The diet of a small group of extralimital giraffe

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Abstract

Giraffe are extralimital in the Eastern Cape Province, South Africa where recent local introductions have persisted despite limited research into their impact on the indigenous flora. The diet of 15 giraffe at the Shamwari Game Reserve was recorded by direct observation during summer (March/April) and winter (July/August) 2001, quantifying diet by frequency of occurrence (individual records scored and expressed as a percentage of the total). Preference indices were also calculated. Habitat use was measured by the number of hours giraffe fed in different habitats. The diet comprised of 14 plant species, the most important species being *Rhus longispina* (47.9%), *Acacia karroo* (25.7%) and *Euclea undulata* (17.6%). Importance of *R. longispina, A. karroo* and *Tarchonanthus camphoratus* fluctuated seasonally. *Rhus longispina* was more important in winter with a corresponding decrease in feeding on *A. karroo*. *Tarchonanthus camphoratus* was only consumed during summer. *Acacia karroo* thickets (previously disturbed areas) were utilized most (summer 12 h; winter 9 h), with alternative habitats utilized more often in winter than in summer. We suggest that the seasonal fluctuation in the importance of *R. longispina* & *A. karroo* reflects the deciduous nature of *A. karroo*.

Introduction

Historical records indicate that the most southerly occurrence of giraffe (*Giraffa camelopardalis,* Linnaeus) in southern Africa was the northern border between South Africa and Swaziland (Skinner & Smithers, 1990). Despite fossil records from the Western Cape Province, giraffe were not recorded along the eastern seaboard of South Africa (Goodman & Tomkinson, 1987; Skead, 1987). However, several private reserves and game farming operations in the Eastern Cape Province have recently introduced giraffe (Castley, Boshoff & Kerley, 2001). Giraffe are thus regarded as extralimital in the Eastern Cape (Castley *et al*., 2001).

The vegetation of the Eastern Cape has evolved in the absence of a browser such as the giraffe (Skead, 1987) and it is likely that giraffe will negatively affect the indigenous flora. Bond & Loffell (2001) demonstrated that the giraffe introduced at the Ithala Game Reserve in the Kwa-Zulu Natal Province altered the species distribution and composition of the savanna ecosystem, through differential mortality of *Acacia davyi*. Woodland regeneration after fire in the Serengeti (which is within the natural range of giraffe) has been prevented by giraffe (Pellew, 1983a). By preventing the vertical growth of tree saplings, giraffe maintain the trees within the fire-susceptible size class (Pellew, 1983a). More recently, Birkett (2002) demonstrated that giraffe in Kenya would have the greatest impact on the 3–5 m size class of trees. This would cause the tree density of the park to decline by 2% per annum if giraffe browsing is combined with that of elephant (*Loxodonta africana*, Blumenbach) and black rhino (*Diceros bicornis*, Linnaeus). Augustine & McNaughton (1998) postulated that an increase in herbivore density in specific areas will reduce selectivity (consumption of preferred species) because of the reduced availability of preferred plant species per animal, while increasing the absolute amounts of tissue removal from the remaining plants to such an extent that there will be a significant negative effect on the species composition of the community.

Keeping in view the potential of large herbivores to modify the vegetation of a region, and the absence of detailed studies on the feeding biology of giraffe in the Eastern Cape Province, the aims of this study were to determine the diet of a population of extralimital giraffe in a small game reserve, and to assess their impact on the indigenous flora.

Materials and Methods

Study area

The Shamwari Game Reserve is situated between 33°20'S; 26°01'E and 33°32'S; 26°10'E in the Eastern Cape Province, South Africa. The reserve is ≈18,000 ha in size, traverses four geological formations (viz. Bokkeveld Series shale; Witteberg quartzites; Karoo sandstone and Sundays River Formations), and ranges in altitude from 196 m to 628 m asl. The semiperennial Bushmans River is the major water source, flowing through the reserve for 27.6 km. Seven major vegetation biomes are represented on the reserve, namely: forest, thicket, fynbos, nama Karoo, grassland, savanna and secondary vegetation. The secondary vegetation comprises old farmland converted to open grassland or successional thickets dominated by *A. karroo* and *R. longispina.* There are 13 vegetation types within the biomes of the reserve (Fig. 1), the sub-tropical thicket (ST), bushclump savanna and *A. karroo* thickets dominate (O'Brien, 2000).

At the time of this study there were 15 giraffe (six sub-adult and nine adult, with an equal sex ratio) on the reserve. Three calves were born during 2001.

Diet and habitat characterization

Direct observations of the diet were made using the interval scan method, making feeding records every 2 min over the period of 1 h (Van Aarde & Skinner, 1975; Tacha, Vohs & Iverson, 1985; Rose, 2000). A feeding record was defined as each instance in which one plant species was consumed by one animal during a particular scan. Therefore, if 10 giraffe were feeding on *A. karroo* during a scan, there would be 10 feeding records for *A. karroo* for that scan.

Observations of the diet were made on 6 days in March/April (summer) and 6 days in July/August (winter). On each day, the first group of giraffe encountered was observed, so as to reduce observer bias for a particular group of giraffe or region. Three 1-h long observation sessions were undertaken each day such that 1 h was completed during the morning (defined as 06:00–09:00), 1 h at midday (11:30–13:30) and 1 h in the afternoon (15:00–18:00). For each 6-day session (i.e. each season's data) there were thus 18 h of observation, six in the morning, six at midday and six in the afternoon. The plant species consumed, the time of the day, the number of animals, the habitat type, other behaviour and weather conditions were recorded. The feeding records for each day of observation were totalled and expressed as a percentage of the total number of records for each day (i.e. frequency of occurrence). Preference indices for seven of the eight most important species in the diet of giraffe were calculated by relating the relative dominance data for each tree species to the frequency of occurrence data using the equation:

$$\text{Preference} = \frac{\text{Relative frequency in diet } (a)}{\text{Relative frequency of resource } (b)}$$

where *a* is the frequency of occurrence of a particular tree species in the diet, and *b* is the relative dominance of that species in the area in which observations of the diet were made. Both values are percentages.

The number of hours the giraffe spent in different habitats was recorded.

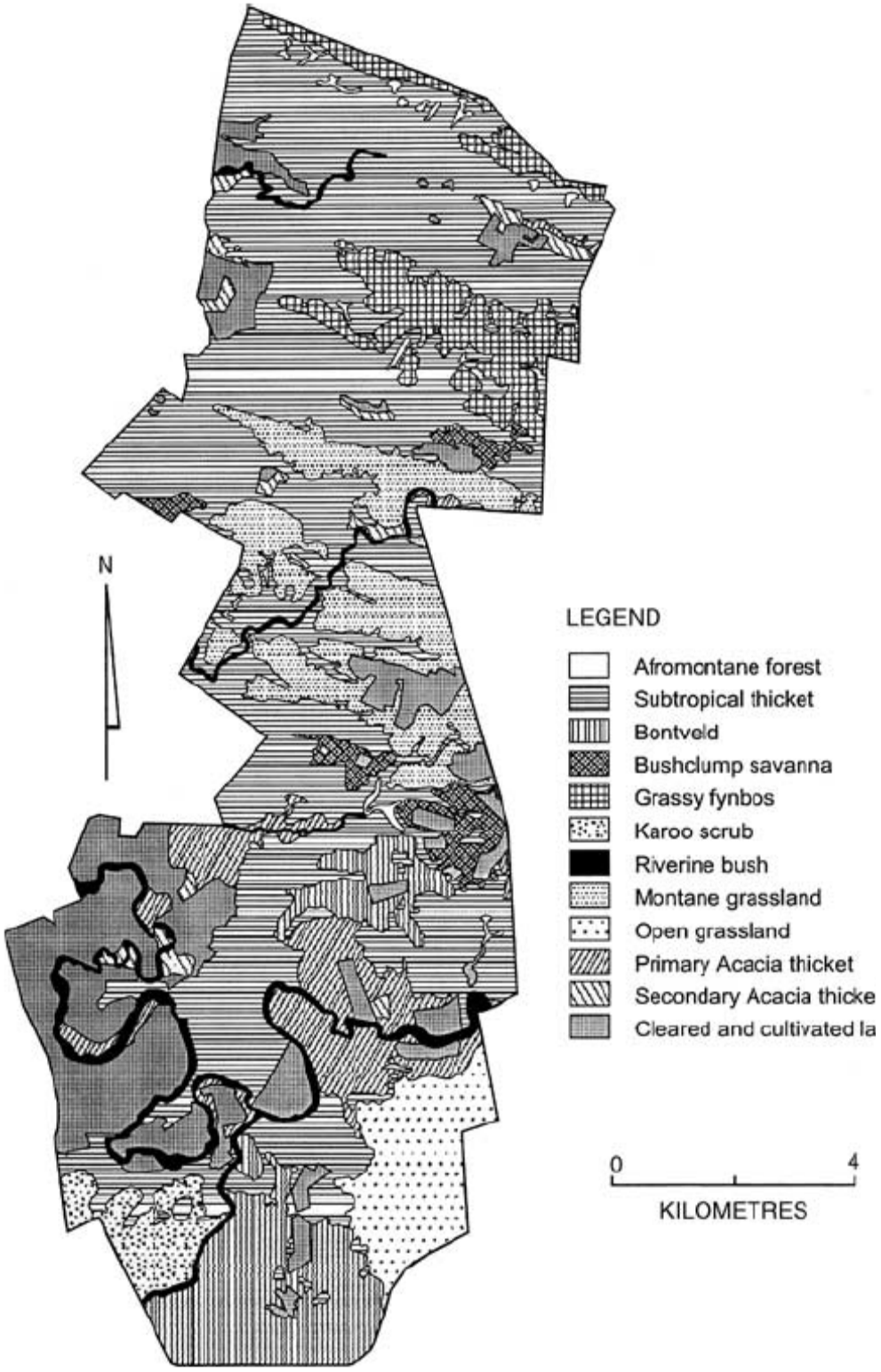

Fig 1 The Shamwari Game Reserve showing the 13 vegetation types found on the reserve (map courtesy O'Brien, 2000). Cleared and cultivated land are grouped as one vegetation type on the figure.

Vegetation characterization

Using the point-centred-quarter method (Cottam & Curtis, 1956; Pellew, 1983b), five transects of 30 points were sampled in the areas where the giraffe were most commonly observed. At each point, four trees were sampled. The tree species, distance from point to tree (m), height of the tree (m) and canopy cover projected onto the ground (m^2) were recorded. Trees of all heights were included in the sampling, as the giraffe were not observed to show any preference for taller trees. From these data the relative density and relative dominance were calculated – density being a measure of how dense a particular area is (in terms of the number of tree species expressed as a percentage of the total for a transect) and dominance being a measure of how dominant certain tree species in a transect are (i.e. canopy cover for a particular species/total canopy cover expressed as a percentage).

Data analysis

Using STATISTICA (Statsoft version 6) a Kruskal–Wallis ANOVA, median test was performed on the diet data in order to test for differences in giraffe diet between different times of the day and season. Frequency of occurrence data for each hour of observation were used in the analysis after arcsine transformation.

The number of hours giraffe spent in different habitats in summer and winter were compared using a χ^2 log-linear analysis (STATISTICA statsoft version 6).

Results

Diet

The giraffe fed on 14 woody plant species during the study, 12 species were consumed in summer and 12 in winter (Table 1). In terms of mean annual frequency of occurrence, the most important species recorded in the diet of giraffe at Shamwari Game Reserve were (in order of importance): *R. longispina* (47.9%), *A. karroo* (25.7%), *and E. undulata* (17.6%; Table 1). The mean annual frequency of occurrence of the remaining 11 species was comparatively low (<11%; Table 1). The species that displayed a frequency of occurrence of >20% on any one day that observations were conducted were recognized as the most important species and were included in the following analysis. The relative importance of these species was not significantly different between the three different times of day during which observations were made (Kruskal–Wallis ANOVA; $P > 0.05$ for all species). Therefore, the data for each day were combined and frequency of occurrence values were calculated for summer and winter (Fig. 2). The thorny taaibos (*R. longispina*) was significantly more important (in terms of frequency of occurrence) in the diet during winter than during summer (Kruskal–Wallis ANOVA; $P < 0.05$; H = 6.8). *Acacia karroo* (sweet thorn) was the most important component of the diet in summer (39%), but was significantly less important in winter (Fig. 2; $P < 0.05$; H = 16.). Cat-thorn (*Scutia myrtina*) and wild camphor bush (*T. camphoratus*) were of similar importance in summer (Fig. 2). However, in winter *T. camphoratus* was not eaten, and *S. myrtina* was of minor importance (Fig. 2). The importance of *T. camphoratus* was significantly different between seasons ($P < 0.05$; H = 4.4). *Schotia afra, Gymnosporia buxifolia, E. undulata* and *Buddleja saligna* were of minor importance in the diet during summer (Fig. 2). However, all four species were consumed more often during the winter, *E. undulata* and *G. buxifolia* being the second and the third most important species, respectively (Fig. 2). Despite the visible fluctuation in the importance of these four species, these differences were not statistically significant ($P > 0.05$).

Table 1 The seasonal importance (in terms of frequency of occurrence) and mean annual frequency of occurrence (M.A.F.O.) of all plant species consumed by the giraffe at the Shamwari Game Reserve

Family	Species	Summer (%)	Winter (%)	M.A.F.O (%)
Portulacaceae	*Portulacaria afra*	–	3.1	1.6
Capparidaceae	*Capparis sepiaria*	–	2.6	1.3
Leguminosae	*Acacia karroo*	39.6	12.9	25.7
	Schotia afra	9.8	11.2	10.4
Anacardiaceae	*Rhus longispina*	34.7	61.1	47.9
	Rhus pallens	12.2	–	6.1
Celastraceae	*Gymnosporia buxifolia*	4.3	17.5	10.9
Sapindaceae	*Pappea capensis*	0.8	2.0	1.4
Rhamnaceae	*Scutia myrtina*	19.4	2.3	10.9
Ebenaceae	*Euclea undulata*	11.4	23.8	17.6
Oleaceae	*Olea europea*	0.8	8.2	4.5
Salvadoraceae	*Azima tetracantha*	6.5	5.7	6.1
Loganiaceae	*Buddleja saligna*	8.6	6.7	7.7
Asteraceae	*Tarchonanthus camphoratus*	18.2	–	9.1

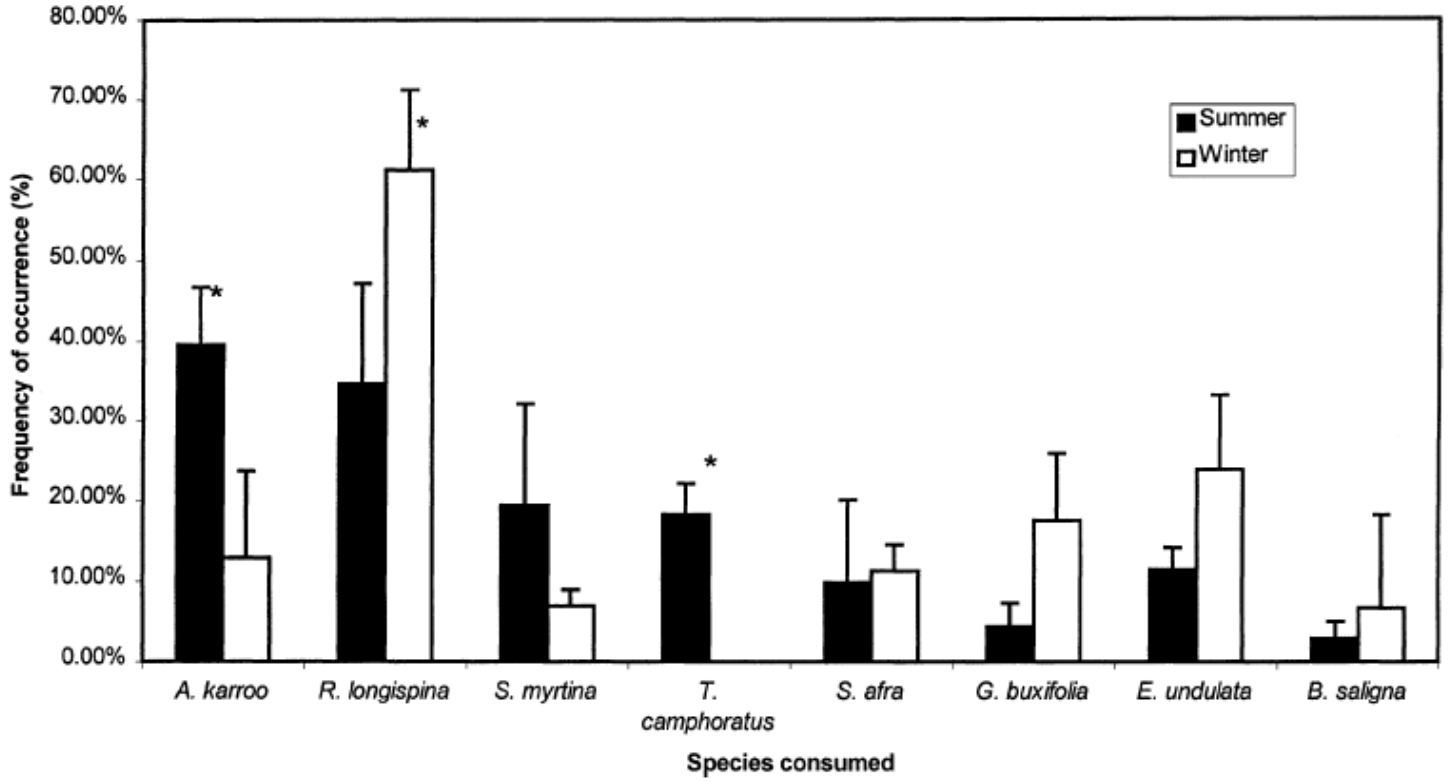

Fig 2 The summer and winter diet of giraffe at the Shamwari Game Reserve. The mean frequency of occurrence values (including SD) for each season is shown. *Statistically significant between seasons (*P* significant at 0.05).

Preference

Preference indices (Table 2) for seven of the eight most important species in the diet of giraffe at Shamwari Game Reserve were calculated by relating the vegetation availability data (Table 3) to the frequency of occurrence data. The giraffe showed preference (i.e. values >1) for all of these species (Table 2). *Schotia afra* had the highest preference index in summer but was relatively unimportant (in terms of frequency of occurrence) in the diet

(Table 2; Fig. 2) while *A. karroo* and *R. longispina* had preference indices that were relatively low. Although *T. camphoratus* and *S. myrtina* were of similar importance in the diet (Fig. 2), their preference indices were markedly different (Table 2).

The change in the preference indices for *A. karroo* and *R. longispina* from summer to winter is reflected by the change in importance of the two species in the diet (Table 2; Fig. 2). Despite the importance of *A. karroo* being significantly different between seasons (Fig. 2), the giraffe still showed preference (i.e. value >1) for it. The increase in the importance of *E. undulata* and *G. buxifolia* is also tracked by higher preference indices (Table 2; Fig. 2). However, the value obtained for *E. undulata* was surprisingly high (Table 2).

Table 2 The preference indices for the most important plant species consumed by giraffe at Shamwari Game Reserve in summer and winter

	Summer	Winter
Acacia karroo	2.7	1.4
Rhus longispina	3.0	32.9
Scutia myrtina	1.9	–
Tarchonanthus camphoratus	3.2	–
Schotia afra	9.1	–
Euclea undulata	–	49.1
Gymnosporia buxifolia	–	1.1

The preference index for *B. saligna* is not shown as no availability data exists for the area in which it was consumed.

Habitat utilization

The giraffe were only observed to feed in three of the 13 vegetation types (habitats) found at Shamwari Game Reserve (Fig. 1). During summer, the giraffe fed predominantly (66.7%) in *A. karroo* thicket (previously disturbed areas) as well as in the bushclump savanna (33.3%). In winter, the giraffe spent less time in *A. karroo* thickets (50.0%) and bushclump savanna (16.7%) but made use of the bushclump savanna/sub-tropical thicket habitat type (33.3%). Habitat utilization by the giraffe at Shamwari Game Reserve was significantly different between the two seasons (χ^2 log-linear analysis; $\chi^2 = 7.4$; df = 2; $P < 0.05$).

Vegetation characterization

The relative density and relative dominance of each tree species in the diet of giraffe at the Shamwari Game Reserve was calculated after completing five vegetation transects in the areas most commonly frequented by the giraffe (Table 3). At Longlee *R. longispina* dominated the transect (65.1%) with *A. karroo* (19.9%) and *G. buxifolia* (8.3%), the two other dominant species (Table 3). However, *A. karroo*, was more common (density = 31.0%) than *R. longispina* and *G. buxifolia* (Table 3). In contrast to Longlee, Matopos was dominated by *R. pallens* (60.8%), which was also the densest tree species in that area (Table 3). The vegetation at Highfield was dominated almost exclusively by *A. karroo* (81.8% relative dominance and 83.2% relative density). In the Longlee thicket *A. karroo* again dominated the vegetation (42.4%), but *R. longispina* (22.6%) and *G. buxifolia*

(27.1%) were more dominant than at Highfield (Table 3). The Public road transect was the most diverse in terms of the number of tree species sampled (Table 3). *Rhus* longispina was the most dominant (37.5%) species in this area, but unlike the Longlee, Highfield and Longlee thicket transects, *E. undulata* was also dominant (29.3%; Table 3). *E. undulata* (19.4%), *Olea europea* (13.4%) and *R. longispina* (13.4%) were the most common (densest) species in the area. However, neither *E. undulata* nor *O. europea* had sufficiently large canopies to result in high dominance values (Table 3).

Table 3 The relative density and relative dominance of each tree species sampled in the five areas frequented by the giraffe at the Shamwari Game Reserve (Longlee, Matopos, Highfield, Longlee thicket and Public road)

	Relative density (%)	Relative dominance (%)
Longlee		
Acacia karroo	31.0	19.9
Rhus longispina	29.3	65.1
Gymnosporia buxifolia	25.9	8.3
Azima tetracantha	7.8	5.4
Pappea capensis	5.2	0.4
Euclea undulata	0.9	0.9
Matopos		
Acacia karroo	12.0	7.3
Rhus longispina	2.4	3.4
Rhus pallens	57.6	60.8
Azima tetracantha	1.6	1.4
Pappea capensis	0.8	0.02
Euclea undulata	8.8	9.1
Buddleja saligna	0.8	0.1
Scutia myrtina	7.2	13.3
Tarchonanthus camphoratus	6.4	3.5
Schotia afra	0.8	0.07
Highfield		
Acacia karroo	83.2	81.8
Rhus longispina	1.8	2.4
Gymnosporia buxifolia	7.1	0.9
Azima tetracantha	2.7	3.2
Buddleja saligna	0.9	0.8
Scutia myrtina	3.5	5.3
Olea europea	0.9	5.7
Longlee thicket		
Acacia karroo	51.7	42.4
Rhus longispina	18.3	22.6
Gymnosporia buxifolia	21.7	27.1
Azima tetracantha	6.7	7.8
Public road		
Acacia karroo	1.5	0.3
Rhus longispina	13.4	37.5
Gymnosporia buxifolia	7.5	1.8
Azima tetracantha	6.0	1.5
Pappea capensis	3.0	1.3
Euclea undulata	19.4	29.3
Buddleja saligna	1.5	0.1
Scutia myrtina	4.5	1.5
Schotia afra	9.0	8.8
Portulacaria afra	9.0	5.1
Capparis sepiaria	1.5	0.5
Olea europea	13.4	6.5
Rhus pallens	6.0	2.0
Tarchonanthus camphoratus	3.0	3.8

Discussion

The number of plant species selected by giraffe is typically high, usually >20 (Leuthold & Leuthold, 1972; Hall-Martin, 1974; Van Aarde & Skinner, 1975; Sauer, Theron & Skinner, 1977; Sauer, Skinner & Neitz, 1982). This is ascribed to the fact that giraffe are capable of traversing large distances within their home ranges where they encounter and use a greater variety of vegetation types (Skinner & Smithers, 1990). However, only 14 woody plant species were consumed by giraffe in this study. This may be because of the small number of observations made during the year of study as several of the palatable plant species consumed by giraffe in their natural range are found in the Eastern Cape (Hall-Martin, 1974; Van Aarde & Skinner, 1975).

The most important species in the diet (in terms of frequency of occurrence) at the Shamwari Game Reserve was *R. longispina*, which was more common in the diet during the winter months. Several *Rhus* species comprise the diet of giraffe in southern and eastern Africa (Field & Ross, 1976; Sauer *et al*., 1977). However, contrary to the present study, these *Rhus* species remained relatively unimportant throughout the year (Van Aarde & Skinner, 1975; Field & Ross, 1976; Sauer *et al*., 1977). *Rhus longispina* itself has not previously been recorded in the diet of giraffe (Leuthold & Leuthold, 1972; Hall-Martin, 1974; Van Aarde & Skinner, 1975; Field & Ross, 1976). Restricted to the Eastern Cape, *R. longispina,* which is similar to *R. burchellii*, is an evergreen shrub or small tree flowering in summer and autumn, and fruiting in winter (Coates-Palgrave, 1983; Pierce & Cowling, 1984; Van Wyk & Van Wyk, 1997). Thus, green leaves are available all year round for consumption by giraffe and our results reflect such year-round consumption.

Acacia karroo was the second most important species in the diet (in terms of frequency of occurrence). Studies performed within the natural distribution of giraffe have shown that *A. karroo* is an important component of the diet (*inter alia*Hall-Martin, 1974; Sauer *et al*., 1977; Sauer *et al*., 1982). *Acacia karroo* is also part of the diet of giraffe in Kwa-Zulu Natal where giraffe are also considered extralimital (Goodman & Tomkinson, 1987; Bond & Loffell, 2001). Furthermore, other species of *Acacia* are well represented in the diet of giraffe in East Africa, cumulatively comprising ~40% of the diet at certain times of the year (Leuthold & Leuthold, 1972; Field & Ross, 1976). The preponderance of *Acacia* spp. in the diet of the giraffe can be attributed to the low levels of condensed tannin in the leaves, and increased shoot production stimulated by the browsing action of giraffe (Pellew, 1983b; Cooper, Owen-Smith & Bryant, 1988). However, significantly less *A. karroo* was recorded in the diet of the giraffe at Shamwari Game Reserve during the winter months because the plant is deciduous and prone to excessive leaf loss during cold conditions in low lying areas (Personal observation; Hall-Martin, 1974; Van Aarde & Skinner, 1975). *Acacia karroo* is one of the few deciduous plant species in the Eastern Cape (Hoffman, 1989; Van Wyk & Van Wyk, 1997) and the observed shift in the importance of *A. karroo* and *R. longispina* (i.e. more *R. longispina* recorded in winter) was a result of a reduction in the availability of *A. karroo* during winter.

Apart from the wild camphor bush (*T. camphoratus*), none of the remaining six species fluctuated in importance seasonally. This result contradicts those of Hall-Martin (1974), Sauer *et al*. (1977) and Van Aarde & Skinner (1975), where the species comprising the diet vary significantly between seasons. However, large stands of deciduous vegetation dominated the areas in which these studies were conducted. All six of the remaining species recorded in the present study are evergreen presenting a potential food source throughout the year (Van Wyk & Van Wyk, 1997).

Giraffe prefer new growing shoots when they are available, as they are higher in water and protein content, and low in condensed tannins (Sauer *et al*., 1982; Cooper *et al*., 1988). Although evergreen trees have distinct leaf

growth phases when new shoots are produced, they do not loose their leaves during the intervening periods as do deciduous trees. Evergreen trees thus provide a year-round food source for browsers such as giraffe and it would be expected that giraffe would show preference for these species so long as they are palatable (e.g. low in condensed tannin and minimal spinescence). The giraffe at Shamwari Game Reserve showed preference for seven of the eight most important species in the diet possibly because of their evergreen nature. Interestingly, although, the giraffe continued to prefer *A. karroo* (i.e. preference index >1) throughout the relatively leafless phase in winter. This initially seems counterintuitive. However, despite *A. karroo* being deciduous, the leaves are relatively high in crude protein and low in condensed tannins (Cooper *et al*., 1988; Sauer *et al*., 1977). Therefore, when the giraffe foraged in areas with *A. karroo* trees present they actively sought out any remaining leaves on the trees.

The fact that most of the preference indices did not correspond to the importance of the different species in the diet may be an artefact of the vegetation sampling technique. The point-centred-quarter method provides the least variable results for distance measures (Cottam & Curtis, 1956). However, as the technique is a representative transect, it may underestimate trees with low frequencies and overestimate dominant tree species. Inaccurate availability estimates exaggerate preference indices, which could have been the case in this study.

Oates (1972) illustrated that food selection by giraffe was not related to plant species availability. *Colophospermum mopane,* which was one of the most abundant food sources in the area he studied, was avoided, possibly because of its secondary chemical compounds (Oates, 1972). However, later studies indicated that the conclusion Oates (1972) reached was incorrect (Hall-Martin, 1974; Sauer *et al*., 1982). *Colophospermum mopane* is indeed avoided somewhat by giraffe because of the high terpentine levels. However, it is an important component of the diet during the dry season when preferred food items such as *Acacia* species lose their leaves (Sauer *et al*., 1982). Thus, giraffe foraging, and consequently preference, corresponds to the availability of palatable browse, which in turn is governed by the phenology of individual species. Our results support this conclusion.

The sub-tropical thicket is a dominant vegetation type in the Eastern Cape (≈15%), distributed in patches along the coast and in river valleys (Lacock, 1992). In the past, sub-tropical thicket was often removed along river banks to be replaced by crops, and was debushed in places to make way for roads and various other farming activities (Lacock, 1992). When farming/anthropogenic pressure on these previously cleared regions is released (i.e. when a reserve such as Shamwari Game Reserve is formed) early successional stands, dominated by *A. karroo* and *R. longispina,* persist (O'Brien, 2000). Our results indicate that the giraffe at Shamwari Game Reserve spend most of their time foraging in these previously cleared patches in summer and winter, but utilize the *A. karroo* thicket less during winter. These modified habitats are less diverse than stands of sub-tropical thicket. Consequently, the giraffe introduced to Shamwari Game Reserve may not have as great an effect on the indigenous vegetation, and may in fact play a positive role in the reduction of such modified habitats.

In terms of the effect of giraffe browsing on the indigenous flora of the region, the giraffe spent most of their time in modified habitats and fed on *A. karroo* when it was available. However, *R. longispina* is a preferred species especially during the winter months, and is present in these modified habitats. Significantly, it is only found in the Eastern Cape. Further studies will attempt to quantify the extent of browsing damage on the important species and address other factors such as group size, reserve size, presence of predators and vegetation type to develop a better understanding of the feeding biology of giraffe in the Eastern Cape Province, South Africa.

Acknowledgements

Financial support from Rhodes University and the National Research Foundation is gratefully acknowledged. Frank Doyle and Jeanne Berkeljon are thanked for assistance in the field; Roy Lubke for botanical advice; Martin Villet for statistical advice; Jackie Rapson for assistance with the construction of the vegetation map and Martin Hill, Pat Hulley, Richard Burchell and two anonymous reviewers for constructive comments on the manuscript. Special thanks to Shamwari Game Reserve for making this research possible.

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