The winter diet of elephant in Eastern Cape Subtropical Thicket, Addo Elephant National Park

R.G.T. PALEY and G.I.H. KERLEY

Paley, R.G.T. and G.I.H. Kerley. 1998. The winter diet of elephant in Eastern Cape Subtropical Thicket, Addo Elephant National Park. *Koedoe* 41(1): 37–45. Pretoria. ISSN 0075–6458.

Direct observational methods were used to establish the winter diet of elephants in Eastern Cape Subtropical Thicket in the Addo Elephant National Park, thereby determining which plant species were most at risk from elephant herbivory. A total of 70 species were identified as food plants for elephants, with the grass *Cynodon dactylon* and the succulents *Portulacaria afra* and *Platythyra haeckeliana* dominating, both in terms of frequency of feeding events and volume consumed. In view of the fact that elephants represent 78 % of the herbivore biomass in the park, it appears likely that elephant feeding restricts the availability of forage for other browsers. Due to the limited time frame of this study, further research is needed to provide a comprehensive record of the elephant diet for all seasons of the year.

Key words: elephant, Addo, diet, succulents, winter.

R.G.T. Paley, Imperial College, London, and Terrestrial Ecology Research Unit, Department of Zoology, University of Port Elizabeth, PO Box 1600, Port Elizabeth, 6000 South Africa; G.I.H. Kerley, Terrestrial Ecology Research Unit, Department of Zoology, University of Port Elizabeth, PO Box 1600, Port Elizabeth, 6000 South Africa.*

* To whom correspondence should be addressed.

Introduction

The elephant population of the Addo Elephant National Park (AENP) is one of only two populations currently extant in Eastern Cape Subtropical Thicket (ECST). Both elephants and habitat are important in conservation terms and as a source of revenue through ecotourism (Kerley *et al.* 1995). The maintenance of a viable elephant population without excessive degradation to the habitat is therefore a major aim of park management (Novellie 1991). Achieving this aim is complicated by the fact that the dynamics of ECST are poorly understood (Cowling 1984; Everard 1987). However, it has been established that ECST, whilst stable, has low resilience (Cowling 1984; Midgely 1991) and is slow to recover from high levels of disturbance (Hoffman & Everard 1987). This, combined with the fact that the density of elephants in AENP has consistently exceeded the 2 elephant/km² limit recommended by Hall-Martin & Barratt (*in press*), suggests it would seem reasonable to expect the impact of elephants on the physiognomy, diversity and dynamics of ECST to be considerable.

Penzhorn *et al.* (1974) found a considerable decrease in total plant biomass within the elephant enclosure, and a change in plant species composition owing to a reduction in food species. More recent studies have reported a reduction in mean plant canopy cover (Novellie 1988; Stuart-Hill 1992) and species richness (Barratt & Hall-Martin 1991; Moolman & Cowling 1994), in spite of an almost fourfold expansion of the area of the elephant enclosure. Nevertheless, Stuart-Hill (1992) found that all but one of the species which were adequately sampled were

able to tolerate fairly heavy levels of elephant utilisation, and Hall-Martin & Barratt (*in press*) describe the overall impact of elephants during the period 1977–1989 as "surprisingly slight".

Information on the diet of elephants at AENP is limited and has been largely inferred from plant-based studies (Penzhorn *et al.* 1974; Stuart-Hill 1992; Moolman & Cowling 1994; Hall-Martin & Barratt (*in press*)). This study sought to identify, through direct observation, which plant species are eaten by elephant and in what proportions; thereby establishing which species are most at risk from elephant herbivory. Given the limited time span, this can be considered a pilot study for the winter season only.

Study Area

AENP is situated at 33°31'S, 25°45'E, with the elephant camp covering an area of more than 11 708 ha (Hall-Martin 1992). Topographically it is characterised by a series of low undulating hills, rising from 71 m.a.s.l. to 354 m.a.s.l. Numerous small pans occur throughout the elephant enclosure but, except in years of abnormally high rainfall, they are dry for the greater part of the year. Permanent water is provided by three artificial water holes and two dams. The region in which AENP falls is generally considered to be semi-arid. The mean daily temperature for January is 32.4°C and 13.5°C for July, however temperatures in excess of 40°C frequently occur in summer (Stuart-Hill 1992). The mean annual rainfall recorded for the period 1960 to 1989 was 445 mm (range 245–665). Rainfall occurs throughout the year, but peaks in late summer (February-March) and spring (October-November) while prolonged droughts occur regularly (Hall-Martin & Barratt (*in press*). The rainfall immediately preceding and during the early part of this study was exceptional. The monthly figures for May-July being between two and three times as high as the long term averages for the last five years (Anon. 1977).

The vegetation of Addo is considered to be Kaffrarian Succulent thicket, sub order Xeric Succulent Thicket (Lubke 1996), which is characterised by a dense tangle of succulent and spinescent shrubs and lianas 2–4 m high (Penzhorn *et al.* 1974; Hall-Martin & Barratt (*in press*)). However the vegetation is not uniform across the park, largely owing to varied historical land use practices. Archibald (1955) described five plant communities within the park. The most extensive being Spekboomveld, in which Spekboom *Portulacaria afra* is the dominant species, but which also contains *Euclea undulata*, *Rhus pterota*, *Azima tetracantha*, *Schotia afra* and *Capparis sepiaria*. The other communities are: Karoo-bushveld, Mixed Shrub and Grassveld, Bontveld and Coastal Bush. Much of the recently acquired land is of uncertain condition and classification, having been utilised for livestock or crop production for many years prior to purchase. This includes large areas of grassland with a high incidence of *Cynodon dactylon* and *Platythyra haeckeliana*, which Johnson (1998) refers to as "areas of previous farmland cleared and ploughed for agronomy". The elephant population has grown steadily since the construction of the enclosure (Penzhorn *et al.* 1974) and now stands at 261 (A. Woodd UPE, *pers. comm.*), which exceeds the current the recommended 2 elephants/km^2.

Methods

General description

Field work was conducted mid June to early September 1997, and formed part of a wider study examining the diet and feeding behaviour of elephants in the AENP (Paley 1997). Elephants were located and observed at close quarters from a vehicle either solo or in family groups. Longer range observations were made through binoculars. It was seldom possible to gain a sufficiently clear view of the elephants feeding at distances greater than 15–20 m, and frequently less. Beyond that, either the smaller plants or the elephants were obscured by dense vegetation. Although it was generally possible to identify the species being eaten, at longer distances it was usually necessary to follow up with direct examination of the vegetation. At close range the parts of the plant from which elephants have recently broken off stems, branches or twigs is often clearly visible. For each observation, the following data were collected:

1. The location of the sample and a brief description of the vegetation community.
2. Sex and approximate age of the feeding elephant.
3. The species eaten. If this could not be identified in the field, a sample was taken and pressed for later identification and reference.

4. The size of the mouthful. This was estimated using the "browse bottle" measure devised by Emslie & Adcock (1994), which compares the amount removed from the plant at each feeding event to the number of approximate litre volumes.

Sampling intensity

Sampling was carried out on an opportunistic basis. Field work began at approximately 08:00 daily and continued until the enclosure gates closed at 17:30. To eliminate any bias as to which areas of the park were monitored, the park was divided into four areas and the order in which they were visited was randomly selected. In addition, to ensure random choice of the group or individual to be observed, an a priori decision was made as to whether to collect data on the first or second group to be encountered within a specific area. Once elephants were located feeding observations commenced immediately, and were continued until the application of one of the following termination rules, which were independent of the behaviour being investigated:

1. Once the sample time had reached 20 minutes. This ceiling was imposed to counteract the tendency towards disproportionate observation of elephants on grassland. Owing to the more open nature of the grassland areas, elephants are more likely to be located and remain visible for longer.
2. When contact was lost with the elephants being observed. Contact was considered maintained as long as its feeding activity had not been obscured for more than 5 minutes. It was only deemed lost when this period was exceeded or the elephant was judged to be moving from the observer and unlikely to return.
3. If the locations of the plants, which had to be inspected to confirm data, exceeded the number which could be satisfactorily recalled from limited notes.

Although sampling was limited to diurnal feeding, this is not expected to significantly effect the results, as elephants have been shown to demonstrate peak feeding activity during the day (Wyatt & Eltringham 1974).

Specific sampling techniques

Two methods were employed to collect data. The primary method used was an adaptation of Altmann's (1974) scan sampling. This involves the observer recording an individuals' current activity at pre-selected intervals, and can be used to obtain data from a large number of group members within a short time period by observing each in turn. Focal-animal sampling in which all occurrences of specified actions of an individual or specified group of individuals and the length of each sample period are recorded (Altmann 1974), was used for solitary elephants and to gain data on harvest rate. The total feeding time was divided by the number of feeding events observed to give the harvest rate. A feeding event was defined as commencing when the elephant reached out to grasp a plant with its trunk and ending when it placed the food into its mouth.

Results

Diet

A total of 1224 observations of elephant feeding were recorded. As identification of some samples proved difficult in the field, 89 observations were discarded, but this did not affect any category of plant specifically. From the remaining 1134 observations, 70 species, from 54 genera and 35 families, were recorded as eaten by elephants (Appendix). By the time field work finished, new dietary species were still being identified, but at a low rate (Fig. 1).

The sample size was sufficient however, to show the species which made up the major part of the elephant diet. The remainder were observed on only a few occasions and were assumed to play a limited role in the diet. For the purpose of analysis they were therefore grouped under the heading of Other

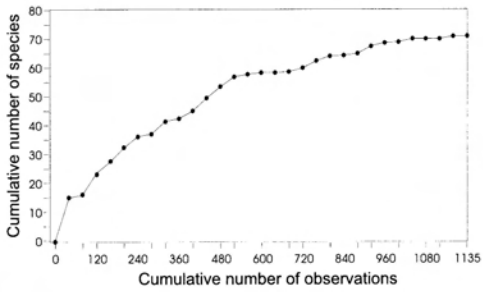

Fig. 1. A species-sample curve plotting the cumulative number of species identified against the cumulative number of observations made.

Table 1

List of the species and their growth form (f=forb, g=grass, sh=shrub, su=succulent) eaten by elephants, for which more than 20 observations were recorded, showing number of observations and estimated volume consumed for each species, and as percentages of the totals for all species

Species	Growth form	Observations	% of Total Observations	Volume (litres)	% of Total Volume
Cynodon dactylon	g	352	31	266.5	29.2
Portulacaria afra	su	89	7.8	48.1	5.3
Platythyra haeckeliana	su	63	5.5	70.9	7.8
Rhus species	sh	55	4.8	34.3	3.8
Euclea undulata	sh	54	4.8	43.9	4.8
Panicum deustum	g	49	4.3	34.9	3.8
Lycium species	sh	44	3.9	21.7	2.4
Chenopodium albium	sh	35	3.1	22.3	2.4
Azima tetracantha	sh	32	2.82	29.3	3.2
Protasparagus species	sh	27	2.38	41.7	4.6
Cuspidia cernua	f	27	2.38	28.1	3.1
Cyanotis speciosa	f	24	2.11	8.6	1
Schotia afra	sh	22	1.94	20.2	2.2
Galenia pubescens	f	21	1.85	13	1.4
Other species		241	21.23	229.8	25.2

(n = 54)

(Table 1). The grass *Cynodon dactylon*, which is most commonly found on the open pastures formerly cleared for agriculture, was clearly the dominant food species during the period of study. Only one other grass, *Panicum deustum*, was among the major food plants. The succulent species *P. afra* and *Platythyra haeckeliana* were well represented (Table 1).

There is a significant positive correlation between the frequency with which a specific species is eaten and its contribution to the total volume of vegetation consumed by elephants ($r = 0.7$, $P < 0.01$, $df = 11$). This suggests that widely differing plant characteristics and morphology did not affect the "bite size" at each feeding event. Thorny shrubs and scramblers such as; *Rhus* spp. (*R. longispina* and *R. pterota*), *Azima tetracantha*, *Lyceum* spp. (including *L. cinerium*, *L. ferocissimum*, *L. oxycarpum* and *L. schizocalix*) and *Protasparagus* spp. (*P. racemosus*, *P. striatus* and *P. suaveolens*) were prominent among the plants eaten, indicating that spinescence does not preclude elephant herbivory.

When the observations were grouped together on the basis of growth forms (Fig. 2), shrubs and grasses ranked highest both in the number of species and volume eaten. The consumption of succulents, forbs and geophytes was substantially lower. When considered in conjunction with the figures for individual species (Table 1), it can be seen that in all growth forms except shrubs, a few species dominate as food plants for elephant. The contribution of shrubs to the diet is much more evenly distributed between species.

Harvest rate

Focal sampling on separate occasions resulted in 40 samples containing varying numbers of feeding events. The harvest rate for a particular sample was calculated by dividing the number of feeding events into the total time, giving a mean time for each feeding event. Owing to the skewed distribution brought about by a small number of uncharacteristically high values (Fig. 3), the medi-

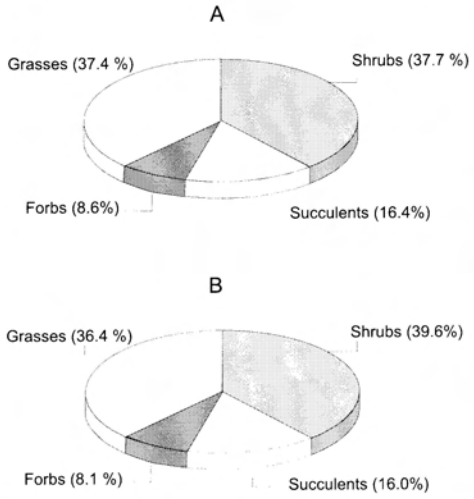

Fig. 2. The four major categories of growth form shown as percentages of: (A) the total observations and (B) the total volume eaten.

an (12.5 seconds) provides the best indication of where the majority of values lie. Because most samples included observations of feeding on a variety of plant types, no definite picture emerged of whether harvest rates were dependant on the type of plant fed on. However the lowest values (i.e. the maximum efficiency) obtained for samples which could be categorised as a particular growth form were: grass (4 sec), succulent shrub (6 sec) and thorny shrub (5 sec). This

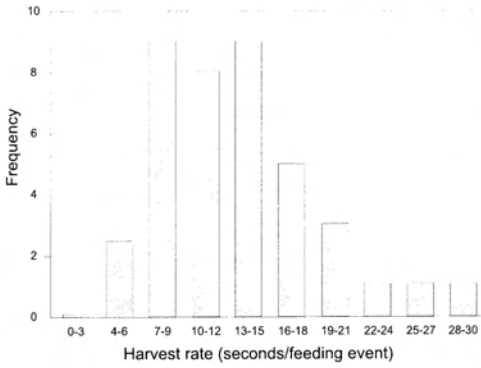

Fig. 3. The frequency distribution of harvest rates (seconds/feeding event) by elephants in the AENP

suggests that there is little difference between the harvest rates for the various growth forms.

Discussion

Diet Composition

From the observations recorded it was possible to establish which were the major plant species in the diet of the Addo elephants during winter. However, the dietary complement of 70 species is probably incomplete given that new species were being identified up to the time data collection ceased. Furthermore, over 511 species of plants were recorded by Geach (1997) as growing in AENP. Since elephants are considered to be catholic in their choice of food plants (Viljoen 1990), it is likely that they would feed, however rarely, on a significant proportion of the total range of species. Nevertheless, when the short time span of this study is considered, a figure of 70 species compares favourably with similar studies conducted elsewhere by Pienaar *et al.* (1966) and Guy (1976), who recorded over 100 and 131 species, respectively. As these studies included data collected throughout the year, it is likely that the number of species identified in this study is a fair representation of the range of species eaten during winter.

The dominant species eaten by elephant differs considerably in some respects from that previously recorded in the AENP. The grass *C. dactylon* is clearly the dominant species (31 % of all observations), yet Armstrong (1955) only mentioned it as part of the diet in passing and Penzhorn *et al.* (1974) only referred to *P. deustum* and *P. maximum* in their list of grasses eaten by elephants. A possible explanation for this was the limited distribution of *C. dactylon* prior to the expansion of the park. Until then it was con-

fined to Bontveld and the occasional clearing in Spekboomveld (Armstrong 1955). It may not have been eaten because it was not available. *C. dactylon* would not usually be expected to feature so prominently in the diet during winter, as in most years the grass would wither and become unpalatable (W. Erlank, AENP, *pers. comm.*). However, the abnormally high rainfall of 2–3 times the monthly average, recorded from May to July, delayed this process by maintaining the levels of grass cover and digestible proteins, as observed by Laws (1970) and Guy (1976). The factors leading to such high levels of *C. dactylon* consumption may conversely have reduced the quantities of spekboom eaten. *P. afra* has long been considered the principal food of Addo elephants (Armstrong 1955; Penzhorn *et al.* 1974; Stuart-Hill 1992) but was recorded as comprising only 5.3 % of the total volume eaten. Perhaps the uncharacteristic abundance of surface drinking water reduced the elephants' need to rely on it as a source of moisture. Furthermore, the increase in size of the park have made other species available as food and may well have brought about the shift in diet which Armstrong (1955) advocated.

Moolman & Cowling (1994) reported heavy utilisation of the Mesembryanthemaceae family by elephants, but apart from *P. haeckeliana* which ranked second in volume eaten, few species of the family were observed being eaten. Similarly, a number of other succulent species that have previously been identified as important food items, including *Sarcostema viminale* (Penzhorn *et al.* 1974; Hall-Martin & Barratt (*in press*)), *Euphorbia mauritanica* and *Crassula ovatum* (Stuart-Hill 1992) were seldom seen being eaten. With expansion, the park now includes areas with *Aloe africana*, which was believed to have been eradicated by elephants prior to 1974 (Penzhorn *et al.* 1974; Hall-Martin & Barratt (*in press*)), no observations of feeding on these species were recorded however. Furthermore, the contention of Hall-Martin & Barratt (*in press*) that *E. undulata* was subjected to a much lighter browsing regime than other woody shrubs, resulting in minor damage to individual plants at any one time, was not substantiated. *E. undulata* comprised over 4.8 % of the total plant matter consumed and the amount taken at any one feeding event was no less than similar species.

Azima tetracantha, *Lycium* spp. and *Rhus* spp. together made up 11.5 % of the total volume eaten thereby supporting Barratt & Hall-Martin's (*in press*) conclusion that thorny shrubs (with the exception of *Capparis sepiaria* which was rarely browsed) were well utilised by elephants. Only 4 observations of *Sansevieria* spp. were recorded in spite of its relative abundance, lending support to the questioning of Archibald's (1955) contention that, along with *P. afra* it contributed most to elephant diet (Penzhorn *et al.* 1974). In addition, the fact that no geophytes were identified as food species supports Moolman & Cowling's (1994) suggestion that these species are little affected by herbivory because of their ephemeral nature and the toxicity of many species.

Grass availablility in ECST is not normally high, yet the amount of grass eaten (36.5 % of total volume consumed) compared to the other major plant types (woody shrubs, succulents and forbs). This is broadly consistent with the findings of Van Wyk & Fairall (1969), Field (1971) and Seme & Tchamba (1993) in other parts of Africa, who found grass to comprise 30 % to 50 % of total food consumed.

Harvest rate

There is a contrast in the values for the mean harvest rate of each sample between Guy (1976) and this study. Guy's values are generally twice as high as those obtained here. There is no obvious explanation for this discrepancy, though greater validity could have

been achieved in the AENP study with greater sample sizes.

Other herbivores

The diet of the Addo elephants overlaps with a number of other herbivores which occur in the AENP, particularly browsers. This is significant because the effect of a herbivore on its habitat can not be measured in isolation. Its impact is inevitably compounded if resources are shared with other species. Comparison among herbivores identifies the plant species which are most heavily utilised and therefore most at risk. Black rhinoceros (*Diceros bicornis*), the other megaherbivore inhabiting the park, is primarily a browser. Woody plant species play an important role in their diet, such that Kotze & Zacharias (1993) found that the ten most frequently eaten species made up 80 % of the measured diet. Although Corcoran (1994) noted a preference for *Acacia* and *Euphorbia* spp. by black rhino, neither of which played a prominent part in diet of elephants, other food plants used in his study are favoured by elephant including *A. tetracantha*, *Rhus* spp. and *E. undulata*. No study specific to the kudu in AENP has yet been conducted, but Owen-Smith (*in litt.*, cited in Skinner & Smithers 1990) has established that in ECST they favour *P. afra*, *Aloe* spp. and *Euphorbia* spp., while 12 of the 16 preferred dietary species of bushbuck (Haschick 1994) also contribute to the diet of elephant. In view of the dominant role that elephants play in this ecosystem (78 % of vertebrate herbivore biomass (Stuart-Hill 1992)), it is likely that elephant feeding severely restricts forage availability for other browsers. This issue needs to be further investigated in order to understand the mechanisms by which these browsers coexist.

The inability of plant based methods to distinguish the effects of elephant feeding from those of other herbivores has been highlighted by Stuart-Hill (1992). Furthermore, Moolman & Cowling (1994) have suggested that without direct observation, it can not be ascertained whether variable levels and forms of impact are a function of differences between species or different stocking rates. Though this study has sought to identify the species and plant growth forms most at risk from elephant herbivory both in terms of frequency and volume consumed, the catholic nature of elephant feeding would suggest that a broader spectrum of species are at risk than the dominant dietary species listed in Table 1. Due to the fact that data were collected in one season only and during a period of unseasonably high rainfall, it is recommended that further research is conducted to provide a more comprehensive data set which accounts for seasonal and climatic variation. The effect of plant species availability on elephant foraging and the degree to which foraging is influenced by habitat specific factors was beyond the scope of this study but nevertheless merit further research.

Acknowledgements

The National Parks Board is thanked for permission to conduct the study at AENP, and the support and assistance of Park Warden F. Mketeni and Senior Game Ranger W. Erlank are gratefully acknowledged. A vehicle was generously provided by the Mazda Wildlife Fund and funding by the Foundation for Research and Developement.

References

ANON. 1977. Addo Elephant National Park records. Unpublished.

ALTMANN, J. 1974. Observational study of behaviour: sampling methods. *Behaviour* 49: 227–267.

ARCHIBALD, E.E.A. 1955. An ecological survey of the Addo Elephant National Park. *Journal of South African Botany* 20: 137–154.

BARRATT, D. & A. HALL-MARTIN. 1991. The effects of indigenous browsers on the Valley Bushveld of the Addo Elephant National Park. Pp. 14–16. *In:* ZACHARIAS, P.J.K., G.C. STUART-HILL & J.

MIDGLEY (eds.). *Proceedings of the First Valley Bushveld/Subtropical Thicket Symposium*. Howick: Grassland Society of Southern Africa.

CORCORAN, B. J. 1994. Foraging behaviour of the black rhino (*Diceros bicornis*) in valley bushveld. BSc Hons project, University of Port Elizabeth, Port Elizabeth.

COWLING, R.M. 1984. A syntaxonomic and synecological study in the Humansdorp region of the Fynbos Biome. *Bothalia* 15: 175–227.

EMSLIE, R.H. & K. ADCOCK. 1994. Feeding ecology of black rhinos. Pp. 65–81. *In:* PENZHORN, B.L. & N.P.J. KRIEK (eds.). *Proceedings of a Symposium on Rhinos as Game Ranch Animals*. Onderstepoort: Wildlife Group of the South African Veterinary Association.

EVERARD, D.A. 1987. A classification of the subtropical transitional thicket in the eastern Cape, based on syntaxonomic and structural attributes. *South African Journal of Botany* 53: 329–340.

FIELD, C.R. 1971. Elephant ecology in the Queen Elizabeth National Park, Uganda. *East African Wildlife Journal* 9: 99–123.

GEACH, B.G.S. 1997. The Addo Elephant National Park as a model of sustainable land use through ecotourism. MSc thesis, University of Port Elizabeth, Port Elizabeth.

GUY, P.R. 1976. The feeding behaviour of elephant (*Loxodonta africana*) in the Sengwa area, Rhodesia. *South African Journal of Wildlife Research* 6 (1): 55–63 .

HALL-MARTIN, A.J. 1992. Distribution and status of the African elephant (*Loxodonta africana*) in South Africa. *Koedoe* 35: 65–88.

HALL-MARTIN, A.J. & D.G. BARRATT (*in press*). The effect of elephants (*Loxodonta africana*) on thicket vegetation in the Addo Elephant National Park. *African Journal of Ecology*.

HASCHICK, S.L. 1994. Foraging and digestion by bushbuck (*Tragelephus scriptus*) and boergoats (*Capra hircus*) in captivity. MSc thesis, University of Port Elizabeth, Port Elizabeth.

HOFFMAN, M.T. & D.A. EVERARD. 1987. Neglected and abused - the eastern Cape subtropical thickets. *Veld and Flora* 73: 43–45.

JOHNSON, C.F. 1998. Vulnerability, irreplaceability and reserve selection for the elephant impacted flora of the Addo Elephant National Park, Eastern Cape, South Africa. MSc thesis, Rhodes University, Grahamstown.

KERLEY, G.I.H., M.H. KNIGHT & M. DE KOCK. 1995. Desertification of Subtropical Thicket in the Eastern Cape, South Africa: are there alternatives? *Environmental Monitoring and Assessment* 37: 211–230.

KOTZE, D.C. & P.J.K. ZACHARIAS. 1993. Utilisation of woody browse and habitats by black rhinoceros (*Diceros bicornis*) in Western Itala Game Reserve. *African Journal of Range and Forage Science* 10: 36–40.

LAWS, R.M. 1970. Elephants as agents of habitat and landscape change in East Africa. *Oikos* 21: 1–15.

LAWS, R.M., I.S.C. PARKER & R.C.B. JOHNSTONE. 1970. Elephants and habitat in North Bunyoro, Uganda. *East African Wildlife Journal* 8: 163–180.

LUBKE, R.A. 1996. Xeric Succulent Thicket. *In:* B. LOW & A.G. REBELO (eds.). *Vegetation of South Africa, Lesotho and Swaziland*. Pretoria: Department of Environmental Affairs and Tourism.

MIDGLEY, J.J. 1991. Valley Bushveld dynamics and tree euphorbias. Pp. 8–9. *In:* ZACHARIAS, P.J.K., G.C. STUART-HILL & J. MIDGLEY (eds.). *Proceedings of the First Valley Bushveld/ Subtropical Thicket Symposium*. Howick: Grassland Society of Southern Africa.

MOOLMAN, H.J. & R.M. COWLING. 1994. The impact of elephant and goat grazing on the endemic flora of South African succulent thicket. *Biological Conservation* 68: 53–61.

NOVELLIE, P. 1988. The impact of large herbivores on the grassveld in the Addo Elephant National Park. South African *Journal of Wildlife Research* 18: 6–10.

NOVELLIE, P. 1991. National Parks Board and Valley Bushveld. Pp. 11–13. *In:* ZACHARIAS, P.J.K., G.C. STUART-HILL & J. MIDGLEY (eds.). *Proceedings of the First Valley Bushveld/ Subtropical Thicket Symposium*. Howick: Grassland Society of Southern Africa.

PALEY, R.G.T. 1997. The feeding ecology of elephants in Eastern Cape Subtropical Thicket. MSc thesis. Imperial College, London.

PIENAAR, U. DE V., P. VAN WYK & N. FAIRALL. 1966. An aerial census of elephant and buffalo in the Kruger National Park and the implications thereof on intended management schemes. *Koedoe* 9: 40–107.

PENZHORN, B.L., P.J. ROBERTSE & M.C. OLIVIER. 1974. The influence of the African elephant on the vegetation of the Addo Elephant National Park. *Koedoe* 17: 137–158.

SEME, P. M. & N. TCHAMBA. 1993. Diet and feeding behaviour of the forest elephants in the Santchou Mountain Reserve, Cameroon. *African Journal of Ecology* 31: 165–171.

SKINNER, J. D. & R. H. N. SMITHERS. 1990. *The mammals of the Southern African Subregion*. Pretoria: University of Pretoria.

STUART-HILL, G.C. 1992. Effects of elephants and goats on the Kaffrarian succulent thicket of the eastern Cape, South Africa. *Journal of Applied Ecology* 29: 699–710.

VAN WYK, P. & N. FAIRALL, 1969. The influence of the African elephant on the vegetation of Kruger National Park. *Koedoe* 12: 57–89.

VILJOEN, P.J. 1990. Habitat selection and preferred food plants of a desert dwelling elephant population in the northern Namib Desert, SWA/Namibia. *African Journal of Ecology* 27: 227–240.

WING, L.D. & I.O. BUSS . 1970. Elephants and forests. *Wildlife Monographs* 19: 1–92.

WYATT, J.R. & S.K. ELTRINGHAM. 1974. The daily activity of the elephant in the Ruwenzori National Park, Uganda. *East African Wildlife Journal* 12: 273–289.

APPENDIX

Family	Species	Observations
Shrub		
Acanthaceae	*Hypoestes aristata*	7
Acanthaceae	*Isoglossa ciliata*	10
Acanthaceae	Unidentified	1
Anacardiaceae	*Rhus longispina*	6
Anacardiaceae	*Rhus pterota*	50
Apocynaceae	*Carissa haematocarpa*	4
Asparagaceae	*Protasparagus racemosus*	20
Asparagaceae	*P. striatus*	2
Asparagaceae	*P. suaveolens*	2
Asparagaceae	*P.* spp.	3
Asteraceae	*Brachylaena ilicifolia*	7
Asteraceae	*Osteospermum calendulaceum*	12
Asteraceae	*Pentzia globosa*	3
Asteraceae	*Senecio linifolius*	2
Capparaceae	*Cadaba aphylla*	1
Capparaceae	*Capparis sepiaria*	3
Celastraceae	*Cassine aethiopica*	11
Celastraceae	*Maytenus capitata*	11
Celastraceae	*M. heterophylla*	3
Celastraceae	*M. polyacantha*	3
Celastraceae	*Putterlickia pyracantha*	7
Chenopodiaceae	*Atriplex semibaccata*	6
Chenopodiaceae	*Chenopodium albium*	35
Ebenaceae	*Euclea undulata*	54
Fabaceae	*Acacia karroo*	17
Fabaceae	*Schotia afra*	22
Flacourtiaceae	*Dovyalis cafra*	2
Flacourtiaceae	*D. rhamnoides*	5
Flacourtiaceae	*Scolopia zeyheri*	1
Loganaceae	*Buddleja saligna*	1
Plumbaginaceae	*Plumbago auriculata*	14
Ptaeroxylaceae	*Ptaeroxylon obliquum*	1
Rhamnaceae	*Scutia myrtina*	3
Salvadoraceae	*Azima tetracantha*	32
Sapindaceae	*Pappea capensis*	4
Sapotaceae	*Sideroxylon inerme*	3
Solanaceae	*Lycium cinerium*	5
Solanaceae	*L. ferocissimum*	9
Solanaceae	*L. oxycarpum*	1
Solanaceae	*L. schizocalyx*	2
Solanaceae	*L.* spp.	26
Sterculiaceae	*Hermannia althaeoides*	3
Tiliaceae	*Grewia robusta*	3
Vitaceae	*Rhoicissus digitata*	2
Vitaceae	*R. tridentata*	5
Succulent		
Asclepiadaceae	*Sarcostema viminale*	5
Crassulaceae	*Crassula ovatum*	1
Dracaenaceae	*Sansevieria aethiopica*	2
Dracaenaceae	*S. hyacinthoides*	2
Euphorbiaceae	*Euphorbia mauritanica*	7
Mesembryanthemaceae	*Mesembyanthemum aitonis*	1
Mesembryanthemaceae	*Platythyra haeckeliana*	63
Mesembryanthemaceae	*Unidentified*	12
Portulacaceae	*Portulacaria afra*	89
Zygophyllaceae	*Zygophyllum morgsana*	8
Forb		
Aizoaceae	*Aizoon glinoides*	13
Aizoaceae	*A. rigidum*	1
Aizoaceae	*Galenia pubescens*	21
Asclepiadaceae	*Cynanchum obtusifolium*	2
Asteraceae	*Cuspidia cernua*	27
Asteraceae	*Cineraria lobata*	1
Brassicaceae	*Lepidium desertorum*	1
Commelinaceae	*Cyanotis speciosa*	24
Geraniaceae	*Galium spurium*	2
Geraniaceae	*Pelargonium peltatum*	1
Grass		
Poaceae	*Cynodon dactylon*	352
Poaceae	*Eragrostis curvula*	2
Poacene	*Panicum deustum*	49
Poaceae	*P.maximum*	17
Poaceae	*Stipa dregeana*	2
Poaceae	*Unidentifed*	5
Total all species		1 134