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SPATIAL ORGANIZATION OF THE KASUNGU ELEPHANT

by

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SUMMARY

Using a recognition file that was compiled during the study, information on movements of individually known elephants was collected over two periods, one of three and one of eight months, in 1978 and 1981/82, respectively. There appeared to be a relationship between the number of animals in the family unit and the size of the home range / activity area, probably as a result of food competition between the members of a unit. Since 1978 the size of the home range / activity area had decreased in general, as a result of compression by illegal activity. Dry-season home ranges of family units appeared to be rather stable over longer periods and larger than the wet-season home ranges that were situated along the river Lingadzi. Dry-season home ranges of bulls only lasted throughout a single dry season. During the wet season bulls ranged over an extended area. In the later part of the dry season, elephant movements were determined by salt licks and the remaining water holes with a relatively high conductivity, at a distance of the river Lingadzi. The social structure of the family units that made up a kin-group determined the time spent with each other and also appeared to influence the actual size of the home range.

RÉSUMÉ

Un fichier réalisé au cours de cette étude a été utilisé pour rassembler l'information obtenue sur les déplacements d'éléphants individuellement connus, pendant deux périodes, l'une de trois mois en 1978, l'autre de huit mois en 1981/82. Il y a une relation entre le nombre d'individus dans l'unité familiale et l'étendue du domaine vital / territoire d'activité, ceci probablement comme résultat d'une compétition pour la nourriture entre les membres d'une unité. Depuis 1978, l'étendue du domaine vital / territoire d'activité s'est généralement amoindrie, comme résultat d'une compression provoquée par des activités humaines illégales. Les domaines peuplés par les unités familiales pendant la saison sèche se sont montrés plus étendus et assez stables pendant de plus longues périodes, en comparaison avec les zones d'habitat situés le long de la rivière Lingadzi pendant la saison humide. Les territoires des mâles pendant la saison sèche ont seulement une durée d'une saison. Pendant la saison humide le territoire occupé par ceux-ci est nettement plus vaste. Pendant la partie finale de la saison sèche, les déplacements des éléphants étaient déterminés par l'emplacement des sources salées et de ce qu'il restait de trous d'eau à concentration saline relativement élevée, loin de la rivière Lingadzi. La structure sociale des unités familiales formant un clan, détermine le temps que chaque individu passe en compagnie des autres, et influence aussi l'étendue réelle du domaine vital.

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INTRODUCTION

The Kasungu National Park, situated in the central region of Malawi, comprises an area of 2450 km² with a vegetation predominantly composed of *Brachystegia/Julbernardia* woodlands. Its altitude ranges from 1000 to 1500 m. The distribution of elephants over the Park is changing continuously due to spatial changes in poaching activities (Bell et al., in prep.). At the moment the distribution is very uneven, most elephants being concentrated in the southeastern part of the Park, as a result of a combination of habitat preference (Bell, 1982) and compression by illegal activity (Bell et al., in prep.). Without significant reductions in elephant numbers, the size of the elephant stratum has decreased by approximately a factor of three since 1978 (Bell et al., in prep.). This situation provides an opportunity to investigate the stability of home ranges situated in the centre of the elephant stratum and the influence of migration towards this centre, as a result of the compression by poaching. In this context it is interesting to examine long-term changes in spatial organization and its possible influence on the social organization of the separate groups and the population as a whole.

Information on movements of family groups and males was collected by using the method of visual identification. A limiting factor of this

method is found to be the low frequency in which particular individuals and family units are encountered in woodland habitat. The number of sightings of the units and bulls mentioned in this paper is limited in some cases. However, it is felt that the material might be of good use, in view of the fact that the work will not be continued for a number of years. The present research forms part of an ecological study that began in July 1978, for a period of three months, and was continued in September 1981, for a period of eight months.

METHODS

Fig. 1 shows the Kasungu National Park with its extensive river systems. The study was mainly carried out in the area around the river Lingadzi, between the Lifupa Wildlife Lodge in the west and the Park Gate in the East (the area is indicated by the dotted line in fig. 1). A Landrover or a motorcycle was used to locate elephants; every group was noted, while date, place of encounter, direction of group movement, and size, sex composition and family structure of the groups were collected. A photographic recognition file of the individual elephants was initiated in 1978 and proved to be a satisfactory method for recognizing both individuals and family units. On several occasions, during both surveys, family units and solitary bulls were followed on foot for at least half a day. During these observations the distance moved per time unit was noted. In fig. 2 the road system of the central region of the Park is shown. During both surveys the roads were travelled at random as much as possible. In addition, excursions on foot were made in those regions were the road system did not penetrate.

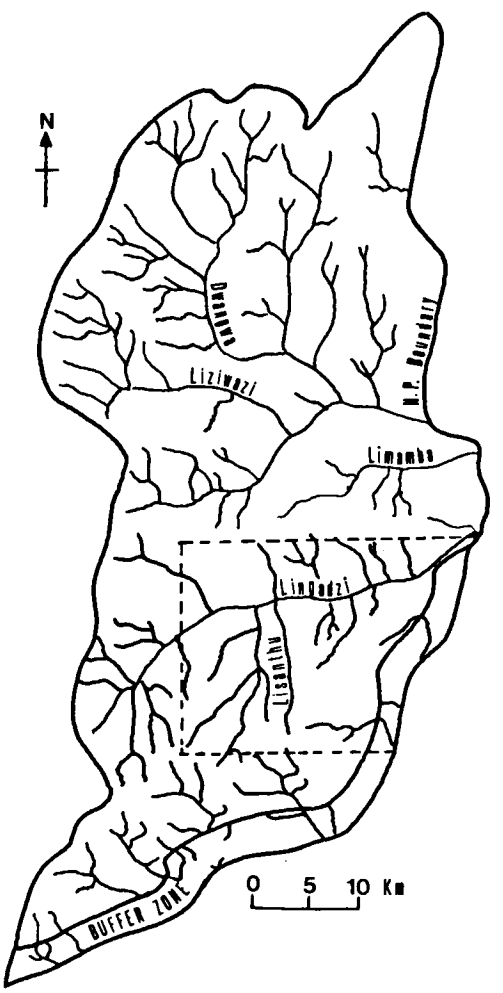

Fig. 1. The Kasungu National Park with its extensive river systems. The survey area is indicated by the dotted line.

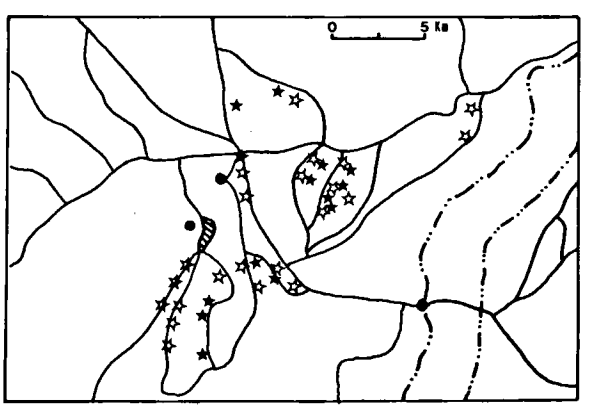

Fig. 2. Network of dirt roads, all running parallel to the rivers. Water holes (open stars) and salt licks (filled stars) at the end of the dry season of 1981. Dots indicate camps.

RESULTS

Home ranges and activity areas

In fig. 3 the number of sightings of three family units and two solitary bulls that were seen on more than five occasions during the dry season is plotted against the size of the home range to

give an estimate of the minimum number of sightings (N_m) needed to calculate the dry-season home range. With the exception of family unit U10, N_m was 6 in all cases. N_m depends on the size of the home range, the ranging behaviour of both the elephants and the ecologist and the state of the vegetation (visibility). The ranging behaviour of the elephants and the state of the vegetation are reasonably constant over the season, while the ranging behaviour of the ecologist was kept as random as possible.

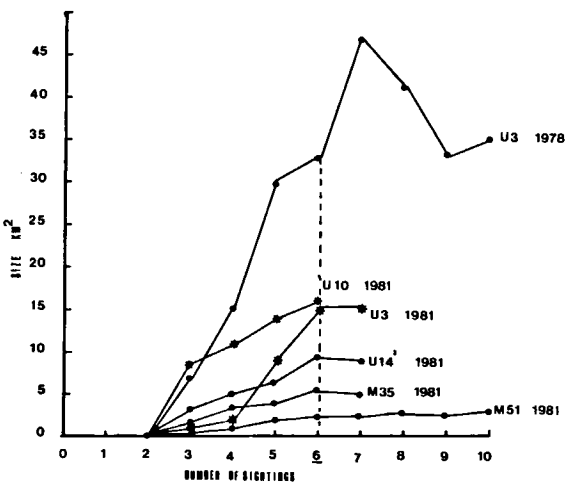

Fig. 3. Plot of number of sightings against size of home range for those family units and males that were seen more than five times at irregular intervals during the dry season of one of the surveys, or both surveys (U3).

As will be shown in this section, the size of the home range depends amongst others on the size of the unit and N_m will increase with an increasing home range. However, in the Kasungu National Park, a thousand elephants are compressed in an area of approximately 200-400 km², depending on the season (Bell et al., in prep.). This results in relatively small home ranges and it is felt that a minimum number of sightings of six for the dry season can be used to calculate the size of the dry-season home range.

During the wet season the visibility in the woodlands decreases. However, wet-season home ranges are mainly concentrated in the open canopy *Terminalia/Combretum* woodlands of the Lingadzi area where during the wet season the visibility is about similar to that of the *Brachystegia* woodlands during the dry season. The minimum number of sightings for the three wet-season home ranges shown in fig. 6 is estimated as seven.

Of those family units and bulls that were sighted on only four or five occasions per season, activity areas were constructed. The activity area is merely an approximation of the home range. The number of sightings for each family unit, solitary bull and bull herd mentioned in this paper is shown in table I.

A total of five family units, four solitary bulls and one bull herd were sighted on at least four occasions during the dry season of 1978. Most of these units and bulls were resighted in 1981/82; however, only three units were sighted on more than four occasions per season, while most bulls were only sighted once or twice. Of

TABLE I

Family units and males with the size of their seasonal home range / activity area and the number of sightings (n.s.). Of those units and males with only four or five sightings, the size of the activity area is given (1978 and 1981 are dry-season home ranges / activity areas, while 1982 are wet-season home ranges).

		size of home range / activity area					
Units	*n* of animals	1978	n.s.	1981	n.s.	1982	n.s.
U55	2			4	5		
U24	4	17	4				
U35	5	16	4				
U3	6			17	7	15	8
U62	7			11	4		
U13	7	22	4				
U3	8	35	10				
U10	11			16	6	5	9
U14	29	156	4				
U14'	15			9	7	9	9
Males							
M8	1	11	4				
M35	1	10	7				
M25	1	15	5				
M43	1	6	5				
M50	1			3	4		
M51	1			3	12		
M15&16	2	18	4				

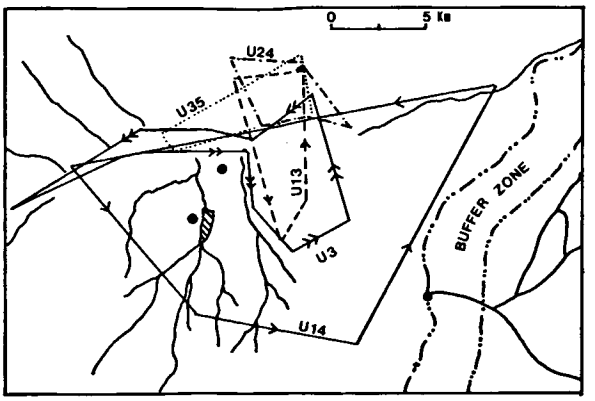

Fig. 4. Provisional home ranges and activity areas of five family units that were sighted on at least four occasions during the dry season of 1978.

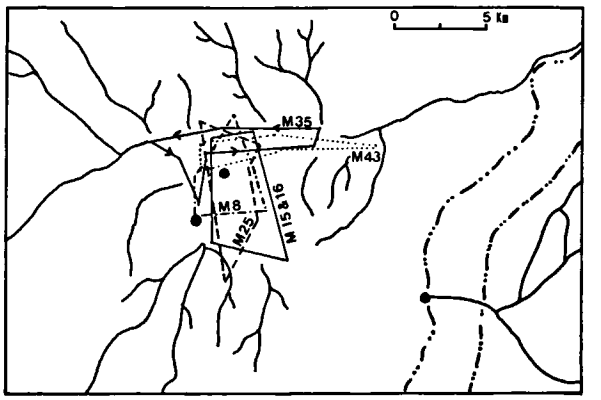

Fig. 5. Provisional home ranges and activity areas of four solitary bulls and one bull group that were sighted on at least four occasions during the dry season of 1978.

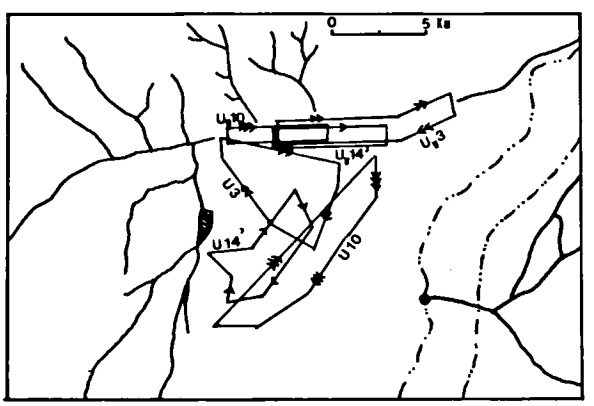

Fig. 6. Provisional home ranges of three family units that were sighted on at least six occasions during the dry season of 1981 and the wet season of 1981/1982. Wet-season home ranges are indicated by U_w and are all situated along the river Lingadzi. (The 1978 dry season home ranges of these units are shown in fig. 4.)

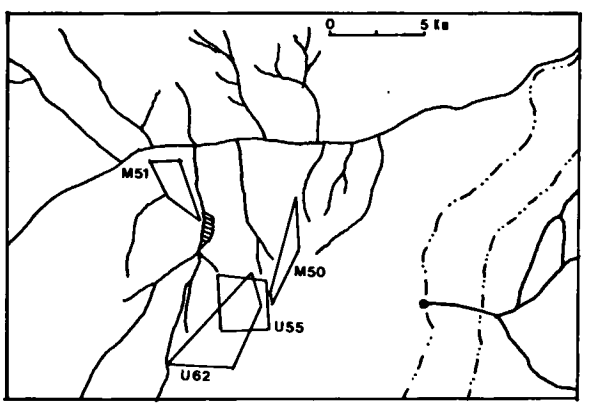

Fig. 7. Activity areas of two family units (U) and two solitary bulls (M) during the dry season of 1981.

those family units and bulls that were sighted on more than four occasions per season, provisional dry- and wet-season home ranges and activity areas were constructed (figs. 4-7).

Figs. 4 and 5, respectively, show the home range and activity areas of five different family units (U), and four different solitary bulls (M8, M25, M35 and M43) and one group consisting of two bulls (M15 and M16), during the dry season of 1978. Fig. 6 shows the home ranges of three family units during the dry season of 1981 and the wet season of 1981/82, the latter indicated by U_w. All three wet-season home ranges are located along the river Lingadzi. Fig. 7 shows the activity areas of two family units which have not been mentioned previously and the activity areas of two solitary bulls, during the dry season of 1981.

Table I summarizes the size of these home ranges and activity areas in relation to the season and the number of animals in the group. As shown in table I, since 1978 family unit U14 has split into two separate groups of which only one group of fifteen animals (U14′) has been

TABLE II

Regression analysis of unit size and size of the home range / activity area for the dry season only, where solitary bulls were taken as the smallest unit (n = number of units).

Year	season	n	correlation coëfficient (r)	slope	intercept
1978	dry	10	0.983 ($P<0.001$)	5.159	0.162
1981	dry	7	0.608 ($P<0.10$)	0.677	4.842
1978&1981	dry	17	0.850 ($P<0.001$)	4.196	-3.468

sighted on more than four occasions per season during the most recent survey. The other group has been sighted on only one occasion.

Table II shows the regression analysis of the number of animals in the unit (solitary males were taken as the smallest unit) with the size of the home range / activity area. There appears to be a significant relationship between the number of animals in the unit and the size of the home range / activity area, probably as a result of food competition between the members of a unit. The fact that the relationship is significant suggests that the activity areas constructed with only four or five sightings are a reasonable approximation of the true home range areas.

Home ranges / activity areas overlap considerably, both among the family units and bulls and between the adult sexes. The data also show that home ranges / activity areas of family units can be relatively stable over a longer period. Family unit U3, for instance, had its home range in exactly the same area during both surveys (figs. 4 and 6), with only a slight shift towards the east during the most recent survey. During this last survey, family unit U35 and U24 (fig. 4) were both sighted twice in the eastern part of their 1978 activity area. Wet-season home ranges of the units that were repeatedly sighted were all situated along the river Lingadzi (fig. 6) and appear to be smaller than the dry-season home ranges (table I).

There are several factors influencing the spatial organization of the Kasungu elephant: illegal activity, habitat preference in combination with seasonal differences in quantity and quality of the food supply, mineral availability, social organization of the population and least of all, water availability (Bell et al., in prep.). Illegal activity is the main factor causing the continuously changing distribution of elephants in the Park (Bell et al., in prep.). Shifting of home ranges, situated in the periphery of the elephant stratum, is most likely also due to shifts in poaching activities.

According to the data presented in table II, the size of the home range area has decreased in general over the past four years. Numbers of elephants have not changed significantly over this period (Bell et al., in prep.), while without any disturbance there would be more than enough available woodland to allow the elephants to disperse. The only likely factor to cause a general decrease in home range size is the compression due to illegal activity. However, one should not forget that the limited amount of data might introduce bias in the results.

The increased quantity and quality of the food supply in the tall grass area of the Lingadzi region is most likely the main factor determining the location and size of the wet-season home ranges.

None of the adult males, for which the 1978 home range and activity areas were constructed and which are presented in fig. 5, were found in that same area during the last survey, and it is concluded that in the Kasungu National Park, home ranges of adult males are temporary. The males leave their home ranges in February and wander through the main clan area along the river Lingadzi until the end of March. This is the mating season (Jachman, 1980; in press) and from aerial survey data (Bell & Jachmann, unpubl.) it appeared that the males that inhabit the northern region of the Park also travel to the Lingadzi area during this time of the year. There appear to be no fixed routes that specific adult males follow during this time of the year and as such, during the wet season, home ranges of male elephants probably cover most of the elephant stratum.

Movements

During the dry season, the main directions of elephant movements observed were N.N.E.-S.S.W. and vice versa, almost parallel to the river Lingadzi, and E.-W. conversely during the wet season. Fig. 2 shows the water holes (open stars) and salt licks in the elephant stratum during the later part of the dry season of 1981. The water holes that remain in the Lingadzi riverbed are not indicated. Elephant movements during this time of the year are determined by the water holes and salt licks shown in fig. 2. These water holes have a much higher conductivity than those remaining in the Lingadzi riverbed (Bell, unpubl.), which remain unused almost throughout the year.

Table III summarizes the information collected on the distance travelled per day by family units and solitary males. There appears to be no difference between the distance travelled per day in 1978 and 1981/82. However, the figures for the last survey are a mean for both the dry- and wet season. Adult males tend to travel more during the mating season (mid wet season), which explains the somewhat higher figure for solitary males during the last survey. The lower figure for the five family units during the last survey can be explained by the fact that family units travel less during the wet season due to an increase in food quality and quantity in combination with a higher intake of grasses.

TABLE III

Distance travelled per 24 hours for several family units and solitary males.

Year	season	distance (km per 24 hours)	number of units or males in sample
1978	dry	2.7 ± 0.8	6 family units
1981/1982	dry/wet	2.5 ± 1.4	5 family units
1978	dry	1.0 ± 0.2	5 solitary males
1981/1982	dry/wet	1.2 ± 0.3	4 solitary males

Spatial organization in relation to social organization

The stable basic unit of the population, the family unit, can be divided into three main structures: (1) The "matriarchal structure", where the unit consists of an adult female with her offspring, of which one or more adult daughters might have reproduced already. In this unit, the difference in age between the two oldest females should be at least eleven years (in the Kasungu National Park). In a sample of 29 well-known groups, 62.0% were of a matriarchal structure. (2) The "sibling structure", where the unit consists of two or more sisters with their offspring. These unit structures could be identified by the differences in age between the adult females in combination with similarities in typical characteristics of tusks and ears. In the sample, 24.1% of the groups were of a sibling structure. (3) The remaining groups in the sample (10.3%) consisted of two similar aged adult females with their offspring. Douglas-Hamilton (1972) has pointed out that ties between individuals are probably strongest between calves of similar age, although of different mothers. Depending on the type and condition of the environment in combination with the elephant density, there is an optimal group size. Assuming that ties between individuals are strongest between calves of similar age, the breaking up of larger groups in a population where 86.1% of the groups consists of mainly sisters with their offspring is most likely to lead to newly formed groups in which the adult females are cousins. Therefore we call this third category of groups the "cousins structure".

Several closely related units form a kin-group (Douglas-Hamilton, 1972). Although the data are scanty, there appears to be a correlation between the time spent together and the degree of kinship between the members of the different units forming a kin-group. Family unit U3 for instance has a typical matriarchal structure and consists of a matriarch with her two adult daughters with offspring. During 25 observation periods, U3 was never sighted with other elephants in the vicinity. Family unit U14′ on the other hand, was sighted in aggregations of up to 30 elephants on several occasions in both seasons, while it also happened that the basic group of 15 animals broke up into 3 distinct family units for a limited period of time, each

with a sibling structure (the "cousins structure" is also a sibling structure). The size of the home range of U14' is extremely small, while that of U3 is relatively large (table I and fig. 6). In 1978, U14 consisted of 29 animals. However, in between October 1978 and September 1981 the group must have broken up in two groups, both utilizing part of the former home range. This process of breaking up might be a gradual process where the two separate groups still frequently join up into larger aggregations. A possible result of this gradual process might be that the area utilized by each group is limited to a minimum in order to meet the rest of the kin-group as frequently as possible.

The members of unit U3 have a docile character, which makes them easy victims for poachers. In addition, during the observation periods it appeared that the maternal behaviour of the 40 year old matriarch was unsatisfactory, which resulted in two of her calves being eaten by lions when only half a year old. The unit decreased from a potential ten animals in 1978 to six animals in late 1981. This unit must have been low in number for a great number of years and was never forced to break up into several groups. The lack of social bonds with other groups seems to result in a relatively large home range. From the data it appears that depending on human disturbance and food availability, the structure of the unit determines the time spent with other units within that kin-group. A unit with a cousins structure for instance, consisting of two adult females with their offspring, will have a far more comprehensive family system with more closely related kin than a similar sized unit with a matriarchal structure.

DISCUSSION

In contrast to other conservation areas in East Africa (Leuthold, 1977), rainfall has little direct influence on the distribution of elephants in the Kasungu National Park. Since 1978 there have been no great fluctuations in the amount of rainfall over the whole season, which is approximately 800 mm per year, while the actual size of the elephant stratum is too small to have long-term differences in rainfall in different areas of the stratum. The only direct influence of water availability is noticeable at the end of the dry season, when elephant movements are determined by the remaining water holes, and at the start of the wet season, when the elephants leave their dry-season home ranges and disperse towards those areas where the first rainfall occurred (Jachmann & Bell, unpubl.). These first movements at the onset of the rains are largely unpredictable as has also been observed by Leuthold (1977) in the Tsavo National Park, Kenya. Indirect influence of rainfall, acting through its effect on the primary production, is of course very important during the first part of the wet season. Many wet-season home ranges seem to be situated near or at least overlapping the Lingadzi river area with its relatively high quality grasslands during this time of the year. Family units with home ranges overlapping the south bank of the Lingadzi have not altered the situation over the past four years, while in addition there is no need for a seasonal shift. Family units with home ranges overlapping the north bank of the Lingadzi seem to move southwards during the dry season, due to a sharp increase in poaching activities in that area (Bell et al., in prep.) and move back during the first part of the wet season. The majority of family units that have their dry-season home ranges south of the Lingadzi will move towards the south bank of the Lingadzi during the wet season, also implying a seasonal shift.

Wet-season home ranges, situated in the Lingadzi area, appear to be relatively small. During most of the wet season, the Kasungu elephants eat mainly green grass and small amounts of green browse (Jachmann, unpubl.), which has also been observed in other elephant populations (e.g.: Barnes, 1982; Hanks, 1969; Wyatt & Eltringham, 1974; Leuthold, 1977). In contrast to the majority of tree species occurring in the *Brachystegia/Julbernardia* woodlands, grasses contain low concentrations of toxins (Barnes, 1982), which, in combination with the increased quantity of the food supply, explains

the relatively small home ranges (i.e. elephants do not have to avoid ingesting lethal doses of toxins, which is presumably one of the reasons for large dry-season home ranges). However, due to the limitations of the method in combination with the period of time spent in the field, little information is available on wet-season home ranges outside the Lingadzi area.

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