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FOOD PREFERENCES OF TWO BLACK RHINOCEROS POPULATIONS

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SUMMARY

Food preferences of two discrete black rhinoceros (*Diceros bicornis* L.) populations were studied in northern Tanzania from 1964-1966. Feeding rhinoceros were watched for a period of one hour, and the plants which they selected and rejected were identified, either as they were feeding or when they had moved on. A technique was used which provided an indication of the relative importance of certain plants in the diet. Observations were made in six different habitat types used by the rhinoceros during the wet and dry seasons. A total of 307 hours was spent actually watching feeding rhinoceros. During this period they were observed eating 191 plant species from 49 botanical families. In all habitat types rhinoceros consume a wide variety of the spectrum of plants available, but are highly selective for herbs and shrubs. At certain periods of the year stenophagous characteristics are apparent, and the species shows a marked preference for legumes. Grasses make up a small proportion of the diet.

INTRODUCTION

During 1964-1966 an ecological and ethological study was made of two discrete black rhinoceros populations in northern Tanzania. One population occupies the caldera of Ngorongoro, and the other the vicinity of Olduvai Gorge on the eastern part of the Serengeti plains. During the study food preferences of the two populations were determined. A total of 165 hours was spent watching feeding rhinoceros in four different habitat types at Ngorongoro. At Olduvai 142 hours of observation were completed in the two major habitat types. One hundred and eighty two rhinoceros were recorded in the two study areas during the three year period (Goddard, 1967).

The two study areas vary considerably. The caldera of Ngorongoro consists mainly of open grassland interspersed with several marshes. Water is widely distributed and relatively abundant. The walls of the caldera consist mainly of scrub with some highland forest on the eastern and south-eastern parts. Mean annual rainfall on the caldera floor is 660.4 mm (26 in).

The study area at Olduvai on the eastern part of the Serengeti plains is more typical of the thornbush habitat of the black rhinoceros in Masailand. The area is bisected by the gorge which is covered in *Acacia-Commiphora* type woodland and scrub with extensive growths of wild sisal (*Sansevieria ehrenbergii* Bak.). The remainder of the study area consists of open plains covered with severely eroded short grassland. Mean annual rainfall at Olduvai is 406.4 mm (16 in) and water supplies are sparse and widely scattered.

METHOD

Conventional methods of food habit determination of large mammals could not be used with these populations. The collection of a representative sample of specimens, and subsequent analysis of stomach contents is not to be contemplated with the black rhinoceros, at least not in the caldera of Ngorongoro and Olduvai Gorge. Because of the absence of a suitable method of identification of browse items in faecal samples, and the probability of the least digested browse making up a proportionally greater content of the faecal bulk, this method was not attempted. As a result of these factors a method was used which was based on direct observation of feeding rhinoceros (Plate 1a). Observations were made from a Land-rover, from trees, and on foot, using 10×40 binoculars. Because of the myopia of the black rhinoceros this method was very practical, and quite feasible.

A feeding rhinoceros was watched for a period of one hour, and the plants which it selected and rejected were noted when it had moved on. At Ngorongoro the docility of some rhinoceros made a close approach to them quite possible in a Land-rover. In a few cases it was feasible to observe the animal feeding from a distance of ten yards or less. Feeding animals were watched for a complete hour. If marked disturbance occurred, either resulting from the activity of the red-billed oxpecker (*Buphagus erythrorhynchus* Stanley), or from the confusion and alarm produced by human scent, the observation was discontinued and the results discarded.

The diet was appraised and food preferences determined by recording a series of stations. A station was considered as the area covered by a hypothetical semi-circle in front of the feeding animal in which it could reach the plants available without moving its front feet. When it moved its front feet in order to reach new plants a new station was noted. The total number of stations visited during the one hour period was recorded, and a note made on the species which were available but rejected. Because of the small size of this hypothetical semi-circle, and the method of feeding of the black rhinoceros (predominantly a selective browser), only one plant species was usually taken at each station. If two species were taken at one station each species was recorded as constituting one half of a station. The number of stations at which a particular plant was selected was totalled and this total converted to a percentage of the total number of stations visited during the one hour period. A grand total of 11,707 stations was examined during the study period.

In most habitat types it was difficult to observe, and accurately record, exactly how long a rhinoceros spent at each station, and a food preference method based on this kind of time system was not used in the field observations. However, observations were also made on the feeding habits of two tame rhinoceros in the Tsavo National Park, at Voi. One animal is 5-6 years old and the other is seven years. These animals are penned at night, but during the day are let out and allowed to roam and feed in the park in the vicinity of Voi. Observations were made on these animals simply by walking alongside the animal and recording the diet. When the diet was calculated on a percentage station basis, as used at Ngorongoro and Olduvai, and simultaneously calculated on a percentage time basis, it was found that both percentages showed close agreement. If, for example, 100 stations were visited during the one hour period and 50 of these stations involved the selection of one plant species then this plant species made up 50 per cent. of the diet in that particular hour calculated on a station basis. When the time spent at each station was recorded, it was found that close to 50 per cent. of the actual feeding time during the hour was spent on eating this particular species. There are a few exceptions to this. For example, the tough, woody branches of *Commiphora* spp. are usually ignored, but on occasion one or two branches of these species are selected during the one hour period. On a station basis these make up a relatively small percentage of the total stations but as some considerable time is spent on chewing the tough stems before moving on, a relatively higher percentage of the total feeding time was spent browsing on these species. In the majority of cases, however, the two calculations show approximate agreement.

In view of this agreement diets were appraised by the following method. Each one hour observation period was examined and the number of stations at which a particular plant species was selected was determined. This was converted to a percentage of the total stations visited during the one hour period. This percentage was in turn, converted to the equivalent percentage proportion of one hour, assuming that the whole hour was taken up by active feeding. In fact, the proportion of each hour spent in actual feeding is fairly constant, so proportions were projected so as to constitute one complete hour of feeding. These hourly proportions were then added for each plant species and converted to a percentage of the total number of hours spent watching feeding rhinoceros in each habitat type during the wet and dry season. Results are shown in columns 1 and 2 of Tables 1-6 for the wet (November-April) and dry (May-October) seasons. These tables also indicate the relative composition of the diet by stations. The total number of stations for each plant species was determined, and this factor converted to a percentage of the total number of stations visited in each habitat type during each season.

It is appreciated that the method does not give a precise measure of the bulk or volume

of each plant species which is consumed. This was never intended. However, the amount of time spent at a station is governed to some extent by the amount of herbage that the rhinoceros can accommodate in its mouth, and hence the size of the bolus swallowed. When compared with the availability and the dominants of the floral complex in each habitat type (described below) the method does, however, provide an indication of the relative importance of the various plant species.

Rhinoceros were located in open areas simply by searching for them with binoculars from prominent viewpoints. In thick cover rhinoceros were located by four main methods: a) Observing and listening for the calls of the red-billed oxpecker, a close avian associate of the black rhinoceros. b) Listening for the sound of a rhinoceros eating. On a quiet morning or evening, this sound can be detected from a distance of over 365 m (400 yd) and the feeding animal located by this method. c) Observing dust "smoke". Rhinoceros are extremely fond of lying in dust depressions made up of very fine particles of dry soil. When the animal exhales while lying in the soil a very fine cloud of dust "smoke" appears above the bush indicating the position of the rhinoceros. A tall tree was selected as close as possible to the animal, and the observer waited until the animal started to feed. d) Climbing tall trees and scanning the bush with binoculars.

Observations were made in all six habitat types but tended to concentrate in areas where it was feasible to obtain adequate data. At Ngorongoro a large percentage of the rhinoceros use the plains as part of their home range during the wet season and hence are out in the open and easy to observe. Thus 62 per cent. (52 h) of the Ngorongoro hourly observations during the wet season were made in this habitat type. In the dry season the rhinoceros at Ngorongoro tend to feed actively mainly in the marsh areas of the caldera floor. Thus nearly 40 per cent. of the Ngorongoro hourly observations during the dry season were made in the marsh habitat. In the open areas data was relatively easy to obtain, but in the forest habitat, extremely difficult. Disturbances caused by oxpeckers, changes in wind direction, lack of adequate trees for observation, interference from the proximity of elephants (*Loxodonta africana* Blumenbach), and the temperament of the rhinoceros, were all factors which account for the relatively low number of hourly observations in the forest and scrub habitat. In the forest habitat at Ngorongoro, for example, 25 hourly observations were started but only five hours of observations were completed successfully.

HABITAT DESCRIPTION

At Ngorongoro the four habitat types studied were plain, scrub, marsh and forest; at Olduvai, the two types concerned were the plain and the gorge. A brief description of each habitat type and the dominant flora available to the feeding rhinoceros is shown below. In both study areas a dominant plant species is one which makes up 20 per cent. or more of the total vegetative cover. Notes on floral dominance were obtained from Herlocker (1967).

1. Plains habitat—Ngorongoro

This is medium height—0.6-1.5 m (2-5 ft)—grassland. Dominants are, in order of importance, *Cynodon dactylon* (L.) Pers., *Digitaria scalarum* (Schweinf.) Chiov., *Andropogon greenwayi* Napper and *Digitaria milanjiana* (Rendle) Stapf. Other species which occur are *Pennisetum mezianum* Leeke and *Setaria pallide-fusca* (Schumach.) Stapf and C. E. Hubb. Herbs occur in very sparse scattered patches across the grassland with *Solanum incanum* L., *Cyathula orthacantha* Schinz and *Pluchea monocephala* E. A. Bruce as local dominants. In the long rains (February-April) small (less than 0.2 ha (0.5 acre) in extent) sparse patches of clover (*Trifolium masaiense* Gillett) appear in this habitat type.

2. Scrub habitat—Ngorongoro

Observations were made in the bush areas of the eastern caldera wall. *Lippia javanica* Spreng. is dominant over medium height—0.6-1.5 m (2-5 ft)—grassland with *Themeda triandra* Forsk., *Sporobolus fimbriatus* Nees, and *Setaria sphacelata* (Schumach.) Stapf and C. E. Hubbard *ex* Moss as dominants in the grass layer.

3. Marsh habitat—Ngorongoro

This is a permanent swamp covering an area of 3.1 km^2 (1.2 sq. miles) known locally as the Munge swamp. Observations were made in the swamp itself, and along

the proximal two miles of the stream edge which feeds the swamp. The dominant species is *Aeschynomene schimperi* A. Rich. which forms a dense thicket with less common species such as *Leersia hexandra* Swartz, *Panicum repens* L. and *Diplachne fusca* (L.) Beauv. found in standing water. *Sporobolus spicatus* (Vahl) Kunth. and *Cyperus laevigatus* L. occur along the periphery of the swamp. A small—0.26 km² (0.1 sq. mile)—patch of *Cyperus immensus* C.B.Cl. also occurs in the swamp.

4. Forest habitat (Lerai Forest)—Ngorongoro

This is a small—2.59 km² (1.0 sq. mile)—forest of high woodland (the crown cover extends 9 m (c. 30 ft) or more). *Acacia xanthophloea* Benth. is dominant with scattered *Acacia albida* Del. to a height of 9-10.7 m (c. 30-35 ft); *Pluchea dioscorides* DC. and *Achyranthes aspera* L. are dominants in the bush layer beneath the acacia canopy. *Cyperus immensus* is dominant in the swamp areas of this forest. The woodland is opening up markedly through the death of large mature trees in the overstorey. The destruction of the overstorey has been accelerated by high water levels penetrating the forest from the rise in the lake level, and by destruction by elephant. With the opening up of the crown layer and the resultant increased penetration of sunlight *Pluchea dioscorides* has rapidly colonized the understorey and forms a dense bush layer of 1.8-2.4 m (6-8 ft) on the floor of the forest. As a result very sparse regeneration of *Acacia* has occurred.

5. Plains habitat—Olduvai

Open, short (<0.6 m (2 ft) high) grassland. Less than 2 per cent. of the total vegetative cover is made up of trees, shrubs, or herbs. Dominants are, in order of importance, *Sporobolus marginatus* Hochst. *ex* A. Rich., *Digitaria macroblephara* (Hack.) Stapf and the sedge *Kyllinga* sp. Herbs occur in very sparse scattered patches across the grassland with *Pluchea monocephala* and *Solanum incanum* as local dominants. In some areas, especially along the edge of the gorge, erosion is so advanced that 50-60 per cent. of the soil has no vegetative cover whatever.

6. Gorge habitat—Olduvai

The main trough of Olduvai gorge. This consists of low woodland (trees less than 9 m (30 ft) high), the crowns covering from 20-70 per cent. of the ground. The only dominant is *Commiphora madagascariensis* Jacq. Lone *Acacia tortilis* (Forsk.) Hayne and *Acacia mellifera* (Vahl) Benth. also occur. Beneath the low woodland is an understorey of bush. The only dominant in the bush layer is *Sansevieria ehrenbergii*. Sub-dominants, in order of importance, are *Euphorbia tirucalli* L., *Salvadora persica* L. and *Barleria eranthemoides* R. Br. Interspersed among the bush layer is medium height—0.6-1.5 m (2-5 ft)—grassland. Dominants in the grass layer are *Pennisetum stramineum* Peter, *Cenchrus ciliaris* L. and *Dactyloctenium aegyptium* (L.) Beauv.

RESULTS

Tables 1-6 show the food preferences of the black rhinoceros in the two study areas. No marked differences in the diet were noted according to sex or age so all observations have been combined. Diets of calves (animals less than one year old) have not been considered, but the diet of immature and adult animals, regardless of sex, were very similar.

Table 1 shows the food preferences of the rhinoceros on the plains habitat of Ngorongoro. With the exception of one species, all herbs and shrubs available in this habitat type are eaten by the rhinoceros, but in varying quantities. The one exception is *Heliotropium steudneri* Vatke, a species which is consistently rejected by the rhinoceros in this habitat type. The herb dominants (shown under habitat description) make up a relatively small part of the diet. Nearly 60 per cent. of the diet is made up of legumes in both the wet and dry season. One herb dominant, *Solanum incanum*, is eaten, but is unpalatable in large quantities. It may be taken during the first quarter of an hourly observation only to be rejected completely at later stages. A marked preference is shown for the green, succulent legume *Trifolium masaiense* during the wet season, and the legume *Indigofera basiflora* Gillett during the dry season. Grass makes up a small proportion of the diet.

Food preferences in the scrub habitat of Ngorongoro are shown in Table 2. Over 50 per cent. of the diet consists of legumes at both seasons of the year. The herb dominant *Lippia javanica* makes up a relatively small part of the diet, especially during the dry season.

TABLE 1

Food preferences of the black rhinoceros on the plains habitat of the Ngorongoro caldera

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Acanthaceae										
Asystasia schimperi T. Anders.	0.70	1.2	9	0.5	A					
Hypoestes forskalii (Vahl) R. Br.	0.11	0.2	4	0.2	SL					
Justicia ellioti S. Moore	1.05	2.0	50	2.5	A	1.21	3.1	76	4.2	A
Justicia matammensis Oliv.	0.40	0.8	14	0.7	A	0.12	0.3	9	0.5	A
Justicia uncinulata Oliv.	0.10	0.2	4	0.2	A	0.10	0.3	2	0.1	A
Aizoaceae										
Glinus lotoides L.	0.10	0.2	3	0.1	A					
Zaleya pentandra (L.) Jeffrey	0.10	0.2	3	0.1	A					
Amaranthaceae										
Achyranthes aspera L.	0.05	0.1	3	0.1	A	0.10	0.3	1	t	SL
Aerva lanata Juss.	0.17	0.3	2	0.1	A	0.42	1.1	44	2.5	A
Amaranthus angustifolius Lam.	2.13	4.1	56	3.0	A	0.34	0.9	12	0.7	SL
Amaranthus hybridus L.	0.50	1.0	15	0.8	A					
Cyathula orthacantha Schinz	3.79	7.2	62	3.2	A	3.25	8.3	72	4.0	SL
Compositae										
Erlangea cordifolia (Oliv.) S. Moore	0.40	0.8	4	0.2	A					
Hirpicium diffusum (O.Hoffm.) Roess.	0.67	1.3	21	1.1	A	0.10	0.3	4	0.2	A
Pluchea monocephala E.A. Bruce	3.19	6.1	154	7.9	A	3.84	9.7	138	7.9	A
Cruciferae										
Erucastrum arabicum Fisch. & Mey.	0.05	0.1	1	t	A					
Rorippa madagascariensis (DC.) Hara	0.05	0.1	2	0.1	A					
Cyperaceae										
Cyperus rotundus L.	0.06	0.1	3	0.1	L					
Gramineae										
Andropogon greenwayi Napper	0.10	0.2	2	0.1	A					
Chloris pycnothrix Trin.	0.01	t	1	t	A					
Cynodon dactylon (L.) Pers.	1.03	2 0	20	1.1	A	0.10	0.3	6	0.3	SL
Digitaria scalarum (Schweinf.) Chiov.	0.48	1.0	9	0.5	A	0.10	0.3	4	0.2	SL
Pennisetum mezianum Leeke						0.30	0.8	11	0.7	SL
Setaria pallidefusca Stapf & C. E. Hubb.	0.30	0 6	3	0.1	A					
Sporobolus marginatus Hochst. *ex* A. Rich.	0.08	0.2	2	0.1	A					
Sporobolus spicatus (Vahl) Kunth	0.05	0.1	1	t	A					
Labiatae										
Leucas bracteosa Guerke	0.79	1.5	16	0.8	A	1.68	4.3	84	4.7	SL
Malvaceae										
Hibiscus trionum L.	0.05	0.1	1	t	A					
Malva parviflora L.	0.30	0.6	7	0.4	A	0.01	t	1	t	L
Pavonia patens (Andr.) Chiov.	0.20	0.4	6	0.3	T					
Sida cuneifolia Roxb.	2.15	4.1	49	2.5	T	1.19	3.1	66	3.7	T
Sida ovata Forsk.	1.00	1.9	27	1.4	T					

TABLE 1 *continued*

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Nyctaginaceae										
Commicarpus pedunculosus (A. Rich.) Cuf.	1.98	3.9	50	2.6	A	0.12	0.3	5	0.3	A
Papilionaceae										
Alysicarpus rugosus (Willd.) DC.	0.05	0.1	1	t	A					
Crotalaria spinosa Benth.	0.17	0.3	26	1.3	A	2.85	7.2	62	3.5	A
Crotalaria vallicola Bak. f.	0.10	0.2	2	0.1	A					
Glycine sp.	0.40	0.8	8	0.4	A					
Indigofera basiflora Gillett	5.76	10.6	129	6.7	A	19.18	49.2	963	54.0	T
Indigofera bogdanii Gillett	1.20	2.3	48	2.5	A					
Medicago laciniata (L.) Mill.	0.05	0.1	1	t	A					
Trifolium masaiense Gillett	18.28	35.6	1040	52.0	A					
Vigna fragrans Bak. f.	0.05	0.1	1	t	A					
Phytolaccaceae										
Phytolacca dodecandra L'Her.	0.05	0.1	2	0.1	SL					
Polygonaceae										
Oxygonum sinuatum (Meisn.) Dammer	0.25	0.5	5	0.3	A					
Portulacaceae										
Portulaca oleracea L.	0.05	0.1	3	0.1	SL					
Scrophulariaceae										
Rhamphicarpa montana N.E.Br.	0.70	1.3	9	0.5	A					
Solanaceae										
Solanum incanum L.	2.60	5.0	56	3.0	A	3.99	10.2	224	12.5	SL
Zygophyllaceae										
Tribulus terrestris L.	0.15	0.3	6	0.3	A					
Total:	52.00	100	1941	100		39.00	100	1784	100	

*Part of plant eaten:

A = stems, leaves, and inflorescence

B = bark

I = inflorescence only

L = leaves only

S = stems only

T = tips of shoots

TABLE 2

Food preferences of the black rhinoceros in the scrub habitat of the Ngorongoro caldera

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Acanthaceae										
Justicia ellioti S. Moore	0.30	2.5	8	3.5	A					
Amaranthaceae										
Achyranthes aspera L.						0.05	0.5	1	0.5	SL
Aerva lanata Juss.	0.10	0.8	1	0.4	A					
Pandiaka fasciculata Suess.	0.10	0.8	1	0.4	A					
Boraginaceae										
Cynoglossum sp.	0.05	0.4	1	0.4	A					
Capparidaceae										
Capparis sp.						0.03	0.3	1	0.5	T
Compositae										
Aspilia pluriseta Schweinf.	0.50	4.2	7	3.0	T	1.43	16.0	47	24.0	T
Erlangea cordifolia (Oliv.) S. Moore						0.05	0.5	1	0.5	A
Tagetes minuta L.						0.06	0.8	3	1.5	A
Convolvulaceae										
Ipomoea wightii (Wallr.) Choisy						0.03	0.3	1	0.5	A
Curcurbitaceae										
Cucumis aculeatus Cogn.	0.25	2.1	3	1.3	LS					
Gramineae										
Pennisetum mezianum Leeke	0.10	0.8	3	1.3	A					
Iridaceae										
Gladiolus psittacinus Hook.	0.10	0.8	2	0.9	IS					
Labiatae										
Ocimum suave Willd.						0.04	0.4	2	1.0	A
Liliaceae										
Anthericum kassneri von Poelln.	0.05	0.4	1	0.4	A					
Malvaceae										
Abutilon longicuspe Hochst.						0.80	8.9	8	4.1	T
Hibiscus aponeurus Sprague & Hutch.	0.55	4.6	8	3.5	T	0 20	2.2	4	2.1	T
Kosteltzkya begoniifolia (Ulbr.) Ulbr.						0 05	0 5	1	0.5	T
Sida cuneifolia Roxb.	0.20	1.6	2	0.9	A					
Mimosaceae										
Acacia lahai Benth.	3.00	25.0	63	27.5	T	1.65	18.3	23	12.3	T
Papilionaceae										
Alysicarpus rugosus (Willd.) DC.	1.05	8.8	11	5.0	A	0.67	7.4	2	1.0	A
Glycine javanica L.						0.33	3.7	1	0.5	A
Glycine sp.						0.02	0.2	1	0.5	A

TABLE 2 *continued*

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Indigofera arrecta Hochst. *ex* A. Rich.	0.25	2.1	5	2.2	T	2.20	24.5	54	27.6	T
Rhynchosia kilimandscharica Volkens *ex* Harms	0.50	4.2	5	2.2	A					
Trifolium masaiense Gillett	1.30	10.8	32	14.0	A					
Vatovaea pseudolablab (Harms) Gillett						0.09	1.0	4	2.0	A
Vigna fragrans Bak.f.	0.40	3.4	12	5.2	A					
Rhamnaceae										
Helinus mystacinus (Ait.) E. Mey. *ex* Steud.						0.02	0.2	1	0.5	A
Solanaceae										
Solanum incanum L.	1.10	9.2	13	5.7	A	0.26	3.0	7	3.6	SL
Withania somnifera (L.) Dunal	0.10	0.8	1	0.4	A	0.05	0.5	1	0.5	A
Sterculiaceae										
Dombeya burgessiae Gerrard						0.15	1.7	6	3.0	A
Verbenaceae										
Lantana viburnoides (Forsk.) Vahl	0.60	5.0	9	4.0	T	0.67	7.4	23	11.8	T
Lippia javanica (Burm. f) Spreng.	1.40	11.7	41	17.9	T	0.15	1.7	3	1.5	T
Total:	12.00	100	229	100		9.00	100	195	100	

*See footnote to Table 1

TABLE 3

Food preferences of the black rhinoceros in the marsh habitat of the Ngorongoro caldera

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Acanthaceae										
Justicia matammensis Oliv.						0.15	0.5	7	0.7	A
Hygrophila spiciformis Lindau	0.15	0.9	1	0.2	A	2.25	7.3	73	7.4	A
Hypoestes verticillaris R.Br.						0.60	2.0	28	2.9	A
Amaranthaceae										
Achyranthes aspera L.	0.57	3.3	15	3.1	A	1.47	4.7	20	2.0	SL
Alternanthera sessilis R.Br.	0.10	0.6	2	0.4	A					
Amaranthus angustifolius Lam.						0.10	0.3	4	0.4	A
Pupalia lappacea Juss.						0.22	0.7	5	0.5	SL
Anacardiaceae										
Rhus vulgaris Meikle						0.06	0.2	2	0.2	SL

TABLE 3 *continued*

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Asclepiadaceae										
Gomphocarpus physocarpus E. Mey.						0.07	0.2	1	0.1	A
Balsaminaceae										
Impatiens hamata Warb.	0.10	0.6	2	0.4	A					
Chenopodiaceae										
Chenopodium fasciculosum Aellen						0.26	0.8	12	1.2	A
Chenopodium opulifolium Schrad. *ex* Koch & Ziz.						0.24	0.8	12	1.2	A
Compositae										
Conzya hochstetteri A. Rich.	0.10	0.6	1	0.2	A					
Erigeron bonariensis L.						0.07	0.2	1	0.1	A
Ethulia scheffleri S. Moore						0.07	0.2	1	0.1	A
Galinsoga parviflora Cav.						0.12	0.4	3	0.3	A
Hirpicium diffusum (O. Hoffm.) Roess.	0.05	0.3	2	0.4	A	0.10	0.3	5	0.5	SL
Pluchea monocephala E. A. Bruce						0.44	1.4	18	1.8	A
Seigesbeckia abyssinica Oliv. & Hiern	0.10	0.6	2	0.4	A					
Sphaeranthus suaveolens (Forsk.) DC.	0.53	3.0	14	2.9	A	0.40	1.3	5	0.5	A
Spilanthes mauritiana (A.Rich) DC.	0.12	0.7	2	0.4	A					
Compositae										
Tagetes minuta L.						0.13	0.4	5	0.5	A
Vernonia lasiopus O. Hoffm.						0.09	0.3	6	0.6	A
Convolvulaceae										
Ipomoea cairica (L.) Sweet	0.45	2.5	10	2.2	A	0.20	0.6	2	0.2	SL
Cyperaceae										
Cyperus dichroostachyus Hochst.	0.20	1.2	4	0.8	L					
Cyperus digitatus Roxb.	0.30	1.8	3	0.6	L					
Cyperus dives Del.	0.10	0.6	2	0.4	L	0.80	2.5	8	0.8	L
Cyperus laevigatus L.						0.25	0.8	6	0.6	L
Cyperus rotundus L.	4.86	28.6	126	26.2	L	1.57	5.1	58	5.9	L
Scirpus confusus N.E.Br.	0.50	2.9	10	2.2	SI					
Scirpus inclinatus (Del.) Aschers. & Schweinf.	0.10	0.6	2	0.4	SI	0.07	0.2	1	0.1	SI
Euphorbiaceae										
Ricinus communis L.						1.55	5.0	29	2.9	SL
Geraniaceae										
Geranium aculeolatum Oliv.						0.07	0.2	1	0.1	A
Gramineae										
Cynodon dactylon (L.) Pers.						0.30	1.0	7	0.7	SL
Odontelytrum abyssinicum Hack.						0.12	0.4	1	0.1	A
Panicum coloratum L.						0.07	0.2	1	0.1	A
Labiatae										
Leucas bracteosa Guerke						0.12	0.4	6	0.6	A
Leonotis nepetaefolia R.Br.						0.75	2.4	34	3.5	T

TABLE 3 *continued*

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Ocimum lamiifolium Benth.						0.48	1.6	17	1.7	A
Ocimum suave Willd.						0.06	0.2	2	0.2	A
Loganiaceae										
Buddleja polystachya Fres.						0.15	0.5	7	0.7	A
Lythraceae										
Lythrum rotundifolium Hochst.						0.43	1.4	20	2.0	A
Malvaceae										
Abutilon indicum Sweet						0.06	0.2	2	0.2	T
Abutilon mauritianum (Jacq.) Medic.						0.80	2.6	8	0.8	T
Kosteltzkya begoniifolia (Ulbr.) Ulbr.	0.20	1.2	6	1.2	A	0.43	1.4	10	1.0	T
Malva parviflora L.	0.65	3.8	10	2.3	A					
Pavonia patens (Andr.) Chiov.	0.10	0.6	2	0.4	A					
Pavonia urens Cav.						0.19	0.6	7	0.7	T
Sida cuneifolia Roxb.						0.05	0.2	3	0.3	A
Sida ovata Forsk.	0.10	0.6	4	0.8	A					
Moraceae										
Ficus capensis Thunb.						0.09	0.3	6	0.6	SL
Nyctaginaceae										
Commicarpus pedunculosus (A. Rich.) Cuf.	0.30	1.8	12	2.5	A	0.25	0.8	2	0.2	A
Onagraceae										
Ludwigia stolonifera (G. & P.) Raven	0.90	5.2	11	2.3	A					
Papilionaceae										
Aeschynomene schimperi A. Rich.	0.60	3.5	9	1.9	A	4.24	13.7	174	17.5	T
Lathyrus hygrophilus Taub.	2.87	17.0	128	26.5	A	0.05	0.2	2	0.2	A
Rhynchosia chrysadenia Taub.						0.11	0.3	1	0.1	A
Trifolium masaiense Gillett	0.70	4.1	35	7.2	A	1.31	4.2	59	5.9	A
Phytolaccaceae										
Phytolacca dodecandra L'Herit.						0.49	1.6	18	1.8	SL
Polygonaceae										
Polygonum pulchrum Blume	0.25	1.5	4	0.8	A	1.59	5.1	28	2.9	A
Polygonum setosulum A. Rich.	0.40	2.4	12	2.5	A					
Ranunculaceae										
Ranunculus multifidus Forsk.						0.16	0.5	3	0.3	A
Rhamnaceae										
Helinus mystacinus (Ait.) E. Mey.						0.15	0.5	10	1.0	A
Rosaceae										
Alchemilla cryptantha A. Rich.	0.10	0.6	2	0.4	A					
Alchemilla sp.						0.05	0.2	2	0.2	A
Schrophulariaceae										
Veronica anagallis-aquatica L.	0.10	0.6	2	0.4	A					

TABLE 3 *continued*

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Solanaceae										
Datura stramonium L.						0.06	0.2	2	0.2	A
Nicandra physaloides Gaertn.						0.06	0.2	4	0.4	SL
Solanum incanum L.	0.20	1.2	8	1.6	A	1.13	3.7	43	4.4	SL
Urticaceae										
Urtica massaica Mildbr.	1.10	6.5	37	7.6	SL	5.67	18.3	193	19.5	SL
Verbenaceae										
Lippia javanica (Burm.f.) Spreng.						0.06	0.2	2	0.2	T
Verbena officinalis L.	0.10	0.6	2	0.4	A	0.17	0.5	4	0.4	A
Total:	17.00	100	482	100		31.00	100	991	100	

*See footnote to Table 1

TABLE 4

Food preferences of the black rhinoceros in forest habitat (Lerai Forest) of the Ngorongoro caldera

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Acanthaceae										
Justicia betonica L.	1.55	51.6	46	52.2	A	1.60	80.0	32	67.0	A
Amaranthaceae										
Achyranthes aspera L.	0.05	1.7	2	2.3	A					
Compositae										
Melanthera scandens (Schumach & Thonn.) Brenan	0.15	5.0	5	5.7	A					
Pluchea dioscorides DC.	0.05	1.7	2	2.3	T	0.40	20.0	16	33.0	T
Spilanthes mauritiana (A. Rich.) DC.	0.10	3.3	4	4.6	A					
Vernonia auriculifera Hiern	0.65	21.7	18	20.3	SL					
Convolvulaceae										
Ipomoea cairica (L.) Sweet	0.05	1.7	1	1.2	A					
Malvaceae										
Pavonia patens (Andr.) Chiov.	0.05	1.7	1	1.2	A					
Solanaceae										
Solanum incanum L.	0.20	6.6	6	6.8	A					
Urticaceae										
Urtica massaica Mildbr.	0.15	5.0	3	3.4	SL					
Total:	3.00	100	88	100		2.00	100	48	100	

*See footnote to Table 1

TABLE 5

Food preferences of the black rhinoceros on the plains habitat in the vicinity of Olduvai gorge

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Acanthaceae										
Blepharis fruticulosa C.B.Cl.	0.20	1.4	2	0.5	A	0.17	1.1	1	0.2	A
Justicia betonica L.	0.75	5.4	18	4.8	A					
Amaranthaceae										
Achyranthes aspera L.	0.53	3.8	12	3.2	A					
Cyathula orthacantha Schinz	0.03	0.2	1	0.3	A					
Aizoaceae										
Zaleya pentandra (L.) Jeffrey	0.12	0.9	5	1.3	A					
Boraginaceae										
Vaupelia hispida (Bak. & C. H. Wright) Brand	0.02	0.1	1	0.3	A					
Burseraceae										
Commiphora subsessilifolia Engl.	0.72	5.1	24	6.4	T					
Chenopodiaceae										
Chenopodium murale L.	0.20	1.4	6	1.6	A					
Chenopodium procerum Hochst. *ex* Moq.	0.19	1.4	8	2.1	A					
Compositae										
Pluchea monocephala E.A. Bruce	2.00	14.3	70	18.6	A	2.97	19.8	493	31.0	A
Curcurbitaceae										
Cucumis aculeatus Cogn.	0.02	0.1	1	0.3	A					
Euphorbiaceae										
Euphorbia sp.	0.02	0.1	1	0.3	S					
Gramineae										
Cenchrus ciliaris L.	0.23	1.7	9	2.3	IS					
Cynodon dactylon (L.) Pers.	0.05	0.4	2	0.5	IS					
Digitaria macroblephara (Hack.) Stapf.	0.01	0.1	1	0.3	IS					
Pennisetum stramineum Peter	0.17	1.2	8	2.1	IS					
Liliaceae										
Asparagus pauli-guilelmi Solms	0.25	1.7	3	0.8	A					

TABLE 5 *continued*

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Malvaceae										
Hibiscus flavifolius Ulbr.	0.02	0.1	1	0.3	T					
Pavonia patens (Andr.) Chiov	0.25	1.7	3	0.8	A	2.00	13.3	265	17.1	T
Sida cuneifolia Roxb.						0.02	0.1	2	0.1	A
Sida ovata Forsk.						0.03	0.2	5	0.3	A
Mimosaceae										
Acacia drepanolobium Harms *ex* Sjostedt	0.25	1.7	3	0.8	T					
Acacia mellifera (Vahl) Benth.	0.70	5.0	16	4.3	T					
Acacia tortilis (Forsk.) Hayne	2.79	20.0	42	11.2	A	4.70	31.0	159	10.9	T
Papilionaceae										
Indigofera basiflora Gillett	2.48	18.0	85	22.9	A	4.91	33.1	600	39.0	T
Solanaceae										
Solanum incanum L.	0.78	5.5	19	5.1	A	0.15	1.1	19	1.2	SL
Sterculiacease										
Melhania ovata (Cav.) Spreng.	1.20	8.6	32	8.6	A	0.05	0.3	3	0.2	A
Tiliaceae										
Grewia lilacina K. Schum.	0.02	0.1	1	0.3	SL					
Total:	14.00	100	374	100		15.00	100	1547	100	

*See footnote to Table 1

TABLE 6

Food preferences of the black rhinoceros in Olduvai gorge

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Acanthaceae										
Barleria eranthemoides R.Br.						0.57	0.6	19	0.5	A
Blepharis fruticulosa C.B.Cl.	0.01	0.1	1	0.1	A					
Justicia betonica L.						0.23	0.2	10	0.3	A
Justicia cordata T. Anders.	0.10	0.5	2	0.3	A	0.11	0.1	4	0.1	A
Ruellia megachlamys S. Moore	0.18	0.9	9	1.3	A	2.31	2.6	100	2.9	A

TABLE 6 *continued*

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Agavaceae										
Sansevieria ehrenbergii Bak.	0.65	3.2	19	2.9	I	2.66	2.9	99	2.8	S
Amaranthaceae										
Achyranthes aspera L.	0.41	2.0	17	2.5	A					
Pupalia sp.	0.05	0.2	1	0.1	A					
Ampelidaceae										
Cyphostemma lentianum (Volk. & Gilg) Descoings	0.10	0.5	5	0.7	A					
Asclepiadaceae										
Sarcostemma sp.	0.04	0.2	2	0.3	S					
Boraginaceae										
Cordia ovalis DC.	0.04	0.2	2	0.3	LS	0.03	t	1	t	LS
Burseraceae										
Commiphora madagascariensis Jacq.	2.19	11.1	46	7.0	T	0.20	0.2	12	0.3	T
Commiphora merkeri Engl.	0.29	1.4	8	1.2	T	0.31	0.3	8	0.2	T
Commiphora subsessilifolia Engl.	1.00	5.0	22	3.3	T					
Capparidaceae										
Capparis tomentosa Lam.						1.59	1.7	55	1.6	A
Maerua triphylla A. Rich.	0.39	1.9	12	1.8	A	0.69	0.7	34	1.0	SL
Chenopodiaceae										
Chenopodium procerum Hochst. *ex* Moq.						0.36	0.4	9	0.2	A
Commelinaceae										
Commelina imberbis Ehrenb. *ex* Hassk.	0.10	0.5	2	0.3	A					
Compositae										
Aspilia pluriseta Schweinf.	0.07	0.4	7	1.0	T	0.85	0.9	27	0.8	T
Helichrysum glumaceum DC.	0.20	1.0	10	1.5	T					
Kleinia longiflora DC.	0.55	2.7	15	2.3	S	1.37	1.4	29	0.9	S
Pluchea dioscorides DC.						0.15	0.2	14	0.3	T
Pluchea monocephala E.A. Bruce						0.09	0.1	5	0.1	A
Convolvulaceae										
Ipomoea jaegeri Pilg.						0.05	t	1	t	A

TABLE 6 *continued*

	WET SEASON					DRY SEASON				
	h	% of total	Stat.	% of total	Part eaten*	h	% of total	Stat.	% of total	Part eaten*
Cucurbitaceae										
Momordica rostrata Zimm.	0.01	0.1	1	0.1	A					
Euphorbiaceae										
Euphorbia tirucalli L.	6.10	30.5	126	19.1	SIB	65.68	70.8	2436	70.5	SIB
Gramineae										
Cynodon dactylon (L.) Pers.	0.09	0.5	5	0.7	IS					
Dactyloctenium aegyptium (L.) Beauv.	0.28	1.4	3	0.5	I	0.10	0.1	5	0.1	I
Digitaria setivalva Stent	0.10	0.5	2	0.3	IS					
Sporobolus robustus Kunth						1.85	2.0	59	1.8	I
Sporobolus spicatus (Vahl) Kunth						0.15	0.2	5	0.1	IS
Labiatae										
Coleus igniarius Schweinf.	3.67	18.3	128	19.3	A	1.97	2.1	87	2.5	A
Ocimum sp.	0.31	1.5	8	1.2	A	1.77	1.9	38	1.2	A
Liliaceae										
Aloe sp.	0.02	0.1	1	0.1	I	1.60	1.7	61	1.8	SI
Aloe volkensii Engl.						0.04	t	1	t	S
Asparagus pauli-guilelmi Solms	1.70	8.5	174	26.2	A	0.39	0.4	16	0.5	A
Malvaceae										
Hibiscus calyphyllus Cav.						0.05	t	1	t	T
Mimosaceae										
Acacia mellifera (Vahl) Benth.						2.46	2.6	90	2.6	T
Acacia tortilis (Forsk.) Hayne	0.13	0.7	5	0.7	A	1.89	2.1	93	2.7	T
Papilionaceae										
Rhynchosia sp.						0.05	t	3	t	A
Vigna fragrans Bak.f.	0.02	0.1	1	0.1	A					
Portulacaceae										
Talinum portulacifolium (Forsk.) Aschers. *ex* Schweinf.	0.04	0.2	2	0.3	A					
Salvadoraceae										
Salvadora persica L.	0.66	3.3	15	2.4	SL	2.35	2.6	116	3.3	SL
Solanaceae										
Solanum incanum L.	0.02	0.1	1	0.1	A					
Verbenaceae										
Lantana viburnoides (Forsk.) Vahl	0.34	1.7	9	1.4	T	0.28	0.3	7	0.2	T
Vitaceae										
Cissus quadrangularis L.	0.04	0.2	2	0.3	S	0.80	0.9	21	0.7	S
Zygophyllaceae										
Tribulus terrestris L.	0.10	0.5	2	0.3	A					
Total:	20.00	100	662	100		93.00	100	3466	100	

*See footnote to Table 1

Table 3 shows food preferences in the marsh habitat of Ngorongoro. Over 70 plant species were selected in this marsh. Prior to 1966 the marsh consisted mainly of a choking mat of dry decaying sedges consisting of several species of *Cyperus*. *Aeschynomene schimperi* had been browsed heavily almost to ground level and did not regenerate beneath the mat of dry sedges. In October 1965 the marsh was burnt completely. By April 1966 *A. schimperi* was established as a firm dominant over 10 ft high, and over 60 per cent. of the diet in this habitat type consisted of this legume during 1966. Prior to 1966 a relatively large part of the diet consisted of sedges of the genus *Cyperus*. Over the three year study period, however, available legumes made up nearly 25 per cent. of the diet.

Food preferences in the forest habitat at Ngorongoro are shown in Table 4. Dominants among the food available make up less than 5 per cent. of the diet during the wet season and approximately 25 per cent. during the dry season. A marked preference is shown for the herb *Justicia betonica* L. No observations were made in the swamp area of the forest.

Table 5 shows the food preferences on the plains habitat in the vicinity of Olduvai gorge. The local herb dominants in this habitat type, i.e. *Pluchea monocephala* and *Solanum incanum*, constitute approximately 20 per cent. of the diet. Approximately 40 per cent. of the diet consists of legumes during the wet season and over 50 per cent. during the dry season.

Food preferences in Olduvai gorge are shown in Table 6. With the exception of *Heliotropium steudneri* all herbs and shrubs available in this habitat type are eaten. *Sansevieria ehrenbergii*, a dominant in this habitat type, makes up less than 3 per cent. of the diet. Only the flowers of this plant are eaten during the wet season, and the stalks are chewed and discarded during the dry season. *Cissus quadrangularis* L. is also chewed and discarded but usually only during the dry season. Chewing may continue for 20 min after which the fibre is discarded. The three species of the genus *Commiphora* are eaten but are usually left untouched. The finger euphorbia (*Euphorbia tirucalli*) is highly palatable and eaten in great quantities. This tree made up approximately 25 per cent. of the diet during the wet season and over 70 per cent. of the diet during the dry season. All parts of this tree are eaten including the bark. Even in the areas of the gorge where this species is not a sub-dominant it is highly sought after. The rhinoceros uses its horns with great dexterity to obtain the higher branches of this tree. Straining upwards and placing its forelimbs on convenient lower branches, it wedges the higher branches between the anterior and posterior horns and simply walks backwards. I have seen higher branches up to 7 in in diameter snapped by this method. When the branch falls, almost all the branchlets are consumed by the animal. The bark is removed with the tip of the anterior horn and the front premolars (Plate 1b). Van Rensburg (1963) has also reported a preference for succulent *Euphorbias* in arid habitats. Lydekker (1926) states (p. 24): "In Somaliland these animals, i.e. black rhinoceros, have a great partiality for the giant euphorbias, which they uproot, and then chew the stems."

It is considered that the marked preference for the succulent, latex-bearing finger euphorbia, and the chewing of xerophytic moisture-rich plants such as *Sansevieria ehrenbergii* and *Cissus quadrangularis* may be an adaption to obtaining water from the environment. The chewing habit is invariably seen only during the height of the dry season. From the study area at Olduvai considerable evidence accumulated showing that the rhinoceros remained attached to its very small home range through the height of the dry season, even when surface water supplies had completely dried out. There was no evidence that rhinoceros in these areas undertook long treks to water. Rhinoceros whose home range was adjacent to permanent water made use of the water supply, but others (up to 27.4 km (17 miles) from the nearest permanent water during the dry season) did not. These however were all animals occupying a habitat where these xerophytic plants are relatively abundant. It is postulated that rhinoceros in this kind of habitat can survive without free water. The finger euphorbia was introduced from India (Dale and Greenway, 1961). It is interesting to speculate on the influence that the colonization and spread of this plant has had on utilization of arid habitats by this animal.

The coprophagous habit of the black rhinoceros has been noted by Klingel (1966). I have observed this habit on eight different

occasions but only in September and October, and in areas where legumes were extremely sparse or dry and sterile at that time of the year. The habit may well be a method of obtaining nitrogenous material contained in the dung, in the absence of a suitable rich source of protein contained in the legume.

Table 7, shows a list of plants which were eaten by rhinoceros at Ngorongoro, which have not been included in Tables 1-6. These were collected from two sources: a) casual observation, b) records collected during an uncompleted one hour observation period. All tables also indicate the part of the plant that was eaten by the rhinoceros.

TABLE 7

Additional list of plants eaten by black rhinoceros at Ngorongoro and Olduvai

	Part eaten*
Acanthaceae	
Monechma sp.	A
Amaranthaceae	
Amaranthus graecizans L.	A
Pandiaka fasciculata Suess.	A
Crassulaceae	
Crassula granvikii Mildbr.	A
Gramineae	
Eleusine jaegeri Pilger	IS
Setaria verticillata L. (Beauv.)	A
Labiatae	
Stachys aculeolata Hook.f.	A
Loranthaceae	
Loranthus sp.	A
Malvaceae	
Hibiscus fuscus Garcke	T
Mimosaceae	
Acacia xanthophloea Benth.	T
Papilionaceae	
Erythrina abyssinica Lam. *ex* DC.	IS
Indigofera microcharoides Taub.	A
Lupinus princei Harms	T
Rhynchosia memnonia (Del.) DC.	A
Trifolium usambarense Taub.	A
Vigna vexillata (L.) A. Rich.	A
Solanaceae	
Solanum aculeastrum Dunal.	LS

*See footnote to Table 1

DISCUSSION

Rhinoceros in the two study areas were observed eating 191 species from 49 botanical families, and are strongly selective for herbs and shrubs. They thus select a wide variety from the spectrum of plants available, but show a marked preference for legumes. At certain times of the year the rhinoceros is highly selective, and not all specimens of a particular plant species available are eaten. On many occasions I have seen rhinoceros feeding through a homogeneous herb patch, and selecting only certain specimens of the same plant species. Others were sniffed but not eaten. Dry sterile specimens were invariably rejected, but on other occasions specimens which appeared identical with their neighbours were not accepted. Apparently the animal can detect which individuals of a plant species have a nutritive value. Grass is eaten, predominantly during the wet season. However, it constitutes a relatively small proportion of the diet and is usually rejected. Herbs which are green and succulent are preferred throughout the year. Several herb dominants, e.g. *Lippia javanica, Pluchea dioscorides*, and *Solanum incanum* soon become unpalatable in large quantities. Legumes on the other hand, especially the green succulent species such as *Trifolium masaiense* and *Lathyrus hygrophilus* Taub., are highly palatable and eaten in large quantities. The marked palatability of lucerne to captive black rhinoceros is probably significant. Several species make up a significant part of the diet during the wet season but only a small part of the diet in the dry season either because they are unavailable or because they are dry and sterile. Rhinoceros also eat plants which are considered highly toxic such as *Phytolacca dodecandra* L'Herit. and *Datura stramonium* L.

Burning did not appear to have any marked unfavourable effect on the habitat of the rhinoceros at Ngorongoro. During the study period six rhinoceros on the caldera wall had their home range burnt out completely. The animals did not leave the area, but continued to browse on the charred shrubs without adverse effect. In fact the regeneration of *Acacia lahai* Benth. which was stimulated in some areas, favoured the rhinoceros. With the onset of the rains, and resultant stimulation of green growth, some rhinoceros continued to feed almost exclusively on charred *Indigofera arrecta* A. Rich., ignoring the non-leguminous green herbs which were appearing in the habitat. The total burning of the Munge marsh (described above) improved the habitat for the rhinoceros. The legume *Aeschynomene schimperi* was present before the fire but had been heavily browsed to ground level by rhinoceros and elephant. Most shoots failed to regenerate under the thick mat of dry decaying sedges. The fire removed this competition and within seven months this

legume covered over 75 per cent. of the marsh, in some areas the growth exceeding 3 m (c. 10 ft). Six rhinoceros from adjacent home ranges, which never before had been seen in the marsh, moved in and made extensive use of the habitat throughout the year.

In Lerai Forest the dominant shrubs of the understorey are relatively unpalatable, and their rapid spread and colonization of the open areas prevents regeneration of *Acacia*. These dominant shrubs are also relatively unpalatable to the elephant. Experimental use of selective herbicides to control these dominants would encourage regeneration of *Acacia* and undoubtedly improve the habitat for both these large mammals.

In the wet season rhinoceros also make use of the heavily overgrazed parts of both study areas, especially at Olduvai. Herbs such as *Solanum incanum*, *Indigofera basiflora* and *Indigofera bogdanii* Gillett quickly appear in these overgrazed areas, the two latter species being particularly palatable to the rhinoceros. Hence areas which are classified as inferior pasture for grazing mammals such as the wildebeest (*Connochaetes taurinus* (Burchell)) offer an excellent habitat for browsers such as the rhinoceros. Thus, heavily overgrazed areas are not necessarily detrimental, but may be considered as an essential part of an environment which supports a broad spectrum of herbivores. The maintenance of the marshes and marsh areas in Ngorongoro throughout the dry season is of considerable importance to the animal.

In terms of numbers and biomass the closest food competitor to the rhinoceros at Ngorongoro is probably the Grant's gazelle (*Gazella granti* Brooke). This opinion was based on casual observations of food habits of other herbivores in the caldera. These gazelle are not sedentary at Ngorongoro but make use of all parts of the caldera floor and walls, concentrating on the peripheral crater slopes during the dry season. They rarely enter dense bush or marshes for prolonged periods, and direct or serious food competition with rhinoceros probably does not occur to any great extent.

The mean annual rainfall on the caldera floor at Ngorongoro is 660.4 mm (26 in) and at Olduvai 406.4 mm (16 in). During the study period the rhinoceros population density was established at one animal per 3.1 km^2 (1.2 sq. miles) at Ngorongoro and one rhinoceros per 6.5 km^2 (2.5 sq. miles) at Olduvai (Goddard, 1967). Considering the different rainfall patterns, the observed densities, and the relative availability of legumes and green herbs and shrubs, it is suspected that the carrying capacity for the rhinoceros at Ngorongoro is twice that of the area at Olduvai. Providing the habitats of the rhinoceros are not destroyed by encroaching cultivation, or by illegal cutting by the Masai, the future of the species in both study areas appears to be good.

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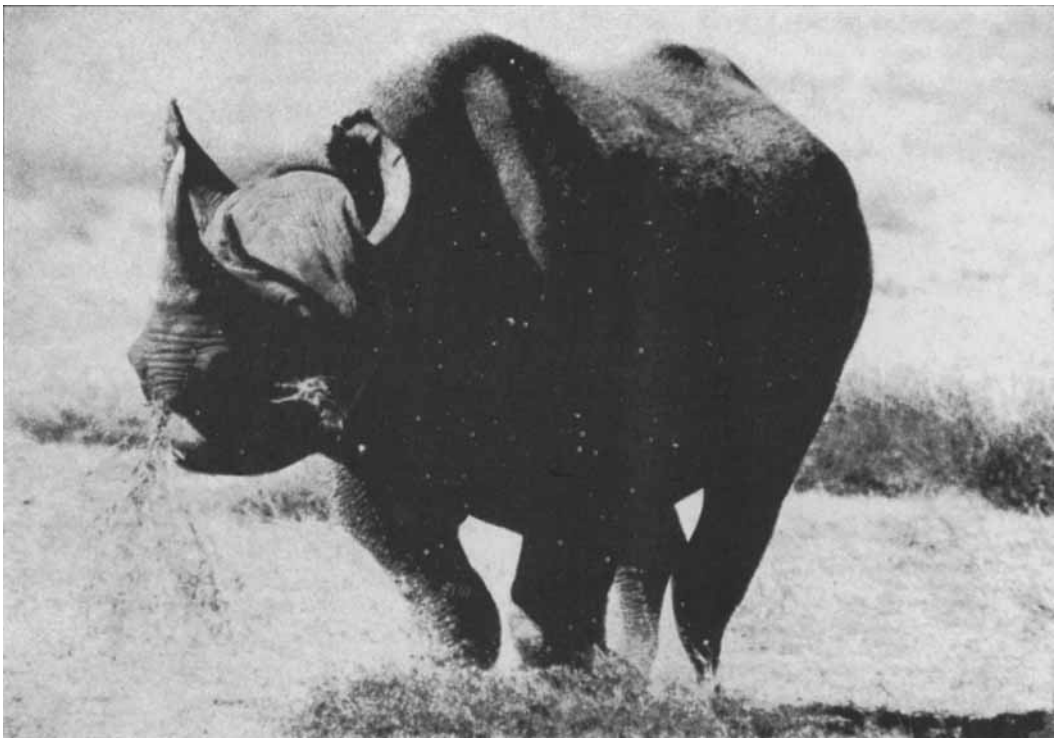

Plate 1a
A tagged immature male rhinoceros eating Pluchea monocephala *on the plains habitat of Ngorongoro. The photograph shows how different combinations of tags allow an individual to be identified at a distance, and how the animal's method of feeding also often allows the foodplant to be identified at a distance.*

Plate 1b
Branch of Euphorbia tirucalli L. *showing bark which has been removed by a feeding black rhinoceros.*