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

Diet and seasonal dispersal of extralimital giraffe at Sanbona Wildlife Reserve, Little Karoo, South Africa

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Dates:
Received: 12 Aug. 2015
Accepted: 03 June 2016
Published: 31 Aug. 2016

How to cite this article:
Gordon, C.N., Eichenberger, L., Vorster, P., Leslie, A.J. & Jacobs, S.M., 2016, 'Diet and seasonal dispersal of extralimital giraffe at Sanbona Wildlife Reserve, Little Karoo, South Africa', *Koedoe* 58(1), a1346. http://dx.doi.org/10.4102/koedoe.v58i1.1346

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South African giraffe (*Giraffa camelopardalis giraffa*) have been introduced as an extralimital species to private farms in the Little Karoo on the basis of economic sustainability, and the need to create a competitive tourism product. However, little is known about the medium- to long-term impacts and ecological sustainability of such introductions. The diet of a population of giraffe on Sanbona Wildlife Reserve, near the town of Ladismith, was assessed via direct observations between January and October 2014, in order to determine their potential impact on the world's most species-rich semi-desert, the Succulent Karoo. Unlike giraffe in their native range, the Sanbona population showed seasonal preference for browse species. *Acacia karroo* (sweet thorn) appears to be the preferred browse species during autumn and spring, with *Schotia afra* being the preferred species in winter, and no significant preference being shown in summer. Giraffe also appeared to seasonally move between catchments where tree species other than *A. karroo* occurs, especially during winter and spring when the tributaries of the Brak River, containing mixed *Acacia* with *S. afra* (karoo boer-bean) and *Euclea undulata* (small-leaved guarri), were visited with increasing frequency. These results largely confirm the importance of *A. karroo* as the main browse species in this environment but also suggest that other species may be important components of the diet of extralimital giraffe in the Little Karoo. On farms where *A. karroo* is dominant, supplementary feed may be needed when *A. karroo* browse is unavailable due to leaf drop.

Conservation implications: *Acacia karroo* was the main browse species of extralimital *G. c. giraffa* at Sanbona Wildlife Reserve, but it switched to *S. afra* during winter. This suggests that an assessment of alternative food species forms part of suitability assessments for the introduction of extralimital *G. c. giraffa* for areas similar to Sanbona.

Introduction

Over the past two decades, large areas in South Africa have seen shifts in land use from agriculture to game farming, for either commercial hunting or ecotourism and the photographic safari industry (Vorster 2011). Most of these land owners base their management decisions on economic sustainability (Grant, Peel & Bezuidenhout 2011), often introducing extralimital species (Castley, Boshoff & Kerley 2001). Charismatic extralimital species, such as the South African giraffe, have been introduced to the Western and Eastern Cape due to their popularity among foreign tourists (Parker & Bernard 2005). The browse preference of South African giraffe has been studied extensively in the Savanna-dominated biomes of Southern Africa (Bond & Loffel 2001; Fennessy 2004) and a few studies have been conducted in the mesic thicket-dominated Eastern Cape, where they are also extralimital (Parker & Bernard 2005). However, no literature is readily available which documents the species dietary preferences or potential impacts in areas further west, such as game farms of the Little Karoo, which straddle the Fynbos, Succulent Karoo and Thicket biomes.

The Little Karoo falls within three unique biodiversity hotspot vegetation types, namely the Succulent Karoo, Fynbos and Subtropical Thicket biomes (Egoh *et al.* 2009). The lower lying areas of the Little Karoo are dominated by Succulent Karoo vegetation, which is the most species-rich semi-desert vegetation type in the world (Mucina & Rutherford 2006). The Succulent Karoo, therefore, is an area of high conservation priority, and as most of the land lies in the hands of private landowners, the growth and ecological sustainability of conservation in the area are dependent on adequately managing these private lands (Pasquini *et al.* 2009). The recent introduction of certain extralimital species, such as giraffe (*Giraffa camelopardalis*), elephant (*Loxodonta africana*) and hippopotamus (*Hippopotamus amphibious*), to the Little Karoo, is a potential cause for concern, as little research has been conducted into their impact on the region's vegetation, or the suitability of local vegetation types to sustain these animals.

Even though 13% of South Africa's total land surface is used for game farming, very little research has been conducted into the impact indigenous herbivore species have on rangelands (Hoffman *et al.* 2009). It is therefore imperative to determine the impacts such extralimital species will have on the surrounding vegetation or habitat.

Three key questions were asked: (1) what is the species composition of the South African giraffe populations' diet, (2) what is the most preferentially browsed plant species and (3) are there seasonal changes in diet and movement across the reserve? The major aim of this study was to determine the major diet species of giraffe introduced to the Little Karoo.

Methods and materials

Study area

Sanbona Wildlife Reserve is located in the Little Karoo region of the Western Cape, South Africa, 49 km northeast of the town of Montagu and 27 km northwest of the town of Barrydale. The reserve is approximately 54 000 ha in size and measures 25 km from north to south, and 30 km from east to west. It is the largest privately owned conservation area within the Western Cape and offers an ecotourism and photographic safari product. It hosts the only free-roaming big five safari experiences in the province (Lynch, Vorster & Vorster 2013), which includes a small population of lions that occasionally predates on the giraffe population (A. Hughes [Sanbona Wildlife Department] pers. comm., September 2014).

Sanbona, established in 2002, consists of 19 formerly agricultural farms which were merged by removing internal fencing. The farms were previously utilised for wheat and lucerne crops, domestic animal production, small-scale commercial game farming for hunting and game sales, recreational farming and tourism (Lynch *et al*. 2013). Sanbona is divided into two main sections: Sanbona North and Sanbona South, which are divided by the Warmwaterberg range. For management reasons, most of the large and dangerous game species are found in Sanbona North; this includes the giraffe population. Sanbona North consists of a more arid environment, dominated by Succulent Karoo vegetation, specifically the Western Little Karoo and the Little Karoo Quartz Vygieveld vegetation types (Lynch *et al*. 2013; Mucina & Rutherford 2006). The landscape is undulating and flat in parts, consisting of low-to-medium-height mosaic Karoo shrublands with both succulent and non-succulent plants. The main drainage line in Sanbona North, the Brak River, is dominated by dense stands of *Acacia karroo,* and there are several smaller tributaries which feed into it. The vegetation alongside these smaller tributaries' consists of a mosaic of species, largely dominated by *Schotia afra* and *Euclea undulata* and interspersed with *A. karroo.*

We recognised four seasons in the area, namely: summer (01 December – 28/29 February), autumn (01 March – 31 May), winter (01 June – 31 August) and spring (01 September – 30 November). Sanbona lies in a transition zone between the summer and winter rainfall areas and experiences slightly higher rainfall averages in winter months. Sanbona South (Renosterveld) receives more rainfall than Sanbona North (Succulent Karoo) due to the rainfall shadow created by the Warmwaterberg range. The reserve is susceptible to sporadic drought and flooding events, and Sanbona North experiences convectional thunderstorms in summer (Lynch *et al*. 2013; Mucina & Rutherford 2006). In the hottest month, February, the mean daily temperature is 21 °C with midday temperatures regularly exceeding 35 °C. June is the coldest month with average daily temperatures of 6.2 °C, and early morning temperatures regularly falling below freezing (Lynch *et al*. 2013).

The study species

Giraffe are an iconic African mammal. Adults can stand 4 m – 5.5 m tall, and weigh as much as 700 kg – 1100 kg (Skinner & Chimimba 2005). Both males and females have ossicones, with the males often thicker, knobbed and hairless at the ends. Giraffe are gregarious, associating in non-territorial, loose, open herds with no fixed social hierarchy. Individuals rarely stay together for prolonged periods of time, with the exception of females with calves (Ciofolo & Le Pendu 2013; Estes 1992; Leuthold 1979; Tutchings *et al*. 2013). Giraffe are generally observed to be exclusively browsers, although some records of grazing behaviour have been reported (Estes 1992; Seeber *et al.* 2012). Giraffe are efficient feeders; not only are they able to browse above the level of most other species, but their tongue is able to navigate around the most aggressive thorns in order to consume up to 34 kg of foliage a day (Estes 1992).

Giraffe are currently listed as 'Least Concern' by the IUCN, as their population is estimated to number approximately 80 000 individuals across Africa (Fennessy & Brown 2010; Tutchings *et al*. 2013). The natural distribution range of giraffe includes the arid and dry savanna zones of sub-Saharan Africa, wherever trees occur (Fennessy & Brown 2010; Tutchings *et al*. 2013). South African giraffe are extralimital to the Western Cape and the Succulent Karoo. Sanbona initially introduced a founder population of six sub-adult giraffe in 2005. In 2008, a further eight individuals were introduced to the reserve (Lynch *et al*. 2013). As of the 2014 game count, the total population stands at 28 individuals (L. Vorster [Sanbona Wildlife Department] pers. comm., September 2014).

Determining giraffe distribution

Since 2008, Sanbona has been collecting distribution data on various species via field guide sighting sheets (standardised forms on which the field guides note the location of various animal species on their daily game drives). For the purpose of this study, sighting sheets from 2009 to the end of 2013 were analysed. Sighting sheets recorded general giraffe sightings and omitted any demographic information. Analysis involved recording all noted locations into an Excel spreadsheet from the hard copy sighting sheets. GPS co-ordinates were collected by comparing written records with Google Earth images of the reserve and a hard copy of the reserve map which shows road and landmark names. GPS co-ordinates were then exported

into QGIS (QGIS Development Team 2014), together with existing reserve shapefiles, in order to map the seasonal distribution of the giraffe for the period 2009–2013.

Direct observations of giraffe behaviour

In order to determine the primary browse species for the giraffe population during the four seasons, direct observations were conducted. We used the interval scan method, as used by Parker (2004) in a study on giraffe in the Eastern Cape. Direct observations involved observing the first group of giraffe we found on a sampling day (lone males were excluded) for two consecutive hours, from a distance of no less than 200 m. Observations were conducted daily, for four consecutive days. Feeding records were recorded by scanning through the group using binoculars, and noting what species each individual was eating every 2 min. Plant species which were not identified through binoculars were identified by following up on foot at the end of the two-hour period.

Data analysis

For the direct observation data, initial analysis involved compiling graphs in Excel in order to determine which species of plants were the most commonly browsed across all four seasons. Shapiro–Wilk tests were conducted on all four data sets to test for normality. The five most preferred browse species were then analysed against each other using the Kruskal–Wallis test, for each of the four seasons, as all four data sets were not normally distributed. All statistical analyses were conducted using Statistica 12 (StatSoft Inc. 2013).

Results

Distribution mapping

The results of the distribution mapping (Figure 1) showed that in autumn and spring, the giraffe utilised very similar areas, with spring showing a slightly larger preference for the smaller tributaries, as well as the Brak River and the main *Acacia* thicket. Autumn showed very little usage of the smaller tributaries, with most of the giraffe clustering around the Brak River and an occasional few straying as far as the Bellair Dam.

There was a more visible difference between summer (Figure 1a) and winter (Figure 1b) distribution, with giraffe showing a marked increase in movement into the smaller tributaries in winter. In both seasons, however, individuals were still found to move quite far from the Brak River and main *Acacia* thicket, but this appeared to be more frequent in winter. In both summer and winter, unlike the other two seasons, individuals were found to move as far south as Tilney Gorge, south of the Bellair Dam, a distance of approximately 20 km.

Direct diet observations

The direct observations revealed that giraffe on Sanbona browse on 17 plant species, including two alien invasive species, namely pink tamarisk (*Tamarix ramosissima*) and old man saltbush (*Atriplex nummularia*). It also revealed that bone forms a part of their diet in the winter months, although the frequency of this could not be quantified. For further analyses, the five most preferred plant species were selected.

Across all four seasons, *A. karroo* was browsed significantly more than any other species ($H = 1552.41$; $n = 4836$; $p < 0.001$; Figure 2). Although *E. undulata* and *S. afra* were not the most favoured browse species, they were significantly favoured over both the *Lycium* species and *Salsola aphylla* ($H = 1552.41$; $n = 4836$; $p < 0.001$). Summer showed no species to be significantly favoured, although *A. karroo*, *S. afra* and *E. undulata* were browsed significantly more than either *S. aphylla* or the *Lycium* species ($H = 254.90$; $n = 1179$; $p < 0.001$; Figure 2a). In autumn, *A. karroo* was browsed significantly more than any of the other four species ($H = 773.03$; $n = 1210$;

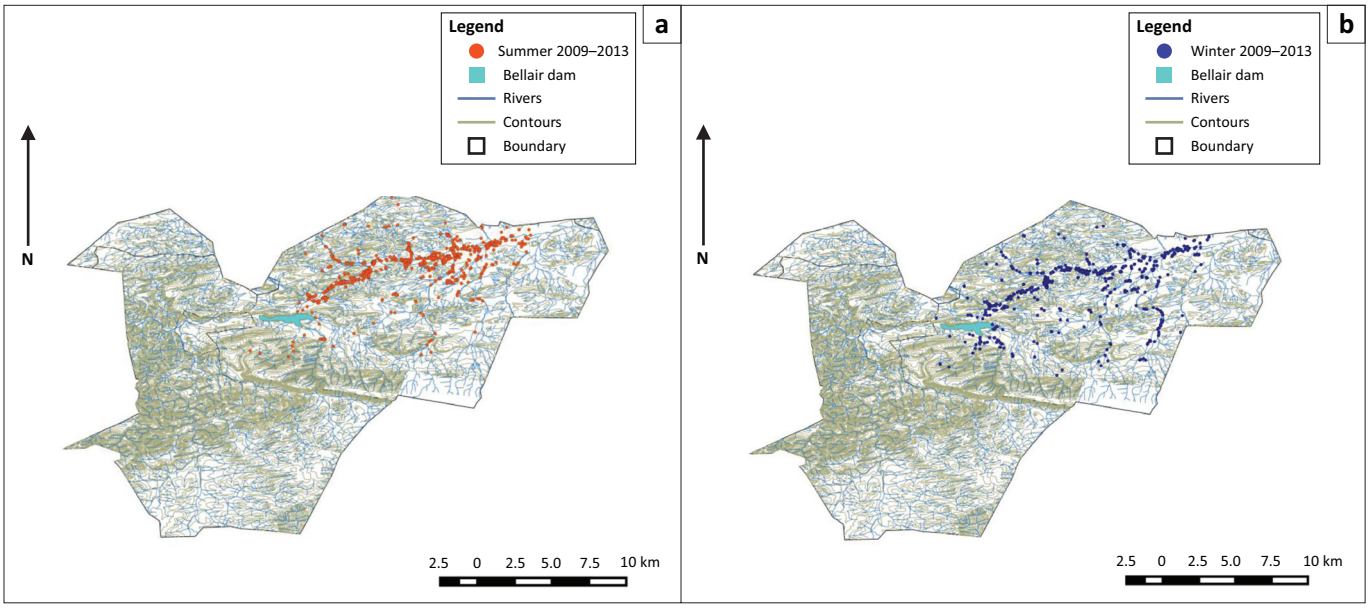


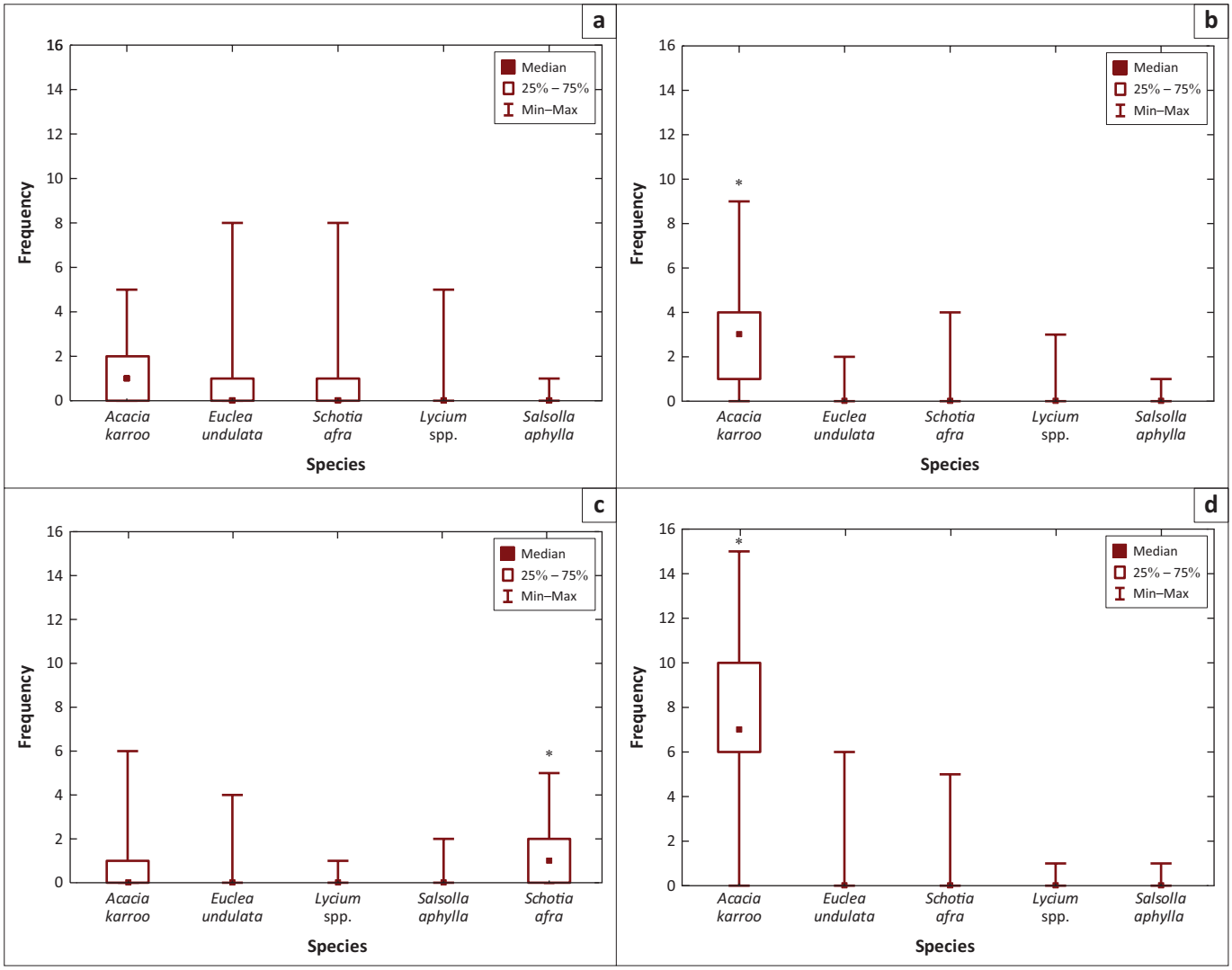
FIGURE 1: Seasonal movement and distribution of giraffe on Sanbona. (a) The summer movement pattern, (b) winter movement pattern. The summer and winter maps showed the largest visual difference, with summer showing a strong clustering around the Brak River and winter showing movement into the smaller tributaries.

$p < 0.001$; Figure 2b), while in winter, *S. afra* was browsed significantly more than any of the other four species ($H = 280.08$; $n = 1225$; $p < 0.001$; Figure 2c). Just as in autumn, in spring *A. karroo* was browsed significantly more than any of the other four species ($H = 1060.70$; $n = 1215$; $p < 0.001$; Figure 2d).

Discussion

The movement patterns of the South African giraffe population on Sanbona appear to be highly seasonal. During summer and autumn, the giraffe cluster around the Brak River, and the main *Acacia* thicket. In winter, there seems to be visible movement out of the main river line and into the smaller tributaries. This coincides to an extent with the seasonal change in preferred browse, as these smaller tributaries are home to most of the reserve's *S. afra* and *E. undulata*. As the *Acacia* thicket in the Brak River is affected by the first few frosts of winter, and the *Acacia* spp. start to drop their leaves, the giraffe begin to actively disperse in search of alternate food sources. Just like giraffe in other arid areas, the Sanbona population seems to migrate and disperse seasonally, following food availability (Fennessy 2009; Le Pendu & Ciofolo 1999).

The giraffe on Sanbona showed strong seasonal preferences for different browse species. Unlike in their native range and in Kwa-Zulu Natal, where browse from the genus *Acacia* was preferred throughout the year (Bond & Loffell 2001), the Sanbona population consumed significantly less *A. karroo* in winter, most likely due to frost related foliage lost, with *S. afra* becoming the most browsed species. These results were similar to those found by Parker and Bernard (2005) in their study of extralimital giraffe in the Eastern Cape. The Eastern Cape study revealed that *Searsia longispina* was the most commonly browsed species in winter. However, since this species is not prevalent on Sanbona, the giraffe population used *S. afra* and *E. undulata* as alternative browse sources in the winter months. The Sanbona giraffes' switch in preference from *A. karroo* to *S. afra* and *E. undulata* as a food source in winter coincided with most of the



*, Denotes significant results; Kruskal–Wallis test.

FIGURE 2: Box and whisker plots to show the results of the Kruskal–Wallis tests performed on the direct observation data of giraffe feeding behaviour. (a) The results for summer, where no individual was found to be significantly favoured, (b) the results for autumn, where *Acacia karroo* was favoured the most, (c) the results for winter, where *Schotia afra* was found to be the most favoured browse species, (d) the results for spring, where *Acacia karroo* was by far the most preferentially browsed plant species.

A. karroo on the reserve dropping their foliage after the first few frost events.

Although not formally recorded, it is noteworthy that the giraffe were regularly observed feeding on plants below 1.5 m in height, particularly *S. aphylla* and *A. karroo*. Several other studies have found giraffe to regularly feed below their maximum foraging height (Leuthold 1978; Leuthold & Leuthold 1972). This feeding behaviour may indicate that available browse at mean foraging height may not be able to fulfil all dietary requirements. This is an important consideration, as little is known about the nutrient requirements of giraffe, and whether available browse in the Little Karoo is able to fulfil these requirements.

Implications for conservation

As is the case for much of South Africa, the majority of the Little Karoo lies in the hands of private landowners and so the challenge of conserving this highly species-rich region lies in finding a balance between managing for conservation and ensuring economic sustainability (Pasquini *et al*. 2009). The introduction of giraffe onto Sanbona, as in many parts of the Western Cape, was driven by the desire to create a competitive tourism product. Anecdotal evidence suggests that giraffe have already been introduced to over 20 properties in the region (J. Gird [Living Lands] pers. comm. September 2014).

The results of this study also provide useful management suggestions for other landowners in surrounding areas who have introduced or intend to introduce giraffe. This study, carried out in the previously under researched Little Karoo, supports the importance of *A. karroo* in giraffe feeding behaviour found by Parker and Bernard (2005) in their Eastern Cape study. Furthermore, it suggests that *A. karroo* phenology may be constraining browse availability during certain times of the year, most likely associated with frosts. The implications of this for any manager or property owner intending to introduce giraffe to their property in either the Western or the Eastern Cape is that extralimital giraffe populations in these regions need sufficient populations of evergreen tree species to utilise as winter browse. If a property contains very few alternatives to *A. karroo*, it may result in managers being forced to provide supplementary feed for their giraffe or face the possibility of suffering fatalities in the winter months. Before giraffe are introduced to any property, baseline vegetation or habitat assessments should be conducted to establish whether suitable sources of winter browse are available.

Acknowledgements

We would like to thank the following Sanbona staff members: Andrew Slater, Ruan Erasmus and Andrew Hughes. Thanks to Justin Gird (Living Lands) for his suggestions and inspired debates about all things wildlife. Thanks to Matt Wijers (SU) and Elsa Bussier (UCT) for their assistance with QGIS, as well as Gillian Gordon (Struik) for her assistance with editing, and Dr Justin Harvey (SU) for his assistance with the statistical analyses.

Competing interests

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

Authors' contributions

The research being reported was carried out by C.N.G., when she was a 4th-year conservation ecology student at Stellenbosch University, and L.E. and P.V. assisted with fieldwork and also carried out some of the fieldwork (one season). S.M.J. and A.J.L. supervised the student. The funding was supplied by the student and Sanbona Wildlife Reserve.

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