

Diet and feeding behaviour of the forest elephant

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Ce travail décrit le régime et le comportement alimentaire des éléphants de forêt dans l'Ouest du Ghana.

Les éléphants se nourrissaient surtout de feuilles et de branches d'arbres. L'herbe, rare dans la forêt, était en proportion négligeable dans ce régime. Trente-six espèces de fruits ont été consommées dont 9 ont constitué la partie principale du régime : *Antrocaryon micraster*, *Irvingia gabonensis*, *Klainedoxa gabonensis*, *Myrianthus arboreus*, *Panda oleosa*, *Parinari excelsa*, *Strychnos aculeata*, *Tetrapleura tetraptera* et *Vitex ferruginea*. C'est pendant la saison sèche que les éléphants ont disposé de la plus grande variété de fruits. Les éléphants ont enlevé l'écorce de 20 espèces d'arbres et particulièrement de 7 d'entre elles : 44 à 100 % des arbres de ces espèces étaient endommagés.

Les éléphants broutaient en forêt claire quand la végétation forestière était facilement accessible. Ils aimaient spécialement les lianes ligneuses. C'est plutôt en forêt dense qu'ils se sont nourris d'écorce et de fruits.

Les éléphants prenaient leur nourriture en tirant à eux les rameaux terminaux ou en dépouillant les branches de leurs feuilles. Rarement ils ont brisé, déraciné ou écorcé les troncs des arbres.

INTRODUCTION

The elephant (*Loxodonta africana*) has been the subject of considerable research in East and Southern Africa. However, to date, little or no information is available on elephants from the tropical closed-canopy forests of West and Central Africa, a significant part of its range. Elephants in this part of Africa are usually given subspecific status — *Loxodonta a. cyclotis* Matschie (Grassé, 1955 ; Laws, 1970).

This paper describes the diet and feeding behaviour of elephants in Bia National Park in the forest belt of western Ghana. Aspects of the diet and feeding behaviour of elephants in forest in East Africa have been studied by Wing and Buss (1970) and by Laws, Parker and Johnstone (1975). Alexandre (1977) studied the role of the elephant in seed dispersal in the Tai Forest, Ivory Coast. His paper indicates the great variety of fruits utilized by elephants of the West African forests.

Martin (1977) estimated that elephants occur over approximately 1350 square kilometers at Bia. Density of elephants within the Bia National Park averages 0.33 km², with a seasonal peak in the dry season related to the availability of fruit within the Park (Short, in prep.).

The study was conducted between July, 1977 and January, 1978.

STUDY AREA

Bia National Park covers 75 km². The 225 km² Bia Game Production Reserve (G.P.R.) adjoins the southern boundary of the park, farmland and secondary forest bordering the park to the north, east and west. The park lies on the watershed separating the Bia, Sukusuku and Esupri rivers. Topography is generally flat, altitude varying between 170 and 200 m.

Rainfall averages 1 500 mm per annum with peaks in May-July and September-October. Streams and swamps within the park become dry soon after the end of the rains. Permanent water is found only in "elephant pools", scattered thinly throughout the park. These pools appear to be dug and maintained by elephants.

The vegetation of the park is lowland tropical rain-forest with characteristics (species composition, structure) of both moist evergreen and moist semi-deciduous forest (Hall and Swaine, 1976 ; Hall, Swaine and Lock, 1976). Emergents rise to a height of 50-60 m. Some are deciduous in the dry season. Woody lianes, slender climbers and epiphytes are common. The forest is indistinctly stratified. Common upper canopy trees include *Pycnanthus angolensis*, *Triplochiton scleroxylon*, *Strombosia glaucescens*, *Celtis mildbraedii*, *Terminalia superba* and *Entandrophragma utile*.

The vegetation of the park can be subdivided into the following categories largely on the basis of forest structure :

(i) Closed forest — forest with a closed upper or mid canopy through which little light penetrates to ground level, resulting in a low density of vegetation at this level (0-7 m).

(ii) Open forest — forest with an open upper and mid canopy through which much light penetrates to ground level. This forest type is characterised by a dense tangle of climbers, shrubs and herbs within easy reach of elephants.

(iii) Forest gaps — these are caused by the death of an upper canopy tree or by a tree fall. They occur within closed forest and generally cover a fairly small area.

(iv) Swamp forest — occurs in moister low lying areas and is characterised by *Raffia* (*Raphia hookeri*) and climbing palms (*Ancistrophyllum* sp.).

The proportions of each vegetation type within the park are given in Table 4a.

METHODS

(1) Fresh elephant trails (0-3 days) were followed and samples of plants utilized by elephants were collected. The age of an elephant trail was estimated by the appearance of dung and broken vegetation. Signs of elephant feeding are conspicuous—plants are broken, climbers are pulled down, leaves are stripped from branches. Elephants sometimes feed in a less conspicuous manner ; for example by plucking single leaves. Such feeding was noted by this survey but was judged to be relatively insignificant.

For each plant sample collected a record was made of forest type (see Study Area and type of feeding. Feeding was classified as : leaf stripping, removal of terminal twigs, breaking of main stem, pushing over of a tree, or barking.

(2) One hundred and ninety dung piles were examined for fruit and seed content (50 — long wet season, 40 — short wet season, 100 — early dry season). Seeds and fruit fragments were picked from the dung pile as it was broken apart and spread out using a machete or a stick.

(3) Barked trees were counted along 75 km of transect line. All trees within 15 m

TABLE 3 : ELEPHANT BARKED TREES

Species	% of trees barked	Sample size	Average maximum height of bark-ing (m)	Mean % of circum-ference barked
<i>Calpocalya brevibracteatus</i>	100	5	2.1	54
<i>Terminalia thomensis</i>	100	5	2.2	39
<i>Bombax brevisauye</i>	82	98	2.8	28
<i>Entandrophragma utile</i>	79	58	1.3	26
<i>Ghibbarta ehte</i>	65	81	2.1	34
<i>Lannea wehbiensei</i>	65	57	2.6	32
<i>Entandrophragma argolense</i>	44	18	1.4	26

TABLE 1 : COMMON BROWSE PLANTS

The most commonly utilized browse plants listed in order of use

T - tree, S - shrub, L - liane

Species	% of trees barked	Sample size	Average maximum height of bark-ing (m)	Mean % of circum-ference barked
<i>Microdesmis puberula</i>	S			
<i>Combretum oymense</i>	L			
<i>Grewia malacocarpa</i>	L			
<i>Gniffonia simplicifolia</i>	T			
<i>Napoleonia vogelii</i>	S			
<i>Exphiala riccia</i>	L			
<i>Compylotemon angolense</i>	L			
<i>Acacia kamerunensis</i>	L			
<i>Alafia karberi</i>	L			
<i>Hippocratea vignei</i>	L			
<i>Motanaha guineensis</i>	L			
<i>Mesogordonia papaverifera</i>	T			

TABLE 2 : FRUIT EATEN BY ELEPHANTS AT VARIOUS SEASONS
(Percentage of dung piles containing seeds of each species)

SPECIES	SEASON		SPECIES	SEASON	
	Long-wet (June-Aug.)	Short wet (Sept.-Oct.)		Long-wet (June-Aug.)	Short wet (Sept.-Oct.)
<i>Strychnos aculeata</i>	66	35	<i>Irvingia gabonensis</i>		26
<i>Myrsine arborea</i>	54	32	<i>Cratogeomys caudatum</i>		17
<i>Klainea gabonensis</i>	32		<i>Cratogeomys caudatum</i>		11
<i>Exaltia wilsoniana</i>	10		<i>Uapaca guineensis</i>		9
<i>Lagenaria breviflora</i>	10		<i>Theobroma cacao (cocoa)</i>		4
<i>Ricinodendron heudelotti</i>	2	15	<i>Strombosia glaucaensis</i>		4
<i>Antrocaryon maraster</i>	2	37	<i>Omphalocarpum sp</i>		4
<i>Duboscia viridiflora</i>	2	10	<i>Telfairia acidentata</i>		3
<i>Vitex ferruginea</i>		32	<i>Treculia africana</i>		3
<i>Grewia malacocarpa</i>		15	<i>Euchlozia coriacea</i>		2
<i>Pithecellobium heckeri</i>		12	<i>Cyrtanthus carmeus</i>		2
<i>Desplatsia sp</i>		7	<i>Swarzia fistuloides</i>		1
<i>Tetragleura tetraoptera</i>		5	<i>Carex kappala (pampaw)</i>		1
<i>Purpuraria excelsa</i>					
<i>Panda oleosa</i>			Without seeds	16	2

Without seeds

of the transect line were examined. The amount of damage (height of barking, percentage of circumference) was determined for all trees of rare species and for every third tree of the common species.

RESULTS

DIET

One hundred and thirty eight species of plants were recorded as browsed. The more commonly utilized plants are listed in Table 1. Most were woody lianes. Woody material (mainly leaves and stems) formed the bulk of the elephant diet. Grass is almost completely absent from Bia and thus does not contribute to the diet to any extent. This was obvious both from an examination of dung (100% woody material) and from the collection of plants utilized by elephants. Herbs were noticeably absent from the diet (Table 4c and Appendix 1).

Fruit was an important component of the diet. Ninety-three percent of all dung piles examined showed some trace of fruit (either seeds or fruit fragments). A total of 35 species of fruit were recorded in the dung (Appendix 2) of which 9 were common (i.e. found in more than 20% of dung of a particular season). These were *Antrocaryon micraster*, *Irvingia gabonensis*, *Klainedoxa gabonensis*, *Myrianthus arboreus*, *Panda oleosa*, *Parinari excelsa*, *Strychnos aculeata*, *Tetrapleura tetraptera* and *Vitex ferruginea*.

The variety of fruits consumed by elephants at Bia was lowest in the long wet season (with a mean of 1.9 species per dung pile). Only three species — *Myrianthus arboreus*, *Strychnos aculeata* and *Klainedoxa gabonensis* were found regularly in the dung at this season. Variety progressively increased to a value of 4.6 species per dung pile in January (mid dry season), the last month of the study.

TABLE 4 : ELEPHANT FEEDING ACTIVITY

(a) elephant use of each cover type			(b) type of feeding	
Cover type	% of each cover type in Bia N.P.	% of elephants use of each cover type		%
Closed forest	83	19.5)	Terminal twigs and leaf stripping	85.7
			Broken main stem of plant	11.0
			Tree pushed over or uprooted	0.4
Forest gap	-) 36	Barking	2.8
Open forest	11	16.5)		
Swamp forest	6	62		
		2		

(c) growth form of plants fed on by elephants

Growth form	No. species fed on by elephants	No. species recorded for park	% utilized
Trees (>8m high)	48	165	29
Shrubs (<8m high)	30	91	33
Climbers (slender climber)	12	82	15
Lianes (large liane reaching canopy)	47	83	57
Herbs	1	111	1
Total	138	532	

The number of tree species having a high proportion of individuals barked was low. Species having greater than 50% of individuals barked were *Calpocalyx brevibracteatus*, *Terminalia ivorensis*, *Bombax brevicuspe*, *Entandrophragma utile*, *Guihourtia ehia*, and *Lannea welwitschii*. Table 3 shows proportions of trees barked, and the extent of barking, of the seven most commonly utilized species. The amount of bark removed from a tree varied considerably from species to species. In *Bombax brevicuspe* and *Lannea welwitschii* bark was pulled away in large strips 0.3-0.6 meters wide and up to 10 meters in length. Elephants would chew a small portion of this bark, finally spitting it out as a large ball of matted fibre. The large, commercially valuable timber trees, *Entandrophragma utile* and *E. angolense*, generally sustained minor damage. Areas of bark, 0.3 to 0.6 meters square were removed on the lower trunk and buttresses.

Occasionally large-girthed woody lianes would also be barked (e.g. *Landolphia hirsuta*, *Acacia spp.*).

FEEDING ACTIVITY

The bulk of elephant feeding is by either the removal of terminal twigs or by leaf stripping. These two forms account for 86% of feeding activity (Table 4b). Only 11% of feeding activity involves the breaking of the main stem of a plant. Broken plants are generally less than 25 cm in girth. The barking of trees, uprooting or pushing over are minor feeding activities (3%).

Elephants appeared to browse mainly in areas of open forest and old forest gaps (Table 4a). Comparatively little browsing took place in closed forest, the major cover type. Thus elephants do not utilize vegetation cover types in direct proportion to their occurrence.

While browsing generally occurs in the more open areas, most barking and the gathering of fruit occurs in closed forest. Fruit trees (e.g. *Parinari excelsa*, *Balanites wilsoniana*, *Tieghemella heckelii*) usually have a large area of trampled ground around their base where elephants have searched for fallen fruit. A network of elephant trails connect most major fruiting trees. Major elephant trails appeared to be used mainly for moving quickly between areas and for moving between fruit trees rather than for browsing — generally elephants would leave these trails and push through the bush to browse.

DISCUSSION

The diet of the elephant in the West African forest zone consists almost entirely of woody material and fruit. Grass, which predominates in the diet of elephants in East Africa (80-90% of bulk) even where sufficient browse appears to be available (e.g. Kibale Forest (Wing and Buss, 1970)) is almost entirely absent from Bia and does not contribute significantly to the diet. In contrast to the East African findings (Buss, 1961 ; Laws and Parker, 1968 ; Wing and Buss, 1970) browse forms the major part of the diet through much of the year in Southern Africa (Williamson, 1975). Williamson found that grass replaces woody material in importance only during the wet season, presumably because of its increased palatability during that season.

The importance and variety of fruit in the diet of elephants in the West African forest is suggested by the work of Alexandre (1977) in the Tai Forest, Ivory Coast. He found that elephants fed upon (and subsequently dispersed) the fruits of 37 species

APPENDIX I - Browse plants utilized by elephants showing the number of records of browsing

(T - tree, S - shrub, C - small climber in understorey, L - large woody liane reaching canopy, E - epiphyte)

Species	No. of records of browsing	Species	No. of records of browsing	Species	No. of records of browsing
<i>L. Acacia kamerunensis</i>	7	<i>T Calypocalyx brevis-bracteatus</i>	3	<i>C Onestis ferruginea</i>	1
<i>L. A. pentagona</i>	6	<i>L Calycobolus africanus</i>	2	<i>S Coffea ebraacteolata</i>	2
<i>C Adenia manii</i>	1	<i>L Campylostemon angolense</i>	8	<i>L Combretum oyemensse</i>	14
<i>T Afroseralasia afzelii</i>	1	<i>C Canthium venosum</i>	1	<i>L C. racemosum</i>	1
<i>L Agelaea nitida</i>	1	<i>C C. rubens</i>	1	<i>L C. sordidum</i>	6
<i>T Aidia genipiflora</i>	4	<i>C C. aestosum</i>	1	<i>C. sp.</i>	2
<i>L Alafia barteri</i>	7	<i>T C. subcordatum</i>	1	<i>S Craterispermum caudatum</i>	5
<i>L A. multiflora</i>	1	<i>C. sp.</i>	1	<i>T Copaifera salikoida</i>	1
<i>L A. schimantii</i>	1	<i>S Carpolobia lutea</i>	1	<i>L Dalbergiella welwitschii</i>	1
<i>T Albisia adianthifolia</i>	2	<i>L Castanolea parviflora</i>	1	<i>T Daviellia ogea</i>	1
<i>T A. glaberrima</i>	1	<i>T Celtis adolfi-friedericii</i>	2	<i>T Desplatsia deweveri</i>	1
<i>T A. zygia</i>	1	<i>T C. mildbraedii</i>	6	<i>T Dialium aubrevillei</i>	6
<i>L Anoctrophyllum opacum</i>	1	<i>E Cercestis afzelii</i>	2	<i>T D. dinklagei</i>	1
<i>T Anigeria robusta</i>	2	<i>S Chassalia kollyi</i>	1	<i>L Dichapetalum crassifolium</i>	1
<i>T Anthocleista sp.</i>	2	<i>T Chrysophyllum albidum</i>	1	<i>T Diospyros manii</i>	2
<i>S Antidesma laetiniatum</i>	2	<i>T C. beguetii</i>	1	<i>T Discoglyprena caloneura</i>	1
<i>S Raphia nitida</i>	10	<i>T C. subnudum</i>	3	<i>S Dracaena surculosa</i>	1
<i>T B. pubescens</i>	2	<i>C Clerodendron buxifolium</i>	1	<i>S Drypetes chevallieri</i>	1
<i>T Blighia sapida</i>	1	<i>C C. volubile</i>	1	<i>S D. gilgiana</i>	1
<i>T Bombax brevicauspe</i>	4	<i>C. sp.</i>	1	<i>C Rutidea membranacea</i>	1
<i>L Bourgingia mildbraedii</i>	1	<i>L Manotes longiflora</i>	1	<i>L Saba thompsonii</i>	1
<i>L Entada soelerata</i>	4	<i>T Maranthes glabra</i>	1	<i>L Salasia debilis</i>	1
<i>S Ficus exasperata</i>	1	<i>S Mascularia acuminata</i>	2	<i>L S. erecta</i>	3
<i>T F. mucosa</i>	1	<i>S cf Mameacylon aymeri</i>	1	<i>C S. howesii</i>	1
<i>S Glyphaea brevis</i>	5	<i>S Microdennis puberula</i>	16	<i>S S. ureganensis</i>	5
<i>L Grevia hookeriana</i>	5	<i>S Millettia rhodantha</i>	2	<i>S Scopophetalum amoenum</i>	2
<i>L G. malacocarpa</i>	14	<i>S M. zechiana</i>	1	<i>T Scottellia klaineana</i>	1
<i>L Griffonia simplicifolia</i>	11	<i>L Motandra guineensis</i>	7	<i>C Smilax kraussiana</i>	1
<i>S Heisteria parvifolia</i>	1	<i>T Myrianthus arboreus</i>	2	<i>S Solanum verbascofolium</i>	1
<i>T Hexalobus crispiflorus</i>	1	<i>T N. libericus</i>	1	<i>T Sterculia tragacantha</i>	1
<i>L Hippocratea africana</i>	6	<i>T Napoleonaea vogelii</i>	11	<i>L Strophantinus preussii</i>	1
<i>L H. clematoides</i>	1	<i>T Nesogordonia papaverifera</i>	7	<i>T Strobosia glaucescens</i>	6
<i>L H. eotypetala</i>	4	<i>L Neupeltis acuminata</i>	2	<i>L Strychnos aculeata</i>	2
<i>L H. macrophylla</i>	1	<i>L N. prevostoides</i>	1	<i>L S. afzelii</i>	5
<i>L H. unguiculata</i>	1	<i>L Ononotis pontyi</i>	2	<i>T Syzygium cf. guineense subsp. occidentale</i>	1
<i>L H. vignei</i>	7	<i>H Palisota hirsuta</i>	1	<i>L Tiliacora dinklagei</i>	1
<i>S Ieolona campanulata</i>	2	<i>T Panda oleosa</i>	1	<i>T Trichilia martincaul</i>	1
<i>L Landolphia forestiana</i>	1	<i>T Parkia bicolor</i>	1	<i>T T. monadelphica</i>	1
<i>L L. hirsuta</i>	3	<i>S Pavetta oxariensis</i>	1	<i>S Tricalysia pallens</i>	1
<i>L L. Oxariensis</i>	1	<i>L Platysepalum hirsutum</i>	5	<i>L Unvia anonoides</i>	2
<i>T Lamia welwitschii</i>	2	<i>T Pycnanthus angolensis</i>	2	<i>C Urena robusta</i>	2
<i>L Leptodermis brachyptera</i>	1	<i>L Rhabdocetylis ferruginea</i>	4	<i>T Vitea ferruginea</i>	2
<i>T Linociera africana</i>	1	<i>L R. preussii</i>	1	<i>S Voacanga africana</i>	1
<i>T Macaranga barteri</i>	1	<i>S Rinorea ilicifolia</i>	1	<i>T Xylopia villosa</i>	1
<i>N Maseobotrya barteri</i>	3	<i>S R. subintegrifolia</i>	4	<i>T Zantocaylium gilletii</i>	1
<i>N Mallotus oppositifolius</i>	3	<i>T Rothmannia hispida</i>	1		
<i>T Mamea africana</i>	1	<i>S R. longiflora</i>	1		
		<i>S R. whitfieldii</i>	1		

APPENDIX 2 - Fruits eaten by elephants

<i>Antocaryon micraster</i>	<i>Grevia malacocarpa</i>	<i>Ricinodendron heudelottii</i>
<i>Aubreggrinia tateensis</i>	<i>Iryngia gabonensis</i>	<i>Strobosia glaucescens</i>
<i>Balanites wilsoniana</i>	<i>Klainedoxa gabonensis</i>	<i>Strychnos aculeata</i>
<i>Buchholzia coriacea</i>	<i>Lagenaria breviflora</i>	<i>Strychnos sp.</i>
<i>Carica papaya</i>	<i>Mamea africana</i>	<i>Swartzia fistuloides</i>
<i>Chlorophora excolsa</i>	<i>Myrianthus arboreus</i>	<i>Telfairia occidentalis</i>
<i>Chrysophyllum beguetii</i>	<i>Onthalocarpum ahia</i>	<i>Tetrapleura tetraptera</i>
<i>Chytranthus carneus</i>	<i>O. elatum</i>	<i>Tieghemella heckelii</i>
<i>Craterispermum caudatum</i>	<i>Pachypodium staudtii</i>	<i>Traculia africana</i>
<i>Desplatsia deweveri</i>	<i>Panda oleosa</i>	<i>Uapaca guineensis</i>
<i>D. subriocarpa</i>	<i>Pierredendron kerstingii</i>	<i>Vitea ferruginea</i>
<i>Duboscia viridiflora</i>	<i>Raphia hookeri</i>	
	<i>Parinari excelsa</i>	

of plant. This compares with 35 species for Bia, of which nine species were significant components of the diet. Wing and Buss (1970) provided only limited information on the use of fruit by elephants in the Kibale Forest. They examined 117 dung piles in mid- late August (dry season). The fruits of one species, *Balanites wilsoniana* occurred in 44% of dung piles (this species is also important at Bia); another species, *Landolphia florida*, was found in 6% of droppings.

The variety of fruit consumed by elephants at Bia was greatest in the dry season. At this time of the year the maximum number of plant species are fruiting (Taylor, 1960).

A few species of fruit, for example *Strychnos aculeata*, were found in dung throughout the year. However, most had seasonal peaks of utilisation. These included *Tieghemella heckelii*, (early dry season), *Parinari excelsa* (mid dry season) and *Balanites wilsoniana* (late dry season). The fruit of *Panda oleosa*, although produced through much of the year, was eaten only during the dry season.

Some fruit appeared to be fed on only incidentally, perhaps when that species was being browsed. Examples are *Grewia malacocarpa* (2 × 1 cm), *Strombosia glaucescens* (2 cm diam.), and *Uapaca guineensis* (2 cm diam.). These were generally the smaller sized fruits which were more commonly eaten by other animals (monkeys, chimpanzees, duiker). Fruits forming a major part of the diet (those eaten in considerable quantities or for most of the year) were generally of large size (*Tieghemella heckelii* (9 × 5 cm), *Parinari excelsa* (4 × 3 cm), *Balanites wilsoniana* (9 × 7 cm), *Tetrapleura tetraptera* (18 × 5 cm), *Strychnos aculeata* (12 cms diam.) and *Panda oleosa* (6 cm diam.). These fruits are characterised by firm, dry, dense flesh, and are therefore probably rich in lipids and proteins (Mc Key, 1975). Thus they may form a valuable supplement to the diet. The dense, dry flesh makes it improbable that they are consumed mainly for their water content.

APPENDIX 3 - Trees barked by elephants

(*Those species where only one tree recorded as barked
although species locally abundant)

<i>Acacia</i> sp. (pennata)	<i>Guibourtia ehie</i>
<i>Allanblackia nairiflora</i>	<i>Landolphia hirsuta</i> *
<i>Bombax brevicauspe</i>	<i>Lannea welwitschii</i>
<i>Calpocalyx brevibracteatus</i>	<i>Napoleona vogelii</i> *
<i>Chrysophyllum subnudum</i> *	<i>Pentaclethra macrophylla</i>
<i>Cyclocladus gabonensis</i>	<i>Petersianthus macrocarpus</i>
<i>Diospyros viridicans</i>	<i>Pteleopstis hylodendron</i>
<i>Entandrophragma angolense</i>	<i>Syzygium guineensis</i> subsp.
<i>E. utile</i>	<i>occidentale</i>
<i>Garcinia kola</i> *	<i>Terminalia ivorensis</i>
	<i>Tieghemella heckelii</i>

The fruit species most commonly eaten showed adaptations to dispersal by elephants. Fruits were inconspicuously coloured when ripe (yellow or green) and possessed a strong smell (e.g. *Parinari excelsa*, *Irvingia gabonensis*, *Bucholzia coriacea*, *Tetrapleura tetraptera*). Alexandre (1977) has suggested that these features have developed in response to the keen sense of smell and lack of colour vision of elephants. Similarly the large size of many of these fruits may be an adaptation to make them attractive to elephants which require a large food intake.

Elephants in forest are highly selective in that they take bark from relatively few species. At Bia elephants concentrated on only seven species. Wing and Buss (1970) list eight species heavily utilized in the Kibale Forest.

Two species, *Pipldeniatrum africanum* and *Parinari excelsa* found barked by Wing and Buss (1970) (60% and 22% of individuals enumerated were damaged) were not barked at Bia. Similarly, *Chlorophora excelsa*, recorded as the most heavily barked tree by Field (*in Laws et al.*, 1975) in Murchison Falls National Park, was not barked at Bia. Possible explanations for this are that :

- (i) elephants, with a greater range of choice in forest, select alternative species.
- (ii) palatability or calcium content may differ for these species between areas.
- (iii) elephants' need for a particular mineral may vary between areas.
- (iv) learnt preferences may differ between areas.

In contrast to the East African savanna, trees at Bia were rarely killed by elephants although one species, *Guibourtia ehia*, was particularly vulnerable to termite attack after barking.

Elephants do not use vegetation cover types in direct proportion to area. Closed forest, the major cover type, is not heavily utilized for browsing. This is in general agreement with the findings of Wing and Buss (1970) and Laws *et al.* (1975). Elephants favour habitat types with an open canopy and dense vegetation at ground level.

In open forest and old forest gaps light intensity is high near the forest floor, leading to the proliferation of climbers, shrubs and young trees within reach of elephants. By their continual use of these areas elephants keep gaps from closing. Jones (1955) described areas in southern Nigeria where high forest was interspersed with patches of scrub 3-7 m high, draped with climbers. These scrub areas appeared to be maintained by elephants.

Similarly, in the Budongo Forest of Uganda elephants may prevent the regeneration of logged areas by continually returning to them to browse (Johnstone *in Laws*, 1970). Here the effect would be magnified by the massive influx of elephants from the surrounding savanna into the forest during the dry season.

While elephant signs (elephant trails, damaged trees, trampled areas) in forest are conspicuous, elephants themselves are at low density and their overall impact on the forest is small. Certainly there is no widespread habitat modification such as that documented for elephants in East (Buechner and Dawkins, 1961 ; Laws, 1970 ; Field, 1971) and Central Africa (Caughley, 1976). Without elephants the forest would be both less species rich and less structurally diverse. Elephants contribute to the complexity of the forest by speading seed and by maintaining open areas.

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SUMMARY

This study reports the diet and feeding behaviour of elephants in the forest zone of western Ghana.

Diet consisted mainly of woody material (leaves and stems). Grasses, being rare within the forest, made up only a negligible proportion of the diet. Thirty-six species of fruit were eaten, nine of which formed a significant component of the diet : *Antrocaryon micraster*, *Irvingia gabonensis*, *Klainedoxa gabonensis*, *Myrianthus arboreus*, *Panda oleosa*, *Parinari excelsa*, *Strychnos*

aculeata, *Tetrapleura tetraptera* and *Vitex ferruginea*. The greatest variety of fruit was available during the dry season. Elephants removed bark from 20 species of trees but concentrated on only seven. Between 44 and 100% of individuals of these latter species were damaged.

Elephants generally browsed in open forest where woody vegetation within easy reach was abundant. Woody lianes in particular were favoured. Barking and the gathering of fruit usually occurred in closed forest. Elephants mainly fed by removing terminal twigs or by stripping leaves from branches. Breaking of the main stem, pushing over, uprooting or barking were uncommon.

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