CLINICAL AND PATHOLOGICAL INVESTIGATIONS ON CAMEL SKIN DISEASES IN SOME CAMEL RICH DISTRICTS OF NORTHERN KENYA

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

Dedicated to my wife Rosemary Chepkwemoi Ngeiywa,
our children Sunday Chepkorir,
Innocent Kibet,
Boever Mutai,
and to the memory of my late grandmother Taprantich.

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ABSTRACT

Clinical and pathological investigations on camel skin diseases were undertaken in Turkana, Samburu, Isiolo and Marsabit districts in northern Kenya between October 1990 and November 1991. Nomadic camel herds were selected based on accessibility. The origin, domestication, population, distribution, socio-economic importance, constraints to development of camel husbandry in Kenya, and diseases of the camel (emphasizing on the skin diseases) are reviewed.

Out of 11,196 camels examined, 53.2 per cent had skin diseases/lesions. All camel herds were found to be infested by ticks and camel flies at varying levels of infestation. The commonest and most widespread diseases were Mange (45.7 per cent), camelpox and skin abscesses (20.1 and 17.4 per cent respectively). In addition to the previously known *Sarcoptes scabiei* var *cameli* , four other new mite species were found.

The first of these was a minute 'beetle-like' mite christened ***Cardiocephaloptes marti,*** new genus and species (new sub-order and new family). This is a tiny lymph sucking mite, about half the size of *S. scabiei*. The body is shaped like that of a beetle. It has a large falsehead which is shaped like the sign of a heart on a playing card with the pointed end facing anteriorly. The male is only three quarters the size of the female. The first and third pairs of legs are similar in both sexes, but there is a marked difference in the other two pairs. Leg two in the male has a characteristic lanceolate appendage sticking out laterally between the femur and the genu, whereas in the female it is somewhat shrivelled. Leg four in the male is short, large and bears a powerful claw, shaped like the dewclaws of a lion, and long straight setae whereas in the female it has only three segments, at the end of which there is a pair of long whiplike setae which are equal in length.

The second and third were large-sized mites belonging to the family dermanyssidae. ***Camelonyssus golfer***, (new genus and species) is a blood sucking mite which bears strong resemblance to members of the genus Dermanyssus except that it has a single long chelicera without chela while the former have two which are both armed with chelae. The gnathosome is so minute as to be absent, being completely masked by the enormous pair of pedipalps and the retractile chelicera. The mite has four pairs of legs each bearing a sucker

borne on a short unjointed stalk. The stalk and sucker together look like the distal end of a golf club, with the bulb facing posteriorly. ***Camelonyssus samburu*** (new genus and species) is also a blood sucking mite similar to *C. golfer* in having a single tubular needle-like chelicera which has no chela at the end. However, it is smaller in size than *C. golfer* although it has a large gnathosome which bears three pairs of long sharp spikes and a long protruding chelicera. Each pedipalp also bears a single spike which is similar to that of the capitulum. All legs have club-shaped suckers which contain a Y-shaped chitinous thickening and the unjointed stalk is short.

The identity of the fourth mite species, the **Baragoi 'Louse-mite'**, of which only one specimen with broken legs was available, has not yet been established except to say it is unlike any mite seen in the literature. Its body is shaped like a bowling pin with the smaller end being the falsehead. The mouthparts are complex and consist of five pairs. The first anterior/outer pair is shaped like pincers with curved bodies and needle-sharp ends. The second pair, which is also curved in conformity with and lies immediately behind the first one, is composed of a lateral half of thick solid chitin ending in a sharp point, while the medial half consists of vanes like in a birds' feather. The third pair resembles the second but is smaller and more blunter. The last two pairs are similar in structure and arrangement, being rod-shaped with sharp anterior ends. The other peculiarity of the mite is a pair of antenna-like structures at the rear end, enclosing a short pair of knob-like structures.

All the five mite species caused similar lesions and responded favourably to treatment with 60 per cent Diazinon (Neocidal® Ciba-Geigy).

The point prevalence rate of ticks on camels was 100 per cent amongst the nomadic pastoralist herds throughout the study period. The sites commonly infested with ticks were the nostrils, sternal, inguinal and anal regions, eyelids, ears, tail and interdigital spaces. In camel calves nymphs were spread all over the body surface and in adults, along the backbone. On parts of the body covered by thick hairs, nymphs could only be detected on palpation. Evidence of tissue damage was common on predilection sites. This was due to tick bite and the resulting irritation and in some cases, infection and abscessation ensued. Ticks attached on the eyelids caused excessive irritation which resulted in marked

lacrimation. One argasid or soft tick was identified as an Ornithodorus species and the following Ixodid or hard ticks were identified:-*Amblyomma gemma, Hyalomma dromedarii*; *H. truncatum*; *H. impeltatum, H. albiparmatum, H. detritum, H. marginatum rufipes, Rhipicephalus punctatus, R. pulchellus,* and *R. pravus*.. Of all the ten tick species identified, male ticks were more abundant than female ticks. Very few engorged female ticks were encountered. Thick and thin blood smears examined from 426 camels were negative for tick-borne haemoparasites known to be endemic in other species of livestock in the area. There was total elimination of ticks from camels treated with two per cent Cypermethrin high-cis (Ectopor®, Ciba-Geigy) at three weeks intervals.

The prevalence of skin necrosis was 6.2 per cent and was usually found occurring in outbreaks affecting several animals at once. The lesions were first noted as firm and painful swellings which later burst leaving ulcers of raw flesh.

The incidence of dermatomycoses was 4.3 per cent. Ringworm, dermatophilosis, sporotrichosis and other miscellaneous fungi were found and are described. The following microoganisms were identified: *Aspergillus niger, A. nidulans, Candida albicans,* Cladosporium species, *Dermatophilus congolensis, Fusarium oxysporum, F. solani*, Mucor species, Scopulariopsis species, Trichophyton species, and *Trichosporon glabrata.*

Myiasis was not encountered in live animals but five camel carcasses examined at Isiolo abattoir were found to harbour the third-stage larvae of the camel nasal bot fly, *Cephalopina titillator*, although the animals appeared in good health during antemortem inspection.

Camel-flies, *Hippobosca camelina* were found in all camel herds except those treated with Ectopor. Other flies were very common and numerous around the manyattas where they attacked all livestock species. Camels suffering or recovering from pox were particularly vulnerable and were severely disturbed by these flies. Recommendations based on the findings and conclusions of this study are given.

CHAPTER ONE

1.0: INTRODUCTION

Kenya has a total land mass of 569,260 square kilometres, of which 80-83 per cent is classified as rangelands (Pratt and Gwynne, 1977). The country has 800,000 camels (FAO, 1989), almost all living in rangelands.

Camels belong to the family Camelidae in the ruminant suborder Artiodactyla (Higgins, 1984; Mason, 1984; Wilson, 1984). The Camelidae are separated from the other ruminants into the group Tylopoda (pad-footed) (Mason, 1984). The genus Camelus comprises two species. *Camelus dromedarius*, the dromedary, one-humped or Arabian camel and *Camelus bactrianus*, the bactrian or two-humped camel.

Camels were first domesticated about 3,000 years ago (Bulliet, 1975) but their subsequent use and importance to man cannot be over-emphasized (Knoess, 1977). Their domestication occurred in Arabia. Later the camel spread southwards from the Horn of Africa to reach Kenya.

The one-humped camel inhabits the arid and semi-arid lands, whereas the two-humped camel is found in cold deserts. 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 per cent are dromedary. Five adjoining countries, Ethiopia, Sudan, Djibouti, Somalia and Kenya contain 84 per cent of the Arabian camels and 60 per cent of the world's total camels (Wilson, 1984).

Available data on the number and distribution of camels, in the rangelands, is based on estimates supplemented by aerial surveys conducted by the Kenya Rangeland Ecological Monitoring Unit (KREMU 1978; Ecosystems 1985). Thus, the information on the camel population of Kenya and their productivity, is very limited. Although there are major fluctuations from year to year, the general trend appears to suggest an increase in the camel population. It is possible that this is a real trend, as the camel population is likely to increase as the rangeland condition deteriorates, and there are reports that camel ownership is spreading to pastoralists who never used camels in the past (Field, 1990).

There are three recognizable breeds of camels in Kenya - the Somali, the

Rendille/Gabbra and the Turkana breeds (Bremaud, 1969; Simpkin, 1983). The majority of camels in Kenya are owned by ethnic Somali, Rendille, Turkana, Gabbra and Borana. Other camel-owning tribes are the Samburu, Pokot, Tugen and Njemps. Therefore, 99 per cent or more of the national herd is kept in nomadic or semi-nomadic pastoral production systems (Schwartz, 1986). Among the five main livestock animal species (cattle, camels, goats, sheep and donkeys), living in the arid lands of Kenya, the camel is the best adapted to the desert and drought conditions (Field *et al.*, 1985). Camels provide the nomadic pastoralists in Kenya and other parts of East Africa with milk, meat, blood as food, hides and transport of water, firewood and tents (Bremaud, 1969; Torry, 1973; Hartley, 1979; Dahl and Hjort, 1984). In addition, among the nomads, the camel herd is a source of prestige, capital and wealth (Hartley, 1979).

A camel derby (the Maralal International Camel Racing), started in 1990 and the local nomads competed, hired out their camels or led the racing camels. This annual event will therefore be an additional source of monetary gains for many years to come in Samburu district.

CHAPTER TWO

2.0: REVIEW OF THE LITERATURE

2.1: Origin of the dromedary camel

The dromedary camel belongs to the order Artiodactyla and family Camelidae consisting of three genera and six species (Wilson, 1984). The dromedary is a member of the Old World group of camels. The New World camels consist of the genera Vicuna (vicuna, illama) and Lama (alpaca, guanaco). The genus Camelus comprises the bactrianus and dromedarius species. The geneology of the dromedary camel is shown in table I.

Table I: The genealogy of the dromedary camel

Kingdom	Animalia
Phylum	Chordata
Class	Mammalia
Order	Artiodactyla (even-toed ungulates)
Sub-Order	Tylopoda (pad-footed)
Family	Camelidae

(Source: Wilson, 1984)

Zeuner (1963) suggested that the Old World camels originated in North America about 40 million years ago. Those that migrated into the cold deserts of Asia developed into the two-humped bactrian camel while those that migrated into the hot areas of North Africa and the Near East developed into the one-humped dromedary camel (Yagil, 1986). The dromedary camel penetrated as far as Olduvai Gorge in Tanzania during the pleistocene era (Wilson, 1984).

2.2: Domestication of the dromedary camel

Domestication does not seem to have changed the dromedary camels much from their wild ancestors (Encyclopaedia Britanica, 1985). The date and place of their domestication is

still controversial. Profsch and Berger (1973) and Bulliet (1975) are in agreement that domestication first took place in South Sahara and not Central Arabia or Central West Sahara as had earlier been reported by Zeuner (1963) and Lhote (1953) respectively. Domestication occurred between 5,000 and 5,500 years ago (Ripinsky, 1975).

In Kenya, the dominant breed is the Benadir of Somalia which is a large framed animal, ranging in colour from pale white to brownish pale white, standing to a height of 2.5 metres when mature, with a neck about one metre long and carrying a small triangular-shaped hornless head (Karue, 1986).

2.3: The population and distribution of the camels

The world camel population is about 19 million, of which 75 per cent are found in Africa (F.A.O., 1988). Somalia and Sudan account for 70 per cent of Africa's camels; Chad and Kenya combined account for a further 12 per cent, and East Africa alone contains 63 per cent of all the Old World camels (Wilson, 1988). Kenya has an estimated number of 790,000 camels (F.A.O., 1988).

The distribution of the dromedary camel is limited to the drylands in Africa and Asia (Salih and Musa, 1988). This distribution is mainly controlled by climate and the disease, trypanosomiasis (Leitch, 1940). Bactrian camels are found in areas with temperatures of less than 21^0C (Mason, 1979). Dromedary camels on the other hand occur in areas of low rainfall (less than 500 mm per year) (Dahl and Hjort, 1976; Yagil 1982). The vast majority of the dromedary camels are found in Africa and its northern and western range limits are marked by the Mediterranean Sea and the Atlantic Ocean respectively. The southern limit is set by a combination of climatic, historic and anthropic factors (Wilson, 1988).

In Kenya the camel region extends from the Uganda border to the Somalia Republic in the northern part of the country and from the foothills of the central highlands to the Ethiopian border (Ayuko, 1985). This region is dominated by three ecological zones, namely eco-zones IV-VI (Ayiemba, 1985). These zones are characterized by low rainfall (rarely exceeds 300 mm per annum), high temperatures, low relative humidity and dry thorn-bushland to annual grassland with or without dwarf shrubs. The percentages of these eco-zones in the major camel keeping districts are shown in table II below.

Table II: Percentage of ecological zones in the camel keeping districts

District Eco-zone	Eco-zone IV	Eco-zone V	Eco-zone VI	Other
Turkana	9	54	35	2
Marsabit	2	24	74	0
Mandera	0	2	98	0
Wajir	0	81	18	1
Garissa	12	82	6	0
Isiolo	6	46	45	3
Tana River	4	93	0	3
Samburu	12	69	7	7
Baringo	19	61	1	19
Kitui	5	92	0	3

(Modified from Migot-Adhola, 1985)

Estimates of camel population figures in Kenya from 1977 to 1988 are shown in table III.

Table III: Camel population figures

District	1977	1978	1980	1981	1982	1983	1988
Baringo	3,914	nda	1,247	2,132	1,297	nda	523
Garissa	50,808	40,820	nda	nda	nda	47,250	42,466
Isiolo	154,996	38,363	nda	nda	nda	nda	52,937
Kitui	2,183	nda	2,886	nda	nda	nda	nda
Laikipia	nda	nda	nda	2,869	61	nda	791
Lamu	219	nda	nda	nda	nda	nda	nda
Mandera	105,314	117,135	nda	nda	nda	nda	76,003
Marsabit	114,992	107,885	nda	46,553	nda	nda	92,160
Samburu	9,456	nda	nda	13,460	nda	nda	13,168
Tana-River	43,139	29,274	34,809	nda	nda	28,632	52,425
Turkana	97,630	nda	nda	69,367	60,910	nda	102,078
Wajir	119,468	199,502	nda	nda	nda	nda	153,362
Total	702,119	532,979	389,42	134,381	62,268	75,882	585,913

Key: nda = no data available

(Source: KREMU as cited by Heath in 1991).

The Census of the Annual Reports of the Animal Production Branch of the Ministry of Livestock Development for 1977 to 1982 is shown in table IV.

Table IV: The number of camels in Kenya

Year	1977	1978	1979	1980	1981	1982
Population	607,000	680,000	790,000	nda	638,000	825,000

Tables III and IV above indicate that statistical data on camels in Kenya is limited.

2.4: The socio-economic importance of the camel in Kenya

Kenya's national economy is growing at a much slower rate than the rate of increase in human population. This means that more and more people will be forced back to the land to survive at the subsistence level. The extensive Kenyan rangelands cannot be cultivated because of the irregular and unreliable rainfall in those areas. Indeed, in the arid zone where water is very scarce, stocking of water-dependent livestock such as cattle is illogical as they contribute to the deterioration of the range (Field and Simpkin, 1985). Instead, greater emphasis should be placed on improving the productivity of the camel which is excellently adapted to the arid and/or degraded conditions, since that beast shuns the more humid regions where camel diseases are likely to be a problem (Field, 1990).

The value of the camel among individual Kenyan pastoral groups varies. The Turkana, who were originally cattle pastoralists at the time when they arrived in Kenya in the 18th century (Stiles, 1987), value it as a species of cow (Odegi-Awuondo, 1985); the Gabbra regard camel husbandry as the mainstay of their subsistence (Pratt and Gwynne, 1977), and most other camel herders regard it as a 'beast of burden' or a means of supplementing their diet and maintenance of cultural values.

Camels are valued as pack or riding animals, as well as for their milk, hides and meat (Encyclopaedia Britanica, 1985). They have long been used as mounts for troops engaged in desert warfare and camel corps were employed by the British and Egyptian armies in the Sudan campaigns of 1896-98 and in the World War I of 1914-18 (Hopwood, 1959). They are also used as draught animals (Schwartz, 1986).

In Kenya, camels are used mainly for the production of meat, milk and blood for food, and for transportation. They are also used for bush control in the ranches. As draught

animals they are used to pull ploughs for earth excavation during surface dam construction for range water harvesting and/or soil conservation activities. Now camel owners are hiring out their beasts, especially in Samburu, to provide labour in institutions such as schools, hospitals, the army and for transportation of tourists in riding expeditions. The Annual International Maralal Camel Derby which started in 1990 has given the camel a new dimension in Kenya.

Amongst most pastoralists however, camel meat is only eaten when adult male castrates are slaughtered during protracted dry seasons, on ceremonial occasions or when a camel dies from disease or predation (Field and Simpkin, 1985). Camel hides are used for making houses by the Rendille and also for making ropes, sandals and skirts by the Turkana. Elsewhere in Africa, camels are used also for ploughing, draught and the raising of water for irrigation purposes (Bulliet, 1975).

There is an increasingly important role for the camel in northern Kenya and the value of the camel in drought conditions is self-evident. They eat plants which are known to be poisonous to other stock without coming to any harm. With the efforts to reclaim arid and semi-arid lands by the Government of Kenya, the establishment of camel ranches has become an economic reality.

Camels are essential to the subsistence of the pastoralists. They do not compete for food with other types of livestock because of their grazing/browsing behaviour. They usually disperse while grazing and constantly move, taking only small portions from each plant no matter how dense or palatable the pasture may be. Hence, they spare even extremely poor vegetation and do not destroy fragile environments as quickly as is the case with other conventional livestock species (Newman, 1984). Their way of feeding, therefore, represent the most rational utilization of semi-arid and arid vegetation (Gauthier-Pilters, 1984). They can be kept in areas which are of no use to other types of livestock and are very resistant to adverse climatic conditions and where there is shortage of browse; they eat even thorns. At the same time, they are very good milk producers.

The camel has adapted to the semi-arid and arid environments by varying its body temperature and so can afford to graze for longer hours, and the horny nature of the oral cavity makes it more suited to a browsing than a grazing diet (Schmidt-Nielsen, 1964). Its

ability to excrete concentrated urine allows it to eat salt bushes and drink brackish water (Yagil and Berlyne, 1978). The camel can live in hot and arid environments because it possesses an efficient water conservation mechanism which affords it an exceptional tolerance to dehydration (Gauthier-Pilters, 1984). The camel's range in body temperature is such that it may rise by as much as 7 °C during the day and hence reduce the need to shed the heat load by sweating and panting (Wilson, 1988). The dromedary camel can therefore be described as the supreme animal for hot, dry and arid lands because it can go for long periods without water. Camels can stay for upto 8-10 weeks without water (Grill, 1987).

Beside its economic importance, and the fact that the camel is the most highly valued animal by the pastoralist, they are also prized according to their role in cultural relations such as the payment of dowry. One may also think of them as a sort of banking system or security against drought, disease and the other natural calamities that affect smaller stock more seriously. For instance, the disastrous 1974-75 drought in Somalia killed 60 per cent of the cattle, sheep and goats, but only 10 per cent of the camel population died (Hussein, 1987).

The level of vitamin C in camel milk is so high that Leitch (1940) considered it to be both prophylactic and curative for scurvy. Knoess *et al.*, (1986) reported that camel milk also has other medicinal properties especially for dropsy, jaundice and conditions affecting lungs and the spleen. Table V below shows the percentage dependency of pastoral communities in Kenya on camel milk for subsistence.

A less well appreciated aspect of the camel is that it has the capability of converting poor quality and rangeland forage into milk and meat. Further more, the milk of camels frequently forms the staple diet of pastoralists living in the arid zones of Africa and the Middle East (Field and Simpkin, 1985). According to these authors, arid and semi-arid lands, suitable for camels, occupy 36 per cent of the earth's surface and are inhabited by 384 million people. Useable land in these dry regions has been (and continues to be) converted into unproductive waste by a combination of ecological and socio-economic factors. It has recently been estimated that the lives of 150 million people in Africa alone are being threatened by drought. Thus the camel is coming increasingly into greater demand by virtue of the fact that it can continue to produce food for people living in a degraded environment

and achieves this with minimal impact and disturbance to the ecosystem.

Table V: Dependency of pastoral communities on camel milk for subsistence

District	Percentage	Camels per adult person.
Wajir	98.8	3.39
Marsabit	97.6	3.58
Mandera	98.7	2.85
Turkana	98.0	1.76
Garissa	96.3	0.96
Isiolo	88.7	1.59
Samburu	20.4	0.91
Tana River	23.8	0.39
Laikipia	11.9	0.05
West Pokot	3.5	0.03

(Modified from Karue, 1986)

2.5: Constraints to development of camel husbandry in Kenya

Camel pastoralism in Kenya is restricted to the arid and semi-arid lands which are geographically isolated from other parts of the country due to poor communication network (Ayiemba, 1985). The marginal resources of these areas have attracted minimal private and public investments because of poor security.

The nomadic pastoralists have been successfully managing their livestock and range resources for many years using their experience and conventional wisdom. So far, little work has been carried out on problems of the camel in Kenya, and Livestock Production Officers have had little to offer to camel herders due to the lack of relevant knowledge on camel husbandry (Ayuko, 1985).

As far as therapeutic treatment of diseases is concerned, accurate drug dosages for the dromedary are rare, and are usually extrapolated from those recommended for other animal species (Ali, 1988). The anatomical, physiological and biochemical peculiarities of the camel warrant more pharmacological and toxicological studies.

Camels are usually extensively managed, and this system presents considerable

logistical difficulties to the field veterinarians (Higgins, 1988). It may be impractical or impossible for the herd to remain in one place for any length of time, which creates difficulties of collecting appropriate samples at the optimal time, especially as there are problems involved in transferring the samples to a diagnostic laboratory. In these circumstances, the importance of making a thorough clinical examination to reach accurate diagnosis is very important.

In many of the traditional livestock-keeping cultures, there is shortage of ready cash. Pastoralists appreciate the value of keeping their animals healthy and are eager to accept any advice or treatment which can be shown to improve their livestock. But since they have little access to trained technicians, they have developed traditional remedies for many of the illnesses they see. Some of these remedies do more harm than good. For example, the branding of camels with hot iron rods at the suspected sites of illness (such as a swollen lymph node), is traumatic, blemishes the skin and can be a source of infection. The resulting scar reveals a camel's health history to whoever is interested in buying it. This may be helpful for the buyer, but does nothing to help the seller's bargaining power.

The epidemiology and control of the diseases of camels have not been well studied (Rutagwenda, 1983). These problems are the main constraints affecting camel production and productivity in Kenya.

2.6: Diseases of the dromedary camel

Although camels are physiologically and anatomically adapted to exploit the scarce desert resources, they are susceptible to a number of diseases (Cross, 1917; Leese, 1927; Richard, 1979; Rutagwenda, 1982; Simpkin, 1983; Wilson, 1984; Ali, 1988; Gitao *et al.*, 1990). Whereas a lot has been written on the skin diseases of other livestock species in East Africa (Green, 1957,1959, & 1962; McCullock and Tungaraza, 1967; Bwangamoi, 1969 a & b, 1971; Bwangamoi and DeMartini, 1970), literature on camel dermatology is very scarce. This is due to the non-sedentary nature of the herds which are constantly moving in search of pasture and water (Mukasa-Mugerwa, 1980; Rutagwenda, 1983). Consequently, the importance of camel diseases for production is uncertain and in most cases controversial (Richard, 1979).

Camels are disease and drought tolerant and it is estimated (Gauthier-Pilters and Dagg, 1981) that in 1973, when drought hit the Sahel region of Africa, upto 100 per cent of the indigenous cattle died but only 20-30 per cent of the camels were lost. According to Wilson (1978) camels suffer from a few diseases and none of them is of any major importance. Richard (1979) however, believed that disease was the most important factor in limiting camel production, yet relatively little is known of the pathology of camel diseases.

It is generally known that there are no diseases that are specific to the dromedary and all the infections that have so far been reported, are known to exist in other domestic animals. Signs of disease, however, are often missing or obscure (Leese, 1927; Curasson, 1947). According to studies on camel diseases in northern Kenya, initiated in 1978 (Wilson *et al.*, 1981), trypanosomiasis, helminthiasis, tick infestations, mange, camelpox and a number of bacterial diseases, were identified as the most important diseases in the area. Table VI gives a list of important diseases of the camel recorded in the literature. Emphasis however, is placed on those diseases commonly seen in the field and where information is more readily available

2.6.1: Camel skin diseases

Camels suffer from a variety of specific and non-specific skin diseases. Skin diseases and conditions of cattle, sheep and goats in Kenya cause heavy losses through their direct effects on the quality of hides and skins and indirectly through lowered milk, meat, and wool production (Green, 1959; Bwangamoi, 1973). Wilson (1980) stated that skin diseases were among the important diseases of camels in northern Kenya. According to the annual reports of the Kenyan Department of Veterinary Services (Anon., 1990) and other workers (Bwangamoi, 1969 a & b, 1971 and 1973; Bwangamoi and DeMartini 1970; Gitao,*et al* 1990), the most common skin diseases in the drier range areas where camels co-habitate with goats, sheep and cattle include dermatophilosis, onchocercosis and demodicosis in cattle, and pox, fungal infection and mange infestation in sheep and goats. Camel diseases recorded in the literature are shown in table VI.

Table VI: Camel diseases recorded in the literature

Causative agents	Diseases
Virus	Camelpox, Rinderpest,Foot and Mouth disease, Rabies (Richard, 1979); Camel Contagious Ecthyma (Orf) (Moallin and Zessin; 1988); Papillomatosis (Munz.*et al.*, 1990)
Bacteria	Anthrax(Leese, 1927); Brucellosis, (Abu Damir *et al.*, 1989); Al-Khalaf and El-Khaladi, 1989). Blackleg, Pasteurellosis, Tuberculosis, Salmonellosis, Corynebacterial Lymphadaenitis, Tetanus, Contagious Pleuropneumonia, Human Plague, Tularemia, Glanders, Influenza, Conjuctival Rickettsiosis (Richard, 1979). Contagious Skin Necrosis (Cross 1917; McGrane and Higgins, 1986); Abscesses, Orchitis (Ram, *et al* 1987); Mastitis (Ramadan *et al.*, 1987)
Fungi	Ringworm (McGrane and Higgins, 1986) Mycoses, Cutaneous Streptothricosis, Lung Streptothricosis, Sporothricosis.(Richard,1979)
Protozoa	Trypanosomiasis, Coccidiosis, Leishmaniasis, Anaplasmosis, Theileriasis, Sarcosporidiosis, (Richard, 1979); Toxoplasmosis, Balantidiasis (Ouhelli and Dakkak, 1987)
Parasites	Arterial filariasis, Subcutaneous Onchocercosis, Taeniasis, Echinococcosis,Coenurosis, Schistosomiasis, Distomiasis Mange, Tick infestations (Richard, 1979), Nasal and Sinus Myiasis (Hussein et al., 1982); Haemonchosis (Richard, 1989; Delatour *et al.*, 1989)

2.6.2: Viral skin diseases of the dromedary

Camelpox is the most commonly diagnosed viral skin disease although recent serological evidence suggests a high incidence of other viral infections (McGrane and Higgins, 1986). In the skin, viruses produce lesions which are a combination of degeneration and proliferation (Jubb and Kennedy, 1970).

2.6.2.1: Camelpox

This is a contagious disease which is widely distributed among camel populations. Most camels contract the disease before reaching three years of age and the disease characteristically spreads rapidly among young stock in a herd. The causal virus is closely related to other variola poxes (Richard, 1976; Munz *et al.*, 1986; McGrane and Higgins, 1986). Outbreaks are often associated with the stress of weaning or poor nutritional status. Most cases are mild and recovered animals seem to possess lifelong immunity to re-infection (McGrane and Higgins, 1986). Occasionally a more severe form of the disease is encountered which may be fatal (Kriz, 1982). Camelpox is potentially zoonotic (Leese, 1909; Marennikov *et al.*, 1974). Suckling calves attain a degree of immunity through colostrum for the first few months of life (Mukasa-Mugerwa, 1980).

Transmission may be either by direct contact or by fomites. The virus is readily inactivated by heat, direct sunlight, weak alkalis, iodine and potassium permanganate (McGrane and Higgins, 1986). Papules are usually first seen on the labial mucosa; these progress to vesicles, pustules and eventually scab formation. During the vesicular stage the camel rubs its lips on solid objects to relieve the itching. As a result the vesicles rupture and may become secondarily infected. Difficulty in eating may be experienced and the camel may lose condition. Regional lymph nodes may become enlarged.

Camelpox is well recognized among camel owners and the need for laboratory confirmation rarely arises (McGrane and Higgins, 1986). However, in cases where Contagious Ecthyma (orf) of camels is suspected, papules or scabs should be examined by electron microscopy to distinguish orthopoxvirus from the parapoxvirus causing orf (Moallin and Zessin, 1988). In Somalia, both orthopoxvirus and parapoxvirus have been isolated from outbreaks of camelpox (Kriz, 1982).

Camelpox virus may be isolated from papules or crusts by inoculation onto the chorioallantoic membrane of hen's eggs. Histopathology of skin lesions or infected chorioallantoic membranes will show eosinophilic intracytoplasmic inclusion bodies (IB) typical of pox viruses (Jubb and Kennedy, 1970).

2.6.2.2: Camel Contagious Ecthyma (Orf)

This disease has been reported in the dromedary camel (Moallin and Zessin, 1988). Histologically the changes in the skin closely resemble those which occur in the pox disease and the development of the disease is very similar (Blood *et al*, 1983). No human infections have been recorded (Moallin and Zessin, 1988). Contagious Ecthyma is a debilitating disease in severe cases as it interferes with eating and drinking (Jubb and Kennedy, 1970).

2.6.2.3: Camel Papillomatosis

Papillomatosis in camels was detected in Somalia in 1986 and 1987 for the first time (Munz *et al.*, 1990). The presumptive diagnosis of the disease was Contagious Ecthyma. Diagnosis was confirmed by electron microscopic investigations which revealed typical papillomavirions in skin lesions. Histopathological sections showed alterations which were regarded as pathognomonic for warts (Munz *et al.*, 1990).

2.6.3: Bacterial skin diseases of the dromedary

The healthy, intact integument is remarkably resistant to bacterial infection and it is accepted that if bacterial dermatitis is to be established, some predisposition is necessary (Jubb and Kennedy, 1970). Bacterial infections frequently complicate the pox diseases, dermatomycoses, and parasitic infestations.

2.6.3.1: Contagious Skin Necrosis

Contagious Skin Necrosis has been reported (Leese, 1927; Peck, 1939; Eldelsten and Pegram 1974; Higgins, 1986) and is characterized by necrosis of the skin, abscessation, sinus formation and enlargement of local lymph nodes (Higgins, 1986). Lesions may occur on any part of the body (Peck, 1939). Various treatments have been tried in an attempt to

cure the condition. This is because the precise cause is unknown although different aetiological agents have been isolated from the lesions (Cross, 1917; Curasson, 1947; Eldelsten and Pegram, 1974; Domenech *et al.*, 1977).

2.6.3.2: Skin abscess

Abscesses involving the skin and subcutis are frequently seen in the camel (Leese, 1927; Ritscher, 1981) and may extend to the lymph nodes. The head, prescapular and presternal lymph nodes are frequently involved (Higgins, 1986). Puncture wounds, bites and secondary infection following diseases such as camelpox may lead to abscess formation.

2.6.4: Mycotic diseases of the camel skin

2.6.4.1: Ringworm

Ringworm is caused by dermatophytes and the condition is characterized by circumscribed, crusty, hairless lesions, one to two centimetres in diameter (Higgins, 1986). Diagnosis of dermatomycoses relies on demonstration of the arthrospores in potassium hydroxide-treated preparations of hair from the periphery of active lesions (Holmes, 1938; Higgins, 1986). The identification of the causal fungus as being either Microsporum or Trichophyton species can be made easily by examination of the spores.(Jubb and Kennedy, 1970). Accurate diagnosis is made by examining skin sections and/or isolates stained with special fungal stains such as Periodic Acid Schiff (PAS), Gridleys, Ziehl Nielsen and Gomori's.

2.6.4.2: Cutaneous streptothricosis

The causative organism is *Dermatophilus congolensis* which is present in the scabs as a Gram-positive, narrow-branching mycelial growth which divides transversely and longitudinally to form "spores" (Jubb and Kennedy, 1970; Gitao *et al.*, 1990). It is a dermatitis occurring in all species and affecting all ages, and is predisposed by cool, wet weather but is not zoonotic (Blood *et al* , 1983). In histological sections, the organisms can be seen in hair follicles above the stratum granulosum (Jubb and Kennedy, 1970).

2.6.5: Ectoparasites of the camel

2.6.5.1: Mites

According to Blood *et al.* (1983), *Demodex folliculorum* infest hair follicles of all ages of all species of domestic animals. Sarcoptic mange occurs in all species causing a severe itching dermatitis. It is an important disease in camels (Leese, 1927; Liebisch *et al.*, 1978), where severe lesions caused by hypersensitivity to the mite occur and often lead to death (Blood *et al.*, 1983). It is an extremely pruritic and contagious skin condition caused by *Sarcoptes scabiei* var. *cameli*, a minute circular parasite (Higgins, 1986). Soulsby (1969) has given the size of the female mite as 330-600 x 250-400 µm and that of the male as 200-240 x 150-200 µm.

Camel sarcoptic mange is sudden in onset and often starts on the medial aspects of the thighs or inguinal region, neck or the flanks (Higgins, 1986), and on the head and neck (Blood *et al.*, 1983). The fertilized females work their way deeply into the epidermis, forming tunnels where they deposit their eggs. The infestation involves thin-skinned areas first (Sloss, 1970). The life cycle of the mite begins with the laying of an egg, from which a six-legged larva emerges (Sloss, 1970; Blood *et al.*, 1983; Higgins, 1986). The larvae escape from the breeding tunnels and develop into nymphae which have four pairs of legs but no genital apertures (Soulsby, 1969). Finally, the nymphae mature into males and females and after mating, the female will start egg-laying (Higgins, 1986).

A working diagnosis of sarcoptic mange is possible on clinical signs alone (Higgins, 1986). A definitive diagnosis is achieved by taking skin scrapings and identifying the causal mite (Sloss, 1970; Soulsby, 1969; Higgins, 1984). A practical method for taking a skin scraping from a camel has been described in detail (Higgins and Kock, 1984).

Sarcoptic mange is usually considered to be a seasonal disease which is particularly severe during cold, wet weather (Leese, 1927; Lodha, 1966; Blood *et al.*, 1979). Control of mange mites on camels is achieved by application of chemicals, but the disease is stubborn and only a thorough regime is likely to succeed (Higgins, 1984 and 1986).

Chorioptic mange mites have been reported affecting a Bactrian camel but Higgins (1986), thinks this infestation is rare and opportunistic. Chorioptic mites are surface-dwelling and resembles the Psoroptic mange mite but have blunter mouth parts and legs with

unsegmented pedicels (Turk and Batte, 1970).

The morphologic characteristics of mange mites are shown below in table VII.

Table VII: Summary of the distinguishing characters of mange mites

	Leg Characteristics		Location of anus
Group	Egg-laying female	Male	
SARCOPTIC (round body)	Sucker on a long unjointed stalk on pairs 1 and 2.	Sucker on a long unjointed stalk on pairs 1,2 and 4.	Terminal
NOTOEDRIC (round body)	As above	As above	Dorsal
KNEMIDOCOPTIC (round body)	No suckers	Sucker on an unjointed stalk on all pairs.	Terminal
PSOROPTIC (Large & ovoid body)	Sucker on a long jointed stalk on pairs 1, 2 and 4.	Sucker on a long jointed stalk on pairs 1, 2 and 3.	Terminal
CHORIOPTIC (Large & ovoid body)	Sucker on a short unjointed stalk on pairs 1, 2, and 4.	Sucker on a short unjointed stalk on all pairs. Pair 4 rudimentary.	Terminal
OTODECTIC (Large & ovoid body)	Sucker on a short unjointed stalk on pairs 1 and 2. Pair 4 rudimentary	Sucker on a short unjointed stalk on all pairs.	Terminal

(Holmes, 1938; Sloss, 1970).

2.6.5.2: Tick infestations

Although tick infestation is of great importance in the transmission of diseases (Blood *et al.*, 1983), it appears that their role as disease vectors is much less important in camels than in other domestic livestock (Wilson, 1984; Higgins, 1986). The importance of ticks to the camel lies in the fact that they cause mechanical irritation leading to secondary infections (Bin Omar, 1986), although heavy infestations can cause direct losses (Blood *et al.*, 1983).

Ticks are active blood-suckers and may cause death through anaemia (Steward, 1950); some species cause tick paralysis (Peck, 1939; Bwangamoi, 1970; Blood *et al.*, 1983). The irritation resulting from the attachment of ticks causes distraction and loss of production and hides are damaged (McCullock and Tungaraza, 1967; Bwangamoi, 1969 a & b; Bwangamoi and Demartini, 1970; Bwangamoi, 1971; Higgins, 1986). Ticks can cause up to 22 per cent mortality in calves below two years of age (Field, 1979).

Camels may be infested with ticks throughout the year although the number of parasites may fluctuate greatly with climate. Survival chances of eggs and immature stages are severely reduced in hot, arid desert conditions (Robson and Robb, 1967). Although there is species predisposition for attachment sites, camel ticks appear most commonly in the perineal, inguinal and axillary regions, between the toes and around the ears, eyes, and lips (Higgins, 1986) and nares. The life cycles of the ticks vary widely. One-host ticks are more easily controlled than those which pass part of their life cycles away from the host (Blood, *et al.*, 1983). The more common camel-infesting ticks include *Hyalomma dromedarii, H. anatolicum anatolicum, H. anatolicum excavatum, Ornithodoros savignyi* (Higgins, 1986); *H. impeltatum* (Walker, 1962); *H. marginatum rufipes*, *H. trancatum*; *Amblyomma lepidum* (Karrar *et al.*, 1963); *A. gemma, Rhipicephalus pravus, and R. pulchellus* (Crees, 1985).

2.6.5.3: Lice and fleas

Lice are small wingless insects that belong to two suborders, sucking lice, Anoplura and biting lice, Mallophaga (Muller and Kirk 1976). They are host specific and spend their entire life on their host and are spread by direct contact or via fomites (Higgins 1986). Large numbers of lice cause considerable irritation and the camel may stop feeding and bite, rub or scratch affected areas. Lice infestation is common during the wet season and if large numbers are present the affected animal's coat may become shaggy and matted. *Haematopinus cameli*,the sucking louse of the camel has been described (Higgins 1986).

Fleas are also wingless insects and some are known to cause reduced productivity in many domestic animal species including the bactrian camel in Mongolia (Higgins 1986). Although fleas are not confined to particular hosts, their chief effects on their hosts are irritation, that they cause because of their frequent bites. According to Higgins (1986),

Vermipsylla species are the commonest in camels. Adult fleas are blood-suckers and so cause economic losses through irritation, inflammation, debility and hide damage as well as reducing the productivity of infested animals. McGrane and Higgins (1986) implicated fleas in the transmission of *Pasteurella pestis* which cause camel plague.

Common acaricides such as Neocidal® (Diazinon, Ciba-Geigy) will kill lice. In-contact animals and other likely fomites must also be treated. Because fleas spend only short periods on their host the major effort for flea control must be directed to the premises where the eggs, larvae, pupae and some adults congregate. Elimination of fleas from animal hosts should coincide with the treatment of the premises Muller and Kirk (1976).

2.6.5.4: Flies

Diptera (flies) forms an important order of the arthropds as they transmit or are intermediate hosts for many bacterial, viral, protozoan and helminth disease agents (Muller and Kirk 1976). However, their effects on the skin are minor and are limited to bites and to myiasis. Many species of biting and nuisance flies pester camels and can act as mechanical transmitters of disease between camels or as vectors of human and zoonotic diseases. The known flies reported (Wilson, 1984; Higgins, 1986) include horseflies (Tabanus species), stableflies (*Stomoxys calcitrans*), hornflies (Lyperosia species), houseflies (Musca domestica), biting midges (Culicoides species) and mosquitoes (Aedes species).

In the case of cutaneous myiasis camels can often clean accessible wounds by licking which will help remove larvae. The larvae of six flies are known (Higgins 1986) to parasitize the camel. Five belong to the family Calliphoridae and one to the family Oestridae. Myiasis can occur following clipping, fire-marking and other traumatic wounds (Mustafa, 1979).

Routine seasonal treatment for mange control, using for example diazinon, protect against fly strike. Particularly valuable herds can be sprayed regularly with snthetic pyrethroids such as cypermethrin (Ectopor®, Ciba-Geigy or Bayticol®, Bayer) to repel adult flies. Precautions include cleaning wounds and injuries that may attract Calliphoridae and dressing them with a wound powder containing an insecticide such as Negasunt®

(Bayer)

The camel nasal botfly, *Cephalopina titillator*, is an obligate parasite of the Oestridae family which attacks only camels (Higgins 1986). Appearance of neurological signs resembling cranial coenuriasis have been described in some affected camels (Hussein *et al.*, 1982).

Prophylaxis is impractical but treatment with rafoxanide (Ranide®, Merk Sharpe and Dohme) is effective (Field, 1990).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1: The study area

This study was carried out in Turkana, Samburu, Marsabit and Isiolo districts in northern Kenya (figure I). Pratt and Gwynne (1977) classifies these areas as arid lands (Eco-zone V) to semi-desert (Eco-zone VI). Table VIII shows geographic and climatic data for Isiolo and Lodwar.

Table VIII: Geographical and climatical data for Isiolo and Lodwar

Parameter	Place Isiolo (Zone V)	Lodwar (Zone VI)
Latitude	00° 21'N	03° 07'N
Longitude	37° 35'E	35° 37'E
Altitude(M)	1,104	506
Annual rainfall(mm)*		
(Minimum)	375	19
(Maximum)	1,279	498
(Average)	613	165
Air temperature °C**		
(Minimum)	16.8	23.7
(Maximum)	30.2	34.9
Potential evaporation (E_o) (mm)***	2561	2714

(Modified from Pratt and Gwynne, 1977).

Key: *Isiolo 34 and Lodwar 44 years of recording respectively.

**Isiolo 22 and Lodwar 17 years of recording respectively.

***Isiolo 21 and Lodwar 8 years of recording respectively.

The characteristic vegetation is dry thorn-bushland to annual grassland with or without dwarf shrubs. In these areas, the moisture index range from -42 to below -50 and rainfall seldom exceeds evaporation. The mean annual rainfall rarely exceeds 300 mm. The temperature in most places does not fall below 20°C at night.

Most of the zone is occupied by pastoral tribes which include Turkana, Samburu, Rendille, Gabbra, Borana and Somali. Livestock kept include camels, cattle, sheep and goats, with some donkeys, but usually not all species are always present. Camels are more important and are often the main source of milk for subsistence.

The majority of camels examined were from Turkana and Samburu districts which are hereby described. Turkana district covers approximately 70,000 KM^2 (Figure II) comprising the whole of north-western Kenya to the west of Lake Turkana. In this harsh semi-desert, maintenance of life is always close to subsistence level. Turkana land is a vast plain from which protrude isolated mountains and ranges of hills. Temperatures are high and fairly uniform throughout the year (average daily range of 24-38^{o}C). Strong winds are frequent and rainfall varies with altitude. Distribution of rainfall is very irregular both within and between individual years.

Samburu district covers approximately 20,800 KM^2 (Figure III). Some high altitude areas in this district are arable although over 70 per cent of the inhabitants (Samburu) are entirely dependent on livestock (Jaetzold and Schmidt, 1983).

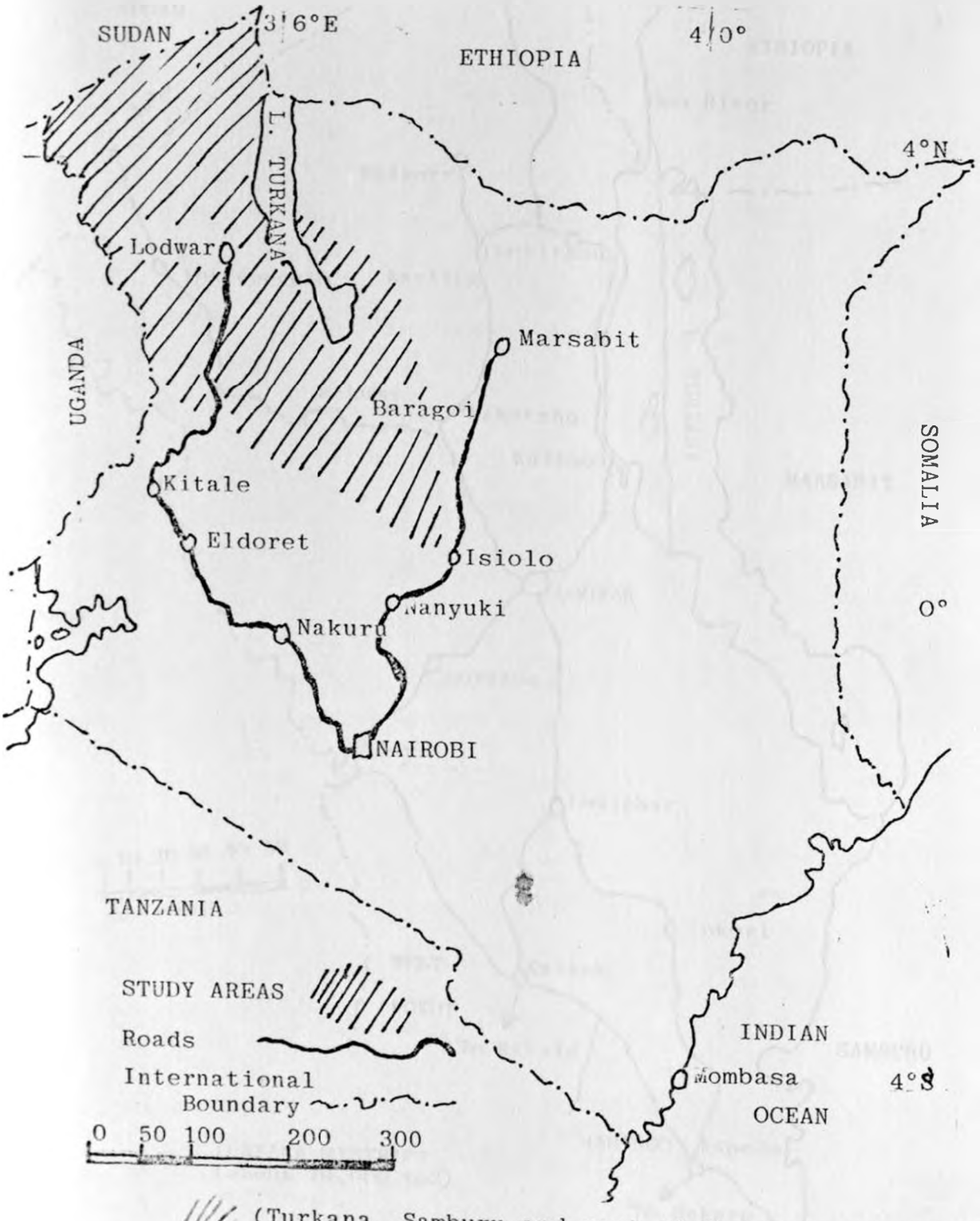

Figure 1: Map of Kenya showing the study area.

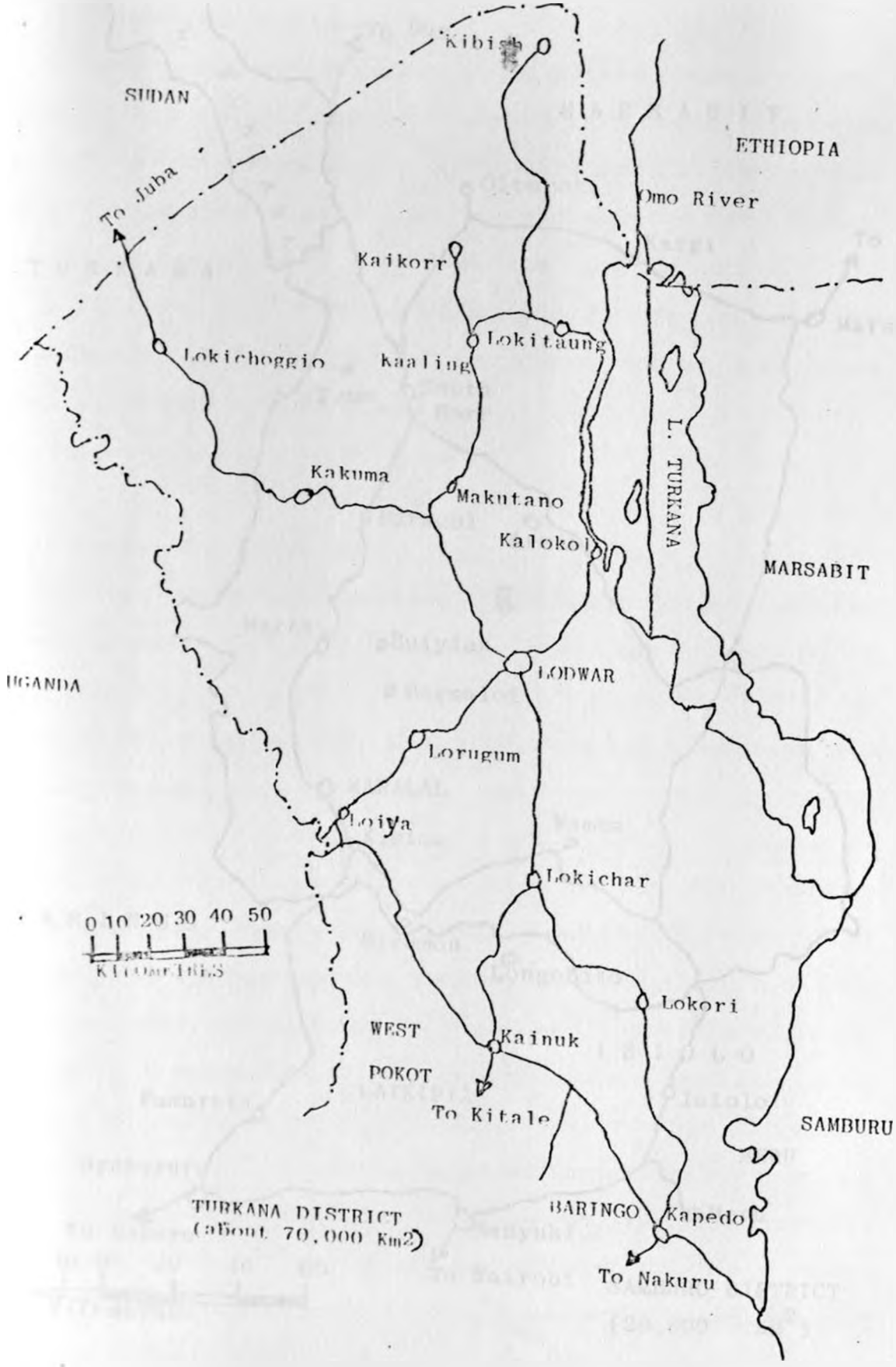

Figure II: Turkana district

Figure III: Samburu district

3.2: Study of the skin lesions

This study was commenced in October 1990 and field work completed in October 1991. Nomadic camel herds were selected based on accessibility of the areas. Project-owned camel herds were also examined. The first one in Turkana district being owned by the Turkana Camel Development Project, P.O. Box 52 Lodwar, and the other three in Samburu, Isiolo and Marsabit districts were owned by FARM Africa, P.O. Box 795 Nanyuki.

In each chosen herd every camel was examined. The principles used in the examination of the camels were like those used and recognized by clinicians for other species of domesticated ruminants (Blood *et al.*, 1983; Higgins and Kock, 1984). Photographs were taken of all skin lesions as they were encountered.

3.2.1: Restraint of the camels

The examination and treatment of a camel is a daunting clinical challenge under field conditions (Higgins and Kock, 1984). The amount of handling that will be tolerated by a camel varies greatly. The nomadic dromedaries were less tame and they had to be driven into enclosures at the manyattas (households) for close examination. In most cases the herdsmen helped in the handling.

Camels are curious by nature although most rarely bite or kick. But, when they do bite or kick the injuries inflicted may be very serious (Higgins, 1986; Idle, 1991). To minimize risks, the camels were examined in the sitting position with a handler restraining the head. The camels which were selected for closer examination were stroked on the flanks, being talked to continuously in a smooth and even voice, to keep them calm and trusting. A rope halter was then put in place (Figure IV) and the camel restrained in its normal sitting position or by tying the fetlock and the forearm together (Figure V). For most procedures this manner of restraint was adequate. Camel calves and certain docile animals were held by the upper lips and tail by assistants. A twitch on the upper lips (nose-rope) proved effective and so did hobbling. For wilder camels the hind limbs were additionally tied. Where necessary, Xylazine (Rompun®, Bayer), the sedative of choice in the camel (Higgins and Kock, 1984) was administered intramuscularly at a dose rate of 1-2 mg/KG bodyweight.

FIGURE IV: ROPE HALTER IN POSITION

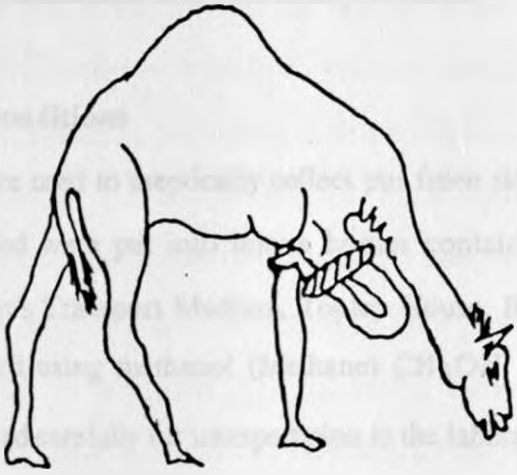

FIGURE V: FETLOCK TIED TO THE FOREARM

Figure IV and V: Restraining methods

3.3: Sampling

Sampling was done monthly and only representative samples of the various diseases/lesions were taken. Sampling was preceded by a detailed recording of the history and adequate restraint. Systematic lesion description and photography were done last.

3.3.1: Suspected viral conditions

Dry scabs were scraped using sterile surgical blades into clean universal and/or bijoux bottles. Scabs and vesicular materials were transported in modified Minimum Essential Medium (MEM) (Eagle, Flow Laboratories. U.K.), heavily supplemented with crystalline Penicillin-G (Sodium salt of Benzylpenicillin, Mac's Pharmaceuticals Ltd, Nairobi) and Streptomycin (Streptomycin sulphate, Helm Pharmaceuticals, GMBH. Hamburg W. Germany) and brought to the laboratory for further processing and examination. Biopsies of skin lesions such as nodules and wart-like lesions were aseptically taken and immediately fixed in 10 per cent formalin. No local anaesthetic was used during excisions.

3.3.2: Suspected bacterial conditions

Sterile syringes and swabs were used to aseptically collect pus from skin abscesses and wounds. All swabs so collected were put into bijoux bottles containing Stuart's Transport Medium (Modified Stuart's Transport Medium, Topley House, Bury Lancs). Direct smears were made and fixed using methanol (Methanol CH_3OH, Laboratory Chemical; Kobian (K) Ltd) and packed carefully for transportation to the laboratory in slide boxes. Hair tufts were also collected aseptically and transported in sterile bottles to the laboratory.

3.3.3: Suspected dermatophytoses

Hair tufts from affected areas were plucked, using sterile thumb forceps, and kept in sterile universal bottles. The periphery of active fungal lesions were also scraped into sabouraud's dextrose agar (SDA) slants (Difco) in universal bottles or bijoux bottles. Sufficient samples were collected from each animal to allow for multiple examinations.

3.3.4: Suspected mite infestations

Both shallow and fairly deep scrapings were made (over areas about two square centimetres) into clean universal bottles. Biopsies were taken from areas representing typical active mange lesions. Local anaesthetic (two per cent lignocaine hydrochloride, COSMOS Ltd., Nairobi) was subcutaneously injected around the chosen sites prior to removal of the biopsies. Relatively small amounts of tissues (about one and half square centimetres thick) were collected and immediately fixed in 10 per cent formalin in universal bottles or 100 ml glass jars with tight-fitting caps. The amount of formalin used was about 10 times the volume of the tissue to be fixed. Three hundred and eighty one (381) camels were treated with 60 per cent diazinon (Neocidal® 600EC, Ciba-Geigy) in four different herds in Turkana and Samburu districts.

3.3.5: Camel ticks and flies

Various tick species and camel flies were collected into 100 ml glass jars containing 10 per cent formalin or 70 per cent alcohol and transported to the laboratory for further examination and identification. All samples collected were promptly labelled, indicating the camel herd, owner and address, date of examination and sampling, herd size, age and sex of animal, disease suspected, significant findings and sample number. Each sample was individually numbered, sample numbers were marked both on the caps and bottles using a diamond pencil or permanent-ink markers. Synthetic pyrethroid pour-on (Ectopor® Ciba-Geigy) was used to control these parasites in five herds (470 camels) in Turkana and Samburu districts.Isiolo hides stores were visited and camel hides examined for the presence of any lesions and physical defects that could down-grade the hides.

3.4: Laboratory procedures

Laboratory procedures were carried out monthly during the course of this research. Histopathology, bacterial and fungal isolations were done at the Department of Pathology and Microbiology, Kabete Campus and at the Kenya Medical Research Institute's (KEMRI's), Centre for Microbiology Research. Direct examination of blood smears, skin scrapings, ticks and flies were also carried out in Lodwar and Baragoi field laboratories.

(3) 80 per cent alcohol 5 Minutes

(4) 90 per cent alcohol 5 Minutes

(5) 90 per cent alcohol 5 Minutes

(6) Absolute alcohol 5 Minutes

(7) Absolute alcohol 5 Minutes

Clearing was achieved using xylene twice, each process lasting five minutes. Clear D.P.X. mountant for microscopy (DPX mountant®, Laborama Laboratories, Nairobi) was used to mount the stained tissues on slides which were then left to dry. These were examined under the microscope (CARL Zeis, Germany).

3.4.2: Cutaneous bacteriology

A wide range of media were used for inoculation. Calf Blood Agar (CBA) (Oxoid), MacConkey agar (Oxoid) and thioglycollate broth were used for every sample. Direct impression smears of samples were then made and gram-stained. All these procedures were done aseptically. Plates were incubated both in an aerobic system and CBA plates were also incubated anaerobically at 37°C and examined daily for growth. Isolates were identified using the standard procedures for propagation and identification (Cowan and Steel, 1965; Cummins, 1974; Carter, 1979). Growths from blood agar were inoculated into a variety of sugar fermentation tubes, urea agar slopes, litmus milk, dorsets egg slopes and the catalase test was performed using 30 per cent hydrogen peroxide on glass slides.

Disc plate antibiotic sensitivities were tested by inoculating organisms isolated onto the surface of blood agar plates with a wire loop so as to obtain confluent growth. Mastring S 6 mm diameter sensitivity discs (Mast Lab, U.K.) were placed on each plate and the zones of inhibition were read qualitatively after incubation at 37°C for 72 hours.

3.4.3: Cutaneous mycology

Collected materials were deposited on slides together with the plucked hair tufts. A few drops of 10 per cent potassium hydroxide (KOH) were then applied and coverslips added. These preparations were allowed to stand for 15 to 20 minutes before being examined under the microscope. Hair shafts were carefully examined for spores.

Where streptothricosis was suspected, scabs were emulsified in phosphate-buffered saline (PBS) (pH7.2) then inoculated onto sheep blood agar (SBA) (6 per cent sheep blood, Oxoid nutrient agar and 0.4 per cent sodium chloride).

Any fungal growth from the field was subcultured into sterile petri dishes which were then observed for one to three weeks at room temperature. From distinct mature colonies, specimens were teased apart and spread on microscope slides which were then flooded with lactophenol cotton blue and examined under the coverslip. Pure cultures from distinct colonies were subcultured into SDA slants in bijoux bottles, appropriately labelled and taken to KEMRI for confirmation of diagnoses and for further identification of species.

3.4.4: Examination and identification of mites

Most of the collected materials were examined in the field. Positive slides were mounted using DPX clear mountant, labelled and transported packed to the laboratory for further examination and identification. The same procedures were used in field laboratories and at the Pathology Laboratory, Faculty of Veterinary Medicine, Kabete Campus.

The accumulated materials were placed on microscope slides then cleared by adding a few drops of 10 per cent KOH before putting on coverslips. These were allowed to stand for 15-20 minutes before being examined. In cases where the mites or their eggs were hard to find, 10 per cent KOH was added and the mixtures stirred. The KOH mixtures were then added to a saturated salt solution in centrifuge tubes and spun at 1,500 rpm for 10 minutes. In this way, the mites and ova were floated to the surface. A drop or two of the surface solution were examined on slides under coverslips.

Deeper dwelling ectoparasites like demodex species and the effects of the parasites on the skin structures were expected to be revealed by the histological procedures described above. Mite identification was done with reference to Baker and Wharton, (1952); Lapage, (1956); Hughes, (1959); Chandler and Read, (1961); Sloss (1970); Soulsby (1969); Georgi (1969); Higgins (1986); and Georgi and Georgi (1990).

3.4.5: Identification of ticks and flies

The ticks were identified with reference to the literature (Walker, 1962; Soulsby, 1969;

Nobble and Nobble, 1976; Higgins, 1986 and Njanja, *et al.*, 1989). Confirmation was done by Dr. Rutagwenda*. The camel flies *(Hippobosca camelina)* and third-stage larvae of *Cephalopina titillator* were identified with reference to Higgins (1986). Four hundred and twenty six (426) camels were bled from the jugular vein (126 in Turkana and 300 in Samburu), and thick and thin Giemsa stained smears were examined using a high power objective of the microscope and under oil immersion for the presence of haemoparasites.

3.4.6: Lice and fleas

These were recorded as they were encountered. Attempts were made to recover whole parasites from the camels or their environment.

Photomicrographs of parasites and lesions were taken with a microscope camera (Leitz Laborlux 12 attached to WILD MPS 11 and WILD MPS 15 Semiphotomat, Switzerland). All microscopic measurements were made using the Schraubenmikrometer Okular 15xSK, WILD Heebrugg.

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CHAPTER FOUR

4.0: RESULTS

In Turkana district, 6,296 camels from 75 herds, were examined between October 1990 and April 1991. A further 4,900 camels from 123 herds, were examined in Samburu, Isiolo and Marsabit districts between May and October 1991. The type and frequency of skin diseases encountered is shown in table IX. Five thousand nine hundred and fifty eight camels or 53.2 per cent of the camels examined had skin diseases. In Turkana and the other districts the incidence of skin diseases was 49.4 and 58.1 per cent respectively. Ticks and camel flies were present at varying levels of infestation in all herds.

4.1: Viral diseases identified

4.1.1: Camelpox

The incidence of camelpox was 10.7 per cent of the population or 20.1 per cent of all skin diseases. The disease was found to affect mostly young animals from six months to three years of age. In that age group, the disease was found to be more serious than in the adults (figure VI a&b.). The author witnessed the death of 15 camel calves killed by camelpox during the study period. The pastoralists are quite familiar with the signs of camelpox.

Camelpox lesions were commonly observed in the head region (figure VII). However, in severe cases, they were generalized. Papules were first observed on the labial mucosa and head, followed by involvement of the whole body. The signs were the classical ones for pox with macules, papules, vesicles, pustules and scab formation appearing successively. Severe pruritis occurred during the vesicular stage when the camels rubbed the affected parts on solid objects such as posts and tree trunks. Ruptured vesicles became secondarily infected by bacteria resulting in a foul smell. Sores developed around the mouth and eyes in severely affected calves whose head lymph nodes became enlarged. An adverse clinical sign in some calves was temporary blindness and inability to see fodder, resulting in malnutrition and weakness. Such cases were the exceptions because in general the disease was benign and ran a course of about three weeks. In herds which received prophylactic antibiotic cover (Oxysentin® 100, Ciba-Geigy), no mortalities were recorded. Viral isolation and

identification was done at the Veterinary Investigation Laboratories (VIL), Kabete.

4.2: Identification of bacterial isolates

The following bacteria were isolated and identified from the superficial wounds, cutaneous necrosis and from abcesses.

4.2.1: Superficial wounds

Bruises and bite wounds were found in 2.6 per cent of camels with skin diseases. Bacterial isolates, which constituted 0.6 per cent of all organisms isolated, included Staphylococcus species, *Escherichia coli*, *Corynebacterium pyogenes* and non haemolytic Streptococcus species.

4.2.2: Cutaneous Necrosis

Necrotizing dermatitis, seen in 6.2 per cent of skin lesions, usually occurred in minor epidemics. The lesions were first noted as firm and painful swellings which later burst leaving ulcers of raw flesh (Figure VIII). The lesions were found on all parts of the body, but the most common sites for them were the centre of the gluteal region, shoulder, the back, the neck and the base of the tail.

Different bacteria were isolated from the lesions but Staphylococcus species, were the commonest, constituting 13.2 per cent of all isolates. *Escherichia coli*, comprised of 7.3 per cent and *Corynebacterium pseudotuberculosis*, *Corynebacterium pyogenes*, Beta (ß) haemolytic Streptococcus species, non-haemolytic Streptococcus species, *Pasteurella multocida*, *Klebsiella pneumoniae*, Anthracoids and Pseudomonas species together comprised a further 12.0 per cent.

4.2.3: Abscesses

Abscesses were in 17.4 per cent of camels with skin diseases (Figure IX a&b). They were commonly located on the lower neck, shoulders, area of the sub-mandibular lymph nodes and on the medial and lateral aspects of the thigh muscles. Twenty one camels had interdigital abscesses (Figure X). Although lymphadenitis, frequently involving the inferior cervical lymph nodes, was very common, no pus was found in them. A dramatic outbreak

of abscesses was encountered in a herd belonging to the Kenya Agricultural Research Institute at Ol Turot Field Station. Out of 118 camels, 85 developed large abscesses on the neck at sites where they were injected with quinapyramine (Noroquin® pro-salt, Norbrook) a month earlier as a 'blanket' prophylaxis against trypanosomiasis (figure XI a&b). Camels with very large ripe abscesses showed obvious signs of pain, anorexia and lactating ones had a drop in milk production. There was no age or sex predisposition. The abscesses were lanced, drained and thoroughly cleaned before systemic and local broadspectrum oxytetracycline was given. All camels recovered without complications.

Cultures from all cases of interdigital abscesses yielded *Corynebacterium pseudotuberculosis* which comprised 20.5 per cent of all isolates. In addition there was *Escherichia coli* (5.0 per cent), Staphylococcus species (3.0 per cent) and *Corynebacterium pyogenes*. (1.8 per cent). All swollen, abscessed lymph nodes of the head yielded Beta (ß) haemolytic Streptococcus species (33.5 per cent of the isolates). Other bacterial isolates from skin abscesses included non-haemolytic Streptococcus species, *Pasturella multocida, Klebsiella pneumonia* and Pseudomonas species (3.1 per cent of the isolates).

Antimicrobial sensitivity results are shown in table X.

Table IX: The incidence of camel skin diseases in 11,196 camels from October 1990 to September 1991

	Disease					
Month	Pox	Bruises	Cutaneous Necrosis	Abscesses	Fungal infections	Mite infestations
Oct.90	115	0	0	90	0	129
Nov.90	0	0	0	28	7	156
Dec 90	37	0	0	35	0	97
Jan.91	0	0	0	32	8	228
Feb.91	331	111	51	196	168	716
Mar.91	15	5	23	38	4	0
Apr.91	58	0	7	44	26	355
May.91	56	8	45	95	60	318
Jun.91	132	15	110	102	26	89
Jul.91	269	14	89	240	48	463
Aug.91	0	0	0	52	33	75
Sep.91	185	2	42	85	97	98
Total	1,198	155	367	1,037	477	2,724

(a): Camelpox in a calf.

Note severity of lesions around the mouth and the restraint by holding the tail.

(b): Close-up of the head of (a).

Note raw bleeding wounds around the mouth and the blindness caused by swollen and tightly closed eyelid. This camel calf could not feed adequately and such cases usually die if not treated for secondary infections using broadspectrum antibiotics.

Figure VI a&b: Pox lesions in a camel calf

(a): Camelpox in an adult

Lesions are isolated and less severe than in calves.

(b): Close-up of a head of an older camel (about three years) with camelpox.

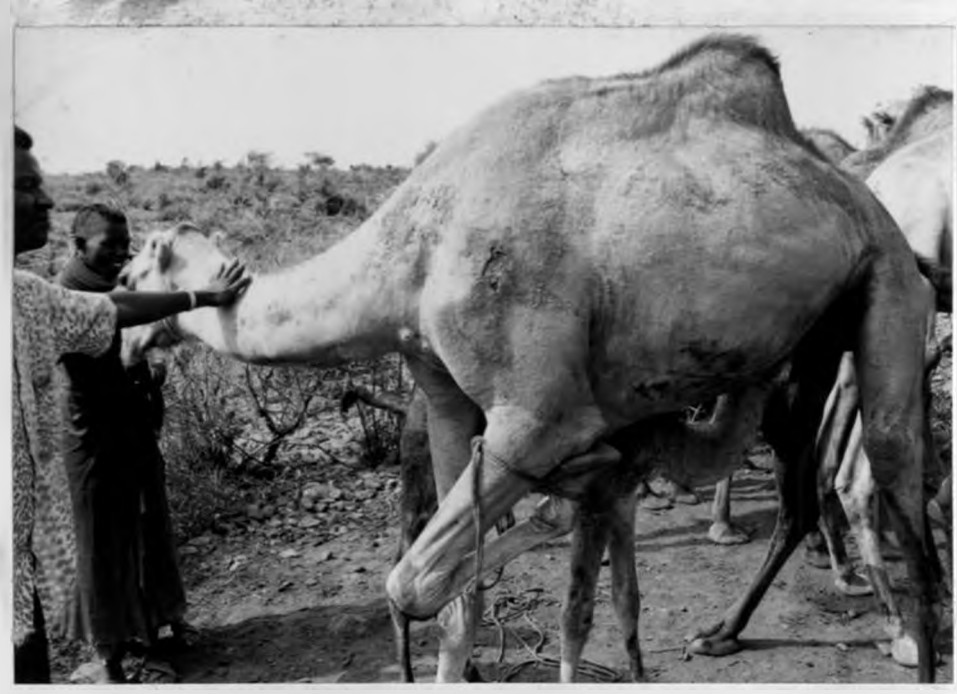
Lesions are less severe and confined to the lips. Note the brand marking denoting probably previous traditional treatment of enlarged regional glands or the clan symbol. Also note the manner of restraint by tightly holding onto the upper lip and the left ear.

Figure VII: Pox lesions in older camels

Table X: Sensitivity of bacterial isolates to antimicrobial agents

Microorganisms	Sensitive to
beta-haemolytic Streptococci	Erythromycin, Lincomycin, Chloramphenicol, Gentamicin, Ampicillin
Other Streptococci	Ampicillin, Gentamicin, Streptomycin, Tetracycline,. Erythromycin, Chloramphenicol.
Corynebacterium pseudotuberculosis	Chloramphenicol, Lincomycin and moderately to Tetracycline.
Corynebacterium pyogenes	Streptomycin, Ampicillin, Gentamicin, Lincomycin and Chloramphenicol.
Staphylococcus species	Ampicillin, Tetracycline, Lincomycin, Chloramphenicol, Nitrofurantoin, Gentamicin, Erythromycin, Cotrimoxazole, Streptomycin, Minocycline.
Escherichia coli.	Streptomycin, Gentamicin, Chloramphenicol, Tetracycline, Minocycline.
Pasturella multocida	Tetracyline, Sulphatriad*, Gentamicin, Streptomycin, Chloramphenicol, Erythromycin.
Pseudomonas species	Gentamicin, slightly to Ampicillin and Tetracycline.
Klebsiella species	Gentamicin, Nalidixic acid, Streptomycin, and moderately to tetracycline.
Bacillus species	Ampicillin, Gentamicin, Tetracycline, Chloramphenicol, Erythromycin and Lincomycin.

*Sulphatriad is a potentiated Sulphonamide.



(a): Cutaneous Necrosis in an adult female

Note the raw ulcer in the scapular region of a cow with calf at foot and the firm nodules on ventral part of the neck before bursting. Also note the method of restraint by haltering the left foreleg and holding onto the lips firmly.

(b): Close-up of skin necrosis on limb.

Cutaneous Necrosis below stiffle joint leading to cellulitis and swelling. Note the urine line. The camel urinates on its limbs so as to lose heat by evaporation instead of sweating.

Figure VIII a&b: Ulcers of raw flesh

(a): Abscess of the popliteal region in a bull.

The abscess is discharging and causing excoriation of skin below it.

(b): Abscess in the ventral thorax of a heifer.

Note the isolated and generalized lesions of camelpox and the official Z3F branding mark identifying the camel to belong to FARM Africa.

Figure IX: Skin abscesses

A close-up of the right foot of a heifer showing an abscess in the interdigital space. Note the 'pad-footed' morphology which separates the Camelidae from the other ruminants into the group Tylopoda.

Figure X: Interdigital abscess

(a): Ripe injection abscess post-prophylactic treatment with quinapyramine pro-salt.

Note the urine line and the ribs showing out. This photo was taken a month after the treatment which was done by laymen using dirty needles and syringes.

(b): Close-up of draining injection abscess.

Note the pus draining out from the ventral portion of the very large abscess and the identification brand marks. Camels with such abscesses showed signs of pain.

Figure XI a & b: Injection abscesses

4.3: Fungal infection

The incidence of dermatomycoses was 4.3 per cent. Ringworm, streptothricosis, sporotrichosis and other miscellaneous fungi were found and are described.

4.3.1: Ringworm

The prevalence of ringworm was 3.5 per cent. Two forms of presentations were encountered. One caused alopecia while the other caused granular lesions (Figures XII a & b). The disease did not present as a herd problem. Spread was reported to be slow and only a few in-contact animals were affected.

Infected hairs had a bent twisted appearance, broke easily and were easy to depilate. Examination of KOH preparations of hair revealed spores arranged in sheets, surrounding the hair shafts, and others arranged in chains within the substance of the hairs. Several different types of growths occurred on culture. Grossly, colonies of Microsporum species had white or tan colours to their front and pale yellow to orange-yellow colours on the reverse. The texture was flat and velvety. Trichophyton species had front colours white, buff, brown-red or yellow and the reverse white to tan, yellow and brown. The texture was powdery to velvety, downy, cottony or granular. Moist to pastry, white to cream-coloured colonies with fringed borders and down growth were suspected as *Candida albicans*. Colonies whose early cultures were white and later changed to greyish-green and were velvety were identified as Aspergillus species.

The Center For Microbiology Research, (KEMRI), identified the following organisms: Trichophyton species, *Candida albicans*, *Fusarium oxysporum*, *F. solani*, *Trichosporon glabrata*, *Aspergillus niger*, *A. nidulans*, Mucor species, Cladosporium and Scopulariopsis species.

4.3.2: Cutaneous Streptothricosis (Syn. Dermatophilosis)

The prevalence of dermatophilosis was 1.3 per cent. This disease was seen in calves in the wetter parts of Samburu district only. Both early stages and chronic lesions were observed. The former were observed as matting of hair into small tufts; this was generalized but did not involved the legs, whereas the latter lesions occurred on most of the body and

also involving the legs and ventral abdomen (figure XIII). Affected areas were irregular in shape, alopecic and varied from 4 to 12 centimetres in diameter.

Examination of direct smears from scab materials revealed branched Gram-positive filaments which appeared divided along transverse and longitudinal planes to form rows of coccoid bodies. These were isolated in pure culture from all suspected samples. The organism developed on SBA, at 37°C after 24 hours as small round, square or irregular greyish white colonies which were one to two millimeters in diameter. A one millimeter zone of complete haemolysis was seen after 48 hours. The colonies were raised, convex, rough, hard, adherent and formed pits in the medium. There were no growths on Sabouraud's Dextrose agar (SDA) or Mac Conkey's agar. The organism grew in nutrient broth with a dense suspension of coarse floccules. Surface pellicles developed later.

The following biochemical properties were found: Acid was produced, from fructose, sucrose, maltose and glucose in 48 hours; Lactose, mannitol and inositol were unchanged. Gelatin was liquified and urea hydrolyzed in 48 hours and catalase was produced. Litmus milk was reduced after 48 hours with no coagulation. There was no gas production and negative reactions were obtained to the nitrate, Methyl Red (MR), Voges-Proskauer (VP) and indole tests. The organism was sensitive to streptomycin, gentamicin, tetracycline, chloramphenicol, minocycline, erythromycin and sulphatriad.

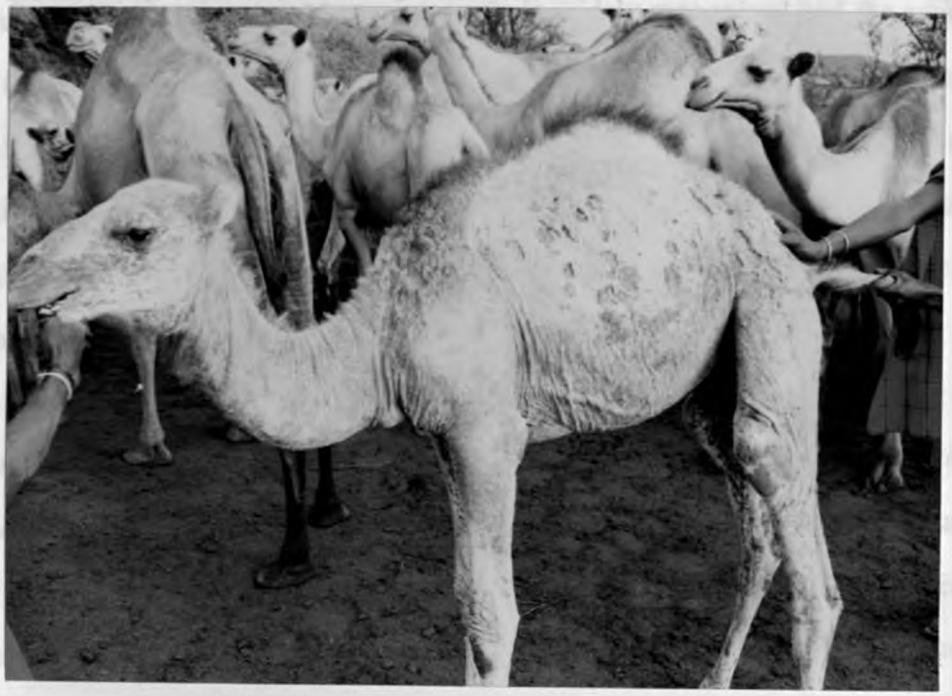
(a): Alopecic ringworm lesions.

Ringworm in an adult cow characterized by alopecia of round patches. Note healed scars on the neck.

(b): Granular ringworm lesions.

Ringworm in a young heifer (about two years) characterized by granular red ulcers in the upper neck region.

Figure XII a&b: Ringworm lesions:- alopecic and granular



Generalized Cutaneous Streptothricosis in a male calf.

Note the areas of alopecia, skin thickening and wrinkling. Such cases usually suffer concurrent infestations by other ectoparasites such as mange mites.

Figure XIII: Chronic Cutaneous Streptothricosis

4.4: Mite infestations

Camel mite infestation, which occurred as a herd problem, was the commonest skin disease encountered. The incidence in 11,196 camels was 24.3 per cent which comprised of 45.7 per cent of all skin diseases. Mange in camels is widely recognized and the owners requested for veterinary therapy which they believed was more effective than traditional medicine. Infestation was reported as starting on the relatively hairless areas of the skin and was associated with the mixing of clean camels with mangy herds or beasts. It was also noted that mange was commonest and more severe during the wet seasons and affected all ages and both sexes.

Clinically, camels were found rubbing against firm objects, biting and scratching the affected areas in an attempt to alleviate the itching (Figure XIV). Hair loss was noticed to start on the head, limbs, neck and flanks before involving the whole body. In chronic cases the skin was excoriated, alopecic and covered by scabs. There was generalized lichenification with concomitant loss of body condition (Figure XV). Loss of, or decreased milk production in lactating cows, slowed growth rates, loss of weight gains and abortions have been noticed and were reported by the camel keepers.

Five different mite species were recovered and identified. Because of concurrent infestation with *Sarcoptes scabiei* var. *cameli* , it was not possible to define the type of lesions caused by the other four. However, all cases responded favourably to treatment with diazinon 60 per cent (Neocidal® 600EC, Ciba-Geigy). Three hundred and eighty one camels were treated (250 in Turkana and 131 in Samburu) thrice at two weeks intervals. In very chronic cases hair started to regenerate after the third medication although at that stage, skin wrinkling was still evident.

4.4.1: *Sarcoptes scabiei* var. *cameli*

Sarcoptes scabiei var. *cameli* (Figure XVI), was the commonest parasite found in all mangy herds in Turkana, Samburu, Isiolo and Marsabit districts. This mite has been fully described in several textbooks and needs no further discussion. After reviewing the literature (Baker and Wharton, 1952; Baker *et al.*, 1956; Lapage, 1956; Hughes, 1959; Chandler and Read, 1961; Benbrook and Sloss, 1961; Georgi, 1969; Soulsby 1969; Sloss, 1970; Muller and

Kirk, 1976; Wilson, 1984; Higgins, 1986; Georgi and Georgi, 1990), the author concluded that the other four species were new and are hereby described.

4.4.2: ***Cardiocephaloptes marti*** new Sub-order, Family, Genus and species.

This parasite was found in camels in Samburu, Isiolo and Marsabit districts affecting 1,043 camels, which was 38.3 per cent of all cases of mange.

Both sexes are shaped like a beetle (figure XVII a&b), the male measures 100 x 60µm whereas the female measures 160 x 75µm on average. The capitulum (gnathosome) is shaped like the sign of a heart on playing cards with the base located posteriorly and the apex anteriorly. It measures 30 x 20µm and 40 x 25µm in the male and female respectively. The chelicerae end in a sharp needle point and a pair of whip-like pseudostigmatic organs curl anteriorly like horns and lies between the first pair of legs and the capitulum. Coxae I and II are widely separated from coxae III and IV (comparable to the sarcoptiformes). The first pair of legs composed of coxa, trochanter, femur, genu, tibia and tarsi are structurally similar in both sexes and measures 55µm in length. The tarsi of leg one (L_1) end in a sharp needle-like structure which is enclosed by a pair of curled setae ending at the same level (figure XVIII).

There is a marked difference in structure of the second pair of legs (L_2) in the male and female. L_2 in the male measures about 55µm and at the lateral end of the femur has a lanceolate structure projecting outwards; the genu and tibia are fused together and the tarsi are shaped like pincers of a crab. L_2 in the female has only three discernable segments with the third one being the longest and it ends in a Y-shape. It measures about 25µm in length.

The third pair of legs (L_3) in the male measure about 55µm and in the female about 80µm in length. In the male the coxa points anteriorly and the trochanter turns sharply at an angle of 90 degrees to point laterally. The segments contain scanty and short setae and the tibia has a nodular swelling from which setae grow and which divides it into a proximal larger portion and a smaller distal portion. The tarsi are subdivided into smaller portions and end in bifurcate tip. L_3 in the female has only four prominent segments and the tip is bifurcate as in the male.

There is a marked difference between the shapes of the fourth pairs of legs (L_4) among the sexes. However, both have three segments and measure approximately 35µm and 25µm

in male and female respectively. At the end of the femur in the male, there is a sickle-shaped claw and a straight cilia-like hair whereas in the female there is a pair of whip-like spines at the end of the femur.

A mass of dark granular material lies across and inside the body between the third coxae in both sexes and there is a line running right across the middle of the body between the second and third pairs of coxae. The chitinized and hard body is fairly smooth in both sexes. The genital pore in the female is located between the third pair of coxae and the anus is terminal as in the male. The palpi in the male has square-shaped tip. Prominent epimeres supports L_3 and L_4 in the male, and the female has a pair of projecting tail-like structures between L_4.

4.4.3: ***Camelonyssus golfer***, new genus and species.
(Suborder: Mesostigmata. Family: Dermanyssidae).

Three specimens of this mite were recovered. However, the 'abdomen' or the rest of the body had ruptured in all specimens during preparation of slides, leading to distortion of structures posterior to L_2. Thus it became impossible to see the dorsal and sternal plates, the anus, the genital pores and the peritremes. Figure (XX) showing complete specimen was drawn by reconstruction of the damaged parts and may not represent the exact appearance of intact specimens.

The pear-shaped body of the parasite was estimated to measure 650 x 326µm. The gnathostome (false head) which is lanceolate is poorly demarcated from the body, i.e is rudimentary and is overshadowed by the palpi and chelicera. It bears a pair of segmented palpi which measures 175µm and is armed with numerous setae. The single retracted chelicera which is tubular and needle-like measures 283 µm and lies between the palpi. The tip of the chelicera ends at the same level with that of the palpi (figure XIX). At the tip of the chelicera there is a stout chela which is shaped like a spear-head.

The four pairs of coxae are evenly spaced and are crowded into the anterior half of the body. The lengths of the legs are L_1 313µm, L_2 275µm, L_3 240µm and L_4 225µm. The legs have six segments:- coxa, trochanter, femur, genu, tibia and tarsus. At the end of each tarsus there are several long setae and a caruncle composed of a short unsegmented stalk and

a club-like sucker. Both the stalk and the sucker form a structure similar to the head of a golf club (figure XIX) hence the name "golfer".

4.4.4: *Camelonyssus samburu*, new genus and species.

(Suborder: Mesostigmata. Family: Dermanyssidae).

Three specimens of this mite were recovered in a damaged state as that of *C. golfer*. This mite resembles the former one but is smaller, measuring approximately 500 x 250µm. The conical gnathostome which is well demarcated from the body, has a width of 50µm at the base and is 65µm long. It bears three pairs of bilateral and symmetrically arranged spikes and a pair of segmented palpi. The palpi are each armed with a single spike and numerous setae. The single needle-shaped chelicera, which is tubular, emerges from between two sharp (and strong) spikes and extends to the level of a line drawn between the two anterior suckers on L_1. It is 157µm long and has no chela.

The four pairs of coxae are evenly spaced and are crowded into the anterior half of the body. The lengths of the legs are L_1 238µm, L_2 210µm, L_3 200µm and L_4 180µm. The legs have six segments:- coxa, trochanter, femur, genu, tibia and tarsus. At the end of each tarsus there are several long setae and a caruncle composed of a short unsegmented stalk and a bell-shaped sucker (figure XXI and figure XXII).

4.4.5: The Baragoi 'Louse-Mite'

Only one specimen of this arachnid parasite was recovered from a yearling calf two kilometres north of Baragoi town. Unfortunately, the distal portions of all the eight legs were broken and missing leaving only the first one or two segment. The specimen was divided into two distinct structures: the head and the body, which measured 324 x 230µm and 1,024 x 505µm respectively (figure XXIII). The head bears the most distinctive features which should make it easy for future researchers to identify this parasite. The mouth part consists of five pairs of structures. The most anterior outer pair consist of sharp-ended pincers and is 90µm long.The second pair of mouth parts is enclosed behind the pincers and consists of a lateral chitinous hooked structure and a membraneous part which is divided into veins like a feather. The third pair is shaped exactly as the second but is only half the size

and length of the latter. The fourth and fifth pairs are rod-shaped with sharp anterior ends. Their bases are wide apart but the sharp ends of each pair meet at an angle of 45 degrees.

The body is pear-shaped and bears four pairs of legs (figure XXIV). The rear end is cut square and it bears a pair of projecting organs that look like antennae. In between them there is a pair of short protruding organs resembling spiracles or alteres. No further observations could be made because the parasite disintegrated in KOH preparation.

One year old male calf with spreading mange lesions.

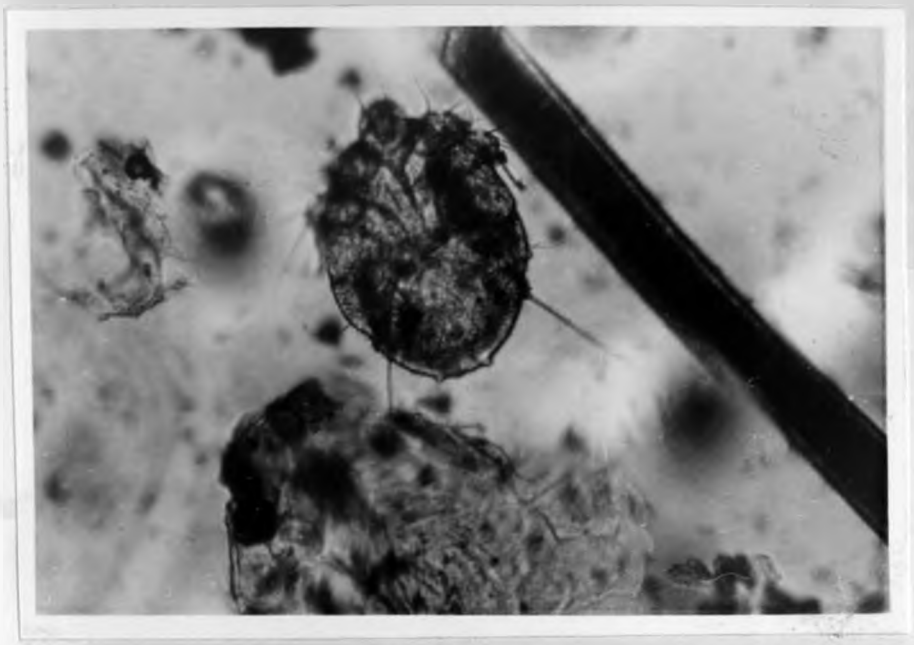
The camel calf is biting at the itching area. To relieve the pruritis, camels scratch against solid objects, bite or may rub on another camel. Note alopecia which is more severe on the limbs, head, neck and ventral abdomen. Skin thickening and discolouration is evident on the hind limbs. The photo was taken a week after acaricide application had been commenced by the owner.

Figure XIV: Mangy camel calf scratching

A close-up of hind limbs of a heifer with chronic mange.

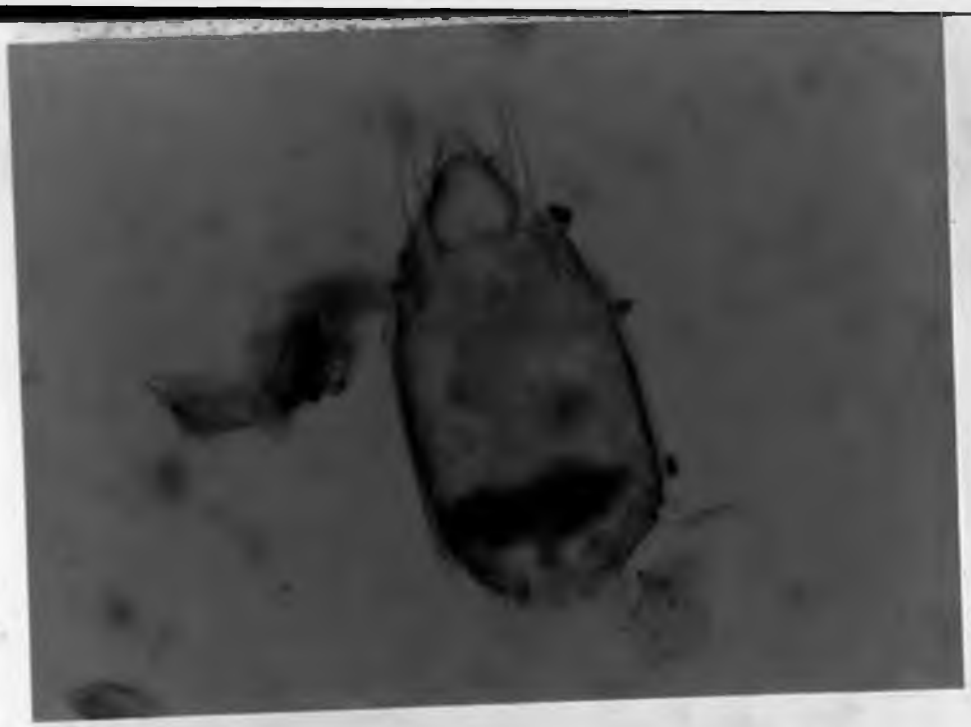
The Baragoi 'Louse-mite' and *C. marti* were recovered from this particular heifer. Note the pronounced skin thickening and wrinkling which now appears as an 'elephant skin'. On the thighs are clusters of ticks and a fly. This photo was taken a month after commencement of treatment with diazinon by the owner who had been advised so. Note also that the hair is regenerating.

Figure XV: Chronic case of mange showing skin thickening



Adult male *Sarcoptes scabiei* var. *cameli*.(X 400).

Figure XVI: ***Sarcoptes scabiei*** **var.** ***cameli***



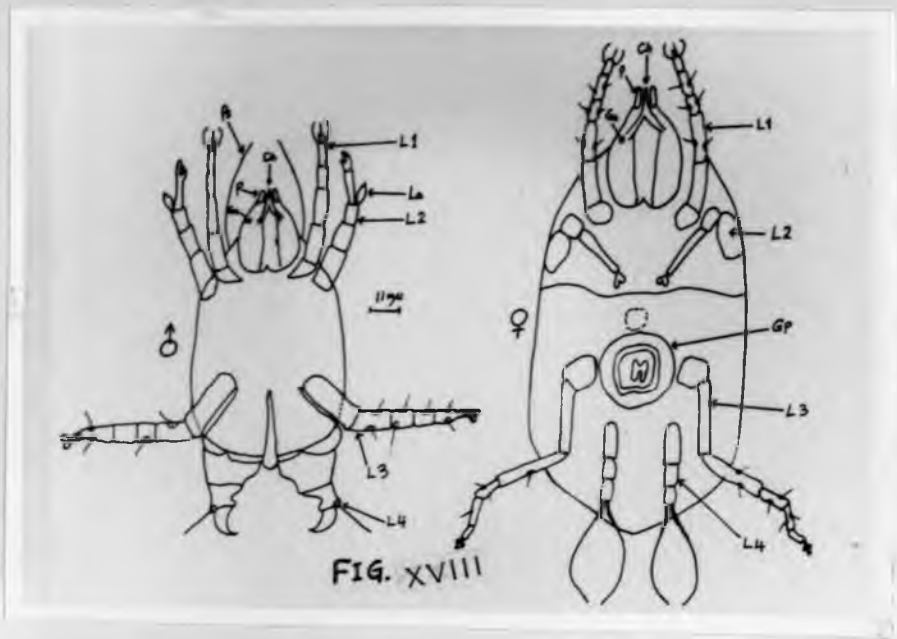
(a): *C. marti* female. (X 400).

Note the beetle shape and the heart-shaped gnathosome.

(b): *C. marti* male with broken L_1 and L_2. (X 400).

Note the black band in the posterior end which is characteristic of all sexes. Also note the modified L_4 for copulation.

Figure XVII a&b: *Cardiocephaloptes marti*



Ventral view of male and female *C. marti*. Free-hand, drawn to scale.

Key:- Ps = pseudostigmatic organ; Ch = chelicera; P = pedipalp; Gn = gnathosome; Su = sucker; St = stalk; L_1 = leg one, L_2 = leg two, L_3 = leg three and L_4 = leg four; La = lanceolate appendage.

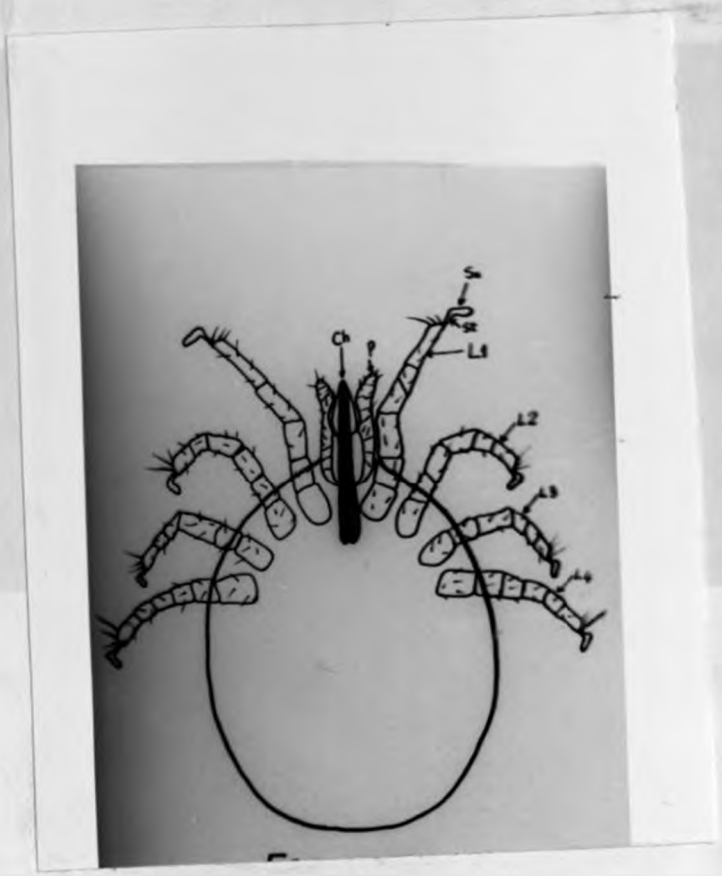
Note beetle shaped configuration, heart-shaped head, lanceolate organ on L_2 in male, massive claw on L_4 in male and whip-like setae on L_4 in female.

Figure XVIII: *Cardiocephaloptes marti* (sketches)

C. golfer (X 100)

Note the shape of the sucker together with the stalk and the retracted chelicera.

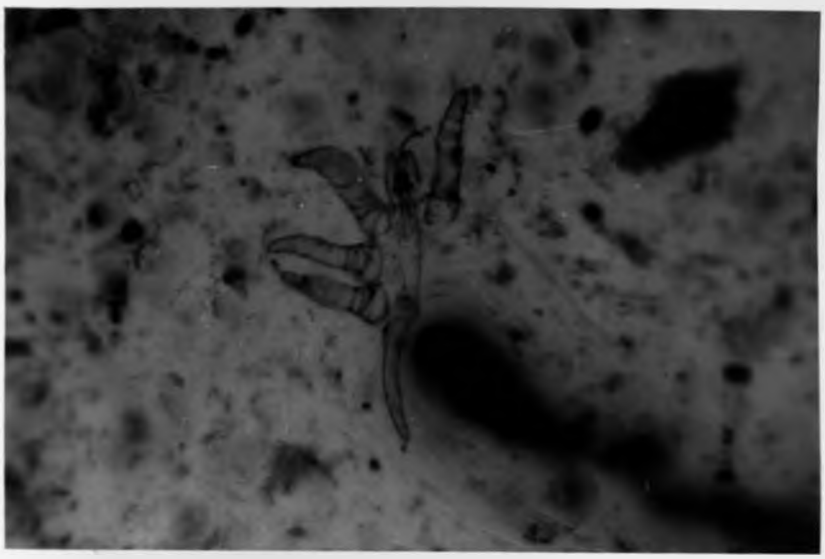
Figure XIX: ***Camelonyssus golfer***



C. golfer unidentified sex, not drawn to scale.

Key:- Ch = chelicera; P = pedipalp; Su = sucker; St = stalk; L1 = leg one, L2 = leg two, L3 = leg three and L4 = leg four. Free-hand drawing. This parasite is estimated to measure 650 x 326µm. Its gnathosome is overshadowed by the pedipalp and the retracted chelicera. Note the spear-shaped chela at the end of the chelicera, the stalk and the sucker which together are shaped like a golf club.

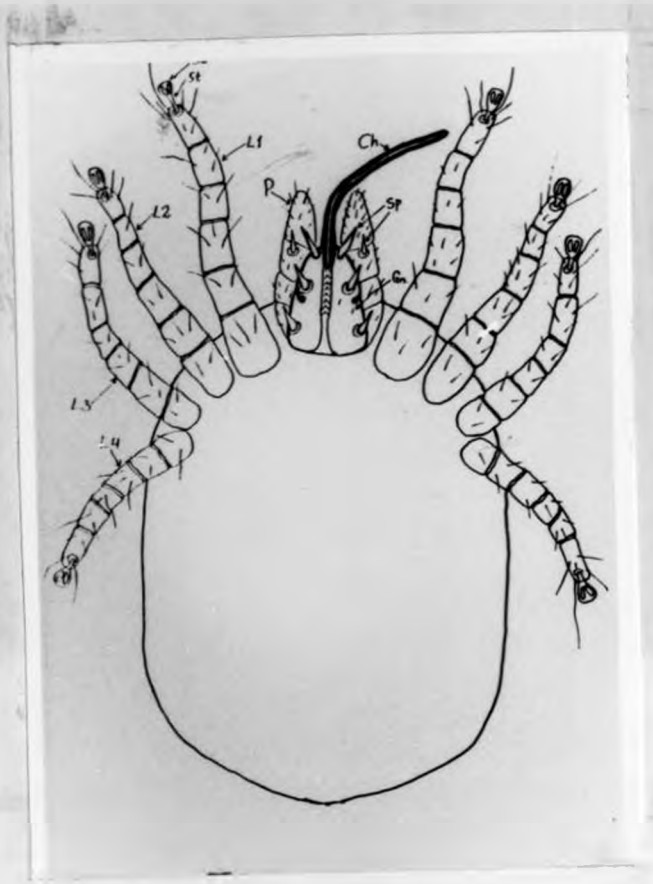
Figure XX: ***Camelonyssus golfer*** **(sketch)**



C. samburu (X 100).

Note the protruding chelicera overshadowed gnathosome and the bell-shaped sucker.

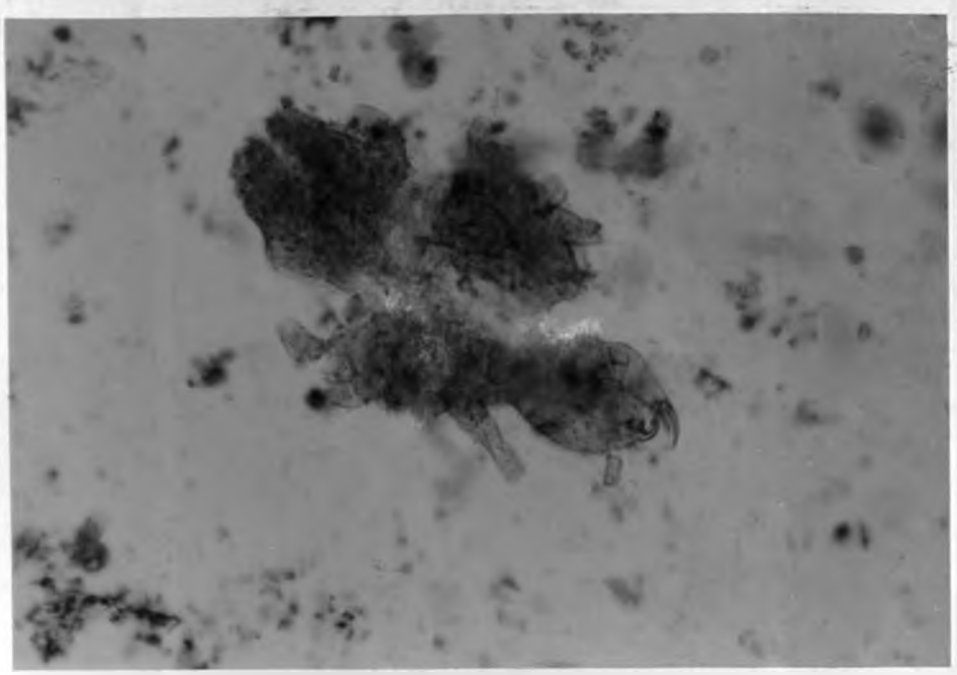
Figure XXI: ***Camelonyssus samburu***



C. samburu unidentified sex and not drawn to scale.

Key:- Ch = chelicera; P = pedipalp; Sp = spikes on gnathosome and pedipalp; Gn = gnathosome; L1 = leg one, L2 = leg two, L3 = leg three and L4 = leg four; Su = sucker; St = stalk. Free-hand drawing.and not to scale. Note the protruding chelicera, the well demarcated gnathosome, spikes on gnathosome and pedipalp and the bell-shaped suckers.

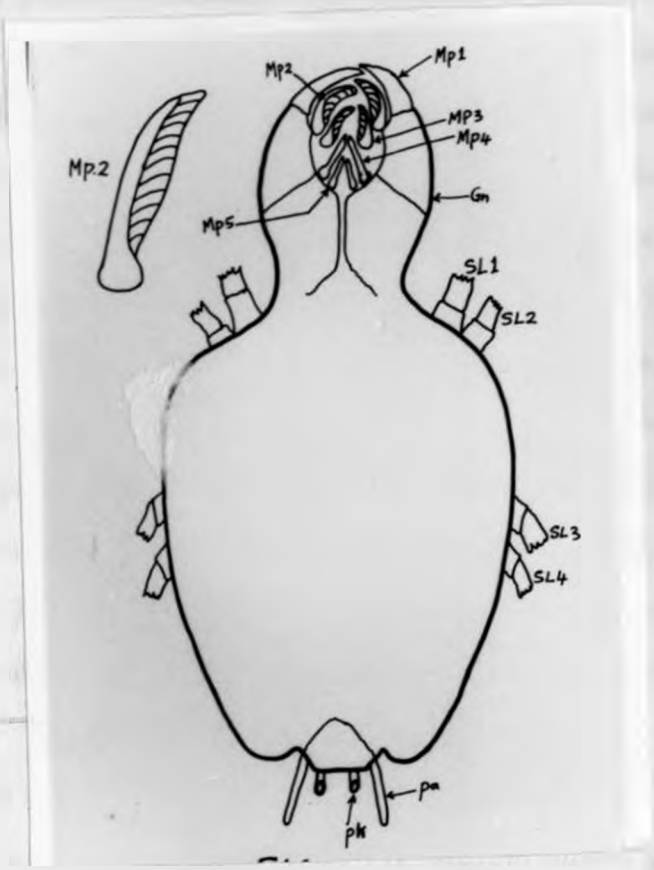
Figure XXII: *Camelonyssus samburu* (sketch)



Disintegrating specimen of the Baragoi 'Louse-mite'. (X 100).

Note the four pairs of stumps and the massive claws.

Figure XXIII: The Baragoi 'Louse-Mite'



The Baragoi 'Louse-Mite' Free-hand drawing to scale.

Key:- Mp 1, Mp 2, Mp 3, Mp 4 and Mp 5 = mouth parts; Mp. 2 = enlarged Mp 2; Gn =gnathosome; SL 1; SL 2, SL 3 and SL 4 = stumps of limbs; Pa = posterior antenna-like structure; pk = posterior knob.

Note separate structure Mp.2 on the left is enlarged sketch of one of the second pair of mouth parts. The third pair is similarly formed.

Figure XXIV: The Baragoi 'Louse-Mite' (sketch)

4.5: Tick infestations

Apart from the project-owned camel herds visited, all other herds were infested with ticks the year round. The pastoralists recognized ticks as a severe constraint especially in calf rearing and tried to keep their animals away from grazing areas known to be heavily infested. Traditionally they practiced hand-picking, but are now using acaricides mostly.

The point prevalence rate of ticks on camels was 100 per cent amongst the nomadic herds throughout the study period. The sites commonly infested with ticks were the nostrils, sternal, inguinal and anal regions, eyelids, ears, tail and interdigital spaces. In camel calves nymphs were spread all over the body surface whereas in adults they were spread along the backbone only. On parts of the body covered by thick hairs, nymphs could only be detected on palpation. Evidence of tissue damage caused by tick bite was common on predilection sites (Figure XXV). The resulting wound often led to infection and abscess formation. Ticks attached on the eyelids caused excessive irritation which resulted in marked lacrimation and conjunctivitis.

The following ixodid or hard ticks were identified: *Amblyomma gemma, Hyalomma dromedarii*; *H. truncatum*; *H. impeltatum**, *H. albiparmatum**, *H. detritum**, *H. marginatum rufipes**, *Rhipicephalus punctatus**, *R. pulchellus and R. pravus*. One argasid or soft tick was identified as an Ornithodorus species (figure XXVI) Although no actual counts of tick load were made, over 90 per cent of the ticks found on the camels were of the genus Hyalomma.

Of all the eleven tick species identified, the males were more numerous than females. Very few engorged females were encountered. It is known that in other animals such as cattle, ticks are vectors of haemoparasites. However in this case, thick and thin blood smears taken from 426 camels were negative for haemoparasites. There was total elimination of ticks from 476 camels treated with two per cent Cypermethrin high-cis (Ectopor®, Ciba-Geigy) at three-week intervals in Turkana and Samburu districts.

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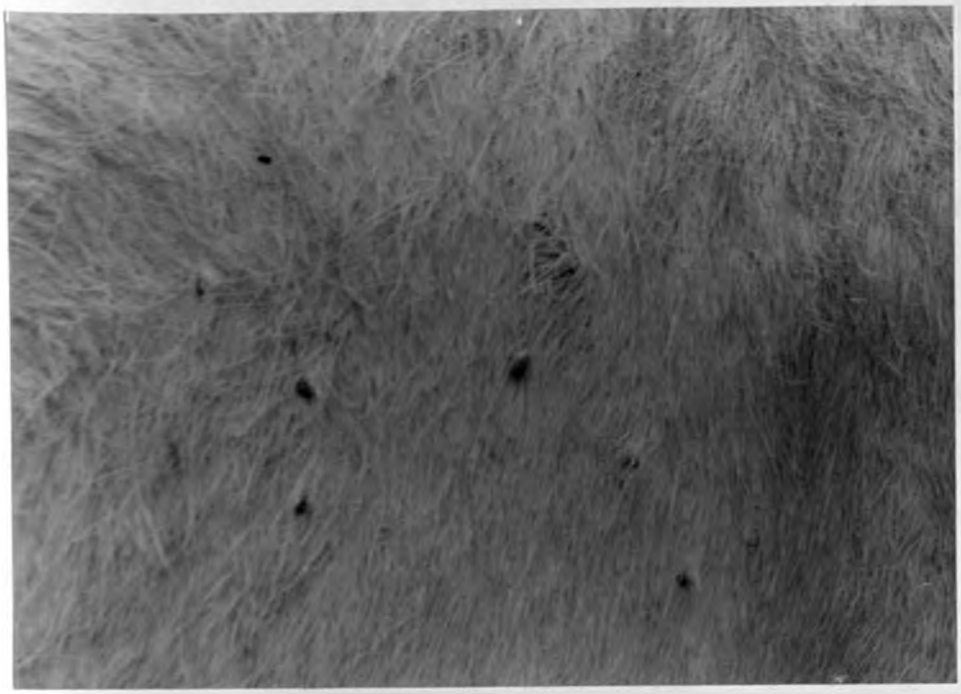
*Tick species identified in Turkana in 1991 by Dr. J.C. Njanja, Veterinary Ecologist, UNESCO/NORAD-TREMU, P.O. Box 310, Lodwar, Kenya.

Close-up of the ear of a heifer

Note that the stump of the ear is infected by Ambylomma species of ticks. The infestation caused hypersensitivity reaction characterized by swelling of the skin, suppuration and haemorrhage. Note also the nuisance fly attracted to the wound.

Figure XXV: Tick hypersensitivity reactions



Close-up of skin on the abdomen region of a heifer showing Ornithodorus species of soft tick.

Figure XXVI Argasid tick species

4.6: Fly nuisance irritation

The third-stage larvae of the camel nasal bot fly (*Cephalopina titillator*), were found in five camel carcasses examined at the Isiolo abattoir and one camel slaughtered at Gus during the month of August 1991. The larvae were found attached to the nasopharyngeal mucosa. The animals appeared in good health during antemortem inspection. The appearance of neurological signs, resembling cranial coenuriasis, in a camel at South Horr was attributed to pathological changes caused by heavy infestation with the nasal bot, but no adult flies were seen on the camels or in the area over a two-week period.

Camel-flies, *Hippobosca camelina* were found in all camel herds except where Ectopor® was being used. The flies are stout, about one centimetre in length, reddish-brown in colour, with pale yellow spots and brown hairy legs which are well adapted for attachment to the host (Figure XXVII a & b). When feeding the flies attach on any part of the body although they prefer the perineum and ventral abdomen from where they are not easily disturbed. Two other flies *Musca domestica* and *Stomoxys calcitrans* were very numerous around the manyattas where they attacked all livestock species. Camels suffering or recovering from pox were severely disturbed by these flies.

4.7: Lice

Only legs (figure XXVIII a & b) which closely resembled those of *Damalinia bovis* (Lapage, 1956 figure 323 page 566) were recovered. In cases of very heavy infestations, the camels were reported to stop feeding and bite, rub or scratch affected areas. The coat became shaggy and matted together. Diazinon (Neocidal®, Ciba-Geigy) was effective in eliminating the lice from the infested herds treated.

4.8: Fleas

Unidentified fleas were found attacking camels at Ol Turot and Marti in Marsabit and Samburu districts respectively. Restlessness was noticed when the camels were driven into infested enclosures for examination.

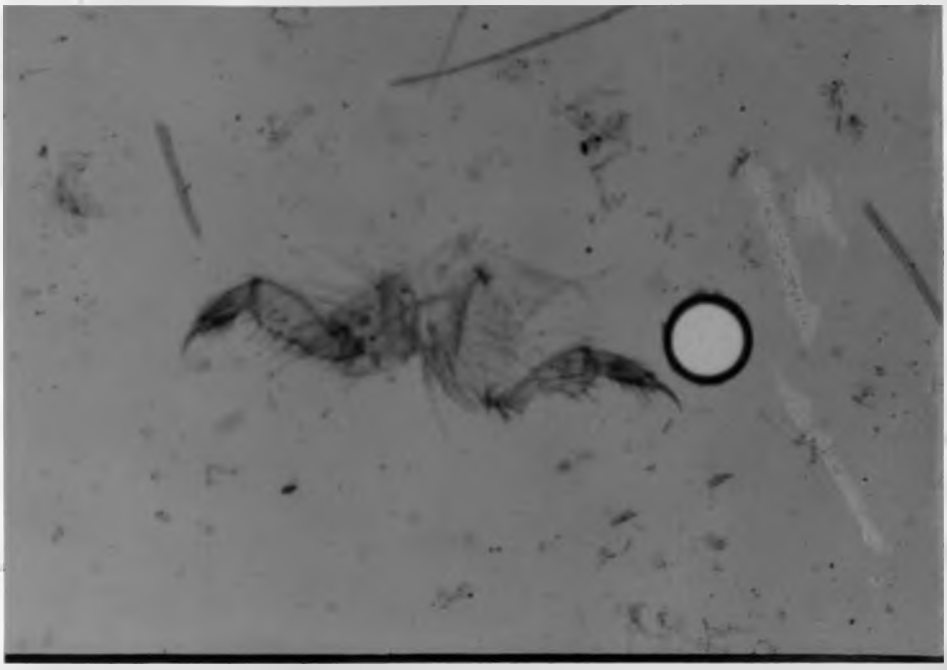
(a): Camel-flies attaching to the host.

Note dozens of camel-flies feeding on the legs of an adult camel cow. Note also the urine stain on the medial aspect of the right hind limb.

(b): Camel-flies specimens in a petri dish.

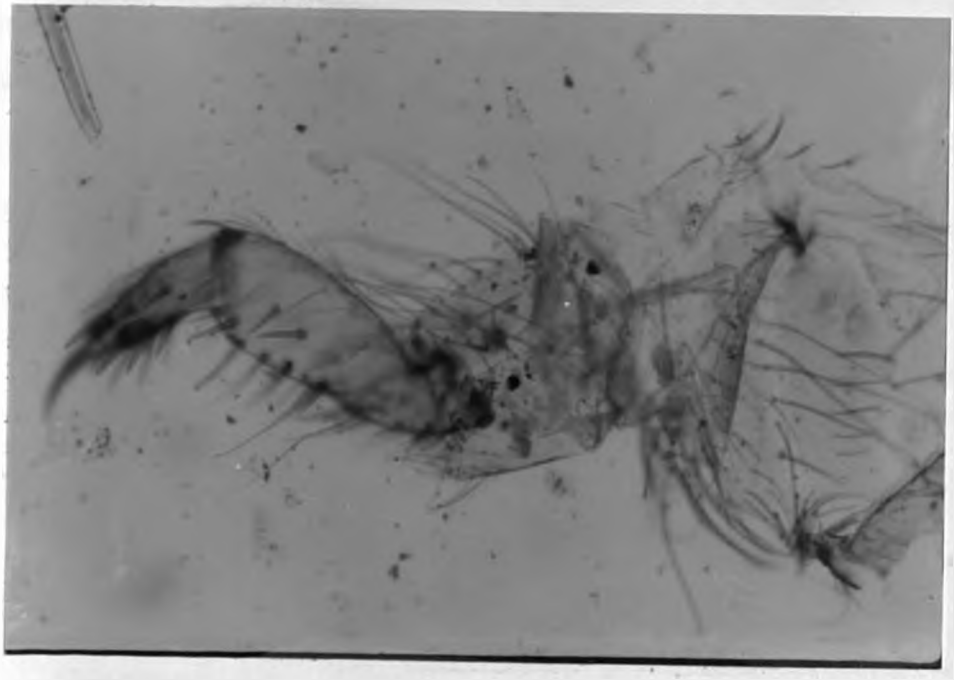
Note five dead adult specimens of camel-fly and an egg in a petri-dish. These flies are stout and are reddish-brown in colour, with pale yellow spots and brown hairy legs.

Figure XXVII a & b: ***Hippobosca camelina***



(a): Fragment of legs of a louse.

The fragments were recovered from skin scrapings from camels with shaggy and matted hair coat suspected to have mange.



(b): Close-up of above.

Bears strong resemblance to *Damalinia bovis*.

Figure XXVIII a&b: Part of Louse legs

4.9: Histopathology

Cases of ringworm showed prominent but focal acanthosis, hyperpigmentation and hyperkeratosis. Histologic sections of hair follicles prepared with Periodic-Acid Schiff (PAS) showed fungal elements staining bright red. Inflammatory cell infiltration was in the papillary layer of the dermis accompanied by advancing hyphal invasion within keratinized epithelium on the surface and in hair follicles. Generally, the histological picture was that of a subacute to chronic dermatitis. Long, narrow, tapering and branching filaments of *Dermatophilus congolensis* were seen in the ostia of hair follicles, growing as a mass of mycelia.

Mite infestation caused acanthosis with intracellular and intercellular oedema in the stratum spinosum. The dermis was infiltrated primarily by lymphocytes and a few eosinophils. Hyperkeratosis and excoriations were also present.

Cases of camelpox had intraepidermal vesiculation in the stratum spinosum resulting from epidermal spongiosis with ballooning degeneration. However, no inclusion bodies were demonstrated in Lendrum stained sections.

The pathological changes recognized are shown in table XI. In all of the 253 histological skin sections examined, no demodicosis or other known parasitic infections such as onchocercosis was observed.

Table XI: Types of pathological changes encountered

Pathological Change	Percentage
Hyperkeratosis	21.9
Dermatitis (all types)	16.4
Mycotic infection	17.4
Alopecia	11.3
Excoriation	9.1
Hair degeneration	7.5
Hyperpigmentation	4.8
Epidermal atrophy	4.1
Microabscesses	3.9
Spongiosis	2.4
Hydropic degeneration of epidermis	1.2

CHAPTER FIVE

5.0: DISCUSSION/CONCLUSSION

There is a growing realization that camels have an important place in pastoral economies in Kenya. The author agrees with an earlier report (Hussein, 1987) that the monetary importance of the camel depends on the way the beast is used in the pastoral system. These days there is a growing tendency towards monetarization of the traditional subsistence economy of pastoralists. For instance, the Samburu pastoralists have now realized the importance of the camel, although they only acquired camels as late as the nineteen twenties (Field, 1990). These people now trade in camels, sell camel milk and hire out their riding and racing animals.

During the period of this study, some of the pastoralists walked 100 kilometres in search of pasture and water. Others watched helplessly as drought decimated their cattle in the lowlands, while cerebral theileriasis killed more in the uplands around Maralal. They spent large sums of money on veterinary drugs to sustain their cattle, sheep and goats. But the drought neither caused any appreciable loss of life among the camels nor did it lower their productivity. Indeed most camel deaths reported were due to an unidentified disease characterized by enlargement of lymph nodes of the head, leading to respiratory distress. *Pasteurella multocida* and *Bacillus anthracis* have been incriminated as the causes of the adenitis but no definitive diagnosis has so far been made.

Camels are not used for ploughing or irrigation in Kenya, possibly because of the pastoral rather than agricultural nature of the camel owner's way of life. In most of these areas there are very few permanent water sources and the rainfall is unreliable and unpredictable. Only a few pastoralists practice rainfed agriculture.

It is impossible for the camel herds to remain in any one place for long periods of time because of the harsh environment. This creates difficulties in collecting appropriate samples at the optimal time. This constraint is further compounded by the difficulty of transferring samples to diagnostic laboratories situated hundreds of kilometres away. In these circumstances, the importance of making a thorough clinical examination in order to reach a correct diagnosis is very important. However, confirmatory diagnoses must be made in the

laboratories in order to understand the epidemiology of the diseases which is very important in the planning and implementation of appropriate preventive and control measures.

Only a few camel hides were found in the Isiolo hides stores compared with numerous cattle hides, sheep and goats skins. This finding confirms further the fact that the camel hide, though very strong, is not yet being utilized for commercial purposes The many camel skin diseases/conditions encountered lower the value of the skin and the traditional branding with clan symbols and trauma caused by thorny browse plants also contribute more defects which downgrade these hides. Utilisation of the camel hide to make various leather products is a viable project and thus feasibility study of introducing tanneries into the camel producing regions should be undertaken immediately.

The pastoralists have a vast knowledge of the problems facing their livestock. It is beneficial to draw on their knowledge and to do this, it is imperative to learn the vernacular names of the diseases affecting their livestock.

5.1: Viral diseases

Although camelpox was diagnosed clinically, no inclusion bodies were observed after using special (Lendrum's) stain. That was not surprising because inclusion bodies only appear early in the disease but may not be seen in chronic cases which were the types frequently encountered. The camels are grazed in remote areas and in most cases the owners report the disease after it has been aggravated by secondary bacterial infection leading to deaths. Due to logistical constraints, virus isolation was not attempted.

The ELISA technique has been used to detect antibodies against strains of camelpox virus but electron microscopic identification of the virus is the quickest and most reliable method (Blood *et al.*, 1983; Munz *et al.*, 1986), which also differentiates pox from orf caused by a parapox virus (Moallin and Zessin; 1988) and camel papillomatosis virus (Munz *et al.*, 1990). Camelpox is endemic in Kenya and there seems to be several distinct antigenic strains of the virus (Tantawi, 1974). Frequently, contagious ecthyma occurs concurrently with camelpox and the symptoms bear close resemblance. However, the Turkana herdsmen know the differential diagnosis of these diseases. Thus camelpox is called 'Loper' or 'Etune'

whereas camel orf is referred to as 'Ngibuorok'. Papillomatosis being rare is not identified as a specific skin disease. Other pastoralists like the Somali, Gabbra and Rendille are also experts in disease diagnosis and differential diagnosis.

Although camelpox was diagnosed clinically only without laboratory confirmation, during this study, the author is confident of his diagnosis because biopsies of vesicles and scab lesions taken from camels in Turkana in 1988 were virologically confirmed as camelpox (Davies, 1988). Knowledge of the etiology, prevalence and distribution of both pox diseases is a prerequisite for their control or to application of appropriate prophylactic measures. Whereas the mortality rate in camelpox can go upto 10 per cent, vaccine development is not advocated for. This is because the author believes it would be very expensive, and the anticipated additional value of the protected animals will not cover those of vaccine production.

At the moment it is unknown what type of immunity any vaccine would produce and for how long. Further more the disease appears to kill calves mainly when secondary bacterial infection sets in and the disease is not a zoonosis. Although Crees (1986), proposed vaccination as the most likely remedy, mobilization of the campaign teams and other logistics such as maintenance of cold chains, which will be recurrent, will be limiting due to the widespread and seasonal nature of the disease. Therefore, the author further concurs with Simpkin (1991) that adequate colostrum feeding and prompt broadspectrum antibiotic coverage of severely affected animals would suffice. However, if camelpox could be eradicated like smallpox in man, then the camel owner could benefit even more.

The relationship between camelpox and the 'swollen head glands' disease (Long'arurei in Turkana language and Nang'arng'ar in the Samburu dialect), needs to be investigated further. The author also believes the abortions reported following camelpox are due to the fever produced in the acute phase of the disease. Should that be the case, and also considering that the disease is very widespread, vaccination could be attempted.

5.2: Bacterial diseases

The bacteria isolated and identified were those already recorded in the literature (Domenech, *et al;* 1977; Wilson, 1984; Higgins, 1986). The inferior cervical lymph nodes were the most commonly affected in all ages but lesions were also found on the hindquarters, on the shoulders or on all parts of the body without any predilection. Purulent lymphadenitis was rare in Turkana but very common in the semi-arid areas of Samburu and Isiolo districts. It is probable that samples yielding no pathogens were either from sterile abscesses or the microorganisms lost their viability during transportation from the field to the laboratory because of the very vast distance covered and the lack of regular transport. Fully equiped field laboratories would solve these problems.

The environment in which the camel is found, dictates that it be nomadic if it is to survive and produce to its optimal potential. Unfortunately, mobility can be severely curtailed by lameness. In this study interdigital abscess which occurred in a few animals, was one cause of lameness which caused a very significant loss of production in the affected animals.

5.2.1: Bruises

Lacerations frequently occur in nomadic camels due to the presence of predominantly thorn bushes on which they browse. Another hazard is the size of incisor and canine teeth with which camels fight one another and inflict serious wounds. The male is usually the offender, particularly in the rutting season.

Only *Corynebacterium pyogenes* isolated from the bruises is considered pathogenic whereas Staphylococcus species and *Escherichia coli* were probably contaminants or opportunists since they abound on the normal intact skin and in the environment. It is recommended by the author that bruises be promptly treated with topical application of broadspectrum antibiotics such as oxytetracycline (e.g. Terramycin®, Pfizer). In severely infected cases, oxytetracycline, ampicillin and penicillin-streptomycin combinations can be used systemically since this study has shown that these bacteria are sensitive to them.

In serious cases, suturing may be indicated if the wound is fresh and clean in order to ensure healing by first intention. This may not be possible under field conditions because

there is the tendency of the camel owners to delay seeking veterinary attention or to attempt to apply traditional remedies to the wound. Heavily contaminated wounds should be cleaned, curreted and suitable antibiotic dressing applied. However, in serious cases it may be necessary to sedate the patient with local anaesthetics where possible. Camels are susceptible to tetanus (McGrane and Higgins, 1986). Therefore, the use of tetanus antitoxin should be considered if the animal's value justifies it. Fresh wounds are attractive to flies, and camels are as susceptible to myiasis as are other species (Higgins, 1986), therefore, it would be beneficial to apply insecticides to reduce the incidence of myiasis.

5.2.2: Cutaneous Necrosis

Although Staphylococcus species and *Escherichia coli* were the commonest isolates from these condition, the author believes that they were not very important pathogens. It is not difficult to envisage how the camel picks these bacteria since it wallows in the dust very often. However, Staphylococcus species which are mainly associated with the skin are potential pathogens and coagulase positive *Staphylococcus aureus* have been reported to cause contagious skin necrosis (Higgins, 1986). *Corynebacterium pseudotuberculosis*, *C. pyogenes* and Streptococcus species are known pathogens (Eldelsten and Pegram, 1974; Domenech *et al.*,1977). *C. pseudotuberculosis* is usually associated with deep-seated lesions such as lymph node abscesses although it may occur in superficial wounds.

Pasteurella multocida causes haemorrhagic septicaemia in camels (Higgins, 1986), but this pathogen has also been associated with wound infections (Buchanan and Gibbons, 1974). Members of the genus Pseudomonas are common inhabitants of the soil and most are occasional animal pathogens. *Klebsiella pneumoniae* and *E. coli* are reported to cause peracute mastitis in camels in India (Kapur *et al.*, 1982). However, their role in skin necrosis is not known. The 'anthracoids' isolated and identified in KEMRI adds more weight to a speculation held by the author that some of the contagious necrotic skin lesions could indeed be cutaneous manifestation of anthrax in the camel, the main reason being the association noticed between numerous cases of sudden death in camels during the wet season and the outbreak of the fresh skin ulcers in the surviving in-contact herds. Although this has been observed for four years, no laboratory confirmation of anthrax was made.

C. pyogenes and Streptococcus species were the most likely pathogens that played a more significant role in Cutaneous Necrosis seen during the study period. The author agrees with Rutter and Mack (1963) that Cutaneous necrosis is very widespread but disagrees with the same authors that it is the most important bacterial disease of camels. This is because according to the author's experience, haemorrhagic septicaemia is fatal and is very widespread in northern Kenya. The swollen head glands and anthrax are other important diseases and pathogenicity experiments may be required to determine the differences in virulence in order to compare objectively their relative importance.

Various treatments have been tried in an attempt to cure Cutaneous Necrosis. Peck (1939), concluded that cauterization with phenol followed by application of saline packs was the most effective and that occurrence could be prevented by increasing the dietary intake of salt. Although this condition has been related to faulty diet, free-ranging desert camels with ready access to salt-bush and salty water springs are unlikely to become deficient in salt under normal circumstances and yet they still suffer from it. Eldelsten and Pegram (1974) treated lesions with intramammary penicillin-streptomycin suspension locally, followed by parenteral administration of long-acting penicillin. Based on the sensitivity results, ampicillin, tetracycline, gentamicin and penicillin-streptomycin combinations are suggested for treating this condition.

5.2.3: Abscesses

Escherichia coli and the Staphylococcus species isolated from abscesses were likely to be opportunists or contaminants since they are ubiquitous in the environment. *Corynebacterium pseudotuberculosis* and *C. pyogenes* isolated were pathogenic. *C. pseudotuberculosis* which was isolated from all cases of interdigital abscess was resistant to most locally available antibiotics. The pastoralist is very quick in noticing illness affecting his stock and lameness is easy to diagnose. The author believes that these people used antibiotics incorrectly in attempting to treat lameness, a fact supported by the bacterial sensitivity results, which showed that the pathogens were not sensitive to tetracyclines known to be possessed. This bacteria is able to survive in the soil and fomites for long

periods, hence, it is usually enzootic wherever it occurs. Skin abrasions (Hein and Cargill, 1981) are known to act as ports of entry of the organisms and camels are prone to abrasions and trauma in their environment. *C. pyogenes* was isolated from the interdigital abscesses and other foot abscesses.

Superficial abscesses lower the value of hides and this could explain why camel skins are not commercially exploited. Lymphadenitis and skin necrosis lower the market value of the animals as reported by Williams (1980). These bacterial diseases are therefore economically important. Injection abscess due to use of dirty needles and syringes can lead to loss of production and lower the market value as was demonstrated in this study.

The drugs of choice for foot abscesses in the camel are lincomycin, ampicillin and gentamicin. Chloramphenicol is a restricted drug since it is very useful in the treatment of certain important human diseases such as meningitis. Long acting oxytetracycline preparations (for example, Terramycin® LA, Pfizer) when used in the correct dosage after draining and properly cleaning the lanced abscess are likely to work.

5.3: Fungal infection

In this study, the species of fungi cultured and identified were those known and reported in the literature. Although the incidence of fungal infection in the population was found to be low (4.3 per cent), there were growths recovered from all suspected samples from each herd examined. This study has therefore shown that dermatomycoses are widespread in camels.

5.3.1: Ringworm

According to McGrane and Higgins (1986) the only important fungal skin infection in the camel is ringworm. The author disagrees with their view and believes that sporotrichosis is an economically important disease of the camel. Trichophyton and microsporum species are the usual cause of ringworm but other fungi are likely to be involved too. All cases of ringworm responded slowly to the sodium salt of bensuldiazinic acid (Defungit®, Hoechst) which was applied.

5.3.2: Cutaneous Streptothricosis

Dermatophilosis occurred only in the semi-arid areas of Samburu district, where the humidity and rainfall were higher than in the arid areas. This finding is in agreement with what had been reported before (Macadam, 1961; Roberts, 1963; Stewart, 1972; Gitao *et al;* 1990). Whereas the findings by Gitao et al. (1990) indicated that only calves were affected, the author's findings were that the disease occurred in both calves and adult camels. The authors' findings are in agreement with what was reported by Blood *et al.* (1983). The camel owners referred to cutaneous streptothricosis only as "skin disease." This implies that either the disease is new to them or they are unable to distinguish it from other skin conditions. No cases of human involvement was reported nor seen, suggesting that the disease was not zoonotic.

5.3.3: Sporotrichosis

Sporotrichum schenckii is the cause of subcutaneous lesions in man affecting mainly the hands, arms and legs. In the camel the lesions were found mainly on the neck and a few were on the limbs. Ulcerated nodules and abscesses suspected to be due to *S. schenckii* were found in all ages and both sexes of camels. The lesions did not subside following antibacterial therapy. In man, sporotrichosis (usually subcutaneous or systemic) is treated by oral potassium iodide, but spontaneous healing may occur. Kwon-chung (1979) reported that strains of *S. schenckii* from certain cutaneous lesions failed to grow at 37°C and this could explain why the causative agent was not recovered from the cutaneous lesions. The fact that this disease has no traditional remedy nor vernacular names, suggests that sporotrichosis is rare or unknown to the pastoralists. Indeed the disease has been reported by only one other worker (Richard, 1979).

5.3.4: Miscellaneous fungi

Candida albicans is the only significant yeast isolate from skin specimen (Campbell and Stewart 1980) and the others are considered to be skin contaminants or opportunistic. In man, *C albicans* invades all areas of the body, causing cutaneous, mucocutaneous and opportunistic systemic infections. Prolonged treatment with broadspectrum antibiotics such

as tetracyclines predispose to development of candidiasis which is extremely difficult to treat in man (Encyclopaedia Britanica, 1985). This means that rational and controlled antibiotic usage must be instituted in the pastoral areas. The pastoralists therefore, need continued education on chemotherapeutics and how this relates to their health.

Mucor species and fusarium species cause mucormycosis and mycotic keratitis respectively (Campbell and Stewart 1980). Scopulariopsis species are common soil molds that can be opportunists in keratitis. Trichosporon species cause white piedra, subcutaneous and systemic fungal infection in man. Aspergillus species occur commonly in the environment.

It has been noted that many animal dermatophytes are zoonotic (Dvorak, 1969). The fact that fungi known to infect human beings were isolated from camel specimens indicates a big danger of zoonosis. Fungal infections from camels to man may increase now that many people are participating in camel racing and riding, also the changes in the environment and the rapid increase in the human population is magnifying the importance and role of the camel.

5.4: Mite infestation

This is the most widespread and recognized condition of the dromedary camel in Kenya. This study agrees with the findings of Richard (1984) that mange is economically important. However, it can be treated with ease by acaricide application (Wilson *et al.*, 1984; Wilson, 1984; Opferman, 1985; Higgins, 1986; Njanja 1991). According to Wilson (1984) sarcoptic mange is the only mange disease of camels, but Higgins (1986), reported chorioptic mange affecting a bactrian camel as a mild disease. Although trypanosomiasis has always been considered as an economically important disease, and the others aroused little interest, mange is a serious disease (Higgins, 1986; Soulsby, 1982; Njanja, 1991). The fact that mange is a notifiable disease in other livestock species and that the pastoralists already practice a traditional therapy justifies the economic importance attributable to sarcoptic mange. This study revealed the existence of other mite species previously undescribed but causing disease in the camel.

5.4.1: *Sarcoptes scabiei* var.*cameli*

Sarcoptes scabiei parasitizes domestic and wild animals and man (Nayel and Abu-Samra, 1986). The fact that this parasite is not entirely host specific means that it can easily be transmitted from one species to another, particularly so under nomadic conditions where the practice of keeping different species in close contact is common. Sarcoptic mange is successfully treated using ivermectins (Opferman, 1985; Njanja, 1991) but this is a very expensive drug which is also not readily available. Ivermectin (Ivomec®, Merck Shape and Dohme) when used incorrectly can be harmful or even lethal to animals and can be a threat to the environment (Hsu, *et al.*, 1989). The authors opinion is that ivermectin, which is a potent, broad-spectrum antiparasitic drug that is safe and effective when given in the approved form, dose, and route should be used to treat camels on the ranches and projects. The nomadic pastoralists who are not yet fully valuing the monetary economy, and so usually posses small sums of money, could use organophosphates which are effective and are commercially available cheaply and in convenient packages.

5.4.2: *Cardiocephaloptes marti*

A review of the literature (Baker and Wharton, 1952; Baker *et al.*, 1956; Hughes, 1959; Benbrook and Sloss 1961; Chandler and Read 1961; Georgi, 1969; Soulsby, 1969; Sloss, 1970; Higgins *et al.*, 1984; Georgi and Georgi, 1990), indicates that this is a new mite species. Baker and Wharton (1952), grouped parasitic mites under three sub-orders. In the first one, SARCOPTIFORMES, the mites have no well-developed stigmata, chelicerae are usually scissorlike for chewing and the palpi are simple. Members of the TROMBIDIFORMES have a distinct appearance. Their non-hairy body is elongated and they posses very short legs situated anteriorly. In the third sub-order, MESOSTIGMATA, members have stigmata in the middle of their bodies, the coxae are evenly spaced and crowded into the anterior half of the body, the tarsi are generally armed with claws and the ventrum is armoured with sclerotized shields.

C. marti is a tiny lymph sucking mite, about half the size of *S. scabiei*. Although the coxal arrangement (i.e., coxae I and II are widely separated from coxae III and IV) is comparable to that of the sarcoptiformes, the distinguishing characteristic of *C. marti* is its

small size, the beetle-shape, lanceolate structure at the end of the femur on L2 in male, the claw of the male on L4 and the whip-like pseudostigmatic organ. It has a large falsehead which is shaped like the sign of a heart on a playing card with the pointed end facing anteriorly. Because this mite is unlike any seen or described before, new sub-order, family, genus and species are proposed.

Artificial transmission and pathogenicity studies need to be done in detail to confirm the extent and severity of this mite's infestation. However, the fact that only this type of mites was recovered from certain herds where the other types were not found indicates that it is pathogenic. The author believes that this mite existed even before but was not diagnosed because of its very small size. In mixed infestations it may be extremely difficult to determine how much damage is due to each type of parasite without prior knowledge of their pathogenicity. The generic name of this parasite was based on the distinctive morphology of the head which is heart-shaped, hence Cardiocephaloptes. The species name denotes the name of the village (Marti) where it was first found. However, specimens of all the new mite species need further assessment and are going to be sent to the International Committee on Zoological Nomenclature for verification and conformity with the acceptable naming.

5.4.3: Dermanyssid mites

The family dermanyssidae contains three genera. In the first one, Dermanyssus, the chelicerae are long and slender, chelae are minute, have a single dorsal plate; the sternal plate has two pairs of setae and the anus is located in the posterior half of the anal plate. Dermanyssus species usually attack birds at night. Ornithonyssus species on the other hand have much stouter chelicerae and their chelae are easily visible; they have a single dorsal plate and the anus is located in the anterior half of the anal plate. These mites usually remain on the host much of the time causing a considerable loss of blood. In the third genus, Allodermanyssus, chelicerae are long and slender with minute chelae; there are two dorsal plates and the sternal plate has three pairs of setae.

Dermanyssids all look alike on casual inspection, and usually the collection from any important infestation is large enough so that some mites will be found with the chelicerae extruded (Georgi, 1969). However, these mites can be differentiated on the basis of their

chelicerae (piercing mouth parts) and the chelae which is the scissorlike structure at the end of the chelicerae as well as the type of sclerotized plates (Georgi and Georgi, 1990).

5.4.3.1: *Camelonyssus golfer*

This blood sucking mite bears strong resemblance to members of the genus Dermanyssus except that it has a single long chelicera without chela while the former has two both armed with chela. The gnathosome is so minute as to be absent, being completely masked by the enormous pair of pedipalps and the retractile chelicera. The mite has four pairs of legs and at the end of each, there is a sucker borne on a short unjointed stalk. The stalk and sucker together look like the distal end of a golf club, with the bulb facing posteriorly, hence the species name, golfer.

5.4.3.2: *Camelonyssus samburu*

This blood sucking mite is similar to *C. golfer* in having a single tubular needle-like chelicera which has no chela at the end. However, it is smaller in size than *C. golfer* although it has a large gnathosome which bears three pairs of long sharp spikes and its long protruding chelicera. Each pedipalp also bears a single spike which is similar to that of the capitulum. All legs have club-shaped suckers which contain a Y-shaped chitinous thickening and the unjointed stalk is short.

The morphology of the two *Camelonyssus species* described above fit well into the family dermanyssidae in the sub-order MESOSTIGMATA. The characteristics used to distinguish mesostigmatids from the other sub-orders are their large sizes and the fact that their coxae are evenly spaced and are crowded into the anterior half of the body. Their tarsi are usually armed with claws and the chelicerae are adapted for piercing the skin in order to suck blood. They possess chelae which are scissor-like structures on the end of the chelicerae. Their bodies are well chitinized and possess dorsal and ventral plates. The small gnathosome is placed anteriorly.

The name Mesostigmatid was given to the sub-order because members possess stigmata or respiratory pores in the middle of their bodies. This sub-order contains five families:- Halarachnidae, Entonyssidae, Rhinonyssidae, Dermanyssidae and Laelaptidae. Of

these families, *C. golfer* and *C. samburu* fit well into the family Dermanyssidae. This family contains the following genera: Dermanyssus, Ornithonyssus and Allodermanyssus, all of which have a pair of chelicerae and chelae. Because the two new mites have a single chelicera they differ from the other three genera. It is therefore proposed to name the genus Camelonyssus or the prickers of camels because they were found living on the dromedary camel.

However, the author believes that the two Camelonyssus species are different. This belief is based on their morphological differences pointed out. The author has also been unable to find from review of the literature any mites from the same species having suckers differently arranged in males and females. The feeding behaviour and whether these parasites are obligate or not need to be studied further. The species name samburu is derived from the name of the district and tribe whose camels were infested by this mite.

5.4.4: The Baragoi 'Louse-Mite'

The identity of this mite of which only one specimen with broken legs was available has not yet been established except to say it is unlike any mite that have been seen in the literature. Although this mite resembles a louse in the gross morphological features, it is a mite since lice are insects with only three pairs of legs. The Baragoi 'Louse-mite' has four pairs of legs, a distinguishing characteristic of the arachnids. The members of the order Acarina differ from insects in the absence of wings, the presence of four pairs of legs in adults and the fusion of the head and thorax (Muller and Kirk, 1976). The structure of gnathostome, particularly the mouth parts of this mite are so distinct that the author feels that if it is described now, albeit incomplete, other researchers who will find complete specimens will have no difficulties in identifying it. The parasite bears resemblance to both mites and lice, hence the name Baragoi 'Louse mite' was given.

According to Chandler and Read (1961), mites of the sub-order onchopalpida have palpi with claws similar to those on the legs. While in the Baragoi parasite the legs were missing, the palpi definitely had claws. Therefore, it is reasonable to classify the Baragoi 'Louse-mite' as a member of the order onchopalpida. The onchopalpid mites are stated to be nonparasitic (Chandler and Read, 1961), although some species of the genus Holothyrus

have been known to poison and kill ducks which swallow them and also cause illness in children in Mauritius. The Baragoi onchopalpid mite was found in combination with *Cardiocephaloptes marti* causing severe dermatitis (figure XV). The lesions strongly resemble those produced by *Sarcoptes scabiei* var. *cameli* which however, were not found in this particular calf. It is not clear whether the Baragoi 'Louse-mite' was responsible for most of the lesions or how much it contributed since two types of parasites were present.

5.5: Ticks

This study confirmed earlier reports that *Hyalomma dromedarii* is the commonest camel tick (Richard, 1979; Rutagwenda,1983; Crees, 1985). The species of ticks recovered were mainly the desert-acclimatized Hyalomma, Amblyomma and Rhipicephalus species reported to survive well in dry areas (Hoogstraal, 1956; Walker, 1974). *H.truncatum* is a known toxin producer and was found at low levels. Ticks were found in the nostrils (predominantly *H. dromedarii*) following application of acaricides. This is not surprising since these areas are inaccessible to acaricide spray as had been observed earlier (Steward, 1950). Other indirect effects caused by ticks were also seen such as hypersensitivity, conjunctivitis and keratitis.

Although the role of ticks as disease vectors in camels is questionable, they cause toxicosis, worry and blood loss leading to anaemia and unthriftiness (Hoogstraal, 1956). Furthermore the bite wounds form portals of entry for other pathogens, such as *Dermatophilus congolensis*, and certain tick species, like those of Amblyomma, produce deep painful bite wounds because of their long mouthparts. These wounds frequently become abscessed or may attract flies causing myiasis. Ticks are a major veterinary problem especially where animals congregate, for example at watering points. Control measures are difficult due to the dispersal of camels in the desert and the owners inability to use acaricides properly. Adequate supervision and regular visits by veterinarians and veterinary assistants are a prerequisite to effective control.

Most of the ticks were restricted to predilection sites thus reducing the area of attention during such practices. The conventional method of handspraying is suggested but the use of slow-release formulations or pour-ons (like Ectopor®, Ciba-Geigy), would be more

efficient considering the environment (Rinkanya and Tatchell 1988) and the location or habitat of the ticks in covered areas like the nostrils. This study showed that application of Ectopor® completely eradicated ticks and kept camel flies away from the treated herds. Although acaricides are available on the market and are relatively cheap, they are very laborious to use as they must be applied at regular and frequent intervals. Furthermore, dips and sprays consume huge volumes of water which is a scarce commodity in the arid lands. The fact that no tick-borne disease was diagnosed during the study and that only low numbers of ticks were found on adult camels demonstrates that a rational non-intensive tick control regime suffices in these rangelands.

5.6: Other ectoparasites

This included the lice, fleas, biting and nuisance flies which are discussed below.

5.6.1: Lice

Only fragments of legs were recovered suggesting the presence of lice in camels studied.If large numbers of lice are present they cause considerable irritation due to their feeding and by their claws digging into the skin. The skin in these areas may be abraded so that lesions resembling those caused by ringworm or mange mites may result. The skin may become shaggy and matted. Although diazinon (Neocidal®, Ciba-Geigy) or coumaphos (Asuntol®, Bayer) will kill lice, the harness and other likely fomites must also be treated.

5.6.2: Fleas

Some unidentified fleas were seen in a Manyatta at Ol Turot in marsabit district but were not recovered from the camels or bomas. Fleas are not confined to particular hosts and their chief effects on their hosts are irritation that they cause resulting in similar lesions as in lice infestations. Although fleas are not obligate parasites, the control measures for lice will suffice.

5.6.3: Biting and nuisance flies

Many species of biting and nuisance flies pester camels and can act as mechanical transmitters of disease between camels or as vectors of human and zoonotic diseases. The

presence of flies around a camel cause considerable distress to the animal; if prolonged this distracts the camels from feeding, inevitably leading to decreased productivity. It is impractical to undertake a comprehensive fly control programme in areas where camels are reared. Flies accumulate at the watering points and campsites which should be targeted if control is attempted. The synthetic pyrethroids offer an attractive alternative to the judicial use of smoke-fires or the practice of avoiding infested areas.

5.7: Recommendations

Within the experimental procedures and limits of this study, the following recommendations can be made: 1. Further information on incidence and detailed investigations of the individual skin diseases is required to identify priorities for further research. 2. It is necessary to learn from the pastoralists who have lived with the camel for many years in order to understand fully the diseases of the camel. There is more advantage in learning the vernacular names of diseases from the local camel owners. 3. There is an urgent need to build and adequately equip simple field veterinary laboratories in the camel districts. Trained technicians and assistants, like the 'Adakar' or 'Barefoot' veterinarians trained by the paravet project in Turkana, should be posted to the camel areas where they should live and migrate with the camel keepers. 4. A simple veterinary drug package should be made readily available to the pastoralists in their areas following comprehensive awareness workshops. 5. Whole parasites of the dermanyssid mites and the Baragoi 'Louse-mite' need to be recovered and detailed descriptions made. 6. Pour-ons like Cypermethrin High Cis (Ectopor ® Ciba-Geigy) which is very easy to apply, is recommended to be used to control the ticks and the camel flies since water is very scarce in the camel areas. Since ivermectins are very expensive, 60 per cent Diazinon (Neocidol ® Ciba-Geigy) is recommended for the treatment of mange.

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LIST OF APPENDICES

Appendix I: Format used in clinical examination of the camel herds

Owners' name. _____ Date _____

District._____ Area._____

Herd composition: No. of males_____

No. of females _____

No. of immatures _____

No. of calves _____

History:

Main skin problem (s)._____

Other disease problems _____

Disease history _____

Treatments given (if any) _____

Skin lesions seen _____

Skin lesion distribution_____

Skin lesion description _____

Samples taken _____

Photographs taken._____

Local names for: Mange _____

Camelpox _____

Cutaneous necrosis _____

Contagious ecthyma _____

Papillomatosis _____

Dermatophilosis _____

Skin abscesses _____

Interdigital abscesses _____

Other known skin diseases _____

Significant finding(s) _____

_____

Appendix II: Camel age determination by dentition

Incisors (Lower jaw)	Years
Milk teeth	0-4
No wear	0-1
Slight wear	1-2
Moderate wear	2-3
Heavy wear	3-4

Adult incisors	Years	
First pair	4.5-5	
Second pair	6	
Third pair	7	No wear
all adult incisors at	9	Slight wear
all adult incisor set	12	Moderate wear
all adult incisor set	15	Heavy wear

The first permanent teeth to appear are the first pair of molars at 12-15 months. At eight years all the teeth are in wear, the first pair of premolars in each jaw are nearly full size and the canine are very large and powerful. From nine years onwards all teeth are more or less worn but actual age can only be determined on the basis of considerable knowledge and local experience. At fifteen years the hair on the tail turns white and the hollows over the eyes get deeper. The average lifespan of camels is given as 20-30 years (Torry 1973); although some have lived to 40 years (Yasin and Wahid 1957).

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

(Modified from Wilson, 1984).

Appendix III: Disc sensitivity tests

Two types of Mastring-S discs were used, patented number KGL1/4 (1) and patented number KGL3/4 (3) (Mast Diagnostics, Mast Laboratories limited, Merseyside, U.K.).

Mastring 1

Disc No.	Drug name	Drug amount	Disc colour
1.	Penicillin	1 Unit	Grey
2.	Minocycline	30 µg	Brown
3.	Erythromycin	15 µg	Orange
4.	Methicillin	5 µg	Buff
5.	Cotrimoxazole	25 µg	White
6.	Chloramphenicol	30 µg	Mauve
7.	Ampicillin	10 µg	Salmon
8.	Lincomycin	2 µg	White

Mastring 3

Disc No.	Drug name	Drug amount	Disc colour
1.	Ampicillin	25 µg	Grey
2.	Tetracycline	100 µg	Brown
3.	Nitrofurantoin	200 µg	Orange
4.	Nalidixic Acid	30 µg	Buff
5.	Streptomycin	25 µg	White
6.	Sulphatriad	200 µg	Mauve
7.	Gentamicin	10 µg	Salmon
8.	Cotrimoxazole	25 µg	White

The zones of inhibition were read qualitatively after incubation at 37°C for 72 hours.

Appendix IV: Classification of *Cardiocephaloptes marti*

Order:	Acarina
Sub-order:	Cardiocephaliformes
Family:	Cardiocephalidae
Sub-family:	Cardiocephalinae
Genus:	Cardiocephaloptes
Species	marti
Host:	Dromedary camel

Note:

Members of the order Acarina belong to the subclass Arachnida in the class Arachnoidea in the Arthropoda and Animalia phylum and kingdom respectively. These parasites posses four pairs of legs as adults, two pairs of mouth parts (chelicerae and pedipalps or palpi), have no antennae and the head and thorax are joint together forming a cephalothorax.

Appendix V: Characteristics of the sub-order Cardiocephaliformes

The distinguishing characteristic are the small size, the beetle-shape, absence of suckers in both sexes, lanceolate structure at the end of the femur, the claw of the male on leg four and the whip-like structure. They have a large falsehead which is shaped like the sign of a heart on a playing card with the pointed end facing anteriorly. Leg two in the male has a characteristic lanceolate appendage sticking out laterally between the femur and the genu, whereas in the female it is somewhat shrivelled. Leg four in the male is short, large and bears a powerful claw, shaped like the dewclaws of a lion, and long straight setae whereas in the female it has only three segments, at the end of which there is a pair of long whiplike setae which are equal in length. There is marked morphological differences between the male and the female.

Appendix VI: Classification of *Camelonyssus golfer* and *C. samburu*

Order:	Acarina
Sub-order:	Mesostigmata
Family:	Dermanyssidae
Genus:	*Camelonyssus*
Species	*golfer* and *samburu* respectively
Host:	Dromedary camel

Appendix VII: Characteristics of the sub-order mesostigmata

Members of the sub-order mesostigmata are characterized by not having a true head, their mouth parts being borne on a small anterior part that is distinctly set apart, called a gnathosoma or capitulum. The chelicerae may be modified into needle-like structures as in Dermanyssus (Bloodsucking mites). Their bodies are well chitinized and have dorsal and ventral (Sternal) plates. Their ventrum are armoured with sclerotized shields and the tarsi are generally armed with claws and caruncles and as the name implies, these mesostigmatids have stigmata (respiratory pores) in the middle of their bodies. A stigma lies between coxae II and IV on each side of the body and is connected to a sinuous peritreme. The coxae are evenly spaced and are crowded into the anterior half of the body.

Appendix VIII: **Turkana, Samburu and Pokot names for some camel diseases**

Disease or sign	Turkana name(s)	Samburu name(s)	East Pokot name(s)
Mange	Emitina/Ekoikoi	Lbebedo	Lomitinaa
Camelpox	Etune/Loper/ Puuru	Abituro	Mokoyon
Trypanosomiasis	Lotorobwo/Ekalich/ Lotegerin/Ediit	Saar	Lokurucha
Swollen glands	Long'arwei/Logoroi	Nolng'arng'ar	-
Orf	Lokituk/Lokou/Lojele/ Ng'iborwok	Abituro	-
Tick infestation	Ng'imadang	Manjeri	Tilis
Helminthiasis	Ng'irtan	Kinyot	-
Anthrax	Lookot/Cholera/ Lotular/Enomokere	Lokochum	Meghat-lewel
Ringworm	Epara	Ngamunyani	-
Foot-rot	Ekichodonu	Ngojini	-
Rabies	Long'okwo	Nkwangeldein	-
Abortion	Akiyechun	Nkibiroto	Torunogh
Diarrhoea	Ekiurtonu/Naothin	Nkorotit/Ngiriata	Kiyitagh
Haemorrhagic septicaemia	Lokolio	Nolgoso	-
Pneumonia	Lotai/Loukoi/Loola	Lkipei	Ralat
Plant poisoning (Caparis tomentosa)	Loturdai	Loturdai	-
Black quarter	Nengewat	Nenkeju	-
Bloat	Akiurur	Mberuri	-
Fleas/Lice	Ng'ilach	Loisus	Tilis

(Sources:- Various workshops and seminars attended by the author and personal communication with the pastoralists).