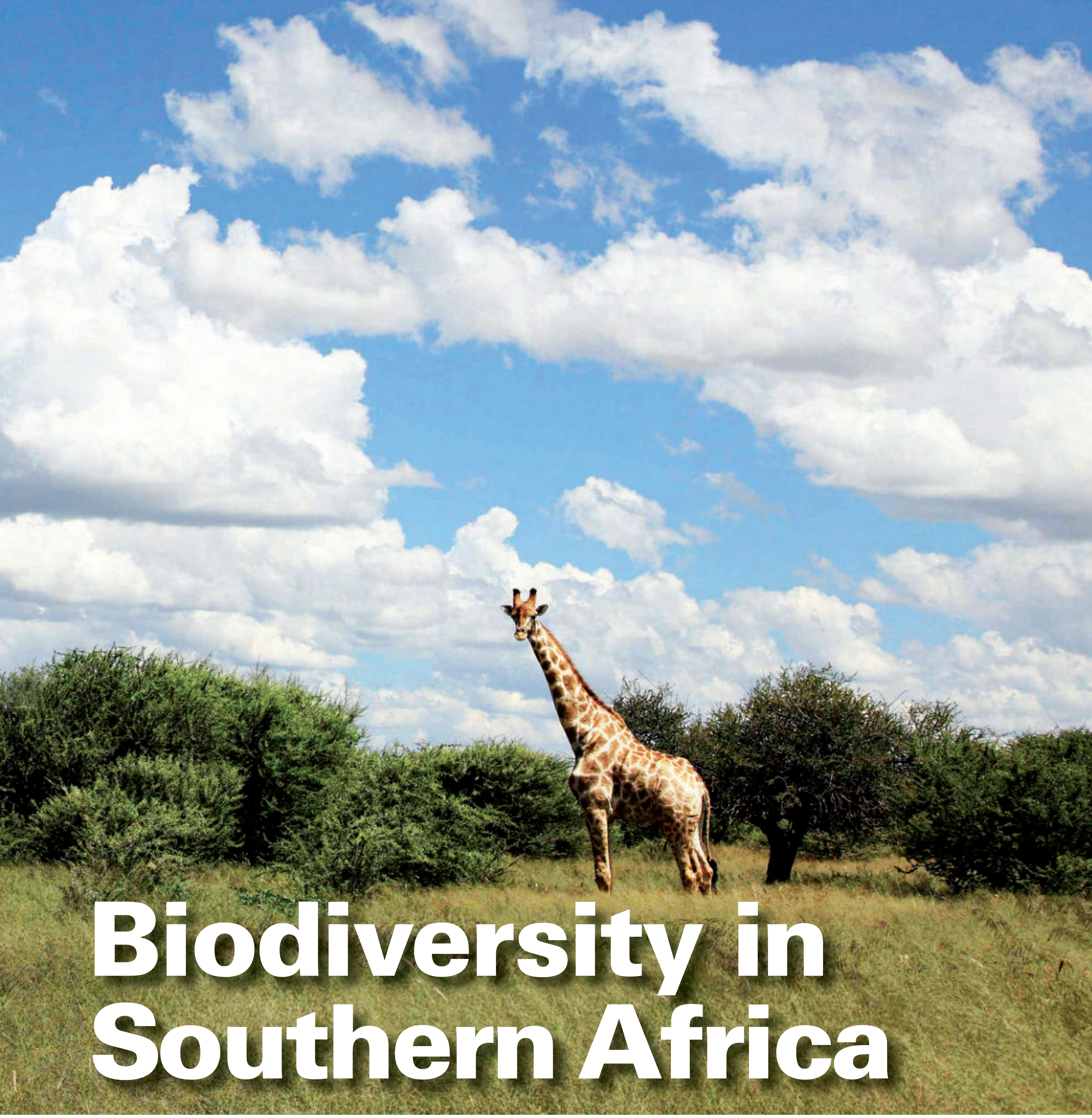

Biodiversity in Southern Africa

Vol. 2

Patterns and Processes at Regional Scale

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BIOTA

Biodiversity in southern Africa

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Biocentre Klein Flottbek and Botanical Garden

and

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Plant Conservation Unit

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Cover photograph: Giraffes on the game farm Omatako Ranch (Observatory S04 Toggekry) in the Namibian Thornbush Savanna.
Photo: Jürgen Deckert, Berlin/Germany.
Cover Design: Ria Henning

Overgrazing favours desert species—differences in arthropod and small mammal communities of the twin sites Gellap Ost and Nabaos

Anke Hoffmann*, Katrin Vohland & Ulrich Zeller

Summary: The impact of two different grazing systems on arthropod and small mammal communities was investigated by comparing species diversity and abundance between Gellap Ost (S10) and Nabaos (S11) on two-hectare plots seasonally during the period 2001–2003. Assessing and monitoring of the small mammal populations was achieved using capture-mark-recapture methods. Arthropods were collected in pitfall traps. For both groups, species richness, total abundance and species diversity were lower in the overgrazed area. The most abundant small mammals were two gerbil species. The Bushveld Gerbil (*Gerbilliscus leucogaster*) occurred frequently at Gellap Ost but did not occur at the overgrazed Nabaos site, while *Gerbillurus vallinus*, a species adapted to xeric conditions, favoured the degraded land. It is also obvious that uncontrolled grazing in the communal lands has led to land degradation, which has affected the biodiversity as indicated by the shift from "savannah communities" to "desert communities" of beetles and small mammals.

Photo 1: Weighing of a captured Bushveld Gerbil. Photo: Anke Hoffmann.

Introduction

The study was conducted on two neighbouring areas with different landuse practises in the Nama Karoo in Namibia. The Nabaos (S11) communal area is highly overgrazed mainly by goats, whereas the adjacent Karakul sheep breeding farm at Gellap Ost (S10) is only moderately grazed. In contrast to the uncontrolled grazing in Nabaos, Gellap Ost is under a rotational grazing system with a lower stocking rate (for more details see Chapter II.4, Observatories S09, S10, S11).

The different grazing systems of these areas not only determine vegetation patterns but also impact animal communities such as small mammals and arthropods. Both groups fulfil important functions in ecosystems. Arthropods play an important role in pollination and contribute to nutrient turnover and soil engineering. Furthermore, they serve as a food source for other animals such as small mammals and birds. Small mammals are important consumers (Kerley 1992a), predators and dispersers of seeds (Price & Jenkins 1986), burrowers, and prey for carnivores and raptors (Kotler 1984, Hughes et al. 1994). Changes in habitat structure and complexity are known to be associated with changes in small mammal community structure and species richness (Rosenzweig & Winakur 1969, Grant et al. 1982, Rowe-Rowe & Meester 1982, Abramsky 1988, Kerley 1992b, Els & Kerley 1996, Avenant 2000). Large herbivores (e.g. livestock) can modify the vegetation layer in terms of structure and species composition to a state where small mammals are affected (Bowland & Perrin 1989, Keesing 1998, Hoffmann 1999, Blaum et al. 2009).

The aim of this study was to assess the influence of the different landuse intensities at Gellap Ost and Nabaos on the diversity and ecology of arthropods and small mammals.

Methods

A two-hectare plot was selected at each Observatory. Small mammal population ecology data (diversity, abundance, reproduction, survival) were assessed during a 2-years capture-mark-recapture study, which was conducted over four consecutive trapping nights per season (= one trapping session) on each plot. 90 Sherman® folding live traps spaced at 15 m intervals were used per plot. Captured animals were individually marked, weighed and sexed (Photo 1). Between October 2001 and August 2003, eight trapping sessions per plot were conducted.

At the same time, 10 pitfall traps were set along a line over a period of eight days in each season to analyse arthropod activity. The arthropods were identified taxonomically at least to family level, and for beetles, specimens were allocated to different size classes

Table 1: Size classes in beetles (Coleoptera) allocated according to their dry weight

Size class	Dry weight [mg]
1	0–0.99
2	1–9.99
3	10–99.99
4	100–199.99
5	200–299.00
6	> 300

Table 2: Ant species at Gellap Ost and Nabaos (Koch & Vohland 2004)

	Gellap Ost	Nabaos
Formicinae		
Camponotus exsanguis Forel, 1990	+	
Camponotus fulvopilosus (De Geer, 1788)	+	+
Camponotus mystaceaus Emery, 1886		+
Myrmicinae		
Messor capensis (Mayr, 1862)	+	
Ocymyrmex dekerus Bolton & Marsh, 1989	+	+
Tetramorium rufescens Stitz, 1923	+	+
Tetramorium sericeiventre Emery, 1877	+	+
Ponerinae		
Pachycondyla cf. *caffraria* (F. Smith, 1858)	+	
Dolichoderinae		
Tapinoma sp.		+
Sum of species number	**7**	**6**

(Table 1). More details can be found in Hoffmann & Zeller (2005) and Vohland et al. (2005).

Results and discussion

Arthropod communities

A total of 16,713 epigaeic arthropods (without considering mites and collembola) from 19 orders were collected over 1,280 trap-nights. Ants (9,466 specimens), beetles (1,673 specimens), and termites (747 specimens) were the dominant arthropod taxa collected. Most animals were trapped during February in both years, during the rainy season (Fig. 1). There was less arthropod activity at Nabaos than at Gellap Ost, with only 38% of the ground active arthropods being trapped at Nabaos.

Ants dominate

Typically, ants were trapped in high abundances and with high biomass. These successful insects mainly act as decomposers, soil engineers and seed dispersers in ecosystems (Hölldobler & Wilson 1990). At Gellap Ost and Nabaos, nine species were identified, with only slight differences in species composition and diversity between the sites (Table 2).

Termites—the omnipresent workers

Three termite species were found at both Observatories: *Baucaliotermes hainesi*, *Hodotermes mossambicus*, and *Psammotermes allocerus* (Vohland & Deckert 2005).

B. hainesi was mainly recorded as alates after the rain in May 2002. This species is endemic to the Northern Cape Province of South Africa, and to southern

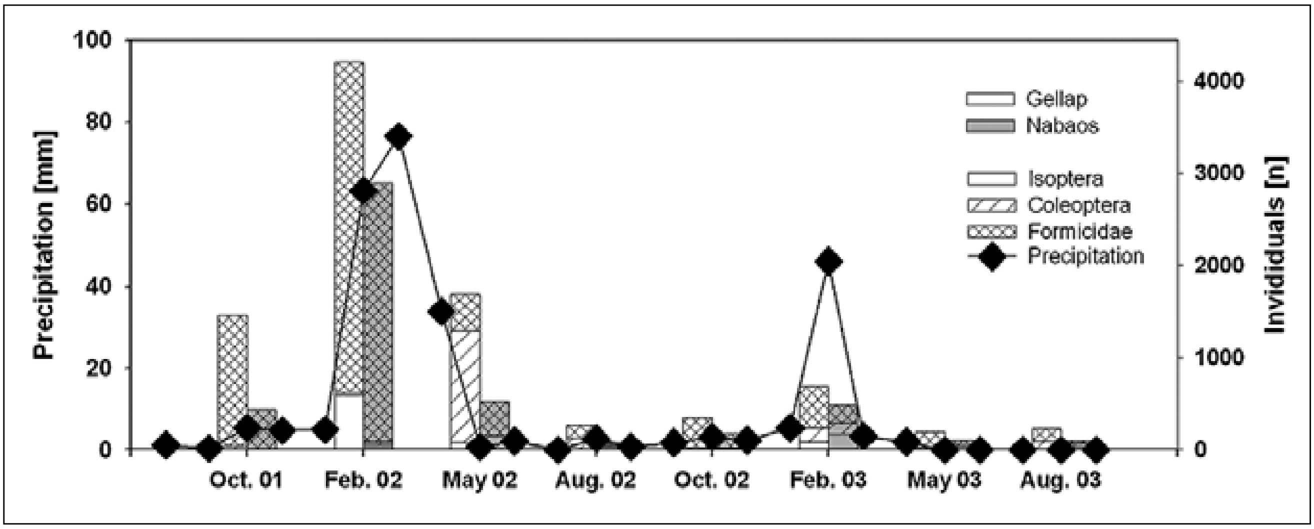

Fig. 1: Monthly precipitation and abundance of the dominant arthropod groups: termites (Isoptera), beetles (Coleoptera) and ants (Formicidae). During the rainy season in February of both years arthropod activity was higher than during the rest of the year. Actual precipitation from 2001–2003 as measured by the BIOTA weather station (K. Berger, pers. comm.).

Namibia. It is distributed in the Nama and Succulent Karoo biomes, where it occurs in the succulent steppe, semi-desert savanna transition, and dwarf shrub savanna (Coaton & Sheasby 1973, Uys 2002). *B. hainesi* build subterranean nests, which can be recognised as small heaps on the ground. This nocturnal species feeds on coarse and fine litter as well as on herbivore dung.

The harvester termite *H. mossambicus* is one of the most widely distributed species in southern Africa (Coaton & Sheasby 1972). It can process large amounts of soil (Grube 2001) and therefore contributes to bioperturbation, and increases water infiltration and nutrient turnover in the soil (Holt & Lepage 2000). On the other hand, *H. mossambicus* can become a pest (Coaton 1958, Mitchell 2002). Even in years with average rainfall, this species is estimated to consume about 25% of the standing grass crop (Coaton & Sheasby 1972). Especially in habitats with sparse vegetation cover, it can locally become a serious pest, as they prefer to settle on bare soil (Coaton 1958). However, despite competition between this species and livestock/game for grass, it probably has an overall positive effect on ecosystem functioning (Logan 1992). As shown in Fig. 2, abundances at Nabaos were lower than at Gellap Ost. This could be a result of the almost complete absence of grassy vegetation cover at Nabaos. The soil at Gellap Ost had a higher organic content and a higher water infiltration rate, which promotes vegetation growth.

P. allocerus is known to consume wood, and has been known to attack man-made wooden structures such as houses, but they also feed on grass detritus (Coaton & Sheasby 1973, Crawford & Seely 1994).

Coleoptera—degradation favours desert beetles

Beetles represented the most species rich taxa (Fig. 3), and many species remain undescribed. Beetles had a variety of forms and functions. As was the case for all groups, the actual results were biased due to the trapping method used. Pitfall traps reflect activity density rather than abundance. However, the results do re-

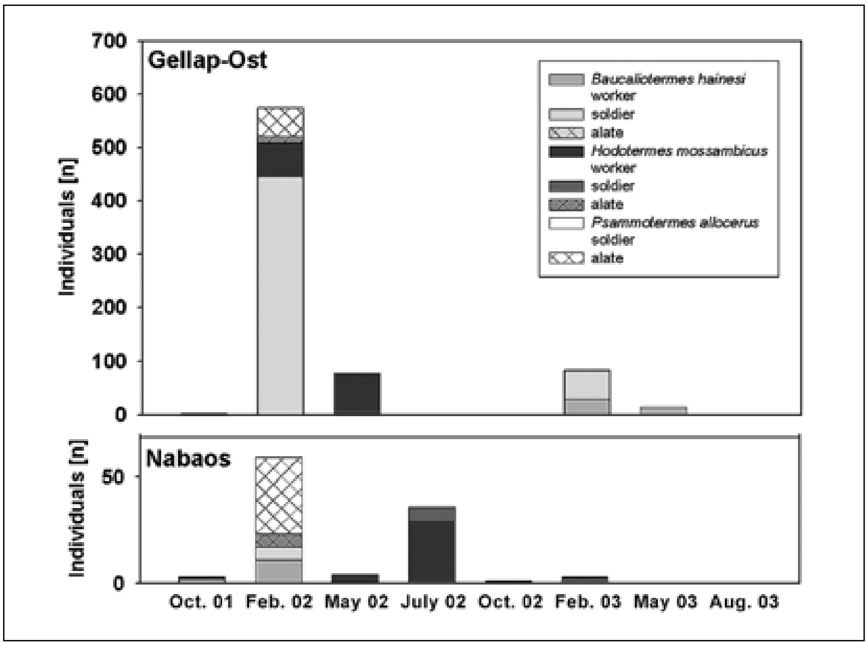

Fig. 2: Termite species at Gellap Ost and Nabaos. Species identity, developmental stage and abundance.

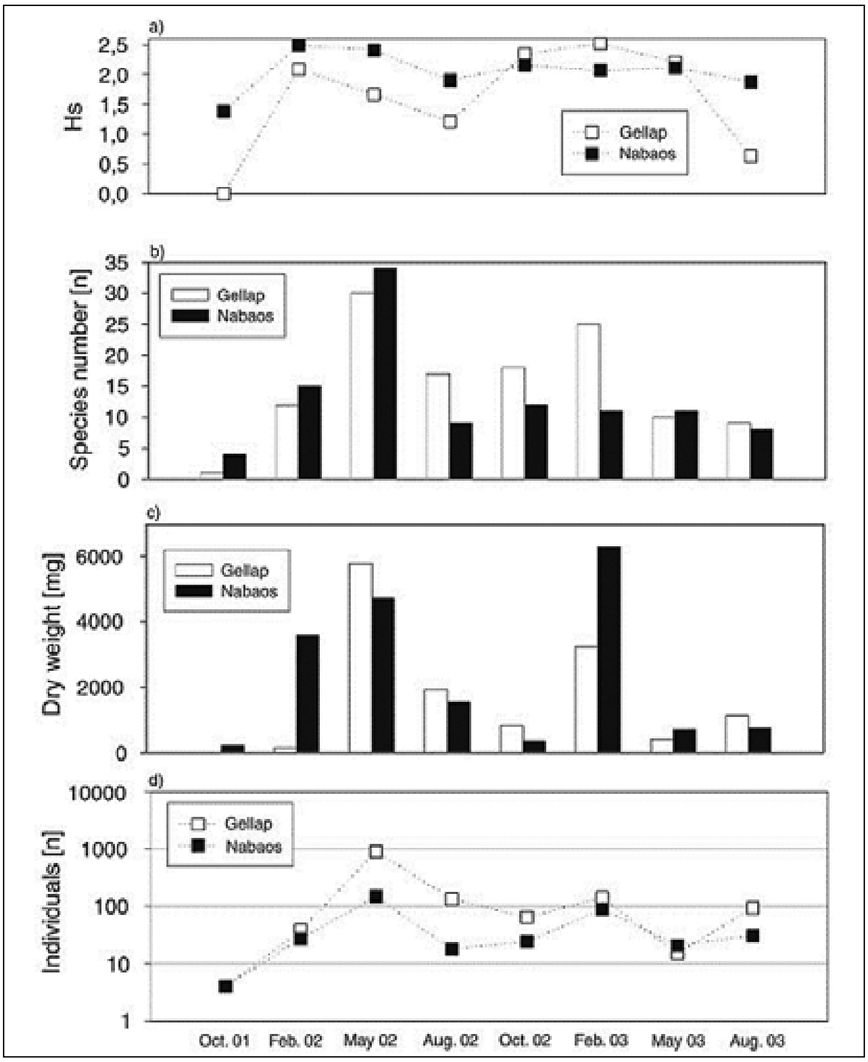

Fig. 3: Coleoptera diversity, abundance and biomass. a) Shannon Wiener index of diversity (HS); b) species number; c) biomass distribution; d) number of individuals (from Vohland et al. 2005 [Copyright Wiley-VCH Verlag GmbH & Co. KGaA. Reproduced with permission]).

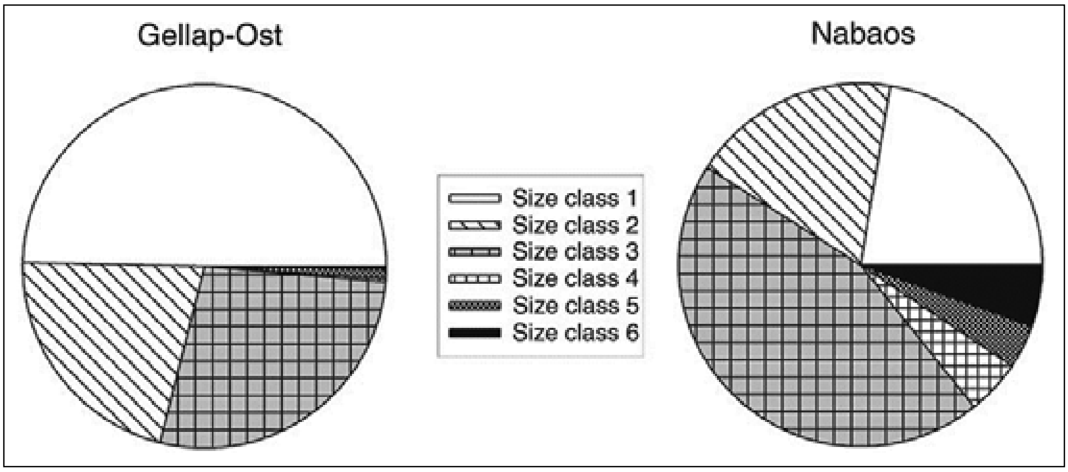

Fig. 4: Coleoptera size class distribution from 1 (light) to 6 (heavy), cf. Table 1 at Gellap Ost and Nabaos, data pooled (from Vohland et al. 2005 [Copyright Wiley-VCH Verlag GmbH & Co. KGaA. Reproduced with permission]).

Table 3: Species diversity and abundance of small mammals at Gellap Ost and Nabaos

		Nabaos		Gellap Ost	
	per plot 2880 trap nights	ind.	%	ind.	%
Macroscelididae					
	Elephantulus intufi	**1**	0.92	**9**	4.45
Muridae	**Gerbillinae**				
	Desmodillus auricularis	**10**	9.17	**3**	1.49
	Gerbilliscus leucogaster			**118**	58.42
	Gerbillurus paeba	**1**	0.92		
	Gerbillurus vallinus	**80**	73.39	**44**	21.78
	Murinae				
	Micaelamys namaquensis	**1**	0.92	**13**	6.44
	Mus indutus			**2**	0.99
	Rhabdomys pumilio	**12**	11.01	**4**	1.98
Nesomyidae	**Cricetomyinae**				
	Saccostomus campestris	**4**	3.67	**9**	4.45
	total individuals	109		202	
	Σ captures	282		629	

veal fundamental ecological differences between the sites.

The largest proportion of beetles trapped were non-alate tenebrionid beetles (Tenebrionidae). The adjacent plots at Gellap Ost and Nabaos shared more or less the same species, i.e. 19 taxa (Vohland et al. 2005). This is in accordance with general knowledge on the Tenebrionidae (darkling beetles), for which the soil substrate is the most important variable in terms of habitat quality (Louw 1983). Tenebrionidae are also known to be affected by habitat modification and diminished habitat diversity, which was clearly visible in this study. Seven species were recorded only at Gellap Ost, whereas only three Adesmiini species were recorded at Nabaos. The higher abundance of Adesmiini in Nabaos was the main contributor to the difference in species composition between plots. These medium to large sized darkling beetles are desert adapted insects that show morphological and behavioural adaptations to cope with arid conditions (Rasa 1994, Naidu 2001, Parker & Lawrence 2001).

The species composition of scarab beetles (Scarabaeidae) is mainly affected by soil characteristics, vegetation and dung quality (Davis 1996, 2002). Therefore, it is possible that the higher dung resource availability at Nabaos is the reason for the higher diversity of dung beetles at this Observatory compared to Gellap Ost.

High diversity of ground beetles (Carabidae) is interpreted as an indicator of complexity in agro-ecosystems and natural habitats (Rainio & Niemala 2003). The diversity and abundance of Carabidae was clearly higher at Gellap Ost than at Nabaos. Carabidae are predators, and they are therefore higher up on the food chain. Therefore, they act as indicators of complex dietary networks. Denser and more diverse vegetation offers more potential prey and shelter, which is reflected in the higher abundance of Carabidae at Gellap Ost.

The higher abundance of large beetle species at Nabaos (Fig. 4) might be due to the lower vegetation cover here, which does not restrict the movements of these predatory beetles, which hunt by sight.

Small mammal communities

A total of 311 individuals (911 captures) representing nine species were caught over 5,760 trap-nights (Table 3). The overall species richness and abundance was lower at Nabaos than at Gellap Ost. This is also expressed by the Shannon Wiener diversity index (Hs): Nabaos (Hs 0.95; 7 species, 108 individuals), Gellap Ost (Hs 1.29; 8 species, 202 individuals). Although fewer species were recorded per trapping session at Nabaos (Fig. 5) compared to Gellap Ost, there was an overlap in the species occurring at the two plots (Table 3).

The most frequently trapped species at the Gellap Ost Observatory, the Bushveld Gerbil (*Gerbilliscus leucogaster*), prefers

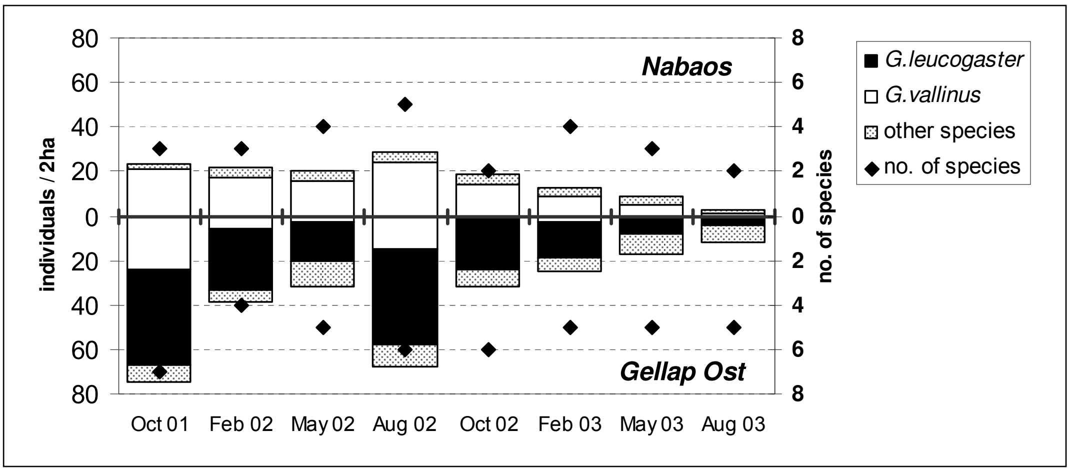

Fig. 5: Species richness of small mammals at Gellap Ost and Nabaos. All captured species and the total recorded individuals (N = 311) over all trapping sessions (5,760 trap-nights). One 'trap-night' refers to one trap being set for 24 hours.

savannah environments (DeGraaff 1981), and did not occur at the degraded Nabaos site (Fig. 5, Photo 2). At Nabaos, the Bushy-tailed Hairy-footed Gerbil *Gerbillurus vallinus*, which is a desert inhabitant, was the dominant species. This species was subdominant in Gellap Ost where extreme fluctuations within the population were documented (Fig. 5, Photo 3).

At both sites, the highest recruitment of small mammals was observed in August 2002, due to high reproduction activity during the rainy season.

Intensive and uncontrolled grazing by livestock in the communal area of Nabaos not only had a clearly negative impact on small mammal diversity and abundance, but it also had an impact on their settlement and survival. Considering all individuals, which had been trapped over at least two successive sessions (≥ 11 weeks), we found a lower overall recapture rate at Nabaos (19.3%, N = 109) than at Gellap Ost (31.8%, N = 202). Five species were recaptured at Gellap Ost: *G. leucogaster*, *G. vallinus*, *M. namaquensis*, *E. intufi*, *S. campestris*. At Nabaos only *G. vallinus* and *D. auricularis* were recaptured. *G. vallinus* showed a distinctly higher recapture rate and a longer 'survival' period at Nabaos than at Gellap Ost (Hoffmann & Zeller 2005). The higher 'survival' rate of *G. vallinus* at Nabaos indicates that this xeric adapted species, which is confined to the western sector of the South West Arid Zone and is known to prefer sandy substrates (DeGraaff 1981, Dempster et al. 1999), has found a more suitable habitat in the degraded lands than in the grassy areas of Gellap Ost. This is in line with the results of a biodiversity study in the rangelands of South Africa (Fabricius et al. 2003), where a communal grazing area was characterised by xeric adapted reptiles and predatory arthropods, whereas a nature reserve and commercial farmland supported more mesic-adapted species.

Photos 2 and 3: The most abundant rodent species at Gellap Ost and Nabaos: Bushveld Gerbil (*Gerbilliscus leucogaster*) and the Bushy-tailed Hairy-footed Gerbil (*Gerbillurus vallinus*). Photos: S. Bengsch and S. Lüdecke.

Conclusion

Although a high resilience is ascribed to the study area (Kuiper & Meadows 2002), we conclude that the land degradation caused by uncontrolled grazing accounts for the impoverished flora and fauna of Nabaos in comparison to Gellap

Ost. The degraded vegetation provides few resources. In comparison with Gellap Ost availability of food is lower, there is less shelter and moisture from dew for arthropods and small mammals. This might lead to a reduction of ecosystem functions provided by arthropods and small mammals, such as soil turnover and soil engineering, and can subsequently reduce water infiltration and cause higher erosion rates. On the other hand "pasture pests" such as *Hodotermes* might benefit. Therefore, reduced abundance and species diversity of arthropods are a clear indicator of vegetation in a degraded state.

In addition, the disruption of habitat structure, cover and shelter leads to a higher predation risk for small mammals. The low species diversity and abundance of small mammals, and especially the dominance and high survival rate of the desert species, *G. vallinus,* in the communal land at Nabaos clearly indicates that landuse at this site has caused deterioration of the ecological conditions there. According to Avenant (2000), biodiversity of small mammals can be used as an indicator of disturbance in an ecosystem, and the dominance of an indicator species, low species richness and low diversity are useful tools for indicating disturbance on the primary producer level. In this study, the gerbil *G. vallinus*, a species adapted to xeric conditions, indicates that the Nabaos communal land is experiencing desertification.

This study also indicates that carabid beetles and some better known darkling beetle groups are suitable indicators for long term monitoring in the Nama Karoo, as they can be identified easily, and results can be compared with future assessments, especially after the application of restoration measures.

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