Seasonal variation of feeding patterns and food selection by crop-raiding elephants in Zimbabwe

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Abstract

Elephants and humans are increasingly coming into conflict because of the conversion of elephant habitat into agricultural areas. In order to identify trends that influence raiding behaviour, the nutritional makeup of food items consumed by crop-raiding elephants over a 2-year period were analysed and a trigger for crop raiding was identified. The point at which the quality of wild grasses declines below the quality of crop species corresponded to the movement of bull elephants out of a protected area and into fields. This finding may have wider implications for developing predictive models of elephant/human interactions.

Key words: crop-raiding, elephants, food selection

Résumé

Les éléphants entrent de plus en plus souvent en conflit avec les hommes en raison de la conversion de leur habitat en terres agricoles. Pour identifier les tendances qui influencent les pillages, on a analysé pendant deux ans la composition nutritionnelle des aliments consommés par les éléphants lors du pillage des récoltes et identifié ce qui déclenche les pillages. Au moment précis où la qualité des herbes sauvages tombe en dessous de celle des cultures, les mâles éléphants sortent de l'aire protégée pour aller dans les champs. Cette découverte pourrait avoir des implications plus vastes, dans le développement de modèles prédictifs des interactions hommes-éléphants.

Introduction

Crop-raiding by elephants is a major conservation concern in Zimbabwe. This behaviour occurs during the cropping season, but its onset is highly variable. In an effort to identify what triggers elephants to raid crops, I determined the role of crops in the overall feeding ecology of the elephants in a protected area in south central Zimbabwe. This study presents the feeding patterns of bull elephants that raid crops and illustrates how seasonal changes in forage quality influence crop-raiding behaviour. The objective of this study was to determine whether changes in the quality of food available to elephants influences the onset of crop-raiding behaviour.

Studies of feeding by African *Loxodonta africana* and Asian *Elephas maximus* elephants has been approached from three general perspectives: (i) descriptive observations of feeding behaviour in the wild; (ii) measurement of various indices of condition from culled animals; and, more recently, (iii) assessments of the chemical composition of food items.

Studies in Africa have demonstrated the diversity of feeding behaviour that elephants exhibit under different environmental conditions (e.g. Wyatt & Eltringham, 1974; Barnes, 1982; Ruggiero, 1992). In general these studies have examined the daily activity patterns, plant selection and defecation rates. Studies conducted on culled elephants have investigated nutritional variation relating to the condition of animals during the period of collection. Various parameters were measured relating to seasonal differences in body condition (e.g. Laws, Parker & Johnstone, 1975; Malpas, 1977; Sharp, 1982; Meissner *et al.*, 1990). Several studies have attempted to assess the factors that influence diet selection in different habitats (Barnes, 1982; Jachmann & Bell, 1985; Jachmann, 1989; De Villiers *et al.*, 1991; Lindsay, 1994). From the above mentioned studies a number of trends emerge. Elephants spend from 70 to 90% of their time foraging and consume between 100 kg and 300 kg (wet mass) of vegetation per day (Wyatt & Eltringham, 1974; Guy, 1976b). Elephants are generalist feeders and tend to eat what is available to them, but they can be very specific about which parts of a plant they eat and when.

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Elephants will choose the food that offers the highest rate of nutrient intake at any given place or time. The main types of food available to elephants during this study were grass and woody browse. Grass and browse have their relative advantages and disadvantages. For grass, intake rates are higher (it is easier to harvest and handle), it is lower in toxins and when its nutrient content is high, its fibre content low (Lindsay, 1994), it also provides a return per unit time feeding that is higher than browse. It may, however, lack certain essential key nutrients and when it matures its nutrient content becomes very low. Browse offers generally higher levels and diversity of nutrients, but toxin and lignin levels are also higher (Jachmann, 1989). In addition bark and woody twigs require more handling time, especially when they are lignified or have thorns. Like grass, intake rates for crops are high and they have few if any chemical or physical defences. Crops retain their high nutrient value as they mature and, unlike grass, have low fibre content when mature.

Guy (1976a) noted that the diet of elephants in Zimbabwe shifted from mainly grass in the wet season to mostly browse in the dry season. This trend has been observed in a number of studies in southern Africa (Sharp, 1982; Lewis, 1986) and East Africa, (Wyatt & Eltringham, 1974; Laws *et al.*, 1975). Lindsay (1994) concludes that after 'a long and rather pointless debate', elephants are recognized as being both browsers and grazers and can fulfil energy requirements from either browse or grass, depending on availability and quality. In areas of abundant green grass, elephants graze, but browse makes up the majority of the annual intake of most elephant populations in southern Africa, where grass availability is highly seasonal (Williamson, 1975).

During the preliminary phase of this study, it was observed that elephants did not necessarily begin to leave the protected area when the crops planted along the boundary were mature. If crop raiding was not linked to the availability of crops, then it was hypothesized that this behaviour may be related to the quality and availability of wild foods.

Study area

The study area is situated in the Sebungwe region of Zimbabwe, in and around the Sengwa Wildlife Research Area (SWRA) and covers an area of 390 km^2. The study area also included fields along the SWRA boundary that are referred to in Zimbabwe as Communal Lands (CLs). A single rainy season usually occurs between November and April, but is highly variable in timing and quantity. The mean annual rainfall is 668 mm (n = 30). The mean annual temperature is 22°C with a range from a maximum of 35°C in October to a minimum 4°C in July. The vegetation is generally dry deciduous savanna woodland. The main vegetation associations are *BrachystegiaJulbernardia* woodland, *Colophospermum mopane* woodland, *Acacia* spp. riparian woodland, riverine grasslands and *Combretum* thickets.

The rainfall regime varied in timing and amount during the 2 years of this study. The variation in the rains affected grass and crop growth that in turn affected elephant feeding patterns. Rainfall during the 1994/95 seasons was below average (287.7 mm), and above average for the year 1995/96 (708 mm).

Three general seasons occur; a hot-wet season, (November to April), a cool-dry season (May to mid-August) and a hot-dry season (mid-August to November). The delineation of seasons is somewhat arbitrary and the onset and duration of a 'season' in the study area can vary considerably from year to year. For the purposes of this study the three seasons were subdivided into early-wet season (EW = mid-December to February), late-wet season (LW = March to mid-May), early-dry season (ED = mid-May to mid-July), mid-dry season (MD = mid-July to mid-September) and late-dry season (LD = mid-September to November). Grass and crops were only collected during the EW and LW. Browse was collected during all the subdivided seasons but were lumped together in 'wet' and 'dry' for analysis.

Methods

All plants on which elephants were observed to feed in the study area were identified through the herbarium at the National Botanical Garden in Harare. Owing to the diverse diet of the elephant and the number of different species of plants available to them in the study area, a subsample of plants was collected for chemical analysis. I used Guy's (1974) 25 species of browse and five species of grass preferred by elephants. For woody plants only leaf material was sampled and for grass and crops the entire plant, without roots, was sampled. The crops sampled were all members of *Gramineae* (maize, sorghum and millet) and were collected in fields adjacent to the SWRA. The majority of samples were collected after observing an elephant feeding on a plant then waiting

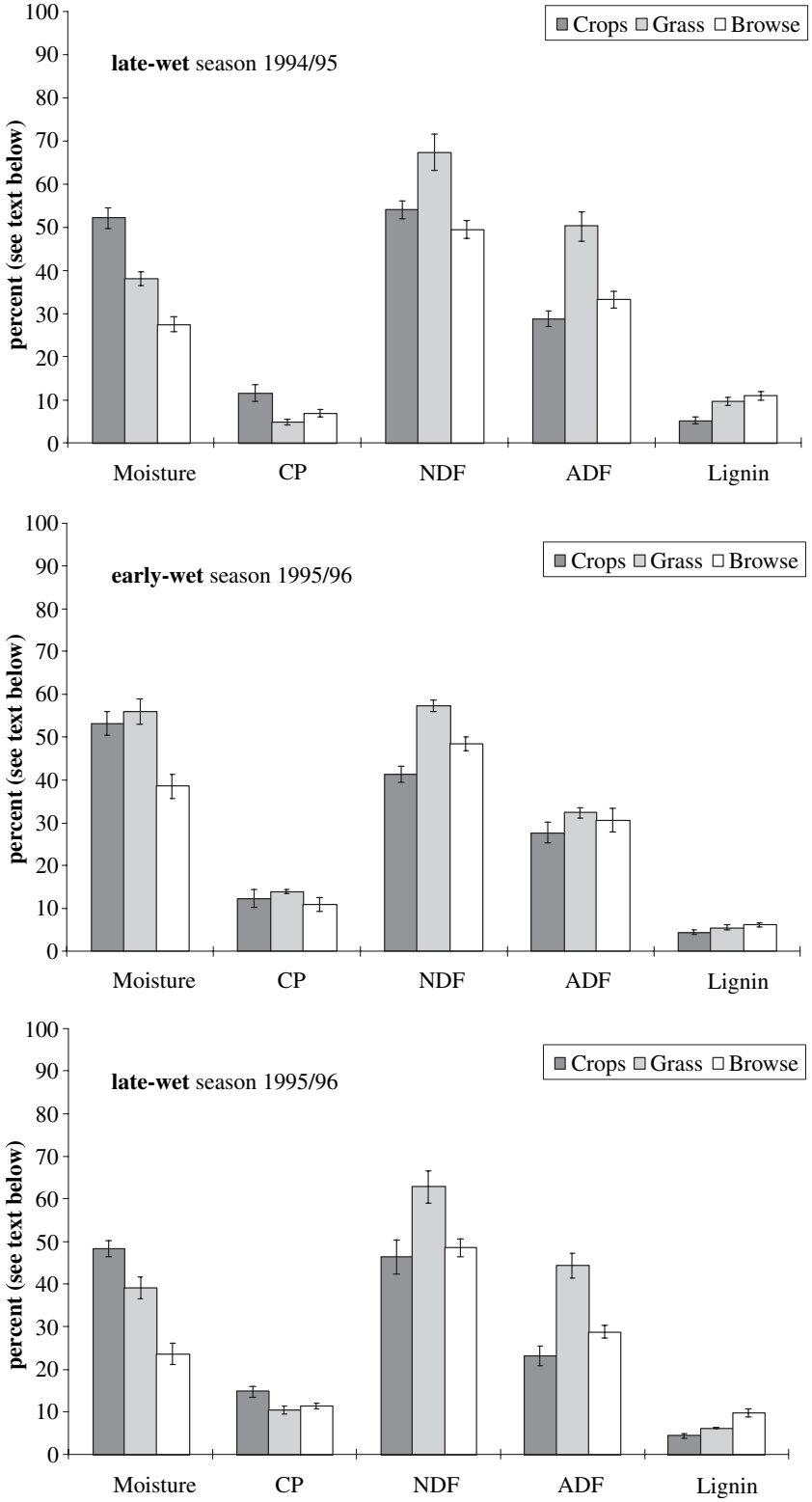

Fig 1 Comparison of the mean values for crops, grass and browse during the late-wet (1994/95), the early-wet (1995/96) and the late-wet (1995/96). The *y*-axis represents the percentage of the total sample for moisture and represents the percentage of dry matter for CP = crude protein, NDF = neutral detergent fibre, ADF = acid detergent fibre and lignin

until the animal had moved away. Two periods were selected for the grass and crop sampling; December 1994 to April 1995 and December to April 1996.

Total digestible nutrients were calculated by the method of Le Roux & Sithole (1974). The crude protein (CP) content of vegetation samples was measured using the standard Kjeldhal method and fibre analyses were made using the technique outlined by Goering & Van Soest (1970).

Statistical tests used were the unpaired *t*-test and ANOVA with Bonferroni modified Least Significant Difference test with a $P = 0.05$. Samples were not collected for all three vegetation categories in all seasons during 1994/95 so only the LW season is presented for this year, as the late-wet season is the period of crop-raiding.

The southern SWRA boundary was patrolled to identify the location where elephants left or entered. The spoor of elephants crossing into the CLs was examined to determine the number of animals and the direction of travel. The number of crossings was assessed taking the mean number of elephants crossing out of and back into the SWRA on any given day.

Results

There was a significant difference between moisture and crude protein for the monthly grass samples collected between January and April (1995–96) between years and across all months. The differences between the moisture content and CP values of grass sampled in the EW and the LW were significant. The values for neutral detergent fibre (NDF) were significantly higher in the LW season, but the differences were not significant for acid detergent fibre (ADF) or lignin.

Moisture values for browse samples were obtained for all five seasons. The CP values were collected in all but the EW season and values for fibre were pooled and 'wet' (samples collected between January and April) and 'dry' (samples collected between May and November) samples were compared. CP values of the browse plant parts did not vary significantly from season to season. No significant seasonal variation in mean moisture or lignin content of browse was found across seasons. There was, however, a significant difference for NDF and ADF. Pooled samples collected in the EW and the LW during the 1995/96 seasons showed no significant seasonal variation in moisture, CP, NDF, ADF or lignin content of browse.

The differences between the moisture values between all food types were significant. Crops were significantly higher in CP than either browse or grass. The fibre content of the crops sampled was generally lower than for the other categories. For NDF and ADF grass values were significantly higher and the grass NDF values were significantly higher than crops or browse. The lignin values for the browse samples were significantly higher than for grass or crops.

The moisture values for grass and crops were significantly different during the EW season of 1995/96 with the moisture value for browse significantly lower than the other values. The values for CP, ADF and lignin were not significantly different. Values for NDF were significantly higher for grass. The differences among the moisture values for grass, crops and browse samples were significant in

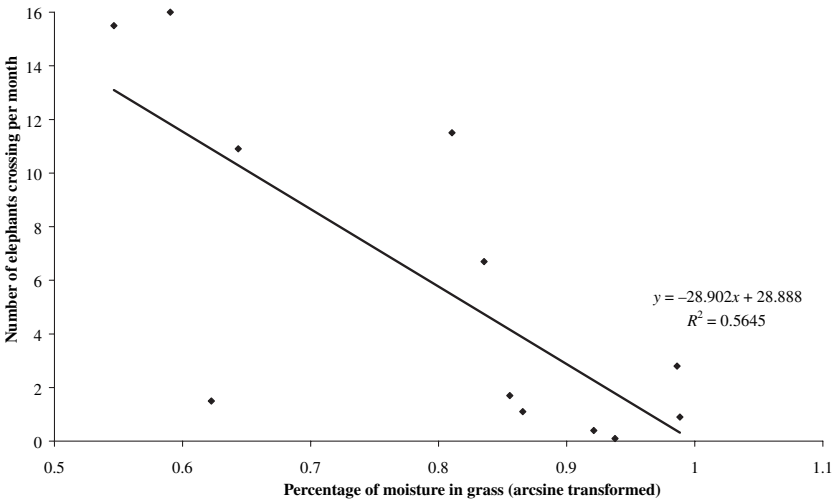

Fig 2 Plot of the mean monthly moisture content for grass and the mean number of elephants crossing out of the SWRA per month between January and April 1995 and 1996. The percentage moisture has been arcsine transformed as the data are percentages (Persons $r = 0.751$, $P = 0.001$)

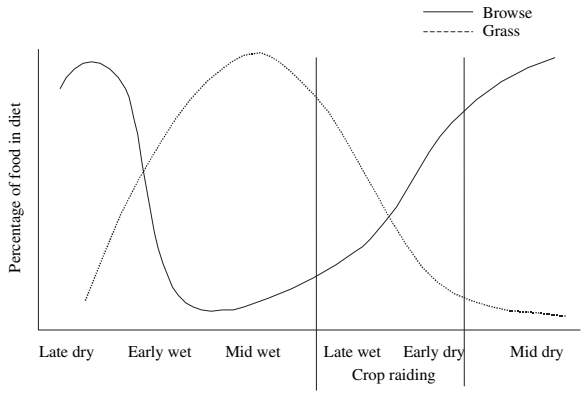

Fig 3 Hypothetical model of the relationship between the percentage of browse and grass in the diet of elephants that raid crops in the SWRA across 1 year. The vertical lines show the period when crop raiding occurs

the LW season 1995/96. The differences between the means of the moisture values for crops were significantly higher relative to the values for browse and grass. The CP values for crops were also higher than for the other two categories. The NDF values were significantly higher for grass compared with browse and crops as were the ADF values and browse was higher in lignin (Fig. 1).

Figure 2 illustrates the relationship between grass moisture and elephants crossing the SWRA boundary into the CLs. The monthly means for crossings and grass moisture are plotted against each other showing a significant correlation. When grass moisture is high, crossings are low and when grass moisture is low, crossings are high.

The results for the 2 years suggest similar trends in the seasonal changes in quality, but the decline in quality occurred more rapidly in the drier year (1994/95). In general, the quality of all three forage categories (browse, grass and crops) was not significantly different in the early-wet season of either year. As the wet season progressed, the quality of crops and grass declined while that of browse stayed relatively constant. The 'quality' of browse, as measured by the above techniques, did not change significantly from season to season and is therefore a steady and reasonably nutritious food source; whereas crops and grass are ephemeral and seasonal in availability and quality. These determinations do not take into consideration the accumulation of plant chemical defences or the seasonal availability of some browse food items (e.g. deciduous trees). The results of this survey suggest a number of trends. (i) In the early-wet season, there is little difference in nutrient quality between grass, crops and browse, (ii) in the late-wet season, the quality of grass drops more quickly than the quality of crops or browse and (iii) browse quality stays fairly constant between wet and dry seasons.

Discussion

Through sampling food items selected by crop-raiding elephants, a correlation was identified between wild food consumption and the timing and intensity of crop damage. The results of this study indicate that the onset of crop raiding and the quality of grass toward the end of the wet season are linked. The switch between grass and browse was earlier in the 'dry' year (1994/95) than in the 'wet' year (1995/96). In the dry year, the transition from consumption of grass to the consumption of browse occurred in late March/early April. Because of the erratic rainfall, many of the annual grasses died off before flowering. During the 'wet' 1995/96 season, the transition occurred in late May.

As grass ages its moisture content drops and it becomes more abrasive and fibrous, thus causing increased wear on teeth and a decline in digestive efficiency. McCullagh (1969) found that there is decrease in the digestibility of protein when the protein content of a food item is low and the fibre content high. Elephants consume more browse as the quality of abundant food items, such as grasses, forbs and climbers, declines. Thus the motivation or 'trigger' for crop raiding during any particular wet season may be a decline in the quality of wild grasses.

A hypothetical model of the relationship between grass, browse and crops is shown in Fig. 3. The period when crop raiding begins in the SWRA appears to be linked to the late-wet season transition, as shown by the early onset of raiding in the wet season during the drought year (1994/95) and the delay seen in the 1995/96 seasons. If this hypothesis is correct, the period when elephants will begin to raid can be predicted from the rainfall pattern and the pattern and rate of grass growth observed in the early-wet season.

Elephants appear to be selecting the maximum amount of highly nutritious food available to them throughout the year as opposed to selecting the most available food. Crops maintain their nutrient quality after wild grasses become desiccated, and remain low in fibre compared with wild grasses. Bulls, who for social reasons are more likely to engage in 'risky' activities, may then select crops to fill the nutritional gap that may exist during the transition from grass to browse.

The comparison of the three main food items available to elephants in the late-wet season indicates that crops provide a food resource higher in quality than wild foods (low in fibre, high in moisture and CP).

Conclusions

The percentage of browse in the diet was high during the late-dry season and dropped off rapidly in the early-wet season when elephants began to consume large quantities of grass. As the amount of grass in the diet dropped off, the amount of browse increased and crop raiding takes place during this transition.

Elephants raid crops when the quality of the preferred food item, grass, begins to decline in their natural habitats. This may be because of the fact that it is just not worth the effort to move into the CLs and risk harassment when the quality of the grass is roughly equivalent to that of the crops. When grass quality and availability begins to decline, it becomes worth the risks associated with raiding crops. If this is a correct assessment of the processes governing elephant motivation to raid crops, then the trigger for crop raiding is predictable.

Acknowledgements

I wish to thank the Department of National Parks and Wildlife Management, Zimbabwe, K. Eltringham, K. Lindsay, N. Leader-Williams. The Wildlife Conservation Society and the USFWS funded this study.

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(Manuscript accepted 23 June 2004)