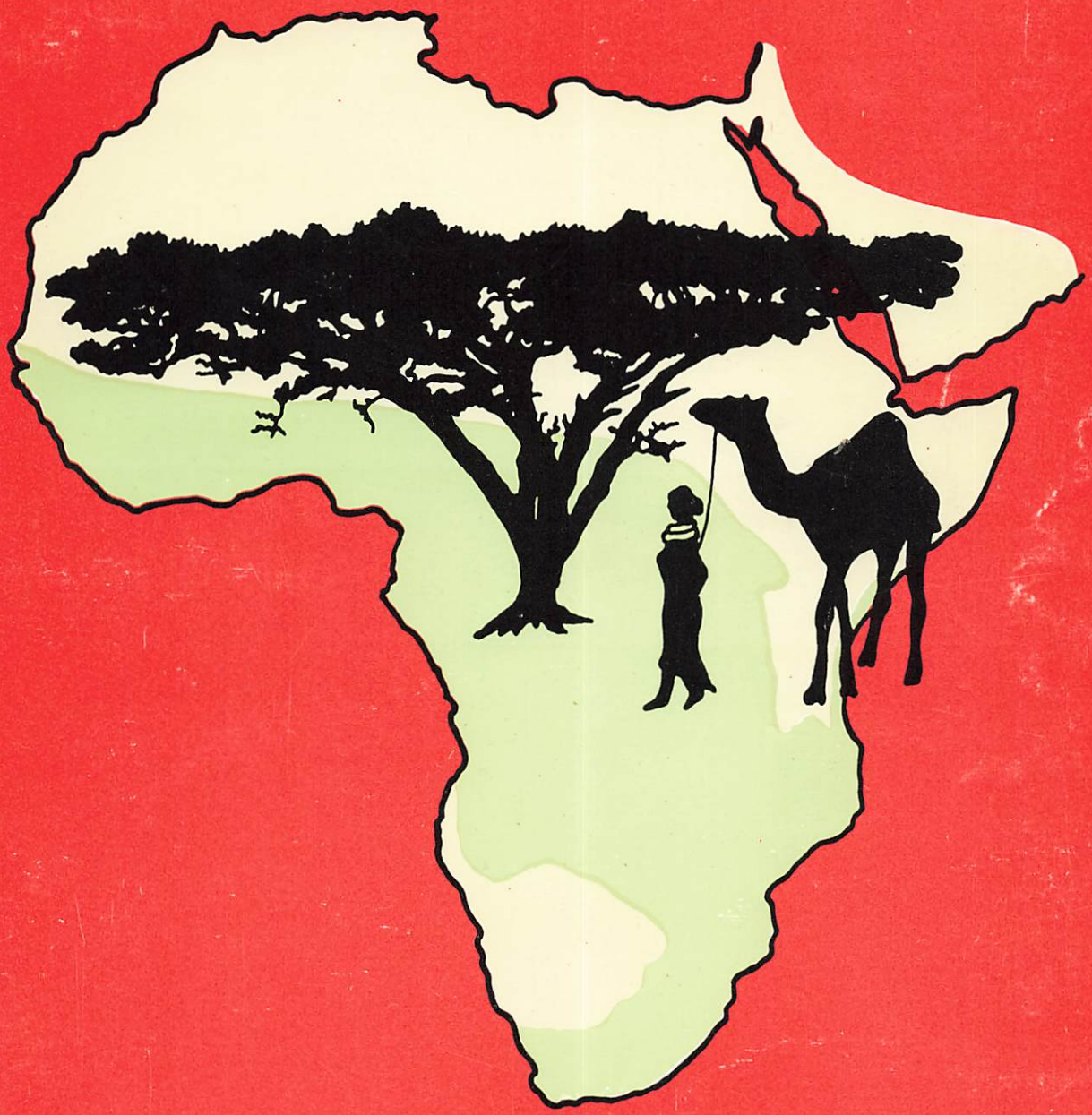
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Technical Report Number E-7



Camel Diseases and Productivity in the Arid Lands of Northern Kenya

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IPAL Technical Report No. E-7

CAMEL DISEASES AND PRODUCTIVITY IN THE ARID LANDS OF NORTHERN KENYA

INTRODUCTION

by

C.R. Field

THE CONTROL OF IMPORTANT CAMEL DISEASES IN THE IPAL STUDY AREA

by

T. Rutagwenda

THE EFFECTS OF DISEASES AS CONTRAINTS TO CAMEL PRODUCTION IN NORTHERN KENYA

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S.P. Simpkin

THE IMPORTANCE OF CAMELS TO SUBSISTENCE PASTORALISTS IN KENYA

by

C.R. Field and S.P. Simpkin

TICK BURDENS OF CAMELS AND THEIR TREATMENT AND CHEMICAL ANALYSES OF CAMEL BLOOD

by

J. Crees

SUMMARY INTRODUCTION TO IPAL AND THE TECHNICAL REPORT SERIES

The Integrated Project in Arid Lands (IPAL) was established by UNESCO with financial support from UNEP 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 international UNESCO programme, Man and the Biosphere (MAB) which has links not only with UNEP's Desertification Unit but also with FAO, in response to the Plan of Action adopted by the 1977 United Nations Conference on Desertification. It is an example of the type of pilot activity that UNESCO and UNEP, together with other organizations 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 first phases 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 22,500 km^2 situated between Lake Turkana and Marsabit Mountain. The project now operates five field stations at Mount Kulal, Olturot, Kargi, Korr and Ngurunit, with the project headquarters in Marsabit which is the administrative centre of the District. Since its establishment the project has researched several aspects of experimental management of the region, concentrating upon 'human ecology' of the nomadic pastoralists in dynamic inter-relationship with the animals, plants and the other resources of a drought-prone, uncertain environment.

During the next three years (1980-83), the investigations in progress will be extended and intensified to develop resource management plans of models 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 resulting in the necessity for constant famine relief measures in this region. Results obtained in the project are the subject of a number of training workshops and seminars in which Kenyan and regional scientists from the Sudano-Sahelian region participate.

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

INTRODUCTION

by

C.R. FIELD

INTRODUCTION

From the very outset in 1976 the staff of IPAL were aware that livestock are the mainstay of pastoral subsistence in the arid lands of Marsabit District in northern Kenya. In such areas rainfall is erratic both in space and time and is insufficient for conventional agriculture. The rainy seasons are too brief and the amount of rain too little to enable the successful growth and harvest of a crop.

Livestock and other ruminants, by virtue of their unique digestive system which is equipped with symbiotic micro-organisms, can digest and convert low-quality high-fibre range forage into the meat, milk, blood and skins upon which nomads subsist.

All five species of livestock kept in the arid and semi-arid desert region exhibit to some degree or another adaptations to life under conditions of extreme hardship. However, the camel, more than any other species, shows a remarkable range of adaptations to the rigours of desert life which make it the most valued species for desert nomads.

While sometimes being ridiculed by the uninitiated as 'a racehorse designed by a committee' the camel is affectionately known by those who recognize its qualities as 'the ship of the desert'. Perhaps it should also be called 'the cow of the desert' since the principal use to which it is put by the Rendille, Gabra, Somali and Turkana peoples is the production of milk. All major cultural activities of the Rendille, Gabra, Degodia and some other tribes centre on the camel as the key species in their pastoral economy.

For these reasons IPAL has placed emphasis on a fuller understanding of the role of this little-understood beast. While fairly extensive research had been carried out elsewhere on the physiology of the camel (Schmidt-Nielsen, 1964, and others), little was known about its ecology, feeding habits, nutrition, disease and productivity. These subjects have been the focus of our studies.

The IPAL research programme on camels has involved three main phases, as follows:

1. A descriptive phase

This involved documenting the system of camel husbandry, their use of the range, feeding habits, nutrition, diseases and productivity, as we found them. Some have called this traditional management, but already some introduced ideas were being incorporated in the observed practices. This phase lasted from 1976 to 1980 inclusive. Some results are already published in IPAL Technical Reports: Field (1978, 1979a, 1983), Lusigi (1981, 1984), Wilson (1983) and Wilson *et al.*, (1981). Other publications include Field (1979b) on camel productivity, Schwartz (1979) on camel transport and Schwartz *et al.*, (1982).

2. An experimental phase

During the initial phase it was observed that the productivity of the indigenous camels was well below its estimated potential. Nutrition and disease were identified as major constraints to productivity. Experiments were designed to determine whether such constraints could be alleviated. The main emphasis was placed on disease and it is the results of these experiments which form the bulk of this technical report. Experiments on nutrition are on going with emphasis on a stocking impact trial to try to determine the correct carrying capacity of a certain range type at Olturot for camels and other livestock. The results of this experiment will form the subject of a later report. The experimental phase reported here lasted from 1981 to 1983 inclusive. Other nutritional studies are to be carried out on the use of *Acacia tortilis* pods to supplement the diets of camels.

3. Management phase

The results of this research are designed to assist in the management of camels for the improvement of their husbandry and productivity. The first step was to dovetail our findings on the camel into an Integrated Resource Assessment and Management Plan for Western Marsabit District (IPAL Technical Report A-6). Here again the camel plays a key role in future plans.

In the livestock section of this Plan the camel is to be in the vanguard of the mobile *fora* camps and will be a test of whether the necessary security can be created to give the owners confidence to use the new areas. The present camel population is little over half of the estimated carrying capacity of the range, therefore there is little risk of overstocking for the time being. Indeed our recommendations are to promote the camel population by all means possible.

Among other things, we recommend the introduction of a nucleus of Somali stud male camels to improve the breed. In the veterinary programme priority should be given to the health of this species on account of their compatability with the environment and the long time needed for them to build up population numbers.

The work described in this technical report has been valuable in influencing our decision to recommend the subsidy of trypanocidal drugs for camels. In addition, recommendations are made on the strategic use of anthelmintics and acaricides.

Nevertheless, there are still some questions unanswered concerning camel diseases and in particular with regard to the best way to control mange, the development and application of a possible field technique for the diagnosis of trypanosomiasis and the diagnosis of a fatal epidemic whose chief external symptom is a swelling of the lymph nodes.

For some time there has been talk of market outlets for camels to the Middle East. This needs to be investigated more thoroughly and in the absence of suitable external outlets greater emphasis should be placed on the development of a small unit for processing animal by-products, including the canning of camel meat.

Demonstration herds of camels will play an important role in the education and extension section of the programme with the effects of a number of different treatments being available for the nomads to see and to compare with their own animals.

Finally camels are to play a vital role in the future transport system of the District. With the cost of oil and the maintenance of vehicles and roads spiralling upwards the clock has gone full circle and the camel has a new opportunity to become the major beast of burden in the area. It has many advantages over conventional vehicular transport, not least of which is that it can reach many areas which are inaccessible because they are too rough for motor vehicles.

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THE CONTROL OF IMPORTANT CAMEL DISEASES IN THE IPAL STUDY AREA

by

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December 1983

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INTRODUCTION

Camels are said to have first been domesticated about 3,000 years ago (Bulliet, 1975) but their subsequent use and importance to man cannot be overemphasized (Knoess, 1977). This domestication occurred in Arabia and soon after camels were imported to the Horn of Africa where they later spread southwards to reach Kenya. In Kenya, the camel constitutes an important component of animal production in the arid and semi-arid areas of northern Kenya. Despite the fact that Gatt-Rutter (1976) claimed that the camel does not thrive south of a line drawn from the Senegal River through northern Nigeria, Lake Chad, Bahr el Ghazal and northern Kenya, at present camels are kept as far south as Rumuruti and Galana, which are nearer to the equator than he thought.

There are two species of camels: *Camelus dromedarius* (the one-humped camel) and *Camelus bactrianus* (the two-humped camel). The one-humped camel inhabits the arid and semi-arid lands of north and eastern Africa and the two-humped camel is found in cold deserts in other parts of the world. There are 17 million camels in the world of which 12 million are found in Africa and 5 million in Asia. Of the world's total camel population, 94% are the dromedary type. It is worth noting that five adjoining countries, Ethiopia, Sudan, Djibouti, Somalia and Kenya contain 84% of the African camels and 60% of the world's total camels. According to recent estimates (Stelfox *et al.*, 1979) the camel population in Kenya is 600,000 dromedaries. Most of these are kept by nomadic pastoralists in northern Kenya while the rest are kept on ranches in other parts of the country. The population of camels in the Integrated Project on Arid Lands (IPAL) study area is estimated to be about 41,000 dromedaries.

Camels possess physiologic and anatomic characteristics which enable them to thrive in desert environments. They can browse 3-5 metres above the ground and are therefore not threatened by smallstock with which they are kept. They have a fatty hump which serves as an energy store and becomes useful when grazing is very poor. They have keratinized epithelium on the lips which enables them to browse on thorny vegetation like *Acacia* which may be present in their habitat. Their eyes are protected from the sun by a supraorbital arch; in addition they have thick eyelashes and

translucent eyelids which allow them to walk through sandstorms with their eyes shut. Physiologically the camel is adapted to be able to lose more water than any other livestock species. The camel has oval-shaped red blood cells, instead of the round ones of cattle, which can expand up to 200 times in size as it drinks enormous quantities of water.

Camels are disease and drought tolerant. It is estimated, for example (Gauthier-Pilters and Dagg, 1981), that in 1973, when drought hit the Sahel region of Africa, that nearly 100% of indigenous cattle died but only 20-30% of the camels were lost. Kenyan camels are divided into three breeds, the Somali, the Rendille or Gabra, and the Turkana (Mukasa, 1981). Camels are essential for the subsistence of the nomadic pastoralists who keep them. They provide milk and are more reliable milkers during the dry season when the supply from cattle and smallstock is very scarce. They also provide meat and blood and are used as draught animals. The blood provides iron and salt and other nutrients for the nomads. Camel milk contains a higher proportion of vitamin C than either cow or human milk and this is of very great importance in the arid areas where fresh fruit and vegetables are not available. Camels are also used to cement relationships among nomadic communities and are usually exchanged as loans or gifts. The importance nomads attach to camels is contained in the Somali saying quoted by Hartley (1979), 'A camel man is a man, a goat man is a half a man and a cattle man is no man at all'. Or, as the Rendille put it, 'A camel is half of God' (Sokotey, 1983 pers. comm.).

Although camels are physiologically and anatomically adapted to exploit scarce desert resources, they are susceptible to a number of diseases (Cross, 1917; Leese, 1927; Richard, 1979; Rutagwenda, 1982). When compared to other livestock species, the literature on camel diseases is very scanty and most studies reported are either of isolated disease outbreaks or surveys on randomly selected herds. There have been very few studies of any duration on the epidemiology or control of diseases in camels. The control of livestock diseases is essential to successful breeding, production and marketing. The planning of disease control includes improved management with an attempt to reduce disease incidence and control parasites. This involves prevention of parasites from gaining access to a host, reducing the spread of a disease once a host has been infected and treatment of the

disease. A fourth approach is that of educating the people on how to handle such diseases.

In practice, no single factor determines which one of the methods or combination of methods is to be used. The choice depends on the epidemiology of a disease, economic feasibility and public health considerations. Herd health control aims to help raise productivity to the highest levels commonly attainable; this involves short calving-to-conception intervals, high feed-conversion rates and the maintenance of continuity in these levels. In order to achieve these things some veterinary costs have to be incurred.

In northern Kenya the main diseases of camels were identified and it was considered important to find out whether already infected camels benefited more from a simple veterinary drug package against the disease identified than infected and untreated animals maintained in the same environment.

OBJECTIVES

BACKGROUND INFORMATION

The United Nations conference on desertification which was held in Nairobi in 1977 formally recognized the progressive degradation of the arid and semi-arid lands as a major environmental crisis (UNEP, 1977). This conference was prompted by a prolonged drought in the Sahelian region of Africa during the early seventies in which many people and their livestock died. The process of desert encroachment was blamed on the impact of human activity upon soils and vegetation.

The United Nations Environment Programme (UNEP) and the United Nations Educational Scientific and Cultural Organisation (UNESCO) embarked on a research programme in order to gain an understanding of the more immediate causes and effects of desertification and to provide information for recommendations on rational land use in the arid lands inhabited by nomadic

pastoralists. Rather than concentrate on human activities alone, an integrated approach was adopted in which the role of animals in causing desertification was to be studied. It was for this reason that studies on the four key species of livestock - camels, cattle, sheep and goats - in the desert ecosystem were carried out.

CAMEL DISEASE STUDIES WITHIN IPAL

Studies on camel diseases within IPAL were initiated in 1978 with the following aims:

(a) Identification of the major diseases of camels with emphasis on epidemiology.
(b) Identification of the possible role of camels in the transmission of zoonotic diseases.

These studies were completed in March 1981 and results were reported in IPAL Technical Report E-6. According to the study, trypanosomiasis, helminths, ticks, mange, camel pox and a number of bacterial diseases were identified as the most important diseases in the area. Subsequent to this study, a study on a comprehensive disease control package was undertaken as part of an M.Sc. degree where a thesis entitled 'An attempt to introduce a comprehensive disease control package on specific diseases of camels and evaluation of the control on camel productivity in Ngurunit, Marsabit District, Northern Kenya' was presented (Rutagwenda, 1982). The aim of this report is to synthesize the results of that study. The objectives of this latter study were:

(a) To institute a comprehensive control package for specific diseases of camels causing constraints to production.
(b) To examine the effect of such control on production.
(c) To recommend a control package to be used to control camel diseases in the IPAL study area.

LITERATURE REVIEW

Diseases of the African camel have not been extensively researched. This is due to the non-sedentary nature of the herds which are constantly moving in search of pasture and water. Consequently, the importance of camel diseases for production is uncertain and in most cases controversial.

According to Wilson (1978) camels suffer from few diseases and none of them is of any major importance. Richard (1979), however, believes that camel pathology is one of the factors limiting production. An attempt is made to list diseases recorded in the literature according to causal organisms.

It is important to realize that most of the diseases recorded have been identified and documented as important diseases of camels in northern Kenya (Wilson, Dolan and Olaho, 1981; Rutagwenda, 1982). Table 1 gives a list of important diseases recorded in the literature classified according to the causal organisms.

MATERIALS AND METHODS

THE STUDY AREA

The IPAL study area (Figure 1) covers approximately 22,500 km^2, or about one-third of Marsabit District, the largest district in the republic. The area partly covers the homes of the Rendille, Gabbra, Boran and Samburu who are the main nomadic tribes in the area. The work was carried out in Ngurunit which is in the south-western corner of the IPAL study area. Ngurunit was chosen because a contract had been made with three pastoralists living close by to loan 60 of their camels to the project for the experiment and also because the work could be easily done from Ngurunit field station.

Figure 1. Location of IPAL study area showing Ngurunit

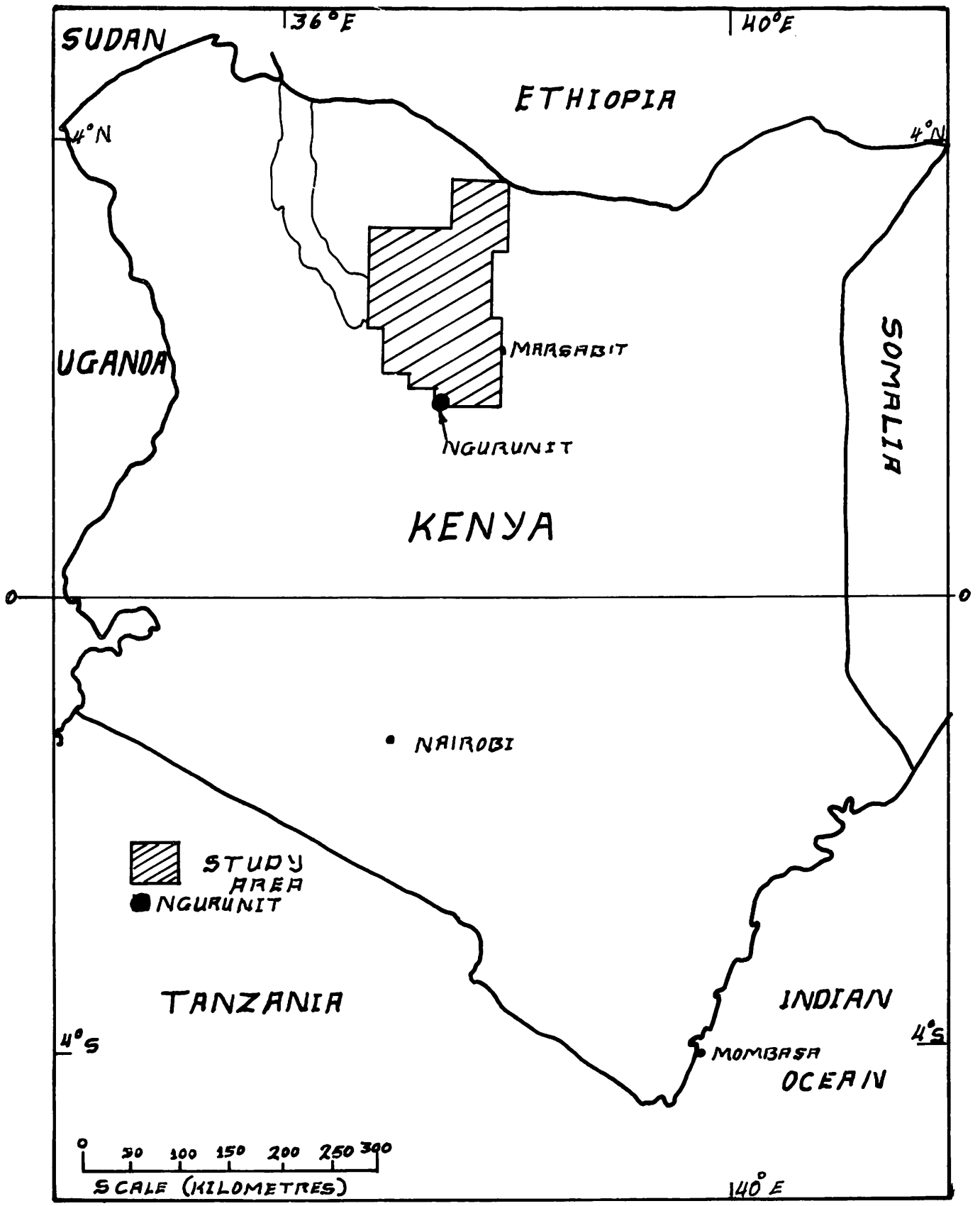


Table 1. Dromedary diseases recorded in the literature

Disease			
Viral	Bacterial	Parasitic	External parasites
Camel pox	Blackleg	Trypanosomiasis	Mange
	Pasteurellosis	Coccidiosis	Ticks
Rinderpest	Tuberculosis	Leishmaniasis	Nasal cavities and sinuses
Foot and mouth disease	Salmonellosis	Anaplasmosis	Myiasis
	Cutaneous streptothricosis	Theileriasis	Mycoses
Rabies	Corynebacterial lymphadaenia	Sarcosporidiosis	
		Arterial filariasis	
	Sporothricosis		
		Subcutaneous onchocercosis	
	Lung streptothricosis	Taeniasis	
	Tetanus		
		Echinococcosis	
	Contagious pleuropneumonia	Cysticercosis	
	Human plague	Coenurosis	
	Tularemia	Schistosomiasis	
	Glanders	Distomiasis	
	Influenza		
	Conjuctival rickettsiosis		

Source: Modified from Richard (1979).

Ngurunit ($1^{o}50'N$ and $37^{o}13'E$) stands at an altitude of 740 metres above sea level and has an annual rainfall of 400-600 mm. The rains in the area are unreliable and occur in two seasons, April and May (long rains) and November and December (short rains). The remaining months receive only a trace or no rain at all. The topography, soils, vegetation, range type and condition of the Ngurunit area have been described (UNESCO, 1982).

EXPERIMENTAL ANIMALS

Two herds of 60 camels each were used in this study. The first herd was selected from a herd of 171 animals, the ones that had been used by Wilson (1980) in the initial disease studies. These camels belonged to an Ariaal Samburu of the Masula clan living close to Ngurunit and were only loaned to the project for the study. The animals had been tagged previously with red tags and hence were known as the 'Red herd'. They received veterinary inputs in the form of prophylactic drugs and also curative drugs on evidence of disease. Between February and March 1981, a further 60 camels were purchased by the project with the assumption that these camels had been under the same kind of traditional management. This herd was given a different colour of ear tag (blue) and was known as the 'Blue herd'. They were kept at Dhur, some 67 km from Ngurunit towards Loglogo, until mid-April 1981 when they moved to Ngurunit. This herd formed a control group whose disease picture and production were compared to the experimental herd. It should be noted that nomadic camels on contract received the veterinary input and the project-owned herd did not receive any treatment. This was because it would be very difficult for a pastoralist to see his camels sick and not do something about it.

For purposes of comparison, the two herds were divided into groups as described by Wilson, Dolan and Olaho (1981). The Red herd consisted of 33 adults (more than four years old) which included one bull, 13 immatures aged between one and four years and 14 calves aged less than one year. The untreated herd consisted of 39 adults, including one bull, 19 immatures and two calves. As it was difficult to purchase camels with their young calves, more immatures were purchased in the Blue herd in order to keep both herds in numerical balance.

HERD MANAGEMENT

The two herds were under the care of the same herdsmen, who were the owners of the treated group. They were herded separately and although they were in contact with other animals on the range, constant attempts were made to separate the treated herd from other animals. The animals were penned at night in separate enclosures (*bomas*) made of thorny *Acacia* branches. The *bomas* were in contact with those of other livestock, mainly cattle, sheep and goats, as a protection against predators.

The management, other than the veterinary input, was purely traditional, that is the herdsmen could decide where to graze and when and where to water the animals. Occasionally the herdsmen would give salty deposits (collected from the Chalbi desert) in water to the untreated herd and mineral bricks (Maclick) would be supplied to the Red herd.

The herds were kept as traditionally as possible and during the course of the study (mid-March 1981 to mid-April 1982) the area around Ngurunit became severely overgrazed and the herdsmen decided to move all the animals to a temporary camp (*fora)* some 30 km east of Ngurunit. The camels were still being closely monitored from Ngurunit. Between March and May 1981, the two herds were monitored for levels of helminths and tick load at approximately one month intervals. The treated herd was given block treatment for trypanosomiasis in March 1981 and drenched with an anthelmintic every 4-8 weeks. The sampling for disease and treatment of the Red herd became established in mid-May 1981.

SAMPLES, SAMPLING FREQUENCY AND LABORATORY PROCEDURES

Unclotted blood samples

At approximately two-month intervals, starting from mid-May 1981, blood was collected from the jugular vein of each camel using a 16 x 1½ gauge needle into small Bijou bottles containing 10 g of ethylene diamine tetraacetic acid (EDTA) as anticoagulant. The bottles were shaken gently to allow easier mixing of blood and the anticoagulant. Packed cell volume (PCV) was determined in the field from this blood using a portable battery-operated Haematocrit Mini Centrifuge Campur M11000 (Munchen Germany). The rest of the blood was put in an ice box and flown to Wilson Airport, Nairobi from

where it could be transported to the Kenya Trypanosomiasis Research Institute (KETRI). At KETRI, the red blood cell (RBC) and white blood cell (WBC) counts were done using a Coulter counter, model ZBI (Coulter Counter Electronics, Inc., Hialeah, Florida). Haemoglobin determination was done from this blood using a haemoglobinometer (Coulter Counter Electronics).

Mouse inoculation test

Mice were obtained from KETRI and flown to Ngurunit where 1 ml of each anticoagulant blood sample was inoculated intraperitoneally in a pair of mice. The mice were kept at Ngurunit for about two days and fed with food and water *ad libitum* before being flown back to Nairobi. The inoculated mice were then returned to KETRI where the tail blood of each mouse was examined for the presence of trypanosomes under a wet film. They were examined from the third day to the 60th day post-inoculation, after which they would be destroyed.

Blood slides

Camels suspected of suffering from trypanosomiasis were periodically bled and blood examined for trypanosomes under wet and thin films.

Serum sample

Blood samples were also collected from each camel in Universal bottles. The 20 ml samples were sent to KETRI where sera were extracted by centrifuging at 4,000 revolutions per minute for 10 minutes. Two drops of sodium azide 0.02% (NaN_3) were added to each serum sample as a preservative. The sera were then stored in Bijou bottles at $-20^{\circ}C$ till required. All the sera were stored in a large serum bank and antibodies to various diseases were checked when required. Two tests were carried out on each serum sample.

(a) Mercuric chloride test

This was carried out as described by Bennett (1933). One drop of undiluted serum was added to 1 ml of freshly prepared 1:20,000 solution of mercuric chloride in a test tube. The contents of the tubes were mixed well and examined after 15 minutes. Sera with distinct opalescence were taken as positive for trypanosomiasis infection.

(b) Indirect haemagglutination test

This was a modification of the method described by Walther and Grossklaus (1972). In this method, the following procedure was followed. Sheep RBC's preserved in Alsever's solution were washed three times with normal saline and packed by centrifuging them at 200 revolutions per minute for 5 minutes. The cells were fixed with 1% buffered gluteraldehyde (in 0.15 m phosphate buffered saline (PBS) pH 7.2) for 1 hour at room temperature with constant stirring on a magnetic stirrer. About 50 ml of 1% gluteraldehyde solution was needed for each volume of packed cells. The cells were then centrifuged and packed as above. The fixed cells were then washed three times with 0.15 m PBS to remove excess gluteraldehyde and suspended in 2.5% of the same buffer. To this was added 1% tannic acid to give a final concentration of 1:20,000 tannic acid. With gentle stirring on a magnetic stirrer, the cells were tanned for 15 minutes at room temperature. The cells were then packed and suspended to the same volume in 0.15 m PBS, pH 6.8. Trypanosome protein extract was added to the cell suspension as below.

The volume of antigen added was equal to the dilution of cell suspension required. This was after antigen titration had been done to establish the optimal antigen concentration for the test. The antigen cell suspension was allowed to stand at room temperature for 1 hour with 15 minutes of gentle shaking in between. The antigen-sensitized cells were packed and then washed with 0.15 PBS, pH 7.2 three times and, lastly, washed with PBS diluent (1% buffered rabbit serum in 0.15 PBS - pH 7.2). The cells were finally made up to 1.25% suspension with the PBS diluent. Then 50 ml of this cell suspension were added to 50 ml of the test sera diluted in haemagglutination buffer on microplates having V-shaped wells. All sera were absorbed with sheep red blood cells and serum dilution was done in PBS diluent. The lowest dilution of negative serum was 1/20 (2 haemagglutination units and above were taken as positive). All sera giving haemagglutination at 1/40 and above were recorded as positive. Negative and positive controls were always used.

Faeces for detection of internal helminth parasites

(a) Faecal egg counts

Faeces were collected from the rectum of each camel and put into labelled Universal bottles once every month. They were subjected to a modified McMaster technique (Anon., 1979). The technique was chosen for its simplicity for it could be done in the field.

Procedure

Glass vials which had two graduation marks at 28 ml and at 30 ml levels were used. A saturated magnesium sulphate solution was poured into the vial up to the 28 ml mark. By displacement, 2 grams of faeces were added until the level rose to the upper mark (30 ml). The contents were mixed thoroughly, and then passed through a coffee strainer. The filtrate was stirred using a dropper and, while stirring, a dropper full of the mixture was withdrawn and used to fill the counting chamber of the McMaster slide. The slide was left for a few minutes to allow the eggs to rise to the top slide. The slide was then examined under low power (x100) of the microscope and all the eggs in the centimetre square of the slide were counted and identified using standard parasitological keys (Soulsby, 1968). The count obtained was then multiplied by 100 to get the total number of eggs per gram of faeces (EPG).

(b) Faecal culture for third stage infective larvae

At approximately three month intervals fresh faeces from a few animals showing high helminth egg counts were cultured using the modified culture technique (Anon., 1979). In this method, about 10 gm of faeces was mixed with sawdust and placed in a jar with the lid lightly fitted. The faeces were then incubated for 7 days at room temperature and on the eighth day the jar was taken out, filled with water and inverted on a petridish on which some drops of water were put. The preparation was left for 24 hours after which the larvae were harvested by pipetting the contents on the petridish and transferring them to a second petridish. The larvae were then killed by adding a few drops of lactophenol and identified under the microscope using the standard parasitological keys.

(c) Postmortem worm counts

A few animals that were postmortemed had their guts subjected to a total worm count and species identification using the method described by Eysker (1978). In this method, the abomasum and small and large intestines were ligated separately at postmortem.

At examination, the contents of the abomasum were opened into a large bucket. The empty abomasum was washed with saline and the mucosa scraped off using a glass slide. The mucosal scrapings were digested at 37°C in HCl-pepsin stirred for approximately 4 hours. The washings and the digested materials were put into separate containers. The same procedure was repeated for both the small and large intestines putting the washings and the digested material of each in separate containers.

Saline was added to each container to make a volume of 5 litres and, after agitating for approximately 15 minutes, three 40 ml aliquots were taken from each container. Formalin was added to make a final dilution of 5% and samples were sieved through a screen. An alcoholic solution of 5% iodine was added to colour the material in the samples. Before collecting the worms, sodium thiosulphate solution was added to the samples until the dark colour disappeared. This procedure gave the worms a brown colour which enabled collection, counting and identification. The counting was done using a dissecting microscope and a binocular microscope was used for identification of species using standard parasitological keys (Anon., 1979).

Tick counting and identification

Ticks were counted once every month to determine the approximate tick loads. Counting was done on one side of the animal, the product being multiplied by two to get an approximate tick load. Counting was done according to predilection site, viz., the nose, ear, tail region and inguinal area. Tick samples from the sites were taken at every counting and kept in labelled Universal bottles containing 70% methanol until identification which was carried out using the keys described by Hoogstral (1956).

Body weight estimation

Body weights were estimated once every month using the method described by Field (1979). This method involved the taking of three body measurements:

(a) Shoulder height

Taken using a height pole in a straight line from ground to the top of the scapular.

(b) Thoracic girth

Taken using a measuring tape along curve just behind the sternal pad.

(c) Hump girth

Taken along the curve over the midpoint of the hump and abdomen using a measuring tape.

A relationship exists between the sum of the three measurements in centimetres and the weight of an animal in kilograms. The estimated body weight in kilograms was obtained by reading off the graph (Figure 2) the sum of the three body measurements in centimetres and the corresponding weight. For purposes of drug administration, body weights were extrapolated from the weights of the previous month. All the body weight measurements were taken very early in the morning before animals went to graze and before they were watered.

Serological survey for brucellosis

For each camel that aborted, a paired serum sample was collected within 4 days of abortion and again 4 weeks later. The samples were subjected to three serological tests, viz. serum agglutination test (SAT), the Rose Bengal plate test (RBPT), and the microtitre complement fixation test as described by Philpot and Auko (1972). At the end of the study period it was felt necessary to screen the Blue herd for brucellosis and 55 serum samples from the herd were analysed by the three tests mentioned.

Conditions observed

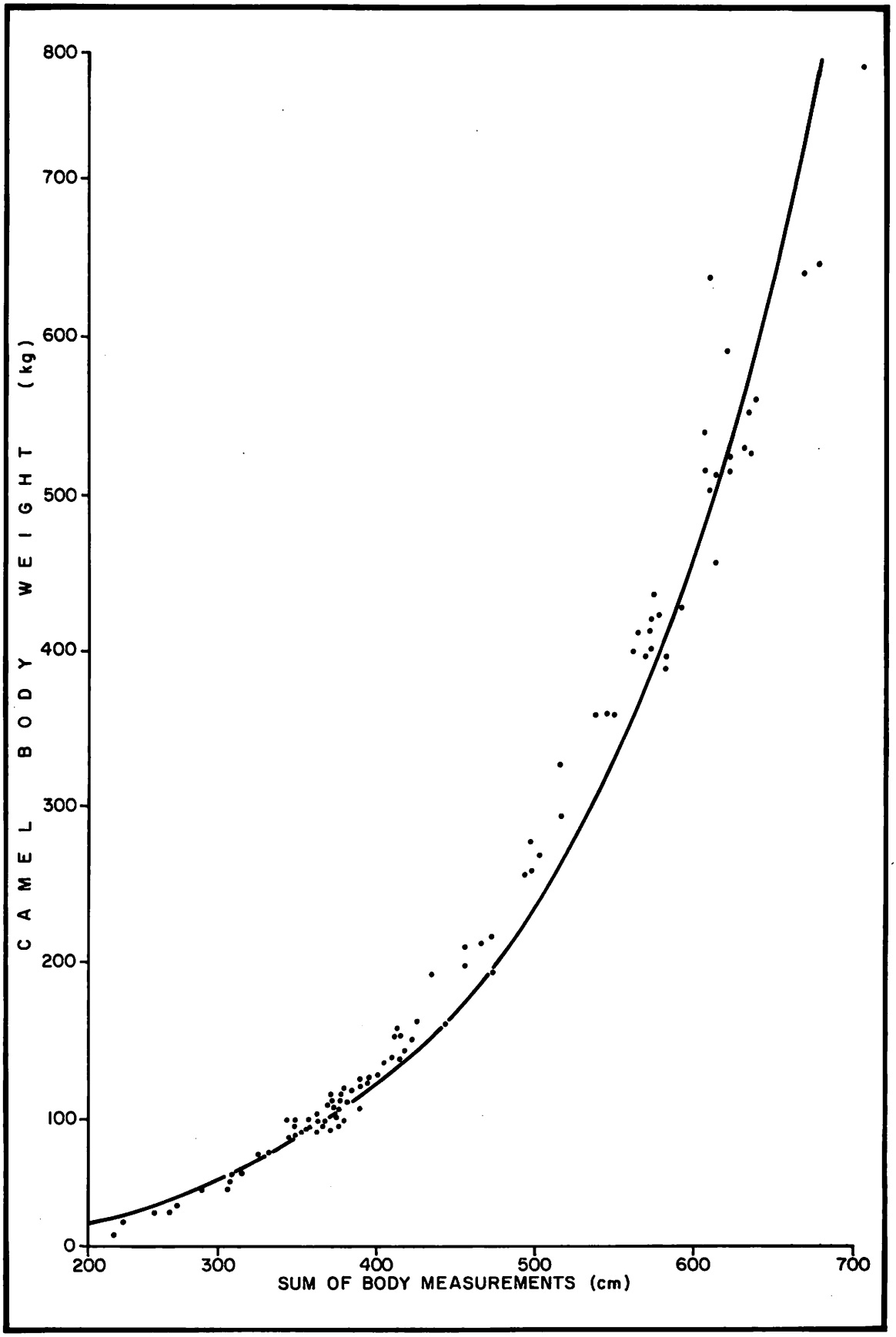
(a) Antemortem

At every visit to the camel herd, which was at least once every week, conditions observed were recorded for both herds and in the Red herd treated as necessary.

(b) Postmortem

A number of postmortems were carried out, where possible immediately after death. However, in some cases this was not possible as a report of a death would arrive

Figure 2. Regression used to estimate camel body weight



Source: Field 1979.

too late. In those that were done, however, standard necropsy procedures were followed and tissues showing gross pathological lesions were taken in 10% formalin for subsequent histopathology. The histopathology slides, stained with haematoxylin and eosin (HE) and Giemsa were examined to aid in the final diagnosis.

TREATMENT AND PROPHYLAXIS OF THE RED HERD

Trypanosomiasis

Animals in the treated herd were given a block treatment of Naganol (Suramin) at a dose rate of 10 mg/kg body weight intravenously in March 1981. A few animals which were later found to be positive were treated individually, a procedure that is recommended for camels in some localities in Kenya (Rottcher, 1982).

Internal Helminths

(a) Nematodes

The experimental herd was drenched once every 4-8 weeks using 10% solution of Panacur (fenbendozole). This is a benzimidozole derivative and was administered at a dose rate of 7.5 ml/100 kg body weight.

(b) Cestodes

Tapeworm eggs were occasionally detected in faecal samples of the treated herd and positive animals were treated with Mansonil (niclosamide) given as a drench at a dose rate of 1 tablet per 15 kg body weight.

Ticks

Acaricide preparations were used against ticks. Bacdip was first used from the start of the study up to March 1982 when stock run out. It was then replaced by Delnav and tick grease was rubbed in the nostrils as engorged ticks survive spraying in the nostrils (Stewart, 1970).

Animals were first hand dressed up to July 1981 but from July 1981 up to the end of the study, camels were sprayed using a hand spray pump once every week. The mixing of acaricide was always done according to the manufacturer's instructions.

This was treated using the method described by Evans and Powys (1979). In the boma was placed a rubbing post which had a sack wetted with old engine oil mixed with Delnav. In addition, all animals in the Red herd were scrubbed once weekly with a hard brush when mange was a real problem.

Anthrax

The Red herd was vaccinated twice against anthrax during the study period using Ngombevac vaccine. This was done at an interval of about 8 months using doses recommended for cattle.

Miscellaneous Conditions

Other conditions such as wounds and abscesses were treated as they occurred. Coccidiosis were treated using sulphur drugs. Bloat, which affected animals after overeating of *Acacia tortilis* pods, and naval infections affecting calves were treated conservatively.

Statistical analysis of data

Data obtained in this study for the two herds were analysed statistically by Student's *t* test. This was used to test whether there was any significant difference between the mean values (PCVs, strongyle eggs, tickload) between the treated and untreated herds using the method described by Kempthorne (1969).

RESULTS

ANAEMIC STATUS

Packed cell volume (PCV) was used as a measure of anaemia using the values for camels reported in the Sudan (Salaheldin *et al.*, 1979) as a reference. During the disease investigation period, packed cell volume of the Ngurunit camels was below normal values and animals showed generalized anaemia. The total white blood cell count of this herd showed persistent leucocytosis which was mainly characterized by lymphocytosis and eosinophilia. The total red blood cell counts and the haemoglobin concentration were normal throughout the study period. During the treatment phase, the mean PCVs of the treated herd and the untreated herd were compared (Table 2 and Figure 3).

Table 2. Mean PCV for the two herds of camels (N in brackets)

Date of Sampling		Mean PCV ± S.E. for treated herd		Mean PCV ± S.E. for untreated herd	
May	1981	21.8 ± 0.57	(55)	21.7 ± 0.39	(55)
July	1981	26.1 ± 0.64	(58)**	23.2 ± 0.65	(41)
September	1981	28.2 ± 0.56	(56)**	25.0 ± 0.62	(61)
November	1981	27.1 ± 0.45	(54)**	24.8 ± 0.55	(61)
January	1982	27.8 ± 0.44	(56)**	25.7 ± 0.59	(69)
March	1982	28.2 ± 0.47	(57)**	25.8 ± 0.37	(57)
May	1982	28.0 ± 0.35	(53)**	24.8 ± 0.38	(39)

** Significant $P < 0.01$

The results clearly show the mean PCVs of the two herds at the beginning of the study period (May 1981) were almost the same for both herds. However, from the beginning of treatment (mid-May 1981) up to the end of the study period, there was a tremendous difference in packed cell volumes which was statistically significant at the 1% level. Haematological parameters were monitored but are not included in this report.

TRYPANOSOMIASIS

The incidence of trypanosomiasis in the Ngurunit camel herd, according to the detection of circulating antibodies and patent parasitaemia, was 79.4% and 9.7% respectively. The trypanosome infecting camels in the IPAL study area was identified as *Trypanosoma evansi*. *T. evansi* was isolated from mice inoculated with blood from infected camels. During the treatment phase, point prevalance rates of trypanosomiasis were used to study the pattern of disease in the camels. Point prevalence rate (PPR) was defined as:

$$\text{PPR} = \frac{\text{no. of cases existing in population at a point in time}}{\text{number of animals in population at same point in time}}$$

Figure 3. Mean packed cell volume (PCV) of the two herds

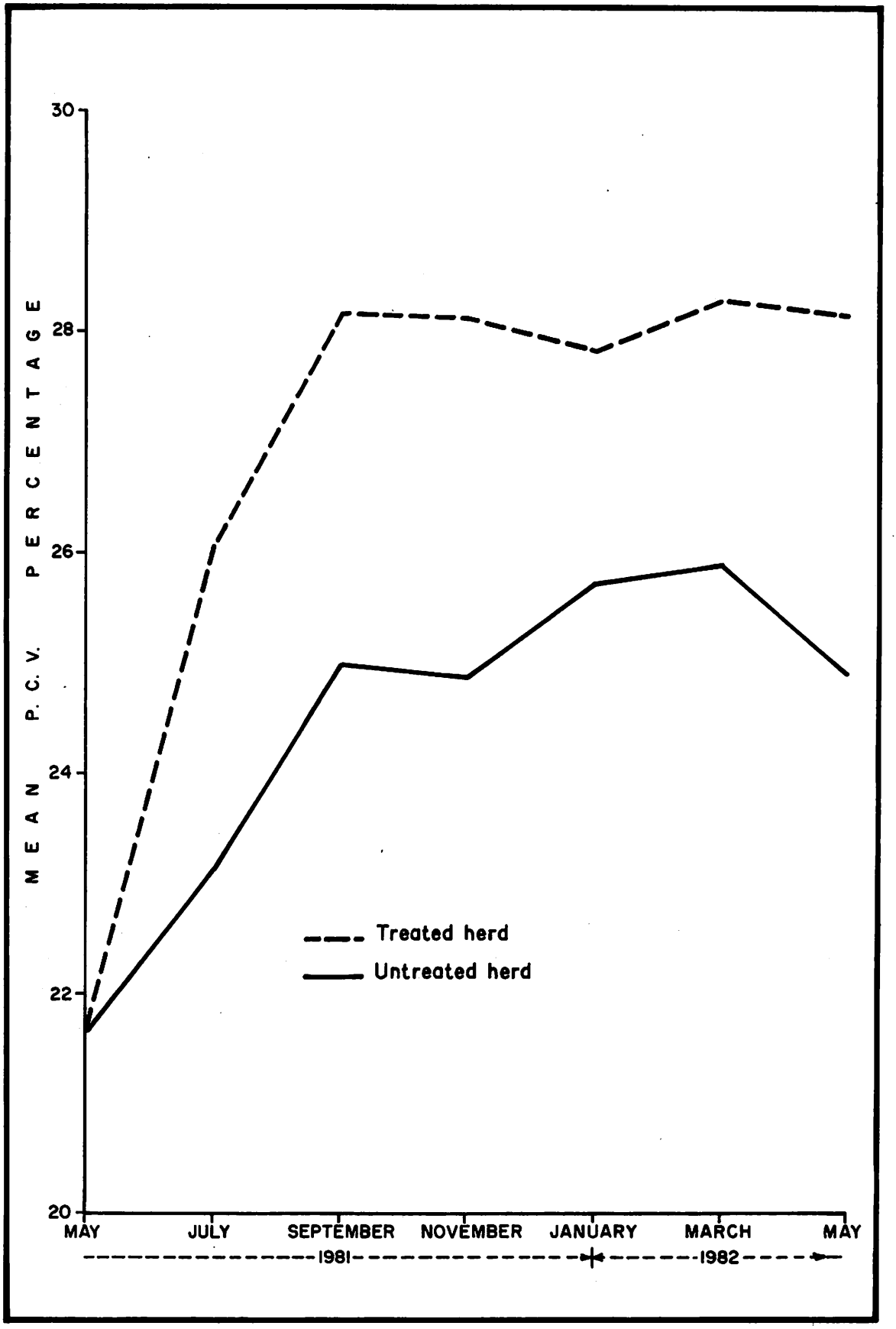


Table 3 gives the point prevalence rates for the treated and untreated animals as judged by mouse inoculation (MI), the mercuric chloride test (MCT) and the indirect haemagglutination test (IHA).

Table 3. Trypanosomiasis point prevalence rates

Date		Treated herd: Number of positive cases			Treated herd: Point prevalence rate %			Untreated herd: Number of positive cases			Untreated herd: Point prevalence rate %		
		MCT	*IHA*	*MI*	*MCT*	*IHA*	*MI*	*MCT*	*IHA*	*MI*	*MCT*	*IHA*	*MI*
May	81	5	5	0	8.5	8.5	0	2	2	0	3.4	3.4	0
July	81	5	5	0	8.9	8.9	0	8	10	0	13.4	16.7	0
Sep.	81	8	12	0	14.5	21.8	0	5	22	0	8.1	36.0	0
Nov.	81	4	12	-	7.7	23	-	7	23	-	11.7	38.3	-
Jan.	82	3	8	-	5.2	14	-	7	10	-	12	17.2	-
March	82	6	8	-	10.7	14.3	-	8	16	-	14.8	29.6	-
May	82	6	10	-	8.6	14.3	-	14	29	-	25.4	40	-

MCT = mercuric chloride test
MI = mouse inoculation
IHA = indirect haemagglutination
\- = not carried out

The point prevalence rates of the two herds were low throughout the period of study. The point prevalence rates for the untreated herd were, however, higher than those of the treated herd for most of the study period. When compared to the mercuric chloride test, the indirect haemagglutination test detected more positive cases than any other tests used. Both herds showed a similar pattern of rise on two occasions. The first one occurred in November 1981 and the next one in May 1982. This slight elevation in point prevalence rate of trypanosomiasis coincided with the appearance of the rains. There was also a concomitant drop in packed cell volume at this time (Figure 3). This was the time after the rains when fly numbers were seen to be on the increase. No trypanosomes were detected in mice inoculated

with blood from either herd during the study period. In a subsequent study, however (Rutagwenda, unpublished) the point prevalence rate of trypanosomiasis in the UNESCO-owned herd (untreated herd) was found to be 20.4% on wet smear. Trypanosomes were detected in mice inoculated with blood from very highly positive camels and were all *T. evansi*. Since the numbers of animals of different age groups in the two herds were small, it was not possible to compare the different point prevalence rates according to different age groups.

INTERNAL HELMINTHS

Gestro-intestinal strongylosis

The mean monthly strongyle egg counts for the two herds of camels and the total rainfall figures at Ngurunit during the period of study are given in Table 4. These results indicate that strongyle egg levels of the treated herd dropped from an initial level of 156 eggs per gram of faeces in February 1981 to 4 eggs/g in April 1981 and rose again to almost 100 eggs/g in May 1981.

From July 1981 up to the end of the study period no strongyle eggs were detected in this herd except in February and May 1982 when the means were very low: 2 and 1.5 eggs/g of faeces, respectively.

The mean monthly strongyle egg counts for the untreated herd are also shown in Figure 4. The results show that egg levels rose from 126 eggs/g in March 1981, reached a peak of 500 eggs/g in June 1981 and then began to fall again. This peak corresponded to one month after the heavy rains after which the egg counts went down and remained between 200 and 400 eggs/g of faeces until the next heavy rains of April 1982. The strongyle egg count of this herd went up again but did not reach the peak observed after the heavy rains of 1981 although they showed a similar trend. Five hundred eggs per gram of faeces is normally taken to be the pathogenic threshold and this was recorded after the heavy rains of 1981, and although they were not recorded again, the data show that camels had the highest number of eggs during and immediately after the heavy rains. The short rains of October to December 1981 did not seem to affect the level of strongyle eggs of this herd.

Table 4. Mean monthly strongyle egg counts for the two herds

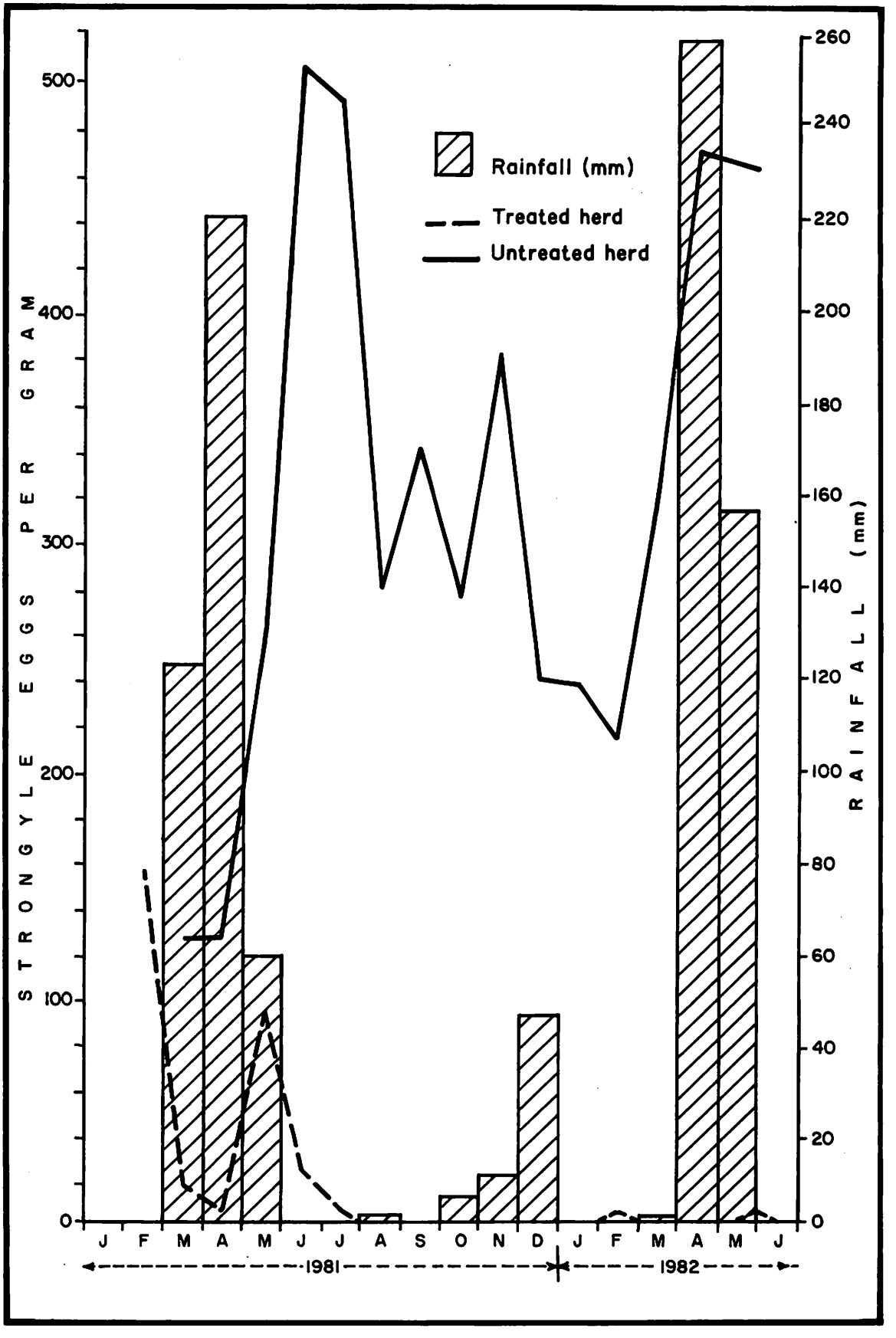
Date	Mean strongyle egg count for treated herd		Mean strongyle egg count for control herd	Total rainfall (mm)
February 1981	156		Herd not purchased yet	
March 1981	15	*	126	122.5
April 1981	4	*	127	220.4
May 1981	97	*	265	56.8
June 1981	25	*	509	0
July 1981	4	*	493	0
August 1981	0	*	277	0.5
September 1981	0	*	342	0
October 1981	0	*	275	5.5
November 1981	0	*	389	9.8
December 1981	0	*	238	46.6
January 1982	0	*	236	Trace
February 1982	2	*	211	Trace
March 1982	0	*	320	Trace
April 1982	0	*	470	Trace
May 1982	1.5	*	465	156.1

* = differences in strongyle egg counts significant ($P<0.01$)

Strongyle egg counts of the untreated herd in relation to age

Mean strongyle egg counts in the different age groups of the untreated herd are shown in Table 5 and Figure 5. The results should be examined with caution because the number of calves in this herd was very small and the adult and immatures in the herd were not similar in structure.

Figure 4. Mean strongyle egg counts of the herds in relation to total rainfall (in mm)



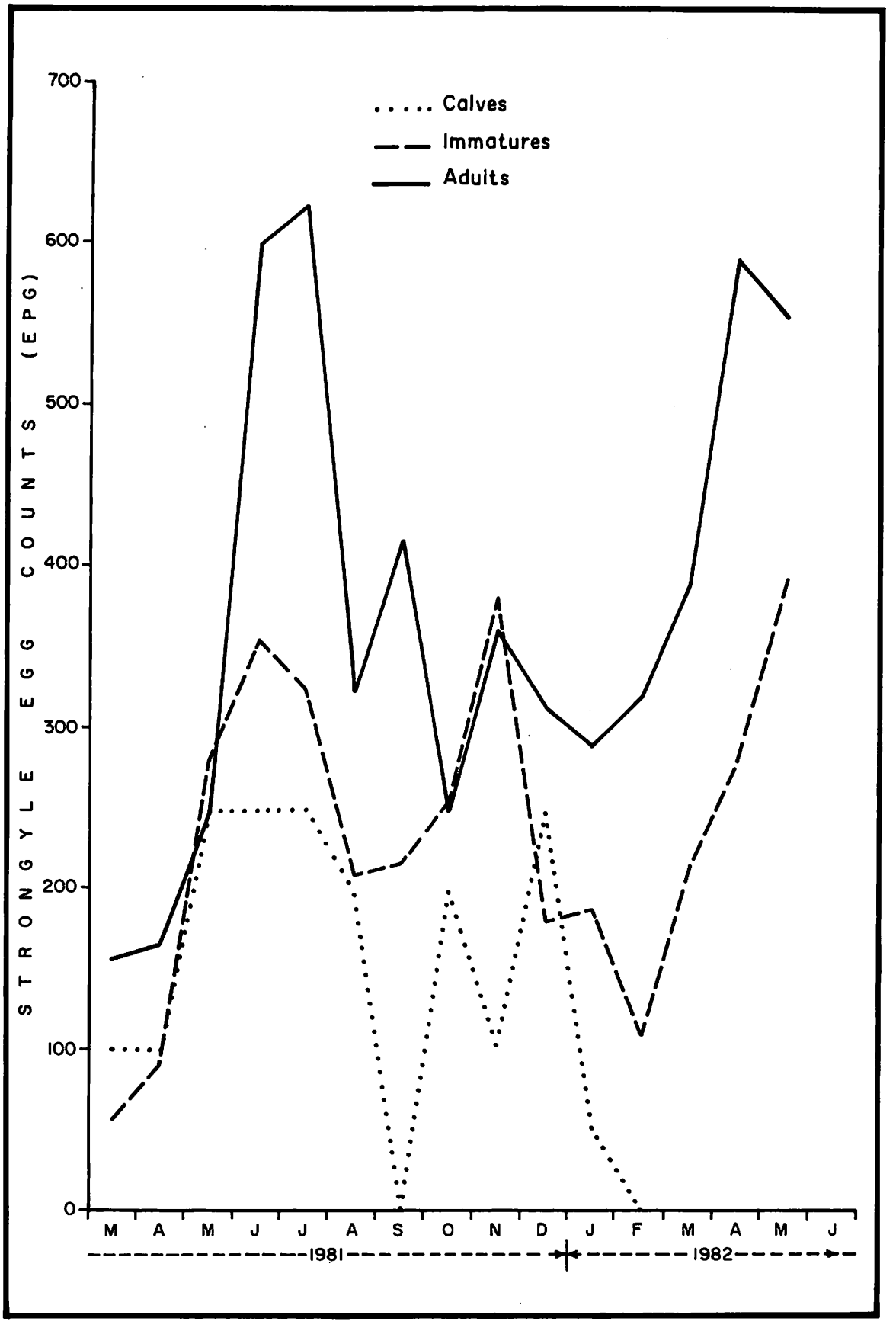
The results do show, however, that calves had lower strongyle egg counts than the adults with the exception of one sampling in May 1981. The mean egg counts of the immature camels were lower than those of the calves at the beginning of the study, but from May 1981 they remained higher than those of the calves until December 1981 when they were lower. From then up to the end of the study period, egg levels of immatures remained higher than those of the calves. Egg levels of adults were lower than those of immatures on three occasions: May, October and November 1981, after which they remained higher than those of immatures.

The mean strongyle egg counts of adult camels were generally very high and reached pathogenic thresholds on four occasions during the study period (during the heavy rains), viz. June and July 1981 and April and May 1982. No attempt was made to divide the herd into different sex groups as sex ratios would not give a representative sample size.

Table 5. Mean strongyle egg counts for the different age groups in the untreated herd (N in brackets)

Date	Calves (0-1 year)	Immatures (1-4 years)	Adults (over 4 years)
March 1981	100 (1)	56 ± 25 (16)	157 ± 49 (28)
April 1981	100 (2)	94 ± 44 (16)	167 ± 45 (32)
May 1981	250 (2)	280 ± 89 (15)	248 ± 52 (32)
June 1981	250 (2)	356 ± 83 (16)	600 ± 135 (35)
July 1981	250 (2)	327 ± 102 (15)	624 ± 111 (35)
Aug. 1981	200 ± 141 (2)	206 ± 78 (16)	321 ± 91 (39)
Sep. 1981	0 (2)	218 ± 58 (17)	416 ± 101 (38)
Oct. 1981	200 ± 141 (2)	256 ± 81 (16)	249 ± 56 (39)
Nov. 1981	100 ± 1 (2)	380 ± 118 (15)	362 ± 78 (39)
Dec. 1981	250 ± 178 (2)	180 ± 55 (15)	315 ± 94 (39)
Jan. 1982	50 ± 35 (2)	188 ± 42 (16)	289 ± 42 (36)
Feb. 1982	0 (1)	107 ± 29 (15)	318 ± 67 (34)
March 1982	No calves	219 ± 61 (16)	388 ± 91 (34)
April 1982	No calves	275 ± 74 (16)	589 ± 131 (35)
May 1982	No calves	394 ± 85 (16)	553 ± 70 (35)

Figure 5. Strongyle egg levels of the untreated herd in relation to age



Internal parasite point prevalence rates

Table 6 shows the percentage of animals affected with internal parasites at each monthly sampling. The results indicate a high point prevalence rate of animals having strongyle eggs in the untreated herd throughout the study period. The highest percentage of animals affected (88.7%) was recorded in April 1982. The results further indicate that a large proportion of animals became infected during and after heavy rains (Figure 5). During the dry months (August 1981 to February 1982) the percentage of infected animals was relatively low remaining between 55.7% and 69.9%. Strongyloides eggs were also present in both herds at relatively low prevalence rates and tended to disappear towards the end of the study period. Trichuris eggs were detected throughout the study period in the untreated herd and were only missed twice in the treated herd (February 1981 and October 1981). The percentage of treated animals having Trichuris eggs was higher than for any eggs of internal parasites. According to this study, it would appear that Trichuris worms responded very poorly to treatment with 10% Panacur (since Trichuris eggs could be detected in the faeces of the treated herd almost throughout). Coccidiosis was detected sporadically and at a relatively low rate of infection except in April 1982 when 20% of the treated herd and 25.9% of the untreated herd were found to be infected. This time coincided with a period of high rainfall (Figure 4) and conditions probably favoured the sporulation of coccidial oocysts. This could also explain the 10% prevalence of coccidiosis in the treated herd in March 1981. Moniezia eggs appeared in the faeces of both herds in June 1981 when many animals became infected. This infection tended to persist in both herds throughout the study period although at a lower level of infection. Ascaris eggs were present in immature animals of both herds at very low prevalence rates during the period of study. Two per cent of the treated herd were infected in April 1981. However, Ascaris eggs were not detected again till the end of the study period.

Table 6. Internal parasite point prevalence rates

Date		Strongyle	Strongy-loides	Trichuris	Coccidia	Moniezia	Ascaris
Feb. 1981	T	25.4	0	0	0	0	0
	U	Not	purchased		yet		
March 1981	T	3.3	18.3	15	10	0	0
	U	44.2	4.7	37.2	0	0	0
April 1981	T	1.9	17.7	13.7	0	0	2
	U	40.7	14.3	12.2	0	0	2
May 1981	T	53.3	0	20	0	0	2
	U	80.4	0	17.4	0	0	0
June 1981	T	20.3	22	6.8	5	68	0
	U	87.7	25.5	23.6	3.6	52.7	0
July 1981	T	0	12	3.5	1.8	72.4	0
	U	77	16.4	24.5	1.6	62.3	0
Aug. 1981	T	0	0	5.5	1.8	24	0
	U	55.7	11.4	19.7	0	37.7	0
Sept. 1981	T	0	0	5.4	0	3.5	0
	U	69.4	20.9	16.1	0	37.7	0
Oct. 1981	T	0	1.8	0	0	32.7	0
	U	68.9	24.6	21.3	0	32.8	0
Nov. 1981	T	0	0	5.5	0	0	0
	U	69.9	25.8	19.4	1.6	2.9	0
Dec. 1981	T	0	2	2	12	0	0
	U	57.4	6.5	9.8	0	0	0
Jan. 1982	T	0	0	1.8	0	14	0
	U	57.4	6.5	9.8	0	0	0
Feb. 1982	T	1.5	0	5.3	0	5.3	0
	U	63	1.8	7.4	1.8	38.8	0
March 1982	T	0	0	9.6	3.6	0	0
	U	77.4	0	3.2	7.5	13.2	0
April 1982	T	0	0	3.6	20	12.7	0
	U	88.7	0	25.9	25.9	9.2	0
May 1982	T	1.5	0	12	3	13.6	0
	U	83	0	30	3.4	43	0

T = treated herd
U = untreated herd

Larval cultures

Twenty larval cultures for third stage infective larvae from faeces collected from the untreated herd were carried out on four occasions during the study period and results are summarized in Table 7.

Table 7. Larval cultures from selected animals having high helminth egg counts (untreated herd)

Date	Number of samples	Worms recovered, % of total		
		Haemonchus	*Trichostrongylus*	*Oesophagostomum*
August 1981	5	75	25	0
November 1981	5	80	15	5
January 1981	5	80	12	8
May 1982	5	88	12	0

The results show that *Haemonchus* was by far the most common strongyle nematode present. *Trichostrongylus* and *Oesophagostomum* were also present at relatively low levels in the untreated herd.

Postmortem worm counts

A total of seven postmortem worm counts were carried out, five from the treated herd and two from the control herd. All five guts from the treated herd were without a single nematode. Of the two camel carcases from the untreated herd, one was of an eight-month-old calf which died of bloat and was without a single nematode. This calf had not showed any nematode eggs in its faeces. The second was a 10-year-old lactating female in which 10,000 *Haemonchus* worms were counted at postmortem.

EXTERNAL PARASITES

Tick loads

Figure 6 shows the mean monthly tick loads for the treated and the untreated herds during the study period. The mean tick load for the untreated herd at the beginning of the study period (March 1981) was lower than that of the treated herd. This was before application of acaricide. This count was made at Dhur some 65 km from Ngurunit towards Loglogo in a relatively dry area where the untreated animals were being herded before being moved into Ngurunit.

The next count was done in April 1981 on both herds of camels which were kept in Ngurunit at the time. The tick load for the two herds was almost the same: 68.9 ± 5.0 for the treated herd and 66.7 ± 3.7 for the control herd. This count was also made before the application of acaricide preparations. From this time, however, up to the end of the study period, the tick loads for the untreated herd remained between 34 ± 2.8 and 74.3 ± 4.5. The tick load was relatively low during the dry months of July to October (Figure 6).

The tick load for the treated herd started at a level of 47.9 ± 4.7 in March 1981 but rose to 68.9 ± 5.0 at the onset of rains in April 1981. Acaricide application started in May 1981 and from then up to the end of the study the tick load was lower than that of the control herd. The lowest value of 4.0 ± 0.5 was recorded in October 1981 and the highest value of 44.0 ± 3.6 was recorded in February 1982.

Figure 6. Mean tick load of the two herds

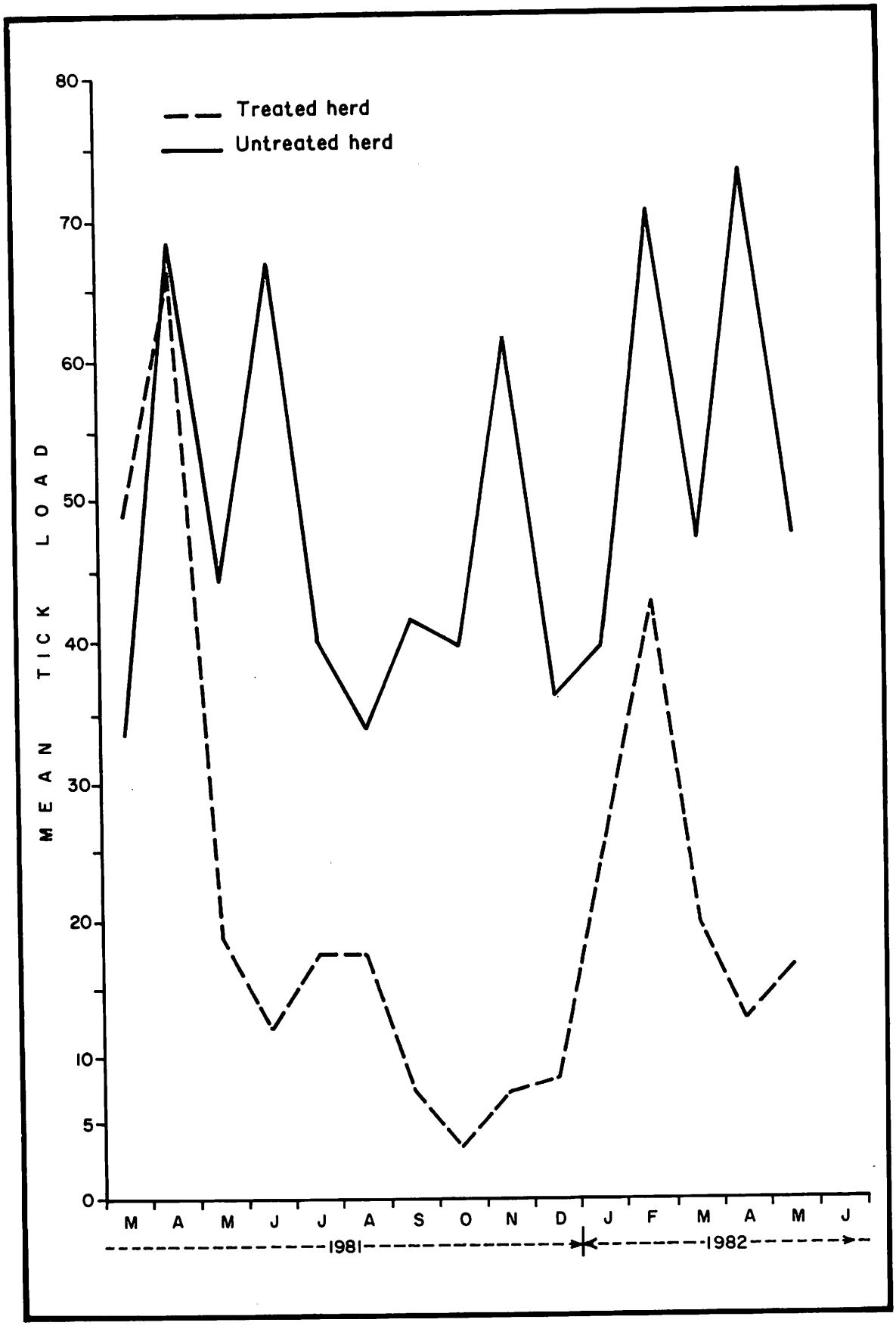


Table 8 gives the mean monthly tick loads for the two herds of camels and results show that the differences in tick load were statistically significant ($P<0.01$) from the time of application of acaricide.

Table 8. Mean monthly tick loads for the two herds

Date	Mean tick load for treated herd (absolute figures)		Mean tick load for control herd
March 1981	48		34
April 1981	69		67
May 1981	19	*	44
June 1981	12	*	67
July 1981	18	*	40
August 1981	18	*	34
September 1981	8	*	42
October 1981	4	*	40
November 1981	8	*	62
December 1981	9	*	36
January 1982	25	*	45
February 1982	43	*	71
March 1982	20	*	47
April 1982	13	*	74
May 1982	17	*	48

* Differences in tick load significant ($P<0.01$)

Tick loads in relation to different age groups of the untreated herd

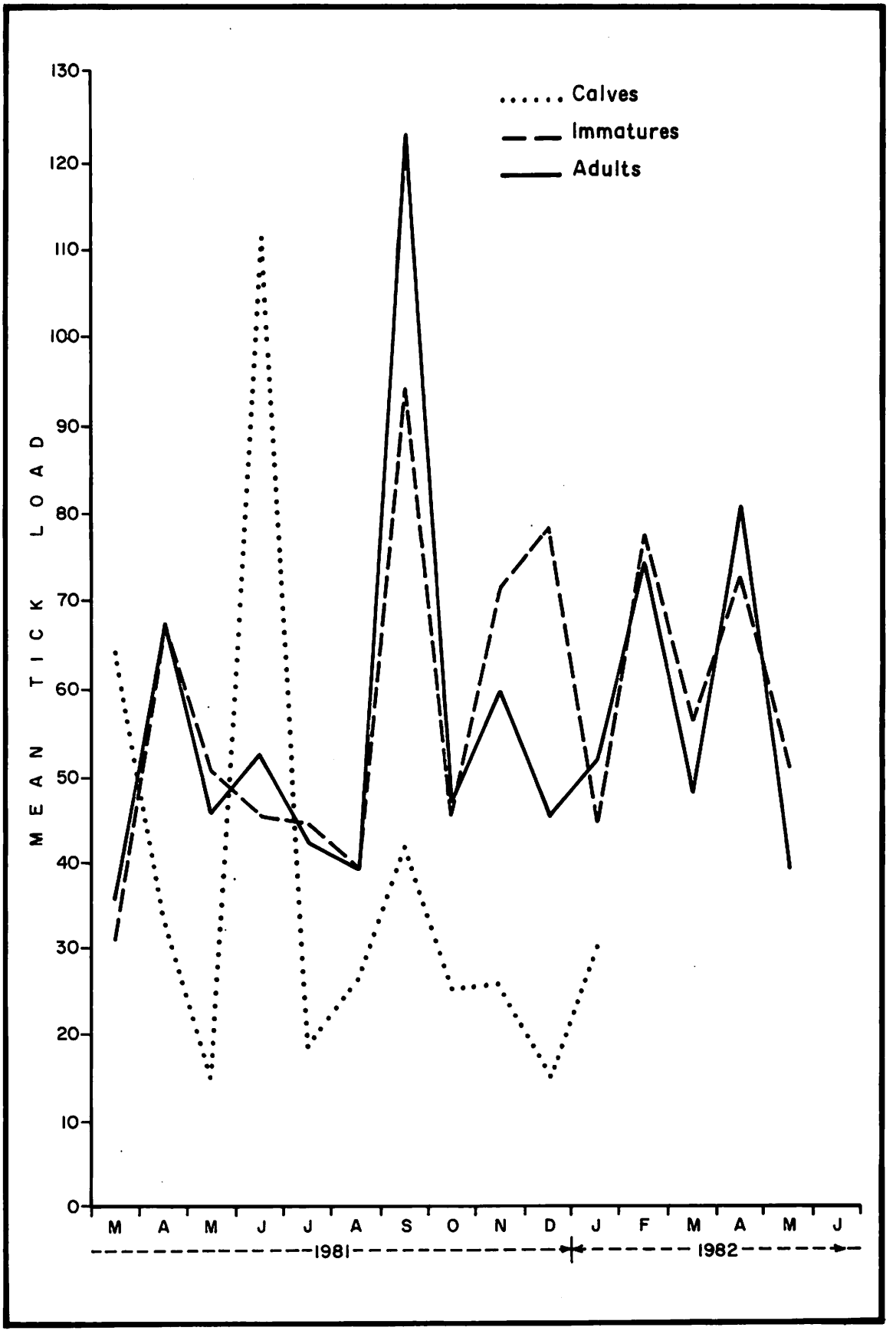
Table 9 and Figure 7 give mean tick loads in relation to various age groups of the untreated herd. Again, these results should be accepted with caution because of the small sample sizes, especially of calves. The results show that calves had the lowest tick loads except on two occasions in March and June 1981.

The tick load increased with age since during the later stages of the study the adults and immatures had higher tick loads than calves. There was, however, no clear cut difference between the tick loads of the adults and immatures.

Table 9. Mean tick loads of the untreated herd in relation to age

Date	Mean tick load ± S.E. (number of samples in brackets)					
	Calves		Immatures		Adults	
March 1981	63 ± 39	(2)	31 ± 6	(15)	34 ± 6	(28)
April 1981	33 ± 19	(2)	67 ± 5	(18)	68 ± 5	(31)
May 1981	13 ± 63	(2)	50 ± 5	(16)	44 ± 4	(34)
June 1981	111 ± 63	(2)	46 ± 5	(17)	52 ± 4	(36)
July 1981	18 ± 12	(2)	44 ± 4	(17)	42 ± 3	(35)
August 1981	27 ± 9	(2)	39 ± 7	(17)	39 ± 4	(36)
September 1981	42 ± 14	(2)	96 ± 10	(16)	123 ± 20	(37)
October 1981	26 ± 14	(2)	45 ± 5	(16)	45 ± 4	(37)
November 1981	26 ± 3	(2)	72 ± 9	(16)	60 ± 7	(37)
December 1981	16 ± 4	(2)	72 ± 3	(15)	43 ± 6	(31)
January 1982	30 ± 3	(2)	44 ± 6	(16)	50 ± 5	(35)
February 1982	No calves		78 ± 8	(16)	73 ± 11	(35)
March 1982	No calves		54 ± 8	(16)	45 ± 5	(33)
April 1982	No calves		72 ± 4	(16)	81 ± 6	(32)
May 1982	No calves		50 ± 5	(15)	38 ± 4	(32)

Figure 7. Mean tick load of the different age groups of the untreated herd



Tick species of camels and their relative abundance

A total of 5,546 ticks were collected from camels and identified during the study period. Of these, 3,550 were collected from the untreated herd and 1,996 from the treated herd. The tick species identified and their relative abundance are shown in Table 10.

Table 10. Tick species and their relative abundance

Tick species	Treated herd (expressed as a percentage of total)	Untreated herd (expressed as a percentage of total)
Hyalomma dromedarii	68.4	68.5
Hyalomma rufipes	23.4	20.7
Hyalomma truncatum	5.0	5.9
Rhipicephalus pravus	0.5	0.1
Rhipicephalus pulchellus	1.6	2.5
Amblyomma gemma	1.1	1.9
Unidentified nymphs	Nil	0.3
Total	100%	100%

These results indicate that *Hyalomma dromedarii* was the most common tick encountered. This was followed by *Hyalomma rufipes* and *Hyalomma truncatum*. *Rhipicephalus pulchellus*, *Amblyomma gemma* and *Rhipicephalus pravus* were also found in very low numbers. At one sampling in July 1981, nymphs were found in the nostrils of the untreated herd but no more nymphs were encountered up to the end of the study period.

Tick predilection sites

The identification of the ticks, according to their predilection sites, is shown in Table 11 for both herds. The results of tick attachment, according to predilection site, indicate that *Hyalomma dromedarii* was found all over the body although it had a preference for the nostrils and ears. *Rhipicephalus pravus* was found in very low proportions in the nose and the

ears of the dromedary. *Rhipicephalus pulchellus* was also found in low proportions under the tail switch of the dromedary, and on one occasion was also found in the ear. *Amblyomma gemma* was present in the inguinal area and tail switch of the camels in relatively low proportions. *Hyalomma rufipes* showed a preference for the tail switch but was also present in the inguinal area and on only one occasion in the nose. *Hyalomma truncatum* was found in the inguinal area and the ratio of male to female ticks indicates that males were generally greater in number than the females. Mechanical effects of ticks such as conjuctivitis, keratitis and festering sores at the sites of attachment were observed on the dromedary.

OTHER EXTERNAL PARASITES

Mange mites

Mange, caused by *Sarcoptes scabiei* var. *camelis*, was a common condition in all age groups of camels but calves were affected most. Skin scrapings taken once during the study period revealed the presence of the mites. Lesions were seen mainly on the head and flank with the affected areas appearing swollen, hardened and wrinkled with a concomitant loss of hair. The animals rubbed the affected parts against any hard objects they could find, including *boma* material. The treatment given to the group of the Red herd calves helped a great deal. This involved mixing acaricide with old engine oil (to make the acaricide stay longer on the animal), then the preparation was scrubbed on to the animal with the help of a hard brush The procedure would be repeated weekly. The preparation would also be used in a calf *boma* by dipping a sack into the mixture then tying the wet sack on to a big stump in the *boma* so that calves could rub themselves on the acaricidal preparation.

Camel flies

Camel flies of the family Hippoboscidae were very common on camels, especially after the heavy rains. It was surprising to note that flies tended to avoid animals which were recently sprayed with acaricide. No quantitative studies of this fly were carried out but it would appear that the flies increase in numbers after the heavy rains.

Table 11. Tick predilection sites

Site	Tick species	Treated herd		Untreated herd	
		% of total	Ratio of male to female	% of total	Ratio of male to female
Nose	*Hyalomma dromedarii*	98.8	3:1	99.8	2:1
	Rhipicephalus pravus	1.1	2:1	0.2	1:0
		632*		1149*	
Ear	*Hyalomma dromedarii*	99.1	3:2	97.5	4:1
	Rhipicephalus pulchellus	0.3	1:1	0.8	3:2
	Rhipicephalus pravus	0.5	2:1	0.1	0.1
	Hyalomma rufipes			0.4	3:1
	Unidentified nymphs			1.1	
		602*		1019*	
Tail switch	*Hyalomma dromedarii*	14.5	3:2	20.9	3:2
	Hyalomma rufipes	70.5	3:2	58.7	2:1
	Hyalomma truncatum	8.6	1:1	12.4	1:1
	Rhipicephalus pulchellus	4.4	3:1	4.0	2:1
	Amblyomma gemma	1.9	2:1	4.0	2:1
		594*		1146*	
Inguinal area (udders and testes)	*Hyalomma dromedarii*	34.0	1:1	22.5	4:1
	Hyalomma rufipes	28.6	1:1	25.0	4:1
	Hyalomma truncatum	28.6	2:1	29.3	4:1
	Rhipicephalus pulchellus	2.4	2:1	13.9	2:1
	Amblyomma gemma	6.5	3:1	9.3	8:1
		168*		236*	

* Number of ticks sampled

BRUCELLOSIS

A total of eight abortions, six in the untreated herd and two in the treated herd, were encountered during the study period. Paired serum samples from these animals were negative for brucellosis on the three tests used (CFT, RB PT, SAT). Since most of the abortions were on pasture and it was difficult to isolate *Brucella* organisms without the presence of the aborted feti, it was felt necessary to screen the whole of the untreated herd for brucellosis at the end of the study. Fifty five serum samples were collected and analysed and it was found that four were positive on RBPT, one of the four on SAT and the rest were negative on three tests.

Abortions

Having failed to detect *Brucella* antibodies from the sera of the aborting animals, the question arose as to what caused these abortions. An attempt was then made to correlate the incidence of the abortions with the occurrence of levels of antibodies to trypanosomiasis (see Table 12). It can be seen from the table that all animals which aborted at one time or another had antibodies for trypanosomiasis and in 75% of cases this was within a month of an abortion. In subsequent studies (Rutagwenda, unpublished) this correlation has been observed in other nomadic camels in other places in the study area and also at Galana Ranch at the coast (Olaho, pers. comm.). Trypanosomiasis is well known as a cause of abortion and it would appear from this study that trypanosomiasis, and probably not brucellosis, was the cause of abortion in these camels. Further work will have to be done to elucidate this.

MISCELLANEOUS CONDITIONS

A number of other disease conditions were encountered during the course of the study and will be briefly mentioned. Some of these were recorded during antemortem examinations while others were common postmortem findings.

Table 12. Abortions and trypanosomiasis records

Animal number	Herd	Date mated	Date aborted	Trypanosomiasis records	
				Mercuric chloride test	Indirect haemagglutination test
509	Treated	April 1981	24.8.81	+ September 1981	-
80	Treated	Not recorded but mated during rainy season March to May 1981	8.10.81	+ September 1981	-
633	Untreated		13.9.81	-	+ September 1981
636	Untreated		1.10.81	-	+ September 1981
667	Untreated		13.11.81	+ September 1981 + November 1981 + March 1982	+ March 1982
684	Untreated		27.11.81	+ July 1981	+ July 1981
660	Untreated		7.1.82	+ September 1981	+ July 1981
663	Untreated		27.3.82	+ March 1982	

+ = positive

- = negative

Bloat

Bloat or rumen overload was a common condition in February 1982 when camels were eating falling *Acacia tortilis* pods. Animals were seen moving from one tree to another eating the pods almost exclusively during this period. One calf from the untreated herd died of acute bloat. However, calves of the treated herd which were in a similar state benefited greatly from the liquid paraffin therapy that was applied.

Myiasis

It was common to find large numbers of *Cephalopsis tittilator* larvae, especially at necropsy of old camels of both herds. In no case, however, was there any indication associating the numerous larvae recovered at postmortem with the cause of death of an animal. However, the numerous larvae cause distress to the animal and lead to secondary bacterial infections.

Contagious necrosis

Contagious necrosis of the skin (Richard, 1979) was common condition in camels, especially during the rainy season when animals were not drinking salty water. The condition tended to disappear spontaneously during the dry season when animals were drinking salty water from Korole wells in the Chalbi desert. The wounds in the treated animals were conservatively treated and responded very well to treatment.

Abscesses

Abscesses at the base of the neck and on the rump and abscessing lymph nodes described by Evans and Powys (1979) were common. Foot abscesses were also common but no quantitative studies of these was carried out and the aetiology was not established.

Hydatidosis

The most important larval stages of cestodes which parasitize camels are those of the adult tape worm *Echinococcus granulosus*. *Echinococcus granulosus* has been reported in the Sudan (Steward, 1950) and Nigeria (Dada, I978). In Nigeria, out of 3,410 slaughtered camels at an abattoir in Kano, 57% were found to be infested with hydatid disease with cysts in lungs, livers and spleens. The incidence of hydatidosis among the Turkana people has been reported to be very high (French and Macpherson, 1983). A great majority of IPAL camels were initially purchased from Turkana and at least 75% of those that have died of other causes have been found to have hydatid cysts in the lungs and liver. This finding supports those from Turkana District which borders the IPAL study area.

THE EFFECT OF TREATMENT ON HERD SIZE

A summary of the numbers of the two herds from the time treatment began up to the end of the study period is shown in Table 13.

Table 13. Animal numbers before and after treatment

Herd	Number present May 1981	Births	Additions	Deaths, including predators	Number present May 1982	Net increase	% increase or decrease
Treated	60 (29)	21	Nil	10	71	+ 11	+18.3
Untreated	60 (30)	12	1	15	58	- 3	-5

Number in brackets = breeding females 5 years or older

Table 13 shows that the treated herd gave birth to more calves, lost fewer animals, and there were fewer abortions (Table 12). At the end of one year of treatment there was a numerical increase of 11 animals (18.3%) in the herd. The untreated herd, on the other hand, had more abortions, lost more animals, and had fewer calves and, although there was an adult camel added to the herd, there was a net decrease of three animals (5%) in one year. Although the structures of the two herds were not identical, the numbers of breeding females were similar.

Mortality and postmortems

Table 14 gives a summary of 25 deaths encountered during the study period, ten in the treated and 15 in the untreated herd, according to various age groups. The results indicate that more deaths were recorded in the calf segment of both herds followed by the adults and the immatures. Malnutrition was a cause of death, mainly in calves in the treated herd. Predators killed two animals, a calf and an adult, in the treated herd, and three animals in the untreated herd, one immature and two adults. Pneumonia caused the death of two camels in the treated herd (a calf and an immature) and one immature in the untreated herd. Other causes of death in the treated herd included one adult camel which died of hydatidosis complicated by pneumonia and one calf which died of urinary bladder rupture. Two calves in the treated herd died of an acute condition similar to ephemeral fever described in cattle and the cause of death of one other calf was not established.

In the untreated herd, chronic trypanosomiasis and hydatidosis complicated by haemonchosis were responsible for the death of one adult camel each. Chronic enteritis was the cause of death of an immature camel. Other causes of death in this herd included acute bloat and severe tick infestations. The cause of death of one calf was not positively diagnosed as the animal was discovered very late.

Table 14. Mortality in both herds

Cause of death, if known	Treated herd n = 10			Untreated herd n = 15		
	Calves	Immatures	Adults	Calves	Immatures	Adults
Malnutrition	1	-	-	4	-	-
Predators	1	-	1	-	1	2
Pneumonia	1	1	-	-	1	-
Chronic trypanosomiasis	-	-	-	-	-	1
Chronic enteritis	-	-	-	-	1	-
Hydatidosis complicated with pneumonia	-	-	1	-	-	-
Hydatidosis complicated with haemonchosis	-	-	-	-	-	1
Rupture of the urinary bladder	1	-	-	-	-	-
Acute bloat	-	-	-	1	-	-
Heavy tick infestation	-	-	-	2	-	-
Undiagnosed acute condition similar to ephemeral fever	2	-	-	-	-	-
Undiagnosed	1	-	-	1	-	-
Total	7	1	2	8	3	4

DISCUSSION

The camel is a basic resource for many pastoralist groups in the arid lands of Africa and Arabia. Its importance arises from the fact that the introduction of high-producing livestock in such areas has proved difficult (Knoess, 1977). The dromedary has enabled desert people to live in a difficult environment and has been a strong supporting factor in historic development of these areas. Besides, nomads attach a lot of tradition to the camel. When droughts occur, camels prove to be the primary source of subsistance and hence the key to survival (Hartley, 1979). Despite their traditional importance, there have been relatively few studies on disease, nutrition and production of the dromedary as compared to other livestock species. Most herds which have been studied in Kenya, for example, belong to fairly sedentary communities and several factors have probably contributed to this change in lifestyle (Dolan, 1980). The loss of mobility in some nomadic tribes has caused a high incidence of inbreeding and inbreeding depression is known to cause poor performance.

The results obtained from camels used in the present study might not have been representative of the true nomadic community, for, according to the owner, the herd had not moved out of Ngurunit area for the last six years and had not moved further than 150 km from Ngurunit for the last 20 years. The control herd was also locally purchased and established and it is likely that owners were selling mediocre animals or animals having originated from poor dams. The difficulties involved in purchasing camels have to be taken into account, but suffice it to say that the herds were suitable for the study and were comparable in structure, except for numbers of calves. However, a survey of diseases of the more traditional nomadic herds would be a worthwhile undertaking and this should be of mixed age and sex groups and preferably from various localities in the IPAL study area. The veterinary clinical service of IPAL (Rutagwenda, 1983) may yield these data and may be very useful in comparing herds from different locations.

Camels have a slow reproductive rate having a gestation period of about one year. In harsh conditions, age at first calving is six to seven years, with a two-year calving interval thereafter (Mukasa, 1981), and in view of this any systematic studies should cover a long period of time.

The study on anaemia showed significant differences between the treated and the untreated herds two months after treatment was initiated. The treated herd had higher PCV than the untreated herd, indicating that the treated animals had a better health status. It is a well known fact that animals suffering from trypanosomiasis are anaemic. Ticks and helminths also suck blood and cause anaemia. It is difficult to single out which particular treatment, i.e. against trypanosomiasis, ticks or helminths was responsible for the differences observed. However, with a relatively lower point prevalence rate for trypanosomiasis (Table 3), low helminth egg levels (Figure 4), and lower tick loads (Figure 6), in the treated herd, agents causing anaemia were reduced and the herd had a better health status, as shown by high PCVs (Figure 3). The higher prevalence of trypanosomiasis, higher helminth egg levels (Figure 4), and higher tick loads (Figure 6) in the untreated herd probably contributed to the anaemic state of the herd. The anaemia was microcytic in character, the white blood cells had leucocytosis which was characterized by lymphocytosis and oesinophilia. This indicates chronic blood loss which could be caused by internal parasites (*Haemonchus*) and external parasites (ticks) and these were detected in sufficiently high levels to explain the PCV findings.

The trypanosomiasis point prevalence rates were low for both herds, being particularly lower in the treated herd than the untreated herd as judged by MI, IHA and MCT. The IHA detected the highest number of positives followed by MCT and no positive cases were detected by MI. The IHA test had been recommended as a promising test for serodiagnosis of camel trypanosomiasis (Verma and Gautam, 1977) and the results obtained in the present study are in agreement with the findings of these workers. The lack of infection in mice does not rule out infection in camels. Probably parasites were

scanty or absent in peripheral circulation in latent infection (Losos and Ikede, 1972), or mice may develop very low parasitaemia which might not have been detected by microscopic examination of peripheral blood (Luckins *et al.*, 1979). In subsequent studies, however, Rutagwenda (unpublished) found 20.3% of the IPAL herd positive for trypanosomiasis with fulminating parasitaemia in positive cases. The herd had at this time moved to Ilim (Range unit 13) from Lependera (Range unit 20) This would indicate that either the camels were challenged at that time with an increase in vectors or the low potency of infection detected earlier had been disturbed by other factors. A study of fly numbers and their infection rates would have been useful at this time.

As judged by IHA, there appeared to be two peaks in point prevalence rates of trypanosomiasis for the two herds. These occurred in November 1981 and May 1982. The rainy season in Ngurunit shows two peaks in April and May (long rains) and November and December (short rains). The point prevalence rates for the two herds appeared to show an elevation corresponding to this rainfall pattern. This probably coincided with the high incidence in fly numbers as had been observed earlier in the Philippines (Yutuc, 1949). The low prevalence rates for trypanosomiasis in the Ngurunit herd, showing that the disease is epidemiologically stable, had earlier been reported by Wilson *et al.* (1981) and the findings of this study confirmed this as judged by MCT and IHA results. Treatment in such an area should be administered only to positive cases to avoid disease instability and drug resistance.

However, results were not available until January 1982 so that positive animals could have been identified early and treated. A few that were positive were treated from January to March 1982. In addition, those that were detected in subsequent surveys have been treated with Naganol and this has resulted in total disappearance of parasitaemia.

Results of internal parasite studies show that *Haemonchus* is the most important helminth in camels. It was observed that peak strongyle egg production in the untreated herd was reached in June and July 1981 and April and May of the following year. This was just after the heavy rains and the type of weather was probably optimal for the survival of the infective strongyle larvae on pasture. In addition, rising *Haemonchus* egg counts at the end of a dry season had been observed in Nigerian cattle (Hart, 1964). This was attributed to inhibited immature stages of the worm resuming development as a result of a decline in the immune status of the host and this probably occurs in camels and was responsible for the rise detected after the rains. Strongyle egg levels of the untreated herd alone, with a few exceptions, showed that adult camels had the highest loads followed by immatures and the least loads were detected in calves. These results, although based on a small sample size of camels and for a short period of time, agree with those obtained in Kenyan camel herds and suggest a stress factor in the adult segment of the herd which is caused by nomadic management where there is great demand for milk from the dam. On an individual animal basis, it was evident that the mature lactating camels had the highest helminth egg loads adding more weight to this stress hypothesis.

Results of other internal helminths studies showed that *Strongyloides* and *Ascaris* worms were low in prevalence, as had been observed earlier (Wilson *et al.*,1981). Coccidial oocysts showed two peaks of occurrence during the period of study in March 1981 and April 1982 while in other months they were either very low or nil. These results agree with those obtained by Christensen (1939) in sheep. *Moniezia* eggs were more prevalent than had been reported in this area. Their importance in pathogenicity is relatively low, however.

This study showed that Panacur 10% solution given at the same dose as that for cattle (7.5 ml/100 kg) can eliminate strongyle eggs from a herd and supports observations made in cattle (Ross, 1975). The low efficacy of the drug on *Trichuris* had been observed in sheep (Kennedy and Todd, 1975) and this was confirmed by the present study. The drug exerts its

anthelmintic activity in the upper parts of the digestive tract and *Trichuris* worms are found further down in the large intestines, hence the reduced activity on the worm as evidenced by this study.

This study identified a seasonal pattern in helminth egg levels and, based on this finding, a regimen to be used for drenching animals so as to maximize on the economic returns while minimizing the costs was suggested and is important in management of camels in these areas. This study showed that strongyle egg levels reach pathogenic or nearly pathogenic thresholds during and immediately after the heavy rains but during the dry season egg levels remain very low. In addition, adult female camels showed higher egg levels than any other age group of animals. From cultures and postmortem, *Haemonchus* was by far the most important nematode recorded. Therefore, dosing all animals at the beginning of each wet season and only female adult camels two months later would be an adequate regime for better economic returns.

The studies on external parasites indicate that ticks, especially the desert-acclimatized *Hyalomma* species, were a problem in nomadic herds. This study identified six species of ticks, three of *Hyalomma*, two of *Rhipicephalus* and one of *Amblyomma*. This study further confirmed earlier reports (Richard, 1979) that *Hyalomma dromedarii* is the most common camel tick species present. In this particular study, more than 60% of the ticks present were of this species. *Hyalomma truncatum* is a known toxin producer and was found in low levels and *H. dromedarii* was found to infest mainly the nostrils and ear confirming earlier observations (Hoogstral, 1956).

Acaricide application on camels reduced tick loads and this is in agreement with observations made in Galana (Wilson *et al.*, 1981). The increase in numbers of ticks observed in the treated herd in March 1982 coincided with the depletion of tick grease and was mainly due to the very many ticks which were present in the nostrils and were inaccessible to acaricide sprays, as had been observed in the Sudan (Steward, 1950). Other indirect effects caused by ticks, such as conjuctivitis and keratitis, were also observed.

Tick loads generally increase with age (Wilson *et al.*, 1981). However, using the untreated herd data, it was difficult to establish whether the adults had higher tick loads than immatures. It must be realized that this study involved a smaller herd of camels as compared to Wilson's *et al.* (1981). This study showed that weekly application of acaricide coupled with tick grease in the nostrils greatly reduces the tick load. Acaricides are available on the market and are relatively cheap, although very laborious to use due to the necessity for frequent application.

Mange, due to *Sarcoptes scabiei* var. *camelii* was a common condition, especially in calves. Application of acaricide in a manner described and recommended by Evans and Powys (1979) helped a great deal. Lesions started around the head and flank. The areas affected became swollen, hardened, hairless and wrinkled.

Camel flies were common after the rains and tended to avoid animals which were recently sprayed with acaricide. Other flies were also observed but no quantitative studies of these were carried out.

Abortions were common in camels. This study showed that brucellosis was probably not the cause of the observed abortions. However, the serological response to trypanosomiasis led to a suspicion that trypanosomiasis was likely to be the major cause of the observed abortions (Olaho, Rutagwenda and Wilson, in press). The low rate of abortions observed in the treated herd could be attributed to the Naganol cover which the treated herd was under and also low levels of antibodies (Table 3).

Predators of livestock in the IPAL study area had been investigated by Kruuk (1980) and this study confirmed his observations. Twenty per cent of deaths in both herds were due to predation. Control of predation is difficult but if Kruuk's recommendations on the use of dogs and provision of alternative methods of fencing are adopted they are likely to be effective. Wilson *et al.* (1981) identified important diseases of camels in Kenya and malnutrition was suspected in certain herds. This study

confirmed malnutrition as an important cause of death, especially in calves, based on lesions observed at histopathology (Rutagwenda, 1982). In this study, 50% and 14.3% of calf mortality in the untreated and treated herd respectively was due to malnutrition. Since malnutrition is a problem resulting from the existing competition between man and calf for milk, this problem should be examined in much greater detail. This study confirmed pneumonia as a problem of camels during and after heavy rains following severe droughts, an observation made earlier by Eldesougi (1979) in Saudi Arabia. Pneumonia alone was responsible for 20% and 6.7% of mortalities in the treated and control herds respectively. Pneumonia complicated with hydatidosis was also responsible for 10% of deaths in the treated animals.

Other causes of camel deaths included severe tick infestations (26.7% in the untreated herd). A condition similar to ephemeral fever in cattle was responsible for 20% of deaths in the treated herd. Trypanosomiasis, enteritis, hydatidosis complicated with haemonchosis in camels originating from Turkana, and acute bloat were each responsible for 6.7% deaths in the untreated herd.

The incidental hydatidosis observed in this study might have a bearing on what has been recorded by scientists in Turkana (French and Macpherson, 1983). Rupture of the urinary bladder was responsible for the death of one calf in the Red herd and one animal died in the bush and was discovered too late to get any important postmortem information.

Other postmortem findings included the presence of the larvae of the nasal fly *Cephalopsis titillator*. Large numbers of larvae were commonly found in the nasopharyngeal mucosa and frontal sinuses of camels, especially very old camels. Their presence in large numbers was, however, not linked with the appearance of clinical disease. In terms of numbers (Table 13) the treated herd increased by 18.3% and the untreated herd was reduced by 5% at the end of 12 months of treatment. These results differ from those obtained by Wilson, Dolan and Olaho (1981) in other Kenyan camels receiving some veterinary inputs. The latter, however, was a four-year study compared to the one year of the present study. Moreover

the present study was based on a smaller sample of animals.

This study showed that adult animals had the highest burdens of parasites, ticks and helminths. Okao (1975) working on fascioliasis control in cattle noted weight gains in treated cattle compared to those that were not being treated. This increase was attributed to the removal of the parasites thereby increasing the food conversion efficiency of the liver.

Removing the indirect effects of stress caused by ticks and worms and reducing the incidence of trypanosomiasis could probably have the same effect, as evidenced by the better performance of the treated herd. This study further showed that adult animals had higher parasite burdens than young ones and in strategic treatment regimes emphasis of treatment should be placed on mature lactating females as they carry the heaviest parasite burdens.

This study showed that desert camels kept on a package of drugs, strategically used, thrive much better than untreated animals in the same environment. It is a well known fact that drugs alone cannot affect growth rate, increase milk production or increase weight. The differences which were observed were probably due to parasites having been removed by the drugs leading to a better performance of the treated animals.

Because of the short duration of this study, no emphasis was placed on production parameters, and in any case 71.4% of calves born to the treated herd were born in the last two months of the study. Moreover, since Kenyan camels are not normally sold it was not necessary to carry out an economic study. Production and economic studies are long-term and are reported separately.

Based on the findings of this study, however, it should be stated that production in nomadic camel herds should improve with simple packages of drugs if they can reduce the high rate of abortion and if management practices can be improved to reduce predation and calf malnutrition. However, livestock marketing should be reviewed because if a small package of drugs can increase the herd size by 18.3% per annum, as in this study, the extra animals may exert pressure on the land and limit the few available resources and worsen the process of desertification.

CONCLUSIONS

Within the experimental procedures and limits of this study, the following conclusions can be drawn.

1. Important camel diseases in northern Kenya can be adequately reduced by incorporation of a simple veterinary drug package.

2. The treated herd had a much higher packed cell volume compared to the untreated herd. This study, however, did not identify what caused the poor anaemic state, although trypanosomes, helminths and ticks were suspected causes.

3. Studies on internal parasites showed that *Haemonchus* was an important helminth of camels (based on culture and postmortem worm counts) and seasonal peaks in strongyle egg levels were observed. Strongyle egg levels increased with increase in age of camels and suggested a stress factor on the adults of the herd, especially adult female camels. This was attributed to competition between calves and man for milk. Other internal helminths, as well as coccidial oocysts, were observed, although at low prevalence rates. Occurrence of coccidial oocysts appeared to coincide with rainy seasons.

4. The study showed that Panacur at a dose rate of 7.5 ml/100 kg body weight can reduce internal camel helminths although it appeared to be less efficient against trichurid worms.

5. The study on external parasites showed that ticks were a major problem especially in young calves where mortalities occurred. This study failed to establish the incidence of ticks with age of camels, however, and this was probably due to the small sample size. Mange was a problem of camel calves but cases responded well to the type of treatment that was applied.

6. Abortions were observed in nomadic herds but this study did not establish whether brucellosis was the cause of abortion. However, trypanosomiasis was incriminated on the basis of serological response.

7. Predators were confirmed to be a problem of livestock in the study area.

8. Malnutrition, pneumonia, tick infestation, hydatidosis, bloat, chronic trypanosomiasis and chronic enteritis were confirmed as causing mortality in camels.

9. The desirable effect of the treatment was the increase in calving, reduction in abortions, and fewer deaths resulting in numerical increase in the herd by 18.3%.

RECOMMENDATIONS

1. One of the objectives of IPAL is to study the causes of desertification and to provide information for rehabilitation of arid lands inhabited by nomadic pastoralists. One of the causes of desertification has been cited as overstocking. Studies on livestock marketing should bear this in mind. In the present study it was shown that nomadic camel herds can increase with a small veterinary package. There is no point in preserving animals from death and debilitation due to diseases using expensive drugs only to have them die from starvation during droughts. It is also believed that nomads accumulate animals in large numbers as an insurance against droughts and other hazards. But once a disease-control strategy has been established, strategic offtake must substitute for the old traditions of accumulation of stock. In view of this, IPAL should explore the possibility of increasing the demand for camel meat both locally and internationally. It should also explore the possibility of exporting live camels to Saudi Arabia where the market is very favourable.

2. Poor management has been the cause of heavy mortality, especially in calves. It is recommended that a study be carried out to find the optimum period required after which calves should be weaned so that both their health and the subsequent fertility of the dam are not affected.

3. Attempts should be made to reduce the incidence of predation by taking into account all practical facilities available to the nomads.

4. The veterinary input packages for camels were found to be beneficial in terms of better health, increase in the herd, fewer abortions and lower mortality. However, the possibility of using even cheaper drugs should be explored as most drugs now on the market are expensive.

5. Further information on incidence of individual diseases is required to identify priorities for further research. Funds being available, it is recommended that individual disease control studies be carried out so that it may be possible to control individual diseases which may be relatively cheaper than a use of a complete package.

6. The control of main diseases in the IPAL study area should involve packages for trypanosomiasis, internal helminths, ticks and mange, administered in the following manner:

   (a) It is recommended that Naganol (suramin) be used on camels with trypanosomiasis after proper and accurate diagnosis has been made so that there is no danger of drug resistance and/or disease instability.

   (b) Anthelmintics should be administered on a strategic basis as seasonal and age effects on strongyle eggs were observed by this study. It is recommended that all camels be drenched with an anthelmintic at the beginning of each wet season and adult female camels be drenched again two months later. This regimen is considered to be adequate. Weekly application of acaricide together with tick grease and scrubbing calves regularly using acaricidal preparations should be adequate.

All these measures should raise productivity in nomadic camel herds.

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THE EFFECTS OF DISEASES AS CONTRAINTS TO CAMEL PRODUCTION IN NORTHERN KENYA

by

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1. INTRODUCTION

The camel *(Camelus dromedarius)* is probably the best species of livestock for protein production, in the form of meat, blood and milk, in arid areas. However the camel is not used to its full capability in northern Kenya and there are several factors such as disease, nutrition and genetic potential that limit its productivity. An experiment was undertaken by the Integrated Project in Arid Lands (IPAL/UNESCO) to determine whether productivity could be improved if disease was controlled by the application of modern veterinary drugs. This report describes the results of these productivity studies.

There are three recognizable breeds or races of camel in Kenya - the Somali breed, the Rendille/Gabra breed, and the Turkana breed, the former being the largest and the latter the smallest. The majority of camels are kept by local tribesmen primarily for milk and draft purposes, and only a few hundred are used commercially on beef ranches, mainly for bush control, milk for the herdsmen and for transport on tourist safaris.

The Rendille people, among whom this study was carried out, are closely attached to their camels both economically and socially. Depending on the season and location, 48-72% of the Rendille diet is comprised of camels milk alone (Schwartz, 1979), and on occasion the diet of herdsmen may consist solely of camels' blood and milk. Camels play an important role in social and ceremonial occasions, being used to cement friendships and bonds, and they are the major component in the dowry given to a girl's father before marriage (Spencer, 1973). There are many taboos and rituals associated with the traditional management of camels.

2. LITERATURE REVIEW

There are a large number of publications on the *Camelidae* family in general, referring to anatomy, physiology, behaviour, productivity, management and disease; but few give comparisons between the topics such as disease and its effect on production. This review will concentrate on productivity figures as well as a few references about disease that include its effect on productivity. A comprehensive review of camel disease literature is given by Rutagwenda elsewhere in this report.

2.1 CAMEL MILK PRODUCTION

2.1.1 General

There have been few in depth studies of camel milk production. Most references only estimate yields, and many studies have been carried out under artificial situations where camels are kept on good rations or on irrigated pasture and not on arid rangelands.

Camels are important as milk producers in arid areas (Knoess, 1977; Hartley, 1979). In northern Kenya camels produce four times the amount of milk than the local breed of cattle under the same conditions (Spencer, 1973; Dahl and Hjort, 1976). In Ethiopia the camel could be the best of the local domesticated species for milk production per unit body weight when kept on rainfed agricultural products. It produces 54% more milk than the local cattle and lactates for a longer period (Knoess, 1976 and 1979).

In the Horn of Africa the camel is mainly kept for its milk producing capabilities since many nomads depend on camels' milk for the major part of their diet (Torry, 1973; Schwartz *et al.*, 1982), and on occasion some of the herdsmen subsist on a diet of camel milk alone.

Total milk yields are influenced by food quantity and quality, watering frequency, climate, breed, age and frequency or interval between milking (Mukasa-Mugerwa, 1979; Knoess, 1977; Dahl and Hjort, 1976 ; Shalash, 1979; Williamson and Payne, 1978, Yagil *et al.*, 1979). Climate influences production by affecting water availability, condition of forage and rate of dehydration. Yasin and Wahid (1957) found that wet season daily yields of camels in Pakistan were twice dry season daily milk yields.

Dromedaries yield more milk than Turkomen cross-bred hybrids and Bactrian camels (Lakoza, 1962; Blagovescenskii, 1963; Kheraskov, 1965; Leupold, 1968); differences are also found between races of camel in the same country.

Experiments show that an increase in milking frequency increases daily yields by a factor of between 10 and 30% (Yasin and Wahid, 1957; Evans and Powys, 1979; Shalash, 1979). Present-day milking regimes vary from milking as often as six or seven times per day to leaving the camels for a few days without milking (Richard, 1979a). In Kenya the majority of camel owners milk their stock twice a day, but many milk four times a day depending on the season and

stage of lactation (Bremaud, 1969; Spencer, 1973); only the Turkana consistently milk their camels four times a day (Bremaud, 1969).

Calf survival also affects total yields. Camels whose calves have died produce less milk and lactate for a shorter period (Field, 1979a; Dahl and Hjort, 1976,; Simpkin, 1981).

2.1.2 Total yields

Table 1 gives a summary of milk production for all types of camel in various parts of the world. Total yields vary considerably, ranging from 720 litres (Belokobylenko *et al.*, 1974) to 12,775 litres (Knoess, 1979). Iwena (1960), quoted in Shalash (1979), gives a general average of 3,000 litres for camels under good conditions, and 1,700 litres for camels under desert conditions. Average total yields calculated from the literature are:

Bactrian camels	- 1,444 ± 848 litres (n=9)
Turkomen hybrids	- 2,745 ± 1,714 litres (n=4)
Dromedaries	- 2,803 ± 1,976 litres (n=46)

According to Lakoza (1962) total yields are comparable to those of yaks, *Poephagus grunniens*, and buffaloes, *Bubalus bubalis*.

The average total yield for camels in Kenya, calculated from four references, is 1,613 ± 410 litres, considerably lower than estimates for dromedaries in other parts of the world.

2.1.3 Daily yields

Daily milk yields range from less than 0.1 litres per day (Nicolaison, 1963 in Mukasa-Mugerwa, 1979) to 35 litres (Knoess, 1979), depending on the stage of lactation. Daily yields peak between 10 and 20 weeks after parturition (Field, 1979a), thereafter tailing off to give low yields at the end of lactation. Mean daily yields for all dromedaries in the literature are 6.45 ± 4.98 litres per day (n=55), but all references to daily yields of Kenyan dromedaries are lower, giving an average of 3.43 ± 0.9 litres per day (n=7). In northern and eastern Africa Dahl and Hjort (1976) estimate the average daily yield to be between 3.5 and 4 litres per day.

2.1.4 Duration of lactation

Duration of lactation also varied considerably, being affected by a number

Table 1. Summary of World Camel Milk Production

(Assume 1 kg = 1 litre)

COUNTRY	CONDITIONS /LOCATION	DAILY YIELD MEAN	DAILY YIELD MAX.	TOTAL YIELD	LACTATION LENGTH	YIELD PER 365 days	SOURCE
		(kgd^{-1})		(kg)	(months)	(kg)	
BACTRIAN CAMELS							
Union of Soviet Socialist Republics		(2.4)		(1,315)	18	(880)	[1]Lakoza and Shokin, 1964
Union of Soviet Socialist Republics		(1.3-2.2)		720-1,223	18	(475-815)	Belokolylenko, *et al.*,1974
Union of Soviet Socialist Republics		(2.9)		1,500	16-18	(1,074)	Terentjev., 1956
Union of Soviet Socialist Republics	Dairy ranch	4-7		1,385-3,600	-	(1,460-2,555)	Kheraskov., 1965
CHINA		5	15-20	1,254	14-16	(1,825)	Dong Wei, 1981
Pakistan		-		800-1,200	16-18		[4]Leupold, 1968
BACTRIAN x DROMEDARY HYBRIDS							
Union of Soviet Socialist Republic	Kazak	(4.3)		-	-	(1,562)	[1]Lakoza and Shokin, 1964
Union of Soviet Socialist Republic	Turkmen	-		981	-	-	[1]Lakoza and Shokin, 1964
Union of Soviet Socialist Republic	Turkmen	(9.1)		5,000	18	(3,330)	Lakoza, 1962
Union of Soviet Socialist Republic	Turkmen	4.2-5.9		2,000-3,000	16-17	(1,533-2,154)	Kuliev, 1959
DROMEDARIES							
Union of Soviet Socialist Republic		-		-	-	(2,397)	[1]Lakoza and Shokin, 1964
Union of Soviet Socialist Republic		8.1	19	4,388	-	(2,957)	[1]Lakoza and Shokin, 1964
Union of Soviet Socialist Republic		2-6.9			7-18	(1,500-2,000)	Kheraskov., 1953, 1955
China		7.5		3,300	16-17	(2,737)	[1]Ensminger, 1973
Pakistan	Good	15-35		5,475-12,775	12	5,475-12,775	[1]Knoess, 1979
Pakistan	Desert	8-10		2,920-3,650	12	2,920-3,650	[1]Knoess, 1979

Table 1 (contd)

COUNTRY	CONDITIONS /LOCATION	DAILY YIELD MEAN	DAILY YIELD MAX.	TOTAL YIELD (kg)	LACTATION LENGTH (months)	YIELD PER 365 days (kg)	SOURCE
		(kgd^{-1})					
Pakistan	?	8	13.5	1,350-3,660	-	(2,920)	Yasin *et al.*, 1957
Pakistan	Good	9-13.6	20.5	2,727-3,636	16-18	(4,125)	[1]Yasin *et al.*,1957
Pakistan	Poor	3.6		1,364	9	(1,314)	[1]Yasin in Williamson and Payne (1979)
Pakistan	Good	(3.1-5.5)		1,700-3,000	18	(1,132-1,998)	[2]I.T.V.M., 1973
Pakistan	Desert	(6.2)		1,700	9		[2]I.T.V.M., 1973
India	Good	6.9	18.2	3,105-8,190	15	(2,519)	[1]Rao, 1974
India	Desert	6.8	9.1	2,430-4,914	18	(2,482)	[1]Rao, 1974
India		10.8			-	(3,942)	[2]Public and Info. Directorate
India		1.8-4.5			7-18	(657-1,643)	Sharma and Bhargava, 1963
India		-			7-18		Hira, 1947 in Shallash,1979
Israel	[+]Water	6.0		(1,643-3,285)	9-18	(2,190)	Yagil *et al.*, 1980b
Israel	-Water	6.2		(1,697-3,395)	9-18	(2,263)	Yagil *et al.*, 1980b
Algeria		4	10			(1,460)	[1]Gast *et al.*, 1969
Libya		8.3-10		2,700-4,000	9-16	(3,030-3,650)	[1]CEF Li, 1977
Tunisia		4		(1,460)	12	(1,460)	[1]Burgmeister, 1974
Egypt		3.5-4.5		1,600-2,000		(1,278-1,643)	[1]El Bahay, 1962
Egypt		2.5				(913)	Ashoub, 1936
N. Africa	Tuareg	∠0.1-10					[3]Nicolaisen, 1963
N. Africa	Bedouin	1-7*					[3]Musil, 1928
Sahara		2.8-5.1		1,022-1,865		1,022-1,865	Capot Rey, 1962
Sahara	Good animal	9		2,500	9-18		Lees, 1927

Table 1 (contd)

COUNTRY	CONDITIONS /LOCATION	DAILY YIELD MEAN (kgd^{-1})	DAILY YIELD MAX. (kgd^{-1})	TOTAL YIELD (kg)	LACTATION LENGTH (months)	YIELD PER 365 days (kg)	SOURCE
Sub-Sahara					9-18 av.=12		Morton, 1982
Horn of Africa			9	1,800	12	1,800	Hartley, 1979
East Africa	Good	5				(1,825)	Morgan, 1972
		3.5-4		945-2,160	9-18	(1,278-1,460)	Dahl and Hjort, 1976
Ethiopia		5-13	40	1,872-2,592	12-18		Knoess, 1977
Ethiopia	Adal.	6.9		2,442	12	2,442	Knoess, 1976
Ethiopia	Eritrea	5-6		1,825-2,910	12	1,825-2,190	Mason and Maule, 1960
Ethiopia	Borana Arwaja		10				Richard, 1979
Somalia		6		1,950	13	(2,190)	Rosetti and Congiu, 1955
Somalia		5		1,950	8-18	(1,825)	Mares, 1954
Sudan		5-10		2,000-2,600	10-12	(2,738)	El Amin, 1979
Kenya	North	4	12		12	1,460	Hartley, 1979
Kenya	North	2.2		1,897	11-16	1,730	[1]Field, 1979a
Kenya	Marsabit	2.7-4		1,019-1,875	13	(988-1,460)	[1]Field, 1979b
Kenya	Marsabit/Gabra		10		10-24		Bremaud, 1968
Kenya	Mandera/Somali		9		10-24		Bremaud, 1968
Kenya	Wajir/Somali		9		10-24		Bremaud, 1968
Kenya	Rendille Tupcha	2.6			20	(949)	Sato, 1976
Kenya	Gabra		11				Torry, 1973
Kenya	Rendille	4.5		1,660	12	1,660	Spencer, 1973
Kenya	Boran	4	12		18	(1,460)	Dahl and Hjort, 1976

[1]In Yagil, 1982; [2]Knoess, 1979; [3]Field, 1979; [4]Dahl and Hjort, 1976.

of parameters including the condition of the animal. Lactation usually ends 4-8 weeks after a camel becomes pregnant (Field, 1979a), and in areas where camels calve twice in three years, lactations of only 7 months are the norm (Kheraskov, 1965). In areas where there is only one rainy season, the lactation finishes at the end of the dry season.

Bactrian and hybrid camels generally lactate longer than dromedaries (Dong Wei, 1981 in Yagil, 1982; Blagovescenskii, 1963). Dahl and Hjort (1976) give an average of 12 months for dromedaries, but from all references the calculated mean is 13.6 $\pm$ 4.11 months (n=48). Mean durations for Bactrain and hybrid camels are 16.75 and 17 months respectively.

2.2 MILK QUALITY AND COMPOSITION

2.2.1 General

Camels' milk varies in colour from being very white (Wilson, unpub.). to opaque (Leupold, 1968), and is similar to other milk in composition (Morton, 1982; Davis and McDonald, 1953 in Yagil, 1982). Composition remains constant during the first six months of lactation (Sestuzleva, 1958 in Yagil, 1982) but is affected by the age of the camel, stage of lactation yield, food and water quality and quantity, disease status, milking interval, and can also vary from individual to individual (Castle and Watkins, 1979).

The taste can be sweet or salty depending on the forage eaten (Rao, 1974 in Yagil, 1982), it is thinner than other milk (Dahl and Hjort, 1976) and has a pH of 6.56 (Shalash, 1979). In Egypt camel milk is said to have a slimming effect and be easier to digest (Shalash, 1979), but Dahl and Hjort (1976) state that, on the contrary, it is more difficult to digest.

Table 2 and 3 provide a summary of camel milk composition and a comparison with the milk of other livestock species. Although Knoess (1977) claims the milk is rich in fat, it is generally lower than the butterfat content of cows' milk (Shalash, 1979; Pratt and Gwynne, 1977). In Saudi Arabia only camels' milk with a fat content higher than 4% can be sold (Saudi Arabia Standards Institute, 1978). In cattle the butterfat content of milk increases as the cow becomes more dehydrated, but the opposite occurs in camels - the fat content, ash, proteins, lactose, magnesium and calcium levels all decrease, only the salt concentration and water content increases (Yagil and Etzion, 1980).

Table 2. The composition of camel milk

	Water content %	Total solids %	Fat %	Ash %	Protein %	Lactose %	Source
Bactrian camels							
Union of Soviet Socialist Republics			5-6				Lakoza, 1962
Union of Soviet Socialist Republics			4.5-6.5				Kheraskov, 1965
Union of Soviet Socialist Republics			3.9-5.85				Terentjev, 1956
Union of Soviet Socialist Republics			5				Terentjev, 1966
Union of Soviet Socialist Republics			5.17		4.35		Belokobylenko *et al.*, 1974
Union of Soviet Socialist Republics	85.02		5.39	0.7	3.8	5.2	Kheraskov, 1961
Pakistan			5				Leupold, 1968
General average			5.8-6.6				Williamson and Payne, 1979
Turkmen hybrid			4.5				Lakoza, 1962
DROMEDARY							
	87.6		2.9				Leupold, 1968
	86.3		5.4	0.7	3	3.3	[1]Barthe, 1905
			2.9	0.6	3.7	5.8	[1]Leese, 1927
			3.4-4.4				[3]Musefield, 1970
	87.2		4.2	0.8	3.7	4.1	[3]I.T.V.M., 1973
	87	13	3.3	0.7	3.9	5.1	[3]Dahl and Hjort, 1976
	87.2	14.3	4.2	0.8	3.5	4.5	[2]Knoess, 1977
			2.9	0.6	3.7	5.8	[3]Leitch, 1940
	87.6	13	2.9	0.77	3.9	5.4	[1]Harbars Singh, 1962
	88.5		4.1	0.7	2	4.7	[1]Harbars Singh, 1962
	85.6	14.4	5.5	0.9	4.5	3.4	Knoess, 1976
		12.4	4				Purchase, 1943
			4				Rosetti *et al.*, 1955

Table 2 (contd)

		Water content %	Total solids %	Fat %	Ash %	Protein %	Lactose %	Source
DROMEDARY				4.95	0.77	3.35	5.5	Dzumagulov, 1976
		86-90		4-5.5	0.8-1.0	3.6-4.7	-	El Amin, 1979
			12.39-13.45	3.8		2-5.5	3.9	Shalash, 1979
				3.8		3.5	3.9	Nawito *et al.*, 1967
				3				Pratt and Gwynne, 1977
				4				Schmidt-Nielson, 1964
		86.5		2.9	0.66	3.9	5.4	[1]Davies, 1940
				3.2		4.2	5.3	Pyke, 1970
				3.0	0.8	3.9	5.5	[1]Davis, 1963
				2.11-2.73				Field, 1979
				3.02	0.7	3.5	5.2	[1]Lampert, 1947
		86.39		4.47	0.7	3.5	5	[1]Kheraskov, 1953
				4.3	0.9		2.8	[1]Grigoryants, 1950
				3.78	0.95	4	4.9	[1]Ohri and Joshi, 1961
				3.08	0.7	3.8	5.4	[1]Khan and Appova, 1964
		87.9		3.8	0.8	3.5	3.8	[1]El Bahay, 1979
		85.7		4.3	0.6	4.6	4.6	[1]Yagil and Etzion, 1980
		91.2		1.1	0.35	2.5	2.9	[1]Yagil and Etzion, 1980
	Average	87.4	13.17	3.97	0.75	3.52	4.68	Knoess, 1979
	Average	86.6	13.4	4.33	0.8	4.02	4.21	Ortiz and Mugerwa, 1979
DROMEDARY								
	Average	87.4	13.2	3.67	0.74	3.67	4.62	
	SD	± 1.56	± 0.82	±0.93	±0.14	±0.75	±0.93	
	n	15	7	34	22	25	23	

1 in Yagil, 1982

2 in Knoess, 1977

3 in Wilson, unpub.

Table 3. General milk composition

Species	Water content %	Fat %	Ash %	Protein %	Lactose %	Source
Cow	-	4.01	0.72	3.3	4.94	Albritton, 1954
Cow	-	4.4	-	3.8	4.9	Mukasa-Mugerwa, 1979
Cow	-	3.5	0.7	3.5	4.8	Leitch, 1940
Barka cow	86.1	5	0.6	3.8	4.5	Knoess, 1977
Cow	86.2	4.4	0.7	3.8	4.9	Ensminger, 1971
Friesian	87.85	3.5	-	3.25	4.6	Knoess, 1979
Adal goat	88.2	2.9	0.6	3.3	2.8	Knoess, 1977
Goat	87.1	4.1	0.8	3.7	4.2	Ensminger, 1971
British goat	-	4.5	0.79	2.9	4.1	Knoess, 1979
Adal sheep	86.4	4.1	0.6	4.4	3.7	Knoess, 1977
Sheep	82.0	6.4	0.9	5.6	4.7	Ensminger, 1971
Buffalo	83.23	7.45	-	3.78	4.9	Knoess, 1979
Horse	-	1.1	0.3	1.9	6.6	Leitch, 1940
Man	-	3.5	0.2	1.5	6.8	Leitch, 1940
Average dromedary	87.4	3.67	0.74	3.67	4.62	Various

The fat in camels' milk consists of volatile, polyunsaturated acids that are closely bound to the proteins. It is difficult to extract (Gast *et al.*, 1969 in Yagil, 1982).

The protein and amino-acid content of camel's milk is equivalent to that of cow's milk (Knoess, 1977) ranging from 2 to 5.5% (Shalash, 1979). The concentration of amino-acids decreases as lactation continues (Wilson, unpub.). The mineral content is higher than cow's milk (El Amin, 1979; Shalash, 1979), being high in iron, copper, manganese and chlorine (Morton, 1982), but low in calcium and phosphorous (Wilson, unpub.).

Camels colostrum can contain 30% total solids (Yagil, 1982), but the milk is usually lower in total solids than cow, sheep and buffalo milk (Shalash, 1979). Total non-fat solids average 8.89 ± 2.46% from 20 references.

Density or specific gravity of camels milk varies with the water content averaging 1.029 ± 0.04 from seven references (Yagil, 1982).

The major difference between camel milk and other milks is that it has a very high vitamin C content. It has three times the amount of vitamin C in cows' milk, and one and a half times the vitamin C content of human milk (Kheraskov, 1961 in Yagil, 1982). Values for vitamin C content range from 2.3 mg/100 g (Knoess, 1976) to 9.8mg/100 g (Kheraskov, 1961); the concentration increases as the lactation continues. Leupold (1968) gives an average concentration of 5.6 mg/100g. Camels' milk is the main source of vitamin C for people in various parts of the world, and is believed to be both prophylactic and curative of scurvy (Leitch, 1940).

2.2.2 Nutritive value

Camel milk with its high vitamin C and water content is very good for human nutrition, especially in arid areas (Gast *et al.*, 1969 in Yagil, 1982). The energy content of milk is given as 670 Kcal/kg by Dahl and Hjort (1976) and 700 Kcal/kg in Kon (1972 in Yagil, 1982) and Morton (1982) The protein content is 3.7g/100g (Kon, 1972). Nutritional requirements for one adult in the tropics are 65 g protein and 2,600 Kcal energy per day (Dahl and Hjort, 1976). To fulfil these requirements he needs 1.8 litres of milk for protein and 4 litres for energy. Table 4 shows estimates of the number of camels

required to cover nutritional requirements of camel pastoralists; figures vary considerably due to size of family and yields or amount of milk available to the people. Gast *et al.* (1969, in Yagil, 1982) give 4-5 kg of milk as sufficient to fulfil a man's requirements for calories, lipids, protein and calcium.

Table 4. Number of camels needed to supply nutritional requirements of camel pastoralists

Country/location /tribe	No. of animals required	Source
East Africa	28	Dahl and Hjort, 1976
Not stated	10-25	[1]Johnson, 1969
Bedouin family	18-20 females	[1]Sweet, 1965
Kababish family	20-25	[1]Asad, 1970
Somali family	10-20	[1]Hunt, 1951
Rendille family	20	Spencer, 1973
Not stated	8	Wilson (unpub.)
Rendille family	11 females	Field, 1979
Somali family	> 28	SOMAC/SAREC, 1982
Ethiopia	25-30	Richard, 1979

[1] Quoted by Dahl and Hjort 1976

2.2.3 Milk by-products

Camels' milk is mostly drunk fresh or slightly soured because extraction of the fat is difficult due to its low content, even distribution throughout the milk, small particle size and the strong bonds between fat molecules and protein (Yagil, 1982; Wilson, unpub.).

Butter made from camel milk is very fine and much of it is lost in the buttermilk. The butter is rich in polyunsaturated fatty acids and is used in cooking or cosmetics (Purchase, 1943; Yagil, 1982). The milk gives a 1.9 - 2.2% yield of ghee, which is white and waxy and slightly flavoured.

Camel milk cheese is difficult to make, needing 50-70 times the amount of rennet needed to clot cows' milk (Purchase, 1943), but it can be made if mixed with 25-30% cows' milk and 6-7 times the amount of rennet needed for bovine milk (Yagil, 1982; Schulthess, pers. comm.). The cheese is very light and friable and the whey still contains 1.6% butter fat (Schulthess, pers. comm.). Alternatively cheese can be made by pressing the curds of naturally soured milk.

Yoghurt is made by boiling the milk and adding a fermented starter after cooking. A product called *Khoa* can be made by evaporating a small volume of milk over a hot flame. After cooking a sweet semi-solid dough is produced which can be kept upto 200 days (Yasin and Wahid, 1959 in Yagil, 1982).

2.3 CAMEL GROWTH AND MEAT PRODUCTION

2.3.1 General

Camels are a good source of protein and meat in arid areas that do not suit other species of livestock (Knoess, 1977). Although camel meat is not universally eaten the demand is increasing (Yagil, 1982; Morton, 1982). In Somalia, where, according to Leitch (1940), camels are mainly kept for their milk production, exports have risen from 174 camels in 1950, to 34,223 in 1975 (Swift, 1979 in Wilson). Large numbers of camels, mainly adult castrates and cull females, are trekked from Kenya (Hartley, 1979), Sudan (El Amin, 1979) and Ethiopia to Libya, Egypt and Saudi Arabia for slaughtering.

North Africa and Saudi Arabia are the main consumers of camel meat. In Egypt the number of camels is declining (Alim, 1976) but the amount of meat eaten is increasing (Shalash, 1979). In many countries the meat is highly prized and the fat eaten as a delicacy (Rosetti and Congiu, 1955), but consumption is low as camels are only slaughtered by pastoralists during long dry seasons, at certain ceremonies or when a camel dies of natural causes (Richard, 1979a; Dahl and Hjort, 1976). Some camels are managed purely for slaughter and are castrated early to increase growth (Williamson and Payne, 1978). In some societies, such as the Gabra and Rendille of northern Kenya, it is regarded as sacrilegious to sell camels to outsiders (Torry, 1973; Sato, 1976), thus limiting the marketability of camels in these areas.

There is a large resource to meet the increase in consumption. Theoretically 1.5 - 7.5% of a population could be slaughtered or exported per annum without

causing a long-term decline in the world camel population (Wilson, unpub.). In north Africa camel numbers are declining due to very high offtake. For example, in 1974 Egypt slaughtered 58.7% of its national camel herd, and in a span of four months in 1977, 20% of the Nigerian camel population was slaughtered (Wilson, unpub.). In Somalia there is a 6.5% annual offtake (Swift, 1979 in Yagil, 1982) but in most countries the actual offtake is between 1 and 5%. More camels are being sold and slaughtered due to an increase in sedentarization and the reduced need for transport animals (Gohl, 1979 in Yagil, 1982).

Bremaud (1969) gives 3% as the possible annual offtake in Kenya, and Mukasa-Mugerwa (1979) estimates that 100,000 tonnes of camel meat could be harvested annually from the herds in Africa. If male camels were slaughtered at less than one year old the annual offtake could be as high as 10% (Dahl and Hjort, 1976), but there might be competition in areas where camels are still important for transport.

It is generally agreed that an organized marketing system needs to be established before the full potential is reached (Morton, 1982).

2.3.2 Growth rate

Camels have a slow growth rate (Leitch, 1940) influenced by climate, forage, amount of milk available, sex and breed of the animal (Schwartz *et al.*, 1982; Field, 1979; Yagil, 1982; Blagovescenskii, 1963; Knoess, 1977). Average birth weights are 25.8kg in Tunisia (Burgmeister, 1975), 30.9kg in Kenya (Field, 1979a), 37.2kg in India (Bhargava *et al.*, 1965), and 35-40kg in Russia (Aueljbekov in Dahl and Hjort, 1976). In most cases birth weights of male calves are higher than those of females (Bhargava *et al.*, 1965, Panasenko *et al.*, 1971), but this difference is not significant statistically.

Weaning occurs between 3 and 18 months, usually at 12 months (Mukasa-Mugerwa, 1979), and does not check growth if the forage is good and the calves have been deprived of milk (Williamson and Payne, 1978; Blagovescenskii 1963), but in calves that have free access to milk weaning can check growth rates temporarily (Field, 1979a). In Sudan, where camels are used primarily for meat, the calves are weaned between 150 and 180kg body weight, at about 18 months of age (El Amin, 1979).

2.3.3 Body weights

Mature body weights are reached at 6-9 years (Schwartz *et al.*,1982; El Amin, 1979), some taking between 12 and 18 years (Field, 1979) depending on sex and breed. Schwartz *et al.*, (1982) believe that mature body weight is not affected by better pasture or management, although absence of these may cause delay, but it is determined by genetic potential. After the first six months males grow faster than females. Camels older than 20 years can be 150-200 kg lighter than their maximum weights (Field, 1979a).

Bactrian and hybrid camels are heavier than dromedaries. In Kenya, camels are generally smaller than other areas although some Somali breed camels reach 700kg liveweight (Richard, 1979; Schwartz *et al.*, 1982). Most range from 400 to 550kg (Field, 1979). Averages for these camels are given as 400kg (Pratt and Gwynne, 1977), 447kg (Bremaud, 1979), and 454-590kg (Williamson and Payne, 1978).

2.3.4 Age at slaughter

Most camels in Africa are slaughtered late in life (Morton, 1982; El Amin, 1979), the average age being 14.5 years in Kenya (Bremaud, 1969). But Watson (1972) reports most of the Somali race of camels slaughtered in Kenya were fairly young and many were females, possibly because most of the males were being exported to the Far East leaving few for local sale. In Ethiopia males are slaughtered at 8-10 years (Richard, 1979b), which is corroborated by Mukasa-Mugerwa (1979), although he states that pastoralists prefer meat of animals 2-6 months old. The Chinese only slaughter cull animals (Dong Wei, 1979) whereas in Russia they are killed between 18 and 30 months, weighing about 300kg, to give the best meat (Lakoza, 1962; Aueljbekov in Mukasa-Mugerwa, 1979).

2.3.5 Dressing percentage

Dressing percentages range from 35% for culled animals in China (Dong Wei, 1979) to 70% in Egypt (Shalash, 1979); the average from 11 references is 52%. Differences are due to:

1. Better fed animals have a higher dressing percentage than undernourished animals (Cerenpuncag, 1969; Kuznetsov *et al.*, 1970).

2. Males have a higher dressing percentage than females (Mukasa-Mugerwa, 1979).
3. Younger animals have a higher dressing percentage than older animals. Highest dressing percentages occur at 30 months (Kulaeva, 1964).

The dressing percentage and meat: bone ratio is higher in camels than pastoral cattle (Mukasa-Mugerwa, 1979; Kuznetsov *et al.*, 1970).

Carcass weights range from 207kg to 650kg for Bactrian camels (Cerenpuncag, 1969). In Africa most carcass weights are between 250 and 300kg (Congiu, 1953; Bremaud, 1969).

2.3.6 Meat quality

The quality of meat depends on the cut and age, meat of a young camel being similar to beef but slightly sweeter and coarser (Leupold, 1968; Knoess, 1977). Older camels tend to be tougher and less tasty (El Amin, 1979; Mukasa-Mugerwa, 1979), but they have a higher protein, crude fat and ash value than camels less than five years old (Shalash, 1979). Although there is no difference between sexes, sterile females are supposed to give the best meat (Hartley, 1979).

Camels' meat has a high water content (Leupold, 1968). The protein and fat content is equivalent to that of lean beef (approximately 22% and 1% respectively; Knoess, 1976), but it has less ash. Protein levels of 73-76% have been recorded (Kulaeva, 1964). Digestibility of the fat is the same as that of beef but less than mutton (Afifi, 1972).

The meat can be eaten fresh, dried or boiled in spices and preserved in fat (Leupold, 1968; Bremaud, 1969). It is best used in sausage production when its toughness and cooking time are reduced (Shalash, 1979; Terentjev, 1956).

Fat is an important by-product. Although eaten as a delicacy in some countries it is a useful replacement for traditional cooking fat. Alternatively it can be stored for three years as suet (Wilson, unpub.). In Russia the fat is used in soap production (Terentjev, 1956). The camel is a better fat producer than other species; the hump can yield up to 150kg of fat (Lakoza, 1962), but yields of 5-18kg are more usual (Cerenpuncag, 1969; Congiu, 1953). Fat can make up 8-20% of the dressing percentage (Terentjev, 1956).

Camel meat is also important in the nomad's nutrition. Eighty per cent of the meat eaten by the Gabra is from the camel. One large castrate may last an entire camp for 2-3 days, and produce enough fat for one family for a whole year (Torry, 1973). It is also the main source of protein for the low income groups in Egypt (Shalash, 1979).

A carcass of 210kg yields 160 kg meat, 10kg fat and 40kg bone (Wilson, unpub.); the equivalent of 35.2kg protein and 238,204 Kcal of energy. If the annual offtake of a herd is 6% then the average meat production of a camel will provide 35 days protein and five days energy requirements of an adult. Wilson concludes that the milk and meat of one camel will provide 52 days energy and 154 days protein; thus one adult requires 7 camels for his energy supply, and only 2.4 camels for his protein supply per annum.

2.4 BLOOD

The consumption of blood, although forbidden by the Islamic faith, is an important part of the diet for many camel pastoralists. Dahl and Hjort (1976) give a value of 80g protein per litre of blood, and it is high in vitamin D and is good for bone formation (Shany *et al.*, 1979 in Yagil, 1982). Figures given for the volume of blood taken are few and far between. The Turkana tribe bleed upto 5.5 litres of blood twice a month (Pratt and Gwynne, 1977). Morgan (1972) and Hillaby (1964) give a figure of 5 and 4.5 litres once a month, respectively. Schwartz (1979) writes that the Rendille bleed immature camels of 2-4 years old, and the yield from one camel can be as high as 35 litres per annum. Wilson (unpub.) believes that not more than 10% of the herd can be bled regularly giving an annual herd yield of 6-12 litres. The blood from one animal provides 1-1.5 days energy requirement and 16-18 days protein requirement (Pratt and Gwynne, 1977).

2.5 REPRODUCTIVE POTENTIAL

2.5.1 Age at maturation

There is little genetic difference in reproductive potential between old world camel species (Schwartz, *et al.*, 1982).

Most female camels mature between 3 and 5 years (Yasin and Wahid, 1957; Matharu, 1966; El Amin, 1979; Dong Wei, 1979), although some females can

reach puberty at 8-12 months (Wilson, unpub.). First calving occurs at 4-6 years (Sato, 1976; Leupold 1968; Leitch, 1940; Hartley, 1979; Schwartz, *et al.*, 1982) but some herdsmen delay mating until the female is fully grown. Females continue breeding until the middle twenties (Sato, 1976; Leitch, 1940; Leupold, 1968; Matharu, 1966) and sometimes upto 30 years old (Yasin and Wahid, 1957). Males mature at 5-6 years and are used for breeding between 6 and 15 years old (Leupold, 1968; Dong Wei, 1979; Yasin and Wahid, 1957; Yagil, 1982).

2.5.2 Breeding cycle

The camel is an 'induced ovulator', requiring coitus to induce release of the ova, and can be considered to be a seasonal breeder even though the female has an all-year-round oestrus cycle (Must, 1969 in Yagil, 1982). The female oestrus cycle follows a 'follicular wave' pattern lasting 24-28 days, and the female is receptive to the male (in heat) for a period between 4-7 days depending on the season (El Amin, 1979; Musa 1979). Oestrus can occur one day after calving (Barmicev, 1939 in Yagil, 1982), but usually occurs one month post-partum if conditions are good (Leitch, 1940; Mares, 1954). Females stop lactating 3-4 months after conception (Schwartz, *et al.*, 1982), but in good conditions they can lactate right up to the next parturition (Leitch, 1940).

The stimulus that makes the male come into rut is not exactly known, but it is related to rain and cold, daylight hours and nutritional state of the forage (Yagil and Etzion, 1980 in Yagil, 1982). In drought years bulls may not come into rut (Torry, 1973).

Gestation lasts just over one year with birth occurring 360-390 days after mating (Leupold, 1968; Knoess, 1976; Matharu, 1966; Hartley, 1979; Evans and Powys, 1979). Parturition occurs in the cooler, wet season (Field *et al.*, 1983; Knoess, 1976; Sato, 1976).

2.5.3 Calving interval

Mating usually occurs one year after parturition, which, when combined with a one-year gestation, gives an average calving interval of two years (El Amin, 1979; Leitch, 1940; Gauthier-Pilters and Dagg, 1981; Dahl and Hjort, 1976). In areas of good forage and with healthy, well managed herds calving

intervals can be reduced to 15-18 months (Knoess, 1976; Terentjev, 1956; Leese 1927 in Yagil, 1982; Leupold, 1969; Kheraskov, 1965; Matharu, 1966). Wilson (unpub.) believes that shorter calving intervals should not be aimed at every year and should only occur once or twice in a camel's lifetime, since it puts the camel under great stress. In poor conditions the calving interval can be as long as 40 months (Torry, 1973), and 30 months is common for traditional pastoral herds (Wilson, *et al.*,1980).

2.5.4 Calving rate

Annual calving rate is between 35 and 40% under normal conditions (Bremaud, 1969; Williamson and Payne, 1978; Richard, 1979b; El Amin, 1979). If all females are fertile the maximum is 50%, but improved management, which reduces calving interval and prenatal mortality, gives calving percentages above 50% (Schwartz, *et al.*, 1982, Dahl and Hjort, 1976), to a maximum theoretical rate of 80% (Mukasa-Mugerwa, 1979). In Russia calving percentages have been increased to 100% per annum by injecting pregnant mare serum gonadotrophin (Yuzlikaev and Akhmediev, 1957 in Yagil, 1982).

2.5.5 Fertility

Reasons for low fertility, according to Mukasa-Mugerwa (1979) and Gauthier-Pilters and Dagg (1981), are:

1. Late age of first calving - possibly due to the slow growth rate caused by poor nutrition.
2. Seasonal breeding limits breeding opportunities.
3. Long gestation, long post-partum anoestrus produce a long calving interval.
4. Limited rutting potential; one stud bull to service many females may lead to a drop in libido, as well as possible problems with penetration.
5. High number of barren females due to internal abnormalities.
6. Failure of follicles to develop and poor conception rates.
7. Embryonic mortality and abortion.
8. A combination of the above factors due to poor nutrition, primitive management methods and little disease control.

Though camels mature later, and have a longer calving interval than cattle, they can produce 7-10 calves in a lifetime, which is equal to the number of

calves produced by local cattle (Yasin and Wahid, 1957; Spencer, 1973). This is due to the longer breeding life of camels.

2.6 HERD COMPOSITION AND GROWTH

Camel herds have a slow intrinsic (natural) growth rate due to late age of maturation, long gestation and low calving rate. The extrinsic (managed) growth rate is controlled by Man and depends on his nutritional and social requirements from the herd. The ratio of stud bulls to adult females is low, and one stud may be expected to cover 40-80 females per season (Knoess, 1977; El Amine, 1979; Bremaud, 1969; Matharu 1966). In Rendille herds the ratio is in the order of 1:5 to 1:19 (Field, 1979; Sato, 1976).

The number of adult females in a herd depends on whether the camels are kept for milking or transport purposes; a theoretical model herd should contain 34% adult females (Dahl and Hjort, 1976). Traditional African herds have a higher proportion of adult females, ranging from 46 to 82% (Richard, 1979b; Swift, 1979; Hartley, 1979; Burgmeister, 1975). In Kenyan herds, the mean is 51.8% adult females.

The Kenya national herd between 1920 and 1964 increased annually by a factor ranging from 2.8 to 18.6%; these figures are very high and are probably due to immigration rather than natural recruitment (Bremaud, 1969). Other sources quote annual increases of 0.3% to 2% in various parts of the world (Bremaud, 1969; Swift, 1979). Sato (1976) gives a growth rate of 3.2% for Rendille herds which reach 1.55 times their original size after a generation time of 13.87 years. Dahl (1979) gives 17 years as the time taken to double the herd size, but only under optimal conditions.

2.7 MORTALITY

Prenatal deaths or abortion rates are given as 9.7% in India (Bhargava *et al.*, 1963), 13.5% in Kenya (Schwartz *et al.*, 1982), 18-19% in Somalia and Tunisia (Wilson unpub.), and figures as high as 50.6% have been reported (Bremaul, 1969). Abortions are generally due to nutritional stress (Leitch, 1940) or diseases such as brucellosis or trypanosomiasis, which if treated or controlled can reduce the number of abortions and premature births (Evans and Powys, 1979).

Calf mortality in camels less than one year old is high, ranging from 6.2 to 70% (Wilson *et al.*, 1980; Williamson and Payne, 1978) in Africa, with a

mean of 35% from 14 sources. Mortality is higher than that for cattle and is caused by poor nutrition (competition with Man for mother's milk), disease and predation (Bremaud, 1969; Sato, 1976).

Field (1979b) found that causes of death in calves less than two years old were: drought 35%, ticks 22%, camel pox 19%. In drought periods calf mortalities of 58-90% can occur (Watson, 1972; Schwartz *et al.*, 1982). The critical period is 2-6 months old when the calves start to browse; calves born in wet seasons have the best chances of survival.

After the first year, mortality rates decrease to 2.3-8% for adolescents (Sato, 1976; Richard, 1979), but can be as high as 3% due to castration mortality alone (Schwartz, 1979). Adult mortality is estimated at 2% per age group (Sato, 1976; Richard, 1979), but in drought years can reach 20-50% (Schwartz, 1979; Gauthier-Pilters and Dagg, 1981).

Field (1979b), from a collection of known-age skulls, estimates only 50% of the population to be alive at 13 years, 25% at 17 years, and life expectancy at 19 years. Other sources give 20-30 years as the average lifespan of camels reaching maturity (Sato, 1976; Torry, 1973), although some have lived to 40 years (Yasin and Wahid, 1957).

2.8 CAMELS AS DRAUGHT ANIMALS

Camels have lost much of their importance as draught animals and only operate in areas unsuitable for vehicles, e.g. deep sand and rocky terrain, or in small-scale agriculture and among nomadic pastoralists. The advent of the motor car and increased sedentarization are the main causes of a reduction in camel numbers in north Africa. The advantage of camels is that they are easy to train and control, and have relatively low maintenance costs (Knoess, 1977).

Castrated males are usually used as they are easier to control than bulls. Rendille and Gabra pastoralists rely heavily on their camels for carrying water to the settlements and for moving their tents and possessions when the homestead moves (Torry, 1973; Spencer, 1973; Schwartz, 1979). Camels have also been used by the Government for Police and Game Department patrols in the arid areas.

2.9 HIDES, HAIR AND WOOL

Hides, or skins, of camels although large are of poor quality and little commercial value (Yagil, 1982; Leitch, 1940; El Amin, 1979). The skins are used locally to make tents, sleeping mats, sandals, ropes, whips, containers and saddles (Leitch, 1940; Yagil, 1982).

Hair and wool production is only significant in areas where there is considerable seasonal variation in temperature. The hair and wool are used for making clothes, blankets, tents, saddlebags and ropes (Leitch, 1940; El Amin, 1979).

2.10 DISEASE

Many of the publications refer to disease in general as being a major factor in camel productivity (Schwartz *et al.*, 1982; Richard, 1979). A review of camel disease literature is amply made by Rutagwenda (1982) and would be too extensive to include here. The references below are those that directly relate to various aspects of productivity.

2.10.1 Trypanosomiasis

Trypanosomiasis is the most common cause of death in camels (Leupold, 1968), causing morbidity among 30% of all camels, and a mortality of 3% (Gattrutter, 1967). Treatment with antricide sulphate improves production by reducing the number of abortions and premature births (Evans and Powys, 1979).

2.10.2 Internal parasites

Dada (1978) reports that 57.2% of the camels slaughtered in Nigeria in 1952 were positive for hydatid cysts (*Echinococcus polymorphous*), most of which were in the lungs, liver and spleen, rendering much of the meat inedible and leading to a subsequent economic loss. Hydatid infects 64% of camels in Iran (Wilson, unpub.) and Man becomes infected by eating the camel's meat.

Treatment with thiabendazole quickly improves the state of health of camels and increases the weight gains by between 6.8 and 11% over those in the control herd (Graber, 1966).

2.10.3 External parasites

Ticks can cause upto 22% mortality in calves less than two years old (Field, 1979b), mainly due to toxins produced by *Rhipicephalus pulchellus* (Torry, 1976) and *Hyalomma truncatum* (Wilson *et al.*,1980); some ticks also carry a virus which causes posterior paralysis and death (SOMAC/SAREC, 1982).

Mange is sometimes given as the second most important cause of loss after trypanosomiasis (Wilson, unpub.).

A summary of camel diseases in order of economic importance is given by Richard (1979b):

1 Trypanosomiasis
2 Internal parasites
3 Mange
4 Pyogenic disease
5 Nutritional deficiency
6 Pulmonary disease
7 Myiasis
8 Camel pox
9 Anthrax

Wilson *et al.*, (1980) agree with the above except for the cases of some herds in Kenya where nutritional deficiency in calves is the major cause of death, camel pox was more important than pyogenic disease, and anthrax was of little importance.

3 MATERIALS AND METHODS

3.1 THE STUDY AREA

Most of the camel research presented here was based at Ngurunit Field Station in the southern part of Marsabit District. However, at times the herds travelled over large distances to different parts of the study area. Detailed descriptions of location, topography, climate and vegetation can be found in other IPAL Technical Reports (e.g. B-1, B-3, and D-1).

3.2 HERD MANAGEMENT

In this experiment two herds were studied; one herd was contracted from two local Rendille pastoralists and was given scientific veterinary treatment. The other herd was bought by UNESCO in February 1981 from various Rendille and Turkana tribesmen and acted as a control, being managed in a traditional Rendille manner. Each herd contained 60 animals at the start of the production experiment in March 1981.

Both herds were under the direct control of one of the Rendille elders and were grazed in the same area during the day time but were kept in different thorn enclosures at night. Reasoning that the general daily management of the two herds was essentially the same, and that both herds were utilizing the same pasture, one can assume that the food intake and the nutritional value of the forage was similar for both herds, and that any differences in production are due to the veterinary input alone.

The routine veterinary input is covered by Rutagwenda's disease study (in this technical report). Traditional Rendille management strategies and treatments are given in Appendix 1.

In November 1982 management of the control herd was altered slightly by changing the herdsmen and increasing the mobility of the herd, in effect creating a *fora* or 'satellite' camp situation as opposed to a more sedentary *manyatta* or homestead style of herding.

3.3 DATA COLLECTION

3.3.1 Disease and health status

Production

1. Milk production was measured weekly by recording the volume of milk produced both morning and evening for one day per week. Time milked, number of teats milked, and the time the calf last suckled or the camel was last milked were also recorded. Taking the above factors into account the total daily yield (including the volume drunk by the calf) was calculated.

2. Milk quality was recorded by measuring the butterfat content and specific gravity of the milk using the Gerber method of analysis.

3. Growth rate was recorded monthly by measuring:
   a. the shoulder height from the ground to the top of the scapula;
   b. the thoracic circumference from just behind the pedestal;
   c. the abdominal circumference around the top of the hump and belly.

   Actual liveweight can be found by extrapolation from a regression curve of the total of the body measurements against body mass (Field, 1979a). The regression equation is given in Appendix 2. All measurements were taken early in the morning before the animals grazed, and a few days before watering.

   Using a sling and scale calf birth weights were recorded within 24 hours of parturition.

4. Matings, abortions, failed conceptions, birth dates and mortality were also recorded. Causes of death were diagnosed by post-mortem. Reproductive potential, including calving interval and calving percentage, mortality and herd dynamics were determined from these data.

5. When camels were bled, the age, sex and condition of the camel, and volume of blood taken were all recorded.

6. Individuals were divided into sex and age groups, age being estimated by eruption of the incisor teeth and tooth wear, and comparision with known-age camels (see Appendix 3).

7. A survey was carried out on the productivity of traditional herds using a questionnaire and interviewing camel owners.

8. Brief visits were made to Ol Maisor and Galana ranches whose owners kindly provided data on the productivity of their camels for comparison.

4 RESULTS AND DISCUSSION

The data from the experiments were analysed using a Student's t test to determine the reliability of the results and their significance.

4.1 MILK PRODUCTION

Information on milk production from the experimental herds and other sources is presented in Tables 5 - 8. Table 5 gives a summary of camel productivity in various parts of the world and between different breeds, and upholds the theory that dromedaries are better milk producers than Bactrian camels. It also shows that total yields in Kenyan herds are much lower than the average for dromedaries in the rest of the world.

Low yields in Kenyan camels are due to a combination of factors, including:

1. Camels are only kept in the marginal rangelands in Kenya; in other countries they often inhabit high-potential areas.
2. They do not receive any food supplement as often occurs in other countries.
3. There is little known about the major diseases among camels in Kenya and they were traditionally kept for subsistence rather than profit.
4. Until recently the management of camels in Kenya has been primitive

Table 6 also shows the overall results of veterinary input on milk production. Veterinary treatment increases mean daily yields by 463 ml ($P<0.05$), an increase of 19.5% , and also lengthens the duration of lactation by over three months ($P<0.005$). The higher daily yield combined with longer duration produces a 66.8% increase in total yield ($P<0.005$), but these overall results do not take into consideration the effects of calf mortality and calving interval which also affect yields (Field, 1979; Kheraskov, 1955).

A comparison between individuals that all have calves that survived the full lactation and a normal two-year calving interval (Table 7) did not yield statistically different results. In fact yields in the non-treatment herd are higher than those in the treatment herd, suggesting that the treatment is not beneficial.

Table 5. Camel milk production averages for regions and breeds (from Table 1)

Region/Breed	Mean daily yield (litres)	Mean total yield (litres)	Mean lactational length (months)	Mean yield per 365 days (litres)
Bactrian	3.54 ± 1.95	1,444 ± 848	16.75 ± 1.49	1,298 ± 709
n	7	9	8	7
Hybrid	5.88 ± 2.29	2,745 ± 1,714	17 ± 1	2,145 ± 840
n	4	4	3	4
Dromedaries	8.6 ± 7.10	3,905 ± 2,766	13.8 ± 4.46	3,113 ± 2,613
Eurasia n	20	18	17	19
North Africa and Middle East	5.25 ± 3.03	2,264 ± 912	13.1 ± 4.3	1,889 ± 845
n	16	12	9	11
Sub-Sahara	6.2 ± 2.71	2,087 ± 511	12.8 ± 3.3	1,957 ± 420
n	12	12	13	10
Kenya	3.43 ± 0.9	1,613 ± 410	15.1 ± 4.73	1,387 ± 305
n	7	4	9	7
This study				
Treatment herd	2.84 ± 0.72	1,146 ± 360	13.1 ± 2.17	1,049 ± 330
n	26	26	26	26
Non-treatment Herd	2.37 ± 1.05	687 ± 448	9.4 ± 4.64	874 ± 570
n	16	16	16	16
Ranch herds	4.08 ± 1.77	1,489 ± 645	12	1,489± 645
All dromedaries from literature	6.449 ± 4.978	2,803 ± 1,976	13.6 ± 4.11	2,323 ± 1,808
n	55	46	48	47
All dromedaries including this study	6.28 ± 4.91	2,699 ± 1,959	13.5 ± 4.08	2,252 ± 1,777
n	58	49	52	50

n = Number of records or animals in the sample

± = Standard deviation

Table 6. The effect of calf mortality on camel milk production

	Mean daily yield (litres)					
	Treatment herd			Non-treatment herd		
	n.	$\bar{x}$	s.d.	n.	$\bar{x}$	s.d.
Calves survived	25	2.86	0.727	3	3.493	1.189
Calves dead	1	2.234	0.859	13	2.116	0.87
All camels	26	2.837	0.722	16	2.374	1.05

	Mean total yield (litres)					
	Treatment herd			Non-treatment herd		
	n.	$\bar{x}$	s.d.	n.	$\bar{x}$	s.d.
Calves survived	25	1,175	337.05	3	1,462	118.92
Calves dead	1	438	-	13	508	251.38
All camels	26	1,146	360.47	16	687	447.86

	Mean duration of lactation (weeks)					
	Treatment herd			Non-treatment herd		
	n.	$\bar{x}$	s.d.	n.	$\bar{x}$	s.d.
Calves survived	25	58	7.55	3	63.3	15.57
Calves dead	1	28	-	13	35.7	17.69
All camels	26	56.85	9.45	16	40.88	20.17

Table 7. Full lactations for camels with surviving calves and a calving interval of 24 months

Treatment herd					Non-treatment herd				
Camel No.	n	dy	sd	ty	No.	n	dy	sd	ty
4	54	3.844	± 1.492	1,453	633	47	4.788	± 3.64	1,575
32	65	3.256	± 1.867	1,482	650	78	2.451	± 1.861	1,338
65	70	2.749	± 2.882	1,347	680	65	3.24	± 2.149	1,474
502	74	2.792	± 1.489	1,446					
505	58	2.931	± 1.919	1,190					
507	60	3.665	± 2.073	1,539					
508	69	2.789	± 1.617	1,347					
532	67	2.575	± 2.566	1,208					
Average	64.63	3.075		1,377	Average	63.33	3.493		1,462
± sd	6.76	0.465		127.13		15.57	1.189		118.92

n = number of records
dy = Daily yield in litres
ty = Total yield in litres
sd = Standard deviation

An explanation for this could be the small sample size: only three non-treatment herd camels fulfil the above conditions and possibly the only reason their calves survived is because the individual mothers were exceptionally high milk producers or were not suffering from any serious disease.

The effect of calf mortality on milk production is shown in Table 6 and Figures 1 and 2, where the differences in yields between the non-treatment and treatment herd animals are significantly different. Camels whose calves survive past weaning have a daily yield 65% higher than those whose

Figure 1. Lactational curve of non-treatment herd camels with surviving calves

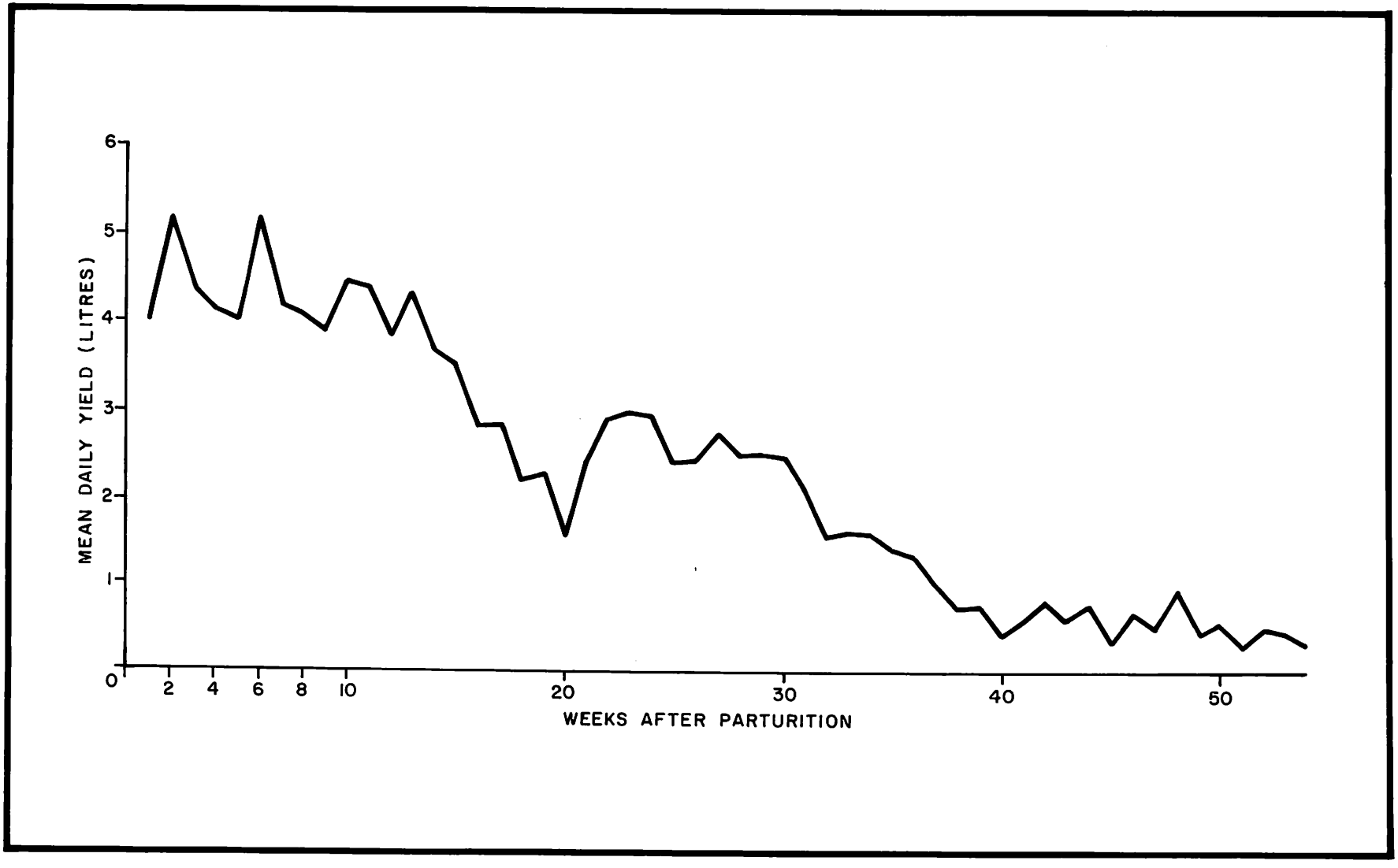
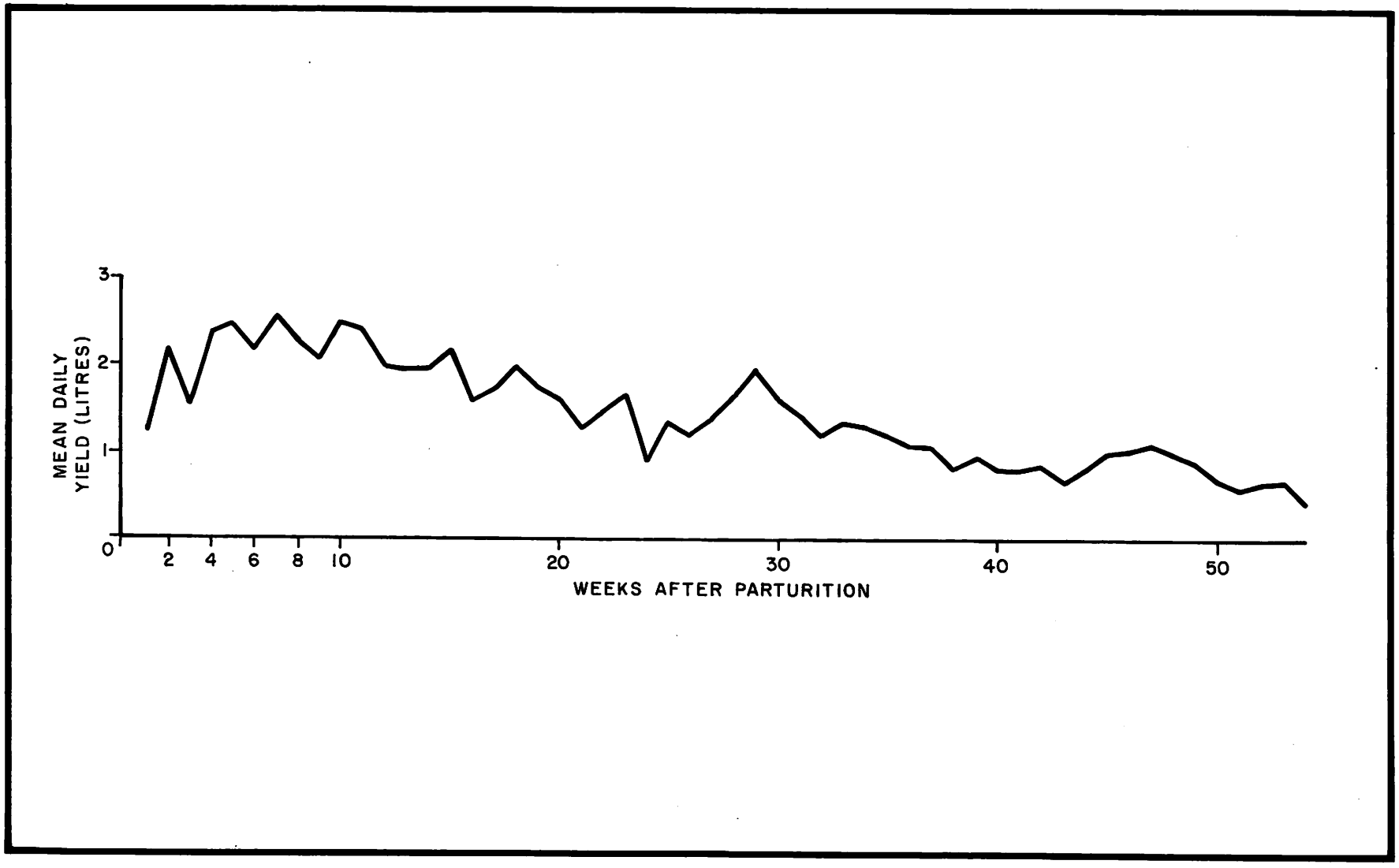


Figure 2. Lactational curve for non-treatment herd camels with dead calves



calves die, and total lactational yield is 2.9 times as high. In this experiment it was calculated that the Rendille camel owners took 52% of the milk before weaning leaving 48% for the calf. Since keeping the calf alive increases the yield by more than 52% it is not worthwhile killing the calf, as some societies (not the Rendille) practise, to enable the people to get more milk. Another advantage of keeping the calf alive is that camels with live calves lactate for an average of six months longer, which is important for people who depend on milk as their staple food for most of the year.

A reduction in calving interval to less than 24 months does not significantly reduce daily yields, but it does reduce the mean duration of lactation and total yield by significant amounts ($P<0.005$ and $P<0.05$, respectively; Table 8). This corresponds to reports that lactation ends shortly after mating (Field, 1979), and Figure 3 shows daily yields slowly decline after mating.

Lactational curves (Figures 3 and 4) show peaks in lactation occur during the first six weeks and smaller peaks occur between 20 and 30 weeks which corresponds to the second rainy season and subsequent abundance of forage.

The highest average daily yields for these experimental camels are much lower than those quoted in the literature. However, some individuals did produce up to 17.6 litres per day during the first few weeks of lactation. From 1,271 milking records in the treatment herd, 2.3% were higher than 10 litres per day, whereas only 1.8% of the records (n=569) were higher than 10 litres per day in the non-treatment herd.

Dehydration also effects daily milk yield (Figure 5). The experimental herds were watered once very 12 days, and daily milk yields are significantly higher ($P<0.025$) on the day after watering than the day before watering. It would seem that camels take at least one day to fully assimilate the water into the body as more milk is produced on the day after watering than on the dame day as watering. Yagil (1982) believes watering frequency does not affect milk yields, but our results tend to disprove this theory, and as dehydrated camels stop feeding and seek shade earlier to conserve water, the grazing time and dry matter intake are reduced and must also reduce milk output over a long period of time.

Figure 3. Lactational curve for all camels in the treatment herd in relation to mating time

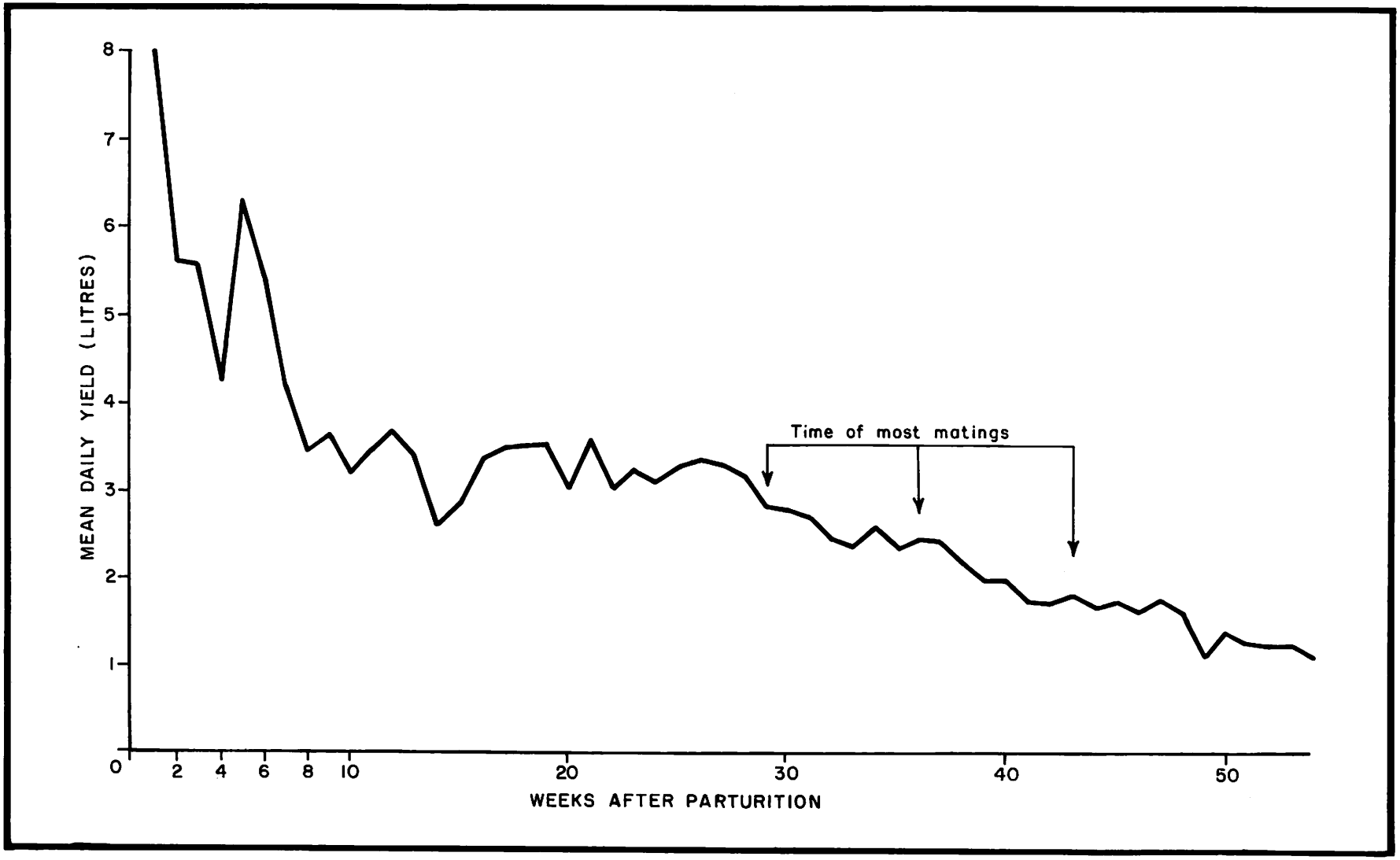


Figure 4. Lactational curve for all camels in the non-treatment herd

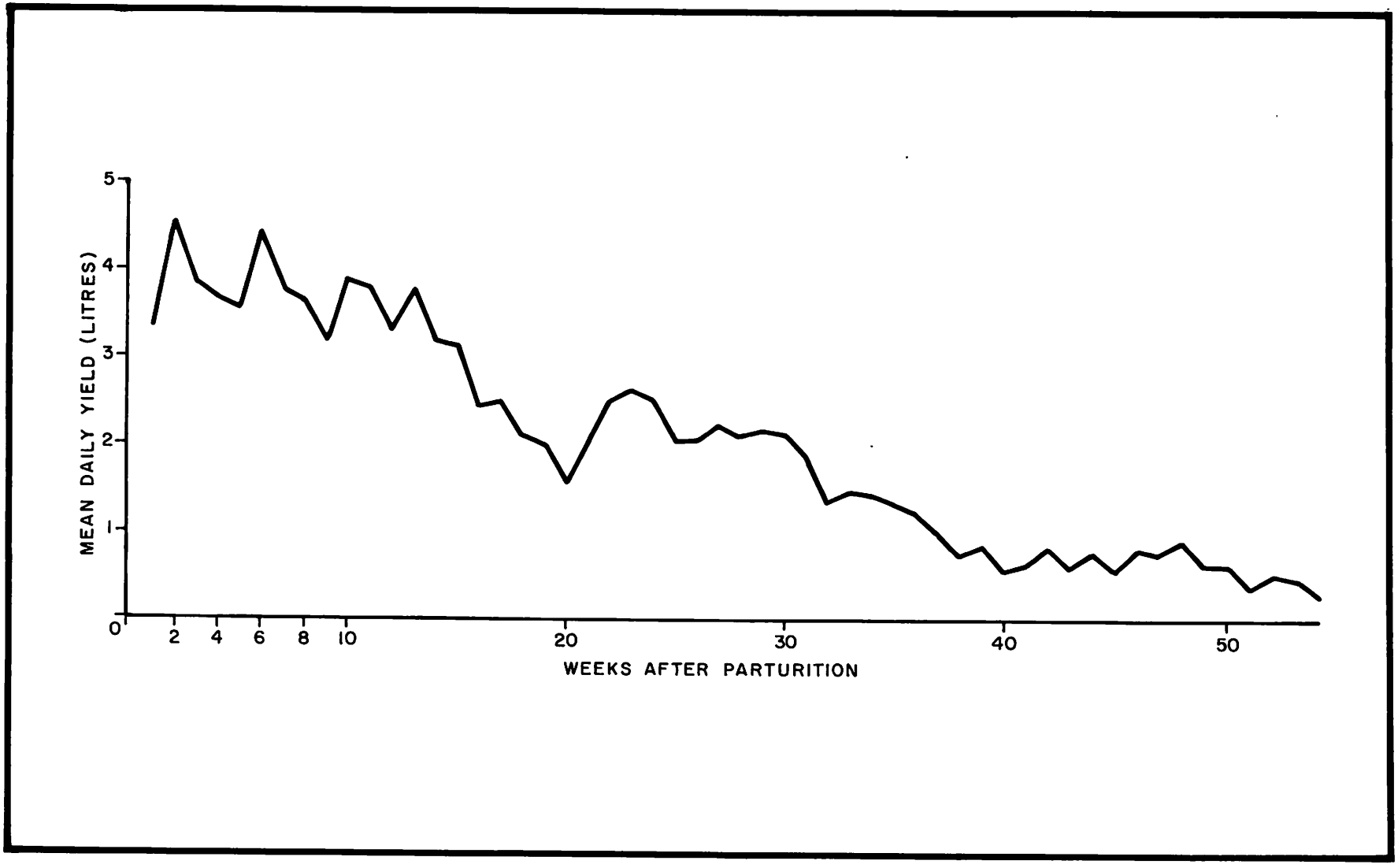


Figure 5. The effect of dehydration on daily milk yields

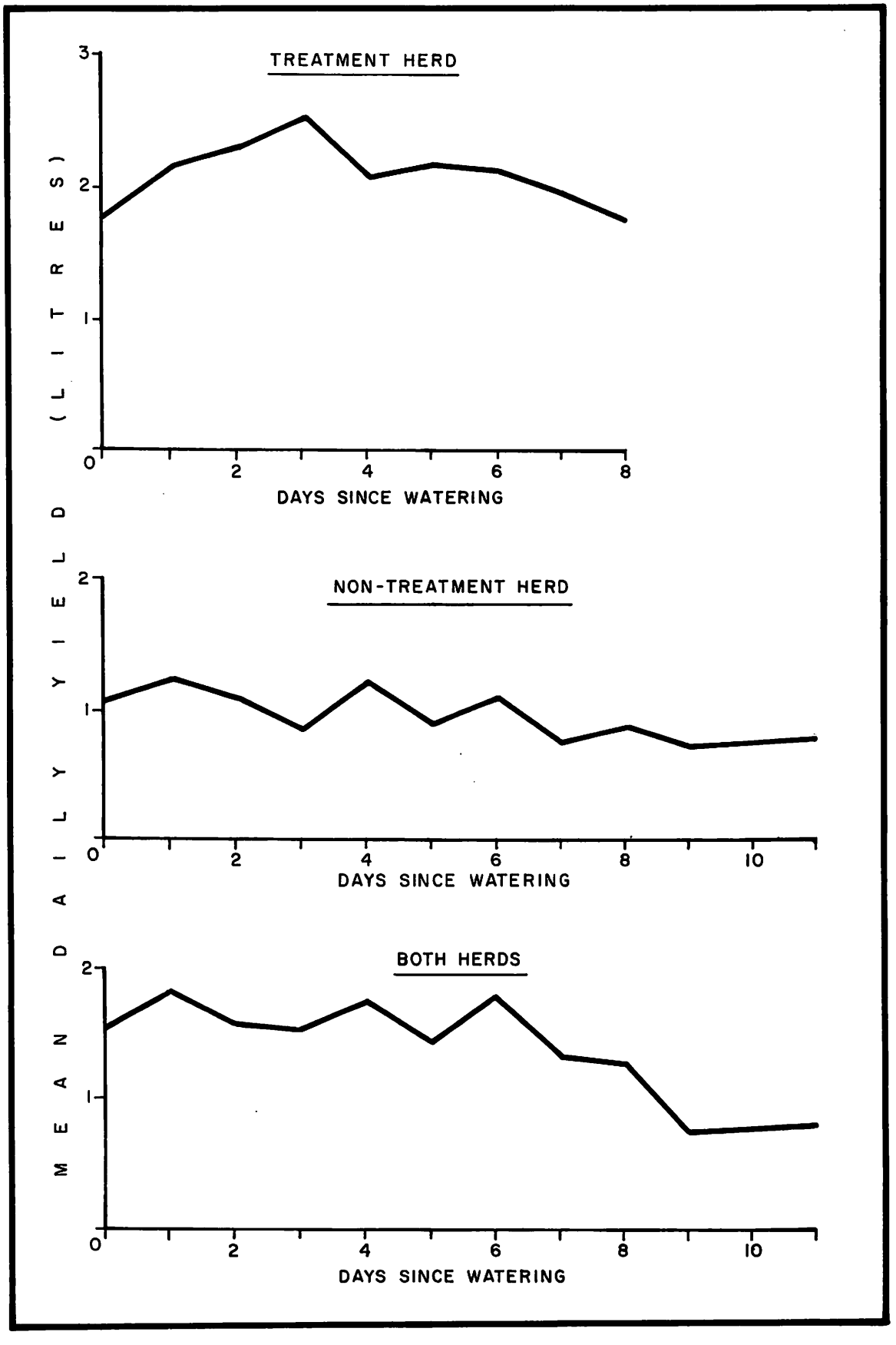


Table 8. The effect of calving interval on milk production in the treatment herd

	Calving interval ⩾ 24 months		Calving interval < 24 months
Mean daily yield (litres)	3.075	No significant	2.787
± s d	0.465	difference	0.777
n	8		13
Mean total yield (litres)	1,377	P<0.05	1,084
± s d	127.13		338.74
n	8		13
Mean duration of lactation (weeks)	64.6	P<0.005	54.7
± s d	6.76		6.16
n	8		13

Table 9 and Figure 6 compare the yields of ranch herds with experimental herds. Daily yields of Galana camels are significantly higher (P<0.005) than all of the other herds. There is no statistical difference between Ol Maisor and the treatment herds, but they are both significantly (P<0.05) higher than non-treatment herd yields. Productivities of both ranch herds should be higher because:

1. they are situated in higher rainfall areas;
2. they are watered more frequently - at 2 day intervals;
3. they receive constant veterinary input;
4. there is little or no competition for forage;
5. they are kept with a view to eventually becoming a commercial enterprise, hence a certain amount of culling and improved breeding are being introduced.

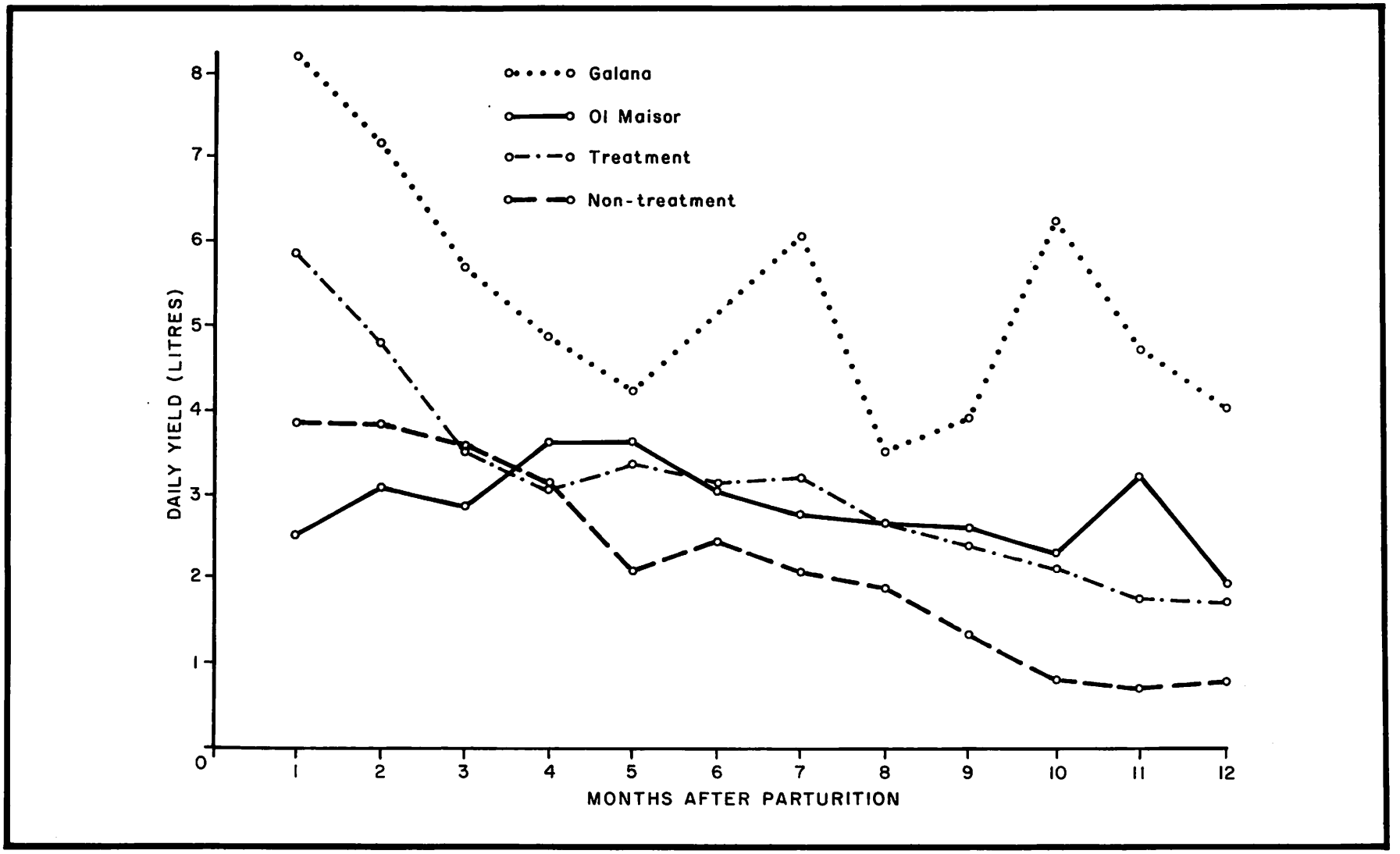
Table 9. Yields of ranch herds and experimental herds

(Litres per day)

Months after parturition	Galana	Ol Maisor	Rendille treatment	Rendille non-treament
1	8.24 ± 4.16 (3)	2.5 ± 0.86 (8)	5.86 ± 1.56	3.84 ± 0.54
2	7.2 ± 0.44 (4)	3.09 ± 0.9 (13)	4.83 ± 1.26	3.84 ± 0.39
3	5.67 ± 1.46 (13)	2.8 ± 0.61 (13)	3.49 ± 0.22	3.54 ± 0.37
4	4.87 ± 1.38 (9)	3.6 ± 0.92 (13)	3.04 ± 0.39	3.13 ± 0.57
5	4.20 ± 1.08 (5)	3.6 ± 1.26 (12)	3.35 ± 0.26	2.04 ± 0.39
6		3.0 ± 0.72 (14)	3.19 ± 0.26	2.41 ± 0.25
7	6.06 ± 1.65 (12)	2.75 ± 0.87 (17)	3.22 ± 0.83	2.09 ± 0.10
8	3.48 ± 1.21 (7)	2.63 ± 0.99 (14)	2.62 ± 0.16	1.87 ± 0.38
9	3.90 ± 1.86 (9)	2.60 ± 1.14 (12)	2.38 ± 0.12	1.35 ± 0.11
10	6.26 (1)	2.32 ± 0.94 (12)	2.10 ± 0.21	0.76 ± 0.18
11	4.73 ± 0.21 (3)	3.20 ± 0.54 (4)	1.73 ± 0.06	0.69 ± 0.10
12	4.05 ± 1.68 (4)	1.9 ± 0.42 (2)	1.68 ± 0.07	0.75 ± 0.15
12 month mean	5.33 ± 1.5 (11)	2.83 ± 0.50 (12)	3.12 ± 1.22 (12)	2.19 ± 1.18 (12)
Total production over 12 months	1,945	1,033	1,139	799

Number of sample in brackets
± Standard deviation

Figure 6. Lactational curves for four camel herds in Kenya



The difference between the Galana and Ol Maisor herds shows the greater potential of Somali breed camels over other breeds. Ol Maisor camels are mainly of Turkana origin and this may be why they do not produce more milk than the Rendille/Gabra treatment herd, even though they are kept under better conditions. Differences between the Rendille treatment and non-treatment herds have already been discussed.

Duration of lactation among ranch herds is approximately 12 months as it is controlled by the herdsmen. If the calving intervals were increased to the two-year period, and if the camels were milked or suckled for longer than 12 months, then the total yields would be higher than present levels.

Results of 52 household surveys give an estimated mean daily yield of 2.3 litres per day, exactly the same volume as the non-treatment herd. However, owners were only able to estimate the volume using cups or traditional milking bowls whose volumes were previously recorded. Owners estimated lactations of 16 months for camels with surviving calves and 14 months for camels whose calves died.

4.2 MILK QUALITY AND COMPOSITION

Table 10 and Figure 7 show butterfat contents for three of the herds; no analyses was done at Galana Ranch due to difficulties in transporting the analytical equipment. Measurements were from milk from camels of all ages and stages of lactation and at different times of the year and all camels were milked at the same frequency, i.e. twice a day. Any differences are likely to be due to varying yields, breeds, food types and health status.

Comparison of Figures 6 and 7 shows the increase in butterfat content as the mean daily yield decreases towards the end of lactation.

The butterfat content of the milk from the treatment herd is lower than that from the other herds due to the higher total milk yield, and this masks any increase in fat content that may result from disease control. Butterfat content for the Ol Maisor and non-treatment herd is very similar. One would expect Ol Maisor fat levels to be lower due to the higher yield, but this effect has been deleted by improved health and forage availability.

There is no proof that breed affects butterfat content, but the total yields in Table 10 reflect the general conditions of each herd.

Figure 7. Butterfat content of milk from three camel herds

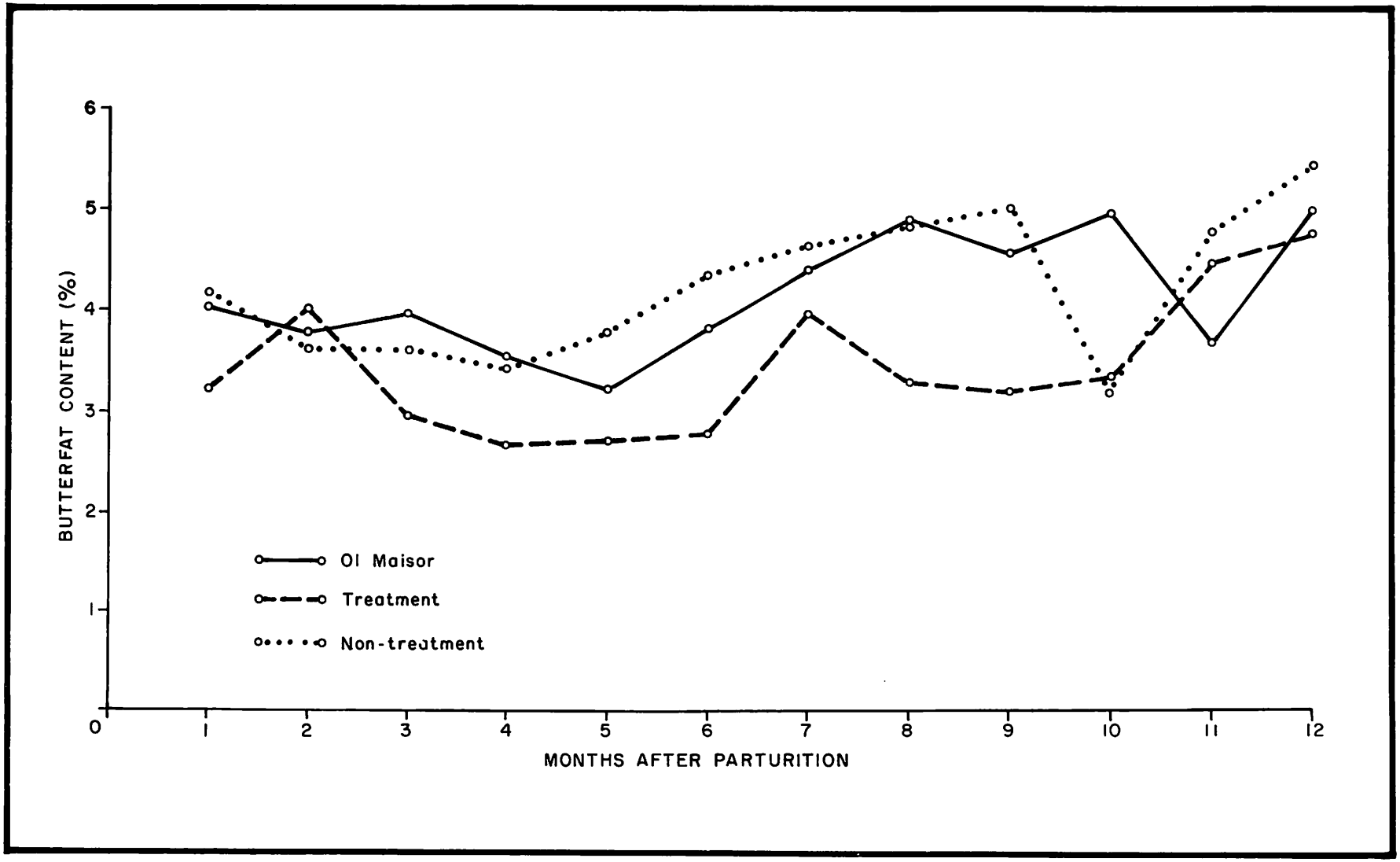


Table 10. Butterfat content of milk from three camel herds in Kenya

	Rendille non-treatment herd	Ol Maisor herd	Rendille treatment herd
Mean butterfat content %	4.06	4.05	3.47
± s d	1.22	1.37	1.28
n	77	151	145
	No significant difference		Significant difference (P<0.005)
Total 12 month milk yield (litres)	799	1,033	1,139
Total 12 month butterfat yield (litres)	327.6	423.5	398.7

A similar experiment to the camel experiment was done with cattle but treatment did not increase yields or butterfat content by significant amounts. Average butterfat contents for the treatment and non-treatment cattle herds were 5.48% and 5.93%, both of which are significantly (P<0.005) higher than those for the respective camel herds. A bulked sample of local goat milk had a butterfat content of 5.95%. These results support sources in the literature that state camel's milk is relatively low in fat.

Mean real density for Rendille camel milk is 1.0301 ± 0.0030 (n= 239), which compares to values found in the literature.

4.3 CALF GROWTH RATES AND MEAT PRODUCTION

Mean birth weights (Table 11) are significantly higher in the treatment herd (P<0.025). Male calves are only slightly heavier than females (not significant) from birth to one year old, thus calf growth rates were calculated using the average from both sexes.

Table 11. Increase in camel weightswith age (kg)

	Treatment herd			Non-treatment herd		
	Males	Females	Both	Males	Females	Both
Birth	29.4 ± 4.1	28.6 ± 6.6	29.0 ± 5.45	25.9 ± 6.3	25.7 ± 5.1	25.8 ± 5.61
	18	20	38	12	11	23
1 month	47.5 ± 8.1	47.3 ± 3.68	47.4 ± 6.08	42.2 ± 5.74	45.1 ± 4.12	43.4 ± 5.21
	17	19	36	11	8	19
2 months	60.1 ± 9.18	56.8 ± 6.63	58.3 ± 7.83	49.9 ± 7.0	49.3 ± 7.94	49.7 ± 7.1
	17	21	38	11	6	17
3 months	65.8 ± 9.89	62.6 ± 7.28	64.1 ± 8.51	54.2 ± 8.18	54.5 ± 6.02	54.3 ± 7.3
	15	16	31	11	6	17
4 months	76 ± 13.07	70 ± 9.53	73 ± 11.48	60.4 ± 8.19	58.8 ± 7.19	59.9 ± 7.6
	16	16	32	10	5	15
5 months	82.4 ± 13.43	75.9 ± 11.25	79.1 ± 12.44	64.2 ± 10.96	60.2 ± 10.16	62.9 ± 10.5
	17	17	34	10	5	15
6 months	93.1 ± 9.94	84.1 ± 9.78	88.2 ± 10.52	71.8 ± 10.93	62.2 ± 9.31	68.1 ± 11.04
	14	17	31	8	5	13
7 months	103.4 ± 12.54	93.9 ± 10.62	98.4 ± 12.3	73.1 ± 15.34	68.7 ± 11.0	71.8 ± 13.7
	14	16	30	7	3	10
8 months	110.7 ± 14.07	103.7 ± 13.2	107.1 ± 13.84	85.0 ± 14.73	72.5 ± 19.09	80.0 ± 15.7
	10	15	29	3	2	5
9 months	112.8 ± 16.73	111.9 ± 14.63	112.3 ± 15.19	81.5 ± 0.71	67.5 ± 21.92	74.5 ± 15.02
	10	14	24	2	2	4
10 months	120.5 ± 17.15	113.6 ± 17.05	116.9 ± 17.14	86.0	75.0 ± 21.21	78.7 ± 16.29
	13	14	27	1	2	3
11 months	117.2 ± 11.94	109.2 ± 20.04	114.2 ± 15.35	85.0	78.0 ± 25.45	80.3 ± 18.45
12 months	136.0 ± 22.97	129.1 ± 19.96	131.8 ± 20.96	90.0	86.0	88.0 ± 2.82
	9	14	23	1	1	2

Upper rows: Means ± standard deviations
Lower rows: Numbers of animals

Table 12 presents calf growth rates in grams per day. Calf growth rates between 0 and 6 months and 0 and 12 months are significantly ($P<0.005$) higher in the treatment herd, but there is no significant difference between 6 and 12 months. Sexual differences in growth are only significant at 0 to 6 months of age.

Table 12. Calf growth rates ($g\ d^{-1}$)

Age (months)	Treatment herd			Non-treament herd		
	Males	Females	Both	Males	Females	Both
0 - 6	351 ± 46	313 ± 46	331 ± 49	259 ± 45	197 ± 53	238 ± 56
	13	15	28	7	5	12
6 - 12	234 ± 119	261 ± 101	251 ± 107	175	82	129 ± 66
	9	14	23	1	1	2
0 - 12	305 ± 47	294 ± 35	298 ± 39	178	164	171 ± 10
	8	12	20	1	1	2

Upper rows: means ± standard deviation
Lower rows: numbers of animals

Figure 8 shows a slight levelling off in calf growth rate between 8 and 10 months when the calves are weaned, but the actual changes in rate are not statistically significant, upholding Williamson and Payne's (1978) statement that weaning does not affect growth if the calves have been deprived of milk or if the forage is good.

Differences in growth rate between the two herds at subsequent ages (Table 13) are not statistically significant except within the 1-2 year-old ($P<0.05$) and 3-4 year-old ($P<0.005$) age groups. The latter can be explained by treated female animals maturing earlier and becoming pregnant at 3-4 years of age, whereas females in traditional herds seldom become pregnant before four years old (Figure 9).

Higher growth rates in treated camels more than one year old prove that treatment increases growth independently of milk supply; treatment herd

Figure 8. Calf growth rates

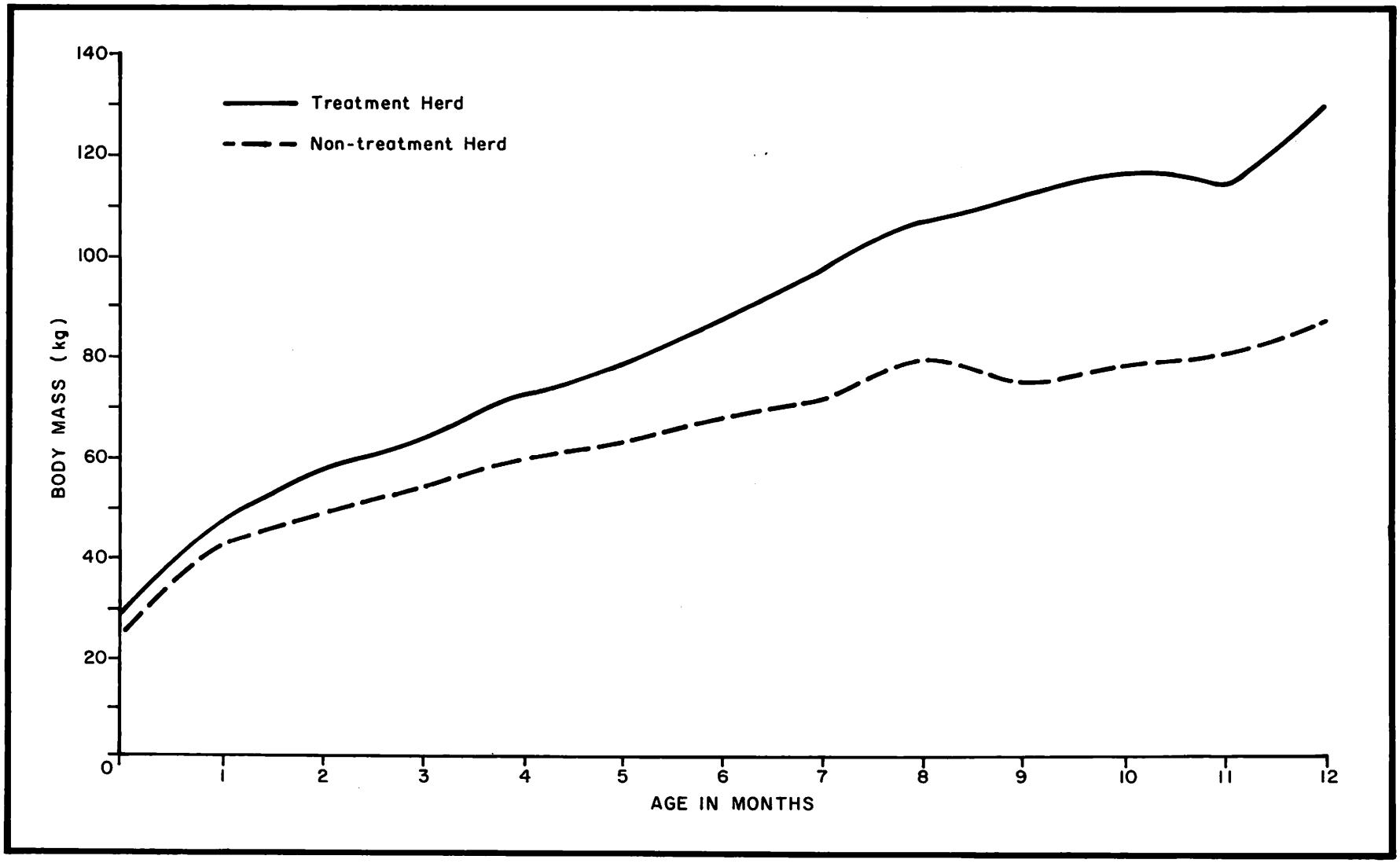


Table 13. Growth rates in the treatment and non-treatment herds ($g\ d^{-1}$)

Age (years)	Treatment herd			Non-treatment herd		
	Males	Females	Both	Males	Females	Both
0 - 1	305 ± 47 8	294 ± 35 12	298 ± 39 20	178 1	164 1	171 ± 10 2
1 - 2	161 ± 29 2	180 ± 80 2	170 ± 50 4	66 1	93 1	80 ± 19 2
2 - 3	95 ± 67 2	115 ± 22 6	110 ± 33 8	59 ± 10 2	91 ± 81 3	78 ± 60 5
3 - 4	121 ± 55 4	142 ± 52 12	137 ± 52 16	71 ± 70 10	46 ± 97 13	56 ± 85 23
4 - 5	184 ± 16 2	86 ± 117 6	111 ± 109 8	124 ± 155 12	162 ± 173 15	145 ± 163 27
5 - 6	205 1	75 ± 12 3	108 ± 66 4	219 ± 49 4	20 ± 142 7	92 ± 152 11
6 - 7	-	4 ± 161 3	4 ± 161 3	33 ± 64 3	20 ± 120 7	-4 ± 106 10
7 - 8	-	-	-	-22 ± 106 3	-73 ± 177 3	-48 ± 13 6
A.L.		92 ± 190 15	92 ± 190 15	64 ± 118 4	-51 ± 179 4	7 ± 153 8
A.M.	-19 1	30 ± 175 12	26 ± 168 13	-88 ± 190 2	-138 ± 182 3	-118 ± 163 5

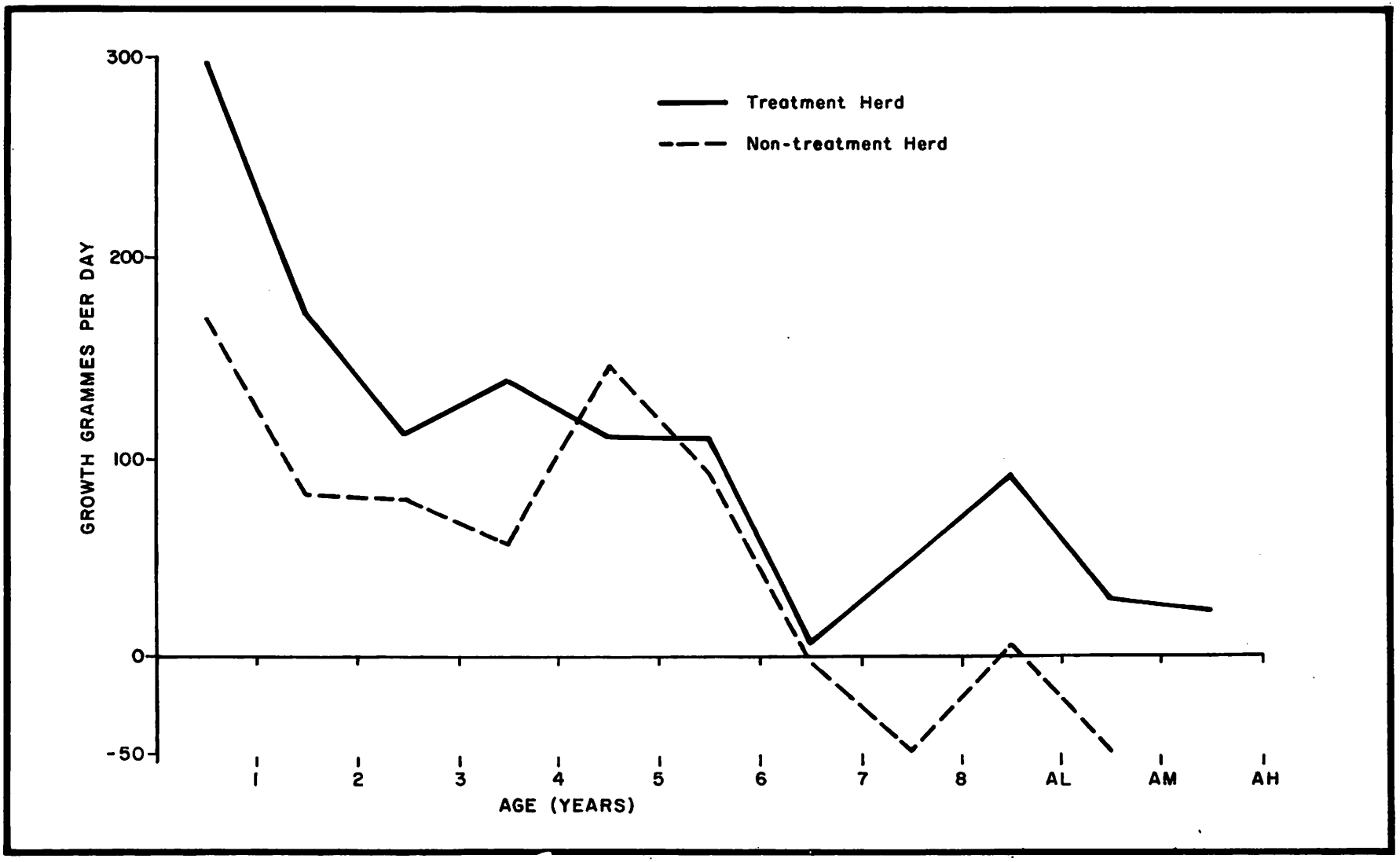
Upper rows: means ± standard deviations

Lower rows: numbers of animals

A.L. - Adult with teeth in light wear

A.M. - Adult with teeth in moderate wear

Figure 9. Growth rates of treatment and non-treatment herds



calves less than one year old had the advantages of both improved health and an increase in milk production from the dam.

Veterinary treatment has increased growth rates by 74% during the first year of life. Further improvements could be achieved by:

1. limiting milk offtake by the herdsman;
2. introducing new genetic stock;
3. general improvement of range quality.

The advantages of the above changes are shown in Table 14 from Field and Simpkin (this report). Camels in the IPAL Olturot herd were allowed to suckle all day and during the first six months have a growth rate 16-45% higher than non-treatment herd calves. Olturot camels were also weaned later than normal giving growth rates more than double that of treatment and non-treatment calves at 6-12 months of age.

Growth rates of Somali camels at Galana Ranch are consistently higher than all of the other herds. A direct comparison with Ol Maisor camels that are under similar conditions shows the advantage of the Somali breed over the Turkana breed.

Comparison between the Ol Maisor and Rendille treatment herd camels shows the advantages of modern animal husbandry and good range management. Ol Maisor camels are of Turkana stock and would be expected to have a lower growth rate than Rendille/Gabra animals, but the increased food availability and watering frequency, together with controlled milk offtake, all contribute to a higher growth rate. Differences in growth rate for indigenous camels in wet and dry seasons show the importance of forage availability.

As the non-treatment herd is of mixed Turkana and Rendille/Gabra stock the effects of veterinary treatment may have been exaggerated, but comparison between the Rendille/Gabra treatment herd and similar indigenous herds proves that veterinary treatment increases growth rate.

Figure 10 shows that veterinary treatment does not alter adult body masses by any significant amount. Males are generally heavier than females, but there is no significant difference in mean adult liveweights between the sexes. Both herds reach asymptotic weights at 5-6 years old, but reach adult mean weight at more than 9 year old.

Mean adult weight of the non-treatment herd (368 kg) is higher than that of the treatment herd (355 kg) due to the higher proportion of adult males

Table 14. Growth rates in various camel herds ($g\ d^{-1}$)

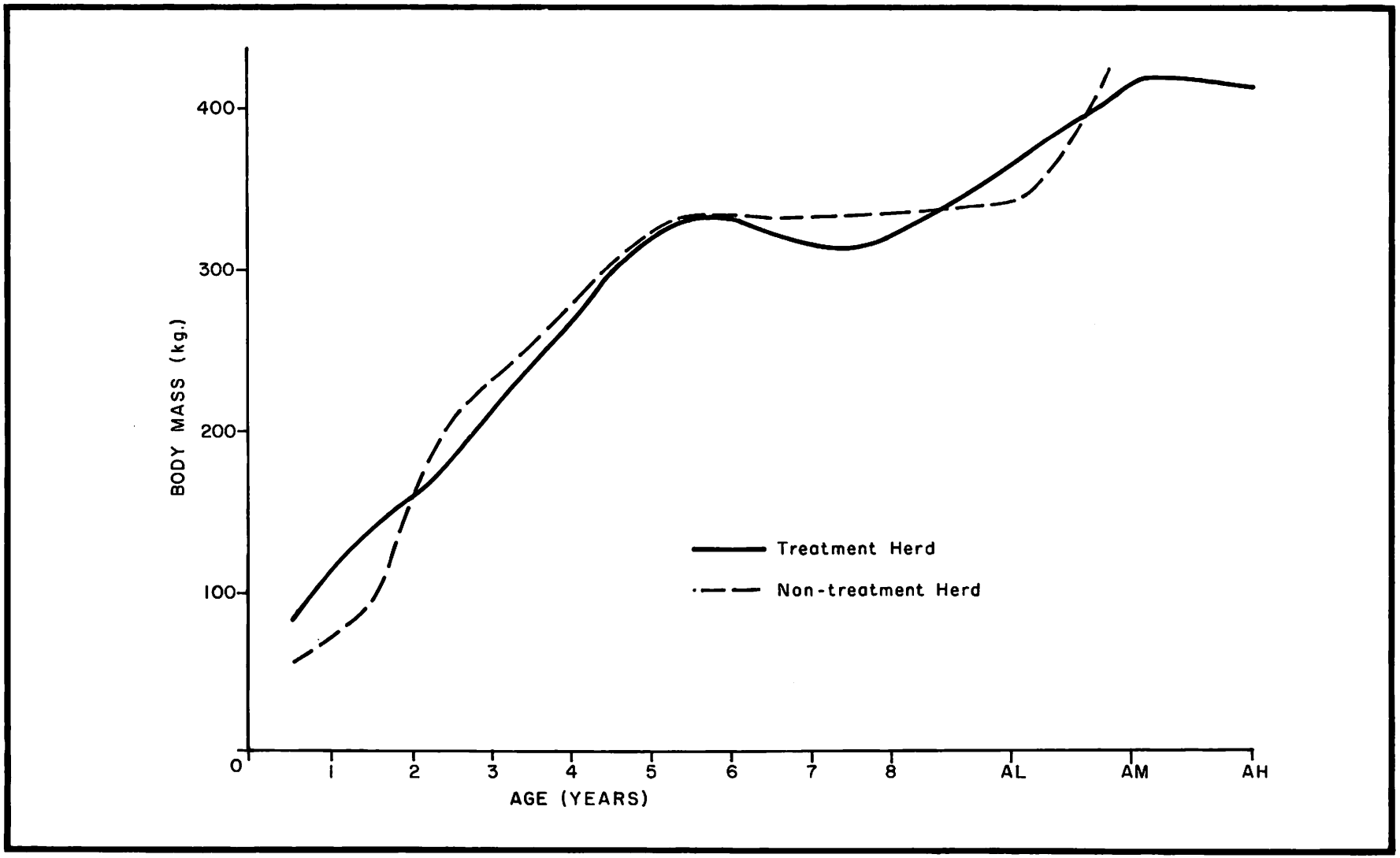
Period (months)	Non-treatment herd	Treatment herd	Ol Maisor herd	Galana herd	IPAL Olturot herd	Indigenous herds	
						Wet season	Dry season
0 - 6	233	331	583	664	505	290	188
6 - 12	129	251	167	445	525	203	
12 - 18	49	150	208	278	215	25	
18 - 24	-	219	236	278	51		
0 - 12	171	298	370	583	415	247	
0 - 48	97	177	253	262			
0 - 60	106	168	216	245			

Source: Field and Simpkin, 1984

Table 15. Mean adult liveweights (kg)

	Treatment herd			Non-treatment herd		
	Males	Females	Both	Males	Females	Both
Body mass	374	347	355	394	341	368
± s d	66	51	53	88	38	71
n	3	7	10	7	7	14

Figure 10. Growth curves for the treatment and non-treatment herds



(Table 15). Most sources give 400 kg as the mean adult liveweight for camels in Kenya, but mean liveweights for adult Somali camels are much higher, ranging from 590 to 650kg, up to 75% heavier than the average camel. Only a few castrated Rendille/Gabra camels reach such weights.

The growth rate for Somali camels on Galana Ranch has been calculated from data in Field and Simpkin (this report) using mean growth rate from birth (42.8kg) to 98% of asymptotic weight (590kg at 6 years). The mean daily growth rate is 245g day $^{-1}$. Mean growth rates calculated by Carles *et al.*, (1981) give 133g day^{-1}, 209g day-1 and 300g day^{-1} for Oryx (*Oryx beisa callotis*), eland (*Taurotragus oryx pattersonianus*), and cattle, respectively. This shows camels to be competetive meat producers, but not as efficient as the improved breeds of local cattle.

4.4 REPRODUCTIVE POTENTIAL AND PRENATAL MORTALITY

The results indicate that age at first calving is affected by breed and size; well managed Somali camels mature significantly earlier ($P<0.05$) than untreated Rendille/Gabra camels (Table 16). In many mammals the age of maturation is related to body size; thus to achieve maximum production the breeding of Somali camels with modern veterinary input should be encouraged.

Table 16. Reproductive potential

	Herd				
	Non-treatment	Treatment	Ol Maisor	Galana	IPAL Olturot
Number	29	56	-	207	15
Calving percentage (per annum)	21.1	47.4	54	53	45
Calving interval (months)	26.8	20.8	22.2	20.1	18.7
Abortions (%)	26	3.2	0	5.3	0
Failed conceptions (%)	10	4.8	-	-	-
Premature births (%)	6	1.6	-	3.5	12
Live births (%)	58	90.3	100	91.2	88
Age at first calving (months)	58	N.K.	-	51	61
Length of gestation (days)	390	385	-	-	-

N.K. = Not known

Traditional Rendille camels first calve at 4 years and 10 months; survey results give 4-5 years as normal. There were no known-age camels that calved in the treatment herd, but the average age at first calving would probably be a few months earlier than untreated camels.

There were no significant differences in the length of gestation between the treatment herd and the non-treatment herd.

Results in Table 16 show that modern management methods shorten the calving interval but breed or genetic potential has no effect. Direct comparison between the treatment and non-treatment herds shows veterinary input can reduce the mean calving interval by six months ($P<0.005$). These results were only recorded over a period of 3-7 years and it is possible that not all the camels in the herds have such a consistently short calving interval.

An explanation for the ease with which shorter calving intervals are achieved is that there are two rainy seasons per annum in Kenya and the reproductive cycle of camels is closely related to climate. In countries where there is only one wet season per annum oestrus and rutting would have to occur out of season which is more difficult to achieve and is not related directly to management, thus making it more difficult to reduce calving interval.

Calving interval is also affected by calf mortality; camels whose calves die less than one month old, have a calving interval four months shorter than camels with surviving calves ($P<0.01$); in such cases the mean calving interval is only 16.5 months.

Calving percentage for the treatment herd (47.4%) is higher than normal figures found in the literature (35-40%), probably due to successful disease control, but it is not much higher than the percentage found in the survey results (46%). Calving percentage for the non-treatment herd is excessively low, this is not only due to infertility caused by disease but could be due to the nomads selling us some of their barren and infertile females when the herd was purchased. Under good conditions one would expect the maximum annual calving rate to be 50%, equivalent to 100% over a two-year period, but the reduction of calving interval has led to some females producing two offspring over a two-year period, giving calving percentages greater than 100%, for example in the Ol Maisor and Galana herds. Culling of barren females on these ranches helps produce high calving percentages.

Poor nutrition, brucellosis and trypanosomiasis are the major causes of prenatal mortality and abortions. The non-treatment herd have a high abortion rate due to poor nutrition and a high prevalence of trypanosomiasis. The rate was reduced radically to only 3.2% in the treatment herd, mainly due to the treatment of trypanosomiasis. Reduction in helminth burdens may also mean better utilization of the forage ingested, thereby reducing the risk of poor nutrition. Camel herds at Olturot and Ol Maisor had no abortions which was due to veterinary input and no excessive grazing pressure. Galana Ranch camels would be expected to have a zero abortion rate, but a high trypanosomiasis challenge in this area may account for the 5.3% abortion rate.

Premature births are caused by the same agents as abortions and one would expect them to follow the same pattern. The high rate for camels at Olturot may be due to the fact that the study was carried out during a serious drought and the camels may have been under nutritional stress. In this experiment it was found that most of the camels giving birth prematurely were camels calving for the first time.

Table 16 shows that well managed, healthy herds have a higher percentage of live births, and breed does not effect the rate.

Failed conceptions were also recorded in the experimental herds. Five animals in the non-treatment herd failed to conceive after being mated. Of these five animals, four did conceive at later dates, one never conceived. In the treatement herd three animals failed to conceive after mating. Of these three animals, two conceived later and the remaining one never did conceive. It can be assumed that in each herd one animal was barren, but the other failed to conceive due to health reasons, thus the number was higher in the non-treatment herd than the treatment herd.

A herd productivity index was calculated to give productivity as liveweight in grams produced per kilogram of dam weight, as follows (adapted from the Trail and Gregory (1981) method, as used by de Leeuw and Peacock, 1982):

$$\text{Herd productivity index} = \frac{\text{Pre-weaning survivability x calving \% x weaning weight}}{\text{Post-partum adult weight}}$$

As shown in Table 17 veterinary treatment increases productivity by over 500% when compared to the non-treatment herd, and when compared to data from surveys and the literature the veterinary treatment almost doubles production.

Table 17. Herd productivity index

	Treatment herd	Non-treatment herd	Survey and literature herds
Pre-weaning survivability	0.88	0.52	0.54
Calving percentage	47.4	21.1	38
Weaning weight (kg)	113	74.5	111
Post-partum adult weight (kg)	387	355	371
Herd productivity index (g/kg)	120.8	22.9	61.4

4.5 MORTALITY

Mortality in calves less than one year old is high, but decreases in subsequent age groups.

Total calf mortality in the non-treatment herd (62.1%) is very high, although calf mortality higher than this is found in the literature. Calf mortality from the Rendille household surveys was only 46.3%. Reasons for the high mortality in the non-treatment herd are:

1. poor management during the initial stages of the experiment, notably lack of mobility and inadequate salt intake;
2. the inclusion of a few low producing dams in the purchased herd;
3. excessive offtake of milk for human consumption by the initial herdsmen;
4. when purchased the herd already had high levels of trypanosomiasis.

The differences in calf mortality between the treatment herd (12.5%) and the non-treatment herd may have been exaggerated by the above causes, but when compared to calf mortality from other sources (i.e. 46.3% from surveys and a mean of 35% from 14 sources in the literature), the effect of veterinary treatment on calf mortality is clearly visible.

Veterinary input also indirectly boosts calf survival by increasing the mother's milk production.

Disease is the major cause of calf mortality (Table 18) but predators, namely lions *(Panthera leo)*, and spotted hyena (*Crocuta crocuta*), are also

important in some areas. Ticks and mange are major diseases causing calf mortality, and are easily controlled by acaricide application. No calves in the treatment herd died of ticks or mange, but 61% of the calf deaths in the non-treatment herd were due to one or both of the above conditions.

Table 18. The mortality of camels in different herds

	Herd				
	Non-treatment	Treatment	Ol Maisor	Galana	Olturot
Total calf mortality < 1 year (%)	62.1	12.5	0	24.2	12
Calf mortality < 1 year due to predation (%)	0	1.8	0	4.0	0
Calf mortality < 1 year due to disease (%)	44.8	5.4	0	20.2	12
Mortality of immature camels (%)	13.3	3.2	-	6.9	9.5
Mortality of adult camels (%)	26.7	4.3	-	9.5	4.8
Herd mortality due to disease (%)	36.7	4.8			

Mortality of immature camels is lower, and again with a higher mortality in untreated herds, but is comparable to levels found in the literature. Castration of immature males can cause 3% mortality (Schwartz, 1979). Adult mortality is again high, especially in the non-treatment herds; adult deaths are often a combination of worn out dentition, leading to poor nutrition, and disease. Veterinary input can increase longevity by eliminating disease.

4.6 HERD STRUCTURE

Herd composition at the start and end of the experiment is portrayed visually in Figure 11 and can be compared with survey results and the average Rendille herd composition from five literature sources (Figure 12). The high percentage of adult females illustrates the importance of the camel as a food (milk) resource to these people, as opposed to societies that keep camels primarily for transport purposes.

Figure 11. Experimental herd compositions

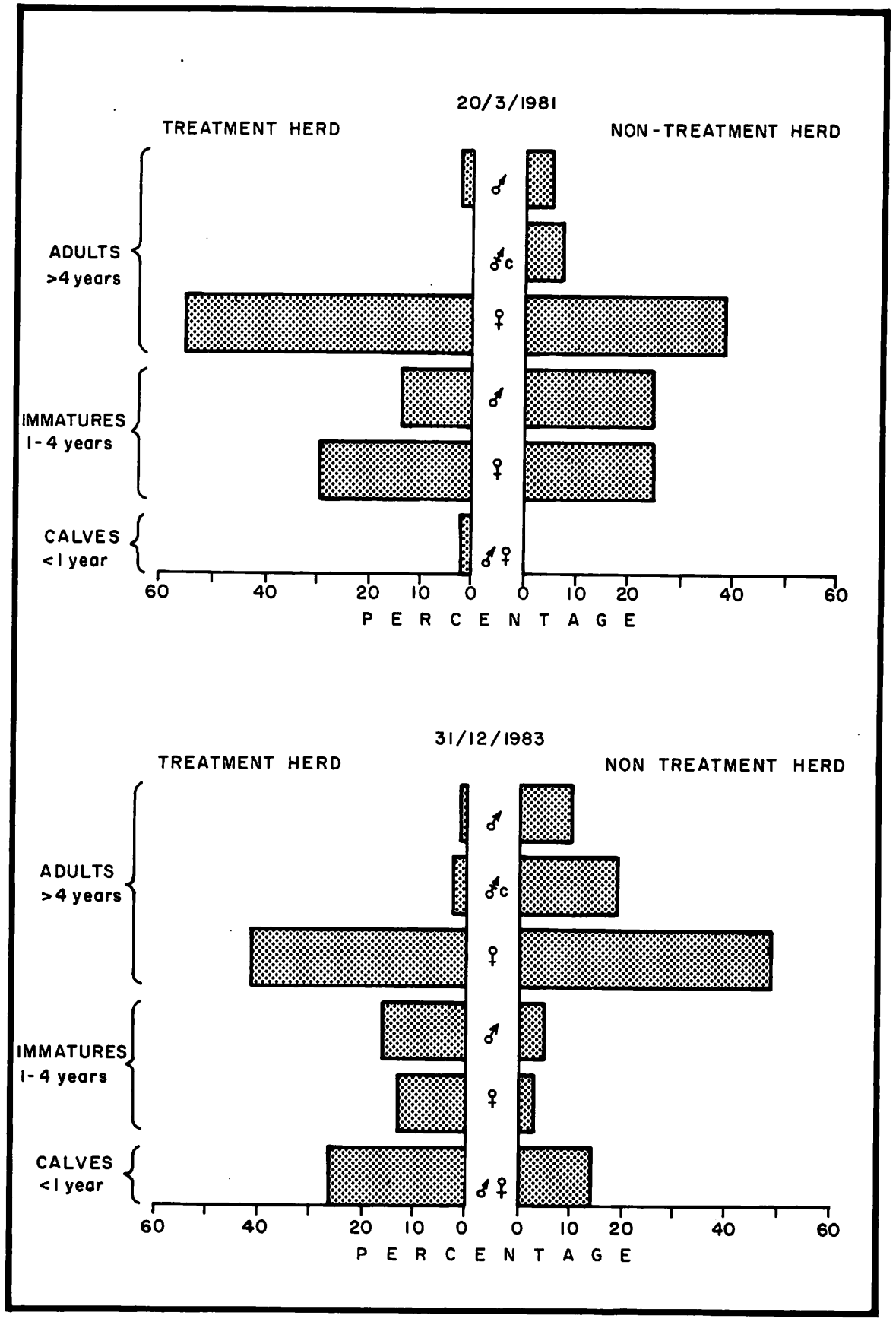
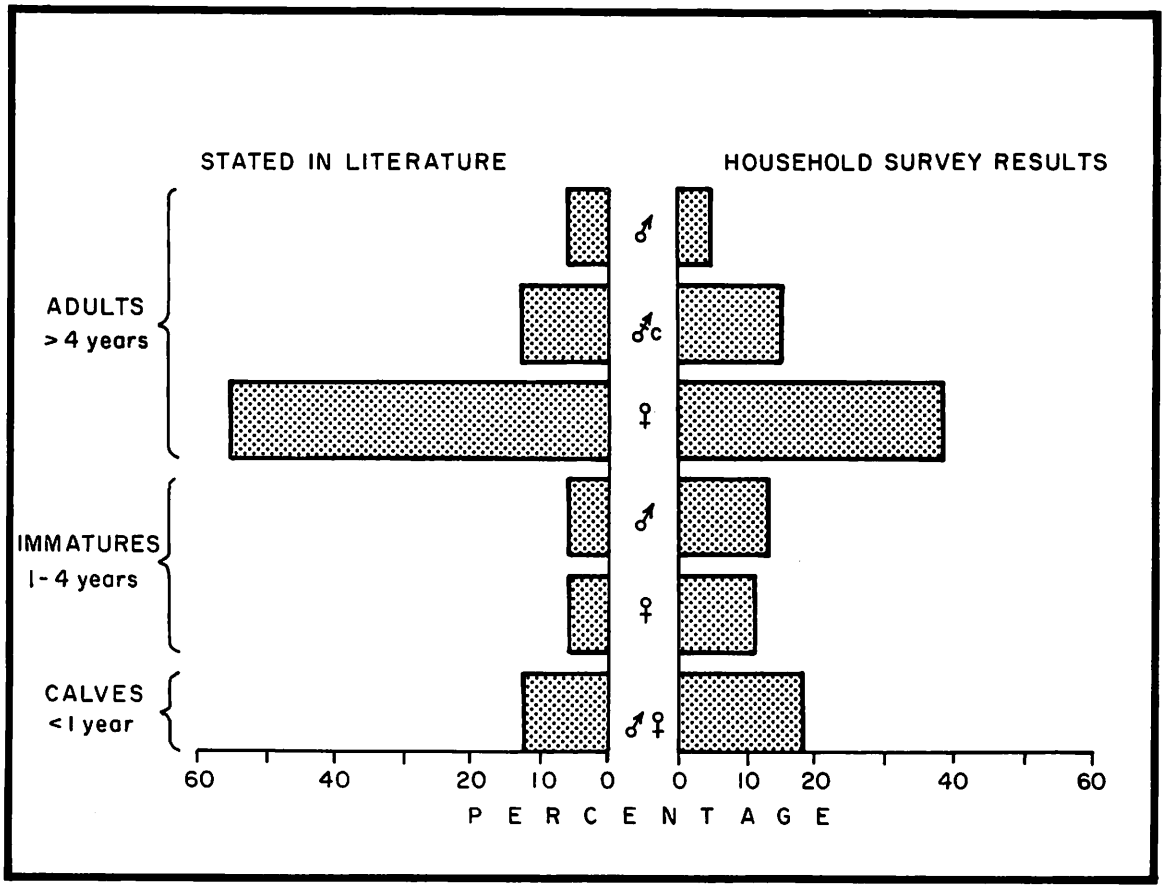


Figure 12. Rendille camel herd composition



At the start of the experiment there were no adult castrates in the contracted herd. Although the owners did own some, they were excluded for the experiment; they also owned two other stud bulls which were used in rotation to mate with the females.

The ratios of stud bulls to adult females in the treatment and non-treatment herd were 1:33 and 1:7.7 respectively. Ideally only half of the females would have to be covered by a male in one season, thus the actual ratios would be half of the above figures, which make them comparable to those cited in the literature for Rendille camel herds.

Low calf percentages in the treatment herd at the start of the experiment suggest a high calf mortality prior to the introduction of modern veterinary drugs.

4.7 HERD DYNAMICS

The histograms in Figures 11 and 12 illustrate trends in mortality and recruitment fairly accurately. One would expect the number of immature camels (1-4 years) of both sexes to be three times the number of calves less than one year old because the immature age group consists of three successive years of offspring. The fact that the composition of immatures is equal to or only slightly higher than the number of calves is indicative of a high calf mortality.

In Figure 11 the histogram of the non-treatment herd at the start and end of the experiment indicates an increase in the proportion of calves, but the actual figures show an increase in the number of adult camels from 50% to 77.8%, whereas the number of immatures and calves had decreased by an equal amount. This represents a declining population with little recruitment to the breeding segment.

The histogram for the treatment herd at the start of the experiment in March 1981, suggests a declining population with little recruitment; but on comparing it with herd structure at the end of the experiment in December 1983 the success of the programme becomes apparent. The percentage of adult camels in the treatment herd at the start and finish of the experiment has decreased by 12.8% and the majority of the herd are now calves and immatures (55.2%). This means the herd has good recruitment and is increasing in number.

Table 19 shows herd dynamics with the real numbers; the non-treatment herd actually declined in number and cannot be regarded as being typical of a traditional herd for reasons already discussed in Section 4.5. Treatment herd camels have increased substantially in number showing an increase comparable to that of the Galana Ranch herd which has the advantage of both modern management and no grazing competition. The higher calf and immature mortality in the Olturot herd has reduced its herd growth rate which one would expect to be slightly higher.

Table 19. Herd dynamics

	Non-treatment	Treatment	Ol Maisor	Galana	Olturot
Number at start	60	60	-	63	12
Number at end	58	104	-	189	21
Change	-2	+44	-	+126	+9
% change	-3.3	+73.3	-	+200	+75
Period (years)	2.8	2.8	-	7	4
% change per annum	-1.2	+26.2	-	+28.6	+15.8

Annual increases in these herds are much higher than any others reported in the text, and are mainly due to veterinary input. The Galana Ranch herd has had some immigration of recently purchased camels, but camels are also being sold, slaughtered and culled from the herd which would equalize the effects of immigration.

The herd doubling times of the treatment herd, Galana Ranch herd and the IPAL Olturot herd are 3.82 years, 3.5 years, and 5.32 years, respectively; these are all shorter than doubling times reported in the literature which are approximately 15 years (Dahl, 1979). These results are indicative of the potential for camel production in Kenya should the supply and administration of veterinary drugs become more easily available to the nomad.

4.8 BLOOD YIELDS

Measured blood yields in this study were slightly lower than records in the literature. A mean volume of 2.86 litres was obtained on each occasion and individual animals were bled once a month giving an annual yield of

34 litres, very close to Schwartz's (1979) estimate of 35 litres. Household surveys have an average of 3.93 litres, which lies between the study's results and the published estimates (Table 20).

Table 20. Bleeding of camels and yields of blood in litres

Age group/Sex	% of total bled	Volume	± s d	n
Adult - males	35	3.20	0.767	8
Adult - females	17	3.24	0.502	4
Immature - males	35	2.26	0.644	8
Immature - females	13	3.02	1.098	3
Mean volume = 2.86 + 0.815 (n=23)				

Results from surveys

Estimated mean volume = 3.93 1 ± 1.17 (n=75).

Mean interval between bleedings = 1.4 ± 0.89 month (n=73).

Bleeding is done by the boys and young men, and usually in the morning before the camels go out to graze. The blood is taken from the facial vein as opposed to the jugular vein which is used for cattle. The volume of blood taken depends on the number of people in the encampment. The maximum volume of blood taken from one camel in this study was 4.3 litres which would suffice approximately ten adults for one day. The blood can be drunk pure but is usually mixed with milk and drunk fresh. Bleeding most often occurs when there is a shortage of imported foods or milk, and blood may be the only form of food ingested for long periods of time.

Seventy per cent of the camels bled were adult and immature males. A similar percentage was found from household surveys. Stud bulls are never bled for human consumption. Significantly ($P<0.05$) more blood is taken from adults than immatures; there is no difference between the volume of blood taken and the sex of the camel. On occasion both pregnant females and immatures as young as 13 months old are also bled.

4.9 HIDES AND HAIR

Camel skins are sun dried and used for covering the tent or house, as sleeping mats or for making sandals and leather ropes. However, cattle and

goat skins are more highly prized than camel skins.

A sample of camel wool was collected from calves less than 8 months old but it proved to be too short for hand spinning.

4.10 CAMEL SURVEY RESULTS

During the study, questionnaires were administered to collect information from the camel owners themselves. Many of the owners are elder men and remain in the homestead or towns whilst the majority of their herd may be away in the *fora* or satellite camps being herded by their younger relatives. Hence some of the surveys were carried out without the camels being present, thereby making the answers difficult to check. Although the elders may not have seen their personal camels recently they were always well informed of their whereabouts, status and condition. Whenever possible, surveys were also made in the *fora* camps. However, the young men proved unreliable in their answers and a few of the completed questionnaires were excluded.

Seventy six questionnaires were satisfactorily completed, these being carried out in Ngurunit, Korr, Kargi, Laisamis and Loglogo locations. All of the people interviewed were Rendille or Ariaal.

4.10.1 Questionnaire results

Question No.:

8 Average family size = 6.96 ± 2.45 people n=48

9 Mean no. of moves of homestead in past 12 months = 4 ± 2.27

10 Mean no. of camels owned = 14.71 ± 10.6 n=76

12

Herd composition	%
Adult males	5
Adult castrates	15
Adult females	38
Immature males	13
Immature females	11
Calves, male	8
Calves, females	10

13 No. of females pregnant = 2.71 = 43%

No. of females lactating = 3.58 = 57%

14 Age at which a camel first calves:

73% give 4-5 years; 9% give 3 years; 16% give 6 years

16 Length of gestation:
70% give 12 months; 30% give 13 months.

17 Maximum no. of calves produced in a female's lifetime
= 12.13 ± 1.46 calves. n = 76
Average no. of calves produced in a female's lifetime
= 8.16 ± 1.51 calves. n = 76

18 Age at weaning: Majority of answers are between 7 and 12 months.

19 Age at castration: 3 - 6 years old.

20 Duration of lactation with calf alive = 15.6 ± 3.75 months n = 73
Duration of lactation with calf dead = 14 ± 5.38 months n = 53

25 Daily milk yield = 2.3 ± 0.89 1/day n = 52

26 Interval between watering = 10.9 ± 2.89 days n = 73

27 Camels bled: most commonly bled camels are adult females and castrates, and immatures of both sexes. Adult males can also be bled on occasion.

28 Volume of blood taken = 3.93 ± 1.17 litres n = 75

29 Bleeding interval = 1.4 ± 0.89 n = 73

30 Number of working or baggage camels = 1.26 ± 1.17 n = 74
(8.6%)

31 From 76 surveys only 20 (26%) owners had slaughtered a camel for food; 7 (9%) had slaughtered for ceremonial purposes; 29 (38%) had loaned or borrowed camels - mainly females but also a few males - for breeding and baggage purposes. Only 6 (8%) had bought or sold camels during the last year, either sold for cash or other livestock.

38

Number of camels died	Total	Per owner
Adults	63	0.84
Immatures	25	0.47
Calves	139	1.88

39

Cause of death	% adults	Immatures	Calves
Glands*	46	31	-
Trypanosomiasis	30	10	-
Ticks	9	21	75
Mange	-	21	11
Anthrax	-	3	-
Predation	13	-	7
Starvation	-	-	5
Other	4	14	2
Total	102	100	100

* Thought to be an exotic form of trypanosomiasis.

43 Most common cause of death %

	1st	2nd	3rd	Occurrence
Glands	20	30	33	64
Trypanosomiasis	16	53	3	63
Ticks	62	8	23	81
Mange	2	0	8	6
Anthrax	0	5	23	13
Predation	0	3	8	7
Other	0	0	3	1
Total	100	99	101	

44 Reasons for choosing present area (%)

	1st choice	2nd choice
Pasture	75	7
Water	11	49
Security	11	18
Freedom from disease	1	26
Proximity to traders	1	0
Total	99	100

45 Most important factor for future development (%)

	1st	2nd	3rd	Occurrence
Improve pasture	39	21	8	68
Improve water	10	26	42	76
Improve security	0	6	16	23
Improve disease control	28	45	26	93
Improve marketing	23	3	8	33
Total	100	101	100	

Total number of calves born in past year = 201

Total number of calves died in past year = 93

Calf mortality = 46.3%

Total number of adult females 435

Total number of calves born 201

Assume calving interval of 2 years = 218 female camels per annum

calving percentage = 92% or 46% per annum.

4.10.2 Discussion of survey results

Most of the survey results have been discussed in their relative sections, but they also provide an insight into the fears and wants of the pastoralists themselves.

The diseases that are named by the pastoralists as being the most common causes of death correspond closely to reports in the literature. Trypanosomiasis causes the highest mortality, especially in adult and immature camels, whereas tick infestations cause the death of most calves (75%). Immatures also suffer from ticks and mange, but the highest mortality is again caused by trypanosomiasis if one includes death caused by swollen glands - believed to be a different form of trypanosomiasis.

Good pasture and proximity to water are major factors determining the location of the homesteads although security and freedom from disease also affect choices to a lesser extent.

When the pastoralists were asked what factor they would prefer to see developed in order to improve the productivity of their camels, the majority chose an improvement in disease control with water and pasture being less important. The improvement of water and pasture would probably be the most important factors for development in cattle and smallstock homesteads.

5 COST BENEFIT ANALYSIS

5.1 COSTS

In this experiment an analysis of the cost of drugs used was found to be approximately KShs 130 per camel per annum. However, blanket treatment was recognized to be excessive and further recommendations were drawn up by the veterinary team to reduce the input of drugs without reducing the returns.

These new recommendations advised are as follows:

1. Treatment for trypanosomiasis with Naganol only when blood tests prove positive.
2. Control of helminthiasis by dosing adult females at the beginning of both wet seasons, and all camels except infants two months later, with 10% Panacur.
3. Spraying with an organophosphate acaricide when needed, concentrating on calves less than 6 months old which could be sprayed weekly depending on the tick challenge.
4. Treatment with various antibiotics and other drugs when the occasion demands.

The estimated cost of the necessary drugs to fulfil the above recommendations is approximately KShs 70 per camel per annum.

5.2 Resulting benefits

A comparison of milk yields of the treatement and non-treatment herds shows an increase of 459 litres due to veterinary input but only half of this (i.e. 229.5 litres) would be available to the people as the other half is consumed by the calf. The retail price of milk in the area is KShs 2.50 per litre, resulting in a return of KShs 573.75 per lactation of 57 weeks, or KShs 314 per annum, assuming the camels lactate once every two years.

Results of body mass do not show any differences in the mature liveweights of each herd. However, growth rates calculated for male camels from birth to four years old show a higher rate in the treatment herd. A difference of 77 grams per day was recorded (Table 13), which means an overall increase of 112 kg after four years, or 28 kg per annum. This is equivalent to an increase in carcass weight of 14 kg per annum. The retail value of camel meat in the area is KShs 8 per kilogram, resulting in a return of KShs 112 per annum for increased meat production. Carcasses of treated camels are likely to be of better quality and have a higher dressing percentage than untreated camels due to the elimination of various diseases, e.g. hydatid cysts.

A monetary value for the increased survival of treated camels has been calculated. The value of a mature male camel is KShs 1,500. The price of female camels is much higher but they are seldom sold. Multiplying the value of the camel by survival rate gives the total value. Further division

by four gives the value per annum. The difference between the treatment herd and other herds is the realized value or return from veterinary input. Since mortality figures in the non-treatment herd may have been exaggerated, the difference between the treatment herd and the results from surveys and the literature will be used. Thus the return is KShs 315 - 173 = KShs 142.

Total benefits are:

KShs 314 p.a. from milk;
KShs 112 p.a. from meat;
KShs 142 p.a. from calf survival.

However, not all the camels are contributing to these returns, therefore they have been multiplied by their relative per cent composition. The herd composition figures used are the mean from household surveys and Rendille camel herd composition found in the literature.

Adult females	=	47.1% of herd	=	0.47 x 314	=	148
Immature males	=	11.3% of herd	=	0.11 x 112	=	12
Calves	=	11.2% of herd	=	0.11 x 142	=	16

Gross return per animal per annum	=	Shs. 176
Cost per animal per annum	=	Shs. 70
Net return per animal per annum	=	Shs. 106

6 CONCLUSIONS

6.1 MILK YIELD

The results show the camel to be the most efficient milk producer in arid and semi-arid lands, giving a higher yield over a longer duration than both cattle and smallstock. Yields are affected by three major factors: breed, health status, and forage availability. Further factors of less importance include watering frequency, calving interval and calf survival.

There is no proof that the butterfat content of milk is affected by breed, but it is inversely proportional to yield.

The introduction of modern management techniques and new genetic stock can increase milk yields by a substantial amount.

6.2 GROWTH RATE

Male camels are generally heavier than females but growth rates of both sexes are approximately equal up to four years of age; females reach asymptotic body weights at 4-5 years, and males at 5-6 years. There is no major check in growth at weaning.

Veterinary input and forage availability affect growth rates and camels reach their adult body weights at an earlier age, but the adult body weights are not altered. Breed is the major factor influencing adult body weights.

From the data available, camels appear to be more efficient meat producers than oryx and eland, but less efficient than cattle. They are less dependent on water and can utilize rangeland unsuitable for cattle.

Veterinary input also improves meat quality and dressing percentages by reducing the amount of infected meat.

6.3 REPRODUCTIVE POTENTIAL

Scientific management and good nutrition are more important factors than breed in reproductive potential of camels. Although camels are said to be slow

producers, they produce as many offspring as the local breeds of cattle. Calving rates are improved by the control of abortions and reduction in the calving interval and age of maturation.

6.4 MORTALITY

Disease, nutritional stress and predation are the major causes of death. Treatment of calves less than one year old, which are the most susceptible age-group, reduces mortality substantially. Disease control also increases longevity.

Elimination of predators would be advantageous by reducing mortality and by facilitating night grazing and its associated benefits.

The results of the cost-benefit analysis and herd growth show the financial profits heavily outweigh the cost of drugs, and also show there is a huge potential for camel productivity in northern Kenya once markets and infrastructure have been established.

7. RECOMMENDATIONS

Many of the problems of pastoralists in northern Kenya could be alleviated by education and development schemes to encourage the people of northern districts to become integrated into the national economy. The whole aspect and answers to the problem of desert encroachment, range improvement and development in this area are amply covered in the IPAL Management Plan (UNESCO, 1984), the recommendations below are directed more towards the advancement of camel productivity and management.

1. Improve range condition (c.f. IPAL Management Plan, UNESCO 1984), since many of the present problems in camel productivity are related to the nutritional stress suffered by camels, and to the outlook and ways of the nomad himself.

2. Encourage the use of modern veterinary drugs by:

   (a) making the drugs more available to the pastoralist, e.g. provision of certain drugs from local town centres or watering points;

(b) demonstrate the advantages and returns of veterinary input;

(c) establish mobile clinics with experienced veterinary staff to administer the more dangerous drugs and diagnose the diseases;

(d) teach school leavers the basics of veterinary care, e.g. symptoms and treatment of the more common diseases.

3. Discourage the use of certain traditional cures which actually do more harm than good, e.g. indiscriminate firing/branding and intentional starvation.

4. Establish markets for camels. At present the Rendille are willing to sell adult castrates but there is no market - only 190 camels have been exported in the last 18 years. Camels could either be slaughtered for local consumption or the meat tinned or dried and exported. There was a camel abattoir at Archers Post which was closed down several years ago, but investigations should be carried out to see if it could be made operational again. Alternatively camels could be exported live to Saudi Arabia or north Africa where there is a high demand for camel meat. The Livestock Marketing Division of the Kenya Government - Ministry of Livestock Development - should be encouraged and aided in their proposals for establishing a camel export market from Mombasa port. Unless there is increased offtake, improved productivity will increase the number of camels which will put further pressure on an already degraded ecosystem.

5. At present the trend is for pastoralists to change from camels to cattle as the primary resource, simply because cattle are more marketable. This trend should be reversed and camel pastoralism encouraged as camels are better adapted to semi-arid areas and have a higher productivity. Establishing a market for camels should automatically change the trend.

6. Predator control to reduce mortality, either by extermination or translocation. Predator control would also mean livestock could be grazed at night, which has the advantages of increased grazing time and reduced water loss and subsequently less dependance on water.

7. Encourage the training of load camels to be utilized for carrying firewood, milk and food. Walking tours with camels are becoming

popular with tourists; this would attract people and money from outside the area, and financial gains would make the people less dependent on their camels for food.

8. Increase the mobility of herds and introduce rotational grazing. In the past many of the diseases were avoided by the larger mobility of the herd. Present pastoralists are less nomadic than in the past, hence tick numbers and worm burdens build up around the homestead and the livestock suffer. Introduction of veterinary treatment may result in less mobility as the herdsmen no longer see the necessity of moving, leading to localized degradation. Even a move of only a few hundred yards away from areas that are dung infested is advantageous from a veterinary point of view.

9. Salt is very important in camel husbandry, and should be made available from veterinary centres in the form of mineral bricks, or rotational grazing schemes should include grazing in salt rich pastures.

10. Control of milk offtake and competition with the calf for the mother's milk. Calves should be allowed to suckle all of the colostrum, and the custom of milking the colostrum on to the ground should be discouraged.

11. Encourage the making of ghee or other milk products that can be stored so that the excess milk produced in the wet seasons can be stored for consumption during dry seasons.

12. Lactating females should be allowed to water more frequently during the dry season. This would increase milk yields and put less stress on milch animals.

13. Somali breed stud bulls should be introduced to the traditional Rendille/Gabra and Turkana herds to improve genetic stock. If Mr J. O. Evans' introduction of Pakistan camels is successful this could also be followed up. It should be noted that there is a danger in introducing large Somali bulls to breed with females of smaller breeds as large calves may lead to problems in parturition.

14. Reduce inbreeding by introducing new stud bulls or encourage the loaning of bulls from other herds.

15. Bleeding of pregnant female camels should be avoided whenever possible.

16. Training the people in other handicrafts so that they can get an income from sources other than their livestock, e.g. leatherwork, tanning, pottery, bee keeping.

17. Change the traditional forms of management to a modern system of animal husbandry and encourage longer grazing hours by releasing animals earlier in the day.

Many of these recommendations can only be carried out after the establishment of an efficient infrastructure and will be long-term objectives. However, several can be implemented on a short-term basis and the immediate returns will be easily seen by the nomad himself.

Appendix 1.

Traditional Management and Veterinary Practices among Rendille and Samburu Camel Pastoralists

The Rendille and Samburu pastoralists follow a horizontal nomadic pattern of management, moving their herds to wherever the pasture is best or the rain has fallen most recently.

The camels are released at 9.00 a.m. in all seasons, and graze until dusk when they return to the night enclosure, sometimes not reaching the enclosure until 9.00 p.m. Most herds are watered once every 11 days on average, but the period may be longer during periods of drought. After parturition both the female camel and the calf are not allowed to drink water for at least one month. Calves are prevented from drinking much colostrum, most of the colostrum being milked onto the ground.

To force a female camel to foster another calf the walls of the anus are sewn together with a needle and twine made from the bark of *Acacia* trees, and a wire or string is tied tightly around part of the upper lip and tied to a post or tree. This may last for up to two days when the blocked faecal passage becomes so painful that the female camel ignores the calf as it suckles and eventually adopts it. Often the upper lip atrophies and drops off.

Castration occurs at 3-6 years of age by open incision and removal of the testes. Human or camel urine is then used to disinfect the wound.

Much traditional management is closely connected to customs and ceremonial blessing for the camels, including prayers, daubing them with blood from sacrificed sheep and the aroma of burnt pine leaves blowing over the camel night enclosure. These leaves are obtained from highland areas and are much sought after by Rendille.

Table A 1. Traditional Rendille/Samburu camel medicines

Disease	Symptoms	Medicine and its preparation	Comments
MANGE *(Ibebedo, S)* *(Haddo, R)*	Loss of hair, bleeding sores, Scratching	Salty water to drink; taken to salt pans to roll in dust and eat salt-rich vegetation. Old engine oil is rubbed onto the skin.	Mite: *Sarcoptes scabei* var. *cameli*. Engine oil was found to work as effectively as modern drugs
JOINT ILL *(Ilgila, S)*	Stiff joints.	The animal is branded with hot irons or stones.	
TRYPANOSOMIASIS *(Saar, S)* *(Omar, R)*	Weakness	Fruits of *Zanthoxylum chalybeum (Loisuk, S)* are crushed, mixed with water and drunk twice a day. Skin of giraffe or goat is burnt and crushed to a powder and swallowed.	
GENERAL WEAKNESS *(Goigoi, S)*		Fruit of *Myrsine africana (Segetet, S)* are crushed and eaten.	
SWOLLEN GLANDS *(Nengima, S)*		The glands are burnt with a hot brand.	
BACTERIAL INFECTIONS *(Ilmangoi, S)*		Sap of *Euphorbia* spp. *(Ilpara, S)* put in wound; or burnt with a hot iron.	
EYE INFECTIONS		Cowrie shells are burnt, pulverized and the powder put in the eye.	
OPEN WOUNDS		The gum of *Boswellia hildebranti* or sheep's fat is melted and poured into the wound. Fruit of *Myrsine africana (Segetet, S)* crushed and drunk in warm milk.	
TICKS		*Cadia purpurea (Ilkirereai, S)* leaves and twigs boiled with tobacco and applied when cool. *Kedrostis* spp.*(Sarhudu, R)* roots boiled with tobacco as above.	
RETAINED AFTERBIRTH		Roots of *Salvadora persica (Sagetey, S)* boiled in water and drunk the next day. Dik-dik faeces soaked in water and the water drunk the next day.	Very effective

S = Samburu R = Rendille

Appendix 2.

Regression Equation for Calculating Body Mass

The regression equation for determining body mass calculated by Field and Muiruri (Field, 1979) is:

$$y = (6.9583)\ (1.0068)^{x} \qquad r = 0.981$$

where y = body mass (kg)

x = sum of shoulder height, thoracic girth and abdominal girth (cm)

r = correlation coefficient

Appendix 3.

Age Determination

Incisors: Lower jaw.

Milk teeth	0-4 years
No wear	0-1 year
Slight wear	1-2 years
Moderate wear	2-3 years
Heavy wear	3-4 years

1st pair adult incisors at 4½ - 5 years
2nd pair adult incisors at 6 years + 2 canines
3rd pair adult incisors at 7 years - no wear

All adult incisors at 9 years - slight wear
All adult incisors at 12 years - moderate wear
All adult incisors at 15 years - heavy wear

15 years - hair on tail turns white, and hollows over eyes get deeper.

Dental formula

Milk teeth	Permanent teeth
$2 \times \frac{1\text{-}1\text{-}3}{3\text{-}1\text{-}2} = 22$	$2 \times \frac{1\text{-}1\text{-}3\text{-}3}{3\text{-}1\text{-}2\text{-}3} = 34$

(Based on Animal Management, War Office, London, 1933)

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THE IMPORTANCE OF CAMELS TO SUBSISTENCE PASTORALISTS IN KENYA

by

C.R. FIELD and S.P. SIMPKIN

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1. INTRODUCTION

It has been estimated that at the present rate of growth (between 3.5% and 4% p.a.) the human population of Kenya will number over 18 million by the end of 1984, which is an increase of 19% since the last national census in 1979. Furthermore, by the turn of the century, it is expected that the population will have doubled and will be increasing at the rate of more than one million per annum. In fact, in less than half a century there may be five people for every one living in Kenya today.

Unfortunately the national economy is growing at a much slower rate than this, which means that more and more people will be forced back to the land and subsistence survival. As the remaining relics of high- and medium-potential land are settled and cultivated there will be an intensification in the use of semi-arid lands of marginal agricultural potential. There is little hope for the survival of forests and woodlands; water conservation will be forfeited and there will be accelerating dessication of the land.

Nevertheless, in northern Kenya in particular, there may remain extensive rangelands which cannot be cultivated because of irregular and unreliable rainfall. For a while these will form the basis of the national livestock economy.

To make way for more efficient agricultural production systems it may be tempting to transpose the existing cattle economy from the Kenya highlands to these rangelands. However, this should be strongly resisted in the knowledge that time is not in our favour. For example, it has taken 60 years to select from indigenous cattle (*Bos indicus)* and produce the highly productive Boran breed which is being ranched on medium-potential land in Kenya today.

Indeed, in the arid zone where water is at a premium, stocking of water-dependent livestock such as cattle should be discouraged as they contribute to the elimination of the herbaceous layer in large areas of annual vegetation around permanent water points and to severe damage of perennial grasslands and woodlands in watershed areas.

Instead, greater emphasis should be placed on improving the productivity of the camel (*Camelus dromedarius*) which is adapted *par excellence* to arid and/or degraded conditions and which shuns the more humid regions where camel diseases are a problem.

Much has been written about the camel as a transport animal and how during Roman times it was replaced in north Africa by wheeled transport, only to regain its former status when roads fell into decay with the fall of the Roman Empire (Bulliet, 1975). A less well appreciated aspect of the camel, however, is that it has the capability of converting poor quality arid rangeland forage into milk and meat. Furthermore, the milk of camels frequently forms the staple diet of pastoralists living in the arid zone of Africa and the Middle East.

It might be argued that the camel is outmoded from the point of view of modern transport (although even this is questionable given the rising cost of fossil fuels and vehicle maintenance) and therefore does not have a role to play in the modern world. On the contrary, arid and semi-arid lands suitable for camels occupy 48 million km^2 or 36% of the earth's surface and are inhabited by 384 million people. Over the past 50 years much of the useable land in these dry regions has been converted into unproductive waste by a combination of ecological and socio-economic factors and it has recently been estimated that the lives of 150 million people in Africa alone are being threatened by drought. Thus the camel is becoming increasingly in demand by virtue of the fact that it can continue to produce food for people living in a degrading environment and achieves this with minimal impact and disturbance to the ecosystem.

2. LIVESTOCK POPULATIONS

All domesticated species of livestock which are found in Africa today have been introduced from adjacent areas. It is noteworthy that camels, although perhaps the last to be introduced, have occupied an ever-increasing niche such that there are now more on this continent than anywhere else in the world (see Table 1).

Table 1. World, Africa, N.E. and E. Africa livestock statistics

Species	World	Africa	% of world	N.E. and E. Africa	% of Africa
Cattle	1,150,508	149,227	13	68,796	46
Sheep	1,056,684	143,301	14	DNA	DNA
Goats	391,375	114,735	29	DNA	DNA
Camels	16,990	12,190	73	9,838	81

Figures are in thousands of head.

Source: F.A.O. 1972, 1973, 1978.
D.N.A. Data not available.

It is thought that the dromedary was first domesticated in southern Arabia about 4,000 years ago but was soon introduced to the Horn of Africa (the north-east and east) where the largest concentration of this species is found today (see Table 1).

Placed in this perspective it is clear that, with the exception of the camel and possibly the goat, Man has introduced to Africa species of livestock which have been domesticated under temperate and sub-tropical conditions and which have been only partially successful in adapting to African conditions. Cattle and sheep, in particular, occupy highland areas where, as mentioned earlier, they are likely to become victims of the expanding human population and agriculture.

While cattle are presently the mainstay of the African livestock economy, problems lie ahead for countries which do not seek alternatives such as the camel. Africa, with one-tenth of the world's human population, has one-quarter of its grassland and one-eighth of its cattle (Table 2). However, per unit area, beef production is 20% and milk production 10% of the world's average. Cattle stocks are growing less rapidly than in the world as a whole (Table 3). Beef and total meat production per head of population are already very low and declining, although milk production is reportedly keeping abreast with the human population (Crotty, 1980).

Table 2. African population and livestock statistics as percentage of world total

Human population	10.2
Arable land	14.3
Grassland	26.4
Cattle	12.6
Beef	5.4
Milk	2.6

Table 3. World and Africa livestock production growth rates (%) 1961-5 to 1974

	World	Africa
Population	21	30
Cattle stocks	19	12
Beef production	35	17
Milk production	20	29
Total meat production	40	22

Source: Crotty, 1980.

In the decade between 1961 and 1972 it appears that the world's population of camels was increasing at a slightly faster rate than other species of livestock (Table 4).

Table 4. World growth rates in livestock 1961-1972 (%)

Cattle	19
Sheep	18
Goats	12
Camels	22

This might be attributed to a number of factors, including a rapidly expanding camel habitat, low offtake rates, use of camels for subsistence only, and improved census methods. One or all these factors may have played a part in the recorded increase amounting to 89% over ten years (1968-1978) in camels in Somalia which, at more than 5 million, is the largest population of any nation (SOMAC/SAREC, 1982).

According to KREMU (1978) there were 607,000 camels in Kenya in 1977. These comprised 3.5% of the world's total camel population. More than half (62%) of the population of camels in Kenya is found in North Eastern Province and Isiolo District and these may be regarded as an extension of the greater Somalia population. The Gabra and Rendille of Marsabit District are distantly related to the camel-culture Galla and Somali peoples, respectively, and own approximately 19% of the national herd, while the Turkana and Pokot in Rift Valley Province own 16%, having acquired camels relatively recently. The Samburu own the remaining 3%, being in the process of building up camel herds as their rangeland becomes progressively more degraded by cattle (Stiles, 1983).

To obtain more accurate figures, ten aerial surveys carried out by IPAL between 1976 and 1979 revealed an estimated mean population of 41,400 camels in 23,000 km^2 of Western Marsabit District. They occurred at a mean density of 1.8 km^{-2} and when converted into tropical livestock units (TLU) comprised 36% of the total livestock units in the area. We have therefore been studying approximately 7% of Kenya's population of camels. Within this area a detailed management strategy has been developed for camels occurring in 11,300 km^2 which approximates to the home range of the Rendille people. Here there appear to be two interrelated foci of livestock, namely the Northern Rendille based on Kargi who own an estimated 8,664 camels, and the Southern Rendille based on Korr who own an estimated 9,979 camels.

3. HOUSEHOLD OWNERSHIP OF LIVESTOCK

3.1 STOCK HOLDING

We have adopted two methods for determining stock ownership. The first uses data from the aerial census of livestock and the national census of the human population. The second has involved more than 150 household surveys among Rendille, Ariaal and Samburu. Results are shown in Tables 5 and 6.

Table 5. Stock ownereship in the Western Marsabit management area from aerial survey data

Species	Number	Density (km^{-2})	TLU[a] (%)	Number owned		Units per family
				Per person[b]	Per family[c]	
Camels	18,643	1.65	40.3	1.4	11.6	14.5
Cattle	24,552	2.17	42.4	1.9	15.2	15.2
Smallstock	107,547	9.52	16.9	8.3	66.7	6.1
Donkeys	235	0.02	0.4	0.02	0.1	0.1
Total	150,977	13.36	100.0	11.62	93.6	35.9

Notes: (a) 1 TLU is equivalent to a 250 kg cow, 0.8 of a camel or 11 smallstock.
(b) A population of 12,900 Rendille people is used.
(c) A figure of eight people per family is used.

Table 6. Average stock ownership per family in Western Marsabit District based on more than 150 household surveys

	Camels	Cattle	Smallstock	Total
Stock per family of 8	12	11	101	124
TLU	15	11	9.2	35.2
TLU as % of total	42.6	31.3	26.1	100.0
TLU adjusted for IPAL area	14.4	7.3	9.6	31.3

In Table 6 the age-specific composition of the herds of each species, together with data on weights at age, have been used to calculate mean liveweight. Since these are lower even than the tropical livestock unit, adjustments have been made where a Marsabit camel = 1.2 TLU, a cow = 0.66 TLU, a sheep = 0.09 TLU and a goat = 0.10 TLU. Thus on average, 31-36 tropical livestock units are owned per household and camels comprise between 40 and 46% of the total.

Analysis of camel herd structure by five different authors over a period of nine years is summarized in Table 7.

Table 7. Percentage composition of camel herds ± sd

Mature males	5.2 ± 2.28
Castrates	12.0 ± 2.55
Mature females	55.0 ± 11.42
Immatures and calves	27.8 ± 12.56

Because of seasonal peaks of parturition the most variable category is the calves and immatures.

Since 55% of all camels are adult females and about half are lactating at any one time, on average each household would have 3.2 to 3.3 lactating camels.

3.2 Minimum requirements in livestock equivalents

The average family of about eight persons, including children, is estimated to have dietary requirements equivalent to 6.5 adults (Brown, 1971). Calorific requirements for pastoralists have been estimated at from 2,000 Kcal for a woman to 2,800 Kcal for a man (Dahl and Hjort, 1976). However, Brown (1971) believed that a pastoralist may be described as 'an active individual doing no heavy work' and having a requirement of 2,300 Kcal per day. Thus family requirements are calculated as ranging from 15,000 Kcal (Brown, 1971) to 18,300 Kcal (Dahl and Hjort, 1976) after adjusting to the larger family size.

Protein requirements are believed to be about 422 grams per day for a family of eight.

Brown (1971) suggests that over the year in most pastoral societies in Africa a diet of 75% milk and 25% meat is a good estimate of actual consumption and that for a standard family this would amount to 16 litres of milk and 2.41 kg of meat. In the event, many families supplement their diet with cereals. We will return to this important point later.

According to Brown (1971) a family's daily milk requirements can be supplied by about 7 cows or 4 camels in milk on any and every day of the year. In order to maintain this level of production a pastoralist must keep 35 to 40 cattle, but less than half the number if camels (Lamprey, 1983). He concludes, that however the figure is calculated, a family of eight persons must maintain 15-17 standard stock units of 454 kg liveweight each. This is equivalent to 27 to 31 tropical livestock units. If these figures are adjusted to the smaller size of animals in the study area, equivalents lie within the ranges indicated in Table 8.

Table 8. Liveweight and household requirements of livestock in Marsabit District

Species	Mean liveweight (kg)	TLU	Household requirements (Range)
Camels	300.6	1.20	22.6 - 25.7
Cattle	164.7	0.66	41.3 - 46.9
Sheep	23.7	0.09	287.3 - 325.6
Goats	24.8	0.10	274.6 - 311.2

As we have seen from Tables 5 and 6, average stock ownership does provide at least these minimum requirements. In practice, however, people usually keep smallstock and either camels or cattle and, less commonly, all three categories. Also, to provide for disasters such as drought, disease and raiding and for

social reasons, pastoralists try to keep rather more animals, i.e. 36 to 44 tropical livestock units. Clearly the average figures shown in Tables 5 and 6 embody considerable variation in stock onwership in terms of numbers, species and individual productivity which will dictate whether or not a household will be dependent on food aid.

It is now necessary to examine the productivity of camels in Marsabit District to determine to what extent they are able to fulfil human requirements and whether they are more efficient than other livestock categories in this respect.

4. PRODUCTIVITY OF CAMELS

4.1 MONITORING OF HERDS

The production of meat and milk by camels has been monitored by us in some detail in Western Marsabit using our own experimental herds. Liveweight gain and daily milk yields have been recorded over a period of two and a half years in three herds.

Results have been compared with less detailed information from two ranches in Kenya. Information concerning the five herds and their management status is given in Tables 9 and 10.

Table 9. Camel herds monitored for productivity data

Herd	Locality	District	Period of observation	Altitude (m)	Mean annual rainfall (mm)
1	Kulal	Marsabit	1976-80	667	200-300
2	Ngurunit	Marsabit	1981-83	750	250-450
3	Ngurunit	Marsabit	1981-83	750	250-450
4	Olmaisor Ranch	Laikipia	1983-84	1,890	580
5	Galana Ranch	Kilifi	1984	270	300-550

Table 10. Status of camel herds

Herd	Approximate number	Breed	Status		
			Veterinary input	Food	Salt
1	20	Mixed	When necessary	Not limiting	In range
2	60	Mixed	Traditional only	Seasonally limiting	Nil
3	60	Rendille	Weekly	Seasonally limiting	Supplement
4	200	Turkana	When necessary	Not limiting	Supplement
5	200	Somali	When necessary	Not limiting	Supplement

From these tables it can be seen that conditions for Herds 2 and 3 differ only in the availability to the latter of weekly veterinary input and salt. Direct comparisons are therefore valid, while we can only make inferences regarding the observed differences between the other herds.

4.2. Camel milk production in Kenya

Milk production has been estimated by separating the calf from its mother for a known period of time and milking half the udder, usually both morning and evening. From this the total daily yield, including the amount the calf has suckled, can be calculated (Table 11).

Table 11. Camel milk production from five herds (litres)

Herd	Mean daily yield	Range	Total production over 12 months
1	4.1	N.A.	1,499
2	2.2 $\pm$ 1.18	0.7 - 3.8	799
3	3.1 $\pm$ 1.22	1.7 - 5.9	1,139
4	2.8 $\pm$ 0.50	1.9 - 3.6	1,033
5	5.3 $\pm$ 1.50	3.9 - 8.2	1,945

The highest yields were from Herd 5 where feed was not limiting and the camels were of the large Somali breed. At the other extreme, productivity by Herd 2 was only 41% of the former. These camels experienced a seasonally limited food supply, were of the small Rendille breed and did not have the benefit of veterinary care. The advantages of the latter are shown in Herd 3 whose only major difference from Herd 2 was a regular weekly veterinary treatment. Here there was a 42% increase in milk yield. Even greater yields were obtained from similar camels with favourable food supplies such as Herd 1 which produced almost twice that of Herd 2. The effect of breed on yield is perhaps shown in Herd 4 which were small Turkana animals and although constrained neither by food or disease nevertheless had the second lowest yield.

4.2.1. Comparison with other areas

Although there are almost 60 records from ten countries of the total yield of camels' milk it is difficult to make comparisons. However, with certain assumptions it may be calculated that the average lactational yield for the dromedary is 2,586 $\pm$ 1,880.39 litres. The average duration of lactation is 13.8 $\pm$ 2.37 months and so, for a twelve month period on a proportional basis, the average yield is 2,249 litres or 6.2 litres per day.

This places the yields recorded for Kenya in perspective, with the poorest (Herd 2) being little more than a third of the world's average. However, there is reason to believe that the latter figure is artificially high as authors trying to promote the camel have omitted the poorer yielding animals as unworthy of mention.

Nevertheless on good nutrition the 'heavy' Indian and Pakistan breeds show a very high milk yield which ranges from 6.9 - 35 litres per day or 2,484-12,775 litres per year. The latter, albeit under optimal conditions, sets a target for the improvement of indigenous traditionally managed Rendille camels which is 16 times greater than their present productivity.

4.3. MEAT PRODUCTION

The growth of camels has been monitored in the same five herds (Field, 1979; Schwartz *et al.*, 1982; Field *et al.*, 1983). In addition, data on 300 indigenous traditionally raised Rendille, Gabra and Turkana camel calves are available. Calves in Herd 1 were permitted to suckle throughout the day and were separated only at night. Results of these measurements are presented in Table 12.

Several points are illustrated by this table.

1. Growth rates at any stage were slowest in indigenous Rendille camel and least of all during dry years.
2. In the first six months after birth these camels grew at less than half the rate of Somali camels on Galana Ranch.
3. Suckling throughout the day in Herd 1 appeared to increase growth rates by 187-265% when compared with indigenous calves until 12 to 18 months.
4. Veterinary input increased growth rates in camel calves in Herd 3 by 14-53% at one year of age and 41% at four years of age. The latter is evidence that veterinary input is increasing growth rate irrespective of milk yield.

In summary, breed, competition for milk with the owner and disease all have a limiting effect on Rendille camels.

The slow growth rate and stunting effect of traditional management on Rendille camels is also apparent in adult camels (Table 13).

The effect of breed on liveweight is also noticeable, with Somali camels being approximately one-third heavier than Rendille camels. This also emerges from average calf birth weights where Somali camels in Herd 5 were 42.8 kg, Rendille camels in Herd 1 were 30.9 kg, in Herd 3 were 29 kg and Herd 2 only 25.8 kg. The former were therefore 66% heavier than the latter.

Table 12. Growth rates of camels in grams per day

Time period	Herd 1 Range		Herd 2	Herd 3	Herd 4		Herd 5		Indigenous Camels Season			
					F	M	F	M	Wet		Dry	
	From	To							From	to	From	to
Birth to 6 months	371	638	233	331	555	611	650	678	270	310	170	206
6 to 12 months	520	530	129	251	139	194	500	389	90	315	-	-
12 to 18 months	200	230	49	150	194	222	222	333	50	-	-	-
18 to 24 months	2	100	-	219	250	222	222	333	-	-	-	-
Birth to 12 months	405	425	171	298	342	397	603	562	247		-	-
Birth to 48 months	-	-	97	177	253		262		-	-	-	-
Birth to 60 months	-	-	106	168	216		245		-	-	-	-

F = female

M = male

Table 13. Weights of adult camels (Kg)

Herd	1	1	2	4	5
Breed	Somali	Rendille	Rendille	Turkana	Somali
Asymptotic weight	650	500	400	460	590
Age at which asymptotic weight is reached in years	-	8	9	5	6
Maximum weight recorded	720	550	525	540	700

5. HERD DYNAMICS

Of vital importance to a pastoral camel herdsmen in both the short and the long term are the dynamics of his herd, that is whether it is increasing or decreasing and what are the causes of the changes.

Peaks of calving may lead to a super-abundance of milk in the household. However, this may be followed by times of severe shortage due to high calf mortality during drought, in particular between the ages of two and six months. Usually, however, camels will continue to lactate at a reduced level provided the skin of the calf is present to provide the necessary stimulus for the milk letdown reflex. Another problem may be faced by pastoralists when the majority or perhaps all females are mated and conceive during the same rainy season. This will mean that they will commence to dry off about three months later. Fortunately in equatorial countries such as Kenya there is a bimodal rainfall pattern and corresponding bimodal breeding and calving peaks in camels. This means that usually among the pastoral herds there are some individual camels calving in each of the wet seasons and this reduces the risk of the household facing a period with no milk at all. In more northerly latitudes, such as northern Sudan, however, rainfall is unimodal and pastoralists may face such periods of milk shortage. This further underscores the need for supplementary stored food such as grain products in these areas

and may explain why pure pastoralism (i.e. without cultivation) is able to persist in northern Kenya. Tables 14, 15 and 16 summarize the herd data.

Table 14. The fertility of camel herds

Herd	1	2	3	4	5
Age at first calving in months	61	58	-	-	51
Calving interval in months	18.7	26.8	20.8	22.2	20.1
Calving percentage	45.0	21.1	47.4	54.0	53.0
Abortions %	0.0	28.9	3.4	0.0	5.3
Premature births %	12.0	6.7	1.7	-	3.5
Live births %	88.0	64.4	94.4	100.0	91.2

Table 15. Mortality within camel herds

Herd	1	2	3	4	5
Calf mortality $<$ 1 year %	12.0	62.1	5.4	0.0	24.2
Calf predation %	0.0	0.0	1.8	0.0	4.0
Calf disease %	12.0	62.1	3.6	0.0	20.2
Immature deaths %	9.5	5.0	15.0	-	6.9
Adult deaths %	4.8	16.7	0.0	-	9.5

Table 16. Herd dynamics

Herd	1	2	3	5
Number at start	12	60	60	63
Number at finish	21	58	104	189
Change	+9	-2	+44	+126
% Change	+75	-3.3	+73.3	+200
Period in years	4	2.8	2.8	7
% change per annum	+18.8	-1.2	+26.2	+28.6

The fertility data show that Rendille camels first calve at about five years while under good conditions Somali camels may calve up to nine months earlier. This may result from faster growth rates due to better nutritional conditions at Galana Ranch.

The mean interval between calves varies from 19 to 27 months. The former is near the lower limit and may only be expected under conditions of good nutrition. The latter is the situation in traditional herds where abortions are relatively common.

The effects of veterinary input on fertility can be seen by comparing Herd 2 under traditional management with Herd 3 which had veterinary care. The latter showed an increase in calving by 26.3% and reduction in calving interval by 6 months, in abortions, due largely to the control of trypanosomiasis, by 25.5% and in premature births by 5%. This gave an overall increase in successful births of 30.5%.

The mortality data show that it is possible with good management to raise all calves through their first year. However, this requires the provision of an adequate supply of milk for a healthy calf and prompt action should diseases occur. By contrast, losses may exceed 50% in traditionally managed herds and this may be entirely due to disease. The role of predation is relatively unimportant in calf mortality. Among the main diseases affecting young calves are mange and ticks. The former is predisposed by malnutrition and both may be treated effectively with acaricides. The problem is now a matter of education through extension and of simple logistics.

6. THE CONTRIBUTION OF LIVESTOCK TO HOUSEHOLD FOOD REQUIREMENTS

6.1. CAMELS

Given that an average family of pastoralists requires 15,000-18,300 Kcal of energy per day and that a litre of camels' milk contains 700 Kcal of energy, the family requires 21-26 litres of milk daily assuming that it has no other source of energy. Similarly, if 1 litre of milk contains 39 grams of protein and daily household requirements are 422 grams of protein then 10.8 litres of milk are required for protein needs.

Since an average Rendille household has 3.3 lactating camels at any one time these animals under different management regimes may be expected to contribute energy and protein requirements of the household as shown in Figure 17.

Table 17. The proportion of the diet of a Rendille household supplied by camel's milk

Herd	1	2	3	4	5
% of required energy	26-32	14-17	19-24	18-22	33-44
% of required protein	62	33	47	43	81

From another point of view we may calculate the minimum herd size of camels required to provide the household needs assuming that no other livestock are kept (Table 18). As before, we assume that half the camels are lactating and female camels comprise 55% of the total herd.

Table 18. Minimum camel herd size to provide energy and protein needs

Herd	1	2	3	4	5
For energy needs	38-46	70-86	50-62	56-68	30-36
For protein needs	20	36	26	28	14

Several strategies present themselves to the camel pastoralist. Firstly he may continue along the present lines. However, there are indications that the growth of human and livestock populations cannot be sustained without some major management intervention. The productivity of the herds is likely to decrease as the rangeland further deteriorates.

Secondly he may try to increase his herd to compensate for declining individual productivity. As we have seen, under the prevailing conditions this should be strongly discouraged as it would necessitate a 6-7 fold increase in numbers to fulfil the energy demand.

This would be self-defeating as the rangeland would not be able to sustain such an increase and would lead to an overall decline in productivity.

Thirdly the camel pastoralist may seek to improve the productivity of his existing herds. Three possibilities have been demonstrated in other herds, namely improved nutrition, minimizing disease and introduction of new breeds. This has the potential also of increasing the herd size so care should be excercised here not to exceed the carrying capacity of the range.

The last strategy involves the husbandry of mixed livestock and the use of energy-rich food to supplement the diet of the family and thereby reduce the dependence on milk as a source of energy during seasons of limited supply. These last two strategies in combination offer the most promising possibilities to the camel pastoralist.

As we have seen, almost all camel pastoralists keep some other category of livestock in addition to the camel. In the case of the Ariaal, who fall between the Rendille and Samburu in culture, they often keep both smallstock and cattle although this has a high demand on labour. Many Rendille rely on smallstock alone to supplement their camel productivity.

It is now necessary to reconstitute the expected diet of a Rendille household based on observed stock holding and the productivity of IPAL-owned flocks under traditional management and with a health programme (i.e. improved management).

It is estimated that camels under traditional management yield 3,630 cc milk per household per day while those under the health programme yield 5,115 cc. The calorific content of the milk is 2,541 and 3,581 Kcal respectively. The protein content is 142 and 199 grams respectively.

With regard to meat production, approximately 26% of the household camels are castrates and young males destined for eventual slaughter. This proportion is equivalent to 3.12 camels per household. Using the growth rates quoted from birth to 60 months (Table 12), we calculate that those under traditional management produce 331 grams of meat per day and those under the health programme 524 grams per day. If the energy value of camel meat is 0.99 Kcal per gram and the protein value is 0.21 grams per gram of edible portion (Dahl and Hjort, 1976) then the animals produce 327 Kcals and 519 Kcals respectively and 69 grams protein and 110 grams protein respectively.

6.2. SHEEP AND GOATS

Under the two management regimes the following average daily yields have been estimated per animal.

6.2.1. Milk yields

Table 19. Milk yields for sheep and goats (cc per day)

Management	Sheep	Goats
Traditional	17.5	35.1
Health programme	17.5	39.2

The protein and calorific values vary between the two species as in Table 20.

Table 20. Protein and calorific value of smallstock milk

	Sheep	Goats
Kcal energy kg^{-1} milk	1,114	700
Grams protein kg^{-1} milk	63	36

These values are used in Table 21 to calculate the energy and protein yields per day.

Table 21. Daily energy and protein yields from smallstock milk

Management	Sheep		Goats	
	Energy (Kcal)	Protein (g)	Energy (Kcal)	Protein (g)
Traditional	19.5	1.1	24.6	1.26
Health programme	19.5	1.1	27.4	1.41

6.2.2. Meat production

Carcass growth rates were also recorded as shown in Table 22.

Table 22. Meat yields from smallstock (g per day)

Management	Sheep	Goats
Traditional	23	20
Health programme	27	24

With an energy value of 23,600 Kcal and a protein value of 1.45 kg per 10 kg of carcass, the energy and protein available can also be calculated as in Table 23.

Table 23. Daily energy and protein yields from smallstock meat

Management	Sheep		Goats	
	Energy (Kcal)	Protein (g)	Energy (Kcal)	Protein (g)
Traditional	54	3.3	47	2.9
Health programme	64	3.9	57	3.5

The normal ratio of sheep to goats in Rendille flocks is 1:1.5. Therefore household ownership of goats varies from 40 to 61 depending on whether data are used from Table 5 or 6, and the sheep vary from 27 to 40.

According to a recent survey of smallstock flock compositions, 40% of both species are adult females while the remainder can be considered as meat producers. Thus the protein and energy yield of a flock of smallstock numbering 101 animals, of which 24 goats and 16 sheep are milk producers and 37 goats and 24 sheep are meat producers, is as in Table 24.

Table 24. Daily energy and protein yield from smallstock flock

Management	Sheep		Goats	
	Energy (Kcal)	Protein (g)	Energy (Kcal)	Protein (g)
Traditional meat	1,296	79.2	1,739	107.3
Traditional milk	312	17.6	590	30.2
Total	1,608	96.8	2,329	137.5
Health programme meat	1,536	93.6	2,109	129.5
Health programme milk	312	17.6	658	33.8
Total	1,848	111.2	2,767	163.3

Note: These figures would be reduced by one-third for the smaller flock size quoted in Table 5.

Thus smallstock may supply from 22 to 26% of energy requirements and 55% of protein requirements of an average household. Under the health programme these proportions increase to 25-31% for energy and 65% for protein.

6.3. CATTLE

Simultaneous records have also been made on two herds of cattle under desert conditions. One received a health programme while the other was managed on traditional lines. Twenty-nine lactating cattle were monitored over a period of 22 months.

6.3.1. Milk yields

Average daily yield of milk per cow for human use for all cattle, whether in milk or not, was 335 cc for the traditional herd and 371 cc for the herd with the health programme. If we take the calorific value of cow's milk to be 700 Kcal per litre and the protein content to be 3.5% then the corresponding values are 235 Kcal and 11.7 grams protein for cows under traditional management and 260 Kcal and 13 grams protein for a cow under the health programme.

In the average household there are between 11 and 15 head of cattle. Of these 36% are adult females, equivalent to 4 to 5.4 animals in the typical household. Thus cow's milk may contribute the following amounts to the home diet.

Table 25. The contribution of cow's milk to daily energy and protein intake

Number of cows	4		5.4	
	Energy (Kcal)	Protein (g)	Energy (Kcal)	Protein (g)
Traditional herd	940	46.8	1,269	63.2
Health programme herd	1,040	52.0	1,404	70.2

6.3.2. Meat production

Data on meat production pertain only to calves at the present moment. They show no significant difference between calves receiving the health programme and those under traditional management, with mean daily weight gains being 170 grams and 179 grams, respectively. If we assume that 64% of the herd are contributing then the number per household is equivalent to 7 to 9.6 animals. Furthermore using the same calorific values for meat as mentioned for smallstock and a 50% carcass, the herd can yield nutrients towards the daily household budget as shown in Table 26.

Table 26. The contribution of beef to daily energy and protein intake

Number of cattle	7		9.6	
	Energy (Kcal)	Protein (g)	Energy (Kcal)	Protein (g)
Traditional herd	1,478	90.8	2,028	124.6
Health programme herd	1,404	86.3	1,926	118.3

Table 27. The combined contribution of milk and meat from cattle

Number of cattle	11		15	
	Energy (Kcal)	Protein (g)	Energy (Kcal)	Protein (g)
Traditional herd	2,418	137.6	3,297	187.8
Health programme herd	2,444	138.3	3,330	188.5

There is no significant difference between the treatments. From this we conclude that cattle may contribute from 13 to 22% of energy needs and from 33 to 45% of protein needs of the household.

We are now in a position to summarize the information from the different categories of livestock under traditional management (see Table 28).

Table 28. Daily yields from all livestock under traditional management

	Camels	Cattle	Smallstock
Average number owned	12	11	101
Energy from milk (Kcal)	2,541	940	902
Energy from meat (Kcal)	327	1,478	3,035
% of required minimum	19	16	26
% of required maximum	16	13	21
Protein from milk (g)	142	47	48
Protein from meat (g)	69	91	187
% of required diet	50	33	56

From Table 28 it is clear that under traditional management there is adequate protein available from the home livestock but that there is a shortfall in energy requirements ranging from 39 to 50%.

Under a health programme daily yields obtainable are as in Table 29.

Table 29. Daily yields from all livestock under the health programme

	Camels	Cattle	Smallstock
Average number owned	12	11	101
Energy from milk (Kcal)	3,581	1,040	970
Energy from meat (Kcal)	519	1,404	3,645
% of required minimum	27	16	31
% of required maximum	22	13	25
Protein from milk (g)	199	52	51
Protein from meat (g)	110	86	223
% of required diet	73	33	65

From these tables it can be seen that whereas the household herds are more than adequate for protein requirements they fall well short of supplying energy needs. Even under a health programme there is still a shortfall of energy ranging from 26 to 40%.

Although we have included a contribution from camel meat in these calculations this is perhaps premature as camels are rarely slaughtered except during drought. Also our management recommendations encourage building up camel herds since they are the least destructive, best adapted and most productive of the livestock categories. Furthermore additional males are required for a transport cadre which will enable livestock to reach and utilize the remotest parts of the range on a rotational basis.

The important position of the camel as food producer for the pastoralist is illustrated in these tables. Cattle, by contrast, contribute substantially less, they damage their environment in the process and there is little hope for their improvement.

Smallstock have an important function, in particular as a source of meat in dry seasons. Their milk contributes little to the diet. Smallstock are also a convenient size for minor trade negotiations and for social obligations. By selling a castrated goat or sheep a pastoralist can obtain KShs 150 with which to purchase 40 kg of maize meal or 20 kg of sugar. These energy-rich sources of food go a long way to filling the shortfall in energy in the diet and they remove the reliance of the pastoralist on milk in an environment which is hostile for milk production.

7. MANAGEMENT POLICY TO OPTIMIZE CAMEL PRODUCTIVITY

Detailed management recommendations for livestock in Western Marsabit have already been published by IPAL (1984).

It is clear from the data so far presented that livestock are producing well below their maximum potential and there is considerable room for improvement.

The three main interventions involve improvements in the spheres of (1) nutrition, (2) disease control, and (3) genetic resource base.

In summary these involve the following management procedures:

1. Nutrition

(a) The introduction of a prescribed rotational grazing programme such that stocking rates remain within the carrying capacity of the range.

(b) Collection and supply of supplementary feed in the form of *Acacia tortilis* pods which will be available at critical times of the year.

(c) Through education and extension, encourage a more equitable balance in the share of milk between the pastoralist and the camel calf.

2. Disease control

Special emphasis will be placed on the control of camel diseases through the veterinary clinics and extension workers already active in the area. The control of the following diseases is of major importance:

(a) Trypanosomiasis;
(b) Helminthiasis;
(c) Ticks and mange.

3. Genetic resource base

The introduction of more productive camels is recommended. Camels of the adjacent Somali breed are preferred, but other breeds such as those from Pakistan should be considered at a later date if they prove adaptable to the conditions prevailing in Kenya.

8. CONCLUSIONS

In what is probably the first and only simultaneous survey of the productivity of all major livestock categories in a part of the arid zone of Africa, we conclude that the camel is a most important source of food for pastoral households.

While the pastoral herds are more than adequate to supply protein needs, they fall short in their supply of energy. This is obtained through the sale of smallstock with which to purchase energy-rich cereals and sugar. Occasionally blood also supplements this need.

The introduction of a health programme for smallstock and camels will probably increase the energy intake of households by about 13%. Improved nutrition and more productive breeds may provide the remaining 26%.

Management recommendations are outlined and the key role of the camel is stressed in so far as it is well adapted to the arid zone and is therefore unlikely to damage its environment excessively should a health programme lift the existing constraints to the growth of livestock populations.

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TICK BURDENS OF CAMELS AND THEIR TREATMENT AND CHEMICAL ANALYSES OF CAMEL BLOOD

by

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1. IDENTIFICATION OF CAMEL TICKS

The following are tables of tick identifications by sex, species and attachment site from the IPAL experimental camels for the period June 1982 to January 1983. Relevant comments may be made as follows:

The first seven tables show the numbers of ticks identified for each of the seven collections. The numbers of ticks are not comparable between months because the numbers of camels from which collections were made were not constant. In the first sampling there was evidently a misunderstanding as only six animals were sampled in the Red (treatment) herd, and the ticks accumulated by camel rather than by attachment site.

In the July, August and September collections it appears that one side each of 20 camels was fully sampled from each herd, but including about 30% calves in the Red herd and less in the Blue (non-treatment) herd.

In the latter three collections 100% samples were taken from one side of 10 or 15 animals in each herd, all being yearlings or older.

The ticks were identified by me, after tuition by Dr T. Rutagwenda for which I am most grateful.

The appearance of *Hyalomma impeltatum* in these collections is of interest as it does not occur in the earlier IPAL records in the author's possession. My identifications of this species have been checked by Dr R. Tatchell of the FAO/DANIDA Acaricide Laboratory project at Kabete, to whom I am also grateful. *H. impeltatum* was collected at several sites in the study area by Miss Jane Walker a decade ago.

Nymphs were not distinguishable by sex or species. From the shape of the mouthparts I would guess that all were *Hyalomma*. At least *H. dromedarii* are known to use camels as first/second hosts. The occurrence of substantial numbers on certain individual camels would correlate with a two-host lifecyle. The situation seen in the field of very large numbers in the thicker coat of

the upper chest and hump does not seem to be well reflected in these figures. Nymphs are hardly visible and very difficult to collect until engorged.

The 'unknown' ticks were generally unidentifiable due to damage at the time of collection.

Hyalomma rufipes is now named *H. marginatum rufipes*.

It seems possible that in August the anus and tail samples from the Blue herd could have been subject to sampling error, and it is suggested that the relative proportions of *H. rufipes* and *H. truncatum* on anus and tail in Table 9 be treated with caution.

Tables 8 and 9 show that approximately 90% of all ticks on the camels were of the genus *Hyalomma* and all of the ticks collected from the nostrils were specifically *Hyalomma dromedarii*. Ticks in the nostrils accounted for 36% of all tick identified.

1.1 RESULTS OF IDENTIFICATIONS

Table 1. Lependera, 25 June 1982

RED HERD

		Camel number						
		70	152	170	505	508	572	Total
Hyalomma dromedarii	M	17	5	-	11	65	13	111
	F	17	2	-	8	48	4	79
H. impeltatum	M	-	-	-	-	1	-	1
	F	-	-	-	-	-	-	-
H. m. rufipes	M	1	-	1	-	3	3	8
	F	1	1	1	-	1	2	6
H. truncatum	M	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-
Amblyomma gemma	M	-	-	-	-	1	-	1
	F	-	-	-	-	-	-	-
Total		36	8	2	19	119	22	206

BLUE HERD

		Nostril	Ear	Axilla and groin	Anus and tail	Others	Total
Hyalomma dromedarii	M	77	85	3	65		230
	F	60	17	5	12		94
H. impeltatum	M	-	-	1	2	No	3
	F	-	-	-	1		1
H. m. rufipes	M	-	-	-	75	samples	75
	F	-	-	-	14	were	14
H. truncatum	M	-	-	5	4		9
	F	-	-	2	1	received	3
Amblyomma gemma	M	-	-	5	1	for	6
	F	-	-	1	-		1
Rhipicephalus pravus	M	-	3	-	-	other	3
	F	-	1	2	-		3
R. pulchellus	M	-	1	-	2	predilection	3
	F	-	-	-	-	sites	-
Unknown	M	-	-	-	-		-
	F	1	-	-	-		1
Nymphs		-	-	-	-		-
Total		138	107	24	177		446

Table 2. Lependera, 23 July 1982 (combined)

RED HERD

		Nostril	Ear	Axilla and groin	Anus and tail	Feet	Other	Total
Hyalomma dromedarii	M	17	10	1	1	1		30
	F	12	6	-	-	-		18
H. impeltatum	M	-	-	1	2	-	No	3
	F	-	-	-	1	-		1
H. m. rufipes	M	-	-	-	11	-	samples	11
	F	-	-	-	4	-		4
H. truncatum	M	-	-	-	-	6		6
	F	-	-	-	2	4	received	6
Amblyomma gemma	M	-	-	-	-	-		-
	F	-	-	-	-	-		-
Rhipicephalus pravus	M	-	-	-	-	-		-
	F	-	-	-	-	-		-
R. pulchellus	M	-	-	-	-	-		-
	F	-	-	-	-	-		-
Unknown	M	-	-	-	-	-		-
	F	-	-	-	-	-		-
Nymphs		-	2	-	-	-		-
Total		29	18	2	21	11	-	81

BLUE HERD

Hyalomma dromedarii	M	63	22	4	4	-		93
	F	1	5	-	-	-		6
H. impeltatum	M	-	-	3	1	-		4
	F	-	-	1	2	-		3
H. m. rufipes	M	-	-	-	21	-		21
	F	-	-	-	3	-		3
H. truncatum	M	-	-	-	2	3		5
	F	-	-	-	-	1		1
Amblyomma gemma	M	-	-	4	-	-		4
	F	-	-	-	-	-		-
Rhipicephalus pravus	M	-	1	-	-	-		1
	F	-	4	-	-	-		4
R. pulchellus	M	-	-	-	2	-		2
	F	-	-	-	-	-		-
Unknown	M	-	-	-	-	-		-
	F	-	-	-	-	-		-
Nymphs			11	3				14
Total		64	43	15	35	4		161

Table 3. Lependera, 28 August 1982

RED HERD

		Nostril	Ear	Axilla and groin	Anus	Tail	Feet	Other	Total
Hyalomma dromedarii	M	81	11	2	-	2			96
	F	60	5	-	-	4			69
H. impeltatum	M	-	-	7	-	-	No	No	7
	F	-	-	5	1	1			7
H. m. rufipes	M	-	-	-	5	2			7
	F	-	-	-	4	-	sample	sample	4
H. truncatum	M	-	-	7	-	18			25
	F	-	-	1	-	14			15
Amblyomma gemma	M	-	-	1	-	-			1
	F	-	-	-	-	-	rec'd	rec'd	-
Rhipicephalus pravus	M	-	1	-	-	-			1
	F	-	-	-	-	-			-
R. pulchellus	M	-	-	-	1	-			1
	F	-	1	1	2	-			4
Unknown	M	-	-	-	-	-			-
	F	-	-	-	-	-			-
Nymphs		-	-	-	-	-			-
Total		141	18	24	13	41			237

BLUE HERD

		Nostril	Ear	Axilla and groin	Anus	Tail	Feet	Other	Total
Hyalomma dromedarii	M	203	83	3	-	29			318
	F	93	16	-	-	2			111
H. impeltatum	M	-	-	5	-	11	No	No	16
	F	-	-	4	-	11			15
H. m. rufipes	M	-	-	-	-	73			73
	F	-	-	-	-	33	sample	sample	33
H. truncatum	M	-	-	1	-	3			4
	F	-	-	-	-	-			-
Amblyomma gemma	M	-	-	-	-	1	rec'd	rec'd	1
	F	-	-	-	-	1			1
Rhipicephalus pravus	M	-	3	-	-	-			3
	F	-	5	-	-	-			5
R. pulchellus	M	-	3	4	-	9			16
	F	2	1	3	-	5			11
Unknown	M	-	-	-	-	-			-
	F	1	-	-	-	-			1
Nymphs		-	22	2	12	-			36
Total		299	133	22	12	178			644

Table 4. Lependera, 23 and 24 September 1982

RED HERD

		Nostril	Ear	Axilla and groin	Anus	Tail	Feet	Other	Total
Hyalomma dromedarii	M	68	15	1	2	4	-	-	90
	F	70	11	3	-	3	-	-	87
H. impeltatum	M	-	-	14	2	-	1	-	17
	F	-	-	12	4	3	2	-	21
H. m. rufipes	M	-	-	2	9	-	-	-	9
	F	-	-	2	22	-	-	-	24
H. truncatum	M	-	-	-	1	21	6	-	30
	F	-	-	1	1	13	3	-	18
Amblyomma gemma	M	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	2	-	-	-		1	3
	F	-	5	-	-	1	-	-	6
R. pulchellus	M	1	-	3	1	-	-	1	6
	F	1	-	-	1	1	-	-	3
Unknown	M	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
Nymphs		-	-	-	-	-	-	-	-
Total		140	33	38	43	46	12	2	314

BLUE HERD 24 September

Hyalomma dromedarii	M	236	61	7	10	7	23	3	347
	F	87	30	1	4	3	10	2	137
H. impeltatum	M	-	-	11	9	1	3	-	24
	F	-	-	3	8	-	5	1	17
H. m. rufipes	M	-	-	-	42	6	-	-	48
	F	-	1	-	12	1	-	-	14
H. truncatum	M	-	-	2	2	12	11	-	27
	F	-	-	1	-	3	3	-	7
Amblyomma gemma	M	-	-	1	-	-	-	-	1
	F	-	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	2	-	-	-	-	-	2
	F	-	-	-	-	-	-	-	-
R. pulchellus	M	-	4	11	30	2	-	-	47
	F	-	-	-	1	-	-	-	1
Unknown	M	-	-	-	-	-	-	-	-
	F	1	2	-	-	-	-	1	4
Nymphs		-	1	-	-	-	1	-	2
Total		324	101	37	118	35	56	7	678

Table 5. *Fora* at Durr, 21 October 1982

RED HERD

		Nostril	Ear	Axilla and groin	Anus	Tail	Feet	Other	Total
Hyalomma dromedarii	M	11	12	1	-	2	-	5	31
	F	15	5	1	-	2	-	4	27
H. impeltatum	M	-	-	4	-	-	-	-	4
	F	-	-	6	-	-	-	-	6
H. m. rufipes	M	-	-	1	3	-	-	-	4
	F	-	-	-	2	1	-	-	3
H. truncatum	M	-	-	4	-	2	1	-	7
	F	-	-	-	-	-	-	-	-
Amblyomma gemma	M	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
R. pulchellus	M	-	-	-	-	-	-	-	-
	F	-	-	4	-	-	-	1	5
Unknown	M	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
Nymphs		-	1	-	-	-	-	119	120
Total		26	18	21	5	7	1	129	207

BLUE HERD

Hyalomma dromedarii	M	106	73	7	3	1	2	-	192
	F	12	9	1	1	-	-	-	23
H. impeltatum	M	-	-	32	2	-	-	-	34
	F	-	-	3	-	-	-	-	3
H. m. rufipes	M	-	-	-	5	3	-	-	8
	F	-	-	-	5	-	-	-	5
H. truncatum	M	-	-	11	-	-	2	-	13
	F	-	-	1	-	-	1	-	2
Amblyomma gemma	M	-	-	1	-	-	-	-	1
	F	-	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	4	-	-	-	-	-	4
	F	-	-	-	-	-	-	2	2
R. pulchellus	M	-	3	8	3	1	-	1	16
	F	-	-	1	1	-	-	-	2
Unknown	M	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
Nymphs		-	11	-	-	-	-	16	27
Total		118	100	65	20	5	5	19	332

Table 6. *Fora* at Kuiyar, 9 December 1982

RED HERD

		Nostril	Ear	Axilla and groin	Anus	Tail	Feet	Other	Total
Hyalomma dromedarii	M	58	20	3	-	-	1	1	83
	F	12	6	1	-	-	-	-	19
H. impeltatum	M	-	-	6	-	-	-	-	6
	F	-	-	5	-	-	-	-	5
H. m. rufipes	M	-	-	1	4	-	-	-	5
	F	-	-	1	2	-	-	-	3
H. truncatum	M	-	-	10	-	2	11	-	23
	F	-	-	1	1	-	-	-	2
Amblyomma gemma	M	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	-	-	1	-	-	-	1
	F	-	-	-	-	-	-	-	-
R. pulchellus	M	-	-	2	-	-	-	-	2
	F	-	2	2	-	-	-	-	4
Unknown	M	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
Nymphs									
Total		70	28	32	8	2	12	1	153

BLUE HERD

Hyalomma dromedarii	M	169	86	2	30	2	18	7	314
	F	5	3	-	2	1	-	3	14
H. impeltatum	M	-	-	14	16	-	5	1	36
	F	-	-	5	3	-	1	-	9
H. m. rufipes	M	-	-	2	99	-	-	1	102
	F	-	-	-	5	-	-	-	5
H. truncatum	M	-	-	16	54	-	32	6	108
	F	-	-	2	2	-	2	-	6
Amblyomma gemma	M	-	-	1	3	3	1	1	9
	F	-	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	-	-	-	-	-	-	-
	F	-	3	-	-	-	-	-	3
R. pulchellus	M	-	8	13	25	1	2	3	52
	F	-	-	1	-	-	-	-	1
Unknown	M	-	-	-	1	-	-	-	1
	F	-	-	-	1	-	-	-	1
Nymphs							1		1
Total		174	100	56	241	7	62	22	662

Table 7a. Six kilometres west of Illim, 13 January 1983

RED HERD

		Nostril	Ear	Axilla and groin	Anus	Tail	Feet	Other	Total
Hyalomma dromedarii	M	33		1	1		-	-	35
	F	29		-	-		1	1	31
H. m. rufipes	M	-	No	-	6	No	-	-	6
	F	-		-	3		-	-	3
H. truncatum	M	-		-	1		-	-	1
	F	-	sample	-	-	sample	-	-	-
Amblyomma gemma	M	-		-	-		-	-	-
	F	-		-	-		-	-	-
Rhipicephalus pravus	M	-	rec'd	-	-	rec'd	-	-	-
	F	-		-	-		-	-	-
R. pulchellus	M	-		-	-		-	-	-
	F	-		1	-		-	-	2
Unknown	M	-		-	-		-	-	-
	F	-		-	-		-	-	-
Nymphs		-		-	-		-	-	-
Total		62	0*	2	11	0*	1	1	77

* assumed

Table 7b. *Fora*, 9 kilometres south-east of Korr, 14 January 1983

BLUE HERD

Hyalomma dromedarii	M	30	21	2	-	-	5	-	58
	F	11	14	2	-	-	-	-	27
H. impeltatum	M	-	-	28	4	-	-	-	32
	F	-	-	21	5	-	3	-	29
H. m. rufipes	M	-	-	1	17	-	-	-	18
	F	-	-	-	6	-	-		6
H. truncatum	M	-	-	11	3	-	1	-	15
	F	-	-	5	1	-	2	-	8
Amblyomma gemma	M	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	-	-	-	-	-	-	-
	F	-	1	-	-	-	-	-	1
R. pulchellus	M	-	-	10	2	-	1	-	13
	F	-	-	3	-	-	1		4
Unknown	M	-	-	-	-	-	-	-	-
	F	1	-	-	-	-	-	-	1
Nymphs		-	-	-	-	-	-	-	-
Total		42	36	83	38		13	0	212

Table 8. Percentage frequency of species by month
(percentages less than 0.5 are not shown)

RED HERD

		June	July	Aug.	Sept.	Oct.	Dec.	Jan.	Mean
Hyalomma dromedarii	M	53	37	41	29	15	54	45	39
	F	38	22	29	28	13	12	40	26
H. impeltatum	M	1	4	3	5	2	4	-	3
	F	-	1	3	7	3	3	-	2
H. m. rufipes	M	4	14	3	3	2	3	8	5
	F	3	5	2	8	1	2	4	4
H. truncatum	M	-	7	11	10	3	15	1	7
	F	-	7	6	6	-	1	-	3
Amblyomma gemma	M	1	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	-	-	1	-	1	-	-
	F	-	-	-	2	-	-	-	-
R. pulchellus	M	-	-	-	2	-	1	-	-
	F	-	-	2	1	2	3	1	1
Nymphs		-	2	-	-	58	-	-	9
Total of ticks		206	81	237	314	207	153	77	1,275

Mean percentage of adult male *Hyalomma* = 54
Mean percentage of adult female *Hyalomma* = 35
Mean of *Rhipicephalus* species = 1

BLUE HERD

Hyalomma dromedarii	M	52	58	49	51	58	47	27	49
	F	21	4	17	20	7	2	13	12
H. impeltatum	M	1	2	2	4	10	5	15	6
	F	-	2	2	3	1	1	14	3
H. m. rufipes	M	17	13	11	7	2	15	8	10
	F	3	2	5	2	2	1	3	3
H. truncatum	M	2	3	1	4	4	16	7	5
	F	1	1	-	1	1	1	4	1
Amblyomma gemma	M	1	2	-	-	-	1	-	1
	F	-	-	-	-	-	-	-	-
Rhipicephalus pravus	M	1	1	-	-	1	-	-	-
	F	1	2	1	-	1	-	-	1
R. pulchellus	M	1	1	2	7	5	8	6	4
	F	-	-	2	-	1	-	2	1
Nymphs		-	9	6	-	8	-	-	3
Total of ticks		446	161	644	678	332	662	212	3,135

Mean percentage of adult male *Hyalomma* = 70
Mean percentage of adult female *Hyalomma* = 19
Mean of *Rhipicephalus* species = 6

Table 9. Mean percentage frequency of species by attachment site (all June data; July data for anus, tail and other; and August data for feet and other, are not included).

RED HERD

		Nostril	Ear	Axilla and groin	Anus	Tail	Feet	Other
Hyalomma dromedarii	M	57	60	21*	3	11	3	26*
	F	43	29	3	-	11	20*	26*
H. impeltatum	M	-	-	26	1	-	2	-
	F	-	-	16	3	2	3	-
H. m. rufipes	M	-	-	1	45	1	-	-
	F	-	-	2	35	4	-	-
H. truncatum	M	-	-	14	2	55*	59	-
	F	-	-	2	3	16	12	-
Amblyomma gemma	M	-	-	1	-	-	-	-
	F	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	2	-	2*	-	-	12*
	F	-	3	-	-	-	-	-
R. pulchellus	M	-	-	2	2	-	-	12*
	F	-	3	13*	4	-	-	-
Nymphs		-	3	-	-	-	-	23
Total of ticks		78	19	20	16	19	7	33
S.D.		51	11	15	15	22	6	64

BLUE HERD

Hyalomma dromedarii	M	83	65	13	7	21	29	25
	F	17	17	1	2	6	4	14
H. impeltatum	M	-	-	30	7	2	3	1
	F	-	-	12	4	2	7	5
H. m. rufipes	M	-	-	1	29	30	-	1
	F	-	-	-	11	5	-	-
H. truncatum	M	-	-	11	6	9	39	9
	F	-	-	2	1	2	14	-
Amblyomma gemma	M	-	-	5	-	11*	-	1
	F	-	-	-	-	-	-	-
Rhipicephalus pravus	M	-	2	-	-	-	-	-
	F	-	3	-	-	-	-	2
R. pulchellus	M	-	3	16	11	11	2	6
	F	-	-	3	1	1	2	-
Nymphs			9	5	20*			33
Total of ticks		170	85	46	86	45	28	12
S.D.		119	38	26	96	76	29	10

* Note that these figures are grossly exaggerated by low sample sizes.

S.D. = Standard deviation

2. TICK COUNTS ON CAMELS

2.1 INTRODUCTION

During the period from the last week of September 1982 until the second week of January 1983, a series of four detailed counts were made of the ticks on camels subjected to a variety of acaricidal treatments. The period spanned the changes in humidity and range condition from the end of a moderate dry season to about three weeks after the end of a substantial wet season. Each of the four counts found the camels in a different area, and, indeed, for the last count the treatment and control herds were not resident in the same area.

2.2. BACKGROUND

All of the treatment herd were subjected to routine weekly spraying with normal-strength 'Delnav DFF' (Wellcome), plus the application of pyrethrum-based 'Tick-grease' (Cosmos Ltd.) in the nostrils, throughout the period covered by the counts, except as explained in Tables 10 to 13. Monthly, up to 23 September 1982, all camels in the herds were subjected to regular half-body tick-counts, and total half-body tick collections were made from about 30% of animals. Subsequent counts and collections during this investigation were made only on adult and sub-adult camels as juveniles tend to carry very few ticks.

2.3 OBJECTIVES

The objectives of this investigation were to compare the effects on tick numbers of various treatments as follows:

A. <u>On the camel's body as a whole</u>:

i) Spraying with double-strength Delnav;
ii) Spraying with normal-strength Delnav;
iii) No spraying as control.

B. <u>In the camel's nostrils</u>:

i) Applying Delnav double-strength } by hand
ii) Applying Delnav normal-strength } with a cloth;
iii) Applying Tick-grease by hand;
iv) Leaving controls untreated.

In each case with and without a superimposed effect of removing ticks physically by hand for collection.

C. In one trial only, on the camel's ears:

i) Applying Delnav normal-strength by hand with a cloth;
ii) Applying Tick-grease by hand;
iii) Leaving controls untreated.

2.4 RATIONALE

(a) During the course of tick counting in earlier months it had been found that the treatment herd had generally lower counts than the control herd, but it was not well established how much of this benefit was due to the direct killing effect of the acaricide on the ticks and how much was due to the natural resistance and immunity of the camels. (The treatment herd are subject to other veterinary inputs as well as the acaricidal treatments and appear in generally better health than the control herd.)

(b) Standard advice on the spraying of cattle states that 8 litres of spray-wash are necessary to thoroughly spray an adult animal. Camels have a larger body surface area, though probably less coat. Camel ticks are generally larger than those found on cattle, though they are more concentrated into specific feeding or 'predilection' sites on the body, some of them not easily accessible for spraying. IPAL experience was that only about 2.5 litres of wash were being used to spray each camel.

(c) A high proportion of a camel's tick load may consist of ticks of the species *Hyalomma dromedarii* attached within the nostrils. Because of the camel's ability to close its nostrils it is almost impossible to spray inside, and separate hand treatments are therefore employed. The interior of a camel's nostril, and any ticks attached therein, may be coated in a highly variable quantity of mucus. I do not know whether larger quantities of mucus are correlated with tick burden, with the presence of larvae of *Oestrus* flies further up the nose, or are due to other causes, but it appears that the mucus affects both the penetration and adhesion of acaricidal chemicals to the ticks, and to the epithelial surfaces to which they attach.

(d) Neither camels nor their owners are very happy about the spraying of ears. The camel's head can be highly mobile and the ears are a difficult target to spray thoroughly. The final trial therefore included, at Mr. Simpkin's request, a comparison of manual treatments of ears instead of spraying.

2.5 THEORY

Again extrapolating from the known situation in cattle in more humid areas:

(a) Delnav DFF applied as a spray at the recommended concentration should kill a high percentage (of the order of 97%), of ticks that come into contact with it on any one occasion.

(b) The Delnav concentrate in the spray-wash mixture preferentially adheres to hair and skin and after drying should continue to kill any ticks attempting to attach to sprayed skin surfaces for a further period of two or three days.

(c) Such residual effect tends to be inferior on hairless skin surfaces, and greasy acaridical preparations are therefore marketed for manual application where necessary to prolong the period of residual effect.

(d) Larval and non-engorged nymphal ticks are so small that they are generally overlooked on routine counts. Counts such as those described are, therefore, mainly of adult ticks, although some of the great individual variation between camels is due to occasional high counts of smaller ticks, presumably engorged nymphs.

(e) Adult female ticks spend from 5 to 10 days on the host, longer if they are not mated, and their probability of being mated may be poor when the population of the species is low. Males tend to spend three weeks or more on the host. In a situation of stable tick loads and stable challenge, therefore, a standard tick burden may take a couple of weeks to re-establish after complete removal of all ticks from a host. Under a regime of weekly acaricide treatments, with a two-day residual effect of the acaricide, all ticks should be affected by the acaricide at least once, and tick burdens at the end of a week are likely to be less than 50% of the stable burden of untreated animals.

(f) Manual removal offers a chance of 100% removal of visible ticks from a host, to compare with the effect of acaricide, but there is, of course, no residual effect following manual removal.

2.6 METHOD

(a) These trials were designed to gain additional information on the immediate effects of acaricidal treatments without disturbing the established routine of weekly spraying and monthly tick collections.

(b) On the first day of each count all ticks were counted on one side of each camel, and the figures in the tables are half-body counts, excepting both nostrils and both ears where these are shown separately. Totals in the tables are of the half-body only, and exclude the nostril and ear counts of the opposite side. Where ticks were collected by hand they were similarly removed only from the one side of the body. Hence ticks were removed from only 50% of nostrils under each of the nostril treatments.

(c) Camels were roughly selected for each treatment and control group to make the groups as directly comparable as possible.

(d) Approximately equal numbers within each group of animals were counted/collected on each side of the body, except that in the first trial all of the control herd animals were counted on the right.

(e) Immediately after the counting/collection on the first day the camels of the treatment groups were subjected to whole-body spraying and nostril and ear treatments as described in the tables. Spraying of the predilection sites was done thoroughly, but minimal attention was paid to the rest of the body ('other' in the tables of counts). Spray usage was of the order of 3 litres per camel.

(f) On following dates, as shown in Tables 10 - 13 ticks were recounted on the same sides of the same camels. Only live ticks were counted; dead ones were ignored.

2.7 OBSERVATIONS

(a) Impressions gained in the field and examination of the figures suggest that few results of significance have been obtained due to geographical, climatic and individual variation, the generally low level of tick burdens counted, and the small sample sizes.

(b) It would appear that tick challenge in *fora* situations was much lighter, at least than the challenge around the long-established *boma* at Lependera.

(c) Counts on the second and third days after treatment show disappointingly high numbers of ticks, and suggest that either the technique of treatment was inadequate or that the acaricides were not highly effective. Unfortunately

the control groups on occasions showed declining counts comparable to the apparent effect in the treatment groups.

(d) It could be said that Delnav applied by cloth in the nostrils was as effective as tick-grease, possibly due to the rubbing action of the cloth aiding penetration through the mucus.

(e) There is indication in Tables 4 and 6 that Tick-grease is possibly more effective than Delnav in controlling ticks on the ears, even when the Delnav is applied with a cloth. Ears are notoriously difficult to treat with a spray lance due to reluctance on the parts of both the camels and the herdsmen. Tick-grease treated ears remained greasy for most of the following week, whereas the grease did not appear to last long in the nostrils. Over 20% of total ticks counted were on the ears, of which 85% were *Hyalomma dromedarii*.

(f) There is little evidence of any benefit in using double-strength Delnav rather than the manufacturer's recommended concentration.

(g) Table 18 illustrates the importance of nostrils and ears in the overall maintenance of a tick burden, and shows that control measures have been no more successful at these sites than elsewhere on the body.

(h) The implication from Tables 19 and 20 is that whole-body spraying with Delnav plus the specific treatment of nostrils as carried out is probably less than 50% effective in controlling *Hyalomma* on camels. Physical removal of ticks by hand was about as efficient over 2 to 3 days i.e. this method has a known 100% efficiency on Day 0, and no residual effect, but the reason for the observed modest efficiency of Delnav over the same period has not been explained.

(i) Enquiries made at Kabete reveal that it is generally understood that organophosphorus acaricides are less effective against *Hyalomma* species than against the small-mouth-part ticks (e.g. *Rhipicephalus*), though the difference has not been quantified. This may help to explain the apparently poor results of spraying and the quantifications done by IPAL may be of wider interest.

(j) It is not known why there was a net reduction in the numbers of tick on the control animals in the combined trial results shown in Tables 19 and 20 above. Over the four month period of the trials, however, there was a progressive decline in the numbers of ticks counted on the control camels, from a half-body mean of 93 to a half-body mean of 16, as the herds moved farther from the home *boma* and improved in bodily condition in response to the exceptionally good wet season.

Table 10. Camels at the home *boma*, Lependera

(Acaricidal treatments, tick collections and total tick counts carried out on 23 September 1982 followed by detailed counts on 25, 28 and 30 September).

Section A

Double-strength Delnav DFF used for whole-body spraying, and for application by cloth in the right nostril. Tick-grease applied in the left nostril.

i) Ticks removed from the counted side of the body by hand, for collection. n = 11

Date	23rd		25th		28th		30th	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Left nostril			3.27	3.82	4.36	3.80	6.45	5.57
Right nostril			1.55	2.11	3.00	2.49	4.09	3.11
Ear			1.45	2.66	0.45	0.82	0.72	0.90
Axilla			0.09	0.30	0.64	0.81	1.36	1.43
Groin			0.18	0.60	0.18	0.60	0.72	1.35
Anus			0.64	0.81	1.36	1.21	1.63	2.29
Tail			0.36	0.67	0.72	1.27	0.72	1.27
Feet			0	0	0.09	0.30	0.45	1.51
Other			0.09	0.30	0	0	0.09	0.30
Total	14.36	7.31	5.27	2.94	7.27	4.31	10.81	4.79
ii) Ticks not removed by hand. n = 11								
Left nostril			2.63	2.46	5.54	4.68	6.91	5.01
Right nostril			3.91	4.21	1.36	1.57	2.45	2.50
Ear			1.55	2.34	0.64	1.03	0.82	0.98
Axilla			1.45	2.16	1.09	1.22	2.27	4.10
Groin			0.82	1.17	0.55	0.82	0.55	1.21
Anus			0.73	0.90	1.55	1.37	1.82	2.04
Tail			1.45	2.70	2.09	2.51	1.91	2.77
Feet			0.27	0.90	0.36	1.21	0.09	0.30
Other			0.09	0.30	0.09	0.30	0	0
Total	17.82	4.07	10.09	4.64	9.55	5.24	11.27	6.03

$\bar{x}$ = Mean

S.D = Standard Deviation

Table 10 continued.

Section B

Normal strength Delnav used for whole-body spraying and application by cloth in the right nostril. Tick-grease used in the left nostril.

i) Ticks removed from the counted side of the body by hand. n = 7

Date	23rd		25th		28th		30th	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Left nostril			2.71	2.69	5.86	5.01	9.57	8.42
Right nostril			4.57	4.28	3.86	2.41	6.57	2.94
Ear			0.29	0.49	0.14	0.38	1.14	1.07
Axilla			0	0	0.57	1.13	0.43	0.79
Groin			0	0	0.29	0.49	0.29	0.76
Anus			0.29	0.76	1.71	2.75	2.43	1.40
Tail			0.57	0.98	0.43	0.79	1.57	2.30
Feet			0	0	0	0	0	0
Other			0.14	0.38	0.14	0.38	0.29	0.49
Total	20.14	7.34	4.14	3.93	8.43	4.43	13.86	9.23

ii) Ticks not removed by hand. n = 11

Left nostril			11.27	17.26	15.36	18.36	16.09	17.50
Right nostril			6.18	8.32	6.45	9.21	10.09	8.51
Ear			2.00	3.49	1.09	1.76	0.82	1.08
Axilla			0.91	2.70	1.91	3.96	1.27	2.87
Groin			0.18	0.40	0.82	1.60	0.73	1.79
Anus			0.82	1.17	1.18	0.75	1.73	1.56
Tail			3.82	5.08	4.00	4.27	4.00	4.52
Feet			0	0	0.64	1.57	0.27	0.90
Other			0.09	0.30	0.27	0.47	0.18	0.40
Total	33.73	34.59	18.09	24.10	21.45	20.46	23.45	18.88

$\bar{x}$ = Mean

S.D. = Standard deviation

Table 10 continued.

Section C

Control herd: no acaricidal treatments carried out.

i) Ticks removed from the counted side of the body by hand. n = 15

Date	23rd		25th		28th		30th	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Nostril			6.40	7.42	14.33	13.55	20.13	17.27
Ear			2.93	3.61	3.67	5.21	4.13	6.14
Axilla			0.13	0.35	0.47	0.92	0.40	0.74
Groin			3.53	3.25	4.67	5.12	2.93	3.15
Anus			2.87	2.53	5.00	2.73	5.67	2.99
Tail			5.00	5.32	3.00	3.95	2.93	2.94
Feet			2.27	2.63	2.07	3.47	2.73	4.15
Other			0.20	0.41	0.80	1.15	0.40	0.83
Total	60.20	44.76	23.33	14.70	36.00	23.62	39.33	23.72

ii) Ticks not removed by hand. n = 15

Nostril			59.20	27.58	48.00	20.86	40.13	16.85
Ear			9.73	25.31	8.80	25.35	8.20	22.86
Axilla			0.20	0.56	0.27	0.46	0.33	0.62
Groin			4.87	4.32	4.73	4.28	3.47	4.31
Anus			9.00	6.52	9.87	6.45	8.67	6.89
Tail			3.87	4.94	3.33	4.48	4.40	5.10
Feet			2.67	4.97	3.00	6.59	2.53	3.18
Other			0.73	1.67	0.47	0.92	0.20	0.56
Total	126.20	61.17	90.27	45.54	78.46	41.61	67.93	35.73

$\bar{x}$ = Mean

S.D. = Standard deviation

Table 11. Camels at *fora* at Durr

(Acaricidal treatment on 13 October 1982 but no tick collection. Detailed tick counts on 13, 16 and 21 October. Tick collection on 21 October).

Section A

Double-strength Delnav used for whole-body spraying and application by cloth to the left nostril. Tick-grease applied in the right nostril. n = 20

Date	13th		16th		21st	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Left nostril	0.45	0.60	0	0	0.45	0.83
Right nostril	0.25	0.44	0.05	0.22	0.40	0.82
Ear	0.35	0.67	0.50	2.01	0.20	0.41
Axilla	0.80	1.47	0.15	0.37	0.20	0.62
Groin	0.15	0.49	0.05	0.22	0.25	0.64
Anus	0.70	1.17	0.20	0.52	0.35	0.67
Tail	0.30	0.47	0.15	0.37	0.20	0.41
Feet	0	0	0	0	0.05	0.22
Other	0.65	1.09	0.65	1.79	1.40	3.03
Total	3.40	2.26	1.75	2.63	2.75	2.97

Section B

Normal-strength Delnav used for whole-body spraying and application by cloth to the left nostril. Tick-grease applied in the right nostril. n = 20

Left nostril	0.95	1.39	0.10	0.31	1.20	1.88
Right nostril	1.00	1.12	0.20	0.70	1.20	2.24
Ear	0.50	1.10	0.10	0.31	0.65	1.14
Axilla	0.40	0.68	0.25	0.91	0.60	1.35
Groin	0.10	0.45	0.05	0.22	0.10	0.31
Anus	0.30	0.80	0.10	0.31	0.15	0.49
Tail	0.30	0.92	0.10	0.31	0.45	0.76
Feet	0	0	0	0	0	0
Other	0.30	0.57	0.85	2.01	5.35	10.13
Total	3.05	2.35	1.70	2.45	8.60	11.05

$\bar{x}$ = Mean

S.D. = Standard deviation

Table 11 continued.

Section C

Control herd: no acaricidal treatments carried out. n = 20

Date	13th		16th		21st	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Nostril	9.45	6.29	8.55	4.54	7.80	5.52
Ear	5.35	5.25	3.65	3.72	5.20	7.92
Axilla	2.60	3.57	1.75	2.47	1.95	3.52
Groin	3.05	3.49	3.00	3.99	1.75	2.83
Anus	1.30	1.08	1.15	1.42	1.00	1.41
Tail	2.30	2.64	1.85	2.56	0.25	1.12
Feet	0.85	1.69	0.65	1.27	0.35	0.88
Other	4.40	7.56	3.65	4.91	1.25	2.00
Total	29.30	13.77	24.25	12.05	19.55	13.13

Table 12. Camels at *fora* at Kuiyar

(Acaricidal treatments and tick collection on 9 December 1982. Detailed tick counts on 9, 11, 13 (14 control herd) and 16 December).

Section A

Normal-strength Delnav used for whole-body spraying and application by cloth to the right nostril. Tick-grease applied in the left nostril.

i) Ticks from the counted side of the body removed by hand. n = 20

Date	9th		11th		13th		16th	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Left nostril	1.85	2.62	0.10	0.31	0.30	0.98	2.69	2.75
Right nostril	1.90	3.09	0.15	0.49	0.45	1.10	1.65	2.25
Ear	1.45	1.70	0.15	0.49	0.80	1.20	2.65	2.70
Axilla	0.80	1.36	0	0	0.10	0.31	0.35	0.81
Groin	0.80	1.64	0	0	0.20	0.89	0.25	0.55
Anus	0.40	0.68	0.05	0.22	0.20	0.41	0.05	0.22
Tail	0.10	0.45	0	0	0	0	0.10	0.45
Feet	0.60	1.27	0.10	0.45	0	0	0.10	0.31
Other	0.05	0.22	0	0	0.10	0.45	0.20	0.62
Total	6.40	4.92	0.45	0.76	1.65	2.08	5.45	4.22

$\bar{x}$ = Mean S.D. = Standard deviation

Table 12 continued.

ii) Ticks not removed by hand. n = 20

Date	9th		11th		13th		16th	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Left nostril	1.90	1.92	0.15	0.49	0.45	1.05	1.65	2.13
Right nostril	0.60	0.82	0.05	0.22	0.25	0.44	1.65	1.93
Ear	1.60	1.57	0.60	0.88	0.85	0.99	6.70	4.90
Axilla	0.95	1.47	0.20	0.70	0.15	0.49	0.60	1.47
Groin	0.20	0.41	0	0	0	0	0.30	0.66
Anus	0.25	0.72	0.05	0.22	0.10	0.45	0.15	0.67
Tail	0.15	0.37	0	0	0	0	0.10	0.31
Feet	0.35	0.75	0.20	0.70	0.05	0.22	0.20	0.62
Other	0	0	0.15	0.37	0	0	0.95	2.04
Total	4.45	3.73	1.20	1.20	1.35	1.73	10.55	6.04

Section B

Control herd: no acaricidal treatment carried out. All ticks from the counted side of the body removed by hand. n = 20

Nostril	8.50	7.51	1.60	2.30	3.05	4.16	2.65	3.76
Ear	5.80	4.56	1.25	1.45	2.25	2.61	2.95	3.85
Axilla	1.00	2.38	0.10	0.31	1.10	2.22	0.40	1.14
Groin	2.20	2.63	3.10	3.42	3.25	3.74	1.30	2.23
Anus	7.30	6.28	0.30	0.92	1.15	2.52	0.95	2.33
Tail	0.10	0.45	0.75	1.37	0.40	0.68	0.05	0.22
Feet	3.05	3.85	1.50	3.43	1.65	2.78	0.70	1.49
Other	0.80	1.54	0.05	0.22	0.10	0.31	0.40	1.35
Total	28.75	15.21	8.65	7.13	12.90	9.14	9.50	7.21

$\bar{x}$ = Mean

S.D. = Standard deviation

Table 13. Treatment herd camels at new *boma* site 6 km west of Illim; control herd 14 km further north-west in *fora*

(Acaricidal treatments of the treatment herd on 6 January 1983, and detailed tick counts on 6, 8, 10 and 13 January. Detailed counts on the control herd on 7, 11 and 14. No tick collections made until 13 and 14 January respectively).

A. Treatment herd

Normal-strength Delnav used for whole-body spraying except the head, and for application by cloth to the right nostril and right ear. Tick-grease applied to the left nostril and ear by hand. n = 30

Date	6th		8th		10th		13th	
	$\bar{x}$	S.D	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D
Left nostril	8.67	6.56	4.20	5.96	3.43	4.39	5.45	7.43
Right nostril	10.47	12.43	2.90	2.84	3.20	4.41	4.90	4.23
Left ear	10.23	7.52	1.00	1.55	1.83	2.65	2.83	3.64
Right ear	8.50	4.07	3.17	1.85	2.90	2.13	3.57	3.12
Axilla	1.20	2.73	0.27	0.68	0.33	0.87	0.40	1.11
Groin	1.50	2.06	0.13	0.43	0.33	0.70	0.33	0.87
Anus	0.30	0.59	0.10	0.30	0.13	0.43	0.37	1.05
Tail	0	0	0	0	0.03	0.18	0	0
Feet	0.37	0.95	0.50	1.31	0.06	0.25	0.10	0.30
Other	0.33	1.30	0.23	0.50	0	0	0.23	0.80
Total	22.33	13.70	6.80	6.78	5.57	5.10	9.53	9.45

B. Control herd

No acaricidal treatments carried out. n = 20

Date	7th		11th		14th	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Nostril	1.60	1.93	2.25	2.24	3.40	3.25
Ear	3.25	2.79	2.30	2.58	2.50	2.14
Axilla	2.00	3.09	1.50	2.69	2.35	2.43
Groin	4.15	3.76	2.55	2.48	3.85	4.68
Anus	1.20	1.74	2.20	2.80	3.15	3.41
Tail	0.35	0.81	0.25	0.55	0	0
Feet	1.85	3.96	1.45	3.43	2.40	4.66
Other	0	0	0	0	0	0
Total	14.40	7.87	12.70	7.66	17.65	9.70

$\bar{x}$ = Mean S.D. = Standard deviation

Table 14. Comparison of tick counts in nostrils treated with Delnav DFF or Tick-grease

A. ex Table 10 Treatments on Day 0

		Day 2		Day 5		Day 7	
		$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Delnav double-strength							
50% of ticks removed by hand	n = 11	1.55	2.11	3.00	2.49	4.09	3.11
ticks not removed	n = 11	3.91	4.21	1.36	1.57	2.45	2.50
Delnav normal-strength							
50% of ticks removed by hand	n = 7	4.57	4.28	3.86	2.41	6.57	2.94
ticks not removed	n = 11	6.18	8.32	6.45	9.21	10.09	8.51
Tick-grease							
50% of ticks removed by hand	n = 18	3.06	3.35	4.61	4.13	7.67	6.76
ticks not removed	n = 22	6.95	12.82	9.09	12.92	11.50	13.41
Delnav combined results							
50% of ticks removed by hand	n = 18	2.72	3.37	2.89	2.27	5.06	3.21
ticks not removed	n = 22	5.05	6.54	3.91	6.96	7.00	7.61
Control							
All ticks removed by hand	n = 15	6.40	7.42	14.33	13.55	20.13	17.27
ticks not removed	n = 15	59.20	27.58	48.00	20.86	40.13	16.85

B. ex Table 11

Treatments on Day 0, no removal of ticks by hand.

		Day 0		Day 3		Day 8	
		$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Delnav							
double-strength	n = 20	0.45	0.60	0	0	0.45	0.83
normal-strength	n = 20	0.95	1.39	0.10	0.31	1.20	1.88
Tick-grease	n = 40	0.62	0.91	0.12	0.52	0.80	1.69
Control	n = 20	9.45	6.29	8.55	4.54	7.80	5.52

$\bar{x}$ = Mean S.D. = Standard deviation

Table 14 continued.

C. ex Table 12

Treatments and tick collections (50% from treatment group, 100% from controls) on Day 0; Delnav used at normal strength only, n = 20 for each group.

	Day 0		Day 2		Day 4		Day 7	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Delnav	1.90	3.09	0.15	0.49	0.45	1.10	1.65	2.25
Tick-grease	1.85	2.62	0.10	0.31	0.30	0.98	2.69	2.75
Control	8.50	7.51	1.60	2.30	3.05	4.16	2.65	3.76

D. ex Table 13

Treatments on Day 0, no removal of ticks by hand, Delnav used at normal-strength only.

Delnav	n = 30	10.47	12.43	2.90	2.84	3.20	4.41	4.90	4.23
Tick-grease	n = 30	8.67	6.56	4.20	5.96	3.43	4.39	5.45	7.43
Control	n = 20	1.60	1.93			2.25	2.24	3.40	3.25

Table 15. Comparison of treatments of ears

A. ex Table 11

Acaricidal treatment by spraying, no removal of ticks by hand for collection. n = 20 each group.

	Day 0		Day 3		Day 8	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Delnav						
double-strength	0.35	0.67	0.50	2.01	0.20	0.41
normal-strength	0.50	1.10	0.10	0.31	0.65	1.14
Control	5.35	5.25	3.65	3.72	5.20	7.92

$\bar{x}$ = Mean

S.D. = Standard deviation

Table 15 continued.

B. ex Table 12

Acaricidal treatment by spraying, normal-strength Delnav only, n = 20 in each group.

	Day 0		Day 2		Day 4		Day 7	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Delnav plus 100% removal of ticks by hand	1.45	1.70	0.15	0.49	0.80	1.20	2.65	2.70
Delnav alone	1.60	1.57	0.60	0.88	0.85	0.99	6.70	4.90
Control 100% removal of ticks by hand alone	5.80	4.65	1.25	1.45	2.25	2.61	3.05	3.87

C. ex Table 13

Comparison of normal-strength Delnav applied by cloth and Tick-grease applied by hand, no removal of ticks by hand; n = 30 in the treatment groups and n = 20 in the control group.

	Day 0		Day 2		Day 4		Day 7	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Delnav	8.50	4.07	3.17	1.85	2.90	2.13	3.57	3.12
Tick-grease	10.23	7.52	1.00	1.55	1.83	2.65	2.83	3.64
Control	3.25	2.79			2.30	2.58	2.50	2.14

$\bar{x}$ = Mean

S.D. = Standard deviation

Table 16. Comparison of the effects of spraying the body as a whole excluding nostrils and ears

A. ex Table 11

No ticks removed by hand, n = 20 in each group.

	Day 0		Day 3		Day 8	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Delnav						
double-strength	2.55	2.24	1.20	1.70	1.90	2.10
normal-strength	1.40	1.50	1.35	2.06	6.65	10.33
Control	14.50	9.13	10.85	5.89	6.55	3.89

B. ex Table 12

Normal-strength Delnav used alone, n = 20 in each group.

	Day 0		Day 2		Day 4		Day 7	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Delnav								
All ticks removed by hand	2.75	2.05	0.15	0.49	0.60	1.19	1.05	1.28
Ticks not removed	1.90	1.97	0.60	0.99	0.20	0.52	2.30	3.21
Control								
All ticks removed by hand	14.40	8.65	5.80	5.71	7.65	6.79	3.80	3.87

C. ex Table 13

Normal-strength Delnav used, no removal of ticks by hand, treatment herd n = 30 and control herd n = 20.

Treatment	3.70	3.23	1.23	1.52	0.90	1.47	1.43	2.38
Control	9.60	6.76	-	-	7.95	6.08	11.75	8.03

$\bar{x}$ = Mean

S.D. = Standard deviation

Table 17. Summed percentage changes from Day 0

(Figures taken from Tables 11, 12 and 13 and also from Table 10 in Section D. Day 0 = 100 in all cases. Figures for subsequent days are the counts of ticks expressed as a percentage of the initial figure).

A. NOSTRILS

		Day 2	Day 3	Day 4	Day 5	Day 7	Day 8
1	No ticks removed by hand						
(a)	Double-strength Delnav n = 20		0				100
(b)	Normal-strength Delnav n = 20		10				126
	n = 50	27		31		59	
(c)	Tick-grease n = 40		19				129
	n = 30	48		40		63	
(d)	Control n = 20		89				83
	n = 20			140		212	
2	50% of ticks removed by hand from treatment groups, 100% from controls						
(a)	Normal-strength Delnav n = 20	8		24		87	
(b)	Tick-grease n = 20	5		16		145	
(c)	Control n = 20	19		36		31	

B. EARS

		Day 2	Day 3	Day 4	Day 5	Day 7	Day 8
1	No ticks removed by hand						
(a)	Double-strength Delnav n = 20		143				57
(b)	Normal-strength Delnav n = 20		20				130
	n = 50	37		37		102	
(c)	Tick-grease n = 30	10		18		28	
(d)	Control n = 20		68				97
	n = 20			71		77	
2	100% of ticks removed by hand from the ears						
(a)	Normal-strength Delnav n = 20	10		55		183	
(b)	Control n = 20	22		39		53	

Table 17 continued.

C. THE REST OF THE BODY

		Day 2	Day 3	Day 4	Day 5	Day 7	Day 8
1. No ticks removed by hand							
(a) Double-strength Delnav	n = 20		47				75
(b) Normal-strength Delnav	n = 20		96				475
	n = 50	33		20		67	
(c) Control	n = 20		75				45
	n = 20			83		122	
2. 100% of ticks removed by hand							
(a) Normal-strength Delnav	n = 20	5		22		38	
(b) Control	n = 20	40		53		26	

D. WHOLE-BODY TREATMENTS AS CARRIED OUT

1. No ticks removed by hand							
(a) Double-strength Delnav	n = 11	57			54	63	
	n = 20		51				81
(b) Normal-strength Delnav	n = 11	54			64	70	
	n = 20		56				282
	n = 50	30		26		75	
(c) Control	n = 15	72			62	54	
	n = 20		83				67
	n = 20			88		123	
2. Ticks removed by hand as described							
(a) Double-strength Delnav	n = 11	37			51	75	
(b) Normal-strength Delnav	n = 7	21			42	69	
	n = 20	7		26		85	
(c) Control	n = 15	39			60	65	
	n = 20	30		45		33	

Table 18. Percentage contribution of the various predilection sites to total tick burden at 7 or 8 days after treatment.

(Treatment routine spraying plus Tick-grease in the nostrils, or as described. Species, instar and sex compositions of the burdens of 21 October and 9 December 1982 and 13 January 1983 will be known after identification of the collections).

TREATED HERD

	30 Sept.	13 Oct.	21 Oct.	9 Dec.	16 Dec.	6 Jan.	13 Jan.	% of all ticks counted
n =	40	40	40	40	40	30	30	260
Nostril	49	25	13	29	26	42	53	38
Ear	6	13	7	28	54	41	33	28
Axilla	11	19	7	17	6	5	4	8
Groin	5	4	5	9	4	7	3	6
Anus	14	15	7	6	1	1	4	6
Tail	13	9	6	2	1	0	0	4
Feet	2	0	1	9	2	2	1	2
Other	0	15	54	0	6	2	2	8

CONTROL HERD

n =	30	20	20	20	20	20	20	150
Nostril	55	32	40	30	28	11	19	36
Ear	11	18	27	20	31	23	14	18
Axilla	1	9	10	3	4	14	13	6
Groin	6	11	9	8	14	29	22	12
Anus	14	4	5	25	10	8	18	13
Tail	7	8	1	0	1	2	0	4
Feet	5	3	2	11	8	13	14	7
Other	1	15	6	3	4	0	0	4

Table 19. Summary of mean tick numbers from all whole body counts with and without spraying and specific treatments for ears and nostrils

A. Complete removal of ticks by hand on Day 0:

			Day 0	Day 2	% change
Treatment herd:	n = 38	$\bar{x}$:	11.23	2.53	77
		SD:	8.14	3.19	
Control herd:	n = 35	$\bar{x}$:	42.23	14.19	66
		SD:	34.69	13.10	

B. Without removal of ticks by hand on Day 0:

			Day 0	Days 2,3 or 4	% change
Treatment herd:	n = 112	$\bar{x}$:	12.99	5.42	58
		SD:	16.69	9.77	
Control herd:	n = 55	$\bar{x}$:	50.31	38.05	24
		SD:	57.44	40.93	

Note: The columns headed '% change' show the percentage change of mean tick numbers from 'Day 0', and in all cases are reductions in the number of ticks. The Day 4 count was in the last trial, control herd.

Table 20. Summary of mean tick numbers from all nostril counts respectively for treatments with Delnav, with Tick-grease, and the control herd.

A. Removal of ticks by hand on Day 0:

			Day 0	Day 2 or 3	% change	Day 4	% change
Delnav	n = 20	$\bar{x}$:	1.90	0.15	92	0.45	76
(50% tick removal)		SD:	3.09	0.49		1.10	
Tick-grease	n = 20	$\bar{x}$:	1.85	0.10	95	0.30	84
(50% tick removal)		SD:	2.62	0.31		0.98	
Control	n = 20	$\bar{x}$	8.50	1.60	81	3.05	64
(100% tick removal)		SD:	7.51	2.30		4.16	

Table 20 (contd)

B. Without removal of ticks by hand on Day 0

			Day 0	Day 2 or 3	% change	Day 4	% change
Delnav	(i) n = 90	$\bar{x}$:	3.93	1.00	75		
		SD:	8.52	2.12			
	(ii) n = 50	$\bar{x}$:	6.52	1.76	73	2.02	69
		SD:	10.75	2.60		3.70	
Tick-grease	(i) n = 90	$\bar{x}$:	3.59	1.49	58		
		SD:	5.34	1.97			
	(ii) n = 50	$\bar{x}$:	5.96	2.58	57	2.24	62
Control	n = 40	$\bar{x}$	5.52	5.40	2	2.65	52
		SD:	6.09	4.76		3.32	

$\bar{x}$ = Mean

SD = Standard deviation

Note: The '% changes' are all from Day 0 and are in all cases reductions in the number of ticks.

3. CHEMICAL ANALYSES OF CAMEL BLOOD

3.1 INTRODUCTION

During the course of the experiments described by Rutagwenda and Simpkin in this report opportunity arose for the analysis of camel blood for its mineral and protein content.

There were two main objectives in doing this: Firstly, camels are known to have a high requirement for salts, whether in mineral form in solution in drinking water, or combined in halophytic vegetation. We wished to know whether the experimental animals were deficient in any of the main minerals. We also wished to know whether there were any differences between the treatment and the control herds, in particular as the former received a mineral supplement.

3.2 METHODS

Blood samples were taken from pre-determined numbers of adult and young camels, into sodium fluoride anti-coagulant for whole blood analysis, and into plain bottles for serum separation. Analysis was carried out for constituents as listed in the tables below. Samples were taken on two occasions eight months apart, both of them at the end of satisfactory wet seasons when the nutritional status of the animals should have been good. The numbers of samples taken on the second occasion were limited by the non-availability of anti-coagulant bottles. The analysis of these samples were carried out by the Biochemistry Section of the Veterinary Research Laboratories, Kabete, whose help is gratefully acknowledged.

3.3. RESULTS

Results of the analyses are presented in Tables 21 and 22.

Table 21. Samples of about 21 May 1982 (Analyses done on 29 May 1982)

1. Red/treatment herd

Camel No.	Age in years	Sex	Igorganic Phosphorus mmol/l blood	Copper micromole/l blood	Calcium mmol/l serum	Magnesium mmol/l serum	Protein g/l serum
5	10-13	F	1.94	8.63	2.5	0.41	100
6	10-13	F	1.87	6.59	2.5	1.32	106
12	N/A	N/A	2.00	8.63	2.4	0.99	89
28	7-10	F	1.42	8.63	2.1	1.15	100
29	10-13	F	2.78	8.63	1.0	0.41	102
32	13-16	F	1.97	9.11	2.37	1.19	86
39	1-2	F	2.20	8.32	2.5	1.07	100
149	2-3	F	1.61	9.26	2.12	1.07	86
152	2-3	F	1.87	6.12	2.37	0.99	85
170	1	M	2.07	9.11	2.12	0.82	100
171	1	F	2.00	9.58	2,0	0.90	80
195	0-2	F	1.42	9.58	2.1	0.82	85
196	1	M	2.33	8.63	2.37	1.15	84
197	1-2	M	1.84	9.11	3.0	1.15	84
216	1	M	2.78	12.25	2.6	1.23	82
250	2-3	F	1.58	8.63	2.37	1.07	100
506	13-16	F	2.00	8.63	2.12	1.11	85
527	13-16	F	1.87	6.91	2.55	1.27	80
530	10-13	F	1.81	10.68	2.5	1.32	102
532	10-13	F	1.42	6.91	2.5	1.15	100
574	13-16	F	2.49	8.63	2.45	1.03	101
No of samples:			21	21	21	21	21
Means:			1.96	8.69	2.31	1.03	92
Standard deviations:			0.39	1.35	0.38	0.25	9.0

Note: N/A = Not available
F = Female
M = Male

Table 21 (contd)

2. Blue/control herd

Camel No.	Age in years	Sex	Ignorganic Phosphorus mmol/l blood	Copper micromole/l blood	Calcium mmol/l serum	Magnesium mmol/l serum	Protein g/l serum
630	5	F	2.20	10.68	2.5	1.23	101
632	13-16	F	1.55	6.59	2.37	1.03	100
634	2-3	M	1.39	8.48	2.45	0.82	98
638	1-2	M	2.78	6.91	2.4	1.32	98
642	1-2	F	2.78	11.30	2.7	1.15	102
646	5	M	1.71	6.59	2.5	0.90	84
649	13-16	M	1.94	6.59	2.37	1.03	85
650	6	F	2.78	11.30	2.5	1.23	102
652	6	F	2.78	13.82	1.6	1.23	102
656	1-2	M	2.20	6.59	2.45	1.03	101
660	5	F	2.78	11.30	2.6	1.23	102
661	5	M	2.78	8.95	2.55	1.32	101
664	13-16	F	1.65	13.19	2.37	1.23	105
666	5	M	1.42	11.30	2.5	1.15	85
672	10-13	F	2.78	8.79	2.45	1.23	101
676	5	M	2.78	8.63	2.37	1.32	102
682	3.5	M	2.39	9.58	2.5	1.27	85
701	13-16	F	1.55	9.26	2.1	1.19	102
971	0-1	N/A	1.81	13.50	2.5	1.15	101
981	0-1	N/A	1.29	13.34	2.62	1.07	105
982	0-1	N/A	1.55	11.46	2.5	1.15	102
No of samples:			21	21	21	21	21
Means:			2.14	9.91	2.42	1.16	98
Standard deviations:			0.58	2.46	0.22	0.13	6.9

Note: N/A = Not available
F = Female
M = Male

Table 22. Samples of 15 January 1983 (Analyses done on 28 January 1983)

1. Red/treatment herd

Camel No.	Age in years	Sex	Inorganic Phosphorus mmol/l blood	Copper micro mole/l blood	Calcium mmol/l serum	Magnesium mmol/l serum
6	10-13	F	N/A	10.36	2.87	1.03
8	6	F	1.32	10.52	3.3	1.03
10	7-10	F	N/A	9.73	2.87	1.03
32	13-16	F	1.45	10.99	3.12	1.15
35	7-10	F	1.94	9.26	2.75	0.99
44	10-13	F	N/A	10.52	2.75	0.99
144	0.5	M	1.29	11.62	3.00	0.99
145	0.5	F	2.07	10.20	2.75	1.03
147	0.5	M	N/A	8.79	3.5	1.23
167	N/A	N/A	1.91	11.30	3.5	1.15
218	0.5	F	1.68	11.15	3.25	1.23
234	0.7	M	1.29	8.79	3.25	1.03
259(?)	N/A	N/A	2.16	8.63	3.1	1.11
530	10-13	F	1.65	10.20	3.00	1.19
533	13-16	F	N/A	8.63	3.00	1.11
567(?)	N/A	N/A	N/A	8.95	2.75	1.11
No of samples:			10	16	16	16
Means:			1.68	9.98	3.05	1.09
Standard deviations:			0.33	1.02	0.26	0.08

Table 22 (contd)

2. Blue/control herd

Camel no.	Age in years	Sex	Inorganic phosphorus mmol/l blood	Copper micromole/l blood	Calcium mmol/l serum	Magnesium mmol/l serum
646	5	M	2.36	11.77	2.62	0.99
650	6	F	1.65	10.83	3.00	1.03
651	7	F	1.94	9.11	3.00	1.07
655	5	F	N/A	11.30	2.87	1.07
674	10-13	F	2.03	9.42	3.12	1.11
681	4	F	1.29	11.30	3.50	1.15
683	4	F	1.94	10.99	3.37	1.19
732(?)	N/A	N/A	1.29	7.85	2.75	1.03
779(?)	N/A	N/A	N/A	9.42	2.75	1.07
No of samples:			7	9	9	9
Means:			1.79	10.22	3.00	1.08
Standard deviations:			0.40	1.31	0.29	0.06

Note: N/A = Not available
F = Female
M = Male

3.4 DISCUSSION

The t-test for differences between samples has been used to compare the means between herds and between dates. Significant differences ($P<0.001$) were observed between herds in all parameters measured in May 1982, but there was no significant difference between herds in January 1983.

Calcium ($p<0.01$), both herds
Phosphorus ($p<0.01$), red herd
Copper ($p<0.05$), red herd

These difference appear not to be related to water status, and may be due to dietary factors or be fortuitous. Surprisingly, the difference between herds observed in May 1982 favoured the control herd which was unexpected.

The combined means and standard deviations of both herds at both samplings are compared below with means and ranges for cattle and sheep in the UK (Rushton, 1981).

Table 23 A comparison of chemical analyses of livestock blood

	Inorganic phosphorus mmol/l blood	Copper micromole/l blood	Calcium mmol/l serum	Magnesium mmol/l serum	Protein g/l serum
Cattle (adults)					
Mean	1.74	18.3	2.5	1.02	63
Range	1.16-2.32	9.42-23.5	2-3	0.65-1.23	53-75
Sheep					
Mean	1.67	15	2.5	1.0	68
Range	0.9 -2.55	9.4-19.0	2-3	0.7-1.2	66-75
Camels (from above)					
Mean	1.96	9.59	2.61	1.09	95
± 2 SD	1.00-2.92	6.00-13.18	1.74-3.48	0.75-1.43	78-112
n	59	67	67	67	42

It can be seen from Table 23 that the inorganic phosphorus and magnesium levels in camels' blood were mostly within the range of those recorded from sheep and cattle in the U.K., although mean values were a little higher. Calcium values for camels were also comparatively high with the exception of two animals which had unaccountably low levels (3%).

Copper levels, however, were rather lower, in particular in animals in the treated herd in May 1982 when 81% were below the minimum levels recorded for sheep and cattle.

Protein values all exceeded the range of values from the cattle and sheep and also from Sudanese and Indian camels (Abdelgadir *et al.*, 1979 and Kumar *et al.*, 1961).

Unfortunately direct comparisons with several other sources of data on camel blood are not possible as analyses have either beem made on serum rather than whole blood or the results expressed in different units than those used here (e.g. Wahbi *et al.*, 1979).

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