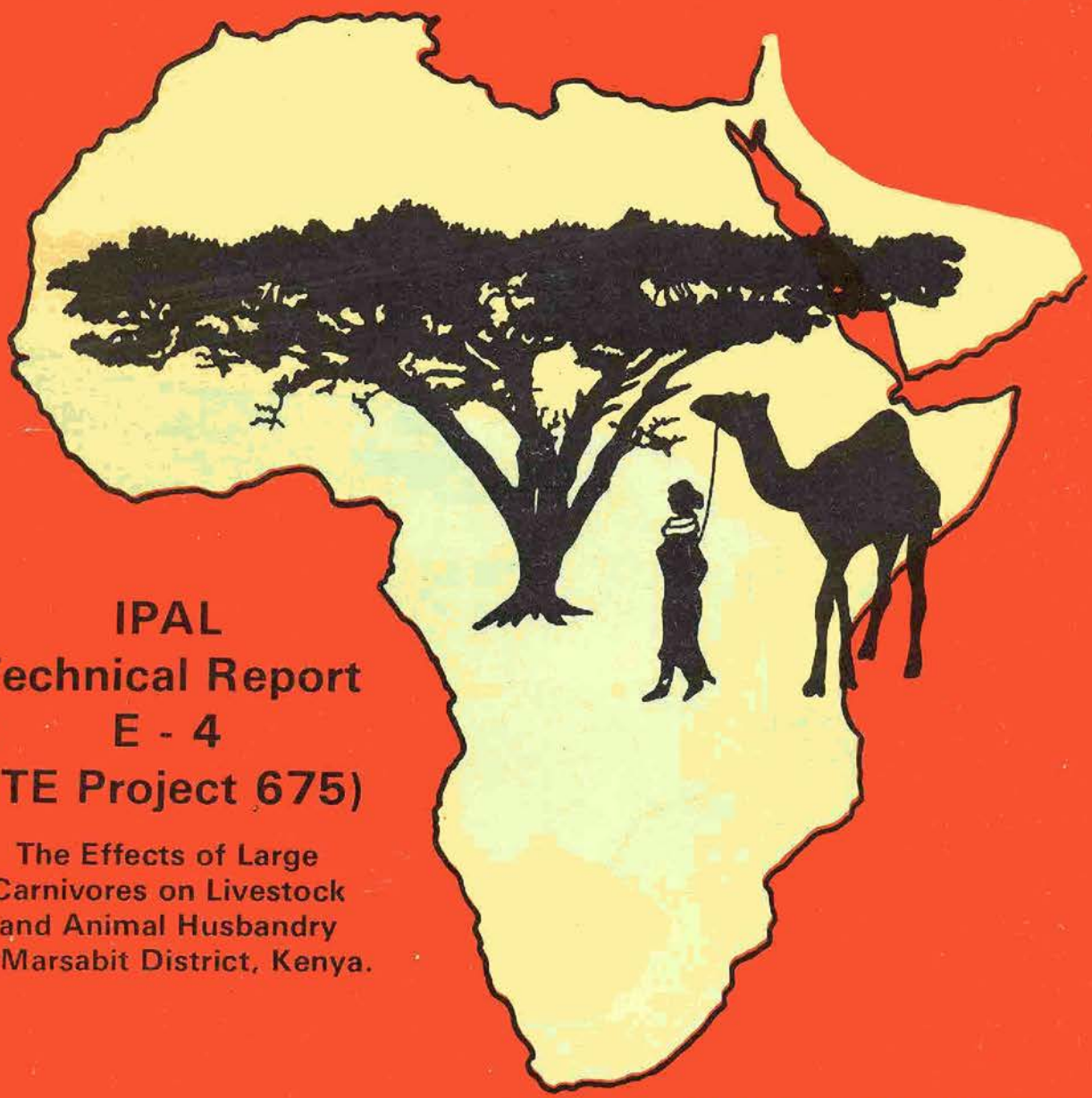
Unesco Programme
on Man and the
Biosphere (MAB)

United Nations
Environment
Programme (UNEP)

Integrated Project in Arid Lands (IPAL)



IPAL
Technical Report
E - 4
(ITE Project 675)

The Effects of Large Carnivores on Livestock and Animal Husbandry in Marsabit District, Kenya.

MAN AND THE BIOSPHERE
PROGRAMME

Project 3: Impact
of Human Activities
and Land Use Practices
on Grazing Lands

IPAL Technical Report Number E - 4

ITE Project 675

THE EFFECTS OF LARGE CARNIVORES ON LIVESTOCK AND ANIMAL HUSBANDRY IN MARSABIT DISTRICT, KENYA.

by

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UNEP - MAB Integrated Project in Arid Lands.

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Summary Introduction to IPAL and the Technical Report Series

The Integrated Project in Arid Lands (IPAL) was established jointly by UNEP and UNESCO in 1976 with the aim of finding direct solutions to the most urgent environmental problems associated with desert encroachment and ecological degradation of arid lands. It forms part of the operations under MAB Project 3, the Secretariat of which is jointly held by UNESCO and FAO, and also those of UNEP's Desertification Unit, established in response to the Plan of Action adopted by the United Nations Conference on Desertification. It is an example of the type of pilot activity that UNEP and UNESCO, together with other organisations and a number of governments, are trying to promote to provide the scientific basis for the rehabilitation and rational management of arid and semi-arid zone ecosystems, through integrated programmes of research (including survey, observation and experimentation), training and demonstration. Phase III of the Project, 1980 - 1983, is supported by funds in trust to UNESCO provided by the Federal Republic of Germany.

During the early operational work of IPAL, a co-ordination unit was established in Nairobi and the initial field work started in the arid zone of Northern Kenya in a working area of 22,500km^2 situated between Lake Turkana and Marsabit Mountain. The Project now operates five field stations at Mt. Kulal, Olturot, Kargi, Korr and Ngurunit, with the Project headquarters in Marsabit, the administrative centre of the District. Since its establishment the Project has worked on several aspects of the ecology and experimental management of the region, concentrating upon the interaction of pastoralists and their livestock with the soils and vegetation of the environment and the constraints to the production of the ecosystem.

During the next three years (1980 - 1983), the investigations in progress will be extended and intensified to develop a resource management plan or model for the area, taking into account the increasing human population, the trend towards sedentarization, the degradation of primary productivity, and the increasing incidence of soil erosion, all of which are factors which contribute to the necessity for constant famine relief measures in this region. Results obtained in this Project will be compared with those from similar research in the Sahel region and other arid regions in the world.

This report is one of a series published by IPAL describing technical findings of the Project and, where appropriate, giving management recommendations relating to the central problems of ecological degradation in the arid zone. The reports are divided into the following categories distinguished by the base colours of their covers:

A. general, introductory and historical: white.

B. climate and hydrology: blue.

C. geology, geomorphology and soils: brown.

D. vegetation: green.

E. livestock and other animal life: red.

F. social and anthropological: yellow.

Summary of Report

1. A survey was made in western Marsabit District over a 4-month period to assess the amount of livestock taken annually by carnivores and the circumstances under which the animals are killed. The way in which people of 4 different tribes protect their livestock is described, especially the construction of thorn fences ('bomas'), and suggestions are made for improvements.

2. The economically important predators are spotted hyaenas, lions and black-backed jackals, though striped hyaenas, cheetah and wild dog are also present.

3. There are significant differences between the carnivores in their selection of livestock; lions take mostly cattle, spotted hyaenas mostly sheep and goats, the other predators only sheep and goats. Spotted hyaenas take relatively more young animals than lions, and jackals take mostly young lambs and kids. Annual predation rates (all predators) vary between approximately 2% and 10%, according to locality.

4. Overall, most livestock is killed in day-time when grazing (72%) only spotted hyaenas kill more often at night. Ninety per cent of all kills are made outside the protection of bomas.

5. The main function of the bomas is to prevent livestock from straying as well as to exclude predators.

6. Rendille herds suffer more predation inside the boma than herds of Samburu or Gabra. Samburu animals are the best protected at night, and Samburu bomas are also the most solidly built ones.

7. There is less predation in 'manyattas' (villages) with dogs, than in those without them.

8. There is large variation between tribes in boma size, shape and structure, but less variation within the tribes. There are significant tribal differences between the numbers of huts per manyatta, the length of boma per manyatta and the length of boma per individual hut.

9 Overall, there is a correlation between the number of huts in a manyatta and the length of boma, and large manyattas are not more efficient in use of boma-material than small ones (except when comparing manyattas of fewer than 4 huts).

10. Recommendations are made for experiments with alternative materials for boma construction, for the use of pesticides to prolong the useful life of bomas by combating ticks, and for research on the use of dogs and the occurrence of rabies.

THE EFFECT OF LARGE CARNIVORES ON LIVESTOCK AND ANIMAL HUSBANDRY IN MARSABIT DISTRICT, KENYA

1. Introduction

1.1 Objectives

The terms of reference of this study were:

- to describe predation by wild carnivores on livestock of the nomadic tribes in the Mt Kulal area, northern Kenya;
- to describe the pastoralists' methods of protection against predation and the environmental cost of these methods;
- to advise on possible alternative methods of protection.

1.2 Background

Several areas in northern Kenya have in recent years changed from tree-covered savannah to sub-desert. This process is being documented by the Integrated Project in Arid Lands (IPAL), a joint effort between the UNESCO programme on Man and Biosphere (MAB) and the UN Environment Programme (UNEP). The desertification is part of a large-scale process affecting north-eastern Africa and the Sahelian zone.

IPAL is investigating the causes of desert encroachment and its effects on the economy of the pastoral people of the region. The results of the research will be applied in the course of management, education and training programmes aimed at preventing further degradation and, in the long-term, promoting rehabilitation.

Amongst the important causes of desert encroachment in northern Kenya is the felling of trees by the nomadic pastoralists when they make their livestock night enclosures or 'bomas' (Lamprey, 1978; Synnott, 1979). The nomads move several times each year, and for every move trees are cut and a new enclosure is built. In the last 2 decades, these moves have become more and more restricted to small areas, centred on recently developed watering facilities and the missions with their dispensaries and shops and

police posts (Sobania, 1980), denuding areas around these centres of their trees. The present study investigates the reasons for making bomas and the effect of this and other predator-protection measures on predation.

The study was used also as an opportunity to gather information which is important for the conservation of large carnivores in this area and elsewhere in Africa. Very little is known about the relationship between carnivores and domestic stock in areas shared by them, and such areas occupy the larger part of arid and semi-arid zones in Africa. The bigger carnivores are, or can be, major tourist attractions and, for that reason alone, careful management and conservation of these animals alongside nomadic animal husbandry is important.

1.3 Methods

The survey for this study was carried out over a period of 4 months, from November 1979 till February 1980. During that period, I was based at the IPAL research station at Gatab on Mt Kulal, visiting most of the study area in one- to 2-week journeys by landrover.

Wherever possible, I made notes on the presence or absence of various species of carnivores, using direct observation by day or at night, as well as tracks in the sand, or faeces. For the purpose of estimating spotted hyaena populations (Section 2.3), I attracted these animals to my car at night, between 2100 and 0100 hours, using previously tape-recorded calls of hyaena on a kill in the Serengeti National Park, Tanzania, played on a UHER tape-recorder and amplified and broadcast through a loudspeaker placed on top of the landrover (Kruuk, 1972). To the human ear, this playback was audible up to 6 km away under still conditions, and hyaenas responded by running towards the sound, calling loudly themselves.

To study hyaena food, faeces were collected from their latrines and analysed as in previous studies (Kruuk, 1972; 1976). No jackal droppings were collected, as they were difficult to find in large

numbers and usually I could not be certain about their origin. For identification of food remains, a reference collection of hair of different prey species was made, using hair from skins in the National Museum, Nairobi, and from livestock in the study area. Whenever I found a recently killed animal in the area, I attempted to reconstruct the cause of death from tracks in the sand, sometimes also using marks on the victim.

Herdsmen of four different tribes were interviewed with the help of IPAL personnel as translators: Samburu, Rendille, Gabra and a few Turkana. All the men present in a 'manyatta' (village) were usually, and unavoidably, interviewed at the same time. Questions were designed so as to avoid herdsmen's subjective interpretations and impressions; for instance, instead of asking the number of kills over a certain period, I enquired about the time since the last kill in that village, details of that kill, then the same of the last but one kill, etc. Whenever possible, cross checks were made; for instance, people were asked about predation on others' herds which could be checked with the owners. I asked to see the site of reported kills if this was practicable, to check on remains, tracks, etc. Care was taken to avoid giving the impression during the interview that any benefits might accrue to the herdsmen from the inquiry.

1.4 Acknowledgements

I am grateful to Drs H F Lamprey, C R Field, H J Schwartz and D Herlocker and to Messrs J Stephenson, H Yussuf and L Frank for assistance during the survey. Drs C R Field, D Jenkins and H F Lamprey provided useful comments on the draft of this report.

2. The study area

2.1 People and general background

The IPAL study area is approximately 20,000 km^2; it is located between the south-east shore of Lake Turkana and Marsabit Mountain (Figures 1 and 2). Vegetation and topography have been described in detail by Herlocker (1979), the climate by

Fig. 1 Location of study area

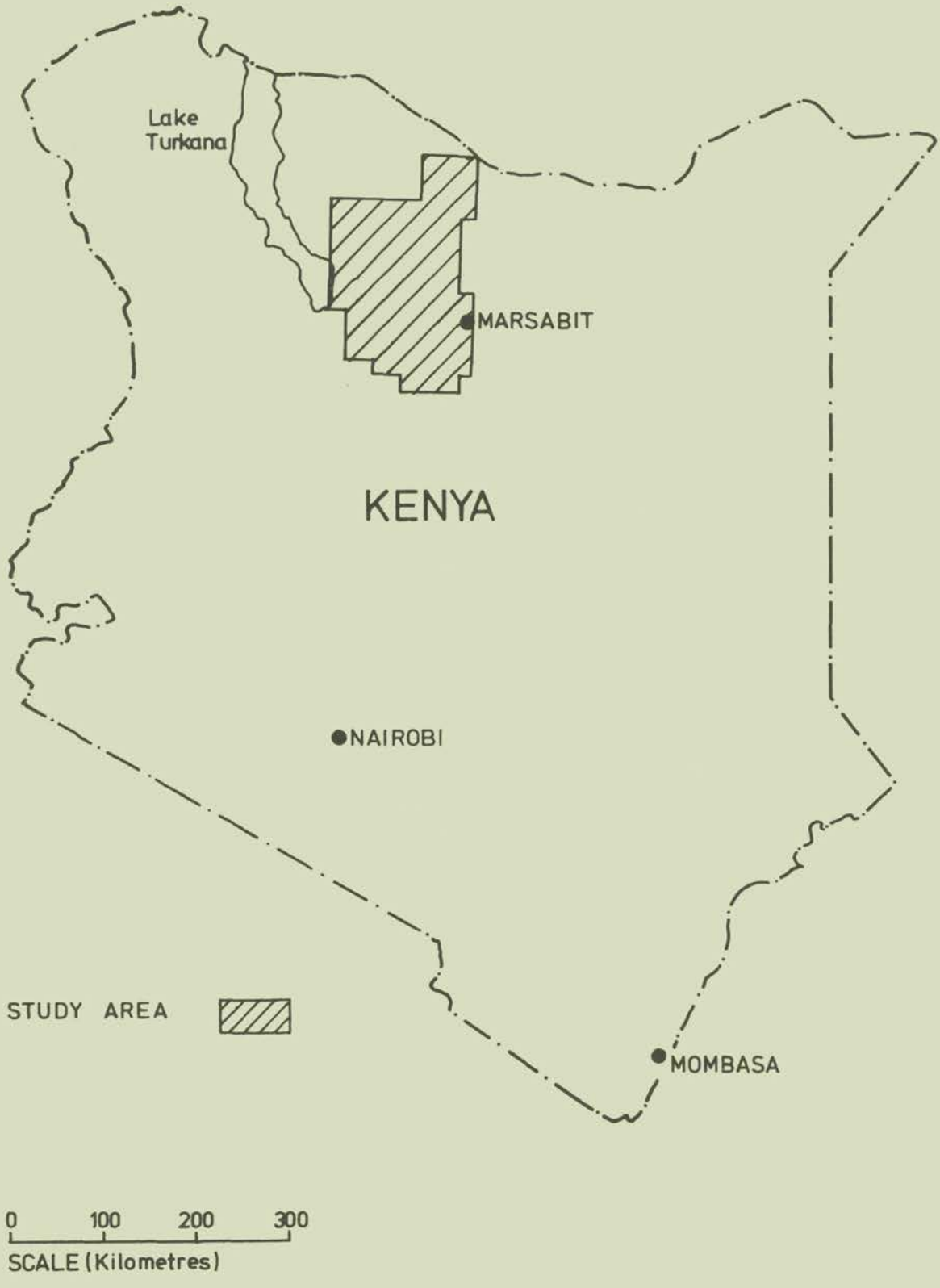
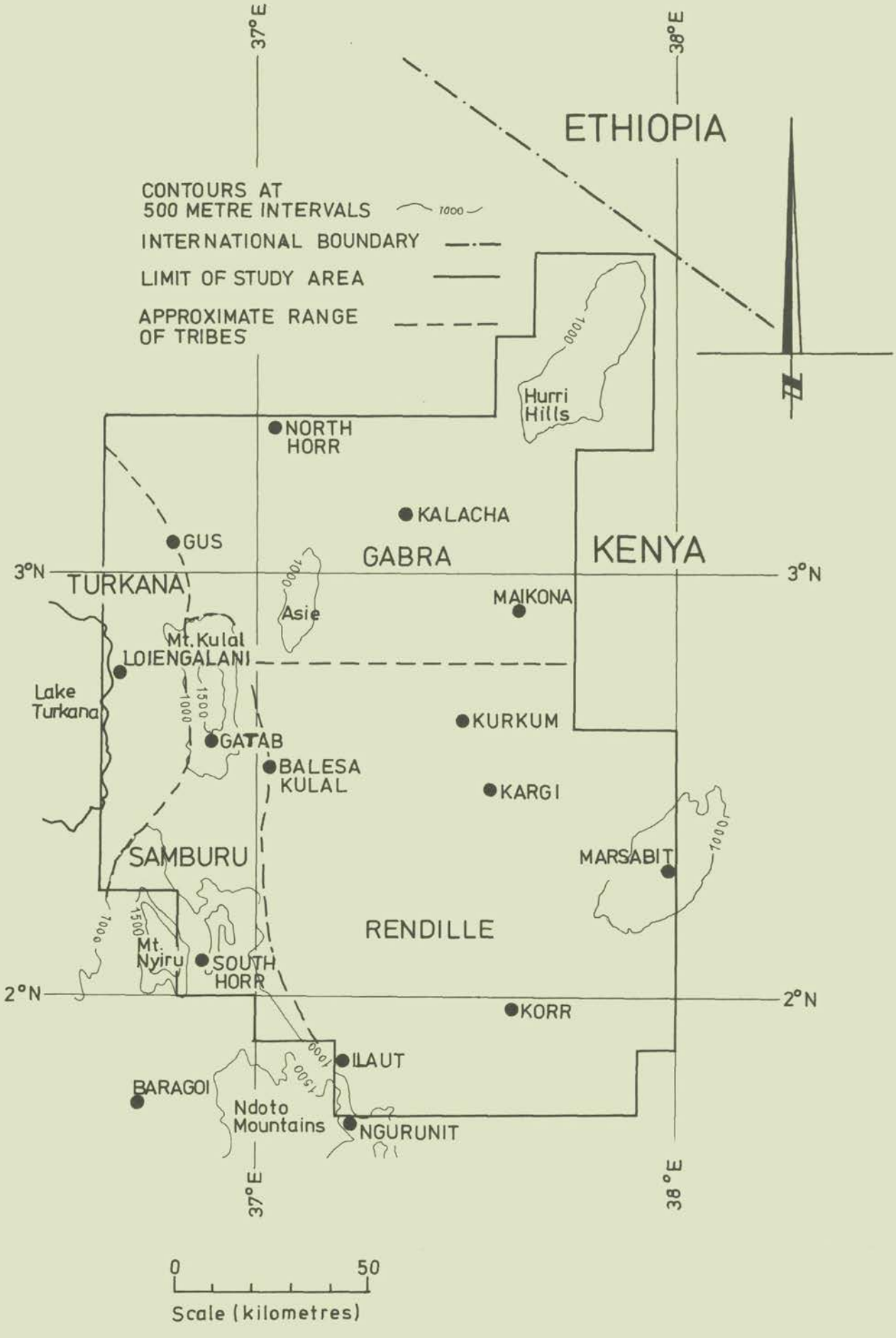


Fig. 2 The study area



Edwards et al (1979) and preliminary surveys of people and livestock have been made by Watson (1970), FAO (1971) and Lewis (1977). With the exception of Mt Kulal itself, the area is characterised by very low rainfall and high evaporation; the vegetation consists mostly of low-density annual grasses, dwarf shrubs, shrub-Acacia and Acacia-bushland, with some areas completely devoid of plants.

The tribes inhabiting the study area are all nomadic pastoralists and they tend to stay in separate areas (Figure 2). Apart from the main tribes indicated, there are a few other people, including Boran, El Molo and Somali. Several relevant anthropological studies have been carried out on the main tribes (for instance on Samburu, Spencer 1975; on Rendille, Spencer 1973; on Gabra, Torry 1973; on Turkana, Gulliver 1955). Some of the differences between the tribes which are important for this survey are summarised in Table 1.

The 'manyattas' (villages) of these tribes are described in Section 5.3.2. A considerable proportion of livestock is kept not in these manyattas, but for most of the year in 'fora-camps', herded largely by boys and men, moving more often and further than the manyattas and without huts. Fora-camps may be many days journey from the manyatta. This inquiry deals almost only with predation on livestock from the manyattas. At night, livestock is usually kept inside a fence made of branches of various species of thorntree, the 'boma' (Section 5.3.2); in daytime, the animals graze or browse in herds, each herd with a herdsman or woman, sometimes with 2. The animals are taken to water once every 2 days (sheep and goats), 4-6 days (cattle) or 7-20 days (camels), depending on the state of the vegetation; water may be as far as 25 km from the manyatta. Sheep and goats are always herded together.

2.2 Livestock and wild herbivores

Despite its large size, the IPAL study area is only part of and ecosystem (Lewis, 1977), and large numbers of livestock move in and out of the area with the availability of grazing and water.

TABLE 1

Habitat and livestock of tribes in IPAL study area

Tribe	Most common habitat in IPAL study area (Herlocker, 1979)	Livestock kept		
		Sheep and goats	Cattle	Camels
Samburu	Mountainous woodland and bushland	++	++	-
Rendille	Bushland and dwarf-shrub; annual grassland	++	+	++
Gabra	Annual grassland, dwarf-shrub, barren land	++	+	++
Turkana	Annual grassland, barren land, dwarf-shrubs	++	+	+

(++ = many, + = some, - = absent)

This movement makes it difficult to summarise livestock densities, and the following figures should be seen as indicating the order of magnitude of livestock numbers. A C Field (in prep.) estimated numbers of sheep and goats; over 7 aerial counts during 1976-1978, the mean was 230,000. For cattle, estimates are even more difficult; fluctuations of cattle numbers are much larger than those of small stock, and the number of cattle can change by a factor 12 within a few months (Lewis, 1977), most animals leaving for the higher grounds when it is dry. As I carried out my survey during a drought which had been going on for almost one year, I used Lewis's dry season estimates for the cattle population, ie 15,000 animals. Camel populations, like those of sheep and goats, are less prone to fluctuations with rainfall; camel numbers for 1977-78 averaged approximately 28,000 (7 counts, Field, 1979). Using these figures, I assumed a mean density of sheep and goats of 11.5 km^2, cattle 0.75/km^2 and camels 1.4/km^2. There are no data available on the numbers of stock owned by the various tribes.

The wild herbivores of the study area were briefly mentioned by Lewis (1977). The main species are the Beisa oryx *(Oryx beisa)*, Grevy zebra *(Equus grevyi)*, Grant's gazelle *(Gazella granti)*, gerenuk *Litocranius walleri)*, dik-dik *(Rhynchotragus guentheri)* and reticulated giraffe *(Giraffa camelopardalis reticulata)*. Between them, all wild species constitute probably less than 5% of the total herbivore biomass.

2.3 Carnivores

During this survey, the following carnivores were observed: lion *(Panthera leo)*, leopard *(Panthera pardus)*, cheetah *(Acinonyx jubatus)*, spotted hyaena *(Crocuta crocuta)*, striped hyaena *(Hyaena hyaena*, tracks and scats), wild dog *(Lycaon pictus)*, black-backed jackal *(Canis mesomelas)* and jackal *(Canis aureus*, unimportant as far as livestock were concerned and only observed in Sibiloi National Park), caracal *(Felis caracal*, one skeleton only), wild cat *(Felis lybica)*, genet *(Genetta genetta)*, dwarf

mongoose *(Helogale parvula)* and slender mongoose *(Herpestes sanguineus)*.

Lions occur near Balesa Kulal, Kurkum, and in an area north-east of Ngurunit; from tracks and sightings by myself and others, it was estimated that there are at least 10 in the study area, probably fewer than 50.

Leopards are very rare, recently almost wiped out by poaching, and largely confined to woodlands.

Cheetah are fairly frequently seen in the study area; they are probably more common than lions, and my guess at their numbers is between 20 and 100.

Spotted hyaena tracks are often found, as these animals prefer to use roads, but they are absent in large parts of the study area such as the Chalbi Desert, the Hedad and elsewhere. To estimate their numbers, I stratified the study area using the IPAL 10 x 10 km grid square map. On the basis of tracks and faeces, and by extrapolating from known areas to other parts with similar vegetation and human utilisation, I estimated that 41/135 grid squares are frequently used by hyaenas, or are 'potential' hyaena country; the other 94/135 are unused, or used very little. I assumed that in the remainder of the study area the same ratio of occupation would apply. In the 'potential hyaena areas' I did 33 playback experiments, which attracted a total of 10 different hyaenas. Each playback covered an estimated area of 5-20 km^2 (Kruuk, 1972); it was likely that every adult hyaena in that area was attracted to the recording and showed up. Thus, it was estimated that the study area is inhabited by 92-368 spotted hyaenas; also, from a subjective comparison of this area with known hyaena densities elsewhere, it appeared likely that the hyaena population would be somewhere within this range.

Striped hyaenas are regularly reported, but I only found tracks and droppings. These are far less common than those of spotted hyaenas, but it is difficult to compare as striped hyaenas do not use roads or latrines as do their spotted relatives (Kruuk, 1976); I cannot make any guess as to numbers.

Wild dogs are diurnal, and they are frequently seen at Balesa Kulal, but rarely elsewhere. Total numbers in the study area must be very low, perhaps 10-40.

Black-backed jackals are frequently seen at night; they are the most common carnivore. I would guess that the population was between 1,000 and 5,000.

3. The food of carnivores

3.1 Introduction

Of the large carnivores mentioned in Section 2, some regularly kill livestock whereas others are harmless; in this Section, the importance of each species will be considered, as well as variations throughout the study area. Unfortunately, it was not possible to collect independent information on all species; for some, only the reports from herdsmen were available, with no faeces or other evidence to check their reports. However, where data from faecal analysis were checked against evidence from interviews with the nomads, there appeared to be good confirmation.

3.2 Evidence from literature, faeces and tracks

3.2.1 Lion

Lions have a widespread reputation for livestock killing, and their preference for medium-sized or large ungulates as prey makes lions likely predators on livestock of all sizes (Guggisberg, 1962; Schaller, 1972). In Sibiloi National Park, along the shore of Lake Turkana north-west of the study area, I found lions with possibly killed crocodiles, oryx, hippo, and lion faeces with Grant's gazelle. I found no lion faeces in the study area itself.

3.2.2 Spotted hyaena

This species, too, is known for predation on domestic stock; its natural prey preferences are rather similar to those of the lion and it is a hunter rather than a scavenger (Kruuk, 1972). On 6 occasions, I came across domestic animals that had been killed by spotted hyaenas only hours earlier, so that the hunt could be reconstructed from tracks; the victims were 2 sheep, one goat, 2 calves and one adult cow. All were killed by a single hyaena after a short chase, at night; all except the goat had been far from a manyatta on their own. The goat was in a herd with others, walking back to the manyatta one hour after dark, and was intercepted by the hyaena about 200 m from its boma. I found no wild herbivores killed by hyaenas.

Faeces of spotted hyaena were easy to find as they occurred in large latrines, and 180 were analysed for food contents. They were collected from 5 different areas, of which 3 were used mostly by Samburu people, one by Gabra and one was the Sibiloi National Park. I was unable to find hyaena droppings in Rendille or Turkana country. The results of these analyses are presented in Table 2.

A large proportion of hyaena faeces contained hair of domestic animals: in Samburu area 75% and in Gabra country 93% of all prey remains were of livestock, mostly sheep or goat. The difference in relative importance of livestock amongst prey remains from the 2 areas is significant ($x^2 = 6.60$, df = 1, $p < 0.025$), and probably due to differences in availability of wild ungulates. The spotted hyaenas in Sibiloi National Park had had access to livestock only for a few weeks, whilst faeces covered a period of several months; this probably explains the predominance of wild herbivores in the diet there.

TABLE 2

Frequency of occurrence (%) of undigested items in faeces of spotted hyaena

	Sibiloi National Park	Samburu areas*	Gabra areas**	Total areas w. livestock	Percentage of total livestock
Sheep and goat	13	47	62	52.2	64.0
Cattle	13	23	15	20.3	24.9
Camel		3	15	7.3	9.0
Donkey		2		1.3	1.6
Dog			1	0.4	0.5
Oryx	9	6		3.9	
					100.0%
Zebra	28	1		0.4	(n = 189)
Grant's gazelle	22	2	3	2.2	
Gerenuk		2		1.3	
Dikdik	3	3		2.2	
Wild cat		1		0.4	
Porcupine		1		0.4	
Hare		1	4	1.7	
Small rodent		2		1.3	
Bird		1		0.9	
Crocodile	13				
Snake		1		0.9	
Cucumber seeds		3		2.2	
Unidentified		1		0.9	
Cloth		(n = 19)			
Total occurrences	101%	100%	100%	100.2%	
	n = 32	n = 153	n = 79	n = 232	
No. of faeces	20	104	56	160	

* 57 faeces from Balesa Kulal, 35 from Mt Kulal southern slopes, 12 from Horr Valley and Ngurunit

** All faeces around Chalbi desert within 30 km of North Horr

3.2.3 Striped hyaenas

In areas without domestic stock, this species is known as a scavenger, to a lesser extent hunting its own prey (birds, reptiles, small mammals) or living off fruit (Ilani, 1975; Kruuk, 1976). Table 3 shows the contents of some striped hyaena faeces from the slopes of Mt Kulal; the diet was much the same as the diet of this species in the Serengeti National Park and it seems likely that, at Mt Kulal too, remains of the larger prey animals are scavenged, although there is no direct evidence. The striped hyaena was never implicated by the herdsmen, in contrast to the spotted hyaena.

3.2.4 Cheetah and wild dog

The usual wild prey of both species consists of ungulates of sheep and goat size (Kruuk & Turner, 1967; Estes & Goddard 1967; Kruuk, 1972); they rarely scavenged. Cheetah do not prey on Masai livestock in southern Kenya, and they even avoid it (Burney, 1979). I found tracks of one cheetah which had killed a gerenuk; one sample of faeces too contained only gerenuk. Also the wild dog in the study area, at Balesa Kulal, must have lived off wild ungulates.

3.2.5 Jackals

Wild food of the black-backed jackal consists largely of rodents, insects and scavenged bits, but also young and even adult gazelle (Kruuk, 1972; Lamprecht, 1978). The species is well known as a lamb-killer in South Africa (Grafton, 1965; Bothma, 1971; Rowe-Rowe, 1976). Jackals frequently scavenged in our camps, and they were seen catching small rodents in Sibiloi National Park. No faeces were collected.

TABLE 3

Frequency of occurrence of undigested items in faeces of striped hyaena, Mt Kulal

Number of faeces containing:			
Sheep or goat	6	=	35%
Cattle	1	=	6%
Dikdik	6	=	35%
Porcupine	1	=	6%
Hare	2	=	12%
Balanites fruit	1	=	6%
Total number of occurrences	17	=	100%
Number of faeces	11		

3.3 Reports on predation from herdsmen

3.3.1 Validity of information

Several biases might arise from the use of information obtained through interviews with the stock owners and herdsmen. People might deliberately give false information, eg in order to draw attention to problems with carnivores or for other reasons, or they might unwittingly be selective about recalling incidents, for instance remembering a camel killed by lions over a longer period than a lamb killed by jackals. Wherever possible, I have tried to check reports, for instance by asking different herdsmen about the same incident, and by inspecting remains of animals reported killed by predators or evidence on kill-sites. Also, herdsmen were not given the impression that there was anything to be gained from the information they gave me. There was no evidence that I was being deliberately misinformed. As one possible check, using faecal analysis, I assessed the diet of spotted hyaenas from areas where I had interviewed the nomads (Table 4), and the evidence from the 2 sources was not significantly different. Also, the calculated offtake by hyaenas from the livestock population, on the basis of independent assessment of the hyaena population, was on the whole compatible with the figure of losses based on interviews (Section 3.3.4).

The bias arising from selective recall of events appeared to be more important, tending to stress the more dramatic predation events. This effect is discussed in Section 3.3.3.

3.3.2 Prey preferences of different carnivores

Table 5 summarises all reports from herdsmen in the study area. All predators except lions take mostly sheep

TABLE 4

Predation on livestock by spotted hyaena

From areas where data were available from faecal analyses as well as interviews with the herdsmen: Mt Kulal, Balesa Kulal, western Hedad, areas within 30 km of North Horr

	Predation by spotted hyaenas reported in interviews	Contents of spotted hyaena faeces
Sheep and goats	57%	64%
Cattle	26%	25%
Camel	13%	9%
Donkey	3%	2%
	99%	100% = 189 occurrences
	n = 68	Number of faeces = 130

$x^2 = 1.73$, df = 2, $p < 0.5$

TABLE 5

Livestock prey of various predators, from interviews over whole study areas

	Sheep and goat	Cattle	Camel	Donkey	Total
Percentages					
Predator:					
Lion	31	37	28	4	100% (n = 139)
Spotted hyaena	46	42	10	2	100% (n = 96)
Cheetah	100	-	-	-	100% (n = 14)
Wild dog	100	-	-	-	100% (n = 23)
Black-backed jackal	100	-	-	-	100% (n = 142)
				Total	n = 414

Lion versus spotted hyaena: $x^2 = 14.1$, df = 2, $p < 0.001$

Spotted hyaena versus jackal: $x^2 = 90.1$, df = 1, $p < 0.001$

and goats, the difference between lion and hyaena and between hyaena and jackal being highly significant. Lions concentrate more on larger kinds of livestock than the others; also, of each kind of stock, lions take significantly fewer young animals than did hyaenas, whilst jackals take almost exclusively young lambs and kids (Table 6). Of the cattle and camels killed by spotted hyaenas, a sizeable proportion are inferior animals; it is difficult to obtain good information on this, but herdsmen mentioned repeatedly hyaenas taking animals that could not keep up with the herd when coming home at night.

3.3.3 Relative importance of different carnivores

Because the number of reports on domestic stock killed by carnivores is possibly slanted towards the larger animals (Section 3.3.1), I compared the total number of reports with the records of only the latest kill in each manyatta (Table 7). Most of these latest kills had occurred within a few days previous to the interview, and none was older than one month; they were unlikely to be biased because of selective recall. There is a significant difference, suggesting that, for instance, lion kills are, indeed, remembered longer than hyaena kills. Spotted hyaenas are the most common killers of livestock, followed by lions, then jackals. Jackals take almost only very young small stock and are on the whole less important than the other 2. Incorporating the reporting bias into the calculations of predation pressure, I estimated that, for each sheep or goat taken by lion, hyaenas take 2.7, for each head of cattle taken by lion, hyaenas take 2.1, for each camel killed by lion, hyaenas take 0.6. Thus, hyaenas inflict considerably more damage than lions. Carnivores other than lions, spotted hyaenas and jackals are economically unimportant.

TABLE 6

Age classes of livestock as prey of different predators

	Percentage classes as 'juvenile'				
	Sheep and goat	Cattle	Camel	Donkey	Overall
Lion	0	8	0	0	2.9%(n = 137)
Spotted jackal	39	25	30	0	31.2%(n = 96)
Cheetah	7	-	-	-	7.1%(n = 14)
Wild dog	22	-	-	-	21.7%(n = 23)
Black-backed jackal	96	-	-	-	96.5%(n = 142)

Lion versus spotted hyaena: $x^2 = 34.1$, df = 1, $p < 0.001$

Spotted hyaena versus black-backed jackal: (sheep and goats only) $x^2 = 74.9$, df = 1, $p < 0.001$

TABLE 7

Latest kills in each manyatta,
compared with total kill record

	Lion	Hyaena	Cheetah	Wild dog	Jackal	Total
Percentage latest kills	26	47	3	0	23	99(n = 34)
Percentage all records	34	23	3	6	34	100(n = 414)

Lion, hyaena, jackal; latest kills versus other records:
$x^2 = 10.2$, df = 2, $p < 0.01$

3.3.4 Estimated annual rate of predation

The rate of predation is extremely variable; some manyattas lost nothing for a year or more, whilst one man lost 8 out of 175 camels in 3 months (ie 17% per annum). It was difficult to obtain good information on this variation, however; although all the people I talked to were willing to give information on predation, they were usually very reluctant to discuss the number of animals they owned, a reluctance well known to other workers (Torry, 1973; Lewis, 1977). I was able to obtain herd-estimates from the Gabra people, however, because my assistant and interpreter, Mr H Yussuf, was personally known to them and trusted. Information on the number of days each manyatta had been in one place and the amount of predation in that place enabled me to estimate the rate of predation (Table 8).

As a check on this rate, I again used data for spotted hyaena alone, calculated as follows. The frequency of occurrence of hair in hyaena faeces is a good indicator of the occurrence of each prey species in the diet (Kruuk, 1972), so I used the percentages in Table 2, 4th column, to assess relative importance of each kind of domestic stock in the hyaena food. It was assumed that hyaena ate 3 kg per day (Kruuk, 1972) and that there were between 92 and 368 spotted hyaenas in the study area. Using mean liveweights for sheep and goats of 27 kg (A C Field in prep.), for cattle 150 kg (FAO, 1971) and for camels 250 kg (after Field, 1979), I calculated that hyaenas eat per year in the study area 1,948-7,790 sheep and goats, 136-545 cattle and 30-117 camels.

The figures for cattle and camels based on occurrence of hair in hyaena faeces are probably too low, as they assume that hyaenas make full use of the carcass. In practice, often no more than one hyaena feeds from a kill (hyaenas usually hunt alone in this area, and they are chased off the carcass by the herdsmen in day time), so an 'occurrence' of

camel-hair in hyaena faeces corresponds to more camel-kills than it would if hyaenas normally ate whole carcasses completely. Hyaenas utilise a sheep or goat carcass much more efficiently, as they can eat almost all of it in one feeding session. This probably explains the discrepancy between my estimates and those of the herdsmen (Table 8), although there are other possible explanations. In Table 8, some estimates are presented also for other herds; in general, the figures are crude but they give an idea of the order of magnitude of losses through predation.

TABLE 8

Estimated annual predation on livestock

	Sheep and goat	Cattle	Camels
Gabra reports, all predators	10.4%	4.4%	1.7%
Gabra reports, only spotted hyaena	1.7%*	4.4%**	1.7%***
Calculated hyaena predation, whole area	0.8-3.2%	0.9-3.6%	0.1-0.6%
Samburu manyatta****	4%	8%	
TLMP herd*****	5.7%		

* 10 kills in 604 'sheep and goat years'

** 23 kills in 527 'cattle years'

*** 7 kills in 291 'camel years'

**** Pers. obs. of mortality, aerial census of stock. Herd size sheep and goats 25, cattle 76 over 4 months.

***** Research herd of Traditional Livestock Management Project, pers. comm. Dr J Schwarz, in Samburu area. Mean herd size 74, over 17 months.

4. Aspects of hunting behaviour

4.1 Time and place of predation on livestock

For every reported incident of predation, the herdsmen were asked whether this took place at night or in daytime, and whether the predator attacked inside or outside the boma. Table 9 shows that most predation takes place in daytime and away from the manyatta; only spotted hyaenas attack more often at night, but also mostly outside the boma. Domestic animals spend more or less equal time inside and outside their bomas (except camels, which are about 14 hours per day inside; C R Field, pers. comm.), and day and night are of approximately equal length in the study area.

Lions are predominantly active at night in areas where they are undisturbed (Schaller, 1972); thus, their preference for day-killing of domestic stock suggests a more efficient protection of the prey at night. Despite all this, at night lions kill significantly more animals inside than outside the boma. Spotted hyaenas, too, are normally nocturnal (Kruuk, 1972), and they maintain this preference when preying on domestic animals; at night, this predator concentrates significantly on the strays and late arrivals, and less than one in 5 of its kills are of penned animals, despite the fact that the proportion of strays and late arrivals is extremely small. Cheetah and wild dog are diurnal hunters elsewhere (Estes & Goddard, 1967; Kruuk & Turner, 1967; Schaller, 1968) and take sheep and goats while they are being herded, in the daytime. Black-backed jackals, too, concentrate on daytime hunting. Taking all evidence together, these data clearly suggest a strong protective effect of the manyatta.

There is some variation in these general trends, and, at least to some extent this variation is due to habits of individual carnivores. For instance, I found one place (Kurkum) where several different Rendille herdsmen reported 2 lions which, night after night, broke into bomas to kill small stock or cattle, on one occasion seriously injuring a person as well. In the area between Korr and Ilaut, a large pride of lions was repeatedly

TABLE 9

Herdsmen's reports of domestic stock killed by various carnivores inside and outside bomas, and by day or at night

Predator:	Percentage killed:				
	Inside boma		Outside boma		Total
	By day	At night	By day	At night	
Lion	0	8	90	2	100%(n = 137)
Spotted hyaena	0	18	3	79	100%(n = 89)
Cheetah	0	0	100	0	100%(n = 14)
Wild dog	0	0	100	0	100%(n = 23)
Black-backed jackal	0	9	91	1	100%(n = 137)
Total	0	10	72	18	100%(n = 400)

Statistical significance:

	Inside versus outside (at night only)	Day versus night
Lion	$z = 1.87$, $p < 0.05$	$z = 9.23$, $p < 0.001$
Spotted hyaena	$z = 5.72$, $p < 0.001$	$z = 8.69$, $p < 0.001$
Cheetah	-	$z = 3.48$, $p < 0.001$
Wild dog	-	$z = 4.59$, $p < 0.001$
Black-backed jackal	$z = 2.77$, $p < 0.01$	$z = 9.40$, $p < 0.001$

reported to kill camels in daytime.

An illustration of the lions' normal nocturnal habits is provided by the kill-records from the Sibiloi National Park, just outside the IPAL study area (Table 10); there livestock had been allowed access for about one month before my visit. A large number of 'fora-camps' moved in, arriving in an area where there were relatively many carnivores living nocturnally and undisturbed upon wild herbivores. The results show that all carnivores killed at night, and inside the bomas. There were very few strays at night, probably due to better and tighter herding in the more open well-grassed country, with relatively many predators. So the predators maintained nocturnal habits, and, although predation on livestock was relatively low, the carnivores did penetrate the protection of the fora-camp to obtain their prey.

In general, however, in a situation where carnivores have preyed on livestock for a considerable period, lions are a threat mostly to the cattle and camels herded in daytime and to ordinary healthy animals, whereas hyaenas and jackals will catch the strays, often the weaklings. Hyaenas have the reputation amongst the herdsmen of taking any goats, sheep or cattle which are left out at night, either through negligence or because the individuals cannot keep up with the herd (through illness, injury, poor condition or when calving). The lambs and kids which are the jackals' usual prey are often left unguarded within a few hundred meters of the manyatta, or they are looked after by a small child; where there is scrubby vegetation, these small animals are easy prey for the jackals.

4.2 Predation around bomas of different tribes

Different tribes are affected by predation on their stock in different ways (Table 11). A larger proportion of Rendille manyattas reported predation compared with Gabra (other differences were not statistically significant), but this may be because Rendille manyattas are much larger. However, of these manyattas which did report predation, none of the Samburu manyattas suffered

TABLE 10

Domestic stock killed in fora-camps, in Sibiloi National Park

Predator:	Percentage killed				
	Inside boma		Outside boma		Total
	By day	At night	By day	At night	
Lion	0	100	0	0	100%(n = 12)
Spotted hyaena	0	67	17	17	100%(n = 6)
Black-backed or golden jackal	0	100	0	0	100%(n = 35)
Total	0	96	2	2	100%(n = 53)

TABLE 11

Manyattas of different tribes with reported predation problems

	Percentage affected by predation	Percentage of affected manyattas with predation inside boma as opposed to outside (no. of affected manyattas = 100%)	Percentage of all manyattas with predation inside boma
Samburu	67(n = 9)	0	0
Rendille	91(n = 11)	70	64
Gabra	46(n = 28)	62	29

Statistical significance: With versus without predation: Rendille versus Gabra $x^2 = 4.75$, df = 1, $p < 0.05$; others n. s.

Manyattas with predation, inside versus outside: Fisher exact probability test, Samburu versus Rendille $p < 0.025$, Samburu versus Gabra $p < 0.025$, Rendille versus Gabra $p < 0.05$.

All manyattas, inside versus outside: Fisher e. p. test: Samburu versus Rendille $p < 0.005$, Rendille versus Gabra $p < 0.05$.

losses of animals from inside the bomas, whilst both Rendille and Gabra reported this frequently; the sample sizes are small, but the differences are significant. This same difference between tribes is apparent when comparing the records for the spotted hyaena (as the most frequent boma-raider) in manyattas of different tribes (Table 12): almost 4 out of 5 sheep or goats killed by hyaenas from Rendille flocks are taken from bomas, but Samburu stock is taken outside only. The differences between the tribes for this small stock predation are significant; for large stock, the differences are in the same direction but not significant. The implications of these differences will be discussed in Section 5.3.2.2 on page 43.

4.3 Scavenging versus killing

Spotted hyaenas as well as jackals have a reputation for scavenging around settlements, and clearly the extent to which this happens is important for understanding the behaviour of these animals around manyattas.

Twelve percent of 160 hyaenas faeces collected in the study area contained small bits of cloth (Table 2), indicating scavenging around human habitation. These 19 faeces were collected in the part of the study area used by the Samburu, and they constitute 18% of the sample from that area; there was none in the sample from Gabra areas, and no faeces were available from the Rendille part. The difference in the occurrence of cloth in faeces from Samburu and Gabra areas is significant ($x^2 = 9.93$, df = 1, $p < 0.005$).

Probably the amount of food obtained through scavenging is relatively small (see also Section 3.3.4), although the area around a manyatta is strewn with bones. Spotted hyaenas can utilise these bones (Kruuk, 1972), but they obviously do not here; virtually all soft parts of slaughtered stock are eaten by the people and the skin is used.

TABLE 12

Spotted hyaena predation on livestock of different tribes, inside bomas

	Percentage of kills inside boma:	
	Sheep and goats	Cattle, camels, donkeys
Samburu	0(n = 19)	0(n = 6)
Rendille	79(n = 14)	9(n = 11)
Gabra	10(n = 10)	6(n = 36)

Statistical significance: For sheep and goats: Samburu versus Rendille $x^2 = 21.0$, df = 1, $p < 0.001$; Rendille versus Gabra $x^2 = 8.4$, df = 1, $p < 0.005$; Samburu versus Gabra n. s.

For cattle etc. no significant difference

5. Protection against predators

5.1 General

In studies of predator-prey interactions, it has been found useful to divide the measures by which a prey species protects itself into 2 categories, direct and indirect anti-predator mechanisms (Kruuk, 1964). Direct anti-predator mechanisms are behaviour patterns shown in response to the actual presence of a predator, serving the function of increasing survival of the potential prey in particular encounters; indirect mechanisms serve to decrease the chance of an encounter taking place at all, but they often have other functions as well.

5.2 Direct anti-predator response of the herdsmen

Only a minority of nomads are armed with spears when herding their stock (Section 5.3.3). With few exceptions, the people who were questioned stated they would not attack a lion even if they were armed; usually the lions were said to run away too fast. In none of the tribes in this area was the killing of lions considered a virtue, as it is for instance amongst the Masai, who frequently can be heard boasting about their lion killing exploits. I was told about 2 hyaenas killed (with spears) when they broke into a boma, and on 6 occasions hyaenas were chased; one jackal was killed by a dog on a similar occasion. On the whole, however, it appeared that direct defence of livestock against predators is rare.

5.3 Indirect anti-predator measures

5.3.1 Dogs

To anyone familiar with livestock herding in more northern latitudes, it is surprising that the nomads in Kenya do not employ dogs for herding. In southern Europe and the middle-East, every herd of sheep is accompanied

by several dogs to protect it against predators; in Britain, in the absence of large carnivores, dogs are used for rounding up sheep. I did see an occasional dog with a herd in northern Kenya, but it did not seem to play an active role around the flock. This was different inside the manyattas where many of the nomads keep dogs for the purpose of warning against danger at night, and for keeping predators away. The dogs in this region look like the almost ubiquitous 'pie-dogs' or pariah dogs of Africa and Asia. However, there were several manyattas with no dogs at all, especially amongst Rendille (Table 13), and on average only 65% of the manyattas visited possessed dogs. Gabra had most dogs, and often at least one per hut; these dogs were also the most noisy during our visits. The Turkana, too, had many dogs, but I had no opportunity to quantify this.

To study the effect of dogs on predation on Gabra stock, I categorised the presence of dogs and the frequency of predation (Table 14); the results clearly suggest that dogs could be very effective in protecting livestock around the manyatta.

The reasons for the low numbers of dogs were not entirely clear. During several months previous to this survey, many dogs had been killed by the Veterinary Department and the police in a rabies prevention campaign; there were several rabid dogs in the area. However, from interviews it also appeared that many Rendille, for instance, had not had any dogs for a long time, and that the people who had lost dogs in the anti-rabies campaign did not seem unduly worried by this. It was stated by several Rendille herdsmen that dogs were rather useless for protecting livestock against predators; Gabra, however, were all adamant that dogs were very effective, bearing out the results in Table 14.

TABLE 13

Presence of dogs in manyattas of different tribes

	Dogs present	Dogs absent	Total	Percentage with dogs
Samburu	5	4	9	56%
Rendille	3	8	11	27%
Gabra	23	5	28	82%
Total	31	17	48	65%

Statistical significance: Rendille versus Gabra:
$x^2 = 8.4$, df = 1, $p < 0.005$

Samburu versus Rendille,
Fisher e. p. test: n. s.

TABLE 14

The effect of the presence of dogs on predation on livestock, Gabra only

	Heavy	Light	Total
No. of manyattas	More than one animal killed per 10-day period	Less than one animal killed per 10-day period	
Dogs:			
Many (1 or more per 4 huts)	4	14	18
Absent or few (less than 1 per 4 huts)	5	1	6
Total	9	15	24

Statistical significance: Fisher exact-probability test, $p < 0.02$

5.3.2 Bomas (= thorn fences)

5.3.2.1 Description. In this section, I will discuss only the bomas made in and around the manyattas; information on the fora-camps is too scanty to be useful. The quantities of wood used by 2 Gabra manyattas was measured by Yussuf (in Synnott, 1979); he found an average of about 2 solid m^3 or 12 acacia trees per household per move, which amounted to 70-100 trees per household per year.

The shape and size of the manyattas, and therefore of the bomas, of the different tribes, were strikingly different (Figures 3, 4, 5, 6), but remarkably consistent within each tribe, and some of the tribal characteristics of the manyattas are summarised in Table 15. The length of boma in each manyatta was measured from aerial photographs. It should be remembered that, whilst these characteristics might be typical for the people living in the study area, they did not necessarily hold true outside it; for instance, Samburu manyattas are considerably larger in the southern part of the tribe's range.

The circular arrangement of huts of Samburu and Rendille was, at least on the face of it, better suited to protection of livestock than the arrangements of huts in the other tribes. This might be explained partly by factors other than livestock protection; for instance, Gabra lived in an area which was often very windy, with sand blowing around, and they had the back of the huts into the prevailing wind direction and the front facing the stock enclosures. The thickest and most complete bomas were made by the Samburu, who encircled their entire settlement with thorn-bush; in Rendille, this outer boma was almost rudimentary with many gaps, according to the inhabitants serving the function of deflecting incoming camels from the huts. The outer

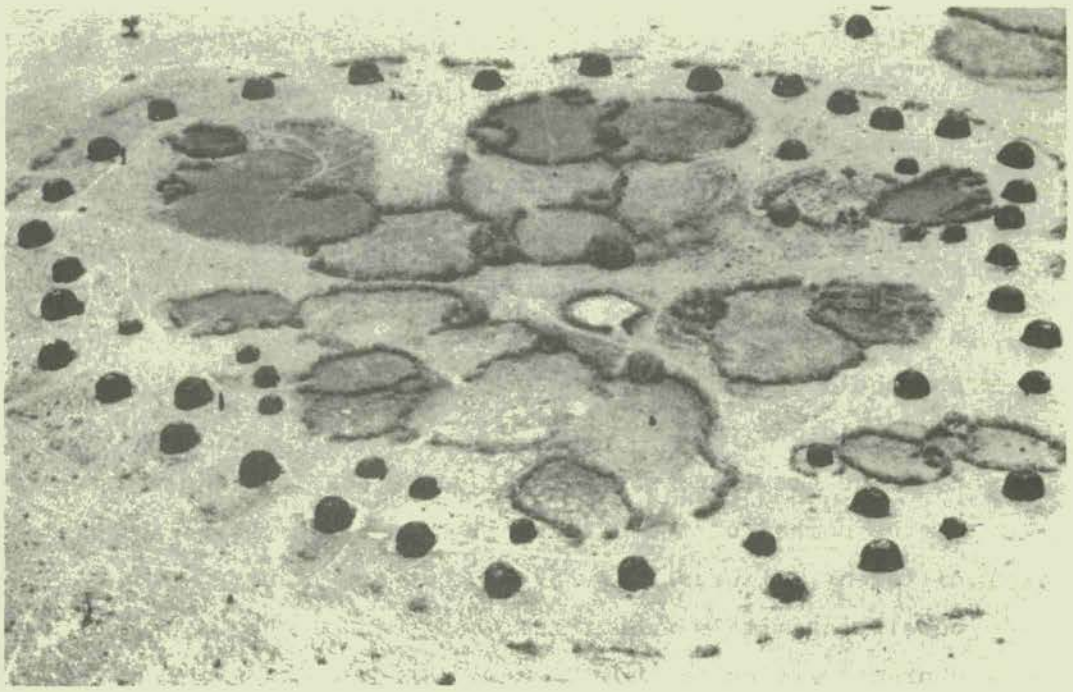


Figure 3: Rendille manyatta. Circular, thin periferal thorn fence, livestock enclosures in centre.

Figure 4: Turkana manyatta. No periferal thorn fence, irregular configuration of huts.

Figure 5: Gabra manyatta. Huts in a line, with the back into prevailing wind.

Figure 6: Samburu manyatta. Circular; thick periferal thorn fence enclosing the huts as well as livestock.

TABLE 15

Some characteristics of manyattas of various tribes

	Mean no. of huts per manyatta	St. dev. of no. of huts % of mean	Arrangements of huts	Outer boma around huts and livestock	Livestock bomas	Mean length of boma per hut, in m.	Mean length of boma per manyatta, in m.
Tribe:							
Samburu	4.0 (n = 18)	44.5	circle	thick and solid	thick	39.4 (n = 55)	118 (n = 16)
Rendille	29.0 (n = 45)	55.1	circle	thin, often absent	thin	18.6 (n = 544)	626 (n = 16)
Gabra	6.6 (n = 37)	64.7	straight line	none	thin	32.5 (n = 99)	190 (n = 16)
Turkana	4.4 (n = 21)	69.5	irregular	usually none	thin	29.1 (n = 75)	137 (n = 16)

Statistical significance: Mann-Whitney test

	Samb/Rend	Samb/Gabra	Samb/Turk	Rend/Gabra	Rend/Turk	Gabra/Turk
No. of huts per manyatta	U = 8 $p < 0.001$	U = 199 $p < 0.01$	U = 183 $p > 0.1$	U = 74 $p < 0.001$	U = 6 $p < 0.001$	U = 280 $p < 0.05$
Length of boma per hut	U = 11 $p < 0.001$	U = 62.5 $p < 0.01$	U = 102.5 $p > 0.1$	U = 27.5 $p < 0.001$	U = 43.5 $p < 0.001$	U = 125.5 $p > 0.1$
Length of boma per manyatta	U = 1 $p < 0.001$	U = 54.5 $p < 0.01$	U = 114.5 $p > 0.05$	U = 21 $p < 0.001$	U = 10.5 $p < 0.001$	U = 86.5 $p > 0.05$

boma was absent in Gabra manyattas, and rarely found amongst Turkana.

The Rendille used a much smaller length of boma per hut, and therefore per unit livestock, than the other tribes (Table 15). Within the sample of Gabra, Rendille and Turkana manyattas, there was no significant correlation between manyatta size (= no. of huts) and length of boma per hut (Figure 7), so there was no indication of households sharing the fencing. Within the Samburu sample, there was such a correlation, suggesting that several families together were more efficient in their utilisation of boma material than one by itself; but here, too, it appeared that, when manyatta size increased beyond 4 huts, the length of boma per hut decreased but little.

The length of boma made by one manyatta was a simple function of the number of huts in that manyatta (Figure 8), although the variance was fairly large. This function did not take into account differences in thickness of the bomas, and the actual amount of material used by Samburu for each manyatta would be larger than Figure 8 suggests.

The differences in use of fencing material between tribes were at least partly related to difference in habitat. Samburu lived in well-wooded areas where several species of *Acacia* were abundant; for them, it was easy to make thick bomas using a lot of material.

This variation in the amount of material used did not necessarily coincide with differences in effect on the environment; for that, differences in primary productivity and vulnerability to erosion, etc, should be taken into account.

Only few species of tree were used for fencing; the approximate order of preference was *Acacia tortilis, A. reficiens, A. mellifera, A. drepanolobium, Balanites*

Fig. 7 Length of boma (thorn fence) per hut, for manyattas of different size. Curve drawn in by eye.

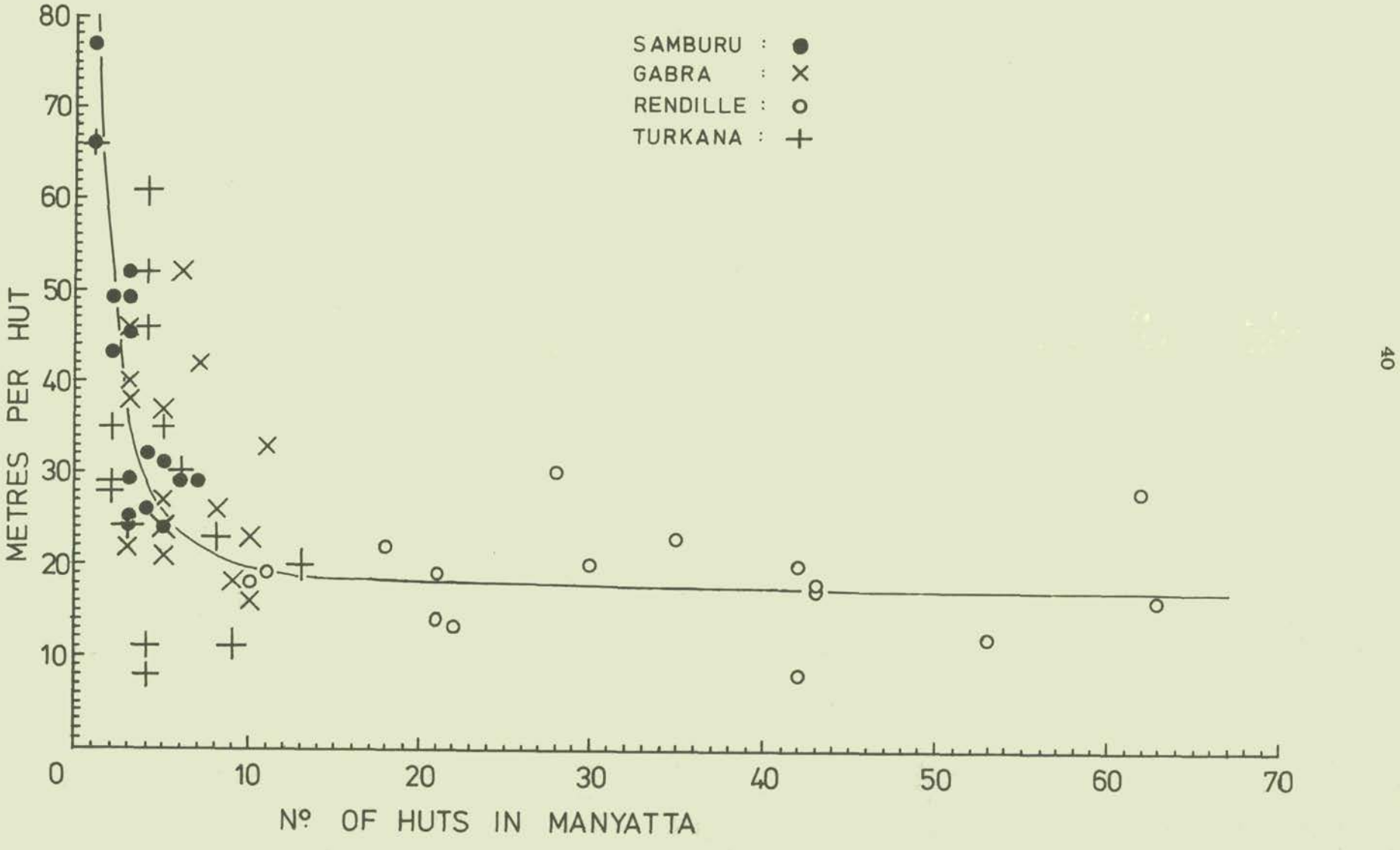
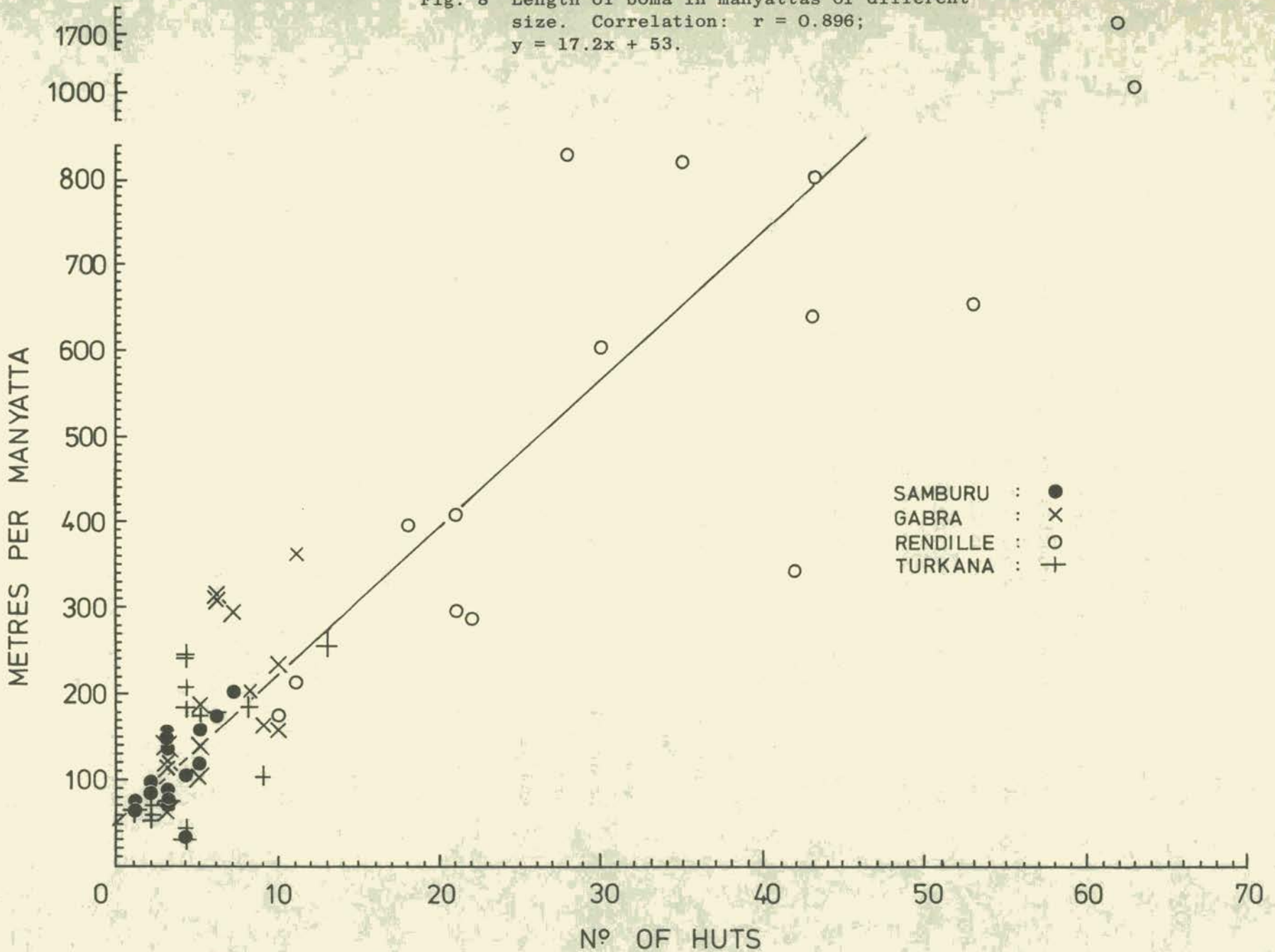


Fig. 8 Length of boma in manyattas of different size. Correlation: r = 0.896; y = 17.2x + 53.



(prop. *orbicularis*), *Commiphora* ssp, *Sueda monoica*. The last 3 species were used almost only when nothing else was available. The preferred species were the flat-topped Acacias; in a well-made boma, the flat top areas of branches in the outer and in the inner layer of the boma faced each other, and often more irregularly shaped branches were put in between these outer and inner layers. A thin boma might consist of only one row of flat-topped branches, always facing inwards, or, if separating sheep and goats from cattle, facing the sheep and goats.

Small stone structures were made sometimes for night-time protection of small kids and lambs, especially by Gabra and Rendille; alternatively, these were kept inside special huts or inside the hut with the people, but usually within special thorn bomas which were very thick and dense.

Amongst the Gabra and Turkana manyattas, there were several which did not use any boma at all around their camel and cattle herds; camels were prevented from straying by hobbling the lead bull and penning the calves within sight of their mothers.

I estimated the heights of bomas around different kinds of livestock inside 13 Rendille manyattas; for each of 30 bomas, the mean height of the fencing was estimated, disregarding the odd branches that might be sticking out. Around sheep and goats the mean height of the bomas was 1.2 m ($n = 16$), around cattle 1.4 m ($n = 6$) and around camels 2.0 m ($n = 8$); the difference between boma heights around camels and the other stock was significant (Mann-Whitney $U = 20$, $z = -3.19$, $p < 0.001$). There were no obvious differences in thickness between bomas of similar height.

In 2 Samburu manyattas, I estimated the mean height of the outer boma and of the bomas separating

the various kinds of stock inside; there was no significant difference, mean outer boma height being 1.3 m, inner boma height 1.4 m (total 29 measurements).

5.3.2.2 The function and the effect of bomas.
All the nomadic people who were asked about the function of the boma said that it was most important for keeping livestock confined, and it served furthermore for keeping predators out. Everyone asked dismissed the idea that bomas could protect against human stock raiders; stock raids tend to take place in daytime and in several documented cases people fled from manyattas being raided rather than seeking shelter there (Fukui & Turton, 1979). Also, a possible ritual significance of the bomas was denied, although the small intra-tribal variation of boma shape suggests that tradition played at least some role in boma building.

Clearly, the anti-predator function of the boma was most important, in that it either prevented stock from straying, or predators from entering. To establish which of these was the primary function, the following arguments should be considered:

(a) indicating the importance of fencing out predators.

1. Samburu had the most complete and solid bomas; they also had least predation inside the boma (Section 4.2).
2 In areas with heavy predation pressure, the bomas were made thicker and higher than elsewhere (eg by Rendille at Kurkum).
3. Manyattas as a whole had a clear deterrent effect on predators (Section 4.2),

but this included the effect of the presence of people and dogs, as well as the boma.

(b) indicating the primary importance of fencing-in of livestock.

1. Herdsmen themselves indicated that it was more important to keep stock in than to keep predators out.
2. If livestock strayed at night, they would almost invariably be killed by predators, whilst few were killed close to people and dogs, even in the absence of a boma (Gabra and Turkana camels and cattle).
3. None of the bomas I saw could exclude any of the important predators; this was confirmed by the herdsmen.
4. Frequently a single layer of Acacia branches was used for a boma; invariably it then faces inwards, making it more difficult for an animal to get out than for one to get in.
5. Heights of boma were adjusted to the kind of stock contained inside (Section 5.3.1).
6. The tribes that construct an outer boma made this similar in height to the fences between the different kinds of livestock.

On balance, it is clear that the boma around livestock served both functions, but that the containing of domestic animals was most important.

5.3.3 Other indirect anti-predator measures

The important carnivores (lions, hyaenas, jackals) are basically nocturnal animals, and daytime herding is likely

to prevent a considerable amount of predation. It is striking, however, that stock is often brought into the boma well after dark, especially during the dry season, and there are many reports of animals being killed at just that time (Section 4.1). This happens especially in the dry season when herds have to go a long way, and the lack of nearby grazing simply forces people to bring in their stock late; however, during these periods, people still leave the manyatta with their flock quite late in the morning (often at 0800 or 0900 when it is light at 0600). One of the causes of these late departures is that often there are not enough people in the manyatta who are traditionally allowed to milk the animals. The synchronisation with daylight is obviously not optimal.

I found some areas with a much higher rate of predation than others (eg Kurkum, Wadako near North Horr), and I questioned several herdsmen on their inclination to avoid or leave such areas because of the predation. Two people mentioned heavy predation by hyaenas and by lions as a subsidary reason for leaving a place, but, in general, the quality of the grazing was put first ("we would like to leave here but there is nowhere else to go where we can graze our animals").

The majority of men were armed with one spear, sometimes 2 when herding. However, many herds are guarded by unarmed boys or women; only 39% of a sample of 44 herds had an armed herder. In this respect, there was no substantial difference between herds of different livestock or from different tribes.

6. Conclusions

Spotted hyaenas, lions and black-backed jackals (in that order) cause important losses to livestock of the nomads (Samburu, Rendille, Gabra); these losses are on average less than 10% per annum. Other carnivores are unimportant.

Livestock is the most important prey of spotted hyaenas and lions in the area; the kind of stock selected by the various carnivores varies with the species.

Sheep and goats are more affected by predation than cattle, and cattle more than camels.

Almost 90% of predation occurs away from the manyatta (village) either when livestock is foraging (by lions, cheetah, wild dog) or when it has gone astray at night or is returning late from the grazing areas (hyaena). The most important factor causing exposure of livestock to predation is human negligence.

There are relatively few domestic dogs in the area; when present, they provided good protection against predation.

The most important function of the thorn fence or boma is to contain the livestock, but it also served to keep predators out.

Of the various tribes, Samburu build the most solid bomas, and predation within their manyattas is lowest. Rendille, Gabra and Turkana bomas are thin, and predation on Rendille manyattas is highest, with Gabra intermediate between Rendille and Samburu.

Variation in shape and size of boma is large between tribes, but small within each tribe.

The length of boma per manyatta is a simple function of the number of huts per manyatta, and therefore is largest in Rendille. Overall, the effect of one Rendille manyatta-move on the environment is much greater than of a move of any of the other tribes.

The amount of boma material used per household is independent of the number of huts in each manyatta, except in Samburu manyattas with fewer than 5 huts, where boma length per household decreases with increasing number of huts.

7. Recommendations

7.1 General

In most predation incidents, negligence of the herdsmen plays an important role, and loss of stock could be prevented by

more vigilance during grazing, by preventing animals from straying and by returning herds to the manyattas in daylight (if necessary leaving earlier in the mornings).

There are 3 general areas of possible improvement in the protection against predators where government or international organisations could play a role, viz (a) predator control, (b) promoting the use of dogs, (c) providing alternative bomas, (d) prolonging the useful life of bomas.

7.2 Predator control

There are many good reasons why a general eradication of predators or the use of non-specific control methods such as poison should not even be attempted (Latham, 1971). However, where individual lions specialise on raiding bomas at night, the assistance of the Game Department should be sought to eliminate such individuals by shooting; there are no suitable alternatives for preventing predation by such animals, who are a danger also to human life. It is unlikely that there are other situations where such action is necessary.

7.3 The use of dogs

The people who keep dogs fare better as regards predation on their livestock, and it would be advantageous if more and also better dogs were to be used. Dogs would be more useful still if they would go out with the herds rather than stay in the manyatta in daytime, because this is when most predation occurs; however, it may be that the pariah dogs are unsuitable or difficult to train for such a role. It would be advisable to try working dogs imported from other areas, under the conditions prevailing in northern Kenya; this could be an important part of the livestock research programme of IPAL.

Around many manyattas there are bones and scraps lying around that would make a good source of food for dogs; moreover, if dogs would clean this up, this offal would cease to be a source of attraction for hyaenas.

The presence of dogs creates a problem as regards rabies, which was common at the time of this investigation and which is an ever-present danger in the area. A vaccine is available which protects dogs against rabies for up to 3 years, produced in Kenya at the cost of approximately K.Sh 2/- per injection; however, veterinary officials in the area confine themselves to shooting some of the dogs in threatened villages rather than treating them with vaccine. A more positive approach to the problem should be encouraged, although it should be recognised that little is known about the effectiveness of either shooting or vaccinating dogs in combating rabies in a nomadic situation. There is a clear case for more research on rabies control amongst the nomads.

7.4 Alternative methods of boma construction

The system used at present of protecting and containing livestock in thorn-bush bomas appeared to be generally effective, especially as used by the Samburu. If improvements would be suggested, it would be amongst Rendille. However, the main reasons for the promotion of alternative means of night-time protection of livestock are the prevention of deleterious effects on the environment of wood-cutting for bomas, especially around places where manyattas are concentrated. These deleterious effects are probably greatest around Rendille manyattas, as they are much larger than those of other tribes and they live in an arid part of the area (though not as dry a part as the Gabra and Turkana). Thus, the need for an alternative to the boma is greatest amongst the Rendille.

Possible alternative methods would be wire-fencing, electric fencing, dry-stone walling, fencing with bamboo screens, palm-leaf ('makuti') fencing. Of these, electric fencing is probably impracticable despite its cheapness: the method is vulnerable to vandalism, there are no local maintenance facilities, and, in dry conditions, the animal is inadequately earthed. The other methods should be tried experimentally to test advantages and disadvantages

(durability, expense, the response of livestock and predators) in the manyatta. Some advantages and disadvantages one can foresee are:

wire-fencing:	fairly expensive, highly durable, easily transportable, see-through (which may attract predators)
dry-stone walling:	labour intensive, immovable, cheap, locally available
bamboo-fencing:	long distance transport by lorry, limited durability, movable, fairly strong and non-transparent
makuti-fencing:	locally available in Gabra and Turkana areas, cheap, movable, fairly strong and non-transparent, perhaps a limited resource

Possibly a combination of methods would be useful, eg wide-mesh wire netting for large livestock and small dry-stone walls for kids and lambs, or wire-mesh netting and makuti-fencing.

7.5 Prolonging the useful life of bomas

Whatever new method of fencing is tried, or if the old thorn-bush fencing is continued, it would be advantageous to promote the use of sprays against ticks in the bomas. The occurrence of ticks is an important cause for abandoning a boma, especially around the settlements where people no longer leave for reasons of better grazing or watering elsewhere. Boma material can be used for much longer if contamination with the various disease-carrying ticks can be prevented.

7.6 Summary recommendations

(a) An experiment should be started to test alternative methods of livestock fencing, as described in Section 7.4, inside a Rendille manyatta.

(b) Pesticides should be made easily available to combat ticks inside the bomas, as they are a main cause for people to abondon old bomas.

(c) Extension and education methods should be used to teach people about the use of dogs.

(d) Trials should be done with different breeds of dogs with the IPAL research herds of sheep and goats.

(e) Research should be started on the occurrence of rabies amongst dogs of the nomads and in wildlife, and the effectiveness of current anti-rabies measures.

(f) Requests should be made to the Game Department to shoot individual lions which specialise in livestock killing.

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