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Feeding behaviour of Giraffe *(Giraffa camelopardalis)* in Mokolodi Nature Reserve, Botswana

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Abstract

Feeding patterns of twelve giraffes were documented during the wet season from February to April in Mokolodi Nature Reserve in southeastern Botswana. The general aim of the study was to better understand how the giraffes sustain themselves in the Reserve. More specifically the study addresses different aspects of feeding modes and feeding preferences, time allocation between different activities and differences between males and females. We used focal-animal sampling and scan sampling to obtain relevant data. It was found that the giraffe mainly utilizes the canopy above two metres from the ground and that the *Acacia* zone was the most commonly used habitat. *Spirostachys africana*, *Combretum imberbe* and *Pelthopherum africanum* were the most highly preferred species in the different habitats. A significant difference between males and females was found for stripping rate where males had the lower rate, probable due to bigger size of male strippings. As we followed the giraffes in the reserve, a significant difference in time allocation to different activities was found between juveniles and adult giraffes. The juveniles tended to spend more time walking and playing around.

Key words: Botswana, Mokolodi, giraffe, browsing, species preference, Acacia,

Contents

1. Introduction

Botswana, in southern Africa, is a country mostly covered by dry shrub- and savanna grassland. Here, where domestic and wild large herbivores are of great importance, it is essential to understand the interactions between large herbivores and their food and the effects of grazing and browsing on the savanna environment. The giraffe (*Giraffa camelopardalis*) is one of the important species, not least as a part of the base for tourism. Tourism today contributes roughly 3 % to GDP in Botswana. It has been identified by the government as a potential source of economical growth and is a part of the government's diversification programme for the economy (Institute for Security Studies, 2001).

Giraffes live in dry savanna woodland, where tree species from genus like *Acacia*, *Commiphora*, *Combretum* and *Terminalia* dominate (Stuart and Stuart, 1997). The giraffes' height makes it possible for them to browse high up in the canopy and thereby avoid competition with other ungulates. This is especially beneficial during the dry season when food is scarce. Several studies have nevertheless shown that giraffes not always take advantage of this opportunity. According to a study in Tsavo National Park, Kenya, the giraffes browsed at a level higher than two metres in 63 % of the time in the dry season compared to 33 % in the wet season (Leuthold and Leuthold, 1972). In the western Transvaal, South Africa, Sauer et al (1977) found that 67.4 % of the browsing took place above 2 metres.

Foraging patterns of giraffe have been reported in several earlier papers. According to Pellew (1984a) there are several choices a giraffe makes that all decide how well giraffes sustain themselves and can meet the requirements for body growth and reproduction. The alternatives can be summarised as to how they make their choice of habitat and food items and the time spent on different activities. In a second paper Pellew (1984b) tested the efficiency of his ideas of feeding strategies in Serengeti National Park, Tanzania, and found that giraffes have similar rates of food intake as other African ungulates. But he also found that their intake is qualitatively better with a higher crude protein intake. Senft et al. (1987) outlined the parameters of foraging on several ecological levels, both on a spatial and temporal scale. On a community scale ungulates must solve different problems; which plants or plant parts to select and how to move through the community.

An important aspect is that many of the savanna trees not only have different chemical characteristics, but also have physical defences such as prickles and spines. A study on the effects of plant spinescence on the feeding of kudu (*Tragelaphus strepsiceros*), impala (*Aepyceros melampus*) and domestic goat in the northern Transvaal showed that browsers modify their mode of feeding due to mechanical defences (Cooper and Owen-Smith, 1986). Such results are also substantiated by Gowda (1996), who presented a more quantative view on spinescence. He found that an increase in spine density decreases the feeding rate of goats. A decrease in biomass loss was also found as a result of decreased feeding rate although the goats changed their feeding technique from pruning shoot tips to picking leaf clusters in order to compensate for the food loss. A later study on giraffe and goat showed how branches on living *Acacia* plants that had their thorns removed suffered greater herbivory (Milewski et. al., 1991).

Ginnett and Demment (1997) tested a hypothesis linking sex-related size dimorphism to differences in foraging behaviour of giraffes. The hypothesis states that males will display behaviours that increase their intake relative to females. The data showed that males spent less

time foraging than females, but more time ruminating. Males had a longer per-bite handling time, but took larger bites and consequently had a shorter handling time per gram of intake. These data led to a greater estimated intake rate for males.

Because of the shifting vegetation and seasonal differences, results from different areas are not directly comparable. Especially concerning species preference there can be difficulties in making comparisons. A study at Tsavo National Park by Leuthold and Leuthold (1972) showed that the five most important food plants during the wet season were totally different from those during the dry season. None of these species were represented in the diet list (>45 species) presented by Pellew (1984a) in a study performed in the Serengeti National Park. This clearly illustrates the variability of giraffe feeding habitats. It is therefore difficult to draw conclusions for successful giraffe population management without area-specific data.

The giraffe feeds almost exclusively on woody plants and is, consequently, a suitable object for a browsing study. We have conducted a Minor Field Study (MFS) on giraffe (*Giraffa camelopardalis camelopardalis*) at Mokolodi Nature Reserve, Botswana. Feeding patterns of twelve giraffes were documented during the wet season from February to April. The general aim of this study was to get a better understanding on how the giraffes sustain themselves in Mokolodi Nature Reserve by examining different aspects of their feeding patterns. More specifically the study addressed different aspects of feeding modes and feeding preferences, time allocation between different activities and differences between males and females.

2. Study area

The study was undertaken at Mokolodi Nature Reserve (24°45' S; 25°55' E) nearby Gaborone, the capital of Botswana, during roughly two and a half months from February to April 2000 (Fig. 1).

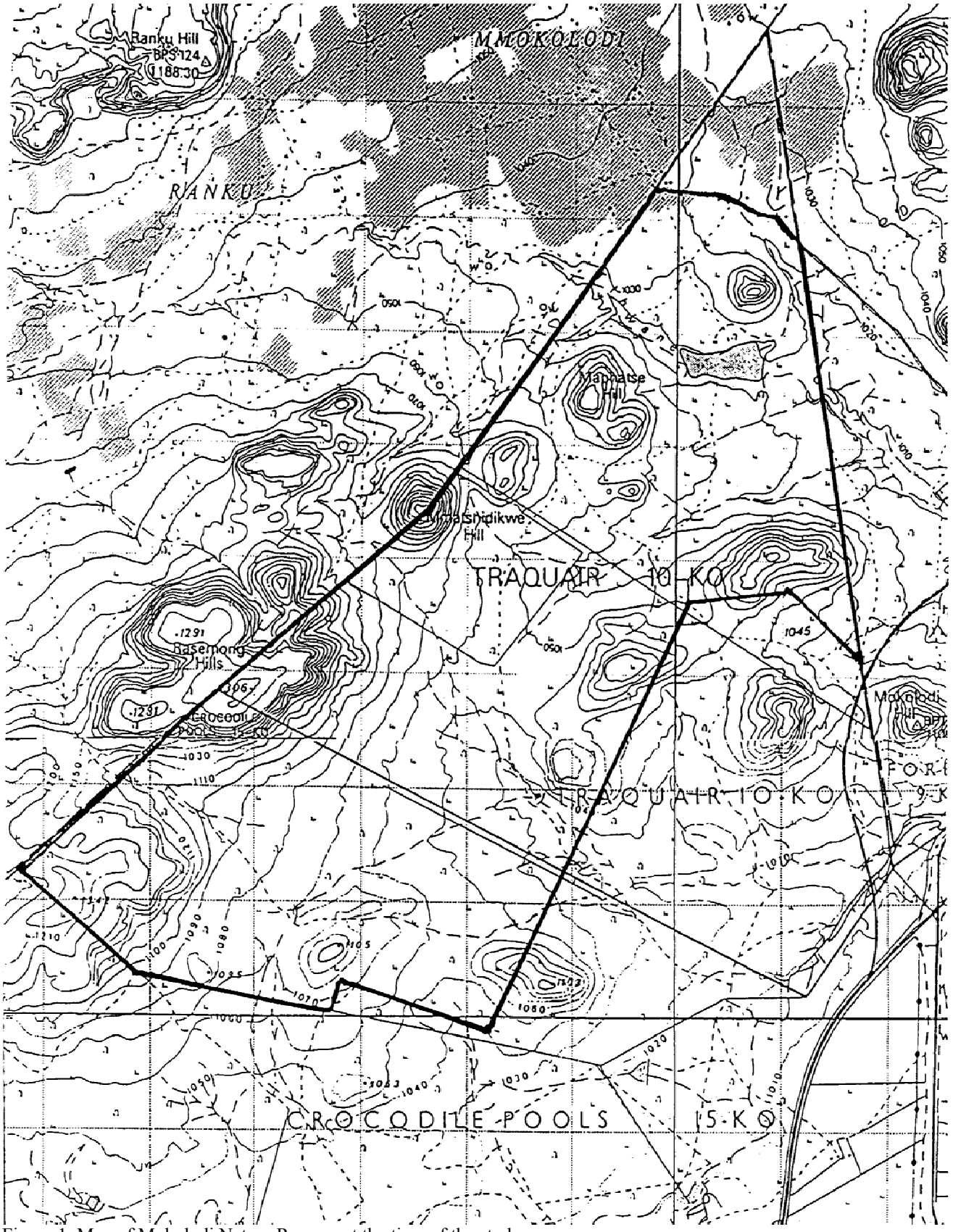

Figure 1. Map of Mokolodi Nature Reserve at the time of the study.

The reserve holds many of the animals earlier common in this part of Africa and aims to promote wildlife and conservation education (Table 1).

Table 1. Some of the animals that can be found at Mokolodi Nature Reserve. (Mokolodi Nature Reserve's species list of the year 2000.)

Aardvark	Hippopotamus	Pangolin
Aardwolf	Honey Badger	Polecat
Baboon	Hyena, Brown	Porcupine
Bushbuck	Hyrax	Reedbuck, Common
Caracal	Impala	Reedbuck, Mountain
Civet	Jackal, Black-backed	Rhinoceros, White
Crocodile	Jackal, Sidestriped	Springhare
Duiker, grey	Klipspringer	Squirrel, Ground
Eland	Kudu	Squirrel, Tree
Elephant	Leopard	Steenbok
Fox, Cape	Mongoose, Banded	Warthog
Gemsbok	Mongoose, Dwarf	Wildcat, African
Genet, Spotted	Mongoose, Slender	Wildcat, Blackfooted
Giraffe	Mongoose, White-tailed	Wildebeest, Blue
Hare, Cape	Monkey, Vervet	Zebra, Burchells
Hare, Red Rock	Ostrich	
Hartebeest	Otter, Cape Clawless	

The reserve is fenced and covered, at the time of the study, about 3000 ha. It is dominated by a mixed shrub and tree savanna. The altitude of the reserve ranges between 1020 and 1306 m above sea level and there is a clear zonation of the woody vegetation where three main types are recognised: *Acacia*, *Combretum*, and *Spirostachys* zone (Skarpe et al. 2000). The Acacia zone is the most widespread and is easily recognised by fine-leafed species like *Acacia tortilis* and *A. erubescens*. The *Combretum* zone is found preferentially on slopes and hills and is dominated by *Combretum apiculatum*. The *Spirostachys* zone is found along the narrow drainage lines of the Reserve, and is defined by containing *Spirostachys africana*. The long-term mean annual rainfall of Gaborone is 538 mm and the rain falls mainly during the summer season from November to April (Botswana Weather Bureau unpubl.).

Due to the heavy February rains in Botswana in the year of 2000, that was said to be the greatest in decades, the vegetation was lush in comparison to other years. The roads were badly damaged by the rains forcing the reserve to close for tourists for long periods of time. We could therefore conduct the study practically undisturbed by other people.

The giraffes were introduced into the reserve from Khutse Game Reserve in central Botswana. Due to a die-off among the giraffes, five of the females were introduced into the reserve shortly before our study. The population consisted of six male and six female giraffes. The population could be further divided into four male and two female adults, two subadults of each sex, and two juvenile females. In the beginning of the study, the birth of a baby giraffe (of unknown sex) increased the number of giraffes from 12 to 13 but no feeding observations were made involving the newborn giraffe. The giraffes could range freely throughout the reserve and group sizes varied during our study.

3. Methods

Two main methods have been used for the browsing study; focal-animal sampling and scan sampling (Altmann, 1974). In this way the giraffes were observed on two spatial scales; the selection of plants on the feeding site and the movement through the habitat. The study was conducted on 12 individually recognised giraffes. All observations were made by tracking the giraffe on foot. Observations were made through binoculars at distances ranging between 20 and 200 meters. Study objects were not consciously chosen in the beginning, but were observed as the opportunities showed themselves. During the end of the study, females and underrepresented individuals were chosen to even out the sampling sizes between sexes and individuals.

3.1 Focal-animal sampling

In the focal-animal sampling study, separate cases of feeding by individual giraffes were monitored. A total of 153 individual observations were made; 89 and 64 of males and females respectively. The number of feeding sites per giraffe is presented in figure 2.

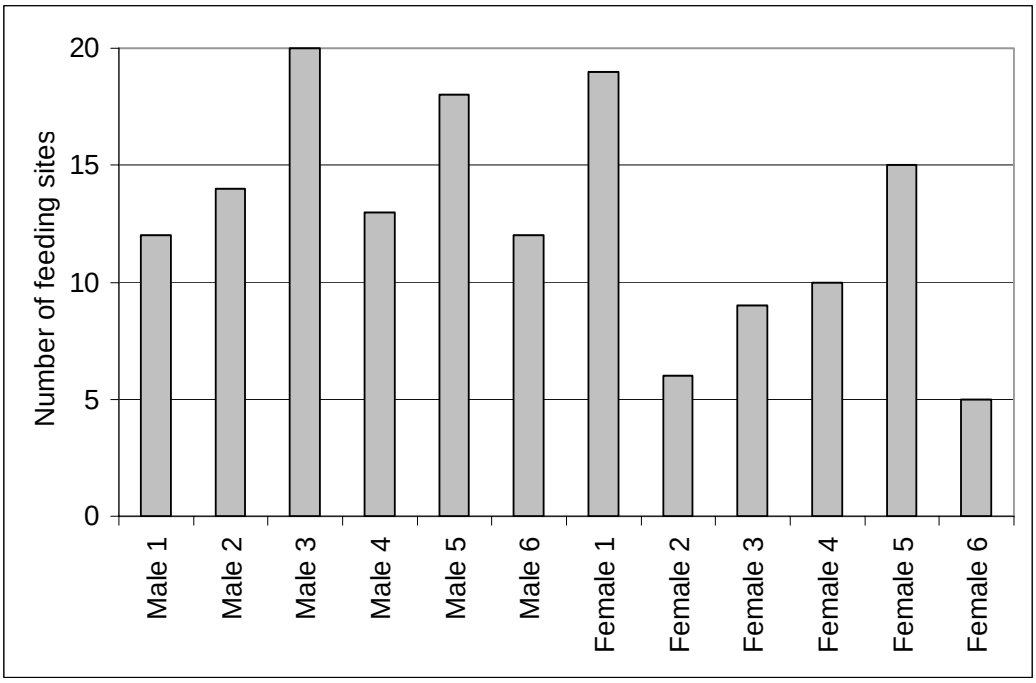

Figure 2. The number of feeding sites for the individual giraffes in the focal-animal scan sampling study.

One observation lasted from the moment a giraffe started to forage on a tree until it stopped and started to forage on another tree. If we could not monitor when a giraffe started to feed on a second tree the observation lasted until the giraffe went out of sight. The number of observations was spread as evenly as possible among the individuals.

Different modes of browsing were recorded:
A pick = a cluster of leaves picked with the teeth or lips
A strip = leaves stripped of twig using tongue or lips
Twig biting = a twig bitten off
A bite = unknown eating mode

When the browsing mode could not be discerned, it was recorded as a bite. This difficulty in identifying feeding modes was mainly due to vegetation obstructing the view.

During each observation, the height level of browsing was recorded for each action of food collection. The level of browsing was divided into six different heights (Fig. 3).

6 – above the head

5 – from the middle of the neck to the head

4 – from the back to the middle of the neck

3 – from the belly to the back

2 – from the knees to the belly

1 – below the knees of the giraffe

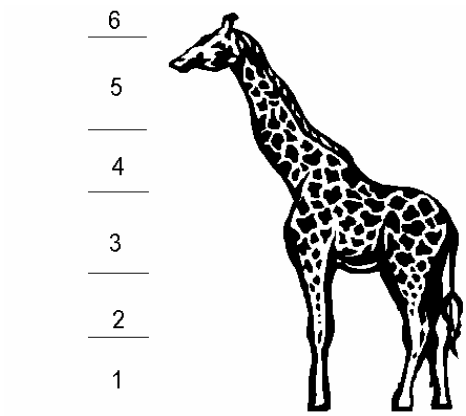

Figure 3. Giraffe browsing level was recorded for each action of food collection on all feeding sites. The relative height was divided into six levels beginning with level 1 on the ground and ending with level 6 above the head of the giraffe.

All observations were recorded on audiotape. During later listening to the recordings each action of food collection was timed to determine feeding rates.

During the focal-animal sampling vegetation samples were collected. On trees where an individual strip (a twig with leaves removed by a stripping mode) could be connected to browsing by a specific giraffe a replica of the strip was cut down using a clipper on a long stick. This replica was cut down from, approximately, the same height as the original and compared to the remains of the original to have a similar appearance and the same diameter at the point where the leaves had been removed. The length of the replica was measured and leaves counted and collected. To facilitate statistical analysis on strip samples additional samples were taken within the diameter range of the original samples. In the end of the study pick samples were taken mimicking giraffe picking behaviour.

Collected pick and strip samples were oven-dried and weighed to calculate mean rates of food intake according to equation (Pellew 1984b):

Mean rate of food intake = mean pick/strip rate *x* mean pick/strip mass
(g min^{-1}) (bites min^{-1}) (g $bite^{-1}$)

To determine species preference at the feeding site level a vegetation assessment was performed around every feeding site in a five m radius.

Tree species preference ratio (relative utilization) was calculated as:

$(F_a/F_b)/(S_a/S_b)$

where F_a is number of browsed trees of species *i* and F_b is total number of trees of all species fed on. S_a is the number of trees of species *i* in the vegetation assessment and S_b the total

number of trees of all species recorded in the vegetation assessment. All observations during the study were pooled and used to calculate species preference for the whole period of the study.

3.2 Scan sampling

A five-minute interval scan sampling was conducted during one day in the beginning of the study and one day at the end of the study (daytime for five and seven hours respectively). The activities were divided into ten categories and the sampling was conducted according to Altmann (1974). The categories used were; standing, walking, browsing, lying, standing/ruminating, walking/ruminating, lying/ruminating, galloping, looking at us and, finally, alternative activities. After locating the giraffe in the morning, we scanned the group every five minutes and recorded what every giraffe was doing. The individuals were scanned in the same order every time to maintain the time separation between observations. The data was used to calculate time allocation, part of total time spent on different activities. Periods when the giraffe could not be seen were excluded from the calculations.

3.3 Habitat use

The study area was divided into three vegetation zones (*Acacia*, *Combretum* and *Spirostachys* zone as described in chapter 2) and all of the observations were ascribed to one of the zones. Habitat use was calculated as the part (%) of all observations that was made in each vegetation zone. All the giraffes in the reserve were rarely together as one group and therefore general conclusions on habitat use for the whole population can not be drawn. However as we observed the giraffes, group sizes were often rather large and constituted a major part of the population. Our results can therefore be seen as a close estimate of the giraffe's preference.

4. Results

4.1 Level of Browsing

Males and females showed a difference in relative browsing height, where males preferred foraging on a higher level compared to females (Fig. 4). Level 5, i.e. mid neck to head, was the most common browsing level for males with 49.0 % of the browsing records. For females the most common browsing level was level 4, i.e. back to mid neck, with 40.4 % of the browsing records. Both males and females utilised the vegetation at level 1 and 2, i.e. under the belly, to a lesser extent. By using a chi-square analysis the two distributions were tested against each other and the results were significantly valid ($p<0.05$).

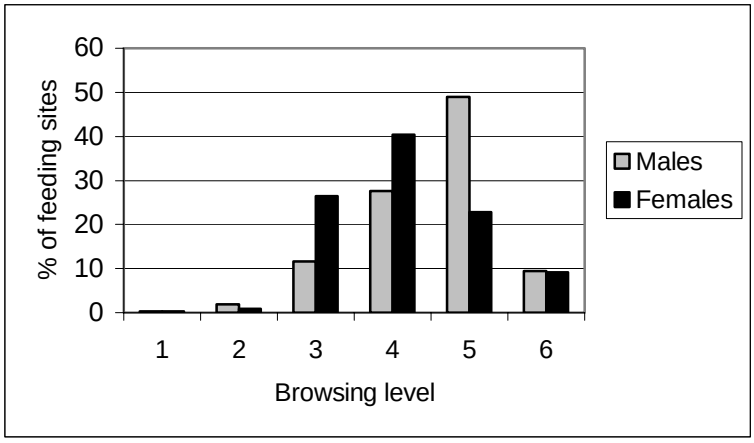

Figure 4. Distribution of browsing levels for male and female giraffes. Recorded levels of browsing were pooled from all feeding sites.

Among the trees, those with a height between three and four metres were most popular by male giraffes. For female giraffes trees between two and three metres were preferred. Trees lower than two metres were utilized only to a lesser extent by both sexes (Fig. 5).

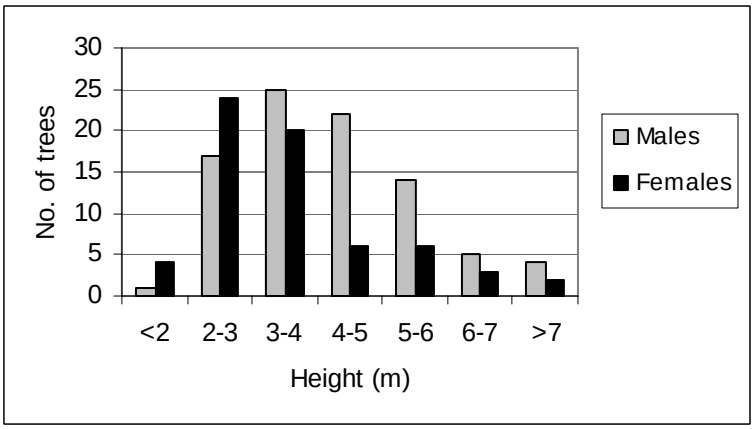

Figure 5. Height of trees browsed by male and female giraffes.

4.2 Species preference

At the feeding sites a total of 31 woody species were recorded. Sixteen of these species were browsed, with a total of 153 feeding observations. Parts eaten included leaves and, when available, soft small twigs. In the *Spirostachys* zone, *Spirostachys africana* was the most preferred species followed by *Acacia nilotica*. In the *Acacia* zone *Combretum imberbe* and *Ziziphus mucronata* were most preferred and so were *Peltophorum africanum* and *Acacia erubescens* in the *Combretum* zone (Tables 2-3).

Table 2. Values of relative utilization for all encountered species in the Spirostachys, Acacia and Combretum zones.

Species	S-zone	A-zone	C-zone
Acacia caffra		2.83	
Acacia erubescens	0.45	3.22	7.75
Acacia fleckii			1.99
Acacia grandicornuta	1.49	2.42	
Acacia mellifera	1.46	1.55	1.66
Acacia nilotica	3.16	2.94	

Acacia robusta	0.99		
Acacia tortilis	0.62	1.31	1.49
Carissa bispinosa			
Combretum apiculatum		0.59	0.38
Combretum imberbe		3.41	4.98
Dicrostachys cinerea		0.68	1.52
Dombeya rotundifolia			
Ehretia rigida		1.11	
Euclea spp.			
Grewia bicolor			
Grewia erubescens			
Grewia flava			
Grewia flavescens			
Grewia monticola			
Maytenus sp.		0.88	
Pappea capensis	2.98		
Peltophorum africanum			9.96
Rhus sp.			
Sclerocarya birrea			
Spirostachys africana	3.41		
Tarchonantus camphoratum			
Terminalia sericea			
Vitex sp.			
Vitex zeyheri			
Ziziphus mucronata		3.22	

Acacia species are preferred parts of the diet. As shown in table 3, three different *Acacia* species are among the most highly preferred in all vegetation zones.

Table 3. Values of relative utilization for the 5 most highly preferred species in the *Spirostachys*, *Acacia* and *Combretum* zones. Condensed results from Table 2.

S-zone		A-zone		C-zone	
Species	Relative utilization	Species	Relative utilization	Species	Relative utilization
Spirostachys africana	3.41	*Combretum imberbe*	3.41	*Peltophorum africanum*	9.96
Acacia nilotica	3.16	*Ziziphus mucronata*	3.22	*Acacia erubescens*	7.75
Pappea capensis	2.98	*Acacia erubescens*	3.22	*Combretum imberbe*	4.98
Acacia grandicornuta	1.49	*Acacia nilotica*	2.94	*Acacia fleckii*	1.99
Acacia mellifera	1.46	*Acacia caffra*	2.83	*Acacia mellifera*	1.66

4.3 Food intake

The time used by giraffe for the browsing mode "strip" showed a significant difference between sexes (t-test, $p< 0.001$). There was no detectable difference between sexes concerning "pick" (t-test, $p>0.05$). No value on twigs was obtained due to a low occurrence of twig-biting. Food intake by picking accounted for more than half of the recorded feeding observations. Mean rates of food intake were calculated for males (no estimate was collected for females) and the result for picking and stripping was 8.49 and 20.85 g min^{-1}, respectively.

There was no significant difference in bite rates between different tree species (t-test, $p>0.05$). There was a significant difference between males and females for stripping rate (t-test, $p<0.001$). There was no significant difference between males and females for biting and picking rate (t-test, $p>0.05$). No estimate for weight of female forage was obtained. Bite was an undefined feeding mode and therefore not tested for (Table 4).

Table 4. Time used for different modes of feeding expressed in percent. Bite samples for male pick and strip on S. africana are presented as dry weight (g/bite). No estimate was obtained for females. The time allocated to different modes of feeding for both sexes on all food species.
Data are mean±95 % Confidence Limits. *=Significant difference.

Feeding mode	% of feeding actions	Bite sample males *(g/action)*	Mean rate, males *(actions min^{-1})*	Mean rate, females *(actions min^{-1})*
Pick	64	0.33±0.13	32.2±1.3	35.6±1.8
Strip	10	1.08±0.64	26.5±2.1*	30.6±4.0*
Bite	26	-	28.5±1.8	31.4±3.0

4.4 Time allocation

The scan sampling resulted in 469 entries. When seen, the giraffe spent most of their time browsing (36 %), followed by walking (20 %) and standing-ruminating (16 %). They spent 10 % of their time looking at us. When comparing females to males, females spent more time actively eating and watching us, whereas males spent more time standing-ruminating (Fig. 6). No significant differences, however, were found (t-test, $p>0.05$).

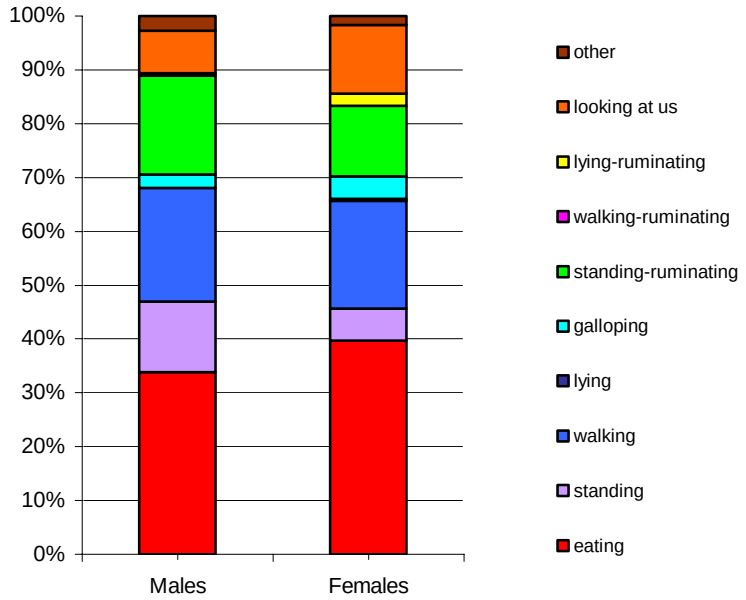

Figure 6. Time allocation for males and females according to five-minute scan sampling.

Comparisons were also made between adults, subadults and juveniles. The juveniles spent significantly more time walking compared to the others (t-test, $p<0.05$). Also juveniles spent less time standing-ruminating and more time on other activities (Fig. 7).

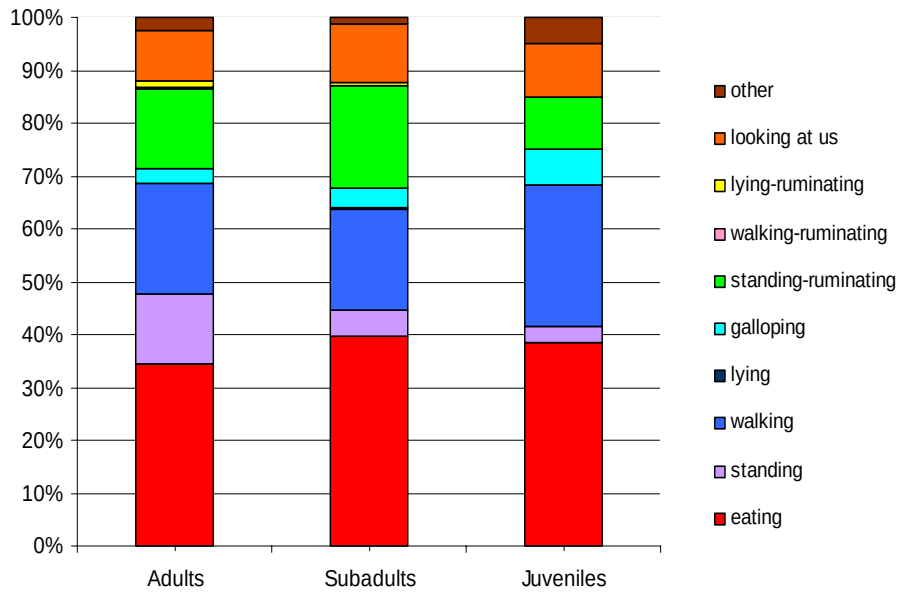

Figure 7. Time allocation for adults, subadults and juveniles according to five-minute scan sampling.

4.5 Habitat use

Judging from the number of observations the *Acacia* zone was the most popular habitat and was frequented at 50 %, followed by the *Spirostachys* zone (34 %) and *Combretum* zone (16 %). The giraffes ranged mainly in two different areas of the reserve. During the first month the major part of the giraffes spent their time in the central part of the reserve where the *Acacia* zone dominates. Here the pattern of movement was very similar between different days. They spent their nights close to one of the hills in the reserve where the vegetation was denser and moved to the more open areas in the day-time. During this time the dominant giraffe male and the pregnant female were elsewhere. During the second (and third) month the major part of the herd had moved to the southern part of the reserve. Here they ranged in all three different zones and the group composition varied more frequently. In general the younger males spent more time together and most of the females stayed together as a group with the juveniles and one or more of the older males. Because of the newborn the females were very edgy. The younger males on the other hand were calmer and often just stared at us when the females would run away.

5. Discussion

5.1 Level of browsing

The results of this study suggest that the upper vegetation layers are of great importance for feeding by giraffe. More than 80 % of the total browsing (males and females) were between level 4 and 6 which constitutes the upper half of the giraffe body (i.e. between two and five metres above ground). This contrasts somewhat to the findings in earlier studies. In Tsavo National Park 67 % of the browsing during the wet season was below two metres (Leuthold and Leuthold 1972) and in Nairobi National Park the giraffes browsed even more frequently below two metres (Wyatt, 1969). In western Transvaal results from a similar study showed that 67.4 % of all browsing were above two metres (Sauer et al 1977). Thus, the results of our study show greater similarities to the study in Transvaal. A reason for this could be that the vegetation is more similar between the Transvaal and Mokolodi than to the other areas. This

conclusion is also supported by the height of the preferred trees. In Mokolodi Nature Reserve, trees lower than two metres were selected in only about three percent of the total recordings. In this study we were not able to sort out the possible reasons for differences between different areas, but one may speculate that the differences could be a result of dissimilarities in vegetation structure or in inherent feeding behaviour. A high browsing pressure on lower levels by other large herbivores may also force giraffe to feed on higher levels.

Further, following the animals on foot in a flourishing savanna posed some problems. Where the forest was thick the giraffe would not let us get close enough to observe their activities. This most often happened in the *Combretum* and *Acacia* zones. Difficulties to observe also became apparent when the giraffe fed on the lower levels and were hidden behind the lower trees. Because of this we suspect that shrubs and smaller trees have been underrepresented in the study. In the *Spirostachys* zone, on the other hand, the forest was not as thick and vision was therefore not limited and sampling could mostly be conducted without problems.

5.2 Species preference

The preferred food species differed somewhat between the zones. No species was the most preferred in all three zones but four different species were among the five most preferred in two different zones (Table 3). This indicates that the giraffes have favourite food species to some extent but that there are differences between habitats.

The most highly preferred food species in the *Spirostachys* zone was *S. africana*. This species also had the highest number of feeding records but was not present in the two other zones. *S. africana* is also among the most highly preferred species in the study in Transvaal (Sauer et al. 1977). In that study there was a seasonal variation in the diet of the giraffes. During the wet season the animals selected their food mainly from deciduous species like *Z. mucronata* and *P. africanum*. Those results resemble ours as those species are among the most highly preferred also in our study. In Transvaal, *C. imberbe* had a higher preference index during the dry months compared to the wet months, while *S. africana* was marginally more popular during the wet season. Also, *A. nilotica* only made up 1.5 % of the total feeding stations and were of no greater importance.
In the wet season, food is probably not limiting and palatability may become the dominant selection criterion, which is one plausible explanation to the high preference for *C. imberbe* and *A. nilotica* in our study. Different methods for determining frequency of species in the habitat may also account for differences in reported preference of species

The high incidence of spines (≥60 % of top five species of each habitat) on species selected for seemingly contradicts the significance of plant defences. However, spines and thorns have been shown to primarily protect against twig biting (Milewski et al 1991, Gowda 1996b) and in this study we observed almost only leaf browsing. It was clear that by picking single leaves the thorns, on for example *Acacia* species, could be avoided. The picking was primarily done with the lips and the giraffe's technique doing so was very refined. Furthermore, as our results show, giraffes have the possibility to browse on different levels in the tree crown and can therefore find the youngest and still unprotected shoots.

Another browsing study at Mokolodi (Bråten 1997, Skarpe et al. 2000) showed different results from ours, both regarding preferred species and the presence of species with mechanical defences. The prior study concentrated on twig biting and the difference in studied foraging modes may account for the discrepancies observed. Also variations of

preferred species between species of browsers may explain the differences between the studies as we focused on giraffe and the twig biting studies included all large herbivores. For example, *Rhus* spp., that were top three food species in all habitats (Skarpe et al. 2000), were clearly avoided by the giraffes.

Our study showed the strongest negative selection for *G. bicolor, Euclea* spp. and *G. flava*. These species were abundant, but totally ignored by the giraffe. This could be a result of these species being shrubs and fairly low-growing. Noteworthy though is that *G. bicolor* is a common ingredient of giraffe diet in studies from other areas (Pellew 1984a). The avoidance of *G. bicolor* at Mokolodi Nature Reserve can be a reflection of palatability and availability of other species resulting from the food abundance during the wet season.

During our stay at Mokolodi, giraffes were seen chewing on bones on several occasions. According to Langman (1978) this could be used as an indicator of nutritional stress and to assess habitat deficiencies. But chewing on bones and also stones are thought to be important ways to supplement a browser's diet.

5.3 Food intake

Compared to a study from Serengeti (Pellew, 1984b), where mean bite rate was determined by feeding trials on three different woody species (*Acacia xanthophloea*, *A. tortilis* and *G. bicolor*) with captive giraffes, the bite rates from our study was about twice as high. This could reflect differences in methods, e.g. that our data are the sum of all species observations. Mean bite rate for *A. tortilis* (both males and females) in our study was 22.39±0.17 bites min^{-1}, which is still higher than the 16.9 bites min^{-1} in the Serengeti study.
Our calculation of dry weight intake per bite of *S. africana* is much lower than recorded intake from Serengeti (Pellew 1984b). And even though the species are different we believe this could reflect a true difference in dry weight intake per bite. As such, the higher biting rate at Mokolodi could be a way to compensate for the lower per bite intake.
In a study from England (Clauss et al. 2001) captive giraffes had an energy deficit due to low food intake, but they were willing to eat more if more palatable food sources were made available.

The seemingly abundant food at Mokolodi and the observed chewing on bones in addition to lower calculated food intake in comparison to other giraffe studies paints a complicated picture. Additional data need to be collected to be able to draw any conclusions of the nutritional status of the giraffe.

Our data showed a significant difference between males and females for stripping rate. The males took fewer strips per minute. The longer handling time for males can be a consequence of the bigger size of male bites. There was no significant difference in bite rates on different plant species. Nevertheless, more spinescent species seem to demand a longer handling time.

5.4 Time allocation

An earlier study (Pellew 1984a) showed a difference in time allocation between sexes. Males, compared to females, tend to allocate more time on look-out for predators and spend less time to browsing. We could not find any significant difference in activities between the males and females at Mokolodi Nature Reserve. We think this could be an adaptation to the circumstances at Mokolodi. There are no predators (important for giraffes) roaming the

reserve and culling and other restrictive measures have not been used, so the time males in the wild usually spend as look-outs can be used for other purposes. The total number of observations was lower than in other studies and additional data could discern if results from other studies apply to the giraffes at Mokolodi as well. However, during the study, female giraffes seemed more at edge and were more often found to be looking at us. This difference in behaviour may be due to the fact that most of the females had recently been introduced to the reserve. The only significant difference in time allocation was between juveniles and older giraffes when it came to walking. The fact that the small ones spent more time walking may be because they simply were more curious about the surroundings.

5.5 Habitat use

The *Acacia* zone was the most used zone in the study followed by the *Spirostachys* zone and the *Combretum* zone. Most of the reserve is ascribed to the Acacia zone and it is therefore not surprising that the giraffe spend most of their time in this habitat. The *Spirostachys* zone was utilised 34 % of the time and this is more than would be expected from the occurrence of *Spirostachys* habitat alone. One of the reasons for this is probably that the *Spirostachys* zone is an open habitat where it is easier for the giraffe to see their surroundings and easier for us to observe them. As previously mentioned, *S. africana* is also a highly preferred species.

The semi-deciduous *Combretum* zone was only to a small extent utilized. This was also the case in Transvaal (Sauer et al 1977). There, *C. apiculatum* was utilised only in the last month of the dry season during severe nutritional stress. In Mokolodi, the *Combretum* zone was found on the rocky hillsides and was partly covered by thick vegetation which made it more difficult for the giraffes to move around and to be on the lookout for dangers. This could be a reason why it is not more often frequented and used for foraging.

5.6 Conclusions

This study will add to the overall knowledge on browsing by giraffes and other ungulates. Our studies were made during the (very) wet summer season in a relatively small, fenced reserve in the southern part of Botswana. The unique conditions in the reserve posed some unique problems and parts of the results are probably direct consequence of that. Due to the often thick vegetation it was sometimes surprisingly difficult to keep up with the giraffes and we spent a lot of time tracking the animals. Making estimations on how old certain footprints were, became a sometimes important part of the everyday studies. On the other hand, due to the relatively small size of the reserve, we soon learnt the most probable locations of the giraffes and how to get there by using shortcuts through the bush. Compared to other studies, the lack of predators in Mokolodi might also influence how the giraffes spend their time between different activities.

In general, our results show more similarities to results from southern Africa than from east Africa. This is valid for species preference, where species like *S. africana, C. imberbe, Z. mucronata and P. africanum* are among the most preferred in the different habitats. It is also true for the level of browsing, where our results show that over 80 % of the total browsing was between two and five metres above the ground, as well as for habitat use, where the Acacia zone was the most the most frequently used and the *Combretum* zone was used only to a lesser extent. These patterns are not surprising as Botswana and South Africa show a great resemblance in habitats and vegetation.

The lower food intake in comparison to other studies and the observations of giraffes chewing on bones could indicate nutritional stress but the results are not conclusive enough to draw any further conclusions.

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