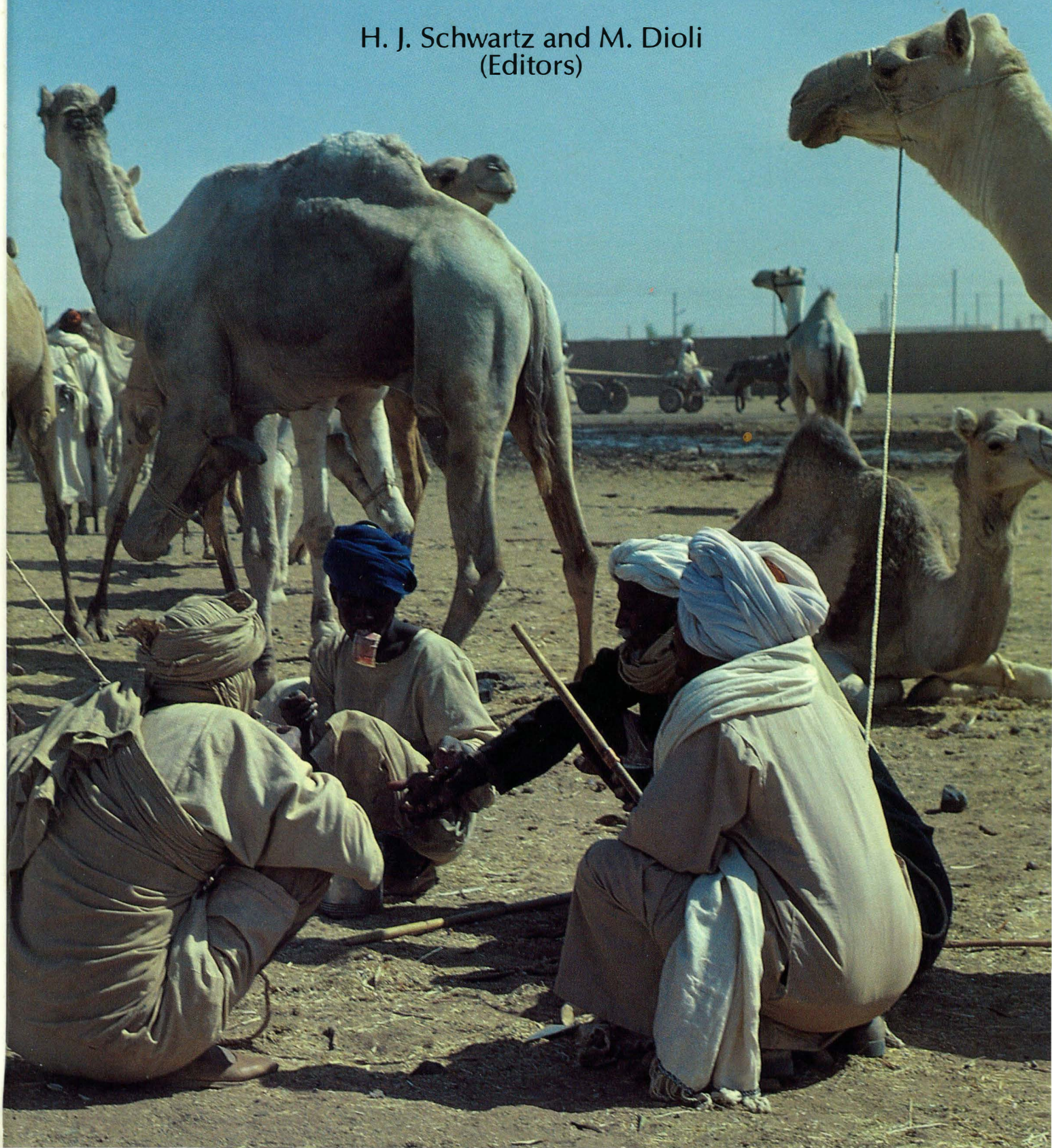
THE ONE-HUMPED CAMEL IN EASTERN AFRICA

A pictorial guide to diseases, health care and management

H. J. Schwartz and M. Dioli
(Editors)



THE ONE-HUMPED CAMEL *(Camelus dromedarius)* IN EASTERN AFRICA

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verlag josef margraf
Scientific Books

CIP-Titelmeldung der Deutschen Bibliothek

The **one-humped camel (C. dromedarius) in Eastern Africa**: a pictorial guide to diseases, health care, and management / H.J. Schwartz and M. Dioli (ed.). With contributions by: M. Dioli ... - Weikersheim: Margraf, 1992
ISBN 3-8236-1218-2
NE: Schwartz, H.J. [Hrsg.]; Dioli, M.

Scientific Books
P. O. Box 105
D-6992 Weikersheim
FR Germany

Title photos:
H.J. Schwartz

Typesetting and layout:
H.J. Schwartz

Printing and binding:
Schönwald Druck, Berlin
FR Germany

ISBN 3-8236-1218-2

The publication of this book was kindly supported by **Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH**, Eschborn, FR Germany. Their valuable contribution is acknowledged with thanks.

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Acknowledgements

The information and illustrations which have finally been assembled in this book were collected in many different locations during more than ten years. Too many people assisted during that time to allow to mention them all individually.

The authors wish to express their sincere gratitude to the many camel owners in Kenya, Somalia, Sudan and Ethiopia, who gave them unrestricted access to their herds to take photographs, to weigh, to measure, to take samples of feeds, faeces, urine, blood and milk and to ask endless questions about the simplest things concerning camels. Three names, however must be mentioned in this context. They are J.O.Evans of OlMaisor Ranch, Guilfred Powys of Galana Ranch, and Lemayan Lengima of the Rendille Clan Masula, all in Kenya. Not only did they allow long-term continued access to their large camel herds for experimental work, which often must have interfered with daily management necessities, but they also enthusiastically shared their great experience with the authors and extended the most generous hospitality to the small armies of researchers which regularly invaded their homes.

Institutional support was received from the Department of Animal Production of the University of Nairobi, the Institute of Physiology of the School of Veterinary Medicine in Hannover, the UNESCO Integrated Project in Arid Lands (IPAL), the German Academic Exchange Service, the Italian Volunteer Service Terra Nuova, the Diocese of Lodwar in Kenya, the Range Management Handbook Project in the Ministry of Livestock Development of the Republic of Kenya and the Project Administration Service (PAS) of the German Agency for Technical Cooperation (GTZ) in Nairobi.

Financial support for the studies which are reported in this book was provided by the German Research Foundation (DFG) through the grants No EN 65/11 and No He 574/12-1, by the Commission of the European Communities through the grant STD1 A-276 and by the German Agency for Technical Cooperation (GTZ) through the grants No 83.9158.3-91.100 and No 86.9162.8. The printing of this book was made possible through financial support by the German Agency for Technical Cooperation (GTZ).

All this is gratefully acknowledged

Preface

In the recent past there has been a renewed interest in the camel (*Camelus dromedarius*, one-humped camel, Arabian camel, dromedary). As a result of this renewed interest a considerable number of books and annotated bibliographies have appeared on the market in the past ten years, which all highlight the great importance, this animal has for the gainful utilisation of arid lands. It is now well documented that the camel produces milk, meat, wool, hair and hides, serves for riding, as a beast of burden and as a draft animal for agriculture and short-distance transport.

For the scientific community the camel has become a fascinating research subject because of its remarkable capacity to adapt to the most adverse environments. For some national and international development aid agencies it appears to have gained the reputation of a universal remedy for the plight of the starving pastoral populations in Africa's arid areas, for others it is just a sentimental reminder of historical times, which has no place in modern development.

This book presents detailed information on the camel, its distribution, adaptation to arid environments, feeding behaviour and nutritional physiology, products, performances, economic importance, productivity, traditional and modern management practices, diseases, health care and post-mortem procedures with special reference to Eastern Africa. It is intended as a management guide to livestock specialists and veterinarians, as well as to extension personnel working with camel herders in Eastern Africa. It is hoped that it may also serve as a reference for animal scientists, ecologists and students in these disciplines.

Introduction

The Camel (*C. dromedarius*) in Eastern Africa

H.J.Schwartz

Distribution and Economic Potential of the camel

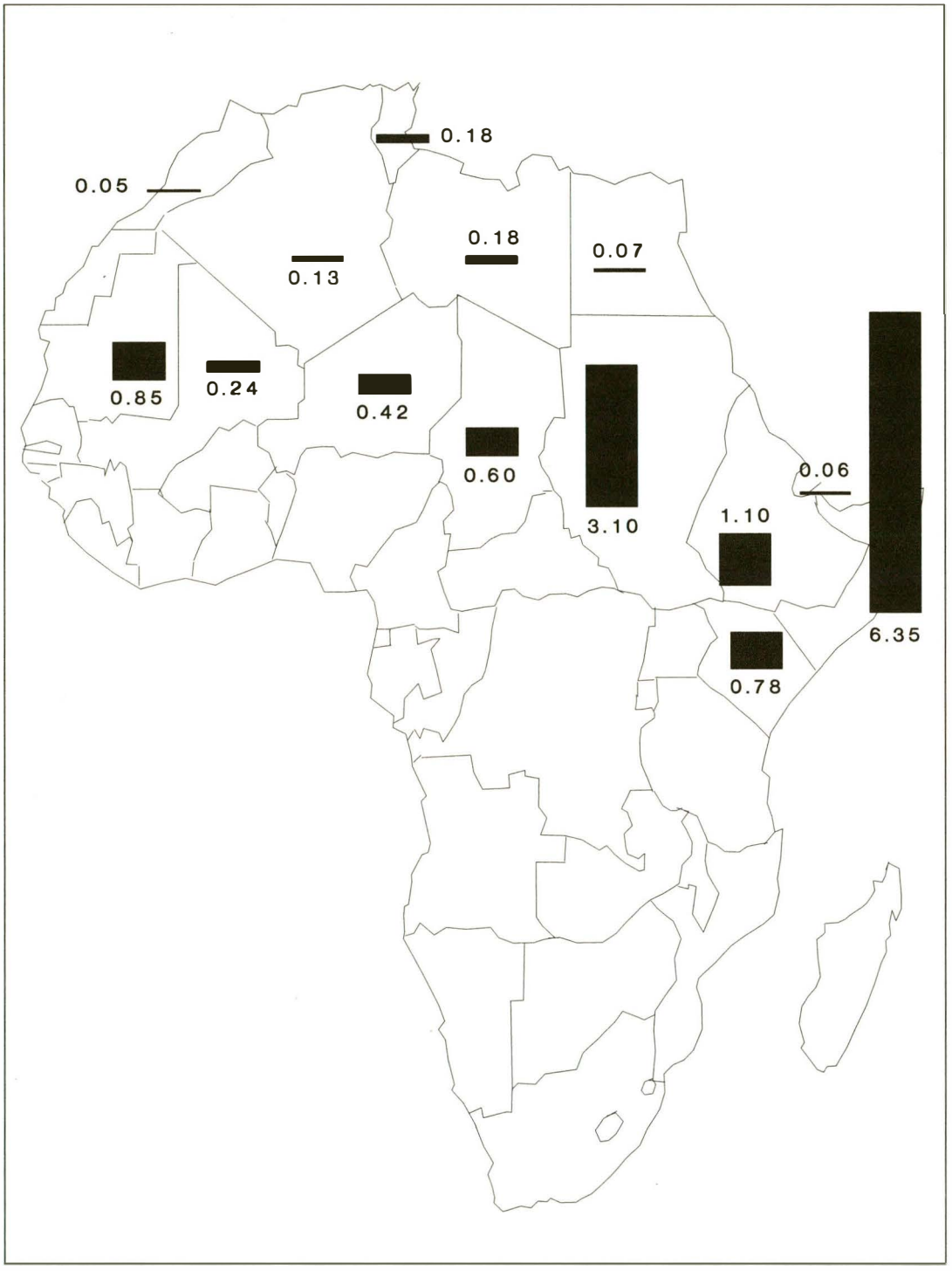
The camel (*Camelus dromedarius*, one-humped camel, dromedary) is an important livestock species uniquely adapted to hot and arid environments. It produces milk, meat, wool, hair and hides, serves for riding, as a beast of burden and as a draft animal for agriculture and short-distance transport. It is most numerous in the arid areas of Africa, particularly in the arid lowlands of Eastern Africa, i.e. in Somalia, Sudan, Ethiopia, Kenya and Djibouti. Approximately 11.5 million animals in this region represent over 80% of the African and two thirds of the World's population of camels (Fig. 1, Tables 1 & 2).

Table 1: Estimated numbers of camels in Eastern Africa and calculated proportion of camels of the total live biomass of domestic herbivores [% DHB] (DHB 1 refers to the total national herd; DHB 2 refers to those areas only where camels are kept which are the arid lowlands of the sub-region.)

Country	Number	% DHB 1	% DHB 2
Djibouti	60,000	34	n.a.
Ethiopia	1,030,000	4	35
Kenya	780,000	6	25
Somalia	6,350,000	57	n.a.
Sudan	3,100,000	15	35

Source: FAO Production Year-book 1989 and Author's estimates

The majority of camels in this region are kept by migratory pastoralists in subsistence production systems. Slaughter for home consumption is rare, offtake of live animals for sale as slaughter stock is limited and the importance of the impact of proposed interventions or development programmes aimed at improving camel as a long-distance transport animal has been declining. Since camel milk is one of the most important staples for the pastoralists, the emphasis is on milk production. There is some sale of milk in the vicinity of rural towns and urban centres, but market integration on the whole remains limited. Since pasture productivity is marginal and forage yields are highly variable by season and year, camels, due to their unique adaptation to hot and arid environments, are the only reliable milk producers in the system.



Map 1: National camel populations in Africa 1988 [million head]

(source: FAO Production Year-book 1989)

Statistics on camel numbers, population changes and levels of production are sketchy at best, and long-term performance records in larger herds are not available. However, general field observations and a few available surveys indicate that slow reproduction, low life-time performance of female breeders and high calf mortality are the major constraints to higher productivity of camel herds in the region.

With increasing human population pressure and declining per capita production of food in Africa there is an urgent need to develop previously marginal resources, such as the semi-arid and arid rangelands, and optimise their utilisation through appropriate livestock production systems, of which camel production is certainly the most suitable one.

From a global perspective the economic significance of camel production is minimal as the comparison of livestock numbers (Table 2) clearly shows. Even for Africa or Eastern Africa alone the economic potential of the camel, judged by numbers only, remains limited in comparison to the other livestock species. Certainly the importance of camel production becomes more evident if one considers the arid lowlands of Eastern Africa alone where camels represent more than half of the regional herds.

It is beyond doubt that camel production makes a significant contribution to national economies in Eastern Africa. Unfortunately it is very difficult to evaluate the economic significance of camel production by conventional parameters like cash flow analysis, gross margin calculation etc. Most camel products never reach any market, but are consumed within the producer community, are traded against kind instead of cash, or are, as in the case of the export trade with slaughter camels, illegally traded past any official control and monitoring.

Table 2: Numbers of domestic ruminants and camels in the world (1988) in million head

Species	World	Africa (whole)	Eastern Africa
Cattle	1,264	181	72
Sheep	1,173	200	65
Goats	520	167	63
Camels	18.9	14.2	11.5

Source: FAO Production Year-book 1989

For this reasons it is difficult to evaluate the economic feasibility of interventions aiming at improvement of camel production, even if biological feasibility can be ascertained. It can safely be stated that this predicament will not be changed in the foreseeable future. Therefore it would be worthwhile exercise to carry out an in-depth study on the economic potential of the camel by using what little hard data is available and extrapolating from other livestock species with modern modelling and simulation techniques.

Considerable effort is required to facilitate development and implementation of feasible and sustainable interventions to improve the present camel production systems. Interventions are conceivable on various levels, on the biological and ecological system level, the managerial and economic level, the institutional and legal level and, probably most important, the political level.

Camel Production in Eastern Africa: a Status Report

General

Recent recurring droughts in Africa and particularly also in Eastern Africa have led to huge losses of livestock, markedly of cattle and, to a lesser extent, of sheep and goats. Camel populations on the other hand appeared only marginally affected. If recently published figures (FAO, ILCA and various others) are correct, a slow but steady increase in camel numbers has occurred here, which caused a growing awareness that the camel, although it has lost its functions in long-distance transport to motorised traffic, still serves as a major food producer (milk and meat) in the semi-arid and arid areas. It underwent a change of image from "ship of the desert" to "food security animal" as a Sudanese veterinarian aptly expressed it.

The last two decades also saw an increased scientific interest in all matters pertaining utilisation and management of arid lands and with it a substantial number of scientific publications on the camel. According to Wilson (1989) most of the publications covered diseases and veterinary aspects (34%), anatomy and morphology (16%), general physiology (12%) and reproductive physiology (10%). Studies on feeding and nutrition, productivity, production systems, camel management and economics are very rare. Those which have been published are either based on small numbers of animals, short observation periods, one-time surveys, interviews or estimates and simulations. Due to the fact that camel production is usually a migratory system and that it is practised mainly in remote areas with harsh living conditions, poor infrastructures and low economic potential such studies would be difficult, time consuming and expensive. As a consequence not a single long-term, methodical study of any aspect of camel productivity under production conditions has been published to date. This makes it virtually impossible to evaluate with any degree of certainty the economic importance of camel production in Eastern Africa.

It can safely be stated that research on camels conducted during the past two decades has had very little if any impact on the promotion and development of camel production. Numerous symposia and learned conferences on various aspects of the camel have taken place in recent years, three bibliographies on camel research have appeared, national and international institutions have established co-ordinating units, produced newsletters and commissioned consultancies. However, to date there is still not a single project or programme in the field focussing mainly on the improvement of practical camel production in Eastern Africa.

Djibouti

Djibouti has a camel population of 50,000 to 60,000 which represents more than one third of the country's domestic herbivore biomass. With about 2.6 camels/km^2 and 1 to 1.5 camels/inhabitant this is the most important livestock species in the country. Most camels are kept by nomadic pastoralists to produce milk for household consumption. Camel meat is consumed almost exclusively at ritual or festive occasions. There is no obvious export of slaughter camels.

A number of dairy camels is kept in Djibouti township and fed with purchased feeds to produce milk for the urban market. This might become an expanding enterprise if traditional reservations against selling of camel milk give way to more commercially oriented attitudes.

It appears that camels are still used for commercial transport as pack animals, particularly on some trade routes into Ethiopia where no road or rail links exist. The use of camels as riding animals seems to be limited.

Ethiopia

The 1989 FAO Production Year-book reports 1.05 million camels in Ethiopia whereas Ethiopian estimates from 1986/87 give 1.7 million as the most likely figure. Camels are kept in the arid lowlands which cover approximately 50% of the country and are the home range of over 2 million pastoralists. The major camel product is milk, by official estimate some 174,000 tons per year, followed by 20,000 tons of meat. Hides, hair, and draught power are recognised as potential products but are not exploited to any significant extent. Riding is common only with camel herders along the Red Sea coast.

Camel milk is not readily sold by traditional camel breeders because of socio-cultural restraints, it should rather be given away freely or shared with strangers. Most recently, however, with some traditions weakening, limited markets for camel milk develop in small towns and expansion of the trade can be expected.

Sales of live camels, usually males or old unproductive females, for slaughter is common practice. A large illegal trade volume to Saudi Arabia via Djibouti and Somalia is suspected whereas official export figures appear sketchy, unreliable and unreasonable fluctuating from year to year.

Until very recently there has been very little systematic research on camels in Ethiopia, and if there was, it was carried out by foreigners. Likewise there are no development projects in the country which feature the camel in any way nor is any attention given to this domestic species in connection with other livestock development programmes.

Kenya

According to recent estimates (FAO Production Year-books, KREMU, Schwartz and other sources) there are between 700,000 and 780,000 camels in Kenya. They represent approximately 6% of the total domestic herbivore biomass in the whole country, but more than 25% in the arid lowlands, where they normally occur. Almost all of these animals are kept by nomadic pastoralists in the arid and semi-arid lowlands of Northern Kenya. The animals are essential for the subsistence economy of these people. They are very reliable milk producers during dry seasons and drought years when milk from cattle, sheep and goats is scarce. At such times camel milk can contribute up to 50% of the nutrient intake of some of the pastoralist groups. Although camel milk is not marketed, it can be safely estimated that the camel milk produced per year for human consumption represents a monetary value of approx. US$ 12 million if calculation is based on the retail price of cows milk (Schwartz, 1990). With the growing interest of the Kenyan government in the development of the semi-arid and arid areas (more than 70 % of the country), camel production recently is viewed as an important sector of animal agriculture, and efforts are made to establish respective development projects.

Adult male castrates serve as loading animals and are of particular importance for water transport. Camels are slaughtered in Kenya only on rare ritual occasions, but those which die of natural causes are usually butchered and consumed. There appears to be some clandestine trade with live camels for slaughter to Arabia via Somalia. The volume of this trade may reach any figure between 6000 and 15000 head per annum.

During the last two decades camel herds have been established on some commercial ranches in Kenya. Here the camels are used for internal transport and to produce milk for on-ranch consumption. Sales of slaughter animals are envisaged. At present the Kenyan market for camel meat is limited, but there is a regular and high demand for slaughter camels on the Arabian peninsula and export opportunities are promising.

Although accurate figures are not available, estimates of camel numbers indicate that the national herd is increasing. Furthermore camel production is spreading slowly to areas which were formerly occupied by cattle and small ruminants only, particularly those where the herblayer was severely damaged by over-stocking with cattle during a recent series of drought years. Thus camels are found today in areas South of the equator, in the marginal highlands of Central Kenya up to elevations of 1500 m a.s.l., already in the sub-humid zone of the country.

Due to the southward spread of the camel population, camels are mixing freely with cattle and are utilising, more than in other regions, semi-arid to subhumid areas. As a consequence, exposure of the animals to contagious diseases and various endo- and ectoparasites is higher than in arid and desertic areas, where camels are commonly found. This leads to increased mortality and morbidity in the herds, which in turn restricts herd growth and productivity.

Since camels are used almost exclusively in subsistence production, very little cash income is generated. Consequently, the contribution of camel production to the overall agricultural production is difficult to estimate and has been grossly underestimated in the past. For this reason camel production was not even mentioned in past development plans and received much less attention than production of cattle and small ruminants. As a result all infrastructures and services specific to camel production are lacking in Kenya.

Somalia

Somalia has the largest national camel population (over 6 million) in the world. Camels account for approximately half of the national livestock herd calculated in tropical livestock units (TLU), with 63%, 40% and 47%, in the North, Central Region and the South respectively. They most likely produce considerably more than half of all the milk in the country and contribute to the country's foreign currency earnings, as large numbers of animals are exported to the Arabian peninsula for slaughter. Consequently, development of camel farming should be a prominent concern of the relevant government institutions.

A large proportion of Somalia's camels is kept by nomadic pastoralists. Due to the unique adaptation of the camel to harsh conditions it is the mainstay of subsistence oriented nomadic livestock production in Somalia. The emphasis is on milk production as the subsistence staple. As a secondary product live animals for slaughter are exported.

Numerous animals are also kept in agro-pastoral systems in semi-arid to subhumid conditions (350-400 mm annual rainfall). Also here the emphasis is on milk production, but with an established and growing market integration, which is pronounced in the vicinity of Mogadishu, Kismayo and other rural townships.

The traditional nomadic production system has remained stable for a long time, particularly through its flexible responses to short-term variations of the climatic conditions. Today, however, numerous demographic, economic and political changes of long-term nature occur which trigger adaptive changes likely to transform this system significantly. The most salient features are an emerging precedence of market oriented production over the traditional subsistence production and spontaneous sedentarisation.

A phenomenon related to increased sedentarisation is the enclosure and privatisation of formerly communal range areas. This practice has gained momentum through water development, the accelerated breakdown of social structures regulating range utilisation, changing of the government land tenure policies which promote agricultural activities in marginal areas, commercialisation of forage production, the emergence of an urban milk market and other factors.

Agro-pastoralism is the predominant land use system in the inter-riverine areas in Southern Somalia and has proved itself an enduring and resilient adaptation to semi-arid environments. In the Bay region a total livestock biomass of more than 8,000 kg/km^2 has been reported in the most intensively cultivated areas of the

country. Presently similar systems are expanding to both the upper and lower Jubba region. Seasonal cultivation of rainfed crops combined with open-range livestock herding is common in the North-West region and is also increasingly found in the Central Rangelands. In the latter region an estimated 50% of the range is enclosed and over 15% is believed to be under cultivation.

The change from a long ranging and highly mobile herding system to a short-range and semi-sedentary one bears the potential for both negative and positive effects. Amongst the most obvious negative effects are:

- the increased risk of environmental degradation,
- increased production risks for the individual herd owner as well as for the industry as a whole due to the disappearance of traditional adaptive management strategies,
- and the accelerated breakdown of social structures which previously served as a form of social security system within herding communities.

The observed trend is clearly a spontaneous response to the fact that the nomadic system of livestock production increasingly fails to secure food supplies for a rapidly increasing population. Given the present demographic and economic tendencies, it is obvious that these trends will not be reversed in the foreseeable future; consequently, it becomes necessary to channel these into some form of controlled development.

While sedentarisation and range enclosure can have various negative environmental impacts, they may also offer opportunities for improved land management, permanent investments into land productivity and the application of innovative technologies. Small favoured areas in the range lands (run-on areas, drainage lines etc) may be used for forage and/or food crops, agricultural by-products may become available in increased amounts to stabilise feed supplies during the dry seasons, deferred grazing systems and small scale water harvesting schemes may be feasible for specific groups (enclosure herders, range livestock associations, agro-pastoralists etc).

There is a high and growing demand for milk and milk products in Mogadishu and other urban centres. This has stimulated camel owners to transport camel milk in small charges (up to 150 litres) by lorry from as far as 150 km. To accumulate such amounts the milk is collected by individual producers for several days and brought to market personally or by a family member, usually as sour or "smoked" milk. Most of this milk appears to come from semi-sedentary herds, which are integrated into agro-pastoral systems. There is no solid information on where and how this milk is produced, nor what interventions would be feasible to increase production, to improve product quality and to streamline marketing.

Sudan

Estimates of the camel population in Sudan vary between 2.7 million (National Statistics, 1989) and 3.1 million (FAO 1988). Camel occur mainly in Kordofan, Darfur and Butana, i.e. in the Northern drylands of the country. Camel milk is an important staple for the pastoralists, but there appears to be little if any marketing of this commodity. There is, different from all other Eastern African countries, a noticeable preoccupation of producers, researchers and planners with meat production, or rather production of slaughter camels, mainly young males, for high price markets in Egypt, Libya and Saudi Arabia. These exports are the mainstay of the Sudan's trade with neighbouring countries. The stagnation of camel numbers in the country, which is again different from all other Eastern African countries, is indicative of the fact, that off-take rates, which according to official estimates in Sudan are between 6 and 12%, are on the high side and may include some fertile females. Another export product are camels bred for racing which are highly valued in Saudi Arabia and the Gulf states. Local markets absorb meat of old and unproductive animals, hides for manufacture of sandals and other leather goods and maybe limited amounts of camel hair.

Sudan has a long established expertise in many aspects of camel research, particularly in the fields of nutritional and reproductive physiology, meat quality and processing, camel diseases and feeding and range ecology. Furthermore there is a considerable allocation of manpower as well as physical and financial resources to support camel production, mainly in the field of veterinary services, in proper recognition of what is Sudan's only export livestock.

List of recent bibliographies on camelids

Farid, M.F.A. (1981): Camelids Bibliography. ACSAD-AS-P15. P.O.Box 2440, Damascus, Syria

Mukasa-Mugerwa, E. (1981): The Camel (Camelus dromedarius): A Bibliographical Review. International Livestock Centre for Africa. Ethiopia.

Saint-Martin, G., Nitcheman, M.F., Richard, D. and Richard, M.A. (1990): Bibliographie sur le Dromadaire et le Chameau. Tome I. Institut d'Élevage et de Médécine Veterinaire des Pays Tropicaux (IEMVT). ISBN 2-85985-167-4.

Saint-Martin, G., Nitcheman, M.F., Richard, D. and Richard, M.A. (1990): Bibliographie sur le Dromadaire et le Chameau. Tome II. Institut d'Élevage et de Médécine Veterinaire des Pays Tropicau (IEMVT). ISBN 2-85985-167-4 (édition complète).

Wilson, R.T., Astier Araya and Azeb Melaku (1990): The One-Humped Camel. An Analytical and Annotated Bibliography. The United Nations Sudano-Sahelian Office (UNSO). Technical Paper Series No. 3.

Chapter I

The Biology of the Camel

H.J.Schwartz

Evolution and general biology

Origins and present distribution

The Camelidae (order Artiodactyla, suborder Tylopoda) are divided into two genera, the genus Camelus (true or old-world camels) and the genus Lama (new-world camels). The Camelidae spread in the late tertiary age from North America to South America, and, via Asia, to Africa, becoming extinct in North America. There are today about 17 to 18 million true camels and 4 to 5 million new-world camels.

The true camels include the one-humped or Arabian camel (Camelus dromedarius), commonly called the dromedary, and the two-humped or Bactrian camel (Camelus bactrianus). It is doubtful whether one should accept the general assumption that these are two different species, since both types can be crossed and hybrids are fertile. The dromedary was probably domesticated on the South coast of the Arabian peninsula in the region of present-day Yemen and Oman around 3,000 to 4,000 years ago and than introduced with the spice trade into North Africa and the Horn of Africa. Today there are about 15 to 16 million dromedaries in Africa, the Middle East and the Indian subcontinent. The Bactrian camel was probably domesticated at the same time in present-day Turkmenistan and in Northern Persia, spreading from there westward to Anatolia and east to Northern China. The world stock of Bactrian camels is estimated at 2 million. The areas of distribution of the two types of camels overlap only slightly. In this area of overlap the hybrids of these two types are found, though nothing is known of their numbers. The wild forms of both types are now extinct.

Breeds

Many camel breeds, distinguished by colour, size, built or other characteristics have been described. A critical summary of these descriptions was given by Wilson (1983). Breeds of camels are not as much differentiated as breeds in other domestic livestock species. Systematic selection for productive traits has never been done in camels, excepting maybe racing camels. Two extreme types can be defined as far as weight and built are concerned (Figure I,1). These are the riding or racing camel and the heavy pack or baggage type. The former is a slender animal with a long and level shoulder, a smallish hump, a markedly tucked-in abdomen and long legs with small feet. The hair in these animals is often short and fine, the skin is thin and supple. Heights may differ greatly, but live weights rarely exceed 400 kg in females and 550 kg in males. The baggage type is much

Plate I,1: Aerial view of a nomadic camel herd in Marsabit District of Kenya. The animals belong to the small East African type (see text). Their colour ranges from almost white over various shades of brown to dark grey. Local pastoralists differentiate about twenty different camel colours.

Plate I,2: A herd of dairy camels in a government breeding station on Fuerteventura, Canary Islands. These animals, although selected for several generations for higher milk yields, still show the wide variation in size, build and colour which is common to most camel herds wherever and by whoever they are kept.

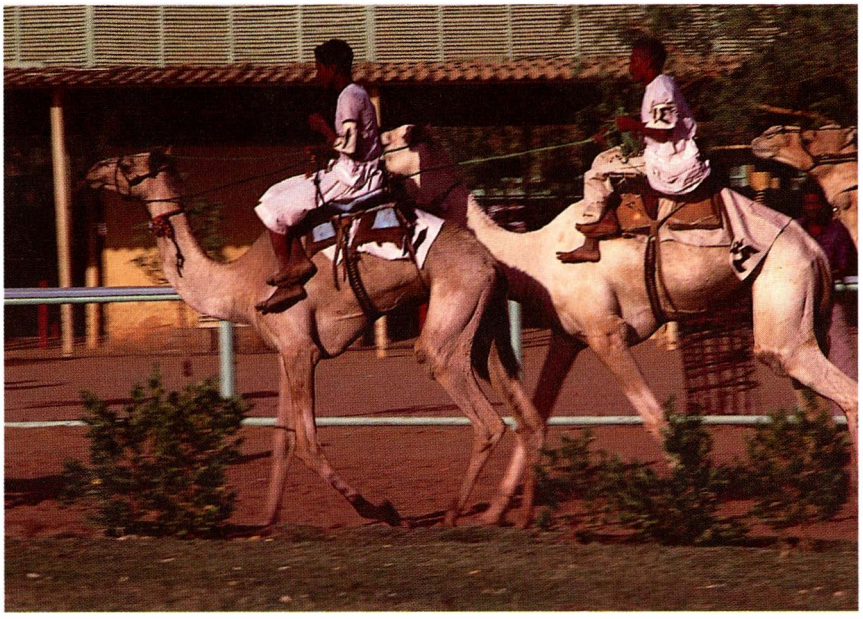
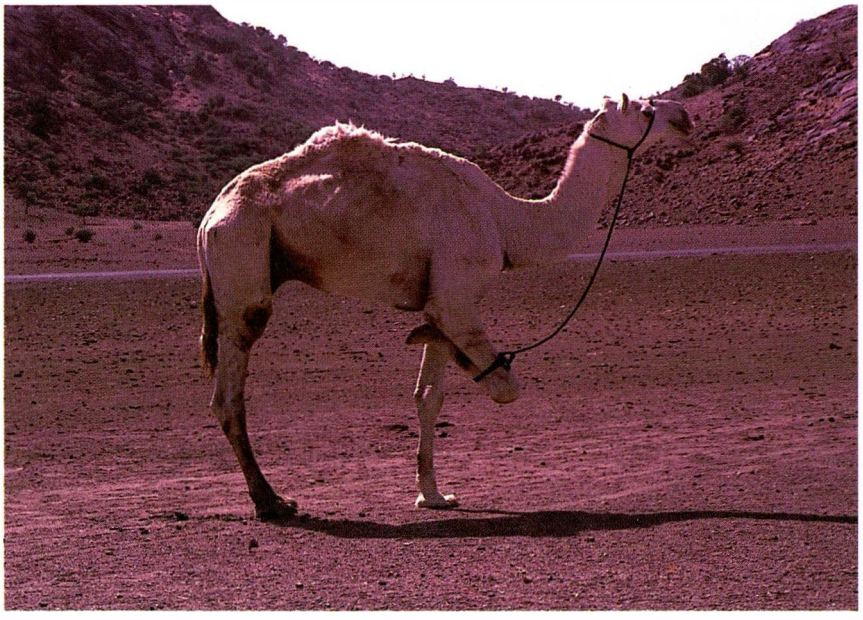


Plate I,3: Two fine examples of the racing type of camel. These are shown in the presentation ring at the racecourse in Khartoum. The smaller one probably weighs around 320 kg the larger one close to 400 kg.

Plate I,4: A Sudanese riding camel of the Anafi breed. It is not the extreme racing type but a sturdier animal of 450 to 480 kg weight, which can carry a rider and moderate quantities of equipment, totalling 150 kg, over 80 to 100 km a day for two to three weeks.



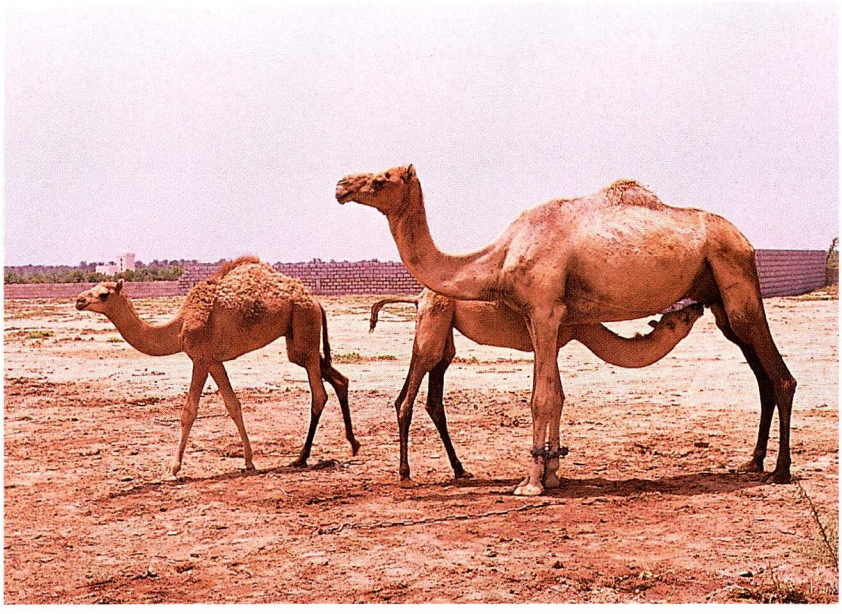


Plate I,5: Riding camels in a stud herd in Bahrein. The animals grow to large size, but remain slender and long legged. Body proportions do not change much from calf to adult. The herd is reputed to produce fine racers.

Plate I,6: A Rendille camel, which could also be called a Small East African in analogy to goats and cattle in the region, with a clan brand in Northern Kenya. It is of the pack animal type, but small, 1,7 m shoulder height, and weighs aroung 420 kg. It is just over six years old, a castrated male (dufaan) raised for ceremonial slaughter.

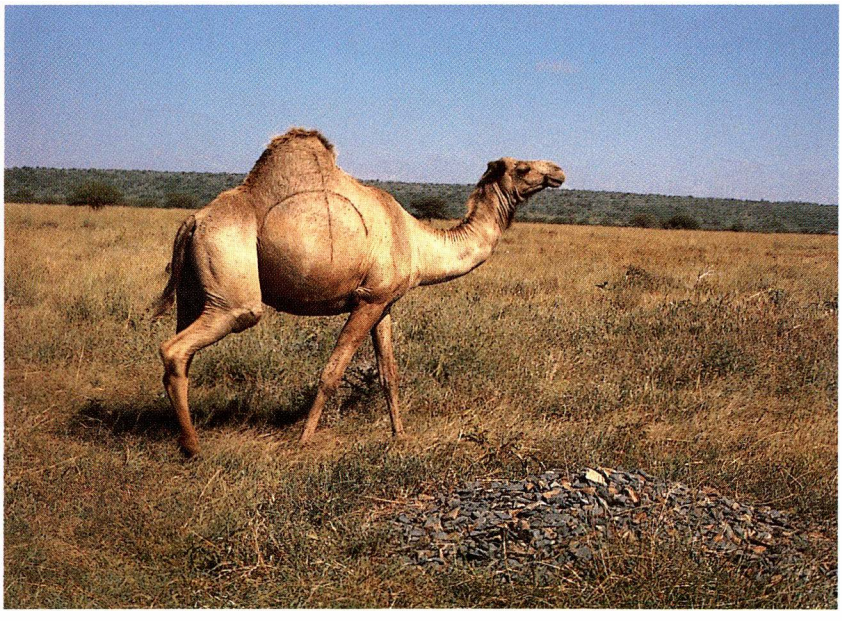


Plate I,7: A Tunisian dairy camel in the ENSA herd in Mateur. The pregnant female is of the heavy pack type and very well fed on pasture and supplementatry concentrates. Daily milk yields in such animals may be well over 10 kg.

Plate I,8: Heavy pack camels of Anatolian origin in the in Berlin Zoological Garden. The animals are shedding their winter coat. Considerable wool and hair production is stimulated by low temperatures. The amount appears to be correlated to the intensity and duration of the cold period.

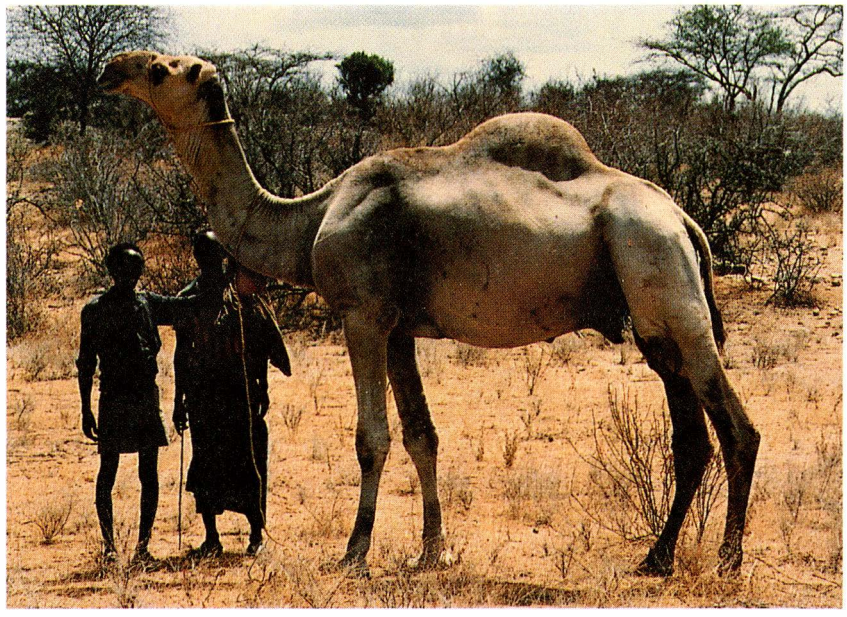
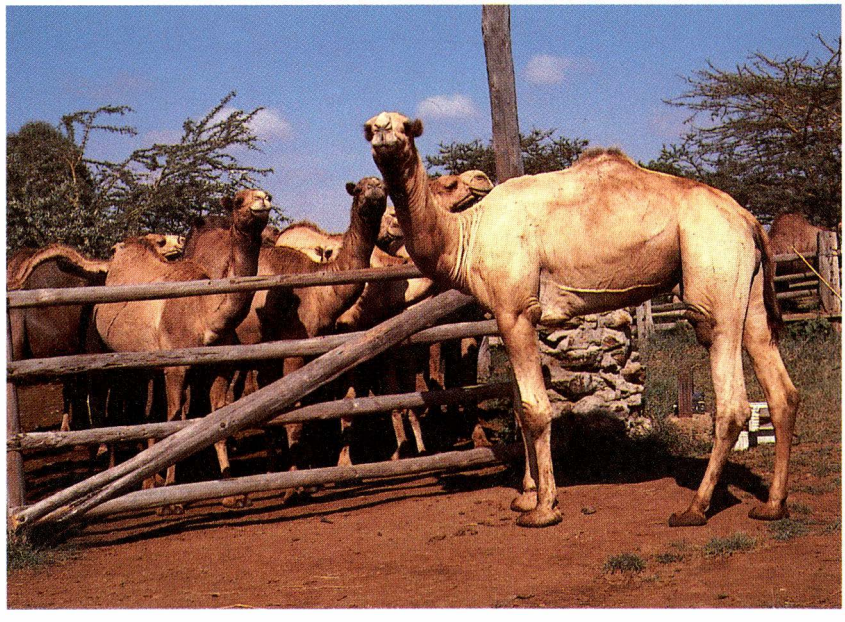


Plate I,9: A fine bull of the Somali (Benadir) breed kept by traditional pastoralists. The animal is approximately ten years old, has a shoulder height of 2,25 m and weighs over 700 kg. It represents an intermediate type between racing and pack camel.

Plate I,10: The animal in front is also a bull of the Somali (Benadir) breed. The herd is kept on a commercial ranch in Kenya. Note the difference in size between the bull (2.3 m shoulder height) and the females which are of the Small East African type.



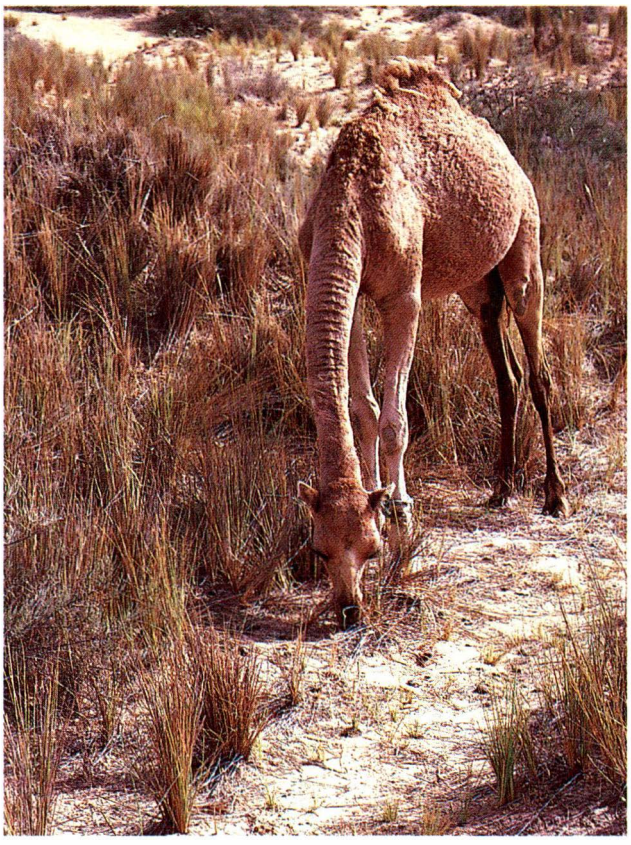
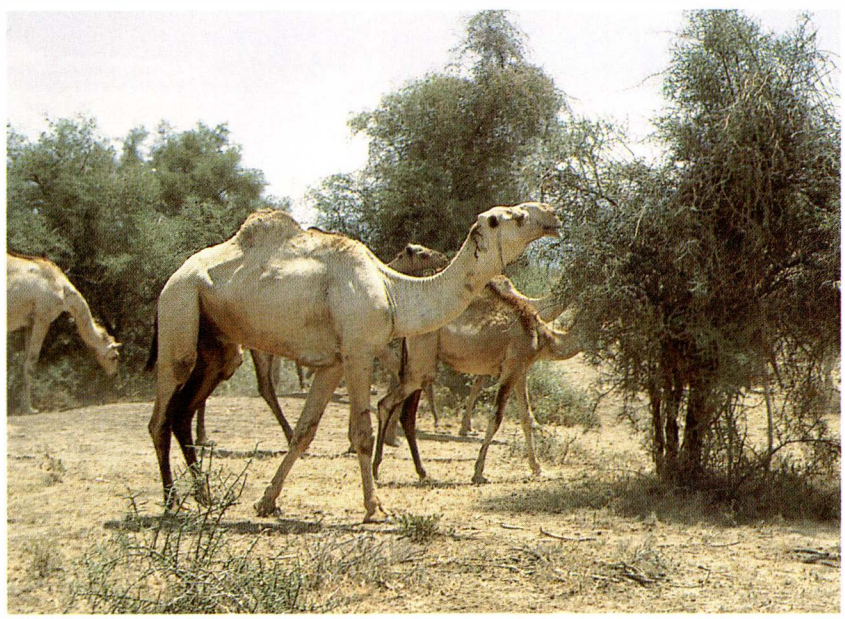


Plate I,11: Camels are very versatile and opportunistic feeders. On the fringes of the great deserts and in dune country they feed on coarse and bulky perennial grasses, halophytic forbs and dwarf shrubs.

Plate I,12: Camels can also efficiently harvest very small annual grasses like Aristida adscensionis growing on clays which are seasonally flooded as in Turkana District in Kenya. Cattle would not be able to harvest such sparse vegetation.

Plate I,13: If given a choice camels prefer to browse. They accept a very wide range of browse species such as the dwarf shrub Duosperma eremophilum, which is abundant in some part of Northern Kenya. Because of the coarse texture and hairy leaves this plant is avoided by other livestock.

Plate I,14: Evergreen bushes and smaller trees become very important during the dry season when the plants of the herblayer are disappearing. Because of their long reach camels can browse to heights of 3.5 m above ground.



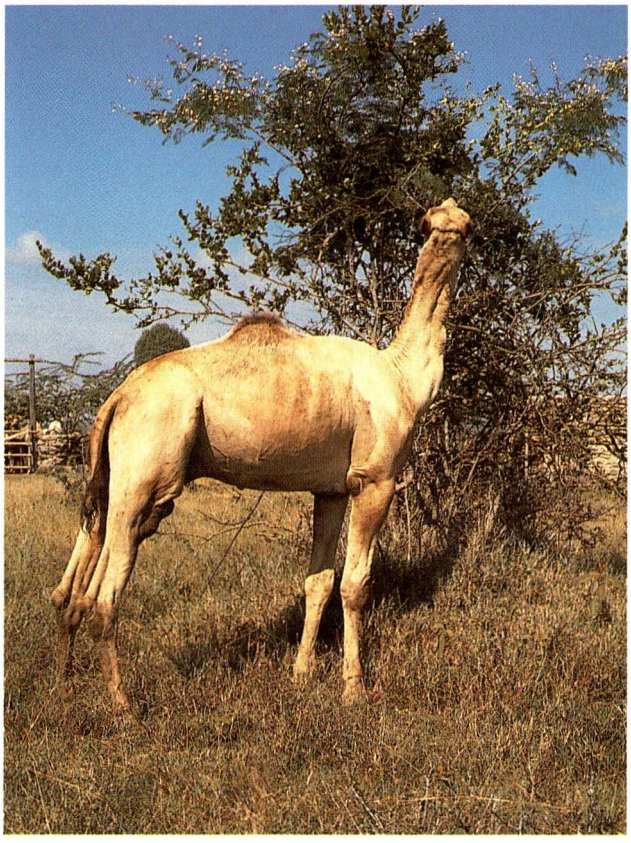


Plate I,15: If available camels prefer broad leafed plants like Cadaba, Cordia or Maerua ssp., which allow large bite sizes. It appears that camels feed like concentrate selectors if good quality forage is available, i.e. they select with great accuracy plant parts of higher digestibility.

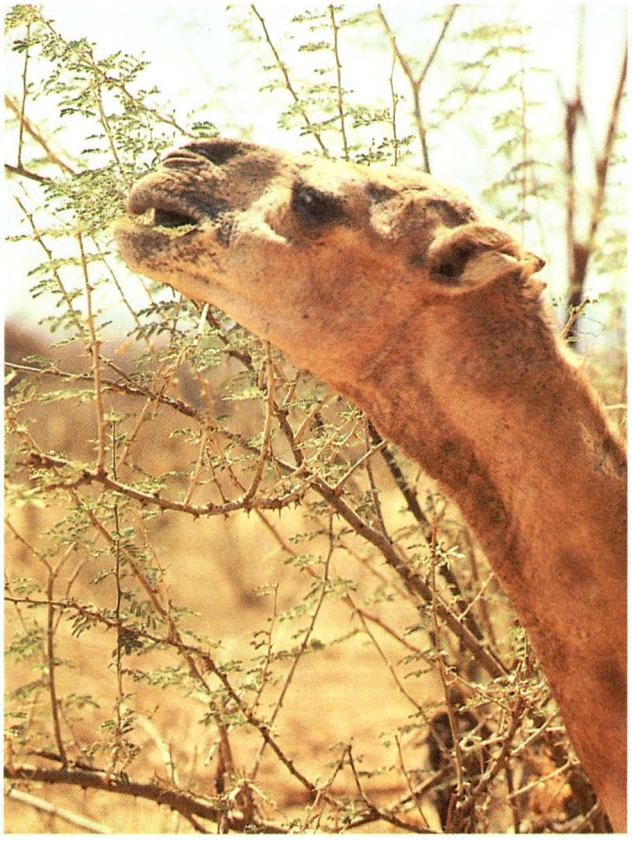


Plate I,16: This shows a camel harvesting the very fine leaves of Acacia mellifera by pulling the branches sideways through the teeth. Usually the softer end of the branch, which is last seasons growth, is bitten off. Although the prehensile lips allow camels to pick even small leaves between thorns they very frequently do not avoid them but ingest them as well.

heavier build with a more balanced appearance of fore and hind quarters. The hump is pronounced in well fed animals, shoulder and rump are relatively short and sloping steeply. The hair is often longer and coarse. The legs appear shorter and sturdier and feet are large. Live weights of 650 kg in females and over 800 kg in males are not uncommon. All described breeds either resemble one of these type or fall in between.

In Eastern Africa the baggage type seems to dominate. Sudan is the only country where a true riding camel can be found, the Anafi breed. There are not too many "breeds" or local types which are distinguished from others by particular characteristics. Size, build, colour and productive traits differ widely within herds but also within tribal, ecological, geographical or political boundaries. Low reproductive rates limit the potential for systematic selection within local populations, and particularly so within the female portion of the herds, although preferences for certain phenotypes and/or high performances are expressed by all camel pastoralists.

In Eastern Africa it is only the Somali camel, especially the "Benadir" type, which appears to be a specialised dairy animal (Plates I,9 and I,10). It certainly presents a more uniform phenotype than other breeds in the region. The animals conform basically to the heavy baggage type, are mostly white, large (1.9 to 2.1 m shoulder height) and heavy (mature body weights from 550 to 800 kg). Reported milk yields range up to 3500 kg in a prolonged lactation of 15 to 16 months. Peak daily yields reach 12 kg.

General Biology

Although Camelidae are ruminating animals they are not classified as Ruminantia. They differ from true ruminants in that they walk on the pads of the two last digits instead of on the sole of the hoof, they have no horns or antlers and they have a completely different stomach system. The same general characteristics of rumination and microbial digestion of fibrous feeds in a large and compartmented stomach system have developed independently in camelids and ruminants and at different geological times. The independent development resulted in marked differences in morphology, histology and motility of the stomach system.

Figure I,2 shows a schematic presentation of the stomach systems of true ruminants (cattle) and camelids. Engelhardt et al. (1988) describes the forestomach in camelids as consisting of three distinct compartments. The largest one is compartment 1 (C1) which is subdivided by a strong muscular ridge into a cranial and a caudal portion. The relatively small compartment 2 (C2) is only incompletely separated from compartment 1. The ventral parts the ventral parts of the compartments 1 and 2 are made up by series of glandular sacs. Compartment 3 (C3) is a long, tubiform, intestine-like organ, situated at the right side of compartment 1. The HCl producing hindstomach (H) is a short terminal part of the tubiform compartment 3 with no clear separation from it. The dorsal parts of the stomach compartments 1 and 2 are lined with smooth stratified epithelium.

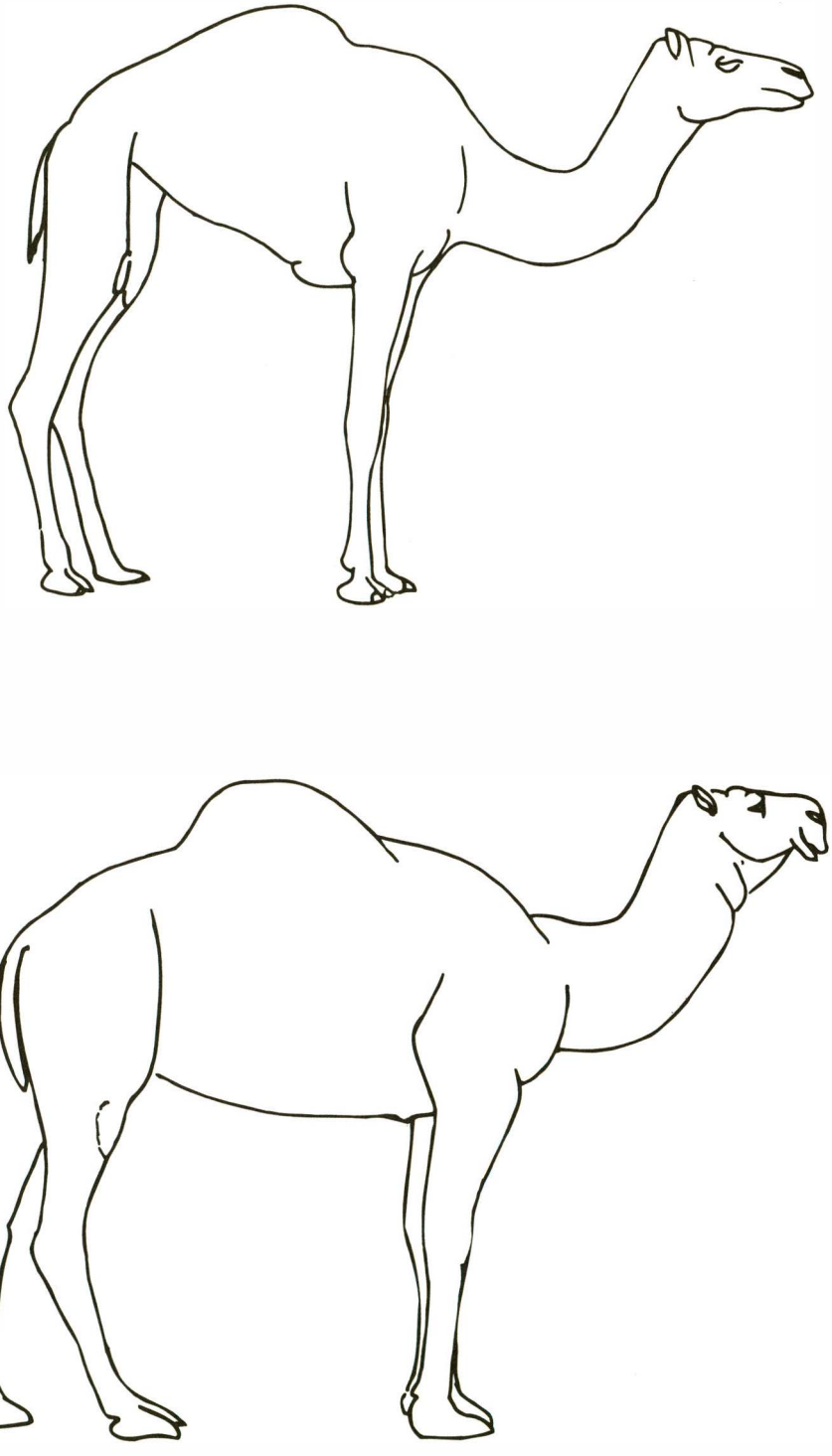


Figure I,1: Schematic presentation of the two main types of camels; the racing camel (above) and the heavy baggage camel (below)

The ventral parts and the entire compartment are lined with glandular mucosa, which is arranged in longitudinal folds in compartment 3. Figure I,3 gives a semi-schematic rendering of the left and right lateral views of a dromedary's stomach. The most striking feature differentiating it from the appearance of the true ruminant stomach are the glandular sacs.

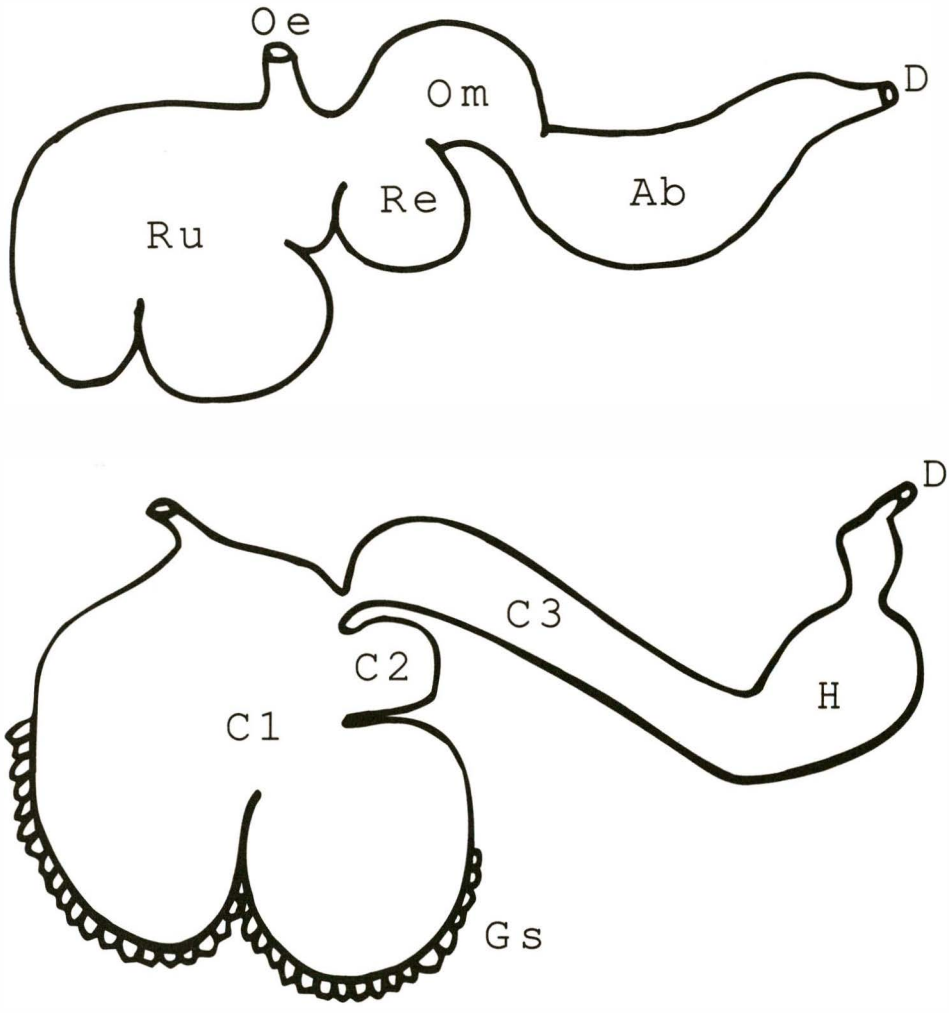


Figure I,2: Schematic presentation of the stomach systems of ruminants (above) and camelids (below); Oe = oesophagus, Ru = rumen, Re = reticulum, Om = omasum, Ab = abomasum, D = duodenum; C1 = compartment 1, C2 = compartment 2, C3 = compartment 3, Gs = glandular sacs, H = hindstomach

Stomach motility also differs strongly between ruminants and camelids. In the former the total digesta in the reticulo-rumen are mixed and transported within the organ some hours after feed intake rather homogeneously; in the latter particles and fluids are separated in a suction-pressure rhythm during the motility cycle, whereby fluids and solutes are pressed into the glandular sacs for potential

absorption, thus selectively retaining larger feed particles in the forestomach for prolonged microbial degradation.

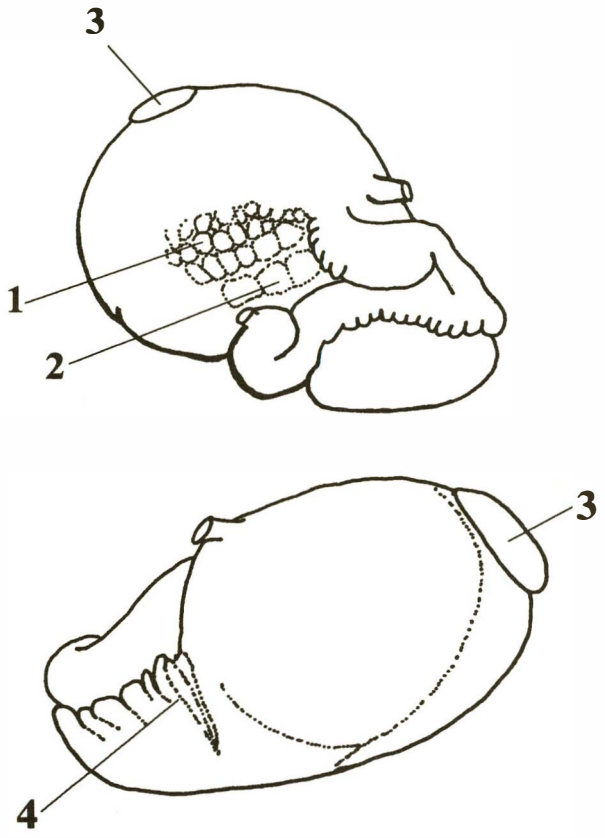


Figure I,3: Semi-schematic rendering of the right (above) and left (below) lateral view of a dromedary's stomach; 1 = dorsal part of the glandular sac of the caudodorsal part of C1, 2 = ventral part of the same, 3 = spleen, 4 = glandular sac of the cranioventral sac of C1. (redrawn after Smuts and Bezuidenhout, 1987)

Adaptation to hot, arid environments

The ability of camelids, and particularly of the dromedary, to adapt to extreme aridity of the habitat is unique amongst large herbivores. The most significant aspect of this adaptation is the economic use of water in almost all metabolic functions. These metabolic functions fall into two major categories, the intermediary metabolism and the maintenance of body temperature, in the usual habitat of the dromedary this generally means cooling. Table I,1 summarises some salient figures relating to water requirements of domestic herbivores kept under East African ranching conditions. Kept under complete water deprivation and at high environmental temperatures camels lose about 1-2 % of their body weight compared to 7-8 % daily loss in taurine cattle under the same conditions. Death by dehydration occurs in mammals inevitably at body weight losses 25-30 %. Thus

camels can survive 15 to 20 days without any water, cattle only 3 to 4. Zebu cattle are slightly more tolerant than taurine cattle and the small ruminants take an intermediate position between cattle and camels.

Table I,1: Some traits related to water turnover and drinking water requirements of domestic herbivores under East African ranching conditions; Source: various authors quoted in King, 1983.

Species	Camel	Goat	Sheep	Cattle
Daily weight loss under complete water deprivation [% body wt]	1-2	5-7	4-6	7-8
Adjusted water turnover [ml/kg body weight/day]	38-76	62-166	50-140	51-150
Maximal urinary osmolar concentration [mosm/kg H2O]	3100	3000	2900	1400
Minimal faecal water content [%]	35	50	45	60
Estimated water content in the selected diet of grazing stock [%]	34	29	26	15

Numerous factors contribute to the superior water economy of the camel. Water losses through urine are minimised by concentrating urine, by reducing renal urine flow and by retaining metabolites in the body fluids. Faecal water loss in camels is likewise comparatively low due to the efficient reabsorbtion of water in the colon. There appears to be no difference between camels and other domestic herbivores concerning the water turnover due to lactation.

At high environmental temperatures up to 80 % of the total daily water loss maybe accounted for by heat dissipation through evaporative cooling. In camels about 95 % of the evaporative heat loss are achieved by sweating. The necessity for sweating however is much reduced in camels by efficient short-wave heat reflection from the light and smooth hair coat, by equally efficient long-wave heat reradiation from a dark skin, but first and foremost by the fact that camels can tolerate fluctuations of the deep body temperature from 34 to 42łC, i.e. they can store considerable amounts of heat during the day and can dissipate this by non-evaporative mechanisms, radiation, conduction and convection, during the cool hours of the night. The highest deep body temperatures are usually reached during the early afternoon, when they produce the additional beneficial effect of lowering the temperature gradient between environment and animal which results in a reduced environmental heat gain.

Feeding behaviour and nutritional physiology

The usual habitat of the camel is not only characterised by high temperatures and scarcity of water, but in consequence of these environmental conditions also by a considerable seasonal variation in available forage quantity and forage quality. Herbivores can adapt to such fluctuations in forage quality by either increased selectivity for high quality plant material or by more efficient digestion of poor quality materials. The camel can do both.

In a series of comparative studies carried out with domestic ruminants, camels and donkeys on a semi-arid thornbush savannah in Isiolo District in Kenya various adaptive mechanisms to fluctuating forage supply were investigated (Engelhardt et al., 1988; Schwartz, 1988; Rutagwenda et al., 1990). Feeding behaviour and dietary preferences were the most important adaptive mechanisms investigated. Figure I,4 shows the mean total number of forage species included in the selected diet of the free ranging animals during one-hour observation intervals. All livestock species ingest higher numbers of forage species during the growing season than during the dry season. Goats, followed by camels accept the highest number of forage species resulting in a more even and thus benign utilisation of the available vegetation; local zebus and donkeys in comparison specialise on a very limited range which can easily lead to overgrazing of certain species.

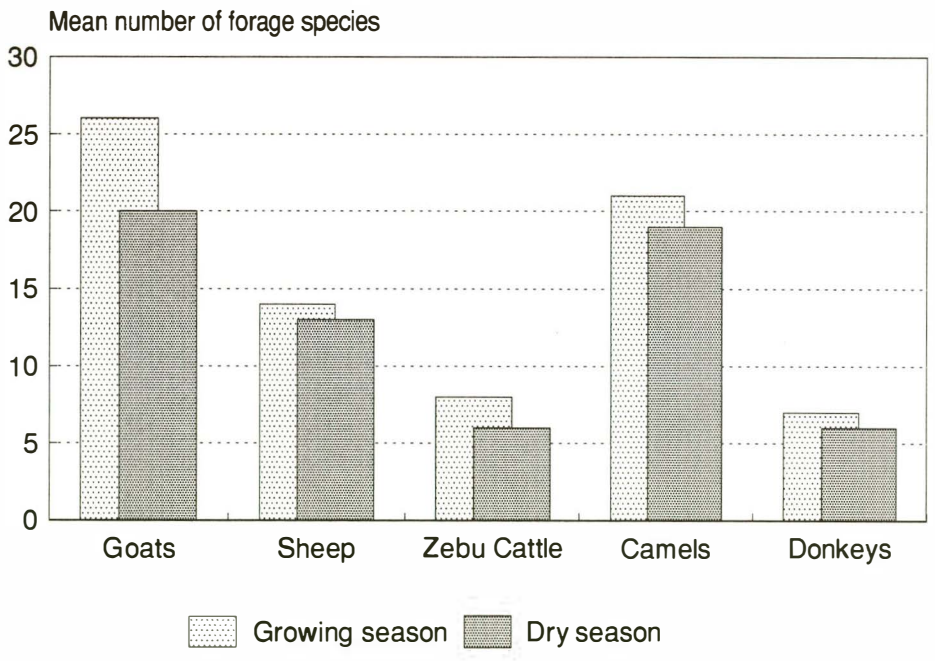


Figure I,4: Mean number of forage species selected by free ranging domestic ruminants, camels and donkeys on a semi-arid thornbush savannah during different seasons; Source: Schwartz, 1988.

Significant differences concerning the preferred feeding height above ground were recorded for the five livestock species. Figure I,5 shows the mean proportion of the total feeding time spent in various strata of the vegetation. Cattle feed near ground level fro over 80 % of the observed feeding time, thus almost exclusively using the herblayer. Donkeys, sheep, goats and camels, in that order, show increasing preference for feeding at greater height above ground. Camels in contrast to cattle spent less than 5 % of their feeding time near ground level and about 70 % at heights of over 1.0 m above ground. Figure I,6 is a schematic presentation of the distribution of different forage qualities at various heights above ground in two distinct seasons. This, and the recorded preference of the camel for higher vegetation strata, gives the camel the advantage of continuous access to high quality plant material since all plants reaching this height are shrubs, bushes and trees, which are deep rooted, often tapping into the groundwater, and remaining green long into the dry season or throughout the year, when the herblayer is dry and highly lignified.

Plant species reaching the higher strata of the vegetation as a rule belong to the dicotyledon group. The dietary preference of camels can therefore also be described in botanical terms. Since over 90 % of their intake comes from dicotyledon plants, they can be referred to as browsers, whereas cattle, feeding almost exclusively in the herblayer and on grasses, are referred to as grazers. Donkeys, sheep and goats, in that order, rank as intermediate feeding types with a certain emphasis to one or the other extreme. Resulting from observed preferences the dietary overlap between the five species is as shown in Table I,2.

Table I,2: Dietary overlap between animal species [% of total feeding time] on a semi-arid thornbush savannah during the dry and (green) season; Source: Rutagwenda et al., 1990.

	cattle	donkey	sheep	goat
camel	3.3 (8.5)	18.9 (7.2)	30.5 (14.2)	47.5 (12.4)
cattle		73.2 (50.5)	49.6 (20.1)	12.6 (23.3
donkey			59.6 (20.4)	29.7 (13.8)
sheep				36.6 (43.0)

The average crude protein and crude fibre content of the diet selected by the various livestock species during the different seasons is given in Table I,2. The protein content of the diets selected by all animals was higher, and correspondingly the crude fibre content lower, during the green season than during the dry season. Cattle were consistently selecting the poorest quality with a marked quality change between seasons. Camels were consistently able to select best qualities with minor differences between seasons. Donkeys, sheep and goats, in that order, took intermediate positions. Camels, but also goats, can be classified

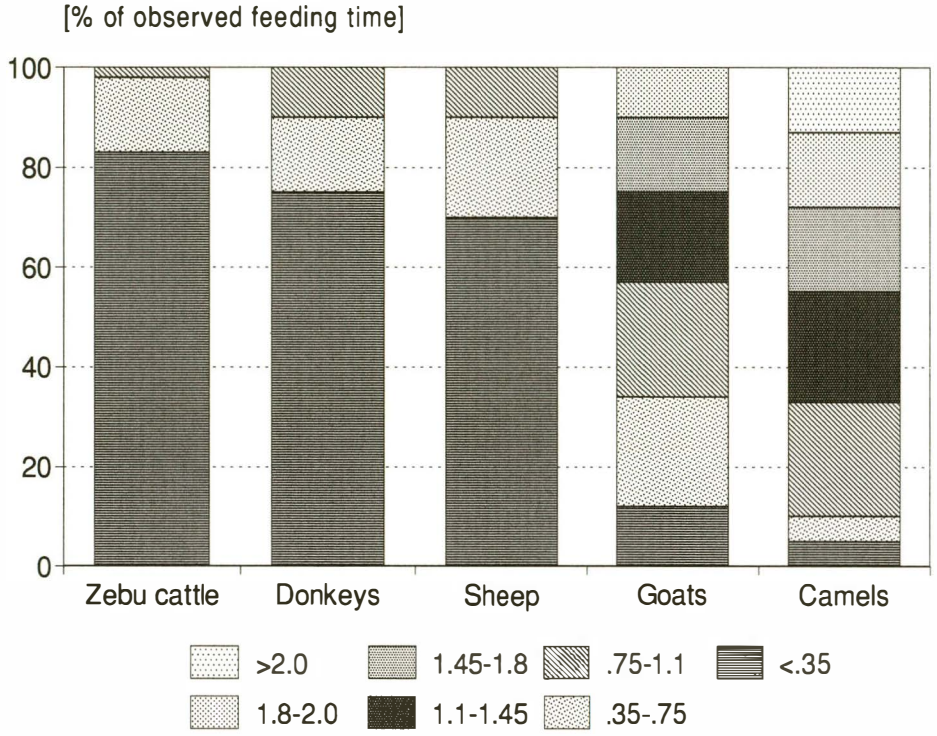


Figure I,5: Feeding time spent at different vegetation strata (height above ground) by free ranging domestic ruminants, camels and donkeys on a semi-arid thornbush savannah; Source: Schwartz, 1988.

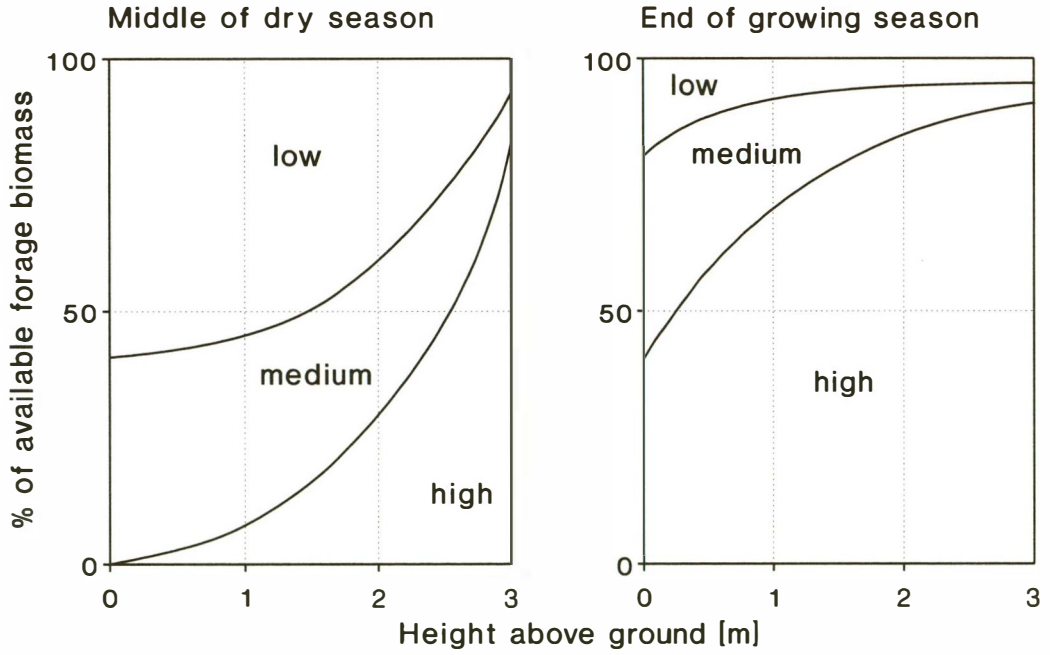


Figure I,6: Schematic presentation of the distribution of three forage quality classes at different vegetation strata (height above ground) on a semi-arid thornbush savannah at two distinct seasons (high < 30 % crude fibre, medium = 30 - 60 % crude fibre, low > 60 % crude fibre); Source: Schwartz, unpublished.

as concentrate selectors according to Hofmann (1988), if the pasture permits such feeding behaviour. However, recent studies carried out with camels in the Butana grasslands in Sudan (Engelhardt et al., in prep) showed that camels adopt feeding preferences almost identical to those of cattle, if grasses are the only forage available.

Table I,3: Range of estimated mean quality parameters of the diet selected by free ranging domestic ruminants, camels and donkeys on a semi-arid thornbush savannah during different seasons; Source: Rutagwenda et al., 1990.

Quality parameter	Crude protein [%]		Crude fibre [%]	
Season	dry	green	dry	green
Cattle	4-5	10-12	37-40	32-36
Donkey	5-8	11-13	37-40	24-30
Sheep	9-11	15-20	20-29	21-25
Goat	11-14	17-22	15-22	16-22
Camel	14-17	18-22	14-22	14-17

If prevented from selecting high quality diets, camels increase digestion of fibrous forages by a increasing the retention time of feed particles in the forestomach. This is effected like in true ruminants by increasing the forestomach volume with a simultaneous and approximately proportional increase in forestomach fluid volume. Figures I,7 illustrates this. Forestomach fluid volumes increased in all species during the dry season. Camels had in both seasons smaller volumes (8.9 and 11.3 l/100 kg body weight) than the other livestock species. The relatively low values in camels and the small difference between growing season and dry season were probably a reflection of the fact that the camels in comparison to the other species were able to select high quality diets throughout the year. If fed on an experimental diet of low quality without any possibility to select high quality plant parts, camels were able to retain feed particles as long as 74 hours in their forestomach. At the same time the forestomach fluid volume reached 17 % of the body weight which is slightly higher than measured for zebu cattle on a semi-arid thornbush savannah during the dry season (Engelhardt et al., in prep.).

In qualification of a previous statement that camels feed as selective browsers, preferring and harvesting only the most nutritious parts of the forage biomass on offer it has to be said that camels can, if necessary, utilize and adapt morphologically and physiologically to low-quality, fiber-rich diets just as well as cattle which are specialised bulk and roughage feeders. Thus, camels can use both feeding strategies exceedingly well, which increases the range of habitats where camels can be kept profitably. It remains to be mentioned in this context that camels, if feeding on low-protein forages can recycle and utilise body urea for microbial protein synthesis much more efficiently than the true ruminants. Experimental reduction of dietary protein from 13 % to 6% was compensated for by near doubling of the urea recycling rate from 47 % to 86 % (Engelhardt et al.,

in prep.). Considering the fact, that low nitrogen or crude protein contents are often the most important nutritional constraint on arid and semi-arid pastures this ability gives yet another advantage to the camel.

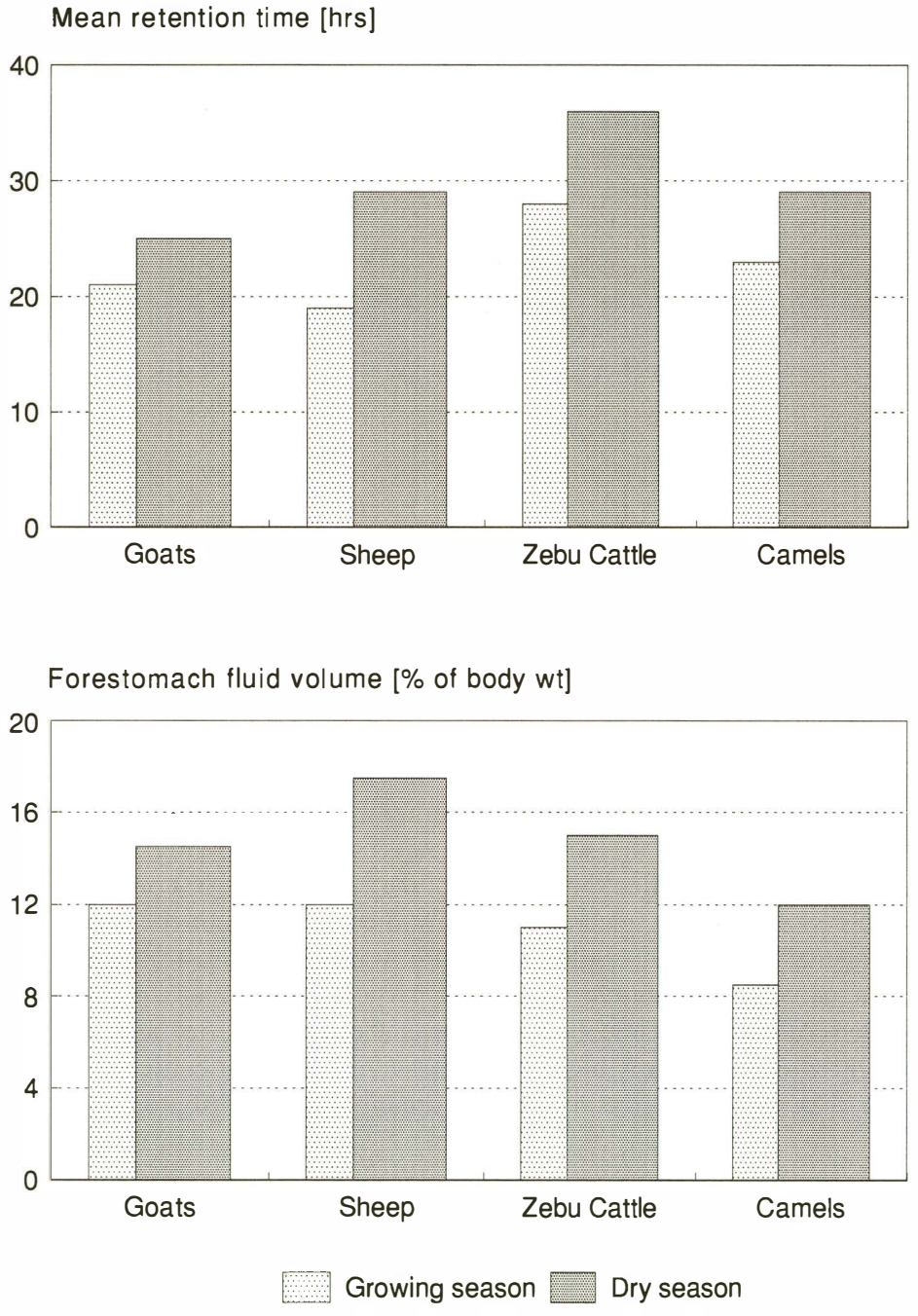


Figure I,7: Seasonal changes of mean retention time of feed particles in the forestomach (above) and forestomach fluid volume (below) in domestic ruminants, camels and donkeys on a semi-arid thornbush savannah; Source: Lechner-Doll et al., 1990.

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Chapter II

The Productive Potential of the Camel

H.J.Schwartz and M.G.H.Walsh

Products and performances

Milk

Milk is the most important camel product in Eastern Africa. Camel milk is a valuable human food source in the arid environments of Eastern Africa. Total dry matter ranges from 12 to 15 %, protein from 2.7 to 4.5 %, fat from 2.9 to 5.2% and lactose up to 5.5 %. Of special importance in areas where food of plant origin is rare is the high content of vitamin C, which may reach 2.9 mg/100g. Estimates of milk yields, be they daily yields or lactation yields, differ widely. Reported daily yields range from 3,5 to over 20 litres, corresponding lactation yields from 800 to over 4000 litres (Table II,1). Lactation lengths likewise show a large variation of 8 months to almost 2 years.

Table II,1: Summary of some reported milk yields; Source: R.Yagil, 1985.

Source	Daily yields [kg]	Total yields [kg]
Williamson and Payne (1979)	9	2,722
Bremaud (1969)	12	-
Knoess (1976)	10.4	2,847
Yasin and Wahid (1957)	9.1-14.1	1,068-4,118
Field (1979)	21	1,887
Leese (1927)	4.8	-
Leupold (1968)	6.7-10	2,700-3,600
Dahl and Hjort (1976)	3.5-4.5	1,890-2,160
Ensminger (1973)	7.5	3,300
Lakosa and Shokin (1964)	8.1-19	4,388
Hartley (1979)	9	1,800
Rosetti and Congiu (1955)	5	3,105-8,190

However, many of the higher yields quoted do not appear to be representative under East African conditions, particularly in pastoral production systems, where the largest proportion of camel's milk is produced. Daily yields between 3 and 6 litres, with total yields between 1500 and 2500 litres produced within lactation periods of 15 to 18 months are most likely the common range of performances. Such yields do not sound very impressive when compared to milk yields obtained from cattle kept in intensive conditions. Considering the local feed base in semi-arid and arid areas which is frequently inadequate to secure the mere survival of cattle such yields are impressive. Beside the absolute quantity of milk produced it

is the persistency of production which is important for the subsistence of pastoral populations since it provides staple food throughout dry seasons and shorter drought periods, when milk production from cattle and goats seizes.

Figure II,1 shows the mean daily milk yields obtained from a group of initially seven, and later five camels, in an experimental herd kept on pasture in the semi-arid lowlands of Isiolo District in Kenya, in relation to rainfall, and, indirectly, to pasture condition. Daily milk yields of the seven animals, which had given birth during a time span of two weeks, were recorded every two weeks for fifteen consecutive months. Two animals dried up completely after approximately nine months, at the end of the long dry season, due to advancing new pregnancy. The mean daily yields declined from approximately six litres at the start of the lactations to under two at nine months, which corresponded with the end of a long dry season of six months (October 1987). After the onset of the November rains and the simultaneous improvement of pasture quality daily yields peaked again at over five litres and were still at three litres five months later, about two months into the next dry season.

The factors affecting milk yields are those common to all dairy animals, nutrient supply, health status, milking techniques, genetic potential for milk production, number of previous lactations or age of the animal. The first three are readily exploitable for increasing milk production providing the respective inputs and services are available and their application profitable; it only requires good husbandry, feeding and health care, corresponding to principles and techniques well known from other dairy species.

Improving the genetic potential for milk production in East African camels is also possible, but only in the very long term. Because of the low reproductive rate of camels selection will be inefficient, since virtually all fertile females will have to be bred and selection can be carried out in male breeding stock only. Cross breeding with recognised high yielding dairy breeds of Asian origin is possible but has two main drawbacks. Firstly it would take 7 to 8 years before the first cross could be tested, secondly it is by no means ascertained that the improved genetic potential could be exploited in the pastoral systems in Eastern Africa. It is quite certain that even a camel cannot produce 5000 litres milk per lactation without concentrates, mineral supplementation and scrupulous hygiene. Similar arguments are valid for embryo transfer programmes which have been proposed. While these promise a genetic short cut they require a "high tech" environment. Even in the industrialised countries and with high yielding dairy cattle economic viability of such programmes still remains doubtful.

Meat

Not much solid information is available on camel meat production whereas estimates abound. Adult camel live weights range, depending on age, sex, breed, nutritional status and stomach fill from approximately 320 to 750 kg; these weights are reached between 5 and seven years of age in pastoral production systems. Some live weight data of different East African camel types are

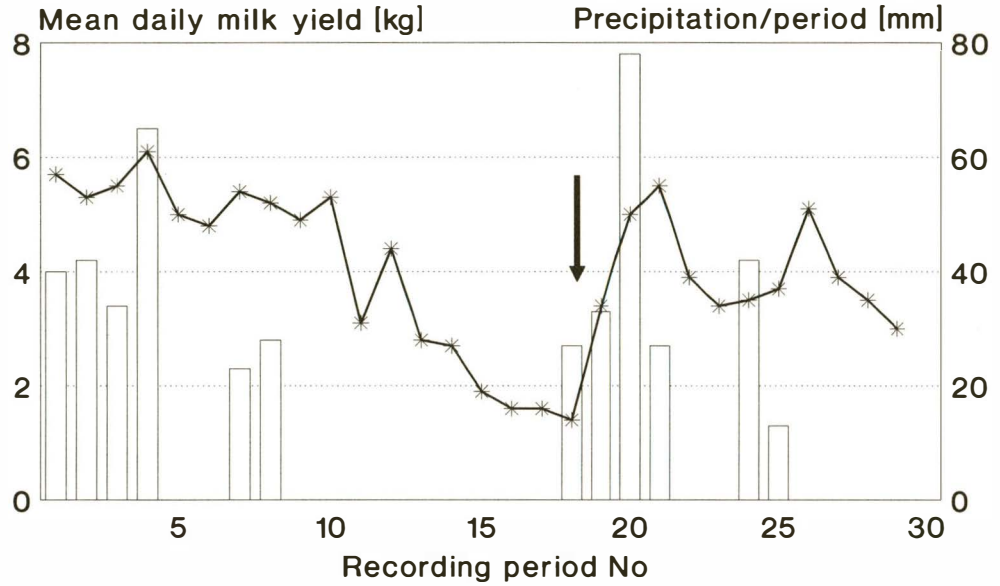


Figure II,1: Mean daily milk yields of 7 (later 5) camels in relation to rainfall on a semi-arid pasture in Isiolo District, Kenya; Source: Author's data. (Recording periods comprise of 14 days; rainfall values are cumulative per recording period; milk yields were measured at the end of each period; line represents milk yields; bars indicate rainfall; arrow indicates change in group size).

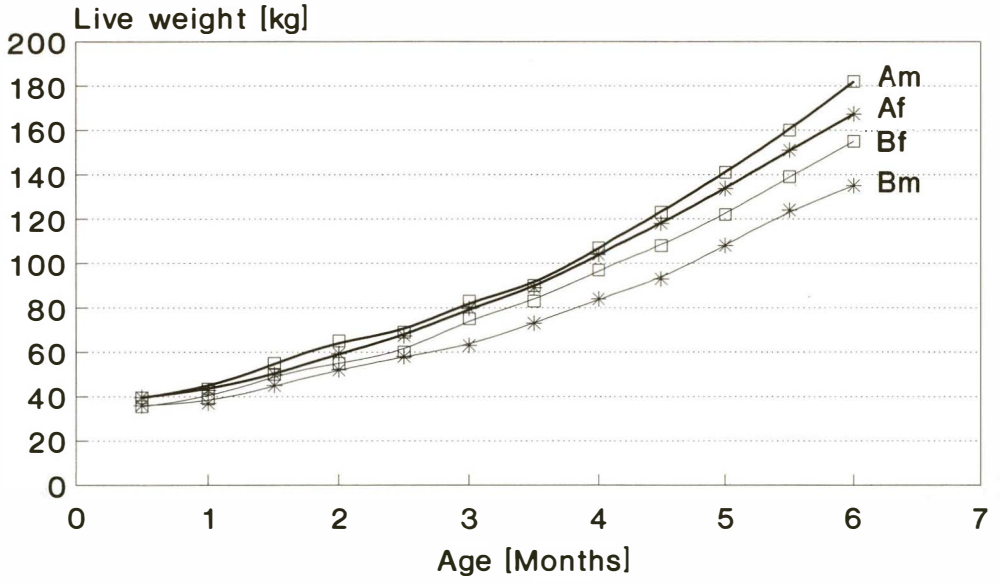


Figure II,2: Average pre-weaning weight development of male and female camels in two herds in Northern Kenya; Source: Schwartz & Walsh, 1990; Author's data. (Af= 8 herd 1 females; Am = 11 herd 1 males; Bf = 18 herd 2 females; Bm = 17 herd 2 males).

summarised in Table II,2. Dressing percentage, as in other herbivores, will range from 45 to 55%. Meat quality is largely age dependant and quite good in young slaughter stock. The majority of camels slaughtered are culls, only a limited number of castrated males are especially raised for slaughter. Camel meat markets and camel meat consumption are, with the exception of Sudan, not very well developed in Eastern Africa, but lucrative export opportunities to Egypt, Libya, Saudi Arabia and the Gulf States do exist.

Table II,2: Live weights of adult camels of different breed/type; Sources: Wilson, 1984 and Author's data.

Breed/type	Sex	No	Mean weight [kg]	æ SD
Darfur[1]	male	21	447.9	84.1
	female	39	414.4	50.8
Benadir (Kenya)[2]	male	21	434.6	29.3
	female	27	425.1	36.3
Rendille-Gabbra (Kenya)[2]	both	48	397.7	60.1

[1] slaughter house data; [2] all animals over five years old

Meat production efficiency of a livestock species is affected mainly by two factors. One is the reproductive efficiency influencing off-take rates, the other is the individual growth potential. As already pointed out before, camels, due to the intrinsically low reproductive rate, cannot be efficient meat producers. Off-take rates of 3 to 5% might already constitute a stress on the population. The fact, that all camel populations in North Africa, Mauritania excepted, and Arabia are declining and that the Sudanese national herd is stagnating in numbers, proves that a pronounced consumer preference for camel meat combined with strong purchasing power can be detrimental to population growth, i.e. can cause a form of "resource mining".

The individual growth is determined by sex and genetic potential and mainly affected by nutrition and by the health status of the animals. Figure II,2 shows the pre-weaning weight development of male and female camels in two different herds, but with a similar genetic background. Herd A was an experimental herd kept on pasture in the semi-arid lowlands of Isiolo District in Kenya. Milk off-take for human consumption was approximately half of the total yield. In tendency male calves grew faster than females, but group differences were not significant statistically. Herd B was owned by traditional pastoralists in Marsabit District in Kenya (Schwartz & Walsh, 1990). Here milk off-take for human consumption was uncontrolled, higher than in herd A, and definitely higher in dams with male calves than in those with females offspring. Weaning weights were significantly lower than in herd A; weaning weights were lower in male calves than in females. Weight differences between male and females calves in

herd B were highly significant, reflecting the differences in nutrient supply between herds and sexes.

The results of a study carried out in three different camel herds in Kenya illustrate the effects of genetic potential and management on growth rates and mature body weights in camels which were recorded in three camel herds in Kenya. Herd 1 and 2 were herds kept on commercial ranches, herd 3 was owned and managed by traditional pastoralists. The main parameters differentiating the three herds are listed in Table II,3.

Table II,3: Parameters differentiating three experimental camel herds; Source: Schwartz, Dolan & Wilson, 1983.

Herd No & name	1 Galana	2 OlMaisor	3 Lengima
Production system	ranch[1]	ranch[1]	nomadic[2]
Camel breed/type	Benadir	Rendille	Rendille
Pasture	improved[3]	improved[3]	natural
Supplementation	no	no	no
Minerals	yes	yes	no
Health programme	yes	yes	no
Breeding system	aseasonal	aseasonal	seasonal
Annual birth rate [%]	57.4	54	42
Calving interval [months]	20.9	22.2	28.4
Female young mortality [%]	0	0	37
Male young mortality [%]	6.2	0	73
Milked out yield [kg]	500	400	950

[1] commercial ranch, main product beef, camels kept for internal transport and milk supply to the herders; [2] traditional nomadic pastoralists, camel milk production for subsistence supply, live sheep, goats and cattle for marketing; [3] rotational grazing by herding, dry season grazing reserves.

Figure II,3 presents growth curves for the three herds. These are approximations for both sexes based on separately obtained regression equations. The Rendille-Gabbra type animals under traditional nomadic management show slower growth and lower mature body weights than animals of the same type on OlMaisor ranch. Liveweights between 400 and 500 kg occur in the pastoral herd (herd 3) in the age group over nine years whereas similar body weights are reached by four years of age on OlMaisor ranch (herd 2). Although the differences in mature weights were statistically significant, there were small in biological terms. This indicates that neither the management inputs (drenching, deticking, mineral supplementation) nor the better pastures (lower grazing pressure, rotational grazing, higher rainfall) affected the final body weights to a large extent. However, the final weights are reached at a much later age in the pastoral herd. Mature body weights of 600 to

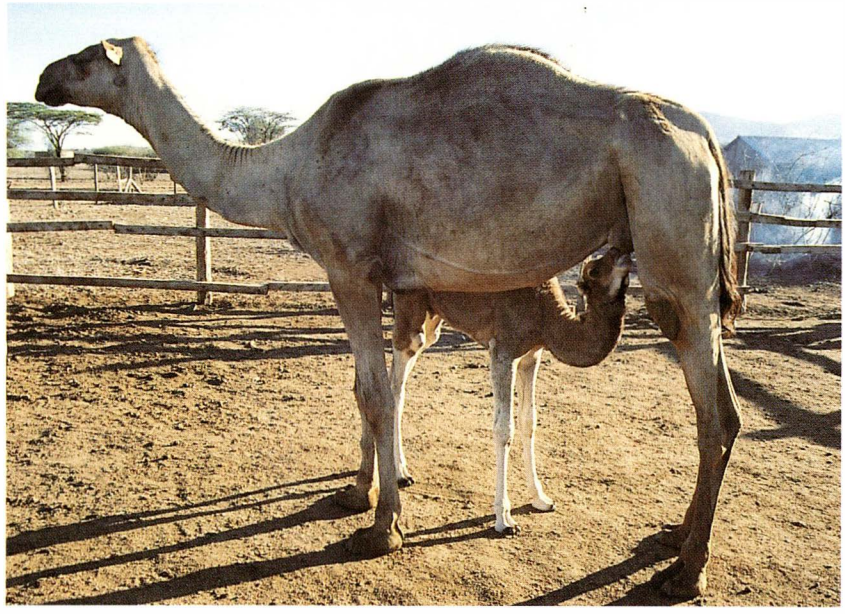


Plate II,1: Milk is the most important camel product in Eastern Africa. Lactations in camels last 12 to 18 months, the calf is usually weaned after about 6 months. In most pastoral production systems the calving interval in camels is 24 to 30 months. Peak daily milk yields in East African camels are 6 to 8 litres.

Plate II,2: Rendille boys milking a camel in a "fora" camp. This is a satellite camp, often far away from the family camp (gob), where young stock and pregnant females are kept to benefit from better pastures. A few animals in later stages of lactation are provided to produce milk for the young herders.

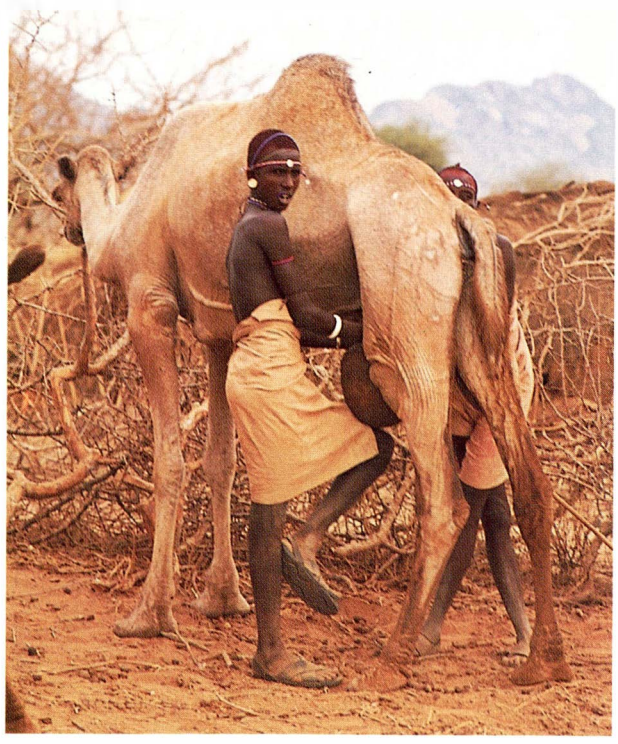


Plate II,3: After the morning milking. Freshly lactating animals are usually kept near the temporary family settlements to produce milk for the households. It is common practice to share out the milk between families. Camel milk may account for than half of the pastoralist's nutrient intake during the growing seasons.

Plate II,4: Collecting the daily water supply for the household is women's work. Even if camels are available for the transport it is still hard work but it also offers regular opportunity for social contacts and the exchange of news.

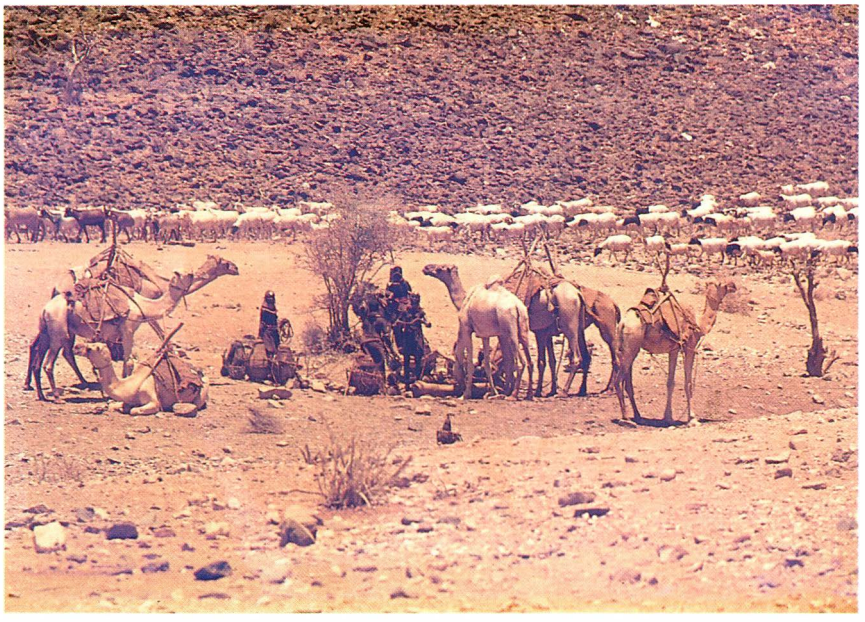


Plate II,5: Camels can carry loads, amounting to approximately one third to one half of their body weight, over distances of 80 km and more per day at a leisurely pace of 4 to 5 km per hour. The two animals here carry two water containers each, each container holding about 40 litres.

Plate II,6: Camels are used to drag thornbushes for building temporary livestock enclosures like the one in the foreground. When the enclosures become contaminated with faeces and parasites they are abandoned and the fencing material is used as fuel.

Plate II,7: Because of their low reproductive rates camels are rarely slaughtered in nomadic systems, although most pastoralists do have a strong preference for camel meat. Older and infertile animals are often sold for slaughter to sedentary groups for cash or kind. Here an open air butcher shop in Northern Kenya offering one complete camel carcass.

Plate II,8: The one-humped camel, other than its two-humped cousin in Central Asia, does not produce much hair or wool under East African condition. Calves are born with a soft woolly fleece which can be shorn once, yield approximately 0.5 to 0.7 kg raw wool. The two calves in the photograph are freshly shorn.

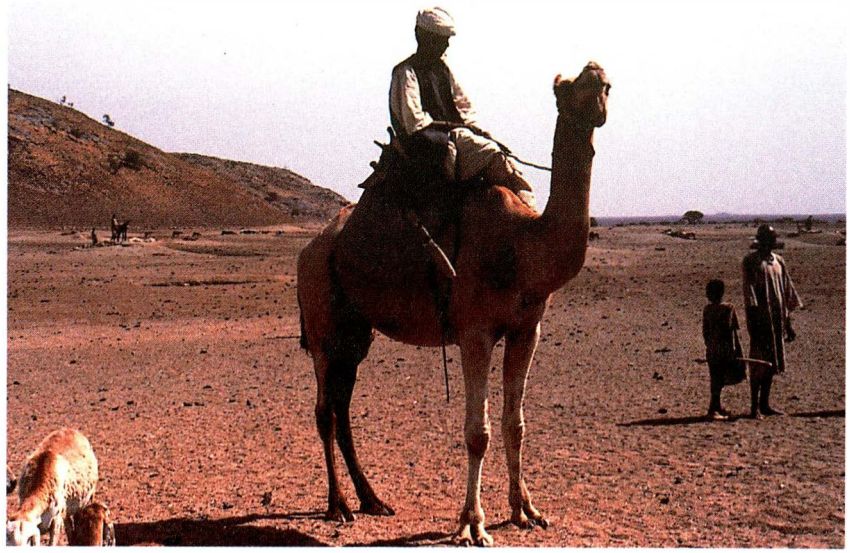
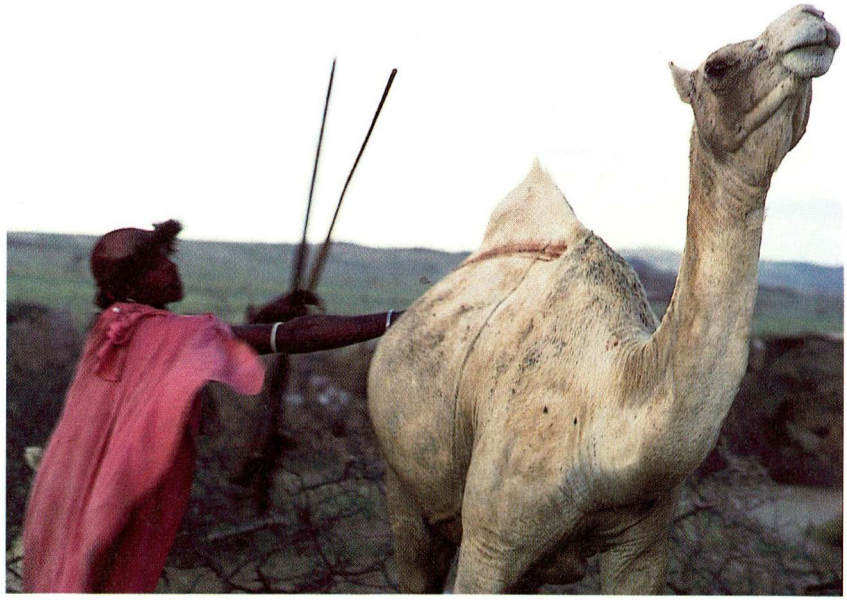


Plate II,9: Camel riding is not very common in Eastern Africa, excepting North Sudan where it is widely practised. The Hadendoa tribesman in the picture is herding sheep and goats mounted on a camel. Note the sword which, even today, is carried low on the right side of the saddle, as it has been for centuries.

Plate II,10: In many pastoral societies the camel carries great ritual and socio-cultural significance. Here a Rendille elder in Marsabit District of Kenya is applying a mark of sheep's' blood on a camels back during a seasonal blessing ceremony called "almado".



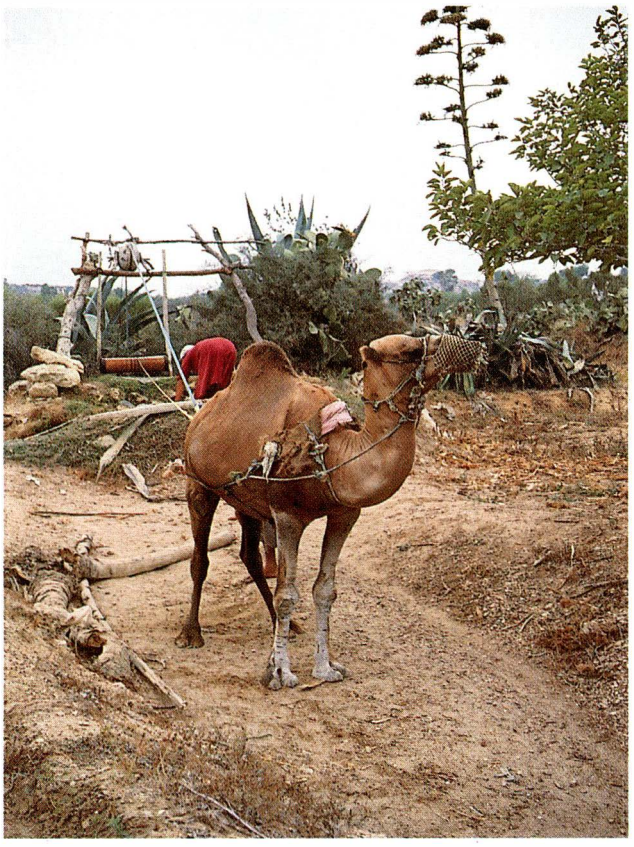


Plate II, 11: The majority of the world's camels is kept by pastoralists. In some areas, in North Africa and on the Indian subcontinent, they are also associated with agricultural activities. One of the more frequent occupations is drawing of water for irrigation.

Plate II,12: With this simple system approximately 110 litres of irrigation water are lifted from a depth of 45 m, which takes about three minutes. In a five-hour working day this animal draws some 11,000 water for the irrigation of vegetable plots.

Plate II,13: Camels can work as draft animals for ploughing, seed-bed preparation and digging irrigation ditches like in the picture above. With their large and soft feet they do not compact loose soil as horses or oxen would do.

Plate II,14: A young camel being trained to pull a cart. The animal is already wearing a harness, but is tied behind a cart pulled by a mule. This way the animal gets used to the cart and the traffic on the road. For a while it will be tied in front of the cart next to the mule before it is actually harnessed in to pull the cart.

Plate II,15: Camels appear to have rather high mineral requirements. Occasionally they show preference for halophytic forage species, for brackish water and salty soil. The calf in the picture is feeding soil from the wall of a termite mound.

Plate II,16: Standard mineral mixtures can be fed to camels as granules or in form of mineral blocks. Mixing mineral granules with an anthelmintic in appropriate concentration results in self-dosing against internal parasites.

700 kg are reached by the Benadir type animals on Galana ranch (herd 1) after the age of six. They are statistically as well as biologically significantly higher than in both other herds. Since management inputs and pasture qualities were very similar for both ranch herds (herds 1 and 2) it can be assumed that the differences between these two herds were due to a greater genetic potential for growth in the Benadir type animals.

The most powerful interventions to improve meat production in camels are improving nutrition, especially of the calves, and reducing mortality through hygiene and health care. In most situations however such inputs will be more efficiently converted by small ruminants, particularly by goats (Table II,4). A careful trade-off analysis of expected benefits is always advisable. It can be assumed that camel meat production in Eastern Africa will remain incidental to milk production. Genetic improvement is faced with the same constraints as were pointed out for milk production.

Table II,4: Comparison of some productive traits of cattle, camels, sheep and goats in Turkana District, Northern Kenya; Source: Schwartz, Schwartz and van Dongen, 1984.

	Cattle	Camels	Sheep	Goats
Annual meat production [kg/TLU][1]	40-50	30-60	180-200	200-220
Annual milk production (kg/TLU lactating female)	350	1250	200	300-500

[1] TLU = Tropical Livestock Unit = 250 kg liveweight; 1 TLU = 1 Cattle = 0.7 Camel = 10 Sheep = 11 Goats

Work

Camels are used for riding, as pack animals, for wheeled transport, as draught animals in agriculture, for drawing water and as a power source for small industries (Schwartz, 1986). It is difficult to estimate the economic significance of the various forms of employment. Within Eastern Africa camels are most frequently used as pack animals, and in Sudan also for riding. Use of camels as draught animals is traditionally practised in some parts of Ethiopia. Occasional use is made of camels for driving oil mills, operating water wheels or drawing irrigation water from deep wells.

Traditional pastoral livestock production in Eastern Africa is characterised by individual stock ownership, communal use of pastures and seasonal migrations of herds and households. The frequency of migrations might range from once to as much as six times per year, and migration distances might be very short or extend over several hundred kilometres. Of crucial importance to these migratory systems is the availability of adequate numbers of loading camels per household. Since seasonal migrations are often feasible only during very limited time periods,

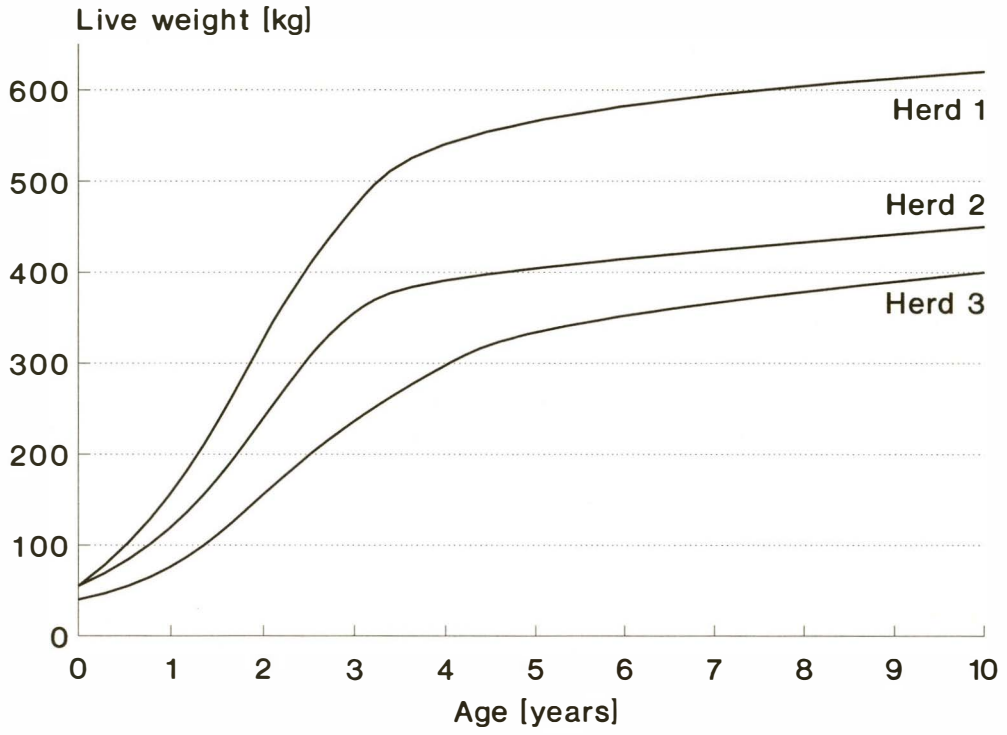


Figure II,3: Estimated growth curves in three camel herds in Kenya; Source Schwartz et al, 1983. (Herd 1 = Galana Ranch; herd 2 = OlMaisor Ranch; herd 3 = Lengima's herd).

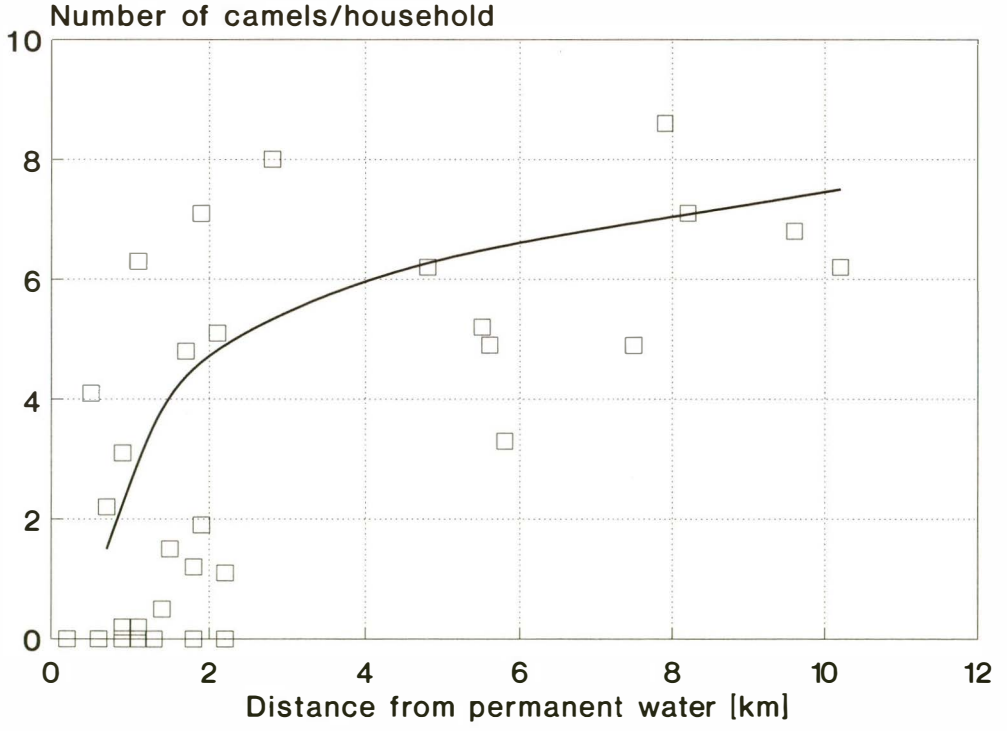


Figure II,4: Settling distances of nomadic encampments from a permanent water source in relation to number of camels per household; Source: Schwartz, 1986.

sharing of animals or borrowing from other households is rarely possible, and lack of transport animals results in a severe management handicap for the affected household. Beside the transport functions during migrations loading camels are regularly used to carry firewood, to a limited extent trade goods, but most importantly water for household consumption.

A study carried out in Northern Kenya (Schwartz, 1984) showed a close correlation between settling distance from a permanent water source and the number of pack camels available per household, which accounted in average for close to 13 % of the total camel herds. Figure II,4 shows the distance between 31 encampments and the nearest permanent water source related to the average number of loading camels per household. All camps with less than three camels per household were located within walking distance from the water source, i.e. within a 2.5 km radius. Five out of eight camps with three to six camels per household were at or beyond 5 km from water, and four out of eight with more than six camels per household settled at or beyond 8 km from the water source.

Maximum settling distance from permanent water and, consequently, the total area from which a camp or settlement site may be selected, are direct functions of the number of pack animals available to transport household water (Table II,5). Pasture areas close to permanent water are usually in poorer condition, due to high grazing pressure, and present a higher contamination risk with respect to intestinal and ectoparasites. Pastoralists who are forced to maintain their herds here have a limited choice of pasture or have to resort to forming satellite herds away from the household which often results in diminished milk and meat supply to the household and can adversely affect the quality of herd management.

Table II,5: Number of pack camels per household, maximum settling distance from a single water source and potential settling area; Source: Schwartz, 1984.

Camels per Household	< 2	2	4	8
Pack camels per Household	-	0.25	0.5	1
Frequency of water transport	daily	daily	2 days	4 days
Maximum settling distance [km]	< 2.5	5	12.5	27.5
Potential settling area [km^2]	177	314	962	3318

Where the camel is integrated in agricultural production, normally in semi-arid to subhumid areas, it serves as a draught animal for plowing and seed-bed preparation, for pulling carts and waggons, for drawing irrigation water and as a pack animal for carrying agricultural produce. These uses are not very common in Eastern Africa, but reports and experiences from North Africa and Asia suggest that the camel performance as a draught animal compares favourably with oxen and donkeys and equals that of horses. There are no systematic studies reported in the literature on work performance of the camel. Estimates of sustainable draught performance, working speed and endurance which are compared to values obtained for other draught animals (Table II,6) still need to be verified experimentally.

Table II,6: Sustainable draught power of various animal species in Africa for heavy work, i.e plowing; Sources: GTZ, 1981; Schwartz, 1986.

Species	Live weight	Sustainable draught power		Working speed	Daily working time
		relative	absolute		
	[kg]	[% live wt]	[kp]	[km/h]	[h]
Donkey	125	20	25	2.0	3 - 3.5
Horse	300	12	35	2.7	5 - 6
Oxen	350	14	50	2.4	4 - 6
Camel[1]	450	8	35	2.5	5 - 6
Camel[2]	450	12	54	2.5	5 - 6

[1] if absolute draught power is assumed to equal that of a horse; [2] if relative draught power is assumed to equal that of a horse

Although the days of the great trade caravans are probably gone for ever, camels remain a cheap and reliable alternative for short and medium distance commercial transport. Many kinds of goods like firewood, food and animal feed, but also building materials, household items etc are regularly transported on pack camels, wherever the volume or the value of the trade is to low to make motorised transport feasible and where roads are bad or nonexistent. The camel is also used for individual transport as a riding animal; within Eastern Africa this particular use is most common in Sudan. Camels still serve as mounts for military and police forces but their importance is declining. Camel racing, however, and other sports and leisure activities, such as trekking and camel safaris have recently become a tourist attraction in many parts and develop into a minor industry.

Leather, hair and wool, manure

There is no doubt that there are some home or small scale local industries in Eastern Africa based on these by-products. Manufacture of sandals and saddlery, of ropes, blankets, tent cloth and carpets are traditional with many pastoral groups. Presently they appear to cater for local markets only and prospects for expansion into export are dim at best. Yields are low and all available reports on quality of leather and fibres are discouraging. There is at present no feasible way to significant improvement.

Only a very small proportion of the regional camel herd in Eastern Africa is integrated with agriculture where feces and urine might be used as fertilizer. Whether dry feces are used as fuel to any great extent is unknown.

Productivity

Productivity of an animal can be defined as product output per animal unit per time unit; i.e. litres of milk per cow and year or hectares plowed per ox team per day. Productivity can also be defined as product output per unit input; i.e. kg wool per man-hour of herding or kg live weight gain per kg concentrate fed. And last not least productivity can be defined as value of product output per unit input in monetary terms.

Productive potential of an animal or a livestock species defines the biological limits, which may be of genetic, nutritional or physiological nature, within which productivity can be realised. Livestock management is the art to exploit the productive potential of an animal or a species to maximum productivity, which in turn is not to be confused with maximum performance.

In it's usual habitat, the hot and arid rangelands of Africa and Asia, the camel is a multi-purpose animal. It produces milk, meat, leather, hair and wool, and serves as riding, pack or draught animal. Productivity of a multi-purpose livestock is a composite value with many facets contributing. Exploitation of the productive potential for the various possible outputs will be a matter of producer preference which in turn is affected by natural, social and economic factors. If a racing camel can be sold for US$ 10,000, there is no need to milk it's dam. However, if camels milk is a subsistence staple, than it does not matter that a good milker is a slow runner.

Meat and Milk

It is important to differentiate continuous (milk, work, fibre etc) from terminal productivity (meat, hides, skins, pelts). The crucial factors determining terminal productivity of a domestic species are the generation interval, the number of off-spring per parturition and the growth rate of the individual. Domestic species with inherently high terminal productivity are rabbits, pigs and poultry, which are all early maturing, produce numerous off-spring and grow very fast. Rabbits for instance can produce 60 off-spring per year under intensive conditions and still about 12 on African small holder farms. Goats may produce as many as 4 off-spring per year under similar conditions in West Africa. Camels in comparison produce 1 calf in 18 month under the most intensive conditions.

Continuous productivity in contrast is determined mainly by the level of production and the length of the productive life span, and also by the product. Hair, wool, but also work performance is usually independent of sex and, within limits, of age. Milk production on the other hand is also a function of reproduction and is definitely sex and age specific.

Jahnke (1982) has calculated productivities of cattle, smallstock and camels (Table II,7) and found that under semi-arid to arid conditions camels were the most productive milkers, whereas small ruminants produced the highest quantities of meat in addition to considerable quantities of milk. If milk and meat were converted into grain equivalents smallstock were most productive with camels a close second, whereas cattle perform poorly.

Table II,7: Productivity of camels, cattle, sheep and goats in pastoral systems on semi-arid to arid rangelands in tropical Africa; Source: Jahnke, 1982.

Production	Unit	Cattle	Sheep/Goats	Camels
Milk	kg/head/yr	66.2	22.0	248.2
	kg/TLU/yr	94.5	220.0	248.2
Meat	kg/head/yr	9.6	3.5	7.4
	kg/TLU/yr	13.7	34.5	7.4
GE (Grain	kg/TLU/yr	215.5	512.0	451.3
Equivalents)	Mcal/TLU/yr	99.0	236.8	191.4

Transferred into an environment with a higher ecological potential and exposed to improved management all species respond with higher productivity, although not to the same extent. Table II,8 shows with an example from Kenya that cattle respond best to improved conditions, followed by sheep, goats and camels in that order. The main reason for this is that camels, that do respond with higher weight gains and better milk yields, cannot react with a greatly improved reproductive performance.

Table II,8: Proportional response in terms of increased productivity[1] by various domestic herbivores to an improved feed base and better management; Source: Schwartz, 1989.

Species	System I [g/kg/yr]	System II [g/kg/yr]	Response [% change]
Cattle (Zebu)	194	394	+ 103
Sheep	260	465	+ 79
Goats	380	520	+ 37
Camels	310	355	+ 14

System I: Semi-arid thornbush savannah, traditional migratory subsistence pastoralism, local breeds; System II: Sub-humid grassland, commercial ranching, health programme, rotation and deferment of pastures, mineral supplementation, up-graded stock based on local breeds

[1] productivity is defined as the total weight of weaners plus the liveweight equivalent of milk off-take produced annually in g/kg adult female live weight.

Productivity, both terminal and continuous, and productive potential are also a function of adaptive performance. The camel is perfectly suited to exploit the hot and arid areas of the world (see chapter I), an environment where other domestic herbivores with the possible exception of the goat often fail to survive, let alone to produce. High adaptive performance, as exhibited by the camel, is often correlated to a reduced productive potential. This can be observed in other species

like the reindeer or the yak, but is also evident in many landraces in domestic ruminants.

Reproduction

Camels are slow reproducers. Females usually produce the first calf at 4 to 5 years of age. Pregnancy is just over 12 months and the calving interval in pastoral production systems is usually 24 months or more. Mating is usually allowed after the calf has been weaned or earlier only if demand for milk is low, because as a rule females cease to lactate during early pregnancy. This results in a slow herd growth when compared to other domestic herbivores (Table II,9; Figure II,5).

Table II,9: Some parameters affecting herd structures in various species of domestic animals under arid and semi-arid conditions in Africa; Source: Wilson, 1984.

Parameter	Animal species			
	Goat	Sheep	Cattle	Dromedary
Age at first parturition [months]	15	15	48	60
No. of young per parturition	1.4	1.05	1.0	1.0
Interval between births [months]	9	10	20	24
No. of young per female per year	1.8	1.4	0.7	0.5
Death rate to 1 year [%]	35	35	30	50
Subsequent death rate [%]	10	10	7	5

Female camels can remain fertile to an age of 25 years and it is often stated that they produce 8 to 10 calves in a life time; in pastoral production systems only a small fraction of the breeding females will reach this and the average life-time performance will be around 6 to 7 calves. Figure II,6 illustrates this common situation with an example from Kenya.

Population growth estimates derived from various simulation models lie between 1.5 and 8% annual population increase provided there is no drought, disease outbreak or any other calamity. Reproduction can be improved under intensive conditions by reducing calving intervals down to 15 to 18 months. This requires either early weaning of the calves or early slaughter of the same which is occasionally practised with male calves to maximise milk off-take for human consumption. The first option requires milk replacers, daily fresh water supply and a quality of management for the calf which are not available in most situations where camels are kept. The second option foregoes part of the productive potential, the raising of males for slaughter or work and has to be regarded as an emergency measure only. Short calving intervals of approximately 15 months can also be observed in pastoral herds after late abortions, stillbirths or early post-natal mortality.

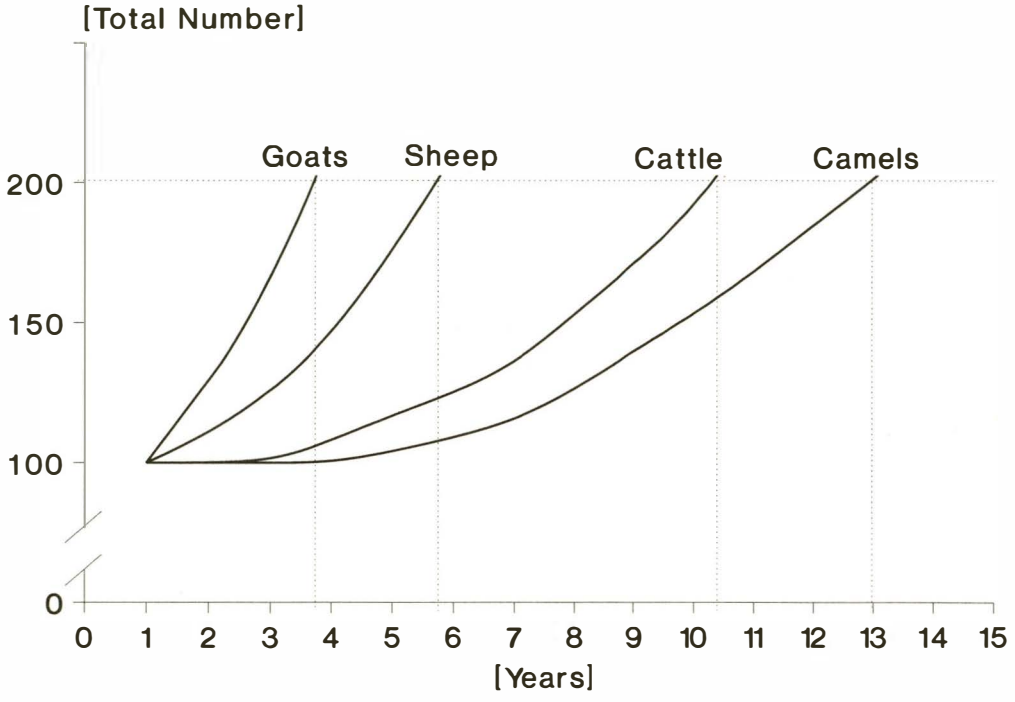


Figure II,5: Projected population growth in indigenous goats, sheep, zebu cattle and dromedaries based on the reproductive parameters shown in Table II,9 and assuming that no catastrophic events (droughts, epidemics etc.) will interrupt herd growth (modified after Wilson 1984).

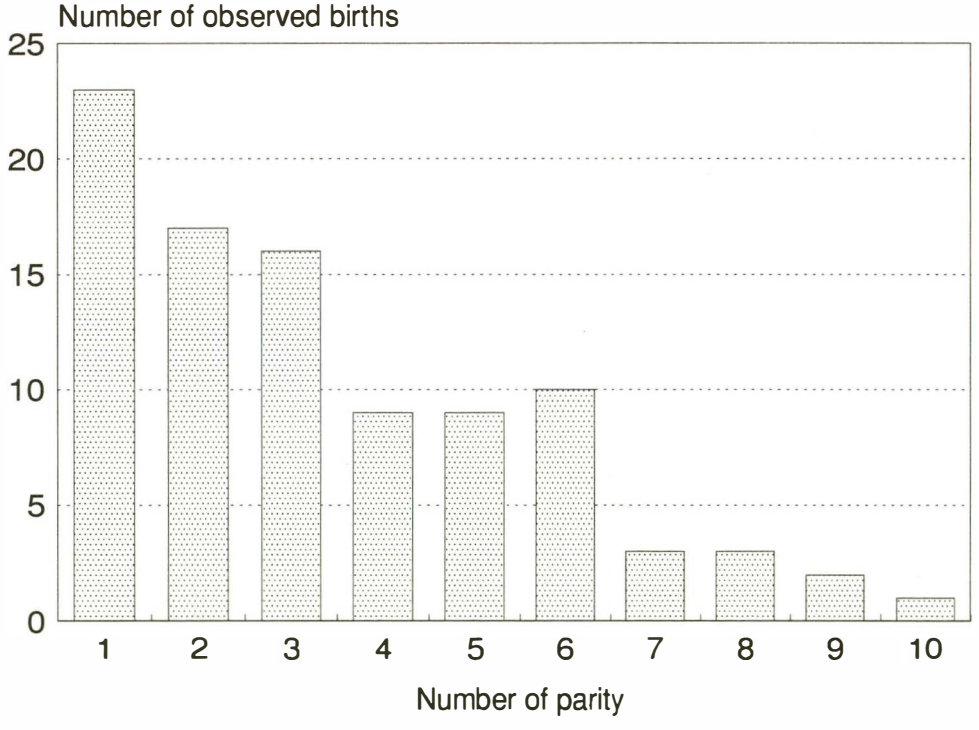


Figure II,6: Number of observed births by number of parity in a herd of camels kept in a traditional nomadic system in Northern Kenya; Source: Author's data.

There is only marginal scope to improve productivity in the camel by interventions affecting any parameter related to reproduction. The intrinsic reproductive rate in camels is low in comparison to all other domestic herbivores and significant improvements are conceivable only at high cost or will be counterproductive with regard to other productivity parameters.

Mortality

A second group of factors affecting herd growth and productivity are those resulting in mortality. As in all species there is an age specific mortality, which is high during post-natal and pre-weaning stages, falls to a minimum in the cohort of the 4 to 12 year old, increasing again with higher age and reaching 100% at approximately 25 to 28 years. This age specific mortality can be sharply emphasised or counteracted by nutrient supply, management practices and incidences of disease. In particular calf mortality is in most cases due to or related to malnutrition or starvation, even if actual mortality causes are diseases or parasitism. A whole range of interventions is conceivable which would have a good chance of significantly reducing early mortality. However, tolerating high calf mortality, especially in male calves, can be a conscious management decision which is economically sound if the production target is milk and the demand for males for slaughter, work and breeding is low (Schwartz, 1989; Schwartz & Walsh, 1990).

Productive Potential

As stated earlier, general field observations and a few available surveys indicate that slow reproduction, low life-time performance of female breeders and high calf mortality appear to be the major constraints to higher productivity in camel herds. However, statistics on population changes and levels of production in Eastern African camel herds are sketchy at best, and long-term performance records in larger herds are not available. This deficiency of information makes it difficult to evaluate the productive potential of camels and to predict in any reliable manner the effects of interventions or innovations aiming at improving productivity in camel herds.

It is a reasonable assumption that any interventions to increase reproductive rates may be futile if survival of calves cannot be improved simultaneously. Since it is common practice that camel herders in the region try to maximise milk off-take by delaying mating of lactating females and by denying the calf, particularly the male calf, adequate access to the dams udder it is questionable whether improved reproduction would lead to increased off-take, unless pastoralists change their production target from subsistence milk to market oriented meat production.

Meat and Milk

In an effort to estimate the productive potential of camels in pastoral herds Schwartz and Walsh (1990) studied three camel herds in Northern Kenya over periods from 18 to 40 months. Productivity indices developed by ILCA (King,

1983) were used to evaluate differences between the herds (Table II,10). These indices, as they were used here, measure productivity in terms of weaner weight produced annually plus the weaner weight equivalent of milk taken for human consumption (Table II,11).

Table II,10: Productivity index calculation; Source: King, 1983.

Parameter	Dimension	Code	Calculation
Birth rate	[%]	A	
Pre-weaning survival	[%]	B	
Young weaned	[%]	C	A x B : 100
Mean weaning weight	[kg]	D	
Total weaner weight	[kg%]	E	C x D
Lactation yield (milked out)	[kg]	F	
Liveweight equivalent of milk	[%]	G	F : 9
Female survival	[%]	H	
Females maintained	[%]	I	H +((100-H):2)
Female liveweight	[kg]	J	
Female metabolic weight	[$kg^{.75}$]	K	$J^{.75}$
Female maintained $^{-1}$			
Weight of weaner	[kg]	L	E : I
Liveweight equivalent of milk	[kg]	M	A x G : I
Productivity indices			
I (female maintained^{-1})	[kg]	N	L + M
II (kg liveweight of female^{-1})	[g/kg]		N x 1000 : J
III (kg metabolic wt of female^{-1})	[g/$kg^{.75}$]		N x 1000 : K

Herd 1 comprised of approx. 420 camels kept on a company ranch situated in the semi-arid coastal lowland of Kenya. All animals belonged to the Somali type with mature body weights for 500 to 600 kg in females and over 700 kg in males and reputed milk yield of 2500 kg or more during 12 months of lactation. The major commercial activity on the ranch is the raising of beef cattle and of sheep and goats for slaughter. The main use of the camel herd is to supply milk for the labour force on the ranch and, to a limited extent, for internal short-distance transport. The sale of males for slaughter is planned, once the herd has been built up to adequate size. Due to careful management, regular veterinary inputs and low off-take for human consumption birth rate, pre-weaning survival and weaning weights are high and almost 80 % of the total productivity is accounted for by the live weight of weaners produced.

Herd 2 numbered approx. 350 animals kept on an individually owned ranch in the sub-humid marginal highlands in Central Kenya. The animals were of mixed origin, mainly from Marsabit and Turkana Districts. The mature body weights were about 20 % lower than those of Somali camels and milk yields rarely exceeded 1500 kg in a lactation of 15 months. The major commercial activity was also beef, mutton and goat meat production as well as some limited wool

production from the sheep.The uses of and the management inputs for this camel herd were identical to herd 1. Birth rates and pre-weaning mortality were similar to those in herd 1. Milk off-take was higher than herd 1 relative to the total milk yields and weaning weights were lower due to the smaller mature size of the animals. Estimated milk off-take accounted for 35 % of the total productivity, almost twice as much as in herd 1.

Herd 3 included 188 animals and was owned and kept by an extended familiy of traditional pastoralists in the arid lowlands of Northern Kenya. The genetic background was similar to that of herd 2. The major use of this herd was milk production for subsistence, water transport and transport during seasonal migrations. The productivity indices calculated for this herd are shown separately for breeding females with male (3a) and female (3b) offspring. Due to the poorer environment and the total lack of veterinary inputs birth rates and pre-weaning survival are much lower than in the two other herds, which results in lower total productivity. There is, however, a striking difference in the productivity data of dams with male and female calves.

Table II,11: Productivity indices for camels (Camelus dromedarius) in three different herds in Kenya; Source: Schwartz and Walsh, 1990.

PARAMETER	Herd 1	Herd 2	Herd 3a	Herd 3b
Birth rate [%]	57	54	44	41
Pre-weaning survival [%]	93	100	27	63
Young weaned [%]	53	54	11	25
Mean weaning weight [kg]	203	188	108	132
Total weaner weight [kg%]	10953	10182	1293	3425
Lactation yield [kg]*	500	500	1050	300
Livewt equiv. milk [%]	55	55	116	33
Female survival [%]	97	97	94	94
Females maintained [%]	98	98	96	96
Female liveweight [kg]	565	427	343	351
Female metabolic weight [$kg^{.75}$]	115	93	79	81
Female maintained^{-1}				
Weight of weaner [kg]	111	103	13	35
Livewt equiv. milk [kg]	32	30	53	14
Productivity index				
I [kg]	143	133	66	49
II [g/kg]	254	313	195	142
III [$g/kg^{.75}$]	1238	1424	840	614

* estimated after interviewing the herders

Since production in the traditional subsistence system is mainly geared to milk production, male calves, which will be of little future value in this respect, face a much stiffer competition with the herders for their dams milk than female calves. They are often allowed to suckle only one teat, or are given access to the dams

udder after all teats have been milked, whereas female calves usually have regular access to two teats. Consequently the pre-weaning survival rate of male calves is less than half of that of females and weaning weights are lower. Total productivity on the other hand is higher in dams with male calves due to the high milk off-take for human consumption, with milk accounting for approx. 80 %. In females with female calves milk off-take for consumption contributes only 30 % to the total. In these animals the input function to the system (herd growth) is conciously given priority over the output function (milk).

The comparison of the productivity indices indicates high calibre management for all three herds. Differences between the two ranch herds are most likely caused by differences in the genetic potential of the animals. Milk off-take in the two herds is limited to ensure maximum herd growth for both sexes since the long-term production target includes sales of male stock for slaughter.

The much lower productivity in the pastoral herd as compared to herd 2 is a result of the much lower productive potential of the available pastures and the lack of veterinary inputs. The major production target here is securing maximum milk off-take for subsistence, which results in a deliberate sacrifice of male calves and consequently in a reduced herd growth.

Herd growth

Since no long-term herd records exist for camel herds etsimates of potential herd growth must remain speculative or the result of mathematical projections. Figure II,7 compares the theoretical stable age structure of the females in a camel herd and the resulting relative reproductive value of each age group, calculated from the reproductive parameters given for herd 3 (Lengima) in Table II,3, to the recorded age structure of the females in the same herd and the observed number of births by age group during 18 months of observation. It is obvious that actual age structure and actual fecundity deviate significantly from the theoretical distribution as a result of stochastic effects induced by management and environmental factors. Moallin (1990) reported that in seven years annual fecundity rates in fifteen camel herds in Central Somalia ranged from 0 to 78% with a mean of 27%. This large annual variation was also attributed to environmental variation.

Schwartz and Walsh (1990) used field data collected in four camel herds in Northern Kenya to carry out a simulation exercise analysing the effects of improved fertility and calf survival on herd growth and herd stability. Recorded fertility parameters and preset levels of stochastiscity typical to African dry-land conditions, but excluding catastrophic events, allowed the calculation of upper and lower threshhold values for herd sizes after 25 years starting from an initial herd of 100 3-year old breeding females (Figure II,8).

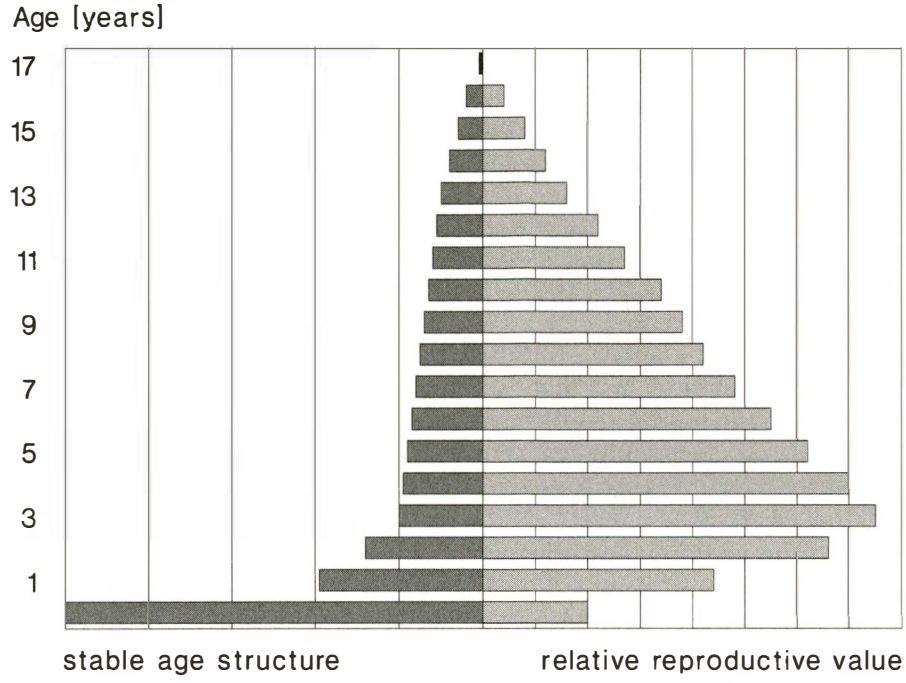


Figure II,7a: Theoretical stable age structure of the females in a camel herd and the resulting relative reproductive value of each age group, calculated from the reproductive parameters given for herd 3 (Lengima) in Table II,3

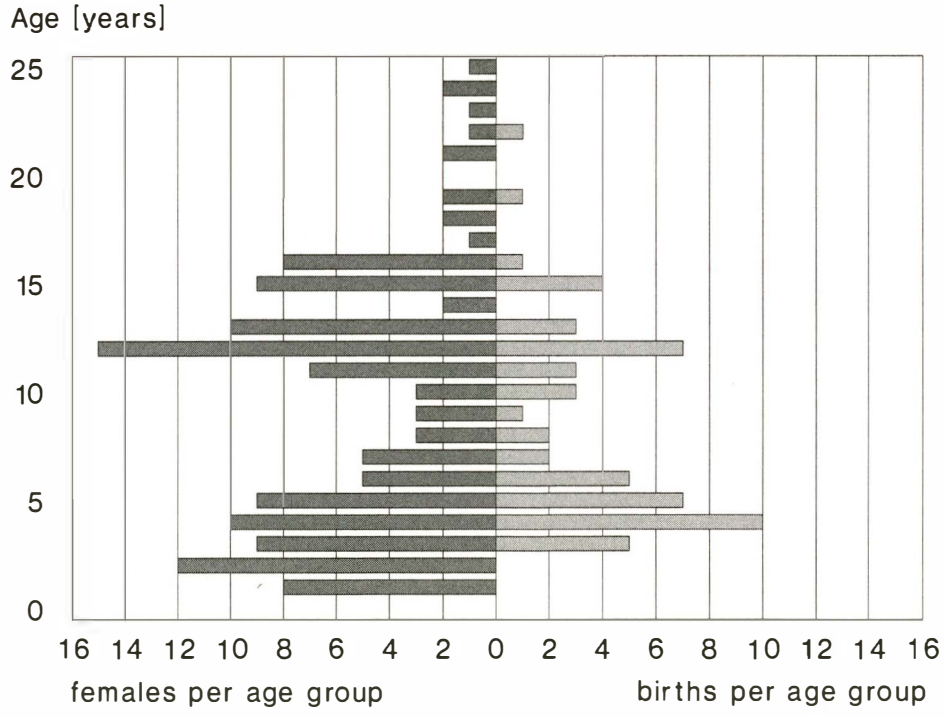


Figure II,7b: Recorded age structure of the females in the same herd and the observed number of births by age group during 18 months of observation

Herd 1 was a herd of 56 mature breeding females with offspring kept in a field research station of the Department of Animal Production, University of Nairobi, in Isiolo District in Kenya. This herd was newly established by purchase of carefully selected breeding stock, given a comprehensive health programme for dams and off-spring and was managed with minimal milk off-take for human consumption. Initial annual birth rate was 82% and pre-weaning mortality was just under 15%. Herds 2, 3a and 3b were those described under the same codes in Table II,11. Simulations of herd growth were carried out (RAMAS/age; Applied Biomath. Inc. 1990) over 25 years with 50 replications for each herd, showing that the pastoral herds realised minimal herd growth, that the research station more than doubled its size, and that the ranch herd took an intermediate position. Projected threshold values at the 95% probability level showed identical trends as the 66% probality estimate, but revealed the higher chances that the pastoral herds might end up with sizes below the initial ones.

The calculated threshold values however, did not allow to differentiate the effects of improved fertility and reduced mortality. In a second step four more camel systems were simulated over 25 years, based on a permutation of 2 levels of fecundity and mortality, representing the extremes of the first simulation, and the identical levels of stochastiscity (Table II,12).

Table II,12: Structure and parameter levels for the various combinations of age dependent fecundity and survival included in the simulation model; Source: Schwartz and Walsh, 1990.

Population parameters		Stochastiscity (coefficients of variation for population parameters)		
age dependent fecundity (f)	age dependent survival (s)	survival of the zero-year old cohort (CV_s)	fecundity (CV_f)	correlation between CV_s and CV_f
high	high	0.2	0.2	0.3
high	low	0.5	0.3	0.6
low	high		0.5	
low	low		0.7	

Figure II,9 shows the median value, the upper and lower quartiles and the total range of the lower thresholds of herd size after 25 years estimated at the 66% probability level on the basis of the pre-set parameters. There are no differences of the median values within survival level irrespective of whether fecundity is high or low. Only the total range of values is greater and maximum values are somewhat higher at high fecundity levels. This indicates clearly that reproductive rates have little effect on projected herd size and that survival is of much greater importance for potential herd growth.

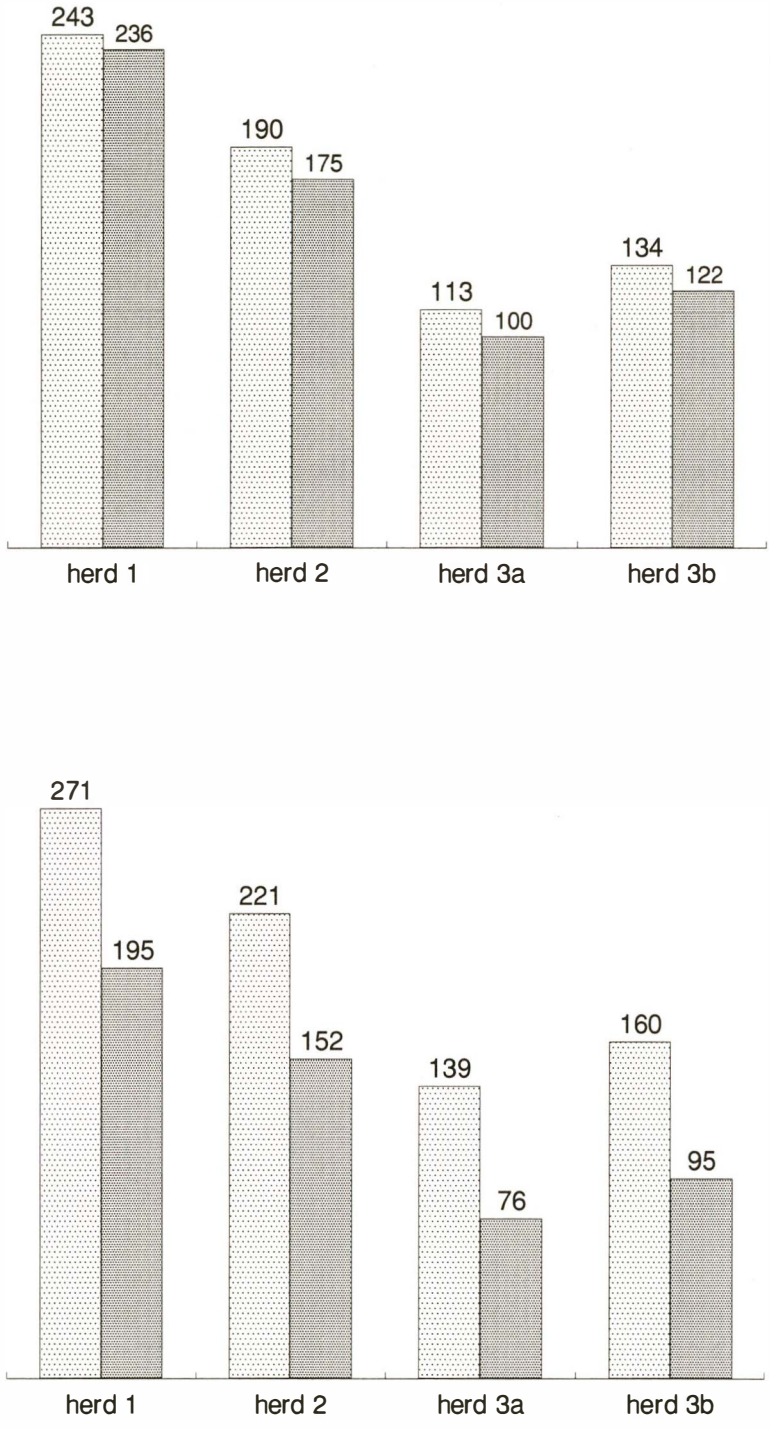


Figure II,8: Upper and lower thresholds of herd size after 25 years, based on an initial herd size of 100 3-year old breeding females, at the 66% (upper graph) and 95% (lower graph) probability level calculated for four camel herds kept in different production systems in Northern Kenya; Source: Schwartz and Walsh, 1990. (herd numbers 2 and 3 refer to herd numbers in Table II,11; herd 1 is a research station herd where an annual birth rate of 80% and a pre-weaning survival rate of 85% was recorded).

Figure II,10 represents a very similar picture with reference to the 66% probability that herd sizes fall below the initial herd size at least once during the 25 years of simulation. This demonstrates that the risk of a population crash is determined to a much larger extent by survival than by fecundity within the given parameters and at levels of stochastiscity typical for African dry-lands and pastoral production systems. This is confirmed by the results of the factorial analysis of variance (Table II,13) which establishes that the single factor most affecting herd growth and herd stability is age dependant survival, followed by the variability for age structured fecundity, age dependant fecundity, variability for survival of the zero-age cohort, the interaction between the two variabilities and their level of correlation in that sequence of importance. Thus control of age dependant survival, particularly in young animals, becomes the most important management intervention conceivable in the pastoral production mode. It is therefore highly doubtful whether increased reproductive efficiency, especially if achieved by intensive inputs such as feed and mineral supplementation, artificial insemination or by reduced milk off-take, will contribute to increased total productivity under conditions prevailing in Eastern Africa.

Table II,13: Analysis of variance of a simulation concerning the 66% probability that 1 camel herd out of 100 will drop below a given threshold; Source: Schwartz and Walsh, 1990.

Source	Sums of squares	df	Mean squares	F-ratio	p
i	82.7	1	82.7	5.1	0.030
ii	5,313.0	1	5,313.0	325.1	0.000
iii	60.5	1	60.5	3.7	0.062
iv	453.4	3	151.1	9.2	0.000
v	2.5	1	2.5	0.2	0.697
i*ii	54.2	1	54.2	3.3	0.076
Error	637.5	39	16.3		

i=age dependent fecundity, **ii**=age dependent survival, **iii**=variability of survival of the zero year-old cohort, **iv**=variability for age structured fecundity, **v**=correlation level between iii and iv.

Approximately two thirds of the world's dromedary population are kept in traditional pastoral production systems in Eastern Africa. These systems strongly emphasize milk production for subsistence and deliberately forego the utilisation of the existing potential for meat production by neglecting sex specific calf survival and/or calf survival in general. The rationale behind this was brought out by the results presented above. Dromedaries are the most efficient milk producers under the prevalent conditions. Risk reduction for herd growth and herd stability can be achieved by improving survival rates of replacement females through veterinary inputs and improved pre-weaning nutrition. If increased meat production should be the declared development target goats and to a lesser extent sheep should become the focus of interventions. This does not imply that

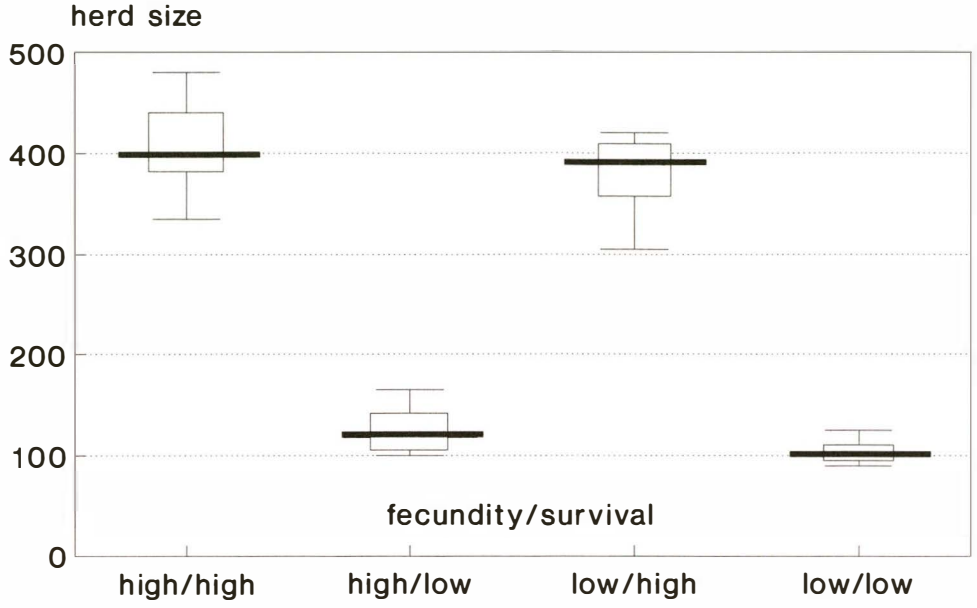


Figure II,9: Box plot (median, upper and lower quartile and total range) of the 66% probability that an initial dromedary population consisting of 100, 3-year old females will be below an indicated threshold level after 25-years given varying fecundity and survival herd profiles; Source: Schwartz and Walsh, 1990.

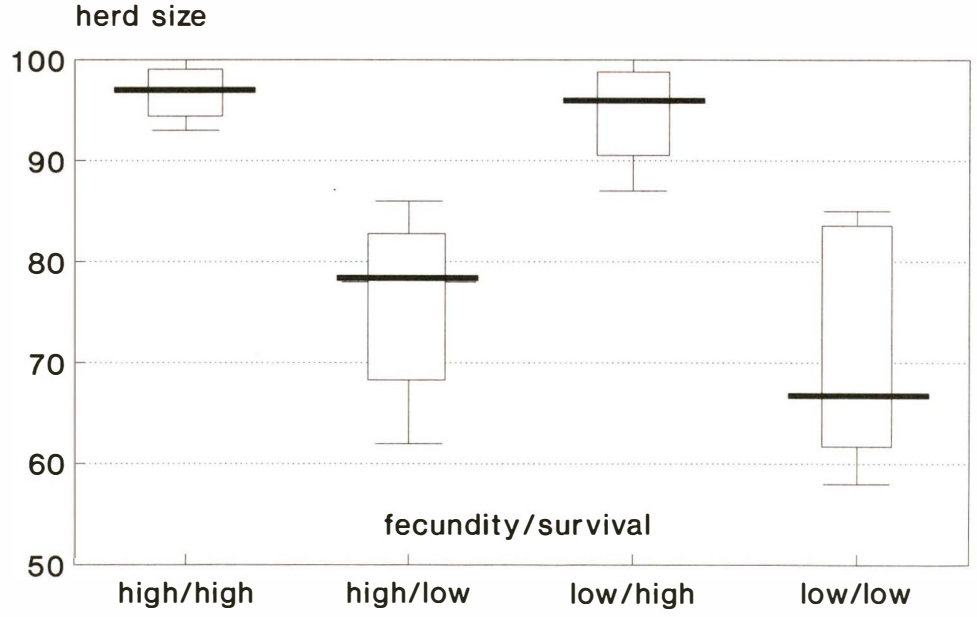


Figure II,10: Box plot (median, upper and lower quartile and total range) of the 66% probability that an initial dromedary population consisting of 100, 3-year old females will be below an indicated threshold level at least once during a 25-year simulation given varying fecundity and survival herd profiles; Source: Schwartz and Walsh, 1990.

improving reproductive efficiency in the dromedary might not be a meaningful intervention under different conditions. High price markets for dromedary meat and low trade-off rates of dromedary milk against meat, as typical for Northern Africa and the Near East, constitute a production environment conducive to improving reproduction in dromedaries.

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Chapter III

Management and Handling of the Camel

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Reproduction

Rutting behaviour of the male

In bachelor herds all bulls appear to go through a quiescent rutting period, which develops into full rut when one male joins a female herd. During the rutting period the incidence of fights among males in mixed herds is very high. After having established dominance only the dominant bull, which is usually the oldest and heaviest, will display a fully developed rutting behaviour throughout the breeding period. Other males only show a subdued version. During rut the dominant bull looses condition quite dramatically due to loss of appetite and consequent reduction in feed intake combined with high motoric activity. Its abdomen is markedly tucked up and the hump gradually decreases in size. In the view of other bulls and humans the bull adopts a typical stance with hindlegs apart to signal it's dominance. Characteristic behaviour patterns are displayed, such as frequent urine spraying combined with tail flapping and resulting in the typical urine mark on the back of rutting bulls, frequent expulsion of the dulaa, repeated loud vocalisation, aggressive behaviour towards other males and human beings, object marking with poll gland secretions and poll gland hump rubbing. The poll gland secret has a strong smell, which may be related to high androgen levels in it. It is of black reddish colour and thick consistency.

Courtship and mating behaviour

During oestrous the camel will seek the bull, may even sit in front of him, showing a certain amount of restlessness, flicking her tail rapidly and urinate frequently. The vulva is relaxed and slightly edematous. A slight discharge from the vulva may be present. The camel bull tends to herd its females and constantly investigates their perineal regions. After having picked up their smell he displays "flehmen" a typical behavioural pattern seen in large ungulates. Receptive females are pursued by him and forced down. Once in sternal recumbency the bull will mount the female from the rear and coitus takes place. During copulation the bull gurgles, frothes and may even extrude the dulaa. Copulation time may vary between minutes and up to half an hour. The same female may be served several times during a day by the male. If the female has conceived she will refuse to lie down and curl her tail up when approached by the male. The earliest time tail curling can be observed is 20 days after copulation, however at this time it does not appear to be a reliable indicator of early pregnancy. If it still persists 2 months later it is reliable. Mid-term pregnant females always show tail curling when approached by bulls; it can also be provoked by men, especially by strangers.

Reproductive biology of the male

Rut is a period of strong sexual activity during a limited amount of time presumably directly controlled by the level of testosterone. There is a significant seasonal variation of gonadotropin serum levels especially FSH in the male camel. However spermatogenesis is continuous throughout the year and rut can be induced with gonadotropin treatment and presumably with good nutrition. During rut the testicles are quite increased in size. A bull in his prime, 7-13 years old, can serve up to 50 females during one breeding season.

Reproductive biology of the female

Puberty in female camels is influenced by several factors such as body weight, breed and animal health status. Female camels become sexually mature around the age of 4 years, therefore first giving birth around five years of age. Dromedaries are supposedly seasonally polyoestrous. In mature female camels the ovarian activity cycles in association with the breeding season. Dromedaries kept near the equator appear to be aseasonally polyoestrous, the main trigger for the onset of the breeding season seems to be not the day length, but the nutritional status of the animals. In this respect it is an interesting fact that among some camel tribes in Eastern Africa it is common practice to forcefully mate female camels whenever a rutting bull is available. With this husbandry technique over 50 % of the camels are reported to get pregnant. The oestrous cycle in camels consists merely of follicular waves, i.e. a continuous development and regression of follicles during the breeding season. Ovulation can be induced by mating, artificial insemination and spontaneously during the height of the breeding season. Ovulation takes place 36-48 hours after the stimulus. Multiple ovulations are possible, but the incidence of twin birth is very low. There is evidence for high early embryonic loss rate. Implantation of the blastocyst takes usually place in the left uterine horn. The exact time for attachment is unknown. The early embryonic development of the camel foetus is comparable with a bovine foetus.

Gestation and Parturition

The gestation period is about 13 months long (370-390 days). Approximately six months after conception the size of the abdomen increases. Obvious indication of approaching parturition 10-20 days before are relaxation of the pelvic ligaments, increased size of the udder and swelling of the vulva. Just prior to parturition the female camel exhibits marked restlessness and tends to segregate from the herd. During the first stage of parturition straining or labour is not apparent in the camel. The second stage with rupture of the water bag and consequent expulsion of the fetus through the vulva is quite rapid and comparable to the situation in the mare lasting only 20-30 minutes. The camel usually lies down during that period. Normal presentation of the fetus is the anterior longitudinal presentation. The umbilical cord ruptures when the mother starts to rise. The expelled fetus is covered by a unique epidermal membrane being characteristic of camelids. The membrane is quite friable and of whitish colour. It is attached to the fetus at the mucocutaneous junctions. Its function is unknown, but it presumably facilitates

delivery. Immediately after birth the dam starts to sniff at the newborn, but does not lick it. Expulsion of the placenta usually occurs during the next hour. The incidence of placenta retention is quite rare in camels, however a higher incidence has been noted in the case of premature birth. Camels are not known to eat the expelled foetal membranes. Involution of the uterus is completed during the first month post partum. Small amounts of lochia are discharged during the first 10 days. The first post partum heat is sometimes delayed until the onset of the new breeding season. The calving interval period is between 24 and 36 months (average 18-24 months) is depending on the breeding management.

Dystocia and injuries related to delivery

The incidence of malpresentation is quite low. Most commonly lateral deviation of the head and carpal flexion has been observed. A high incidence of post partum injuries such as vaginal tears, complete rupture of the perineum and vulva and posterior ataxia are seen in heifers bred to early by a large sized bull. Faulty laymen assistance may also cause lacerations by applying to much traction when removing the fetus. Vaginal prolapse is a quite commonly seen condition related to vigorous laymen assistance during delivery. Untreated and neglected post partum injuries may result in permanent infertility.

Neonatology

The body weight of a camel neonate ranges between 25-45 kg. Signs of premature births are obvious weakness, lower body weight, general lack of pigmentation and short hair with a silky feel. Within an hour a healthy neonate camel starts to get up and explores the mother to find the udder. Calf rejection is not uncommon, particularly in young and inexperienced dams. Several traditional methods to "persuade" the mother to accept the calf exist. Due to the widespread believe among camel herders that colostrum is dangerous for the newborn the neonate quite often does not receive the adequate amount. High neonatal mortality rate might result from this management practice. Immediate care of the neonate should include routine dipping with iodine of the umbilical cord shortly after birth and provision that adequate colostrum intake Immediately or not later than 24 hours after birth occurs. Neonates, who appear weak and show a poor sucking response should be bottle fed or intubated if feasible until they gain strength. Meconium is passed over a couple of days and retention is rare. The most common neonatal diseases are joint ill and neonatal diarrhoea. The incidence of congenital diseases such as angular limb deformity is generally low.

Seasonality of breeding and births

Seasonality of breeding and births is, in most domestic species and breeds in the higher latitudes, interpreted as an effect of increasing day lengths during spring time. In Eastern Africa, near the equator, this effect is minimal and female camels, like all other domestic animals in do not show a distinct seasonal

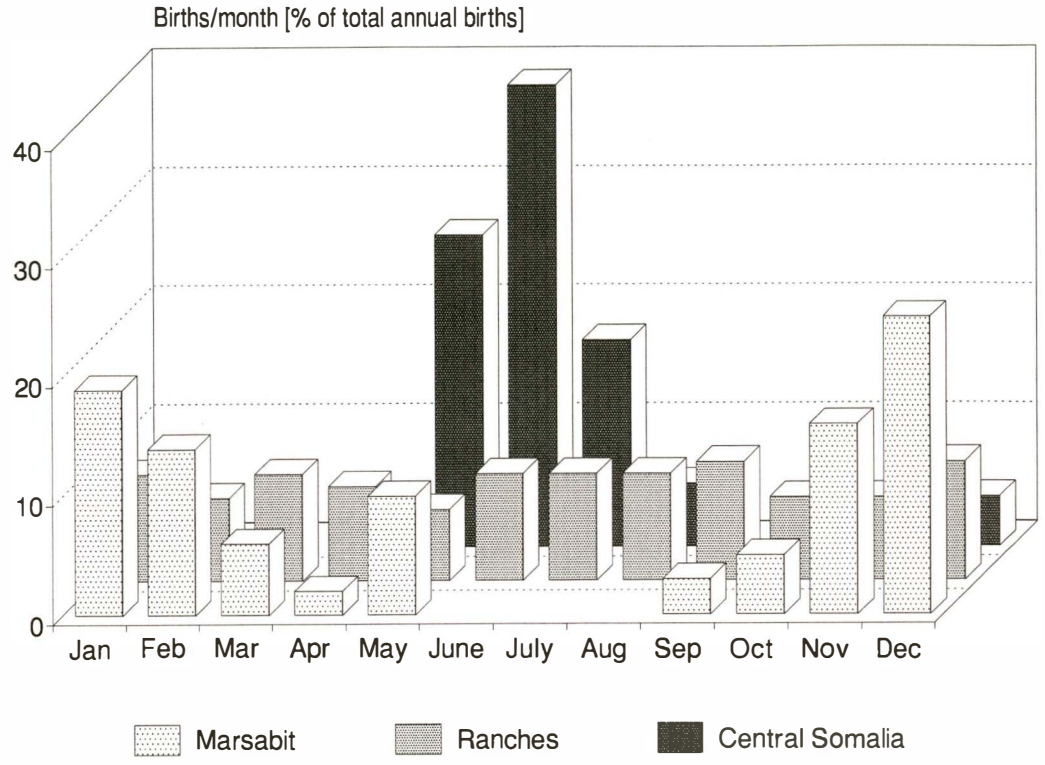

Figure III,1: Seasonal distribution of births in camel herds kept by nomadic pastoralists in Central Somalia and in Marsabit District, Kenya and on commercial ranches in Kenya; Sources: Moallin, 1989, Schwartz, 1992.

anoestrus. There is however a very marked seasonal incidence of matings, and hence births to be noted at almost all locations within the region. It appears that the main factor affecting this seasonality is nutritional. With the new pasture at the beginning of the rains particularly the bulls show increasing sexual activity which ultimately results in seasonal calving. Strong seasonality of births was reported in nomadic herds in Northern Kenya (Marsabit District) and in Central Somalia (Figure III,1). In both cases the calving season coincides with the main growing season of the vegetation, which is from November to May in Marsabit District in Kenya and from May to July in Central Somalia. There is no evidence that this marked seasonality of matings has any adaptive mechanism increasing the survival chances of newborn calves which are mainly born at the beginning of the dry season, when milk yields start to decline. In several camels herds kept on commercial ranches in Kenya no seasonal peaks in birth rates were noted. This aseasonal distribution (Figure III,1) might be an effect of the even provision of fodder through pasture rotation and strategic supplementation during the dry season.

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Conformation

Normal conformation

In general there is a quite distinctive sexual dimorphism in camels. The male camel is usually taller and of heavier built than the female. Furthermore the whiskers tend to be longer, the tushes more pronounced and in general there is a better overall muscle development. In geldings castrated before 3 years of age the sexual dimorphism is less distinctive. They attend full height but are of slighter built, the voice is more high pitched, the preputial sheath is reduced in size and the dulaa (soft palate) cannot be inflated. The effects of castration are enhanced the earlier the castration is performed. There is considerable variation in type within dromedary camels. Classification can be based upon geographical habitat or production type such as draught animal, milk animal, meat and racing camel. Established breed standards for camels based on these breed types are yet lacking (see Chapter I), however certain confirmation characteristics are common to all dromedary types. Important confirmation characteristics of the dromedary are its well developed prominent forequarter, which is higher than the weak appearing hindquarters. Joint angulation is wider in the forequarters compared to the hindquarters, therefore frontlegs appear straighter and more in line. The elbows are clear of the body. A prominently arched back followed by a 15-20 degree from the horizontal inclined short loin. The rump is also quite short with an excessive downward inclination of 45-50 degrees from the horizontal resulting in a so called goose rump. Setting of the longer and wider feet in the front is square and even. In the back the feet are slightly camped under and turned outward.

Commonly observed conformation faults

The most commonly observed conformation faults in the camel are angular deformities of the skeleton, especially of the limbs. They are most frequently seen in very young calves. Hyperflexion of the fetlock (Plate III,27), undershot knees (Plate III,28) and lateral deviations of the carpal joints (Plate III,29) in newborn calves are often of temporary nature and disappear without treatment.

Figure III,2 shows a schematic presentations of correct and faulty positions of the pectoral limb in lateral view. The normal position the straight or "post" leg. Angular deformities of the fetlock might cause some mild discomfort and predispose to lameness. Camped frontlimbs, either forward or behind, might be symptoms of acute painful conditions of the abdomen or chest, or might indicate wounds of the foot, particularly solar wounds. Figure III,3 shows a similar presentation of the pelvic limb. The straight leg and the leg camped behind are both normal in the camel, if the hind leg is camped forward it is often an indicator for an acute, painful inflammation in the abdomen.

Pigeon toes, splayed fetlock and brushing knees (Plates III,21, III,22 and III,23; Figures III,4 and III,5) are conformational faults of limbs commonly seen in large sized and heavy camels living in hilly areas. Malformation can predispose to other

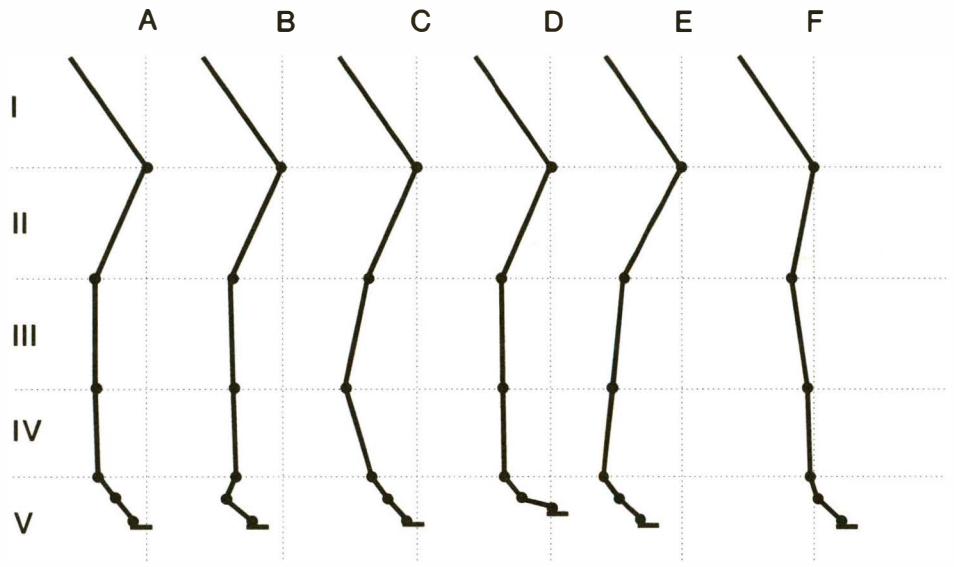

Figure III,2: Schematic presentation of normal and faulty position of the pectoral limb of camels in lateral view: A = normal (straight or post leg); B = contracted flexor tendons of fetlock; C = calf knee; D = hyperextension of fetlock; E = camped behind; F = camped forward; I = scapula; II = humerus; III = radius/ulna; IV = metacarpal bone; V = digital bones

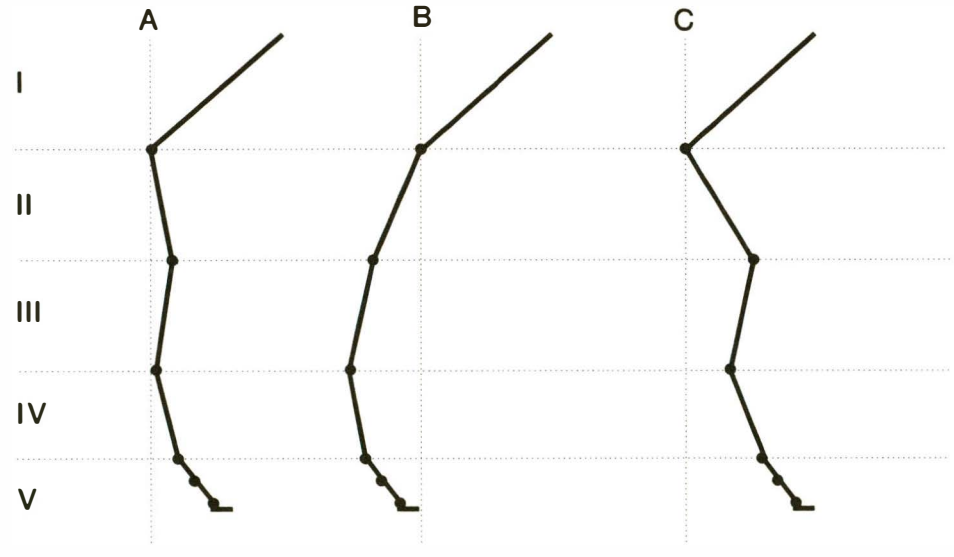

Figure III,3: Schematic presentation of normal and faulty position of the pelvic limb of camels in lateral view: A = normal (straight); B = camped behind; C = camped forward; I = pelvis; II = femur; III = tibia; IV = metatarsal bone; V = digital bones

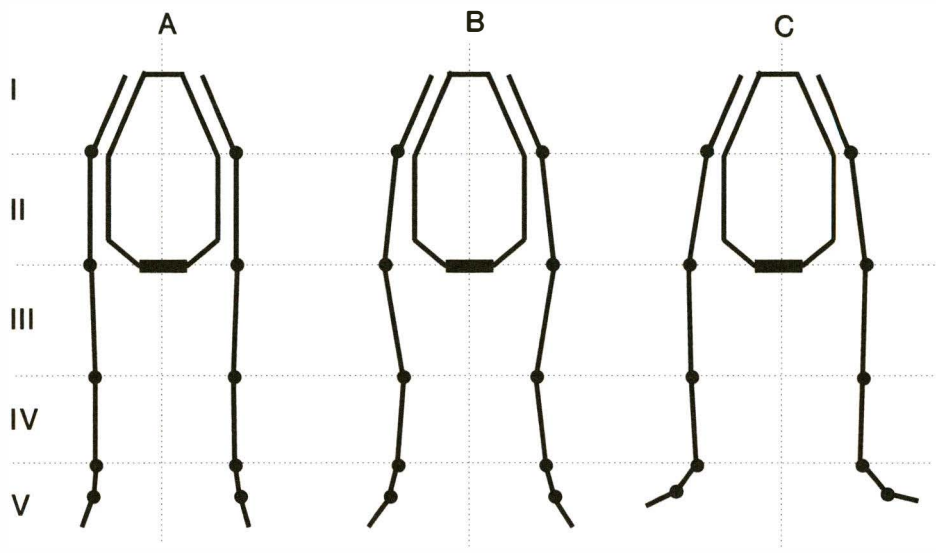

Figure III,4: Schematic presentation of normal and faulty position of the pectoral limbs of camels in frontal view: A = normal; B = carpal valgus (predisposition to C) C = angular deformity of the fetlock (splayed); I = scapula; II = humerus; III = radius/ulna; IV = metacarpal bone; V = digital bones

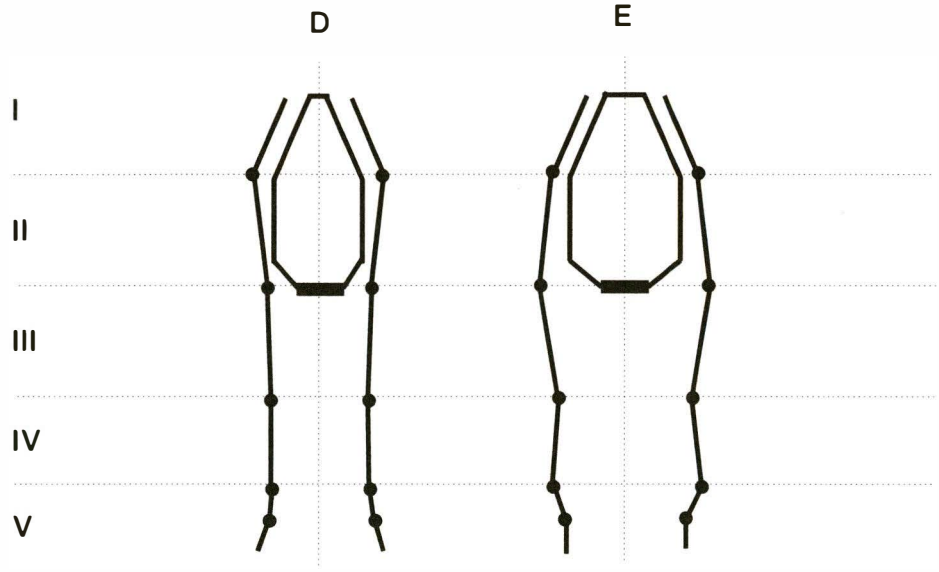

Figure III,5: Schematic presentation of normal and faulty position of the pectoral limbs of camels in frontal view: D = narrow chest (predisposition to brushing elbow and brushing pedestal; E = angular deformity of the fetlock (pigeon toes) I = scapula; II = humerus; III = radius/ulna; IV = metacarpal bone; V = digital bones

joint problems and lameness. Affected camels rarely show a good working performance. Camel pastoralists often try to treat these conditions by branding the affected joints. Occasional success is achieved in young animals which are still growing; however, they might have mended without treatment as well. In mature animals the condition cannot be corrected.

Plates III,24, III,25 and III,26 show conditions commonly seen in animals with narrow chests. The formation of a narrow chest (Figure III,5) in camels can be related to nutritional deficiencies during the early post-natal growth stages. This condition can predispose to other problems like brushing elbows or a brushing pedestal. Constant friction can lead to painful skin lesions and excessive scar tissue growth of the irritated area. Working ability can be severely impaired.

Rare congenital defects

Some examples of rare congenital defects like Ectopia cordis, parrot mouth, short digit one and idiopathic alopecia are shown in Plates III,30 to III,33. The are of little economic importance, being rare by definition. Camel pastoralists would not use such animals for breeding if they survive to maturity.

Udder conformation

Conformation of the udder is of great importance in camels, just like in all dairy animals. The camels udder resembles closely to that of cattle. A desirable udder conformation in camels would include all characteristics which are desirable in cattle when milking is done by hand. Plate III,39 shows an udder of excellent conformation. The quarters are well and evenly developed, the teats are large, well developed, distinct and evenly spaced. Plates III,34 to III,38 show udder with commonly observed faults. Due to the limited reproductive performance of camels there is little chance to improve udder conformation by selective breeding, since all fertile females have to be bred in order to maintain adequate herd growth.

References and further reading

Conformation

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Age determination

Although most camel herders will know the age of every single animal in their herds proper determination of an animals age can be important when it is traded, when it has to be treated or when a decision on breeding has to be made. Lacking records examination of the teeth is still the most reliable method. Estimation of age is based on information regarding to eruption time, signs of wear, shape of the teeth and angle of teeth (Plates III,41 to III,64). To examine the teeth the camels head is restrained by grasping the lower and upper lip. The head is then slightly pulled downward. During examination camels usually vocalize a lot. Due to the small and narrow space of the camels oral cavity the premolar and molar teeth are difficult to see. Age determination therefore is mainly based on the appearance, shape and angle of the frontal teeth including incisors and canines.

Table III,1a: Dental formula of the deciduous teeth of camels (modified from Rabagliati 1924)

type	eruption	comment
Upper jaw		
Incisor 1		absent
Incisor 2	never	rudimentary, completely covered by gums
Incisor 3	2-4 months	very small (pea-size); not always present;
Canine	2-4 months	small blunt, slightly pointed forward; 1.5 cm long;
Premolar 1	ca. 1 month	sharp cutting edges; distinct neck;
Premolar 2	ca. 1 month	triangular occlusal surface; folded surface; distinct neck
Premolar 3	ca 1 month	square shaped; folded occlusal surface; neck less distinct;
Lower jaw		
Incisor 1	ca 14 days	small, conical with a well developed neck; form an angle of 45 degrees with the mandible.
Incisor 2	ca 14 days	
Incisor 3	1-3 month	
Canine	2-4 month	shaped like incisors;
Premolar 1	1 month	rectangular; distinct neck
Premolar 2	1 month	rectangular; no distinct neck;

Deciduous = temporary; Incisor 1 = centre; Incisor 2 = lateral; Incisor 3 = corner.

Plate III,1: Extrusion of the dulaa (soft palate) by a mature bull is a typical behavior of rutting bulls. Only mature bulls older then 9 years have a full sized dulaa. Gargling sounds, profuse salivation and grinding of the teeth accompany inflation of dulaa.

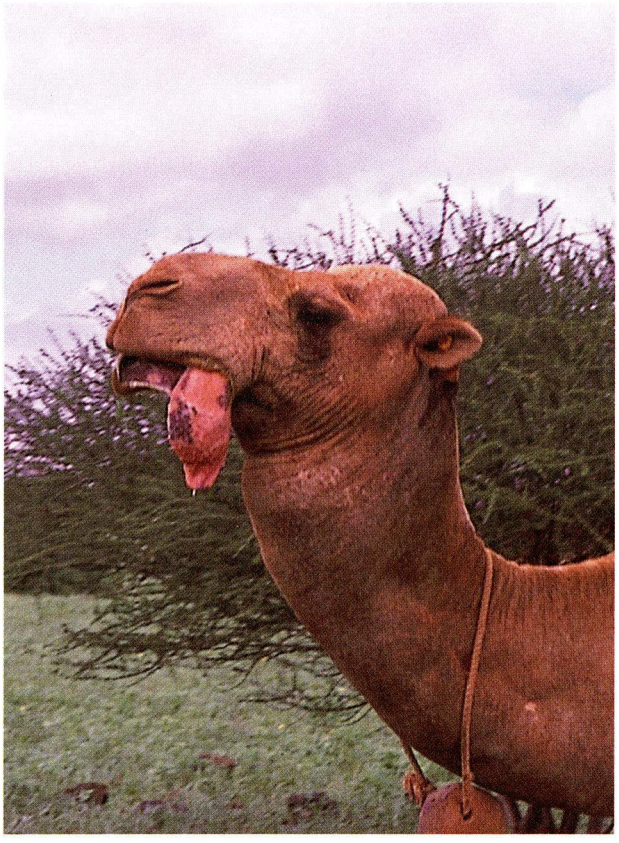


Plate III,2: Secreting occipital glands in a mature bull. Occipital gland secretion is of blackish colour, thick consistency and a strong unpleasant odor. Gland secretion is only observed during the rutting season. First secretion in young bulls is observed when they approach the age of four to five years.

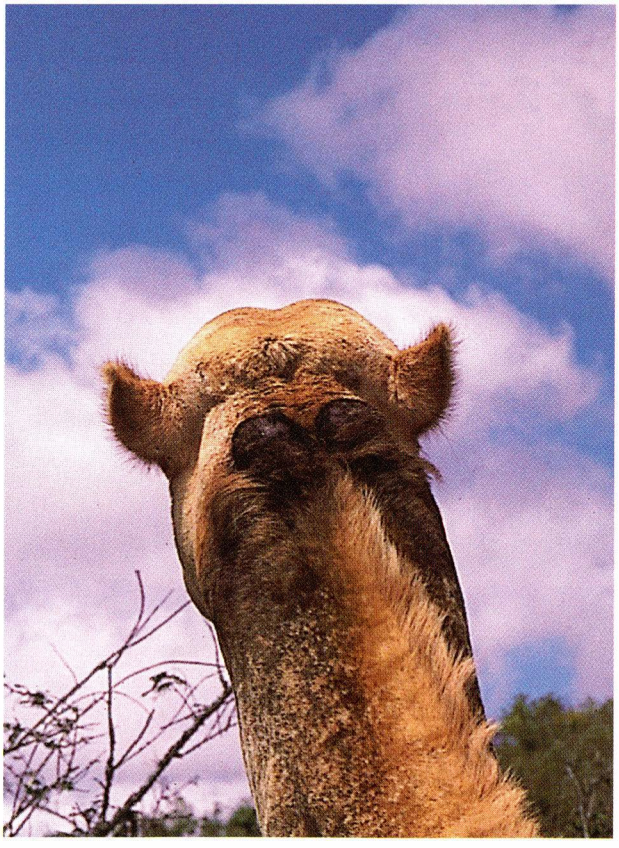


Plate III,3: Typical scent marking behavior of rutting bull. The poll gland secretion is rubbed onto shrubs. This behavior is repeatedly displayed throughout the rutting season especially in the presence of other bulls.

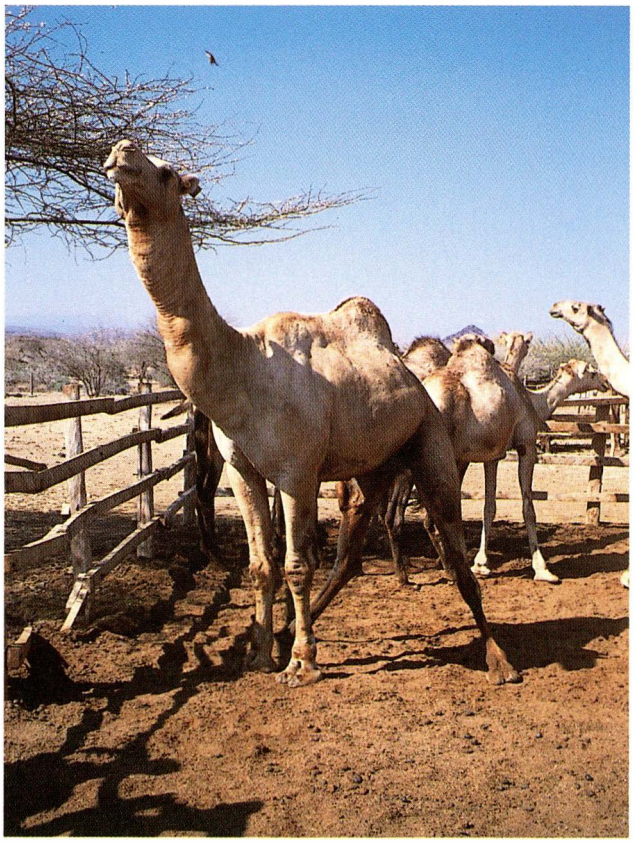


Plate III,4: Typical stance of a rutting bull. The legs are widespread. When approached by humans or other males the bull will tend to position himself laterally so he seems bigger and more threatening. Urination is frequent. Hereby the tail is kept between the legs so it gets soaked with urin. Frequent flicking of the tail disperses the urin on the rump and legs.

Plate III,5: Rutting bull approaches a female until physical contact. The females tail is curled up. This behavior is thought to indicate early pregnancy.

Plate III,6: The bull is investigating the perineal region of one female. Smell of urine and accepting behavior of the female allows the bull to detect females who are in estrus.

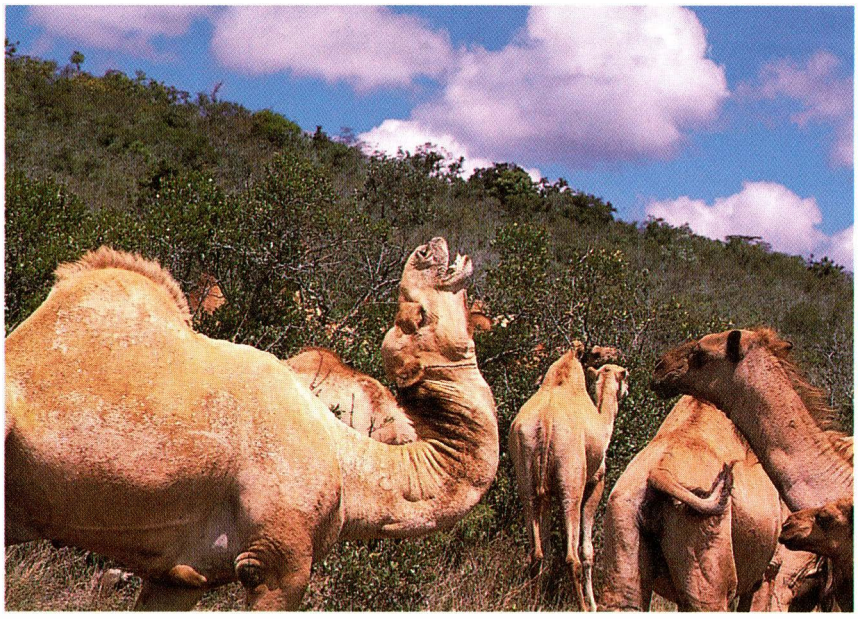


Plate III,7: Flehmen is a typical behavior of ungulates displayed after having picked up the females urinary smell.

Plate III,8: Characteristic mating position of all camelids. Young unexperienced bulls sometimes need assistance by the herder to enter the female correctly.

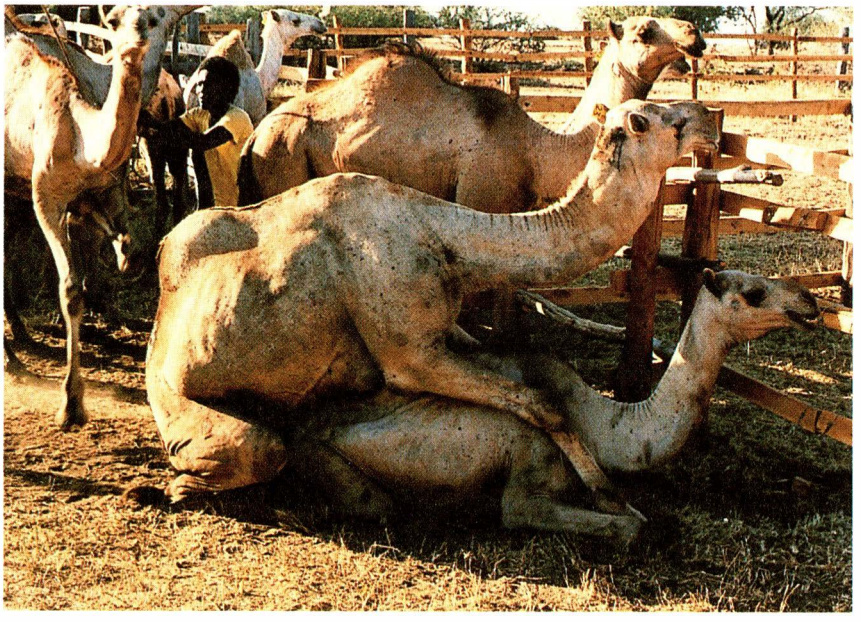


Plate III,9: Relaxation and softening of the pelvic ligament is characteristic sign that parturition is near. In this particular female parturition took place a couple of hours later.

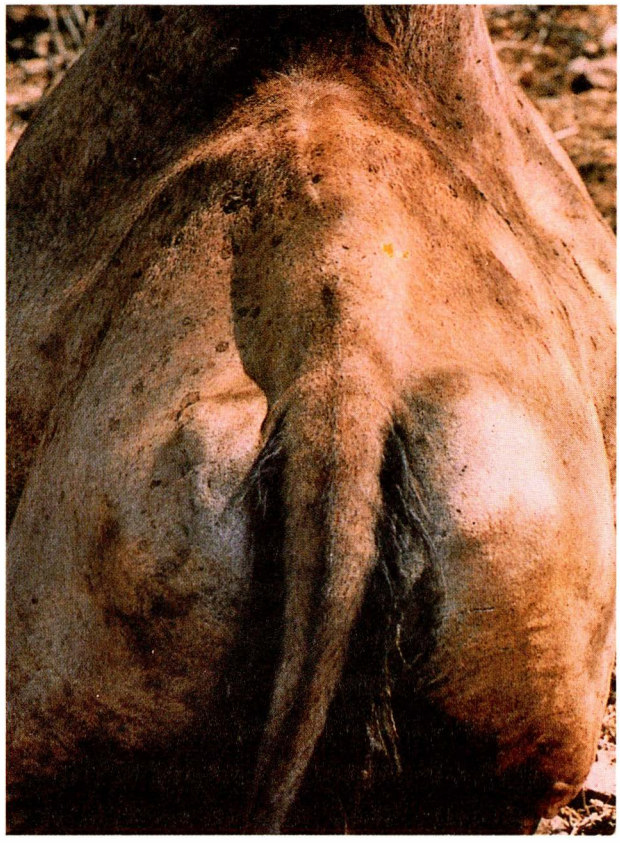


Plate III,10: Early delivery of an anterior presentation. The water bag is already ruptured. Female camels during third stage labor commonly lie down in lateral recumbency. However some females do deliver while standing. The anterior presentation is the most common one in camels.

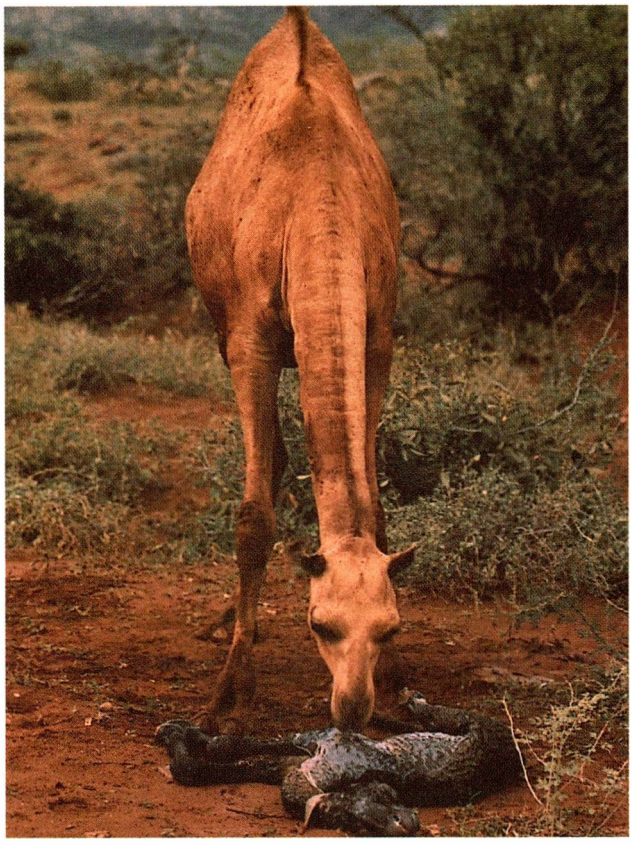


Plate III,11: Immediatly after birth the female approaches the newborn and sniffs it. In camels the maternal bond and individual recognition of her offspring is by smell. The newborn is covered by a thin membrane which is unique in camels.

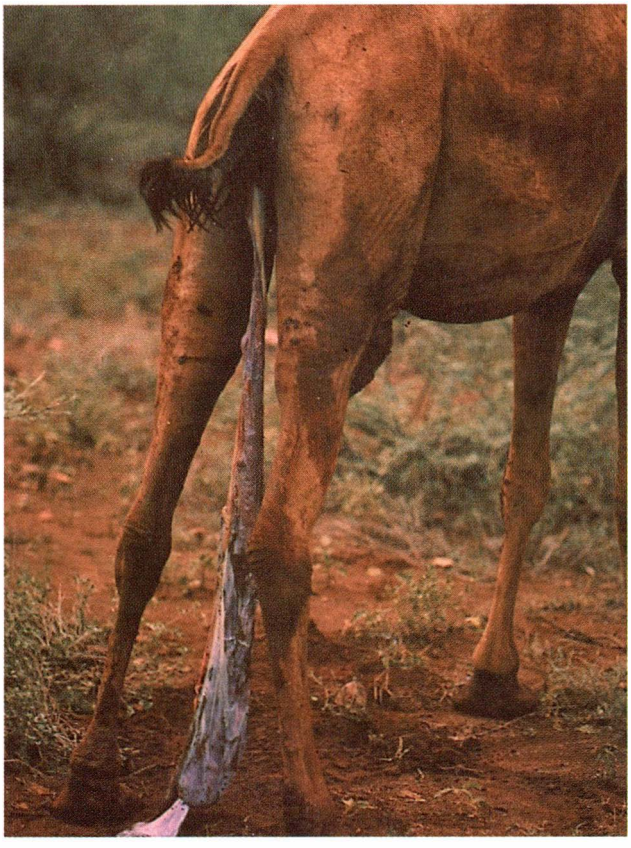


Plate III,12: Expulsion of the placenta is usually completed during the first hour post partum. Camels do not eat the placenta like other ruminants. The expulsion is rapid and retention is very rare.

Plate III,13: Well guarded new born. During the first day the female will usually not leave the newborn and be very protective. It will bite or kick any stranger attempting to get to close to the young.

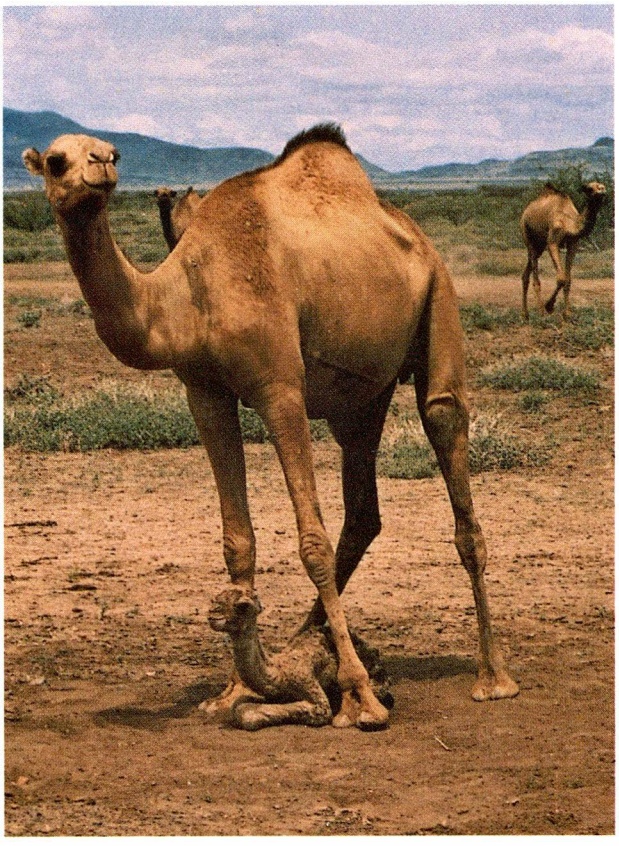
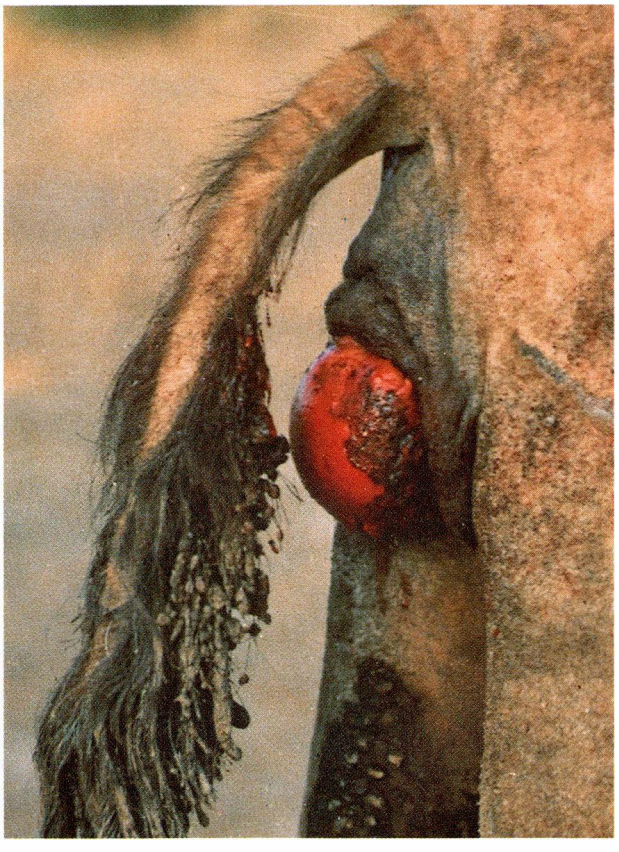


Plate III,14: A vaginal prolapse. This condition is commmonly seen during the late pregnancy. After parturition the condition is improving and the prolapse eventually resolves. However during the next pregnancy it will occur again. Faulty layman assistance during dystoccia is thought to predispose this condition. Prolaps of the uterus is extremely rare in camels.



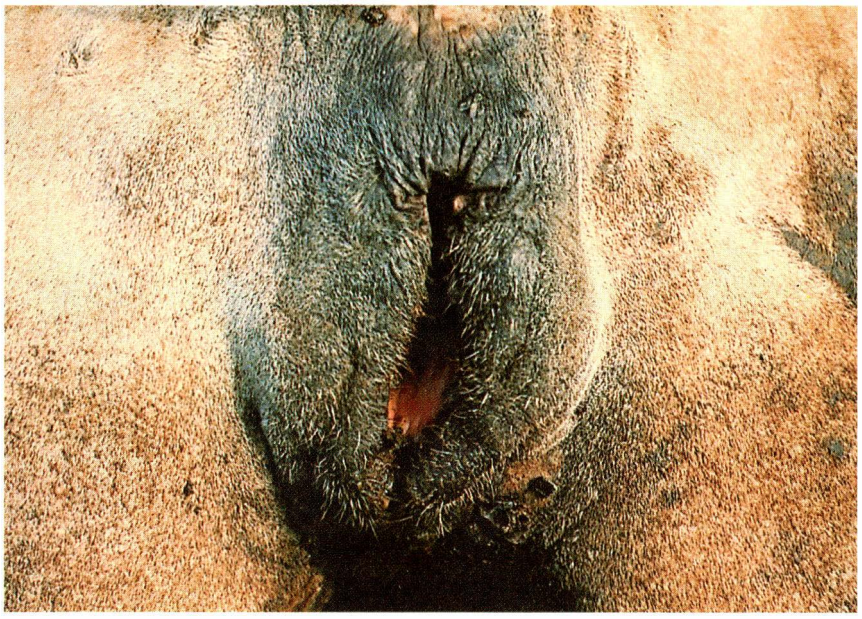


Plate III,15: External view of a complete recto-vaginal tear.

Plate III,16: Internal view of a complete rectovaginal tear. This is a common sequela to faulty forced extraction. If thes injuries are left untreated they commonly get infected. This condition can result in impaired fertility.

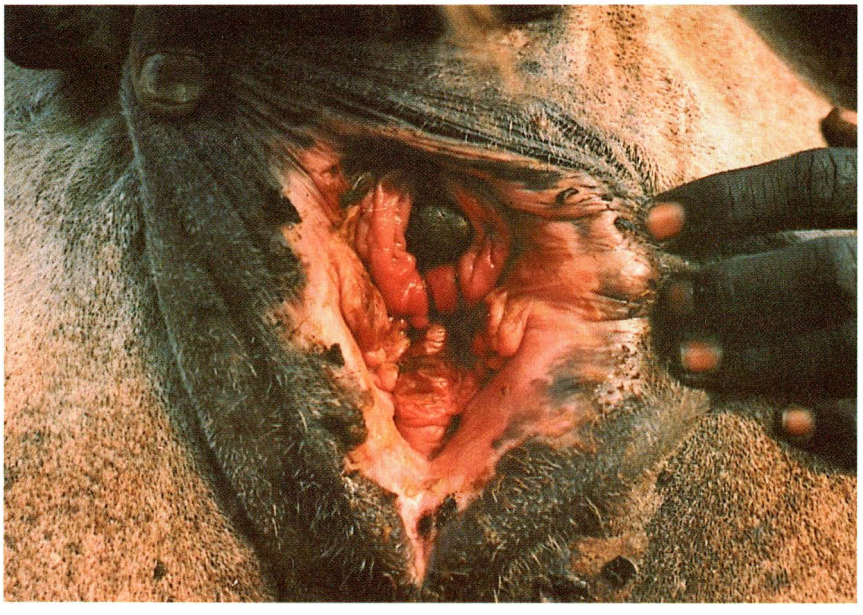


Plate III,17: Portrait of a prematurely born calf. According to the breeding records the gestation period was just under one year. Birth weight of the very small sized calf was 25 kg. The calf survived for 5 days.

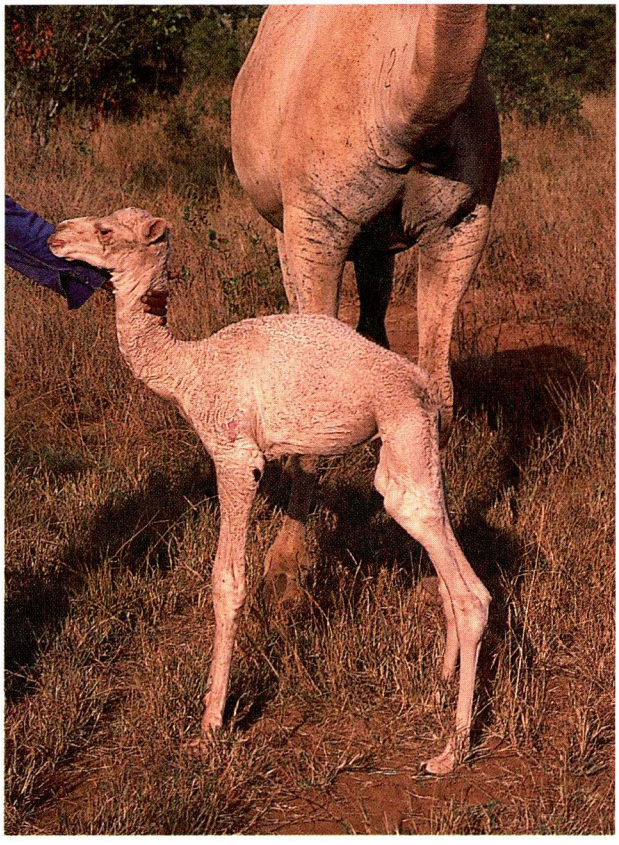
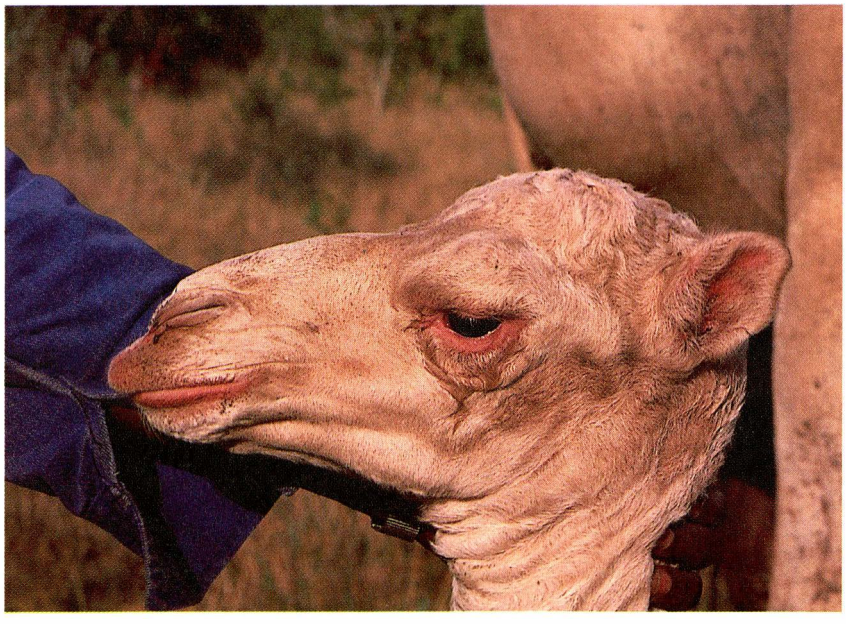


Plate III,18: Lateral full body view of the same calf. Charcateristic signs of prematurity are lack of pigmentation especially at the lips, eyelids and other natural body orifices.



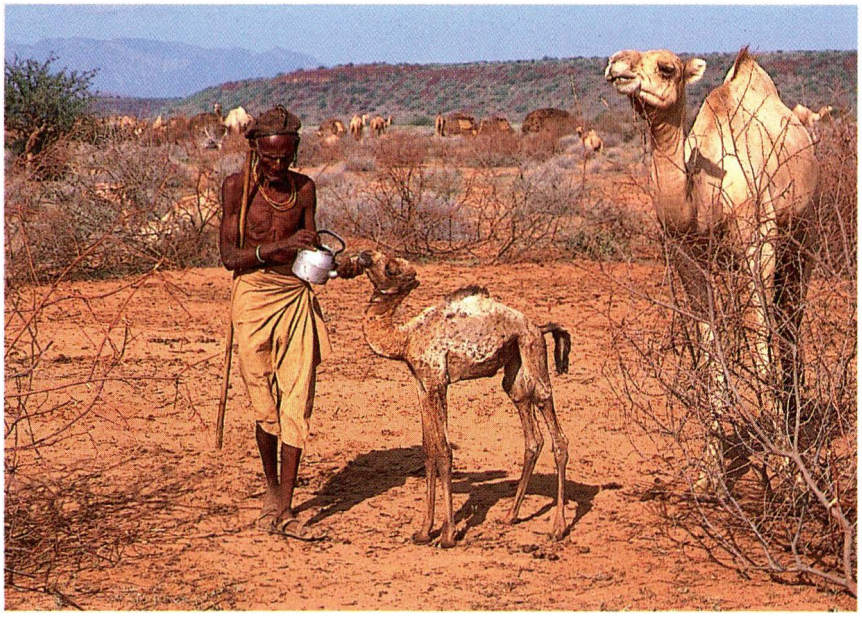


Plate III,19: A premature calf one month old. This calf (birth weight 20 kg) was raised by the herdsman. It was regurlarly bottle fed in addition to normal suckling. Its hair was cut to prevent nynph infestation.

Plate III,20: A healthy neonate. The neonate is wearing traditional charms of the Turkana tribesmen made out of bark fiber to prevent diarrhea and pox like diseases. These charms are put on immediately after birth and left until they are worn off.

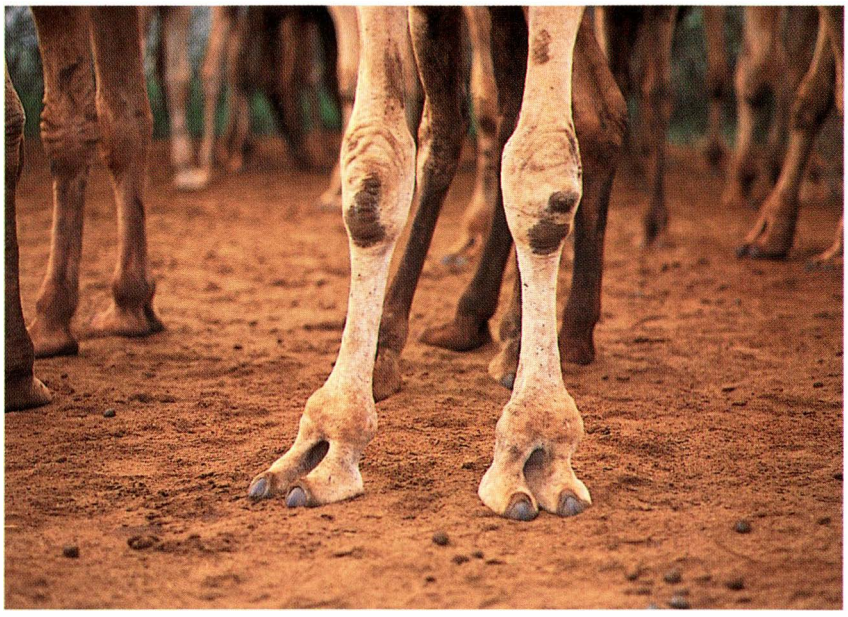
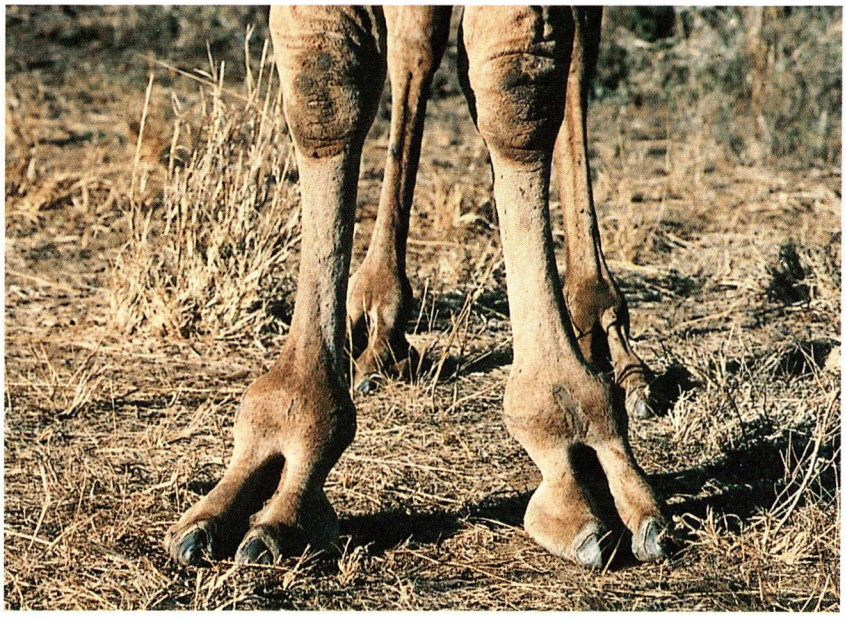


Plate III,21: Pigeon toes are a common angular deformity of the fetlock.

Plate III,22: Splayed fet lock is another common angular deformity of the fetlock.



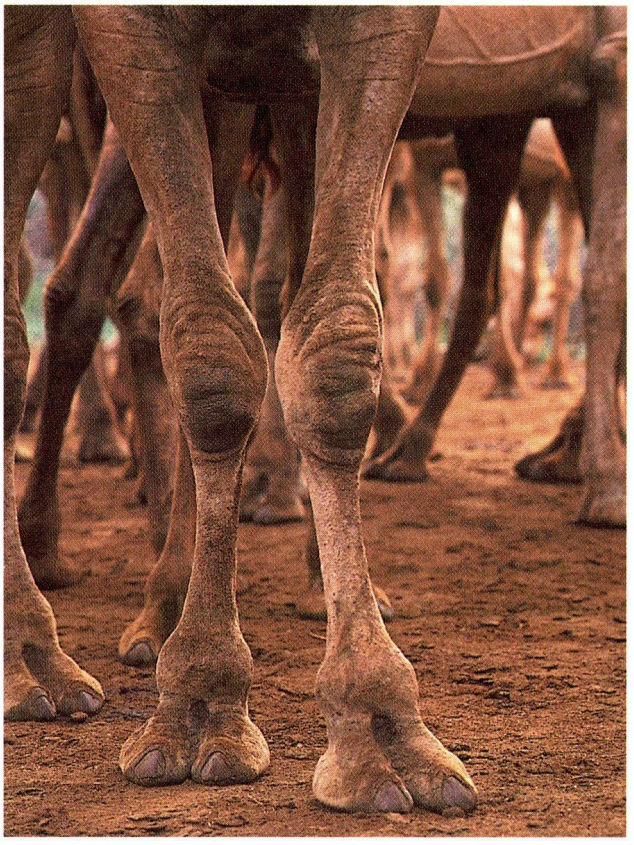


Plate III,23: Brushing knees is an angular deformity of the whole limb. These conformational faults of limbs are commonly seen in large sized camels living in hilly areas. Malformation can predispose to other joint problems. Affected camels rarely show a good working performance. Branding of joints is frequently used to treat the condition.

Plate III,24: Narrow chest. Adult animal on the left has a normal sized chest. The animals chest on the right is too narrow. This condition is related to undernourishment during the growth period.

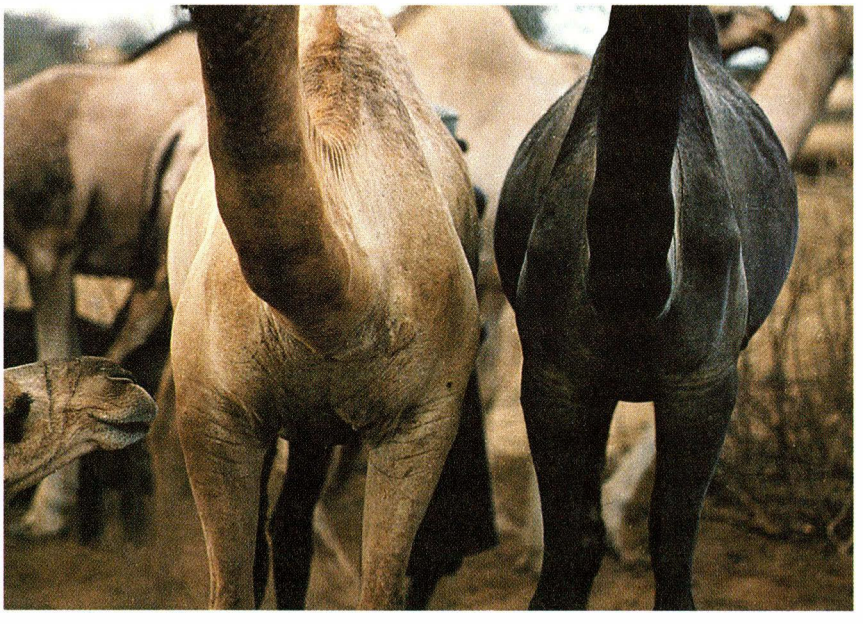


Plate III,25: Narrow chest causing brushing elbow. Constant friction can lead to painful skin lesions and excessive tissue growth of the irritated area.

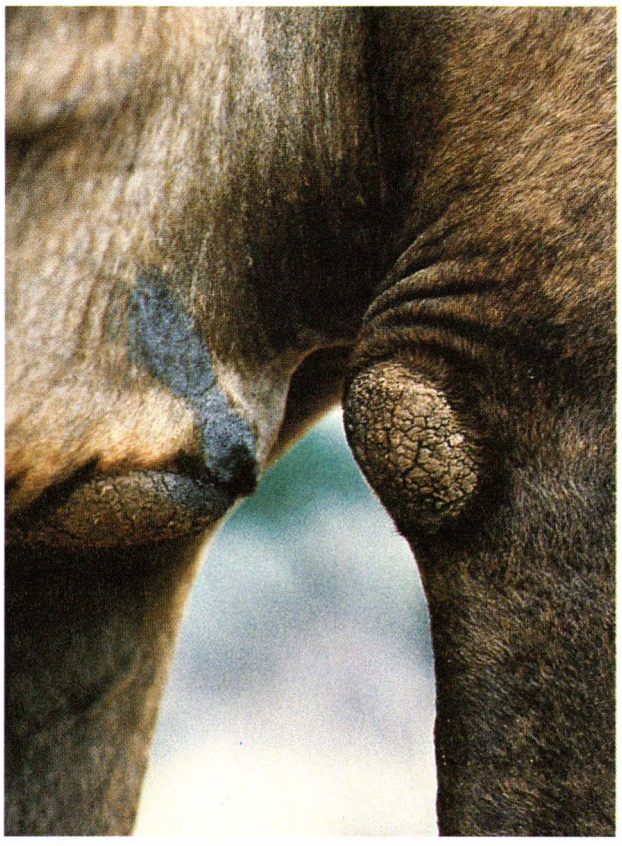
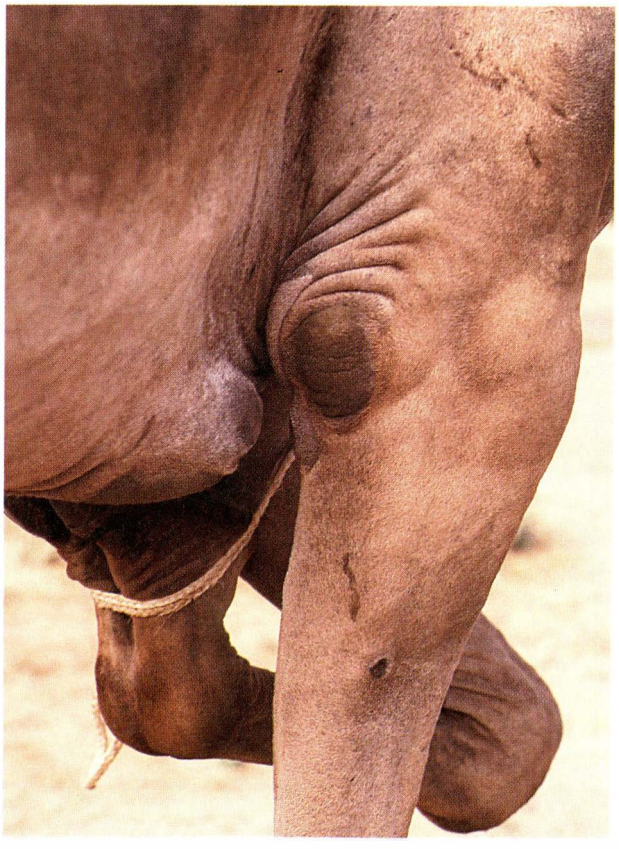


Plate III,26: Narrow chest leading to brushing pedestal. Constant friction is painful and may lead to reduced work ability and performance in severe cases.



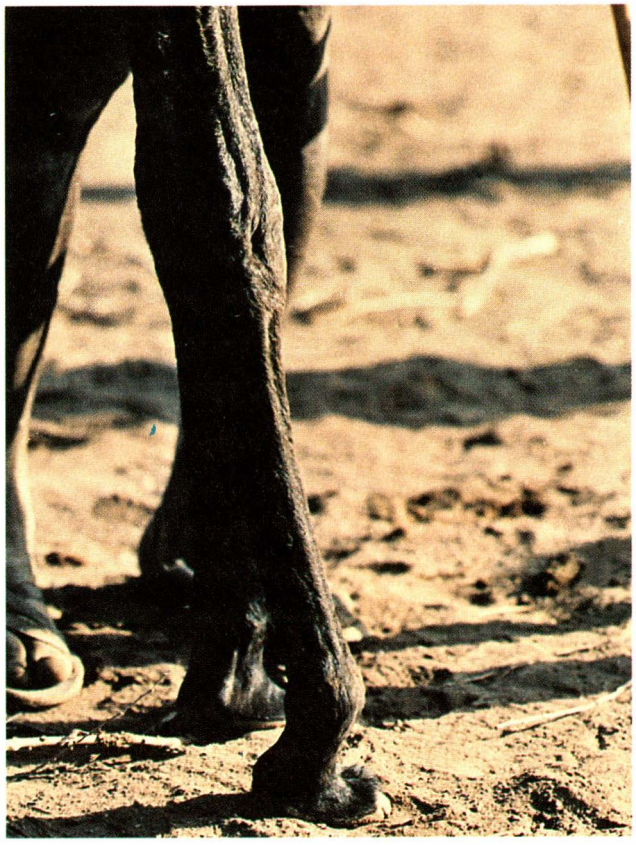


Plate III,27: Hyperflexion of the fetlock caused by extreme contraction of the flexor tendons.

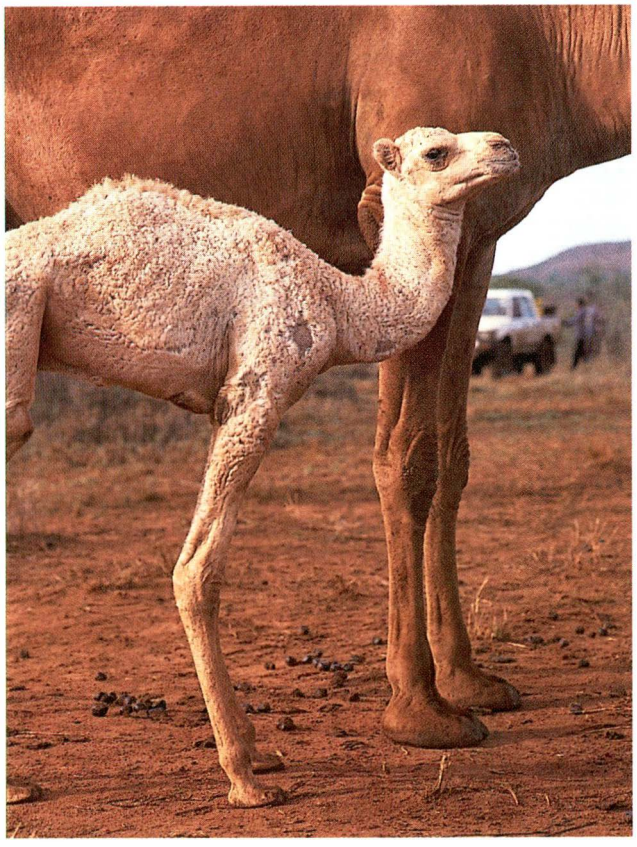


Plate III,28: Undershot knees in an otherwise healthy neonate. Usually this condition resolves without treatment within two to three months.

Plate III,29: Severe bilateral deviation of the carpal joints. Commonly seen faults in newly born or very young calves. The majority of these conditions resolve without treatment.

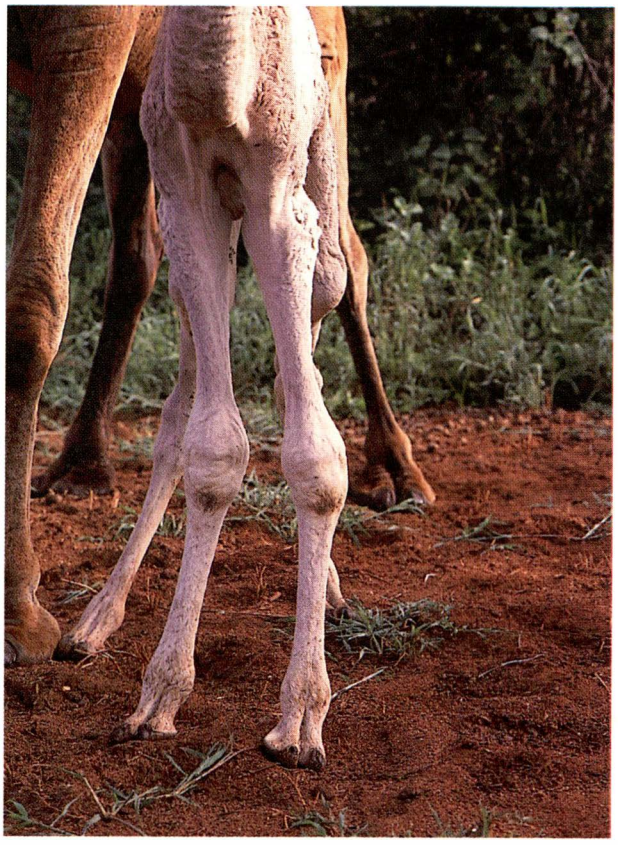
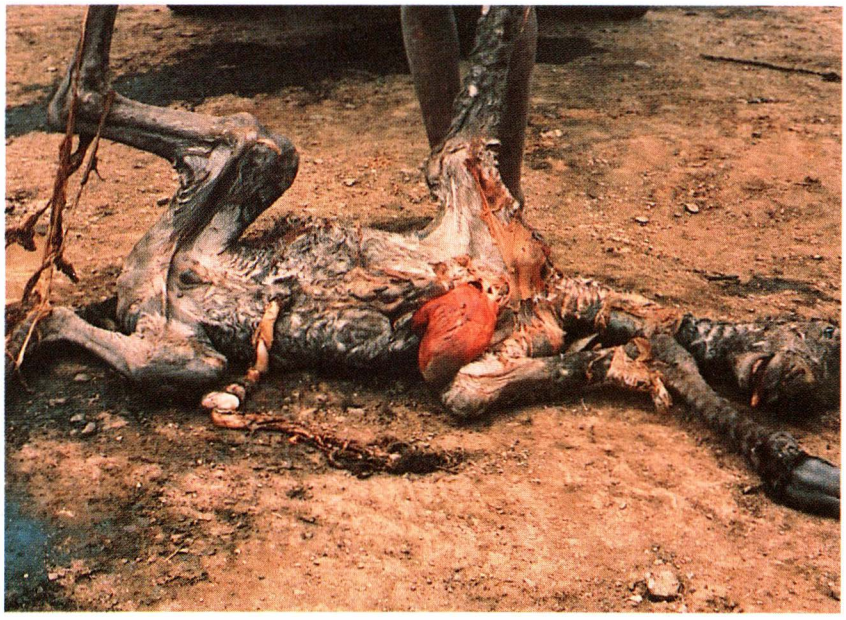


Plate III,30: Ectopia cordis. This is a closure defect of the ventral body wall during development of the fetus. The calf was stillborn. This is a very rare congenital defect.



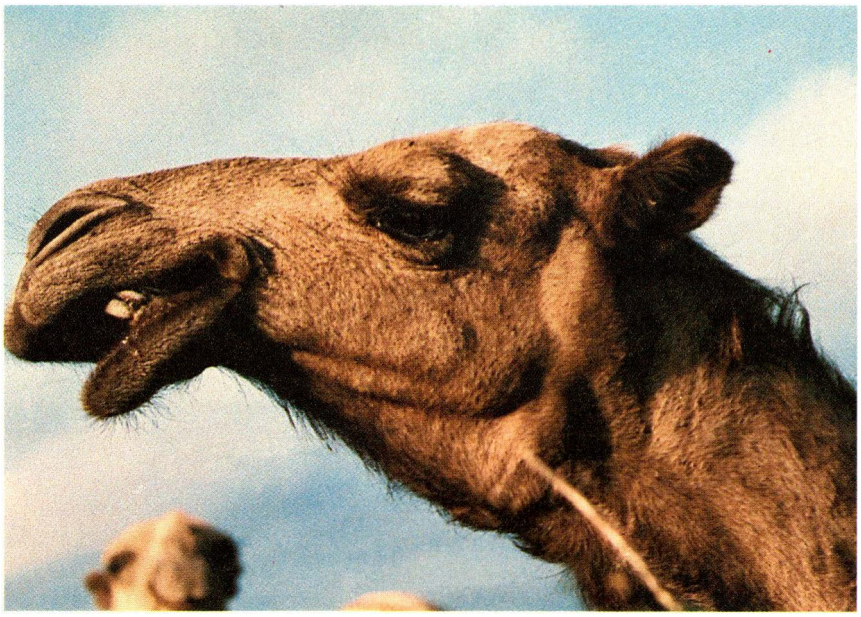


Plate III,31: Parrot mouth, a rare congenital defect. In this condition the mandibula is much shorter then the maxilla. This particular animal did not have any grazing problems. However, camel herdsmen did not breed this animal.

Plate III,32: Shortened digital bones (digit one), a rare congenital defect. This particular camel had problems when walking and the herdsmen branded her.

Plate III,33: Idiopathic alopecia, a rare congenital defect. This female camel (7 years old) was born with this condition. Apart from complete baldness the camel had no other health condition problems.

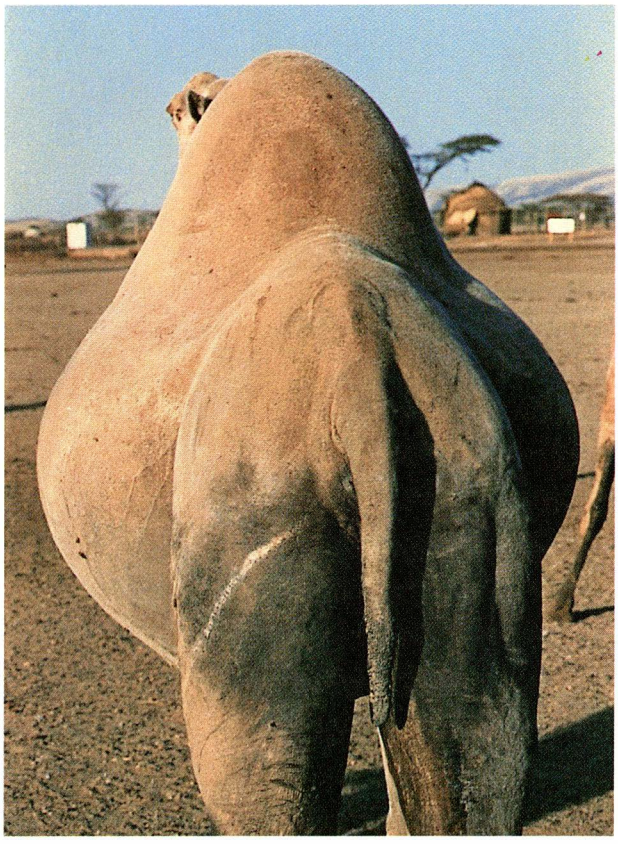
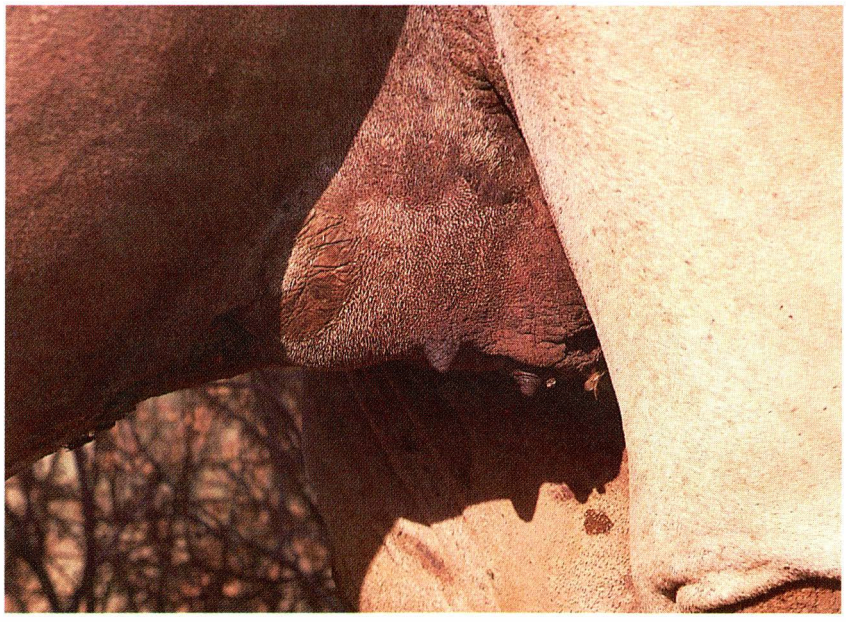


Plate III,34: Udder of a mature female with very small teats that are very difficult to milk.



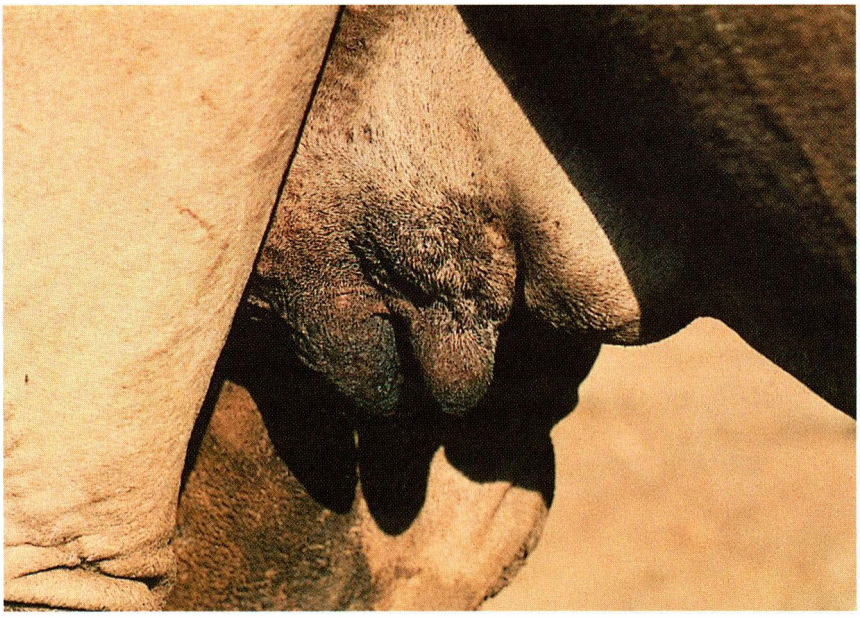


Plate III,35: Udder with very well developed teats, but insufficiently spaced. This can predispose to spread of infections from one quarter of the udder to the adjacent one.

Plate III,36: Well developed udder with teats not sufficiently developed.

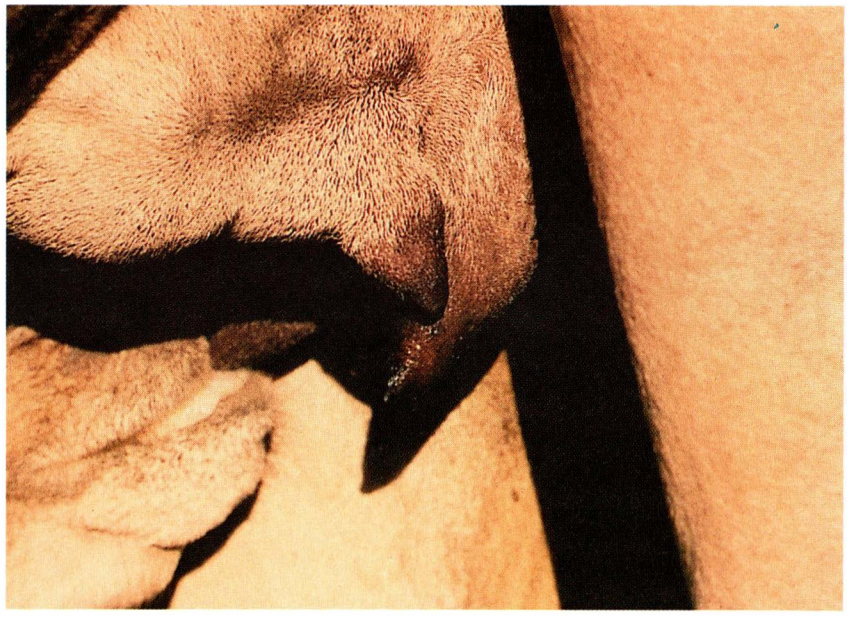


Plate III,37: Poorly shaped udder. The teats are to close. There is no distinction between the quarters of the udder half.

Plate III,38: Congenital deformation of teats in one udder half. Teats are fused at the base. There is no clear distinction between the two teat bodies.

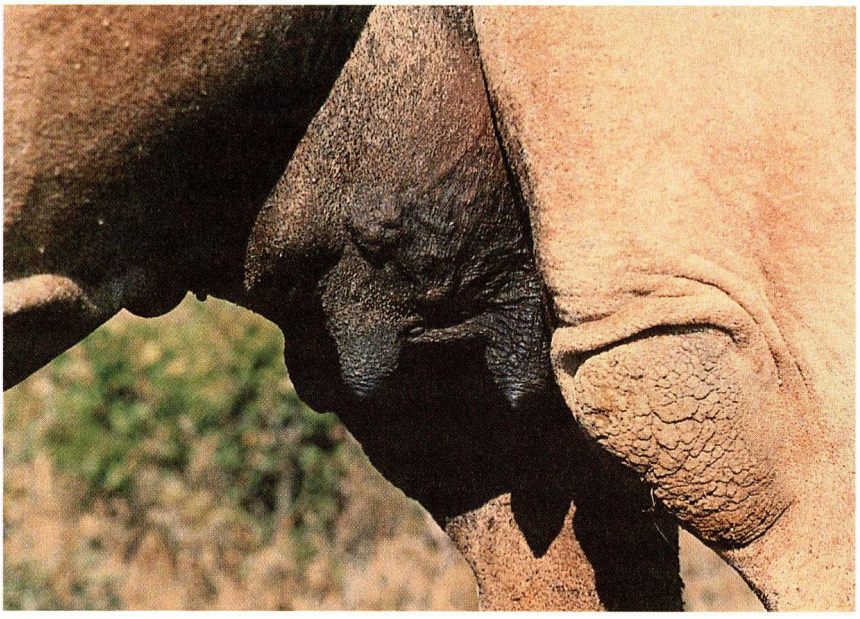
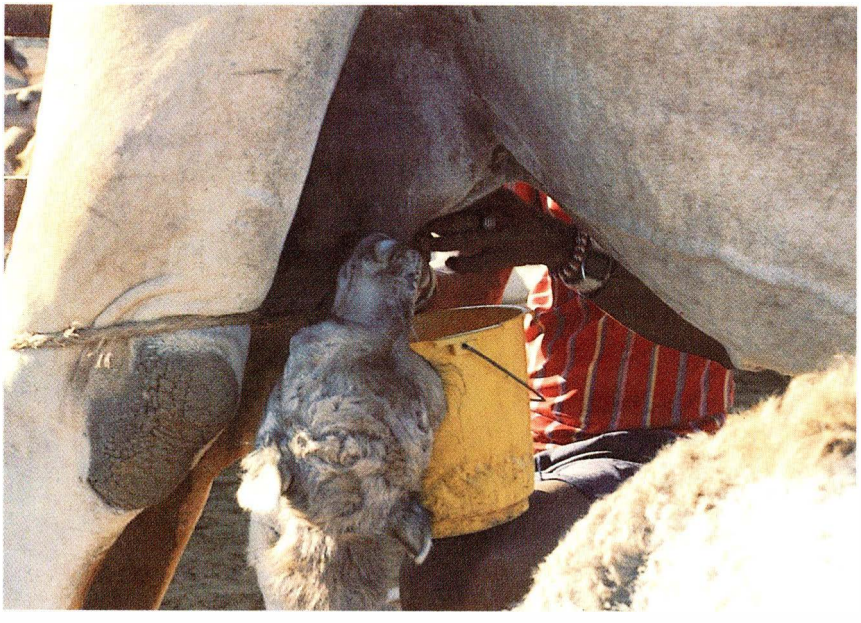


Plate III,39: Excellent udder conformation. The quarters are well and evenly developed. The teats are well developed, distinct and evenly spaced.

Plate III,40: Spacing of teats is an important characteristic, since both, milker and calf, usually need access to the udder at the same time.



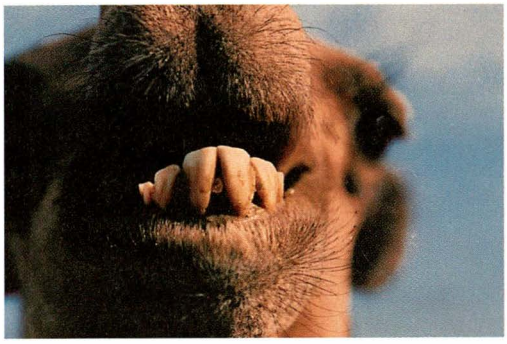



Plate III,41 & 42: Immature 3 year old male. All deciduous incisor teeth are fully erupted. Wearing of teeth has not started. On the lateral view the canine is visible. All incisors have a pronounced neck. The canine is in close vicinity to the third incisor and similarly shaped.


Plate III,43 & 44: Female, 3 year and 6 month old . Wearing of deciduous teeth has started.

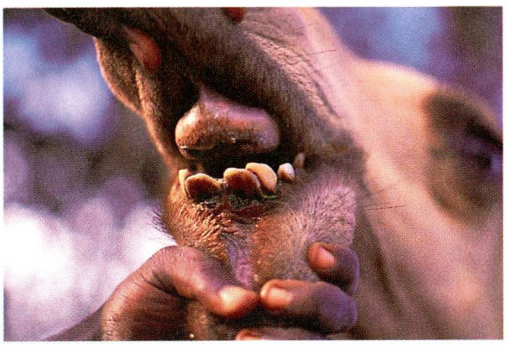
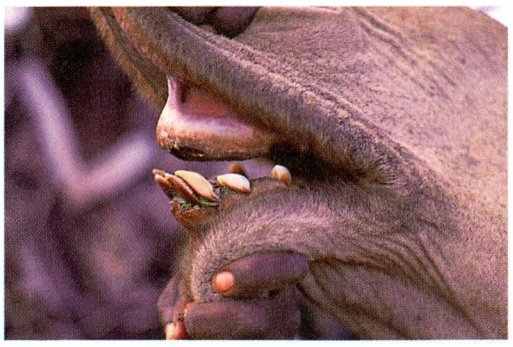



Plate III,45 & 46: Female, 4 years and three months old. The permanent incisor 1 has erupted. Deciduous incisor 2 and 3 are still present. Wearing is obvious. In the lateral view the deciduous canine is clearly visible.

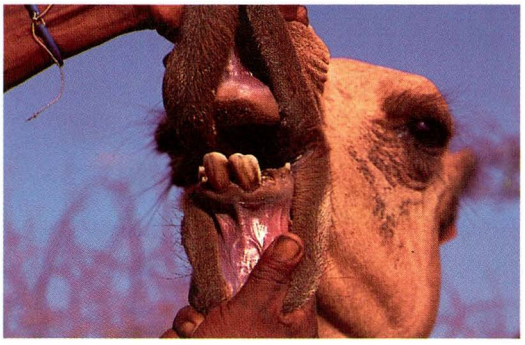
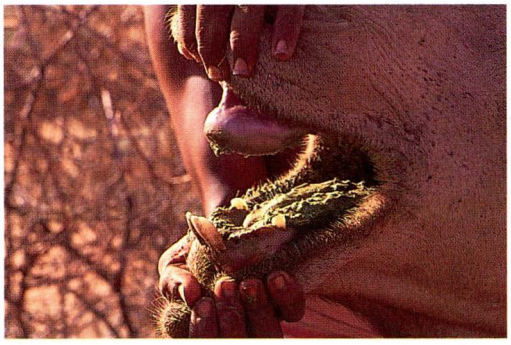



Plate III,47 & 48: Female, 4 years and 8 month old. The first permanent incisor has fully erupted and the second is erupting. The third deciduous incisor is already missing. Deciduous canine is still present.

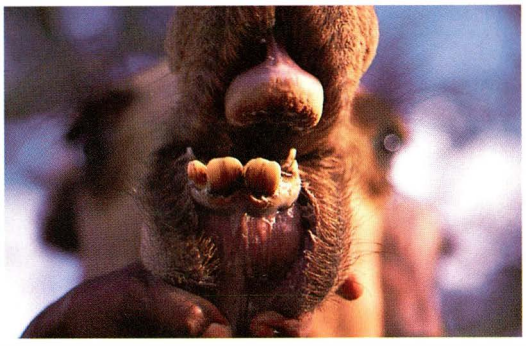



Plate III,49 & 50: Female, 5 years and 2 months old. Permanent Incisor 1 and 2 fully erupted. The third deciduous incisor is gone, but deciduous canine is still present.

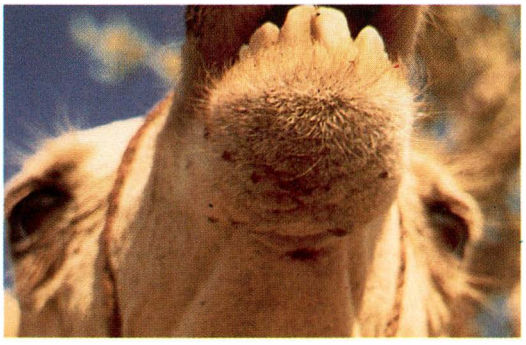



Plate III,51 & 52: Male, 7 years and 2 month old. All permanent teeth are fully erupted. Wearing of teeth has not taken place. Both upper and lower canine are present but have not reached full size. Upper incisor 3 is fully erupted, but has not reached full size. In its shape it is similar to the canine. The first premolar is erupted.


Plate III,53 & 54: A bull estimated age 10 years old. All teeth including the canines have reached full size. Wearing of incisor 1 has started. Distance between canine and last incisor is greatly diminished. There is a similarity to carnivore canines. Premolar 1 has also started to erupt.


Plate III,55 & 56: A female estimated age 11 years old. There is slight wear of incisor 1. The canine is much smaller, which is typical for females. The upper incisor 3 is also erupted and of small size.


Plate III,57 & 58: A female estimated age 15 years old. Wearing of incisor 1 and 2 has taken place. The brown discoloration of all teeth is probably a nutritional effect. The upper incisor 3 and canine are present and full sized.

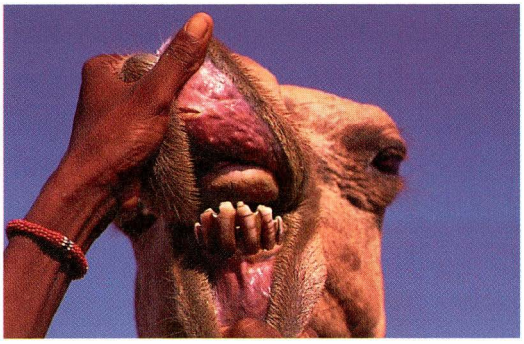
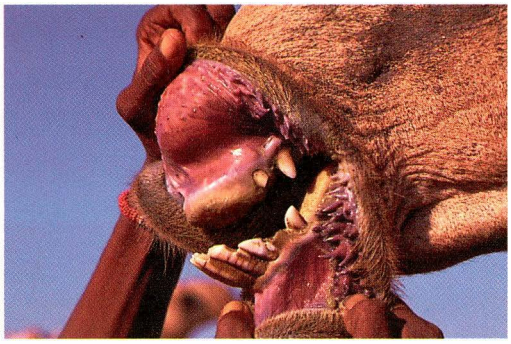



Plate III,59 & 60: Female estimated age 20 years old. All incisors are worn. Lower canine starts to show wear with upper incisor 3.

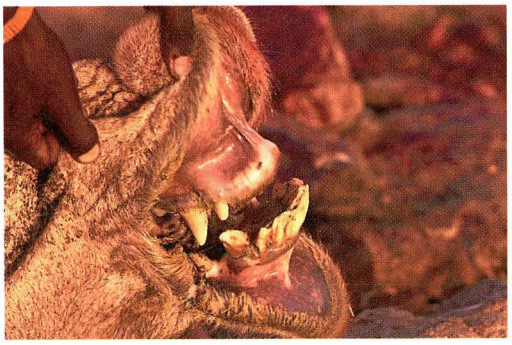



Plate III,61 & 62: Male estimated age 25 years old. All teeth are worn. Crown of the canine is lost due to wear.


Plate III,63 & 64: Female estimated age 30 years old. Incisor 1 is lost. Profound wear of the remaining teeth.

Plate III,65: Weighing crate specially designed for camels. The weighing mechanism is under foot and sideways. A construction like for cattle crates, with the weighing mechanism over head, is not possible due to the height of at least 3.5 m which would be necessary for camels.

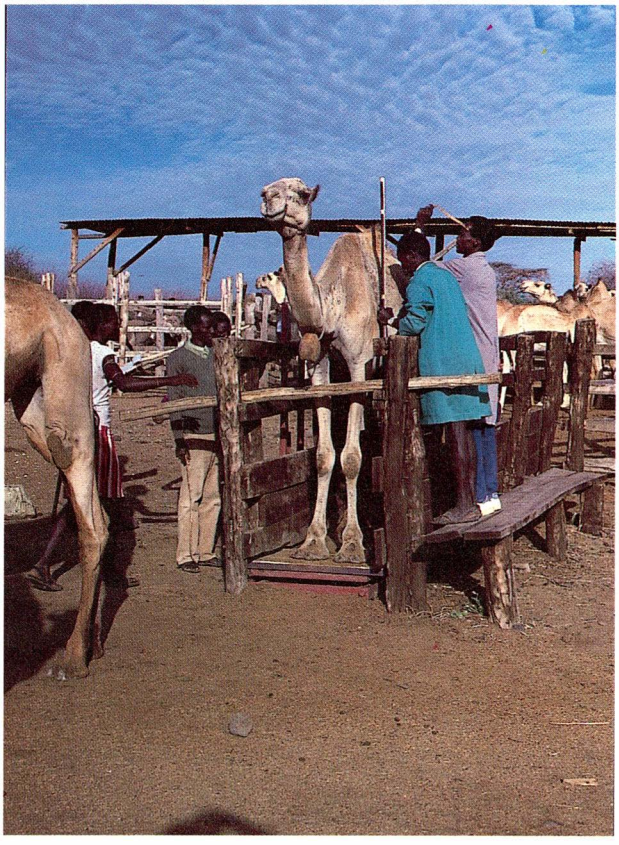
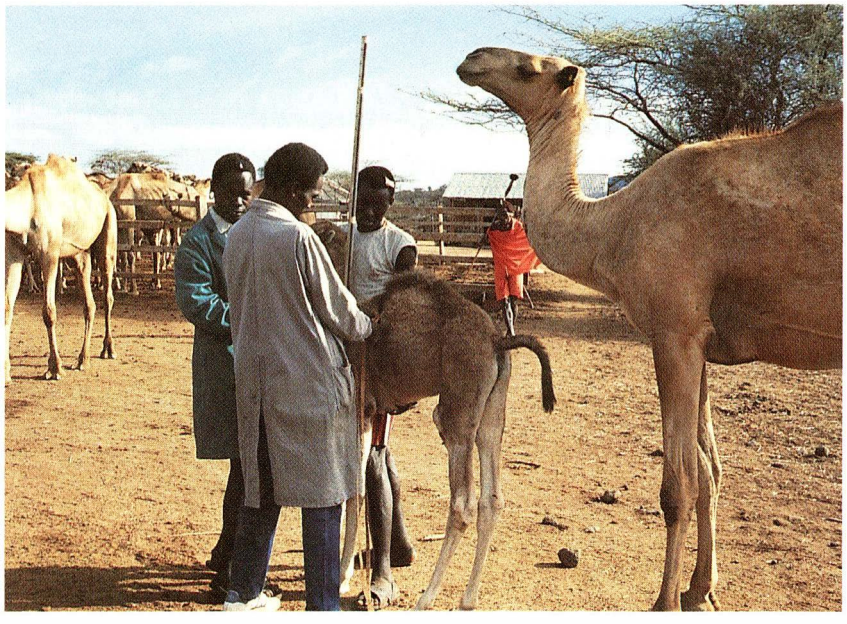


Plate III,66: Taking height and girth measurements to calculate body weights.



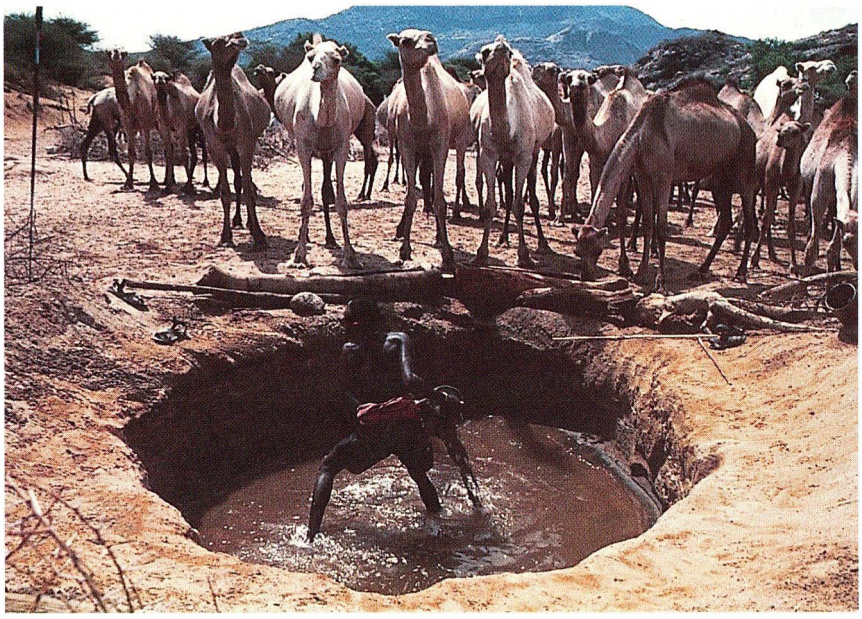


Plate III,67: This is a traditional watering well dug into the riverbed. The herds are watered in small groups using troughs.

Plate III,68: Unhygienic and faulty watering management. When left unguarded camels like other livestock contaminate water with feces and urine.

Plate III,69: Contaminated watering sites are a very important source in spreading of diseases and endoparasites.

Plate III,70: This is a modern concrete camel well in Wajir, Kenya. It is less labor intensive, more animals can be watered at the same time and sanitation is good.

Plate III,71: Watering camels at a dam outside one of the big Gezira irrigation schemes.

Plate III,72: Contamination is avoided by constructing small temporary watering throughs from clay on the banks of the dam. Note the piece of cloth which prevents destruction of the through by accidentally spilled water.

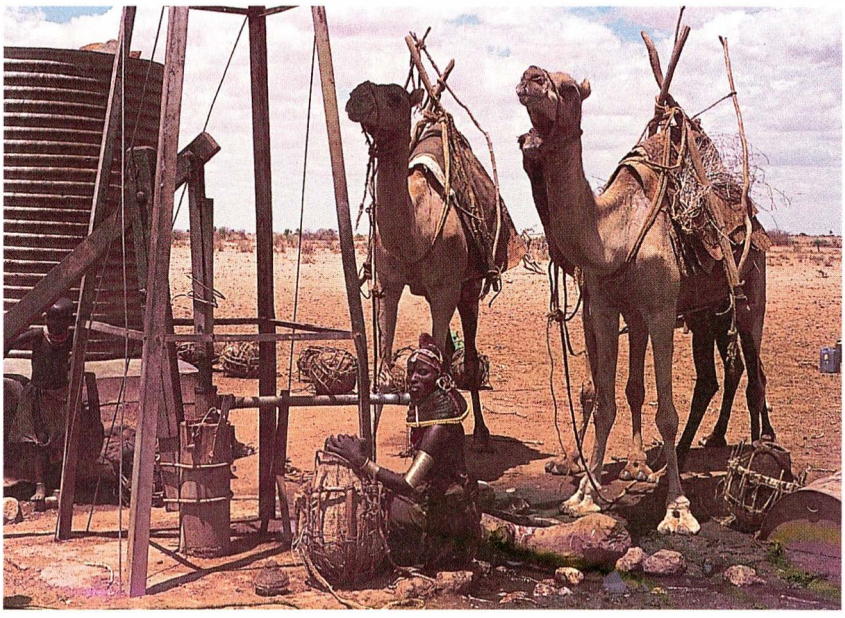


Plate III,73: Traditional Rendille (Kenya) pack saddle for water transport. The saddle consists of several sticks, some loose pieces of rawhide and ropes made from Sansivieria fibres. It is reconstructed at every loading. It holds two or four water containers woven from wild Asparagus fibres.

Plate III,74: Traditional Rendille (Kenya) pack saddle for household migrations. Three camels are needed to transport one complete hut with all household goods.

Plate III,75: Modified Sudanese riding saddle, adapted as a pack saddle, made from locally available materials in the Small Ruminant and Camel Research Unit, University of Nairobi.

Plate III,76: Sudanese riding camel with saddle on the Omdurman market.

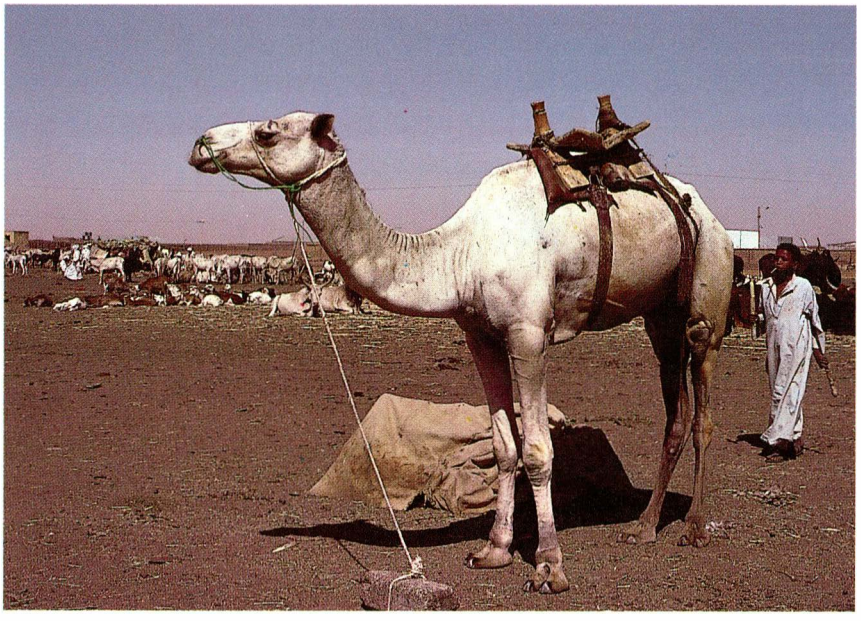


Plate III,77: Seedbed preparation using a camel for ploughing (Tunesia). Camels are rarely used in Eastern Africa as draught animals with the exception of some small areas in Ethiopia.

Plate III,78: A camel cart loaded with maize stalks (Tunesia).

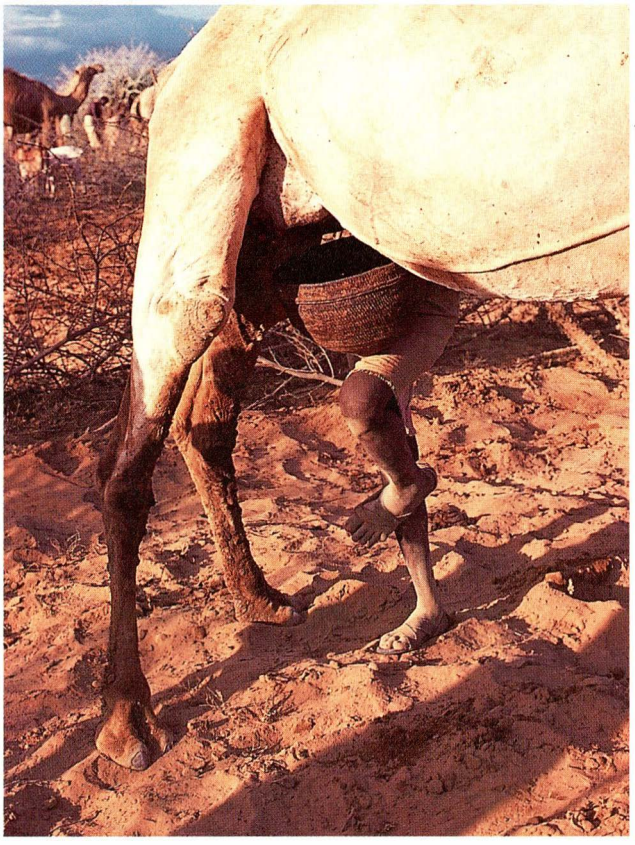


Plate III,79: Traditional milking technique. For the majority of camels the presence of the calf is absolutly necessary to stimulate milk let down. Milking frequency varies between 2-6 times daily depending on season, stage of lactation and milk yield.

Plate III,80: Some camels tend to bite and kick when they are milked. To prevent kicking a single leg hobble is commonly used. To prevent the camel has from biting wooden plugs are attached to the ear. When the camel attempts to bite the sudden movement of the plugs irritates the camel and it is distracted from aggressive behaviour.

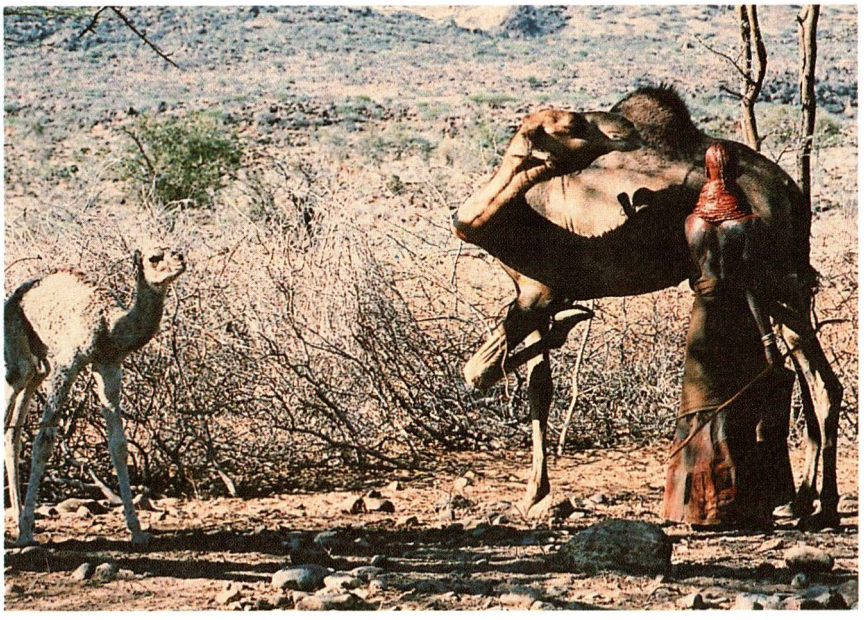


Table III,1b: Dental formula of the permanent teeth of camels (modified from Rabagliati 1924)

type	eruption	comment
Upper jaw		
Incisor 1*		absent
Incisor 2*		absent
Incisor 3*	5.5-7 years	third pair of "tushes"; thick pointed, slightly curled backward; no distinct neck;
Canine	6-7 years	sharp knife-like borders; in females much smaller; in males 5 cm long
Premolar 1	6.5-7.5 years	may be absent in females; short and thick; slightly curved backward;
Premolar 2	5-5.5 years	small ; triangular shaped; distinct neck;
Premolar 3	5-5.5 years	circular; twice the size of P2;
Molar 1	12-15 month	distinct neck; square;
Molar 2	2.5-3 years	no distinct neck; rectangular;
Molar 3	5-5.5 years	no distinct neck; pyramidal;
Lower jaw		
Incisor 1*	4.5-5 years	spatulate; no distinct neck; 45 degrees;
Incisor 2*	5.5-6 years	spatulate; no distinct neck; smaller than I1.
Incisor 3*	6.5-7 years	spatulate; no distinct neck; smaller than I2;
Canine	6-7 years	same as upper permanent
Premolar 1	6.5-7.5 years	second pair of "tushes"; short and thick; may be absent in females;
Premolar 2	5-5.5 years	triangular; distinct neck;
Molar 1	12-15 month	rectangular; distinct neck;
Molar 2	2.5-3 years	twice the size of M1; rectangular; no distinct neck;
Molar 3	5-5.5 years	rectangular; no distinct neck; largest teeth in mouth.

* In camels the angle of the incisors changes from approximately 30 degrees in young animals to nearly perpendicular in old animals.

Appearance and shape of teeth can be greatly modified by the quality of diet, nutritional deficiencies, congenital malformation and dental diseases. Furthermore accumulation of tartar, discolouration and accidental loss of teeth can lead to wrong age determination. The "tushes", upper and lower canine, upper incisor 3 and upper and lower premolar 1 are very well developed teeth in mature males. In females and geldings these teeth are less developed or even absent. Aging camels,

who are older than 12 years has to rely heavily experience in judging wear, available history of the animal and good judgement of physical appearance. It is always recommendable to include other guide-lines such as appearance of the animal, sexual maturity, known calvings in females, signs of advanced age such as grey hairs, scars and skin texture, when estimating an animals age.

Table III,2: Age determination in camels using the dental formula, 1 to 7 year old animals.

Tooth Age	I1	I2	I3	C	P1	P2	P3	M1	M2	M3
1 and 2 years:										
upper	-	-	d	d	d	d	d	p	-	-
lower	d	d	d	d	d	d	-	p	-	-
13 teeth										
3 and 4 years:										
upper	-	-	d	d	d	d	d	p	p	-
lower	d	d	d	d	d	d	-	p	p	-
15 teeth										
5 years:										
upper	-	-	p	d	d	p	p	p	p	p
lower	p	p	d	d	d	p	-	p	p	p
17 teeth										
6 and 7 years:										
upper	-	-	p	p	p	p	p	p	p	p
lower	p	p	p	p	p	p	-	p	p	p
34 teeth all permanent.										

I = incisor; C = canine; P = premolar; M = molar; d = deciduous; p = permanent

References and further reading

Age determination

Osman, F., Arnautovic, I. 1985. Anatomical Studies on the incisor, canine and first premolar teeth of the one humped camel (Camelus dromedarius). Acta. Veterinaria Beograd. 35 (5-6), pp: 353-366.

Rabagliati, D.S. 1924. The dentition of the camel. Cairo Government Press.

Saber, A.S., Schenk-Saber, B. 1989. Radiographical determination of age in the camel fetus (Camelus dromedarius). Anat. Histol. Embryol. 13 (3), p: 286.

Weight determination

To be able to determine a camels weight is most important for proper dosing with drugs and, to a lesser extent, to help in deciding on breeding, culling, slaughtering and, in rare cases, in feeding the animals. Because of there great height camels can not be weighed in regular cattle weighing crates, which usually have the weighing mechanism over head at approximately 2 m above the crate platform. For unimpeded access camels would require an entry height of at least 3.5 m. It is even better to use a specially constructed platform with the weighing mechanism under foot, so that all overhead frames are avoided which irritate the animals. A mechanical weighing platform is shown in Plate III,65. Hydraulic or electronic platforms are also available. The former is also a cheap and robust alternative, the latter one the most elegant solution but at a prohibitive price for most applications.

As in all livestock body in camels can be calculated from body measurements. Boué (1949) had developed a technique involving three measurements, i.e. shoulder height (H), thoracic girth (T) and abdominal or hump girth (A). If these measurements are taken in meters weight (P) in kg can be estimated from the following formula: P = 53 * (TAH). This technique was applied by Schwartz et al. (1983) together with weighing on a hydraulic weighing platform and using a slightly modified formula: Live weight [kg] = SH [m] * TG [m] * HG [m] * 50.

Table III,3: Correlations between body measurements (Figure III,6), estimated and measured live weights of Small East African camels on Ol Maisor Ranch, Laikipia District, Kenya (n = 328); Source: Schwartz, H.J., unpublished.

	SH	TG	AG	Measured weight
Estimated weight (EW)	.93	.95	.95	.98
Height (SH)		.95	.92	.95
Thoracic girth (TG)			.94	.97
Hump girth (HG)				.94

The three body measurements were, as to be expected, highly and positively correlated to each other. It is therefore also possible to use only one of them to estimate live weight with little loss in accuracy. The thoracic girth appears to be the most reliable parameter in this context, as Wilson (1984, p. 154) confirms. Live weight of tall and slender camels, like the racing type or very young calves of all types will be overestimated, whereas the live weight of short and compact animals tend to be underestimated by the formula if the same numerical factor is used. Accordingly the numerical factor in the formula has to be adjusted to age and/or type of animal.

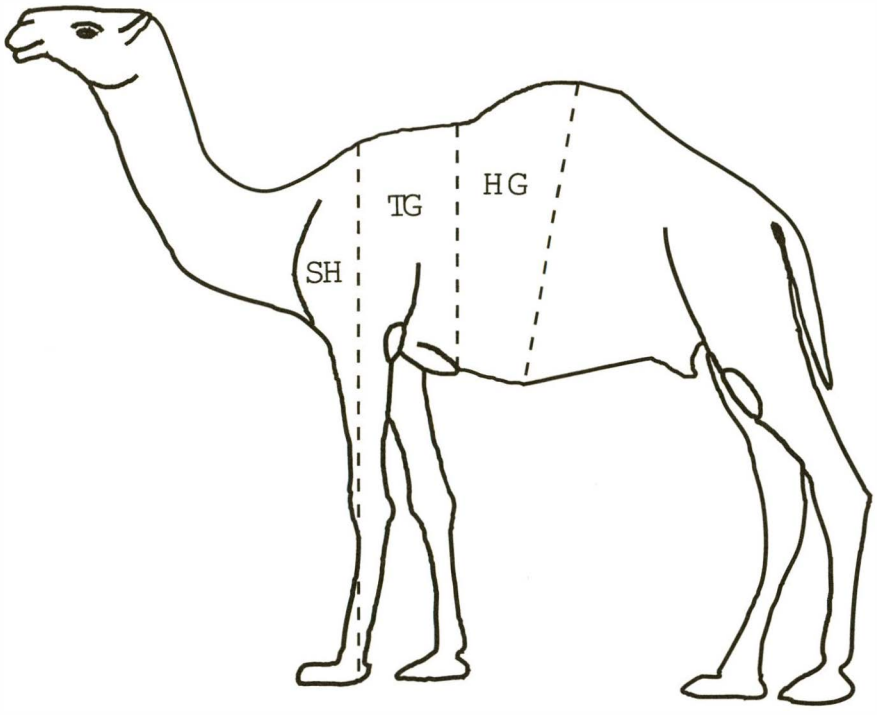


Figure III,6: Body measurements for the calculation of liveweight in camels after the formula: Live weight [kg] = SH [m] * TG [m] * HG [m] * 50 (SH = shoulder height; TG = thoracic girth; HG = hump girth).

References and further reading

Weight determination

Boué, R., 1949: Revue d'élevage et de médicine vétérinaire des pays tropicaux, 3, 13-16.

Field, C.R., 1980: Camel growth and milk production in Marsabit District, Kenya. In: Workshop on Camels, Khartoum, Sudan, 1979. International Foundation for Science, Stockholm, 215-240.

Schwartz, H.J., Dolan, R.B., Wilson, A.J., 1983: Camel production in Kenya and its constraints: Productivity. Trop.Anim.Hlth.Prod. 15, 169-178.

Wilson, R.T. 1984: The camel. Longman, London and New York

Traditional management practices

Watering

In most areas in Eastern Africa where camels are kept, permanent surface water, such as rivers and lakes, springs and artesian wells, is rare. During the rainy season many temporary streams, lakes pools and puddles form naturally and man made dams and reservoirs fill up. All livestock including camels usually find all the drinking water they require. In addition to that, fresh green forage is available which gives camels almost all water they need. It has frequently be observed that camels go without any drinking for several weeks during such times. In areas where watering points are numerous, well spaced and easily operated the usual watering interval for camels is 3 to 4 days. Watering intervals of 5 to 7 days are still considered normal, intervals longer than 7 days already constitute a stress on the animals.

During dry seasons watering camels is the most important, time consuming and arduous work which pastoralists have to perform. When the surface water disappears and the vegetation dries up camels have to be watered regularly from subterranean sources. For times immemorial these water sources have been man made water-holes and wells or varying depths. Most commonly found are shallow wells dug into seasonal water courses (Plate III,67). This type of wells is regularly filled in again by seasonal flooding and has to be reconstructed when the waters recede. With the progressing dry season water levels in such wells tend to fall and the wells will be dug deeper and deeper. It is not uncommon to see wells dug to depths of 10 to 12 meter with 6 to 10 people standing on rickety scaffolding lifting water from the bottom in small buckets for many hours per day.

Other wells, dug into hard soil or chipped and chiselled into rock, are of a more permanent nature. They are usually narrow in diameter, can be quite deep and the water is lifted by rope or by rope and pulley. This is usually done by hand, very rarely by using animal draught. Although these technologies, if they can be called by that term, are very simple they have the great advantage over open surface watering, that contamination by urine and faeces is minimal. The animals are watered from troughs and have no direct contact with the water source.

Water requirements of camels, although low in comparison to other livestock species, are still quite high in absolute terms. At the height of the dry season, when ambient temperatures are high and the vegetation is dry, an adult camel requires approximately 80 to 100 litres of water every 5 to 8 days. If the pasture consists mainly of halophytic plants and/or the available water is rich in minerals the requirement will increase. It will also increase in lactating animals. A herd of 100 camels during the dry season might require as much as 10,000 litres of water three times in the course of two weeks, all of which might have to be lifted bucket by bucket from a depth of 8 to 10 m. It is not unlikely that the labour force available to water the herds during the dry season has been one of most important factors restricting herd growth in the past.

In view of this it is not surprising that most camel herding ethnic groups in Eastern Africa have or used to have rather strict and complex rules regarding water rights which often, though indirectly, implied land use rights as well. With the advance of government supported water schemes providing dams, catchments and first and foremost deep bore holes with motor or wind driven pumps much of this traditional control over natural resources has disappeared, often without being replaced by any other mechanism.

Working

That camels can be very versatile working animals has been stated before. In Eastern Africa, excepting Sudan, their use is largely limited to that of a pack animal. Camels are widely employed for transporting water, huts and household goods during seasonal migrations, firewood and, to a lesser extent, commercial goods. Despite this the technology used is simple to primitive. Pack saddles in the region are usually only a collection of sticks, ropes and pieces of rawhide which has to be refashioned at every loading (Plate III,73). Quite often there is no distinction between elements of the saddle and elements of the load, as for instance when huts are shifted during seasonal migrations. The main support elements of the huts are then used as supporting frames for the load, thus replacing the saddle, a very economical way to exploit the scarce loading capacity (Plate III,74).

The preferred pack animal is the castrated male. Females are rarely used since their main task is production of milk, and entire males can be difficult to manage during the rut. Training the pack animal requires no great sophistication. The animals are usually quite docile and can easily be guided by a rope halter or by a rope attached to a nose peg or ring. Strings of pack camels are formed by attaching the guide rope to the pack saddle of the animal in front (Plate II,5). 7 to 9 pack camels in one string are considered, by the Rendille tribesmen in Northern Kenya, the maximum manageable number for one person to guide in this way.

In Sudan there is a rich tradition of camel riding in both the civilian and the military sector. Riding saddles (Plate III,76) and pack saddles are well developed; the former ones are often ornately carved and richly decorated with brass or silver and covered with tooled leather or carpets, signalling the social status of the rider. In Sudan camels are also more frequently engaged in work such as operating water wheels, oil mills and occasionally also as agricultural draught animals. Harnesses and implements, however, are as a rule only crudely adapted versions of those developed for donkeys, mules and horses and tend to limit efficient exploitation of the camels potential draught power.

Milking and related problems

Camel are milked traditionally by men in most pastoral societies. Because of the height of the udder this is done standing with one knee raised to support the milking bowl (Plates II,2, III,79). Under most circumstances one udder half is milked and the other one simultaneously suckled by the calf. Occasionally both

udder halves are milked at the same time by two herdsmen. Not all camels accept this, particularly during the early stages of lactation, and in most the calf has to suckle first to stimulate milk let-down. In later stages of lactation it is normally sufficient that the calf is present but does not need to suckle. Sometimes, when the calf is stillborn or dies early after birth, its skin is used to build a calf dummy that is shown to the mother to induce the release of milk. This can be successful when the mother has had calves before, it almost never works in the first lactation. In many such cases the mother will simply dry up within a week, looking like she had never delivered. These animals are quite often immediately bred again with good success.

The frequency at which camels are milked is variable; it depends on supply of and demand for milk. Season, the quantity of milk produced per animal, the number of milking camels present, availability of other food for the herders household and sex, age and health of the calves are factors affecting the milking frequency. Higher frequencies commonly produce a higher total yield, which is noticeable up to four milkings a day. It is not unusual to milk camel up to seven time a day.

To increase the amount of milk taken for human consumption strict control is exercised of the amount of milk suckled by the calf. The standard routine is to separate the calves from their mother during day and night and leave them together only for short periods after milking. To achieve this calves are kept in separate night enclosure and are herded separately during the day. Another widespread system, practised by Somali herders, is to allow the calf to follow their mothers during the day, but to tie some or all of the teats with soft bark to prevent suckling (Plate III,89). In improved management systems an udder basket serves the same purpose. Muzzling the calf during night time (Plate III,92) has the same effect as keeping it in a different enclosure. It cannot be used during the day since it would prevent the calf from grazing.

Milking camels are normally very docile and gentle animals which accept handling and milking with ease. In first lactation mainly there may be cases of anxiety or aggressiveness which require some mild form of restraint to facilitate milking. One of the simplest is to close one foreleg, most frequently the right one, on itself, i.e. tying the fetlock to the forearm to unbalance the camel should it try to kick (Plate III,80). In a variation of this technique one foreleg can be tied to the other, fetlock to carpal joint, which has the same unbalancing effect.

If the animal is particularly aggressive, habitually trying to bite the milker, in addition to tying a foreleg holes are pierced through both the ears and wooden plugs are suspended by short strings from the ears. With each quick movement of the head the pendulous plugs keep hitting the camel in the face disorienting it. The animals learn rather fast and the device can be removed after a few days. Some few camels are particularly prone to kicking when they are milked. In this case the rear legs are tied together just under the knee joint (Plate III,81) or a stick is tied across both rear legs just over and behind the knee.

Camels, particularly young ones, quite often refuse to nurse their calves. When this happens, they must be forced to accept their calf, otherwise milk production

would cease within days. Pastoralists have developed several elaborate techniques to reach this objective all based on the same principle. All these techniques rely on causing increasing degrees of discomfort or even pain to the mother which will absorb her attention to such an extent that she will "forget" to reject the calf. After the calf has suckled a few times the device is removed and in most cases the relief is so strong that the mother will accept the calf permanently.

In the case of a mother only mildly refusing to suckle the calf by moving away whenever the calf approaches, one front foot is bent on itself (Plate III,88) so that the leg must support the weight on the extremity of the metacarpus. The position is quite uncomfortable, since the camel cannot walk and sit down properly.

In other cases, when the mother shows aggressiveness towards the calf another technique is applied. First the nasal septum of the mother is pierced, a string is passed through and she is tied to a tree with her head kept unnaturally high. This position appears to be extremely uncomfortable to the camel. The calf, which is tied to the same tree or to the mothers foreleg, can suckle without any interference. Usually a few hours of this treatment suffice to force complete and permanent acceptance of the calf.

If the mother is not only persistent in refusing the calf, but also openly aggressive and biting andor kicking it, a widely used technique, called "Qalla'h" by Somali herders, is the last remedy for this behaviour. The techniques aims at copying the process of parturition by causing intense abdominal pain with contractions and a "heaviness" in the vaginal area. Like in the natural parturition sequence these artificially created symptoms are completely relieved when the calf is accepted.

To simulate the immediate pre-parturition pain the anus of the camel is closed mechanically that it cannot defaecate. At the same time soft bark fibres are tied around the nostrils forcing the camel to open mouth breathing. Closing of the anus between two wooden stick and tying of the nostrils is shown in Plates III,83 to III,86. The discomfort produced by the two devices and the intense abdominal pain caused by the closure of the anus become so severe that acceptance of the calf will be achieved after a few hours. Often the acceptance of the calf is permanent since the relief on removal of the anal implement is so intense, and resembles so closely the one felt at delivery, that there is a strong second chance to form the maternal bond.

The maximum time that the anal device can be kept on is probably 8 to 10 hours, but the procedure can be repeated several times if it does not work immediately. This can be the case when the technique is used to force an animal to accept a foster calf. If the camel is just refusing to release milk, only the anal device without closing the nostrils or, reversely, closing the nostrils without anal closure might be used with good success. In a crude variant of this technique may close the anus just by stitching it using Acacia thorns and string. The risks involved in this are obvious.

Plate III,81: High hindleg hobble. This hobble is easily put in place by one person and no further assistance during milking is needed.

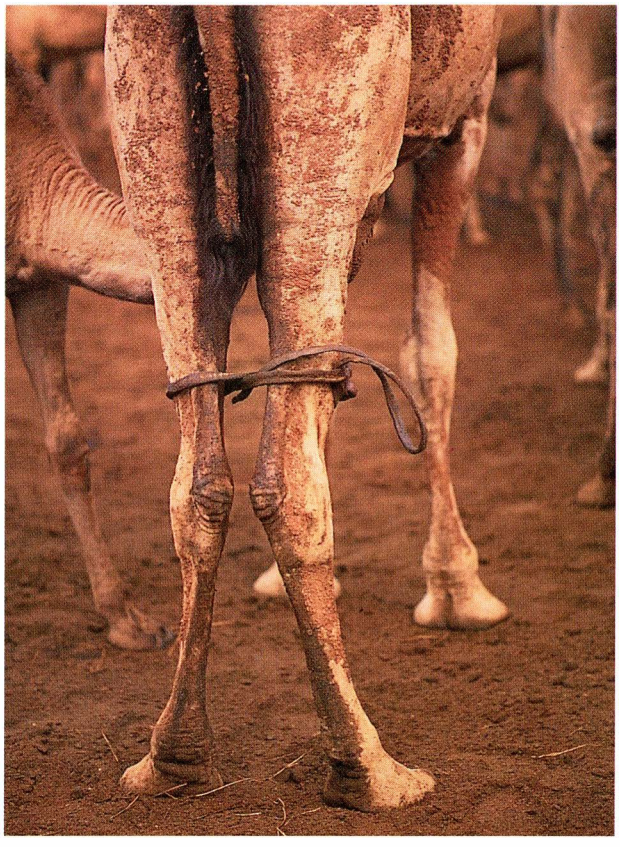


Plate III,82: Stifle hobble. This technique provides more access to the udder since hindlegs are pulled backward. It requires two people to put this particular hobble in place.

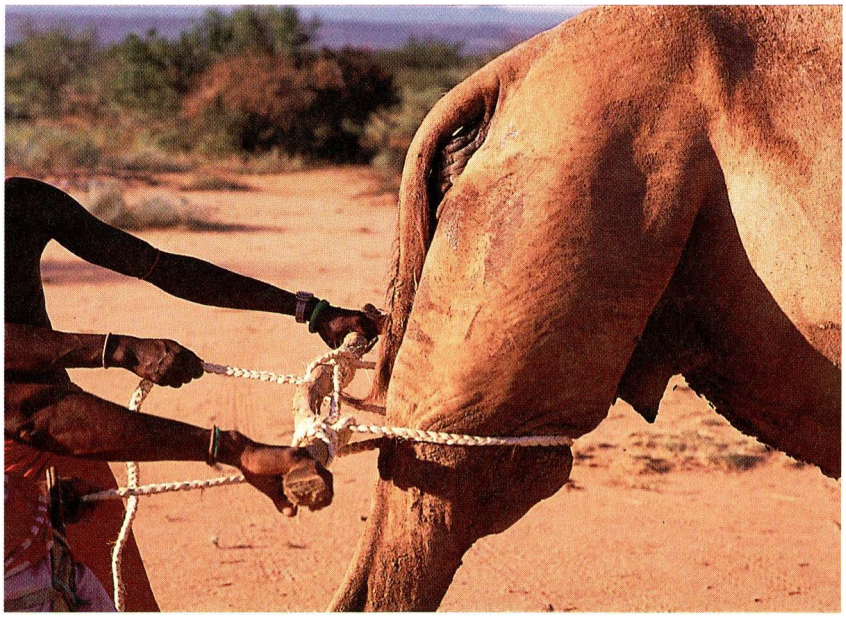


Plate III,83: The perineal device is used to force a female to suckle its calf or to be milked (see text). It consists of two sticks, usually made of Acacia wood, flattened on one side and indented at the ends to facilitate tying.

Plate III,84: The perineum including the anus is grasped and stretched and the sticks are placed above and below.

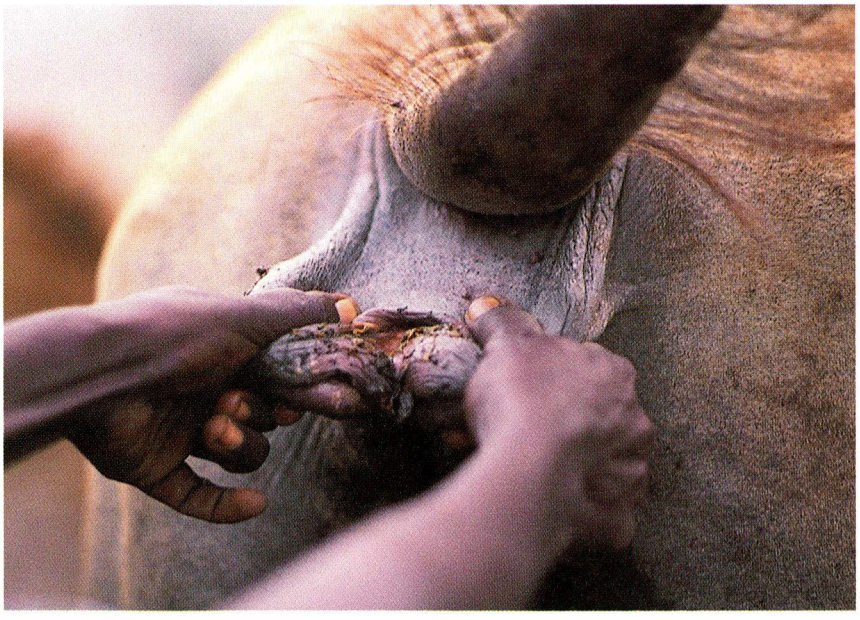


Plate III,85: After placing the device the string is several times tightly passed and secured at the end of the sticks. Anus and vagina are tightly closed and passing of feces and urine is prevented.

Plate III,86: Technique used to force the acceptance of a rejected calf. A piece of bark fibres is tightly placed over the nostrils. Due to the nearly complete closure of the nostrils the camel is forced to open mouth breathing which causes acute discomfort and distracts the animal from aggressive behaviour against the calf.

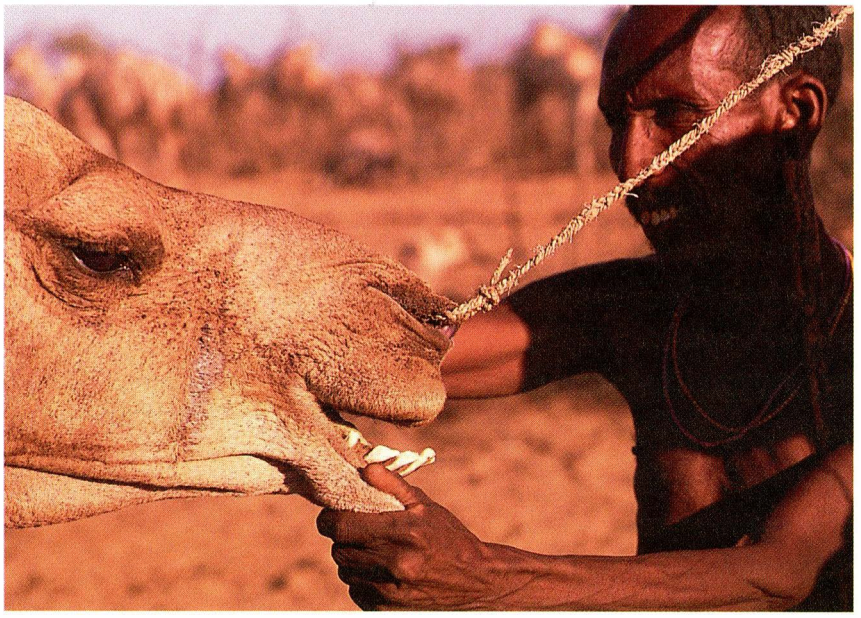


Plate III,87: A technique to force the acceptance of a rejected calf used by Rendille tribesmen. A thin rope is passed through the perforated nasal septum. The rope is then tied to a tree in a way that the head is pulled forward and upward at the same time. The camel stays tied up for several hours, which is usually enough.

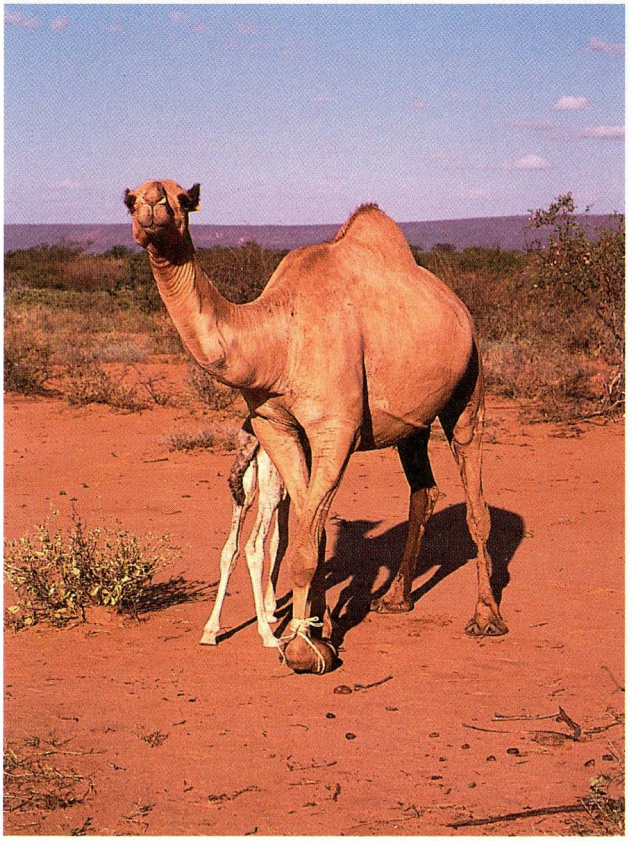


Plate III,88: Technique used to force the acceptance of a rejected calf for moderatly uncooperative mothers. Rejection may be caused by sligthly painful udder. A single hobble flexing the fetlock is placed. This device is kept on during the grazing time and removed at night. If this technique after one to two days is without success other methods are tried.

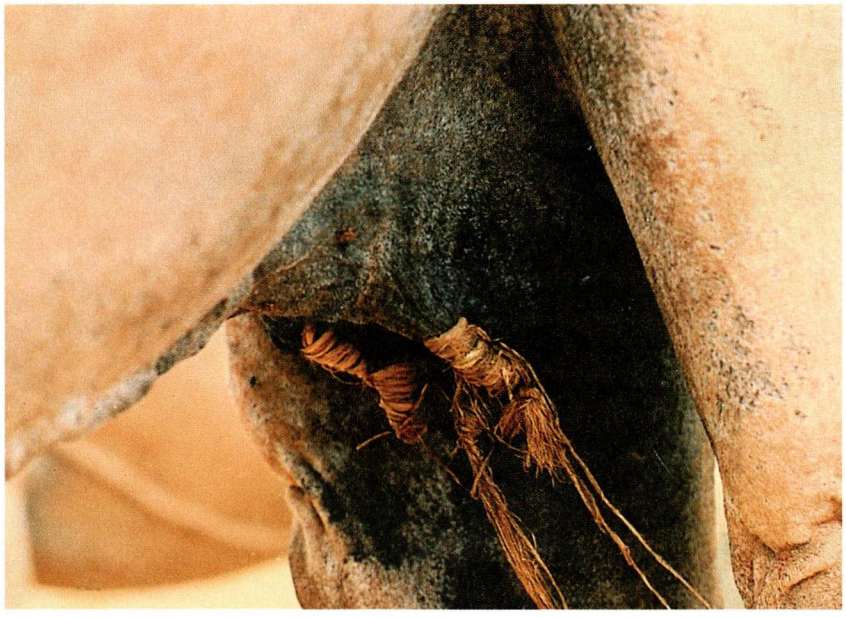
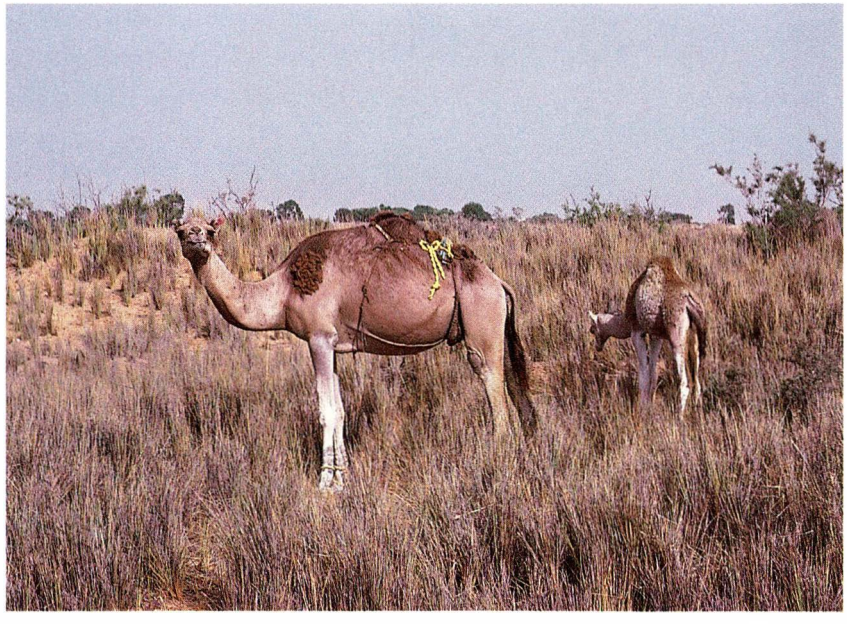


Plate III,89: Tying off teats. In Somalia and Northern Kenya two or four teats are tied off using soft bark. This technique is used when dam and calf are herded together during grazing time. At milking time the device is removed. The calf is allowed to suckle to stimulate milk let down and then the camel is milked. After milking the device is replaced.

Plate III,90: The udder basket is used in the same way as the technique above. It is easier to handle and completely safe for the female whereas the previous techniques might cause some discomfort.



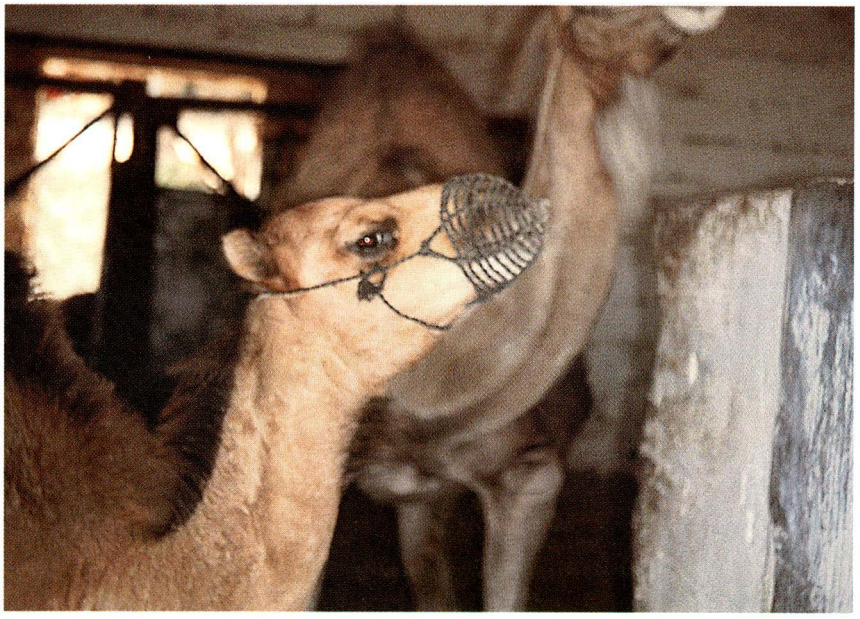


Plate III,91: The calf muzzle is mainly used during night time when animals are kept in enclosures or indoors, where they cannot feed. It is obvious that it cannot be used during grazing time.

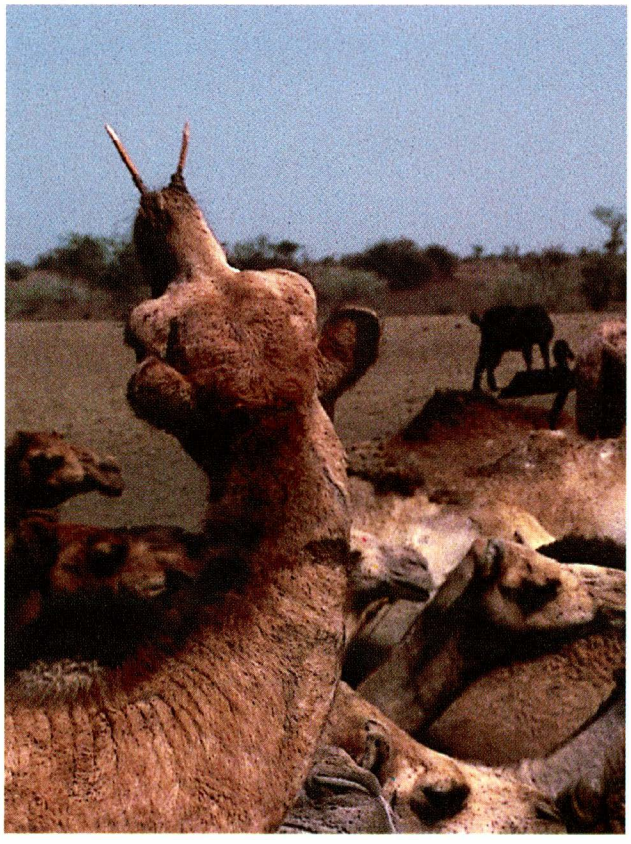


Plate III,92: In older calves, which are already weaned completely, Acacia thorns are pushed through the upper lips from inside and fixed in place with Acacia resin. If the calf tries to suckle it pricks the dams udder and is kicked away immediately. The thorns can be removed after a week to ten days.

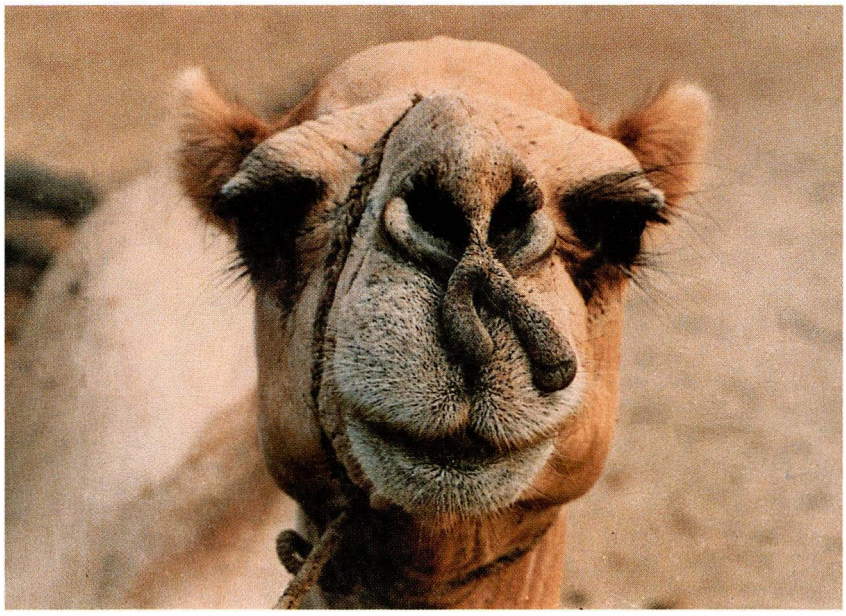


Plate III,93: Another techique to prevent suckling is to cut a thin stripe from each nostril, but left attached to form two dangling skin flaps which appear to make suckling quite uncomfortable to the calf.

Plate III,94: A thin stripe of skin is cut from the nose. The bark is tied around the skin flap so it stands upright. This has the same effect as the two skin flaps dangling from the nostrils.

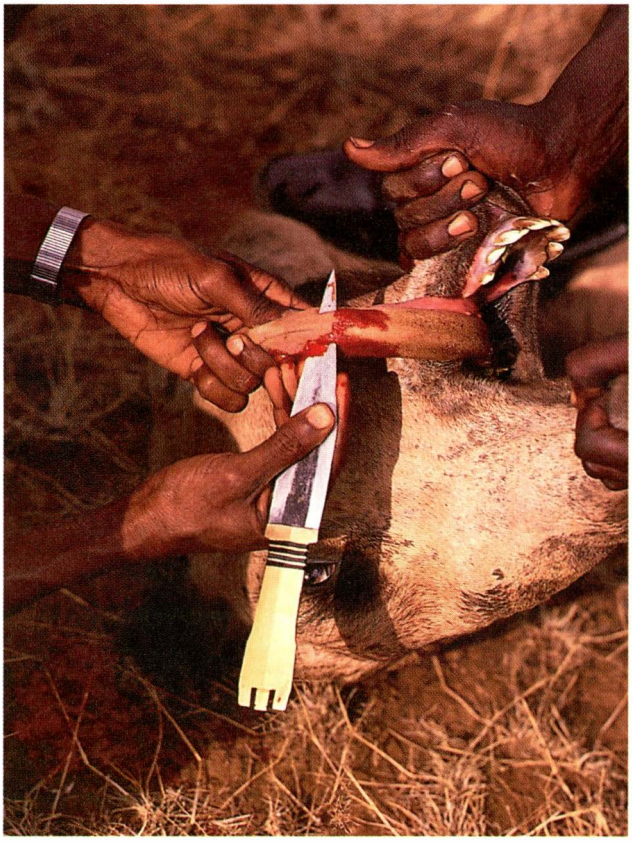


Plate III,95: A thin stripe of dorsal tongue mucosa is severed from the tongue muscle. The two layers are separated on a length of 10 centimeters and kept apart by a layer of camel hair. The incision is placed in the middle of the back of the tongue making suckling very painful but. Grazing is not impaired.

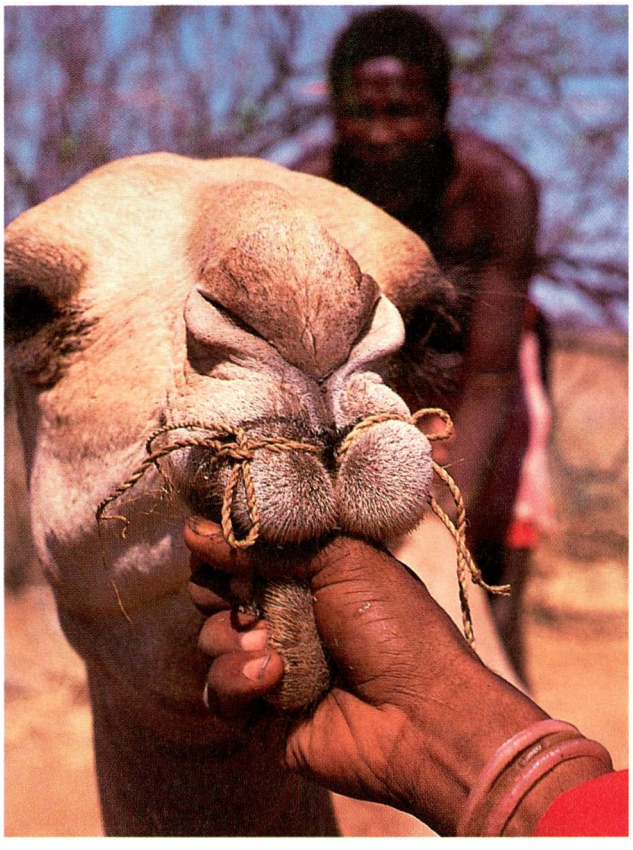


Plate III,96: This technique impairs the movement of the camels prehensile upper lip, which are needed during suckling. A thin ropes is used to tie a figure of eight around the split upper lip.

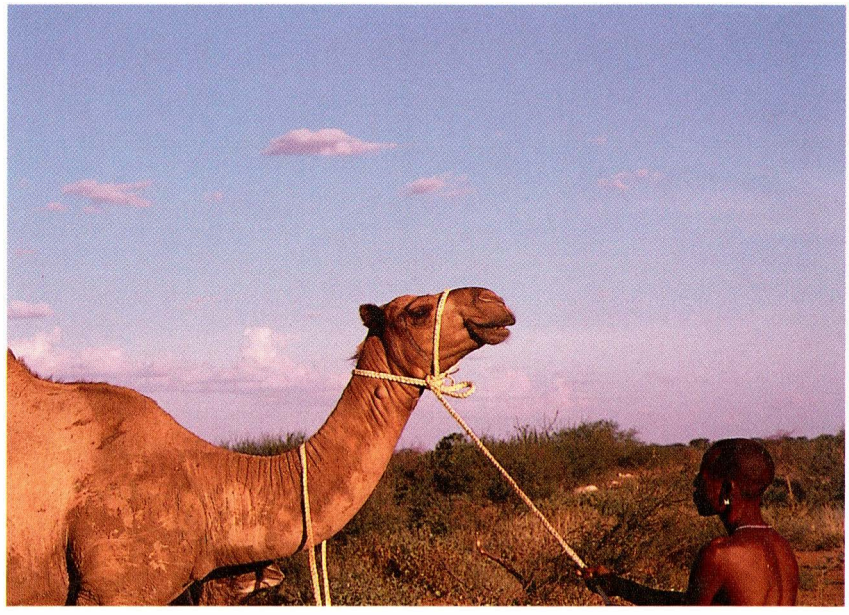
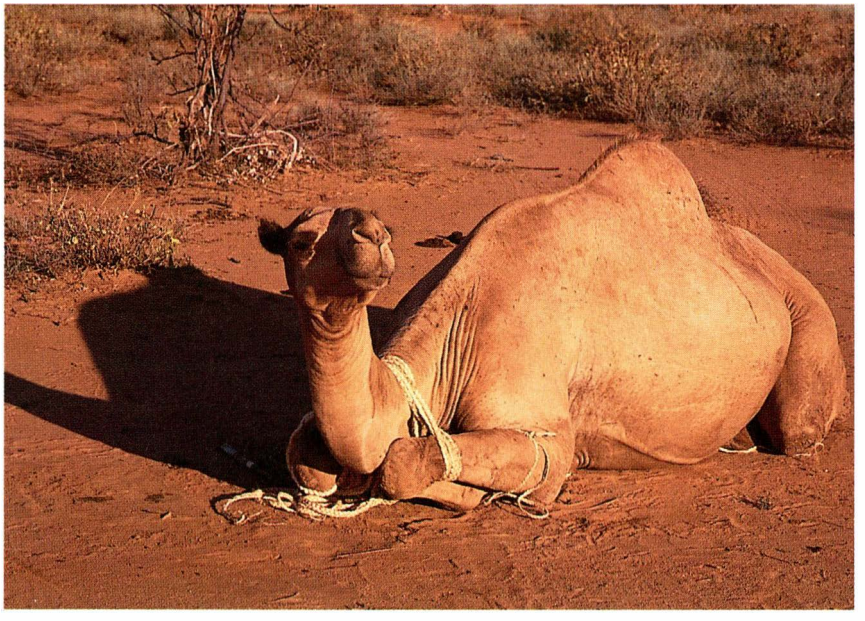


Plate III,97: Halters are used for both sexes of adult animals. Use of halters is widespread.

Plate III,98: A moderate pressure is applied for the manual lip twitch. The lips are very sensitive and the head is easily controllable. This technique is often used for easily manageable animals.

Plate III,99: For animals that are more difficult a rope lip twitch is used. This technique is particularly used on adult bulls, but also females. The rope is passed behind the canine.

Plate III,100: Neck movement can be limited and animals kept sitting by a tight rope leading around the flexed forelegs and over the neck.



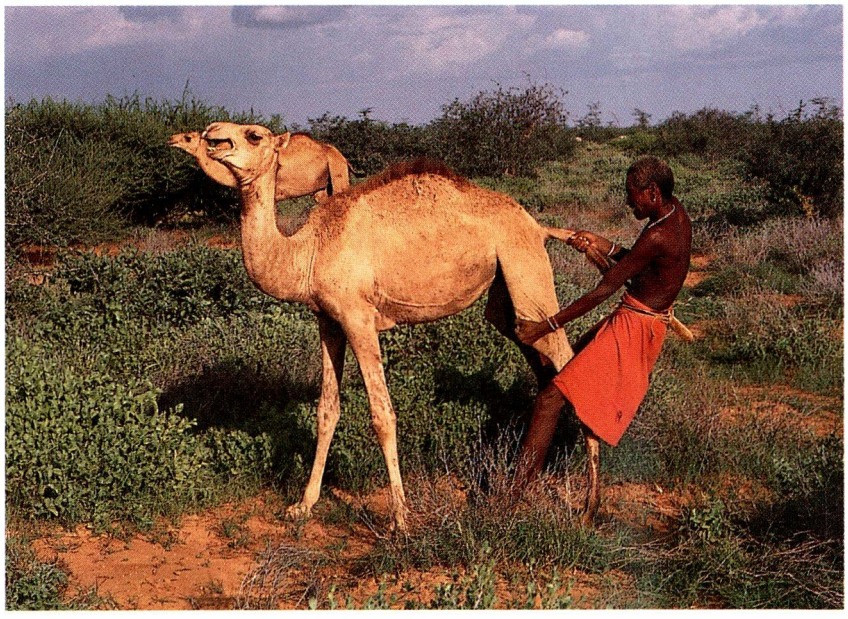


Plate III,101: A simple technique used on juvenile camels. Only one man is needed. The tail and one hindleg is grasped. Short lasting physical examinations, and application of drugs can be done this way.

Plate III,102: A commonly used front leg hobble. The leg is flexed at the carpal joint and fixed in this position. The animal can still move around, but only in a limited range and with limited speed.

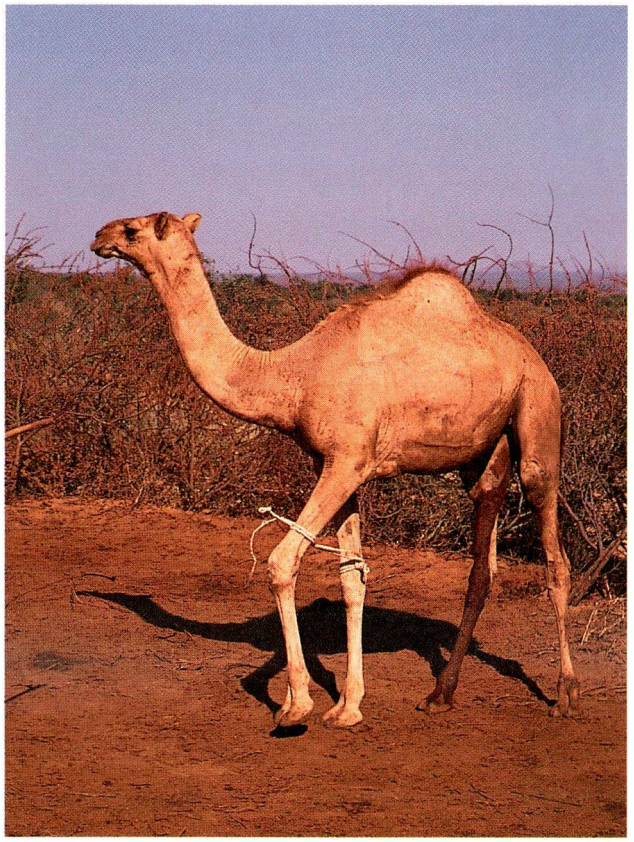
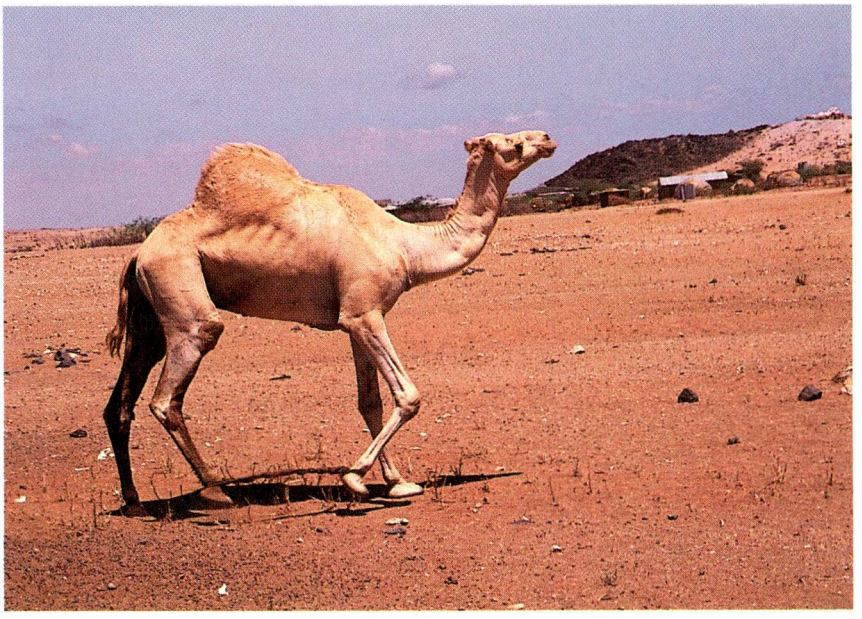


Plate III,103: This technique is used when moving single animals which show inclination to run away. A high frontleg hobble is placed. This restricts the animal to slow walking.

Plate III,104: Another technique, but used for the same purpose as the previous one. Front and rear leg on the same side are tied together. The hobble is just placed above the fetlock. The animals can move but only slowly.



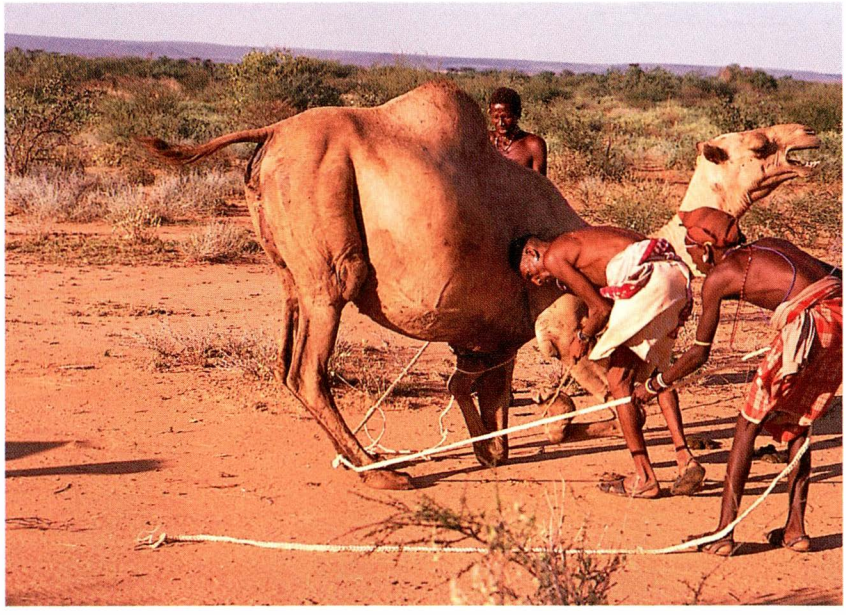
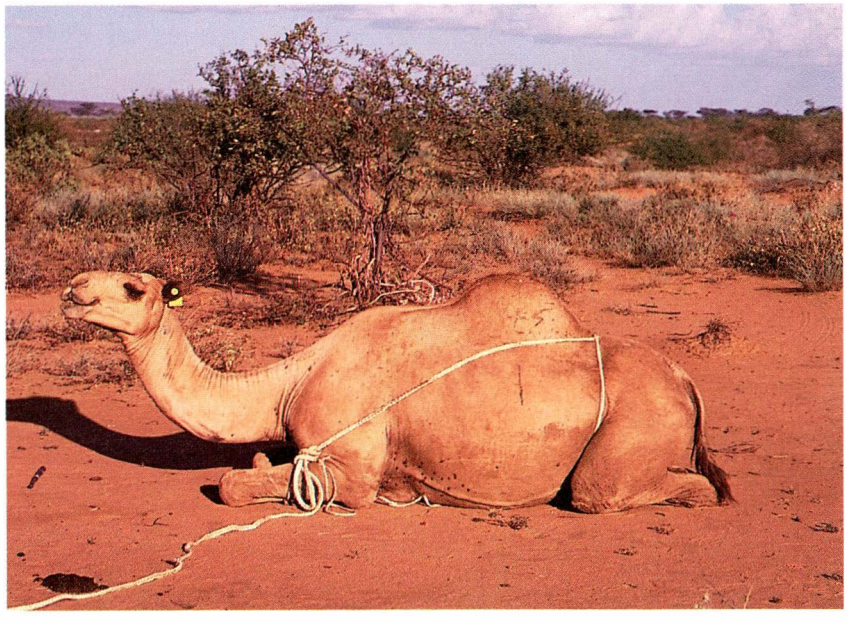


Plate III,105: This is the initial stage of a technique used to immobilize an animal completely. To throw the animal a rope is passed behind the hindlegs and than pulled forward. It is used on both sexes, mainly on adult animals.

Plate III,106: The animal is secured and tied in sternal recumbency.



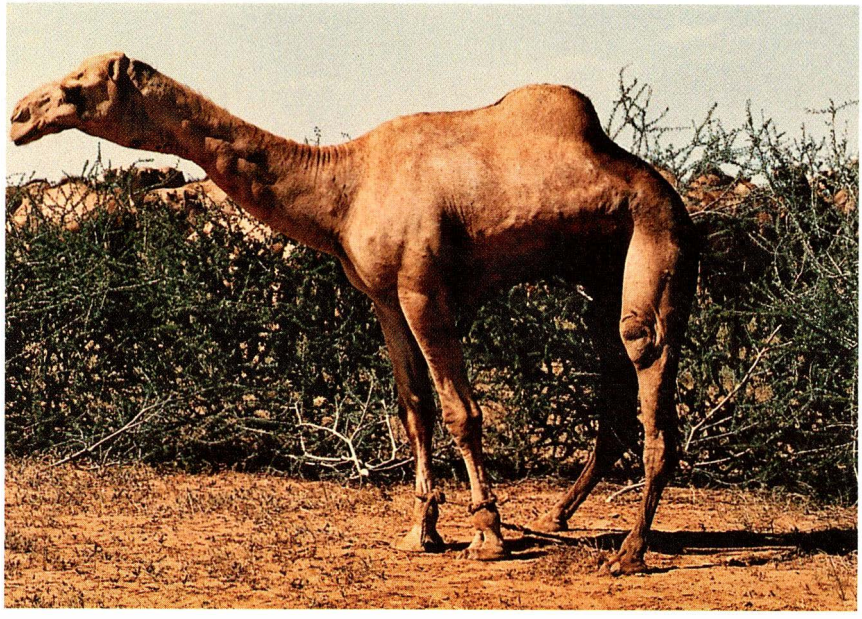
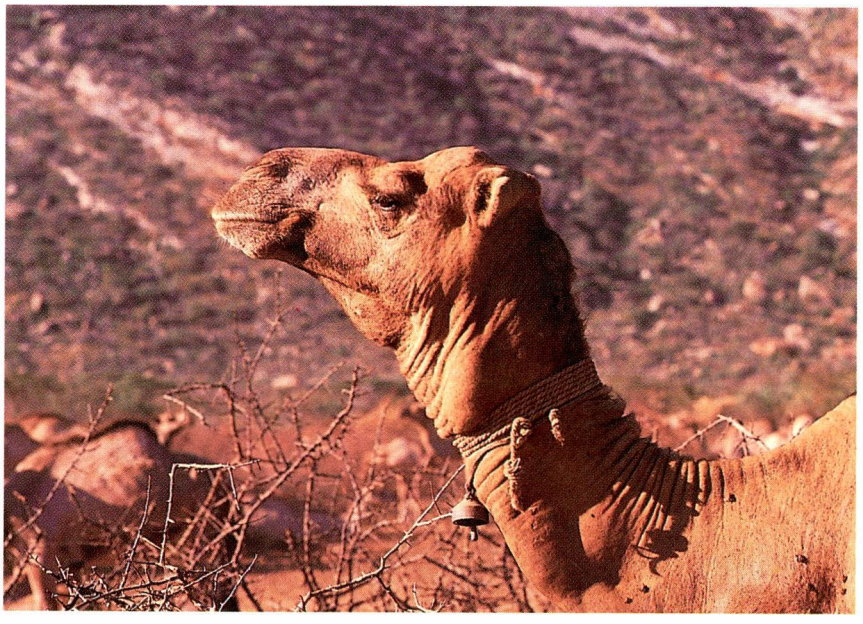


Plate III,107: This technique is used to restrain rutting bulls from fighting. The bull is staked out by ankle ropes. This technique is used by Somali herders. Sometimes the ankle ropes are not secured to the ground.

Plate III,108: This is a technique used by Rendille herders. A tourniquet is placed around the bulls neck which causes discomfort by restricting blood flow and breathing whenever the animal exerts itself. This device allows normal activity, but not fighting, running off etc.



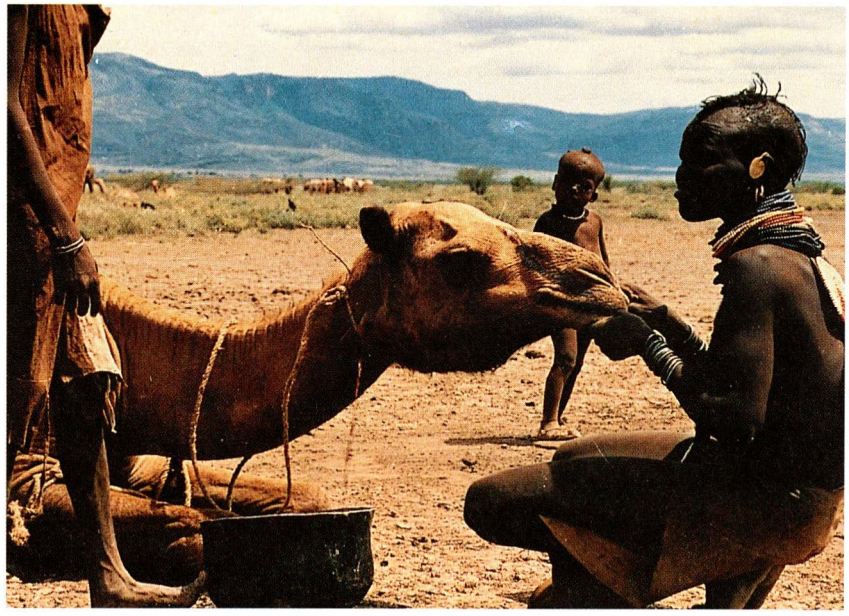


Plate III,109: Usually only geldings are bled. The animal is restrained in sternal recumbency and the head is fixed by a manual lip twitch. A tourniquet is placed and the jugular vein is pierced. Up to 5 litres of blood can be taken in a single bleeding. The blood is either consumed fresh or mixed with milk and fermented.

Plate III,110: Surgical castration is done by a longitudinal scrotal incision using the traditional wrist knife of the Turkana tribesmen.

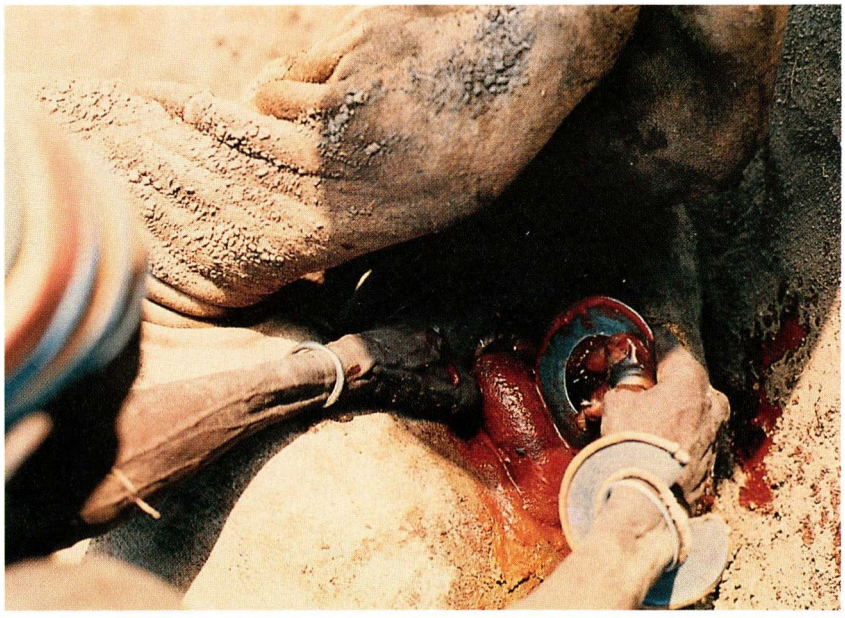


Plate III,111: The same animal ten days later. Large amounts of granulation tissue had formed due to severe spermatic cord infection. This is a common sequela to traditional castration. A common fatal complication is internal bleeding, since no vessels get ligated or crushed.

Plate III,112: Female camels with a rather horizontal angulation of the rump frequently have a problem when rising or walking. This application of branding is meant to improve weakness of the hind quarters. The success of such treatments could not be ascertained

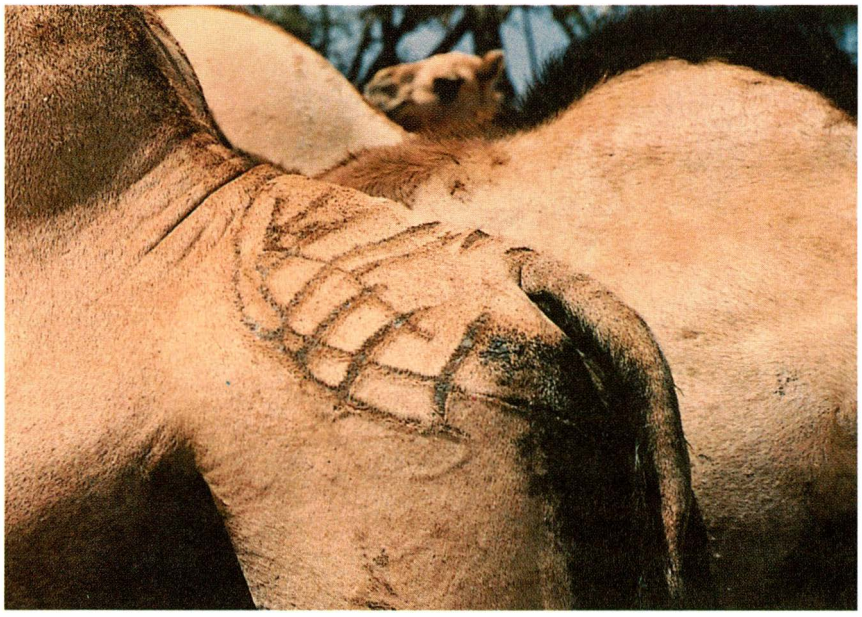


Plate III,113: Branding of the stifle joint. The stifle joint is most commonly affected by painful swellings and subsequent intermittent lameness. Branding appears to improve the condition at least temporarily.

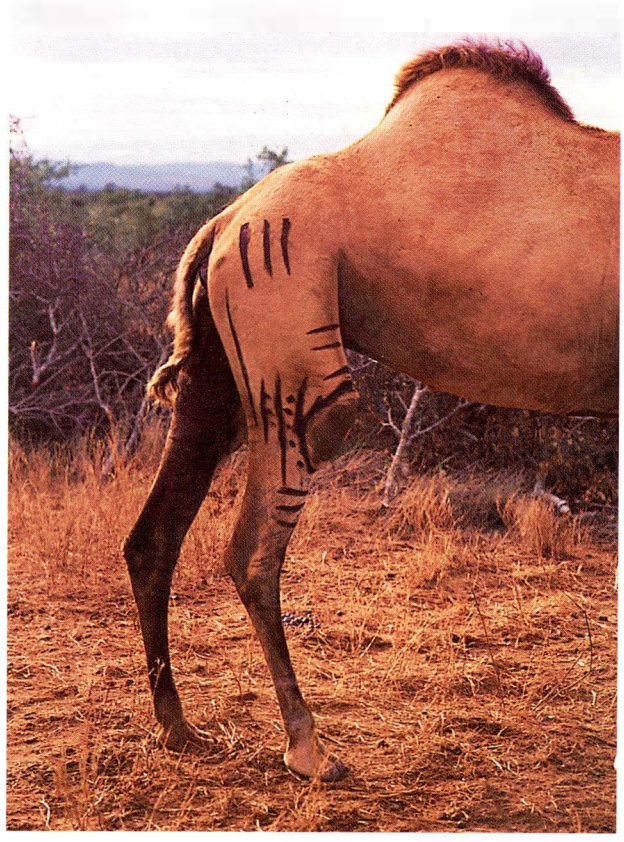
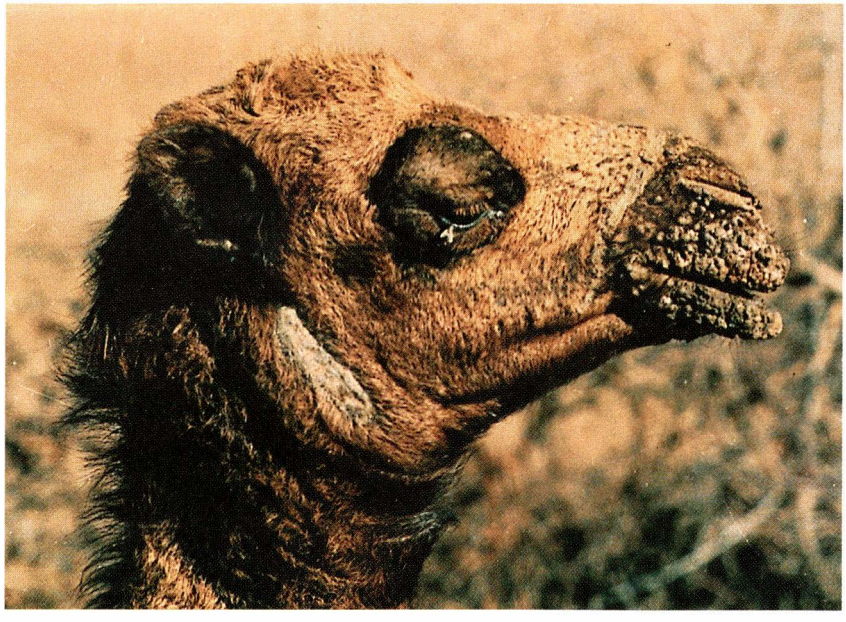


Plate III,114: Branding of the mandibular lymphnode. The patient is a young camel with a previous history of camel pox.



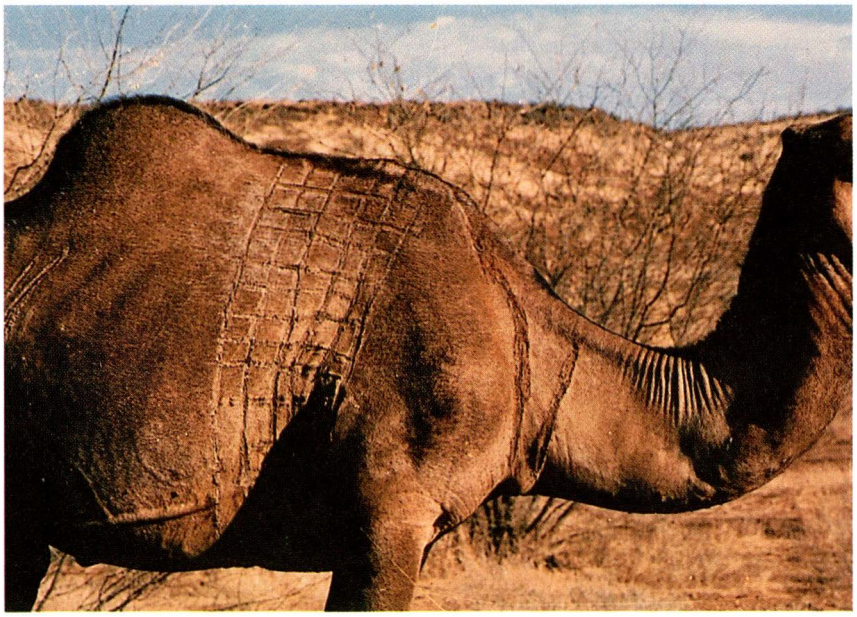


Plate III,115: Branding of the chest as a treatment of pneumonia. Branding of the abdomen is only done if abdominal edema is present due to trypanosomiasis infection.

Plate III,116: Wither wounds heal very slowly. To prevent wound pecking by birds the wound is covered with mud and oistrich feathers are attached which act as a scarecrow and keep birds away.

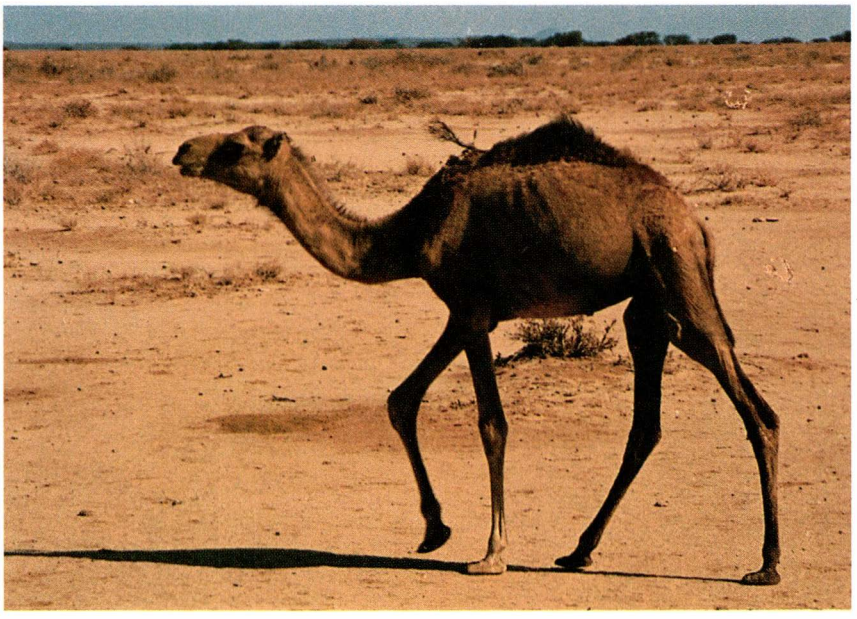
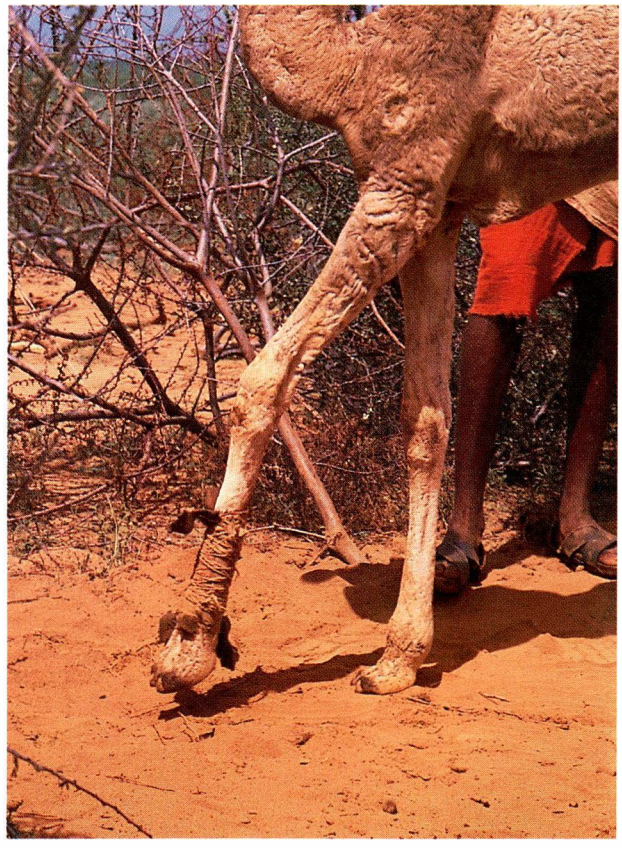


Plate III,117: Boots made of leather or as in this picture out of an old inner tube of a car tire are used as a protective bandage for solar wounds when the wound is not suppurating.

Plate III,118: Young calf with a fractured canon bone. This treatment is applied frequently but not always successful. This particular calf died shortly after, but of a different cause.



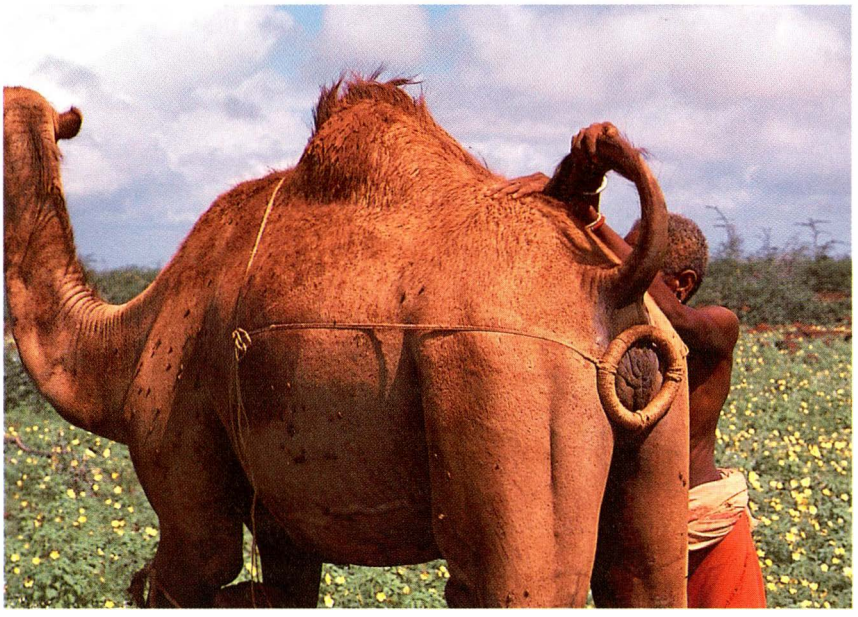


Plate III,119: For treatment of vaginal prolapse, this device is placed over the vulva after delivery. The device is fixed with two ropes around the belly and two leading ropes around the neck.

Plate III,120: The first step in slaughtering a camel. The animal is brought into sternal recumbency, the head bent laterally and with one quick incision all major cervical vessels severed. Immediately after the nuchal ligament is severed.

Plate III,121: The skinning begins with a dorsal incision along the lenght of the body.

Plate III,122: The carcass is completely skinned.

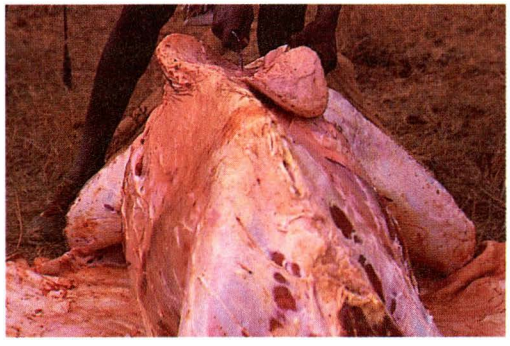


Plate III,123: The hump is sliced lengthwise into two parts and removed.

Plate III,124: The scapula is severed from the rib cage.

Plate III,125: The ribs are removed.

Plate III,126: The complete gastro-intestinal tract is removed.

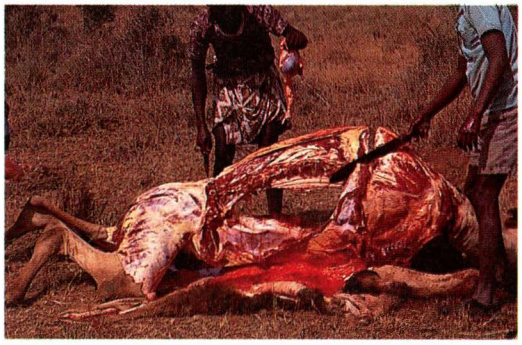


Plate III,127: The spine is cut out.

Plate III,128: Upon removal of the spine the carcass collapses.

Plate III,129: The hide is split.

Plate III,130: This is a traditional slaughter and meat inspection station at Korr. The set up is very inexpensive, but suitable. The slaughter is performed on a rock pile for hygienic reasons.

Plate III,131: This is the similar, but modern set up with concrete slab in North Korr. The place is easy to clean.

Plate III,132: Traditional butchering of small stock and cattle is often carried out with the carcass suspended from a tree or simple scaffold. With camels this would have to be approx. 6 m high.

Plate III,133: Recommended injection site for subcutaneous injections. There is enough loose skin to pick up a fold.

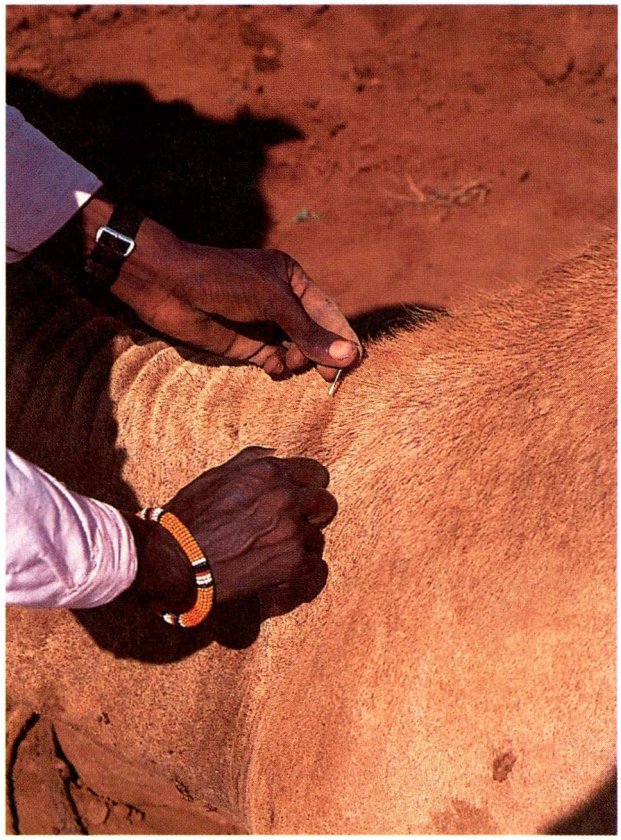


Plate III,134: Site for deep intramuscular injection at the neck.

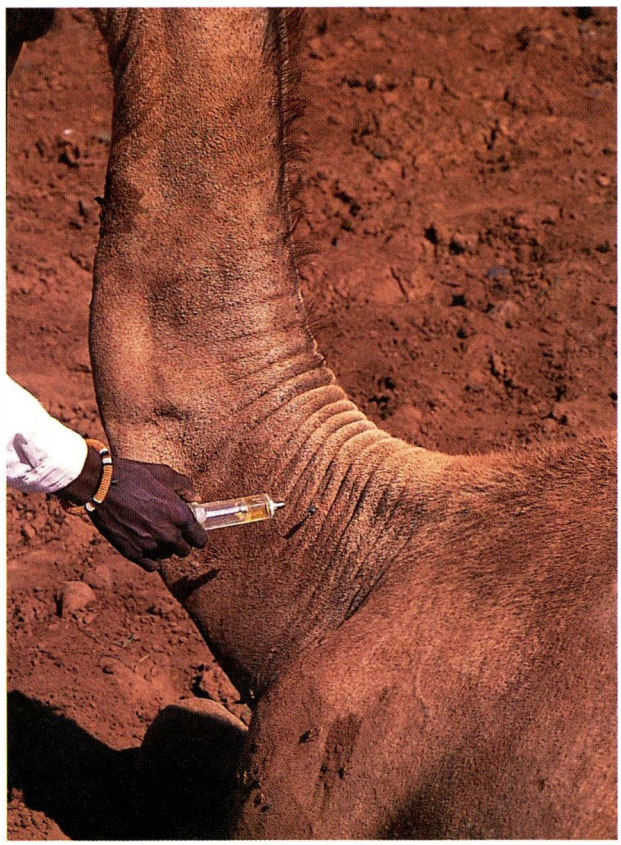
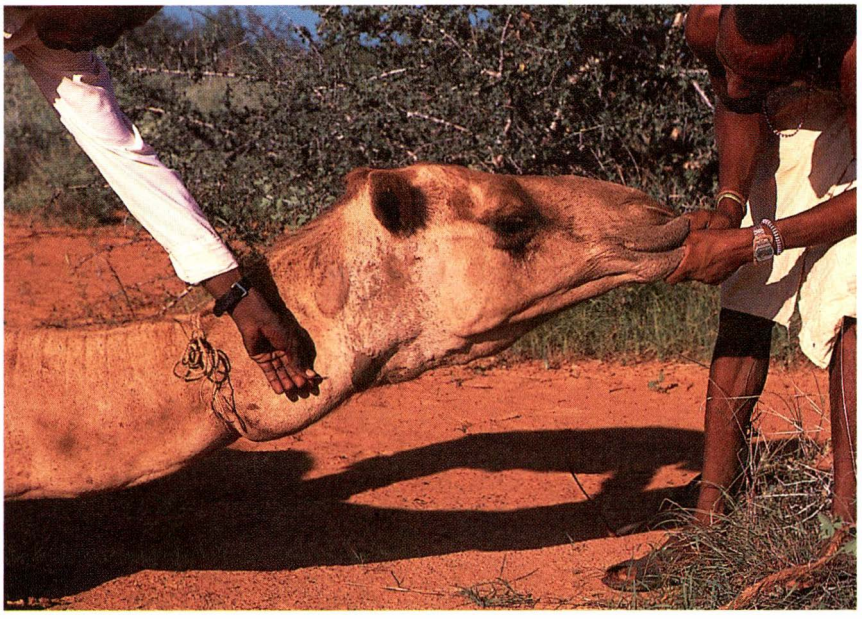


Plate III,135: Site for deep intramuscular injection at the rump.

Plate III,136: Site for intraveneous injection and blood sampling at the jugular vein.



There is still another strategy to make a camel accept a calf which has been refused initially. It relies on strengthening the maternal instinct, it so to speak constitutes the soft psychological approach to the problem. Camels are naturally gregarious animals and tend to form very dense groups with body contact during the night. The refusing mother is isolated from the main herd, often taken out of ear shot, and kept for the night in a small separate enclosure together with the calf. During the night a herdsman clad in a lion skin or that of another predator approaches the enclosure repeatedly simulating by noise and behaviour a predator intending to take the calf. At the slightest protective action of the mother he will withdraw, but repeat the attack after a few moments. The isolation from the herd and the natural gregarious instinct of the camel will strongly stimulate the mother to protect the calf at first by seeking close contact. If that happens she will usually accept it. All the techniques described can be applied in a combined approach and varied to fit the circumstances. They are frequently used also to force a lactating female which has lost its calf to accept a foster calf.

Weaning

Camel calves are usually weaned at an age of 6 to 12 months. If milk is either in abundant supply or demand is low, the herders do not interfere and calves suckle until their mothers dry up, which might be as long as 18 to 20 months. This is rarely the case. Normally there is stiff competition for the milk between calf and herder and weaning is done, when the calves intake of forage is sufficient to sustain it. The easiest way of weaning is to transfer the calf to a different herd. Since this is not always possible other weaning techniques were developed.

One is shown in Plate III,92. Sharp little sticks or large thorns are pushed through the upper lips of the calf from the inner side and fixed in place with gum or resin. If the calf now tries to suckle it will prick the dams udder and will get kicked away. Other methods make suckling painful to the calf; one is to partially cut a small skin flap from the nose of the calf and tie this in an upright position with bark fibres (Plate III,94), the other is to separate a thin strip of the dorsal mucosa from the tongue muscle (Plate III,95). The first is painful when the calf tries to massage the udder, the second one makes sucking quite painful. Both techniques do not impair grazing or browsing. Cutting narrow strips from the nostrils but leaving them attached (Plate III,93) makes suckling likewise painful, whereas tying the prehensile parts of the split upper lip with thin string in a figure-eight knot makes it impossible for the calf to keep a hold on the teat (Plate III,96). With all these techniques weaning can be achieved within a few days.

Restraining

Contrary to their reputation, well handled camels are friendly and docile and maybe even affectionate, if they know a person well. Nevertheless there are occasions when they need to be restrained or immobilised. This can be done best quietly but with determination and without any physical abuse. Many camels can be controlled with minimal effort, using a halter or just the manual lip twitch as in Plate III,98. A quick and efficient way to restrain calves and immatures which are

not too heavy, for a brief inspection, drenching or injection is to grasp them by the tail and the lower neck, virtually hugging them to ones chest. Slightly larger animals can efficiently be held for a few minutes by grasping the tail and one hindleg just above the knee (Plate III,101).

Adult animals can be controlled and guided with a rope halter in most situations. Should it be necessary to keep an animal from moving fast it is common practice to tie one foreleg to itself, fetlock to forearm (Plate III,100). The animal can still move around over considerable distance and feed, but it cannot run. Other hobbles (Plates III,103, III,104) serve a similar purpose but allow some more freedom of movement. They are applied to keep animals from straying too far away from the herd.

For longer or painful treatments such as branding or castration it is necessary to immobilise a camel in a sitting position. One technique is shown in Plates III,105 and III,106. It might still be required to restrain the head which can be done by the manual lip twitch or also by a rope twitch which can be fixed securely behind the lower canines. There numerous variations to this technique, one also for immobilising an animal lying on its side.

Some restraining techniques are specifically suited to control bulls in the rutting season. To keep a rutting bull from fighting other males and from wandering off in search of females in other herds, his forelegs are tied together with a short rope just above the fetlocks, efficiently restricting him to very short strides (Plate III,107). In another method, which is favoured by Rendille tribesmen, a tight rope collar slightly constricts blood flow in the jugular and creates a slight discomfort (Plate III,108). If the bull tries to engage in any strenuous activity blood flow and breathing becomes rapidly impaired and the animal is forced to calm down immediately. Grazing and other quiet activities are not hindered at all by this device.

Bleeding

In East Africa there are a number of pastoralist groups which bleed cattle to consume their blood either fresh or mixed with milk and fermented. Some ethnic groups which keep camels follow this practice. In Islamic societies this is never done.

It is mainly younger males or castrates which are bled. Immature and fertile females are generally excepted. Bleeding is done through a small incision in the jugular vein which is kept turgid by a tourniquet (Plate III,109). An alternative bleeding site is the facial vein. The amount of blood collected at one bleeding varies with size, weight and nutritional status of the animal, 5 to 7 litres are often taken in one bleeding from an adult animal. Animals are commonly bled twice or three times a year. If the need arises bleeding intervals can be reduced to approximately six weeks without detrimental effects on the animals, provided the feed base is adequate.

Castration

Camels are castrated for two purposes; one is to obtain large but docile pack animals, the other is to raise surplus males specifically for slaughter. The age at which the operation is performed depends largely on that. Generally camels are castrated rather late in most of Eastern Africa. The major reason for this is, that the selection decision whether to retain an animal for breeding or not, is only made when the animals approach sexual maturity at approximately four years of age. By then it is easier to judge the potential development than at an earlier age. Males which are castrated at that age are usually destined for slaughter. Normal age at slaughter is 6 to 7 years, when the animals are fully grown and have developed the large hump, which is typical for geldings. If the animal is to be used as pack animal castration is done after the animal has reached full maturity at 7 to 9 years of age. By that time the hump will not any more develop to the same proportion after castration, which would be cumbersome for saddling and loading.

Surgical castration is the common method. The technique is not very sophisticated; two longitudinal incisions are made on the scrotum, the testes pulled out and cut off with straight cuts (Plate III,110). Blood vessel are neither crushed nor ligated. Post-operative complications are infections (Plate III,111), internal bleeding (Plate V,28) and scrotal or inguinal hernias. Bloodless castration by crushing the spermatic cord between two sticks or by using one stick and a small wooden mallet, as it is commonly done in cattle, sheep and goats, is very difficult in camels since, especially in young bulls, the scrotum is very tight and the scrotal skin is very thick.

Traditional treatments

Camels diseases are quite well known to most pastoralists in the region and diagnoses are very often correctly made. In most local languages there is an extensive vocabulary on diseases and health conditions (see Chapter IV). There is also a wide range of treatments which include herbal preparations for oral administration, ointments, rinses and disinfectants for external application, branding for curative purposes and treatments for wounds, abscesses and fractures. Some of these are applied very effectively. They all have in common that they are readily available and applicable in remote areas and, more important, that they are cheap.

Most widely spread and most frequently applied as a treatment is branding. It is used against a wide range of conditions, but mainly against swollen joints, stiffness and lameness, general musculo-skeletal faults, pneumonia, swollen and suppurating lymph nodes and abdominal oedema. Against conjunctivitis branding is applied around the orbit. The main effect is enhancing localised blood flow, thereby aiding the healing process in cases of localised infections and inflammations. The branding is normally applied extensively in lines, circles and points and is thus serving also an additional purpose, namely to decorate the animal. Quite often this is the major motive for branding an animal, as might be seen also in Plates III,112 to III,115.

Traditional treatments of wounds and fractures and other physical conditions are also quite well developed. Some typical examples are shown in Plates III,116 to III,119. Herbal preparations, ointments and disinfectants are known, but not universally applied, unless there is a specialist in these fields.

Slaughter

In contrast to other livestock species camels are slaughtered and butchered in a seated position (Plates III,120 to III,130). The reason for this is that camels would require a scaffold at least 5 m high to facilitate butchering a hanging carcass. Butchering camels lying on the back is also not practicable because the distinctly arched spine and the hump make balancing the carcass virtually impossible. Instead they are seated normally, front and hind legs are tied, the head is bent sideways and backwards, and the large blood vessels at the base of the neck are cut with one quick stroke of the knife. Death is immediate. The carcass is kept in the sitting position. For better balance of the carcass the hind legs are pulled backwards and outwards. The nuchal ligament is cut just in front of the shoulder, so that neck and head rest on the ground.

Skinning begins with a long incision along the spine and the crest of the hump. The skin is removed down the sides and cut off the legs before the elbow and knee callosities. Butchering begins with splitting and removal of the hump. Removal of the various cuts is always done symmetrically to maintain the balance of the carcass. The spine and the long muscles of the back are left intact until all internal organs are taken out. Then the spine is cut out between the withers and the pelvis and the remainder of the carcass collapses and is cut into smaller pieces. At last the skin is cleaned out and cut in two symmetrical pieces.

Modern management practices

General management

Virtually all camels in Eastern Africa are kept in traditional production systems. Only a minute fraction of the regional herd is kept on modern, commercial ranches or in research stations, which extend improved management to camels. Even in these rare cases there are no management techniques which are specific to camels, but rather solid and common sense management measures applicable to all large domestic herbivores. This includes supplementary feeding, mineral supplementation, regular watering, preventive treatments against the major endemic parasites and diseases, curative treatments of acute disorders and controlled reproduction. As stated before, little systematic research has been done on the effects of improved management on the productivity of camels to date. This section will therefore deal not so much with general management aspects but will concentrate on aspects of modern health care only.

Health status assessment

Camels usually inhabit remote areas, where diagnostic facilities and laboratories are very scarce. As rule the diagnosis of diseases and disorders has to be based mainly on clinical symptoms and the diagnostic exclusion of other diseases. The health status of a camel or a herd of camels is not easy to assess. The appearance of the animals can be quite deceptive. Hollow flanks, a retracted abdomen and a shrunken hump might be indicative of a severe systemic illness, but might also be the result of a weeks dehydration, which is quickly reversed, when the animal can drink its fill of 100 to 120 litres of water.

In the process of interpreting signs of disease it is essential to develop a proper diagnostic routine. This should include an evaluation of the animals environment, particularly the supply of forage and water. General information on the health history of the herd and the individual animal also needs to be ascertained before a general inspection and a clinical examination is attempted.

Much of an animals health status is reflected by general appearance, condition, conformation, posture and behaviour, which can be judged by careful observation. Weight loss is characterized by hollow flanks, a retracted abdomen, a flabby hump and, in extreme cases muscle atrophy, especially of the hind quarters. Temporary loss of body weight and condition is normal in dehydrated animals, in camel bulls during the rutting season, in lactating females and in animals which are overworked. A gradual, but permanent decline in body weight can be observed in very old animals. In young animals a prolonged weight loss is always indicative of a chronic generalised disease.

When camels drink after a longer dehydration an instantaneous weight gain of 100 kg or more can occur, which would be equivalent to a 25 to 35 % weight increase in an adult camel. The improvement in general appearance is also quite remarkable. Due to the generalised subcutaneous which develops shortly after watering previously emaciated animals might appear well nourished and sleek within one or two hours. Edema however, can also be clinical symptoms of acute typanosomiasis, camel pox and contagious ecthyma.

Reluctance to move, adoption of specific postures, restlessness, vocalisation such as grinding the teeth or grunting at certain movements indicative of painful conditions. Painful conditions of the extremities may result in resting of limbs, frequent shifting of weight from limb to limb. Grunting when rising or sitting down may either indicate abdominal pain or a traumatized pedestal pad. An extended neck together with strictly abdominal respiration, dilated nostrils or open mouth breathing points to acute chest pain.

Camels are gregarious animals. They may separate temporarily into small groups or even individuals while grazing, but they rarely go out of sight. Longer voluntary separation from the herd or seeking shade when the herd is still feeding is a safe indicator of illness.

Animals suffering from prolonged illness appear dull and do not respond well to external stimuli. When sitting the head is more often extended forward and rested

on the ground than usual. Normal grooming behaviour such as sand bathing, rubbing and scratching is reduced or completely lacking, resulting in a soiled and dull appearing hair coat. Due to their reduced motoric activity the animals are quite often covered by abundant flies, other insects and tick birds.

Excessive grooming behaviour, on the other hand, is usually caused by ectoparasites or by allergic and irritant contactants such as insect stings, plants and drugs. Excessive grooming can result in localized hair loss, inflammation of skin, excoriation, secondary infections of small lesions and necrotic thickening of skin.

Clinical examination and diagnostic procedures

Table III,4: Protocol for a clinical examination of camels

General information	Herd, animal identity, sex, age, weight
Main symptoms	descriptive
Appetite	descriptive
Last watering	
Rectal temperature	morning, evening
Respiration	
frequency	
quality	laboured or free
Pulse	value, regular, irregular
Mucous membranes	pale, pink, red, haemorrhages
Palpable lymph nodes	
Stomach motility	
(Rectal palpation)	
Faeces	
consistency	pellets, shaped, unshaped, liquid
colour	
visible parasites	descriptive
Urine	
quantity	
colour	
Discharges	quantity, colour, consistency
eyes	
nostrils	
mouth	
vagina	
Miscellaneous	

Table III,4 suggests a protocol for a routine clinical examination of camels. As such it is not specific for camels. Specific is rather what has to be considered normal or a pathological deviation in camels. The major points are discussed below. General information on the patient, description of the main symptoms and the current displayed appetite is still unspecific to camels. Number of days since

last watering can be an essential aspect of judging the animals condition (see above).

Body temperature: Camels show a marked diurnal fluctuation of body temperature (Chapter I). The range of normal values is given in Table III,5. High temperatures during the morning are indicative of fever. Accompanying symptoms are hyperlacrimation, injected conjunctivas, increased respiratory and pulse rate, loss of appetite, dull and depressed appearance, decreased urine production and later rapid weight loss.

Table III,5: Normal values for physiological parameters* in resting adult camels

Parameter	Value
Temperature	35.5 - 41.0 łC
morning	35.5 - 37.5 łC
evening	39.0 - 41.0 łC
Respiration	5-12/min
Pulse	32-50/min

*Besides pathological conditions a variety of environmental and host factors including age, sex, ambient temperature and watering interval, stress, and physical work out have an effect on these parameters. A physiologically increased respiration, pulse rate and body temperature can be seen in young animals, stressed and frightened animals, during the rutting season, after physical work-out and at high ambient temperatures.

Respiration rate: Camels are obligate nasal breathers of a pronounced abdominal respiratory type. Open mouth breathing is always an indicator of discomfort, stress or illness. Respiratory rate is best established by watching flank movements from a distance or by thoracical or tracheal auscultation using a stethoscope. Laboured breathing, coughing and snoring are always indicative of respiratory diseases. Coughing occurs more often during the night or after resting, when the animals rises. Nasal and/or ocular discharge is frequently seen in the case of fever, local irritation and inflammation due to parasite infestation, frontal sinus infection, ocular diseases and upper respiratory diseases.

Pulse: In adult animals evaluation of pulse is best done with the animal sitting. Several arteries including the posterior tibial artery, the middle sacral artery and the femoral artery are equally accessible and suitable. In adult animals matted hair and dirt crusts on the hindlegs can make reliable pulse detection quite difficult when using the posterior tibial artery. Attempting to use the femoral artery requires patience since the animal might object the presence of a hand there. In young and immature camels the tail artery is the most convenient. Cardiac auscultation can be used instead if pulse can not be reliably detected. Intermittent irregular pulse is not uncommon in camels and is not always a sign of illness.

Palpation of lymph nodes: Important superficial lymph nodes, which are palpable are shown in Figure III,7 Temporary swelling of peripheral lymph nodes is most commonly due to localized or systemic infections. Site of infection and peripheral lymph node reaction correspond. In systemic diseases all peripheral lymphnodes may be affected. The swollen lymph node may be tender to touch, hot and the overlying skin edematous and reddened. Increased sensitivity to touch and warmth is indicative of active infection. In the process of healing enlarged lymph nodes do regress in size, however not to their original size and are often insensitive to touch.

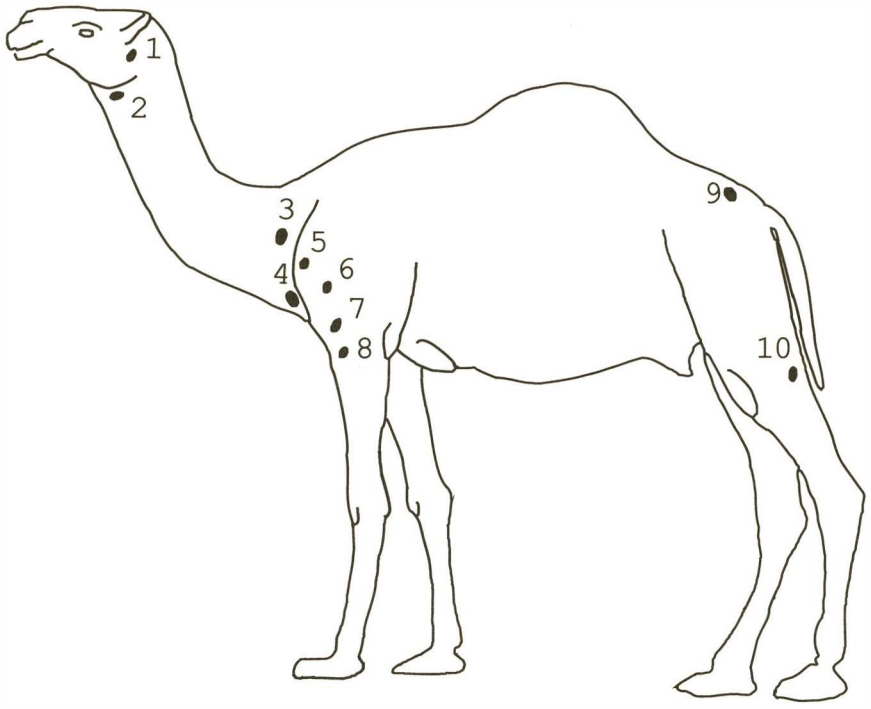


Figure III,7: Schematic drawing of palpable lymph nodes in camels: 1 = pre-parotid; 2 = pharyngeal; 3 = pre-scapular; 4 = inferior cervical; 5 + 6 = external thoracic; 7 = pectoral; 8 = cubital; 9 = ileo-pelvic; 10 = superficial.

Abdominal examination: Stomach motility in camels is different from ruminants, consisting of a total of 12 contractions per cycle. A typical motility cycle is 4.5 minutes long, including a pause of approximately 2.5 minutes. About 2-3 audible contractions per minute can be noted when auscultating on the left flank. Passage of a stomach tube for taking samples of stomach fluid and particles is possible in camels.

Rectal palpation: Rectal examination should be performed in a sternal recumbent animal. In camels the rectum is quite tight and friable. The examiner should have small hands and use sufficient lubrication to reduce risk of rectal perforation. Bladder, large intestines, left kidney and the female genital tract can be palpated. Reliable pregnancy confirmation is possible from the late second month of pregnancy onwards. A prominent corpus luteum can be felt and the left horn is markedly increased in size compared to the right one. Reaching the left ovary can be sometimes quite difficult.

Urination, defecation and salivation: Camels frequently urinate and defecate especially after rising. Daily output of urine ranges between 0.5- 5.0 liters/day, depending to a large extent on the animals status of hydration or dehydration. The colour is usually light yellow but can turn dark yellow during dehydration. Faeces are usually well formed pellets of light to dark brown colour. In the early rainy season faeces may take a light green colour, become less well formed or even take a liquid consistency, depending on the water content of the available forage. During prolonged water deprivation faecal water content may drop to approximately 30 %. Excessive salivation in camels is unusual. Increase in salivation is suggestive of plant poisoning, snake bite, facial paralysis and central nervous disorders such as rabies. In bulls, during the rutting season, excessive salivation is an essential part of the mating behaviour.

Urine collection is best attempted by free catch. Female camels can be catheterized, but their urethral opening is quite small and a suburethral diverticulum just in front of urethral opening makes insertion of a catheter quite difficult. Male camels can not be catheterized due to the presence of a urethral recess at the ischiatic arch. Faeces are likewise best sampled by free catch which is not too cumbersome since camels tend to drop some pellets every few minutes. Grab sampling from the rectum is also very easy.

Body fluids and excretions such as urine, saliva and faeces can change in colour, volume, frequency of excretion, consistency and smell, which often points to specific disorders (see Chapter IV). A dark reddish to dark brown discolouration of urine indicates the presence of blood, myoglobin or haemoglobin. This is a serious clinical finding, just like a black and tarry appearance of the faeces caused by occult blood. Many East African pastoralists claim that they can diagnose acute phases of trypanosomiasis by the smell of the animals urine. In a survey conducted by Wilson and Schwartz (1983) such diagnoses could be confirmed at a rate of about 75 to 85 % of all infected cases in two herds.

Blood collection: Convenient sites for blood collection are the jugular vein, the medial volar metacarpal vein and the dorsal metatarsal vein. Veins are either raised by digital pressure or using a tourniquet. Total blood volume in camels is 93 ml/kg body weight. Camels have large oval shaped erythrocytes. These may rupture when blood is transferred from a syringe into a vacuum sampling container too rapidly and with too much pressure on the plunger, thus giving a faulty diagnosis. Measurement of haematokrit values in camels is not as valid as an indicator of the health status since the "normal" range is very large.

Haematokrit values ranging from 18 to 42 have been measured in the same animals within a time span of ten days at various stages of mild dehydration.

Drug administration

Oral application of drugs is done by drenching, bolus administration or through medicated feed. Drenching and administration is best accomplished with the animals seated, the head is than immobilised and tilted backwards slightly and the liquid medication poured onto the back of the tongue. Boli and tablets should also be placed as far back as possible. Medication of feeds is rarely done since most camels have to find their food on pastures. One exception is the dosing of granulated mineral mixtures with anthelminthics, which has become a proven technique.

Injection of drugs has to be prepared with the same hygiene as in all other livestock. For subcutaneous injection the preferred sites are just in front of the shoulder. This is one of the few sites on the camels body with the skin loose enough to be grasped and lifted. A needle without syringe attached is inserted under the skin and should be easily moveable underneath. On suction no blood should appear in the hub of the needle. If accidentally a blood vessels is hit the needle needs to be repositioned. Then the drug is injected and the needle together with the syringe still attached is withdrawn. Injected volumes should not exceed 50-100 cc per injection site.

The sites mainly used for intramuscular injection sites are the neck and gluteal muscles. The needle should be placed firmly and deeply into the muscle. Then the syringe is attached and the drug injected. If a blood vessel is punctured the needle has to be repositioned. Injected volumes should not exceed 15-20 cc per injection site.

Intravenous administration of drugs is usually via the jugular vein. The vena jugularis is very large in camels and can be easily raised by applying pressure with the palm in the cervical groove. Another method for raising the vein is the use of a tourniquet sitting low near the base of the neck. When the needle has been inserted the pressure is released or the tourniquet loosened and the drug slowly and steadily injected. After administration the needle with the attached syringe is withdrawn. Simple digital pressure for a short period of time in case of blood leakage from the puncture site will stop the bleeding. In rutting bulls caution is advised when restraining for blood sampling or intravenous drug administration, there is a high risk that they injure their dulaa by biting on it.

Chemical restraint and general anaesthesia

In rare cases camels may be aggressive and can not be approached easily to administer drugs or take blood samples. In this case chemical immobilization may be necessary. Simple delivery systems to administer drugs are blow pipes and stick poles. For details on these techniques literature on chemical restraint of zoo and wild animals should be consulted.

Several injectable drugs such as chloral hydrate, guaiacolate and inhalant anaesthetic agents such as halothane and isofluran have been successfully used in camels. General anaesthesia using those agents is not suitable for field or on-farm use, for these applications the references and selected further reading section in this chapter should be consulted.

Table III,6: Dosage regime for tranquillizing, sedating and immobilizing drugs commonly used in camels.

Name	Dosage [mg/kg body wt]	Appli-cation	Effect
Xylazine [1)]	0.25-0.50	IM	Sedation 30-60 min
	1.0-2.0	IM	Anaesthesia 90 min
Yohimbine	0.125-0.25	IM	Antidote
Propionyl-promazin [2)]	0.2-0.5	IM	Sedation 2-4 hours
Ketamine [3)]	5.5	IM	Sedation 20 min
Ketamine/xylazine	1.0-2mg	IM/IV	Anaesthesia 30 min
Etorphine [4)]			Immobilization
adult animal	0.25-0.5*	IM	Immobilization
young animal	0.5-2.0*	IM	Immobilization
Diprenorphine	2x dose etorphine	IV/IM	Antidote

* the dosage here = [mg/ 45 kg body weight]

1) Rompun (Bayer) is the first choice as a sedative drug for camels. It is a sedative effecting good muscle relaxation and has a slight analgesic effect. Onset of the effect is approximately 15 minutes after intramuscular administration and is indicated by a pendulous lower lip, closed eyelids, increased salivation and bradycardia. Higher doses as indicated in Table III,6 may be required in excited or stimulated animals. There is a considerable risk of abortion under Rompun sedation in late-term pregnancies. Atropine sulphate at a dose of 0.01-0.02 mg/kg body weight can be safely administered intravenously to counteract bradycardia and increased salivation. Doxapram hydrochloride or Dopram V (Willows Francis), a strong CNS stimulant, has been used effectively at a dose 0.05-0.13 mg/kg body weight, administered intravenously, to hasten arousal and counteract respiratory problems.

2) Combelen (Bayer) produces sedation with moderate muscle relaxation, but without analgesia. There is also a strong sympatholytic effect which can cause circulatory problems and possible paradoxical reactions. The onset of effect takes 20 minutes after injection and is indicated by general sedation and marked tachycardia.

3) Ketanest (Bristol Laboratories) and Vetalar (Parke Davis) cause dissociative anaesthesia with good analgesic effect, amnesia and increased muscle tone. Excitement, convulsions and apnoe may occur shortly after

administration, especially after intravenous injection. Onset usually takes place after 10 minutes. Under Ketamine eyelids stay open, an application of eye ointment to prevent drying of the cornea is therefore recommended during prolonged procedures. A marked tachycardia is noticeable.

[4] M99 and M50:50 (American Cyanamid), Large Animal Immobilon and Revivon (C Vet) are very potent narcotic analgesics. They are extremely dangerous for people to handle. Cutaneous or mucous contact, inhalation or accidental injection of minute amounts can be fatal. It is mandatory when using etorphine that naloxone, the narcotic antagonist, has to be at hand for immediate administration to in case of accidental contact. Camels under etorphine immobilization show severe muscle rigidity, muscle tremors, opisthotonus, tachycardia and respiratory depression.

Curative treatment of camels with drugs

Most of the information regarding efficacy and dosage recommendations for antimicrobial and antiparasitic drugs commonly used in camels is based on clinical use. The recommended dosages have been usually derived by extrapolation from those recommended for other large species such as the horse and cattle. It should be kept in mind when using new drugs that species differences may result in prolonged withdrawal periods, adverse reactions such as local tissue irritation and toxicity. An example is the trypanocide Berenil, which is widely used in cattle, is fatal for camels, causing death within 15 minutes after application.

With regard to the camels ability to adjust its water household to longer periods of water deprivation it appears very likely that pharmacokinetics of drugs, which are predominantly excreted by the kidneys, will differ significantly from what is known for other domestic species. For that reason frequent watering or, better even, free access to drinking water should be essential part of all repeated or prolonged drugs treatments of camels to prevent accumulation of drugs or their metabolites in body tissues. The most important literature on drugs commonly used in camels is presented in the references below.

Good nursing care

The importance of good nursing care for treatment success in any given disease is evident. However, the camels original habitat and the production systems where camels are normally kept, are not conducive to the application of a state-of-the-art nursing programme. Nevertheless there some rules and measures which could be observed under most circumstances.

Weak and debilitated animals should be kept separated from the herd. The enclosure should provide some shade and should be sheltered against wind. Dry and clean bedding and, during cold nights, blankets may be useful. Recumbent animals should be shifted once or twice a day to reduce the risk of sores. Watering should be daily, especially when animals run a high temperature or have profuse

diarrhoea. Easy access to feed should be provided. When branches cut from trees are fed, they should be tied to a fence post or tree or be held by a person that the camel can pull the leaves off. Wounds should looked at daily and cleaned if necessary. The same applies to discharges from eyes, ear and nostrils. Treatment of animals with contagious diseases should be done by one person that will not handle healthy animals. Close monitoring of sick animals and daily evaluation of their condition are a necessary routine during any given treatment.

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Chapter IV

Important Camel Diseases

M.Dioli and R.Stimmelmayr

Generalized Conditions

Camel pox (Orthopox cameli); gedderi (Ko), furuk (So), afturru (Re), abdarra (Ga), ettune (Tu) [IV,1]; (colour plates IV,1; IV,2; IV,3; IV,4;)

Etiology and epidemiology: Camel pox is one of the most important viral diseases in East Africa. Causative agent is an orthopox virus orthopox cameli. Camel pox outbreaks occur mainly during early to middle periods of the rainy season. The disease is highly contagious. Mainly horizontal transmission, but scabs, contaminated tools, cloth, grazing areas and human beings also serve as fomites. Camel pox is most often found in young and immature camels. Recovered animals show a stable and lasting immunity, presumably life long.

Clinical findings and pathogenesis: Affected animals show characteristic skin lesions. These pox lesions either occur in a localized form mainly around the head especially on the lips or a generalized form. Initial stage of the localized formis characterized by moderate depression, mild fever and anorexia. At this stage enlargement of mandibular lymph nodes is oftenobserved. One to three days after onset papules appear around nostrils and lips. These evolve over a couple of days into vesicles, which eventually rupture. Facial edema is quite common during this stage of the disease. In later stages of the disease, these pox lesions become covered by thick brown scabs and scar formation takes place. Between onset of disease to the disappearance of the crusts about 3 weeks elapse. Clinical symptoms of the generalized form are more severe. Affected animals show high temperature, severe depression and anorexia. Vesicles develop all over the body. Severe secondary infections are common and affected animals deteriorate rapidly. Septicemia, decreased food consumption and resultant general weakness can precipitate death of these animals. In dry climate the disease course is usually benign, however in wet climate the mortality can be very high.

Treatment and control: Mortality from camel pox is usually low, but among calves can reach 40-50 percent under poor management conditions and wet, humid climate. The high morbidity rate makes pox an economically important disease due to its severe impact on productivity such as growth and weight gain of the calves. The development of a vaccine is possible and will be considered in the near future. Along with a vaccination programme, improved management strategies could diminish the prevalence of this disease. Further education of herd owners about the etiology of Camel pox, strict separation of diseased and healthy

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[IV,1] Key for vernacular names of common camel diseases: Ko = Khordofan; So = Somali; Sa = Samburu; Re = Rendille; Ga = Gabbra; Bo = Borana; Tu = Turkana

young camels, improved veterinary treatment protocols including long acting antibiotics, improved hygiene and general supportive treatment will decrease the significance of camel pox in the future.

Contagious ecthyma (Parapox cameli); the vernacular names are often identical to those for camel pox; (colour plates IV,5; IV,6)

Etiology and epidemiology: The parapox virus responsible for camel contagious ecthyma has only been recently identified. Pox-like lesions are produced in dromedary and bactrian camels. The disease is highly contagious. Mainly horizontal transmission, but scabs, contaminated tools, cloth, grazing areas and human beings also serve as fomites. According to recent studies in East Africa the virus is endemic along with the true camel pox virus. The virus is morphologically different from orthopox virus and can easily be identified by electron microscopy.

Clinical findings and pathogenesis: Clinical symptoms are similar to those caused by the orthopoxvirus. A diagnosis based on these lesions can only be presumptive. An aid to differentiating it from camel pox is the susceptibility of all age groups, among immature and adult animals the incidence is higher than that of camel pox. In immature camels the lesions are mainly found around the mouth and nostrils and occasionally on the eyelids. Due to the intensive pruritus animals spend a lot of time scratching and rubbing the affected area. This results in hemorrhages and quite extensive skin excoriations which leads to impaired grazing ability and suckling. Both localized and generalized skin lesions have been observed. The generalized form is more often seen and outcome of the disease is less severe than with generalized camel pox. Whether recovered animals have a lasting immunity is not clear, but according to clinical observations in the field recovered animals were not affected during new disease outbreaks. For treatment and control see recommendations for camel pox.

Camel papillomatosis; no vernacular names were collected; (colour plate IV,7)

Etiology and epidemiology: Simultaneous outbreaks of contagious ecthyma and papillomatosis have been only recently reported in camel herds located in Somalia. Electron microscopy revealed typical papilloma virions in the submitted biopsy samples. Outbreaks of the disease have been observed mainly during the rainy season. The definitive etiology of transmission is inconclusive, but presence of oral lesions seem to be related to disease manifestation. Morbidity rate is quite high. Mortality rate from camel papillomatosis is nil in adult animals, but among affected calves mainly 6 months to 1.5 years of age under poor management conditions and inclement weather, mortality rate might be significant. Again whether recovered animals have a lasting immunity is not clear, but according to clinical observations in the field recovered animals were not affected during new disease outbreaks. There is no data available about the zoonotic potential of camel papillomatosis for human beings and other livestock.

Clinical findings and pathogenesis: Camel papillomatosis has been observed in all age groups. Clinical symptoms are completely different according to the affected

age group. In adult camels the disease resembles bovine papillomatosis. Characteristic nodules are found mainly around the head, neck, shoulder and udder are found. The nodules are persistent and require surgical removal or cauterization. In immature animals proliferative localized or generalized skin lesions develop about a week after exposure to a sick animal. Lesions appear to be very itchy and affected animals spent a lot of time scratching and rubbing the affected area. This results in hemorrhages and quite extensive skin excoriation leading to impaired grazing ability and suckling activity. A high incidence of conjunctivitis with severe secondary bacterial infection due to lesions on the eyelids and the surrounding periorbital tissues has been noted too. Other clinical findings include marked edema of the head and swelling of the mandibular and cervical lymph nodes. Approximately 3 weeks after formation the scabs drop off. A different clinical picture of camel papillomatosis has been observed among camel herds located in Kenya, where disease outbreaks are not seasonal. There seems to be a relation between previous camel pox infections. Again mainly 0.5 to 1.5 year old animals are affected. Cauliflower like skin lesions approximately 0.1-0.5 cm evolve mainly around nostrils and lips. There is no pruritus or pain associated with skin lesions. The lesion persist for quite along time, but eventually skin protrusions fall off leaving no marks. Recovered animals develop long lasting immunity. Presently no data is available whether the causative agent is identical to papilloma virus found in Somalia. Clinical symptoms of Camel pox, contagious ecthyma and camel papillomatosis in immature animals are quite similar therefore can be easily confused. Electron microscopy has proven to be a useful and efficient tool to differentiate pox like diseases.

Trypanosomiasis; guffar (Ko), dukan = T.evansi (So), korbarar = T.congolense (So), omar (Re), ghanti (Ga), saar (Sa), louta (Bo), lokipi (Tu); (colour plates IV,8; IV,9)

Etiology and epidemiology: Throughout Africa trypanosomiasis caused mostly by T. brucei evansi infection is the major protozoal disease affecting camels. The biology of Trypanosoma brucei evansi infection is different from tsetse fly transmitted trypanosomiasis. It is characterized by simple mechanical transmission using biting flies such as Stomoxis ssp. and Tabanus ssp. as vectors. The biology of tsetse transmitted animal trypanosomes such as T. vivax T. congolense and T. brucei brucei is cyclical. It requires a period of maturation in the fly each subspecies using a different fly organ for this purpose. After transformation and multiplication in the fly the trypanosome becomes again infective for the animal host. Camels are usually not kept in endemic tsetse fly areas, therefore the role of tsetse fly transmitted surra is insignificant. Disease outbreaks of mechanically transmitted surra show a seasonal pattern associated with increasing numbers of biting flies during the rainy season or shortly there after. Occurrence of disease is also correlated to fly prevalence in riverine and watering areas. All age groups are susceptible, but immature, stressed and lactating animals are extremely vulnerable.

Clinical findings and pathogenesis: Pathogenesis of trypanosomiasis caused by either of the above described trypanosomes is similar. During blood sucking the fly inocculates trypanosomes into the animal skin. After a few days trypanosomes invade the lymph and blood system, where they multiply through binary fission. Trypanosomes can enter other body compartments such as the central nervous system and joints, thus being less accessible to treatment and to clinical diagnosis by demonstration of the parasite in the peripheral blood stream. The severe anaemia in trypanosomiasis infection is multi-factorial and caused by haemolysis, direct traumatic effect on the red cells and red cell sequestration in the spleen. The chronic form of trypanosomiasis in camels is more common than the acute form. A considerable proportion of animals die within 2 to 5 months after contracting the disease. An exception hereby is tsetse fly transmitted trypanosomiasis with T. congolense, which is quickly fatal in infected camels. Affected animals show high fever, anorexia and marked generalized edema and deteriorate rapidly and die. The chronic form of T. evansi infection is characterized by a progressive weight loss, intermittent high fever, marked generalized muscular atrophy especially the rear end, pale mucous membranes and occasionally abdominal edema. Affected animals may also exhibit a characteristic sweet odour due to an increase in urinary ketone levels. Common laboratory findings are a decreased PCV between 18 -20 % (normal 24-42% with an average of 30%), a responsive anaemia and perhaps demonstration of the parasite in stained blood smears. Additional clinical findings are hyperlacrimation, overall decrease in food consumption. and irregular grazing activity. Clean late term abortions and birth of premature calves are very common features of the disease in pregnant animals. Lactating animals show a progressive decrease in milk production. An increase in respiratory diseases among camels affected by trypanosomiasis has also been noticed.

Necropsy findings: Post mortem findings are non specific. A known history and findings such as generalized muscular waste, pale and watery muscles, serous atrophy of fat, swollen lymph nodes, presence of edema and evidence of anaemia are suggestive of trypanosomiasis.

Treatment and control: A combination of improved management practices, chemoprophylaxis and therapy is currently used. To reduce the risk of exposure, areas where biting or tsetse flies are abundant should be avoided by camel herders. If not feasible watering at night or at noon reduces the risk of exposure to infection, since fly activity is low around noon and during the early night (7 - 10 pm). Furthermore watering camels in small groups limits exposure time since they spent less time at the watering site. A new generation of pour-on insect repellants may be helpful incontrolling new infections. Successful chemotherapy and prophylaxis is limited by increasing drug resistance, due to subcurative doses of trypanocide drugs, drug tolerance for example phenanthridines only temporary effective and specific toxicity of some trypanocides such as Berenil (Hoechst). Treatment of non sedentary camel herds is only advisable if it is performed regularly. Treatment of whole herds in case of high abortion rates is recommended at the beginning of the rainy season and later followed up by continued treatment of affected animals.

Table VI.1: Recommended drugs for trypanosomiasis caused by T. b. evansi (adapted from Röttcher et al. 1987) For solution of trypanocidal drugs 5% dextrose or lactated Ringer solution is recommended.

Drug	Rec.Dosage	Effect
Isometamidium chloride[1)]	50-100mg/100kg Bw. IV[5)]	curative
Suramin[2)]	12mg/kg Bw., IV (upto 20mg/kg Bw)	curative (not T.congolense) prophylactic for 3 weeks
Quinapyramine:		
methylsulphate[3)]	3-5mg/kg Bw., SQ[6)]	curative (T.congolense, T.evansi)
chloride methylsulphate[4)]	5-8.3.mg/kg Bw., SQ	curative, prophylactic for 4-6 months.

1) Samorin: not well tolerated at high dosage; intramuscular administration produces severe local reactions.
2) Naganol, Antrypol: paravenous injection results in thrombophlebitis and abscessation. especially if prepared solution concentration is more than the recommended 10 %. One Naganol treatment will protect for a period of 3 weeks from any new infection.
3) Trypacidesulphate, Noroquin, Antricidesulphate
4) Trypacide Pro-Salt Beware local tissue reactions are common and can persist for along time.
5) IV = intravenous
6) SQ = subcutaneous

Hemorrhagic septicaemia; garir (So), ngarngar (Sa), khanid (Re), khando (Ga), khandich (Bo), lorarrurei (Tu); (colour plates IV,10; IV,11; IV,12; IV,13

Etiology and epidemiology: Hemorrhagic septicaemia is quite prevalent in East Africa among cattle and camels. Outbreaks of the disease occur mainly during the rainy season and are commonly seen in low lying areas which are regular seasonally flooded. Environmental stress factors such as high humidity and heavy Hyalomma dromedarii infestations are thought to be important predisposing factors. The disease is usually seen in adult animals, but all age groups can be affected. The morbidity of the disease is low, but mortality rates can reach 50-80 % among affected animals. Mode of infection is believed to be either by ingestion of contaminated foodstuffs or by arthropods. The bacteria is not particularly resistant and does not survive longer than 24 hours on pasture.

Clinical findings and pathogenesis: Disease onset is acute. Clinical characteristics include high fever over 40°degrees Celsius, increased respiratory and pulse rate

and general depression. In camels, localization chiefly to subcutaneous tissue results in hot, painful swellings around the neck. The mandibular lymph nodes and/or the cervical lymph nodes are usually enlarged. Signs of respiratory dispnoea such as dilated nostrils or open mouth breathing, rapid and shallow breathing and cyanotic mucous membranes are seen. In the majority of cases hemorrhagic enteritis is present as well characterized by obvious clinical signs of acute abdominal pain and excretion of tarry feces and discoloured urine (coffee-like). In these cases prognosis is guarded. Affected animals seldom recover and usually die in the next 24 to 48 hours.

Necropsy findings: On post mortem the most obvious findings are generalized internal petechiation especially under the serosa of the intestines, the heart and the lymph nodes. Gelatinous fluid may be present around the lymph nodes. Hemorrhagic enteritis and lesions of early pneumonia may be also present. Overall the clinical and necropsy findings are rarely conclusive and differentiation from anthrax, blackleg, septicemic salmonellosis and acute leptospirosis is usually done by bacteriological examination. The absence of bloody discharge from the natural body orifices and a normal appearing spleen on post-mortem can be used to initially differentiate hemorrhagic septicaemia from anthrax.

Treatment and control: Since hemorrhagic septicaemia is an acute and quite often fatal disease, early treatment is essential. High dosages of sulfadimidine or sulfamethazine and other antibacterial drugs should be given systemically. Oral sulphonamides are also recommended for treatment of the enteritis. During recovery supportive treatment such as supplemental feeding and frequent watering is recommended and will hasten recovery. In endemic areas prophylactic vaccination programmes before the rainy season may be helpful.

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Plate IV,1: Two young camel calves 6 months old with the localized form of camel pox. The right shows marked generalized facial edema, lesions on the lips and around the nostrils. The enlargement of both mandibular lymph nodes and multiple lip lesions are invisible in the left. These are characteristic clinical signs of pox like diseases. In one third of the cases of camel pox facial edema is present.

Plate IV,2: Head of an immature animal. There is purulent ocular and auricular discharge. Pox lesions on the eyelid can lead to conjunctivitis. Secondary bacterial infection of pox lesions is a common sequela.

Plate IV,3: An immature camel with the generalized form of camel pox. Multiple slightly raised pox lesions are present at the base of the neck. Some of the pox lesions are already scabbed over. The ventral superficial cervical lymph nodes are moderately enlarged.

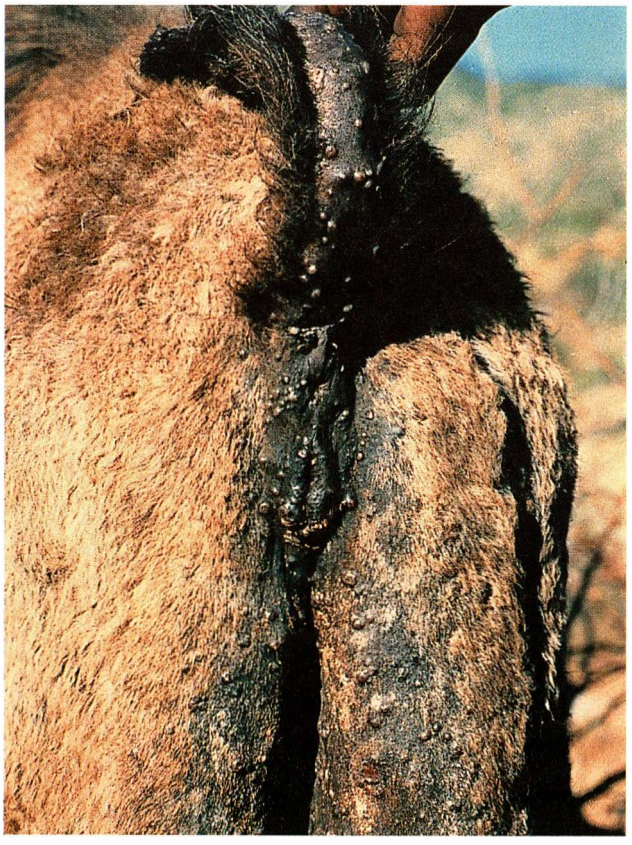


Plate IV,4: Another case of generalized camel pox. Multiple skin lesions are present in the perineal area. Lesions involve also vulvar lips and the anus.

Plate IV, 5: An immature animal one year and seven months old showing contagious ecthyma. There is a marked swelling of the throat area just below the mandibula. Only a few skin lesions are present on the lips. The mandibular lymph nodes are enlarged.

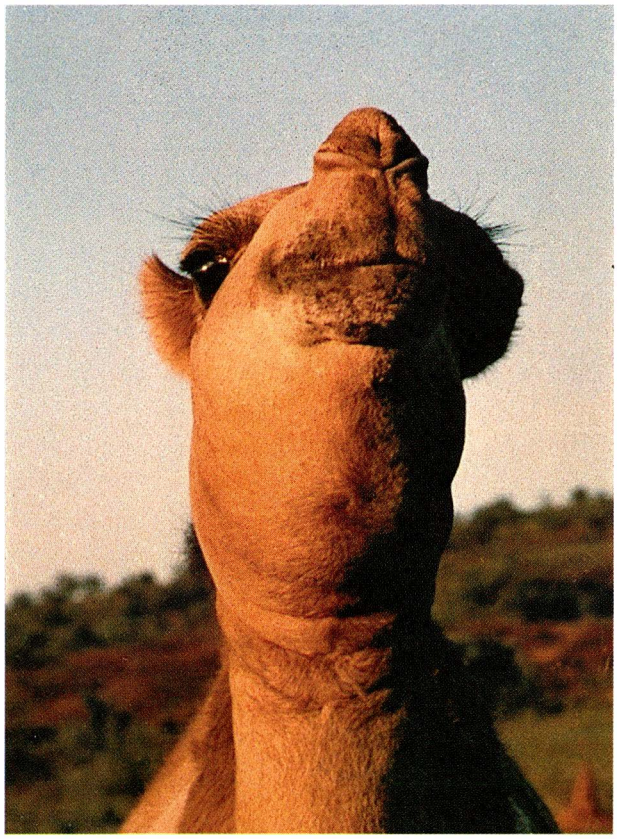
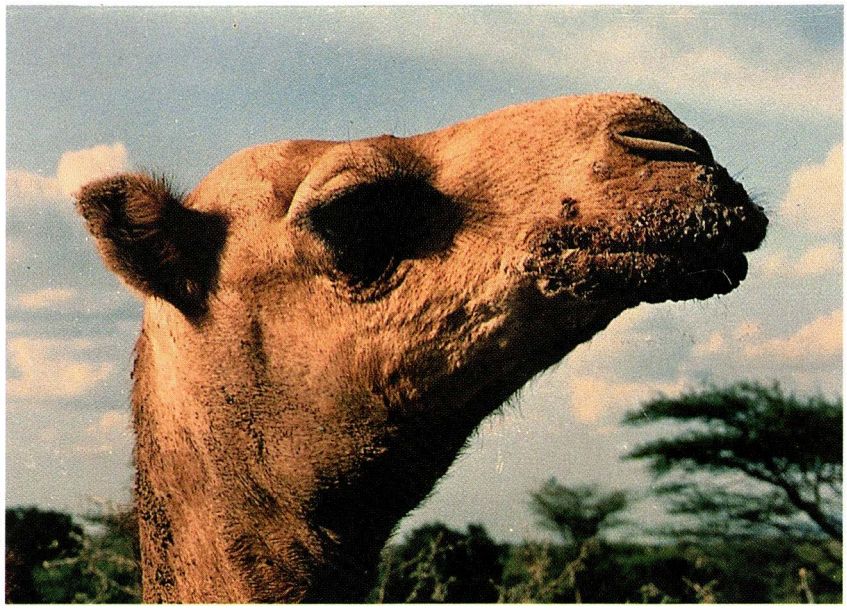


Plate IV, 6: An immature animal one year and six months old. Many lesions are present on the lips. The enlarged lymph nodes are prominent. There is no edema.



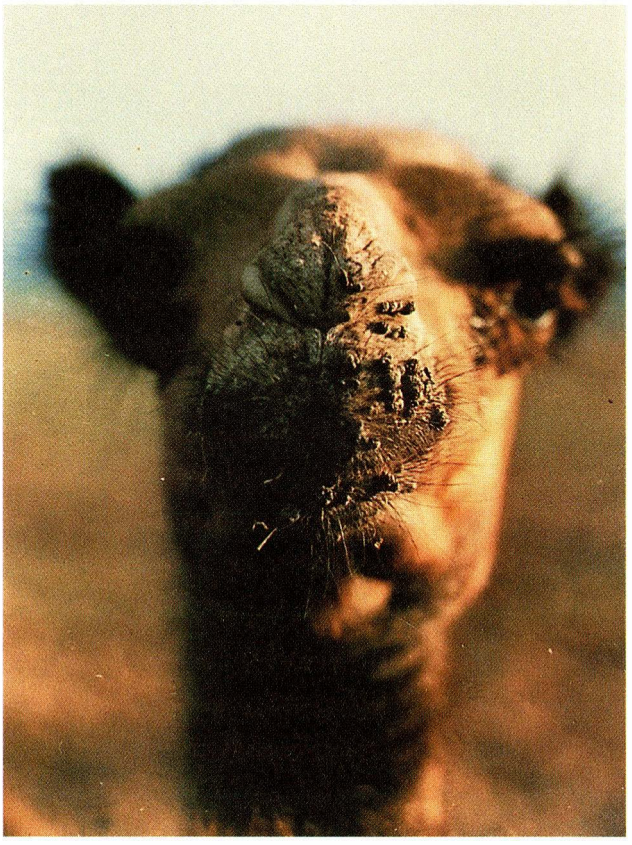


Plate IV, 7: An immature animal 1 year and six months old showing camel papillomatosis. Several cauliflower like lesions can be seen on the lips. There are no swellings or enlarged lymph nodes.

Plate IV, 8: Characteristic general appearance of chronic trypanosomiasis infection. The adult animal is severely emaciated, total lack of hump, retracted abdomen. There is generalized muscle atrophy more pronounced at the hind legs.

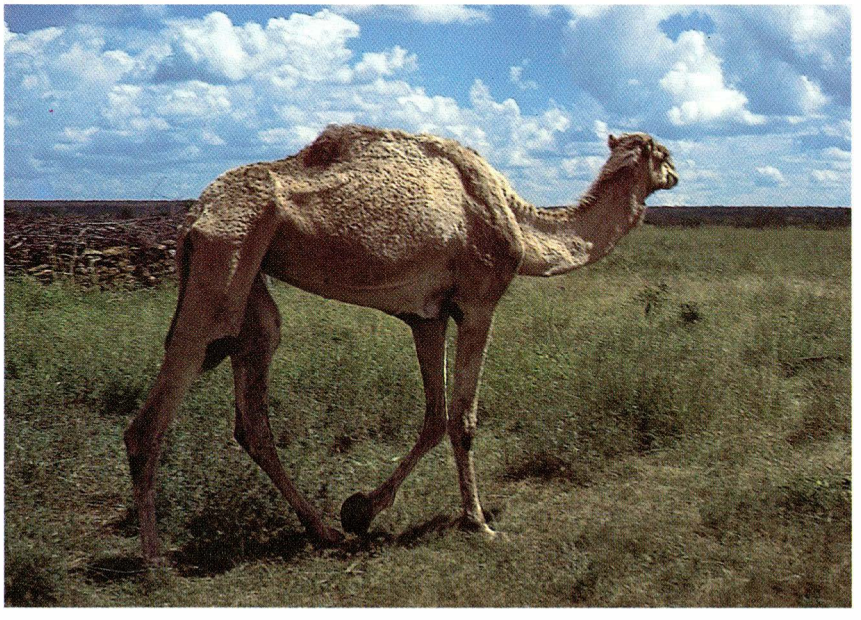


Plate IV,9: A non infected late term abortion. This is very common during the acute febrile episodes of trypanosomiasis infection. The fetus is near term, the estimated age is over 11 months.

Plate IV,10: Initial stage of hemorrhagic septicemia in an immature animal about two years old. There is a non specific swelling of the mandibular region due to enlarged lymph nodes. The early clinical signs of hemorrhagic septicemia caused by pasteurella can easily be confused with septicemic salmonellosis or anthrax.

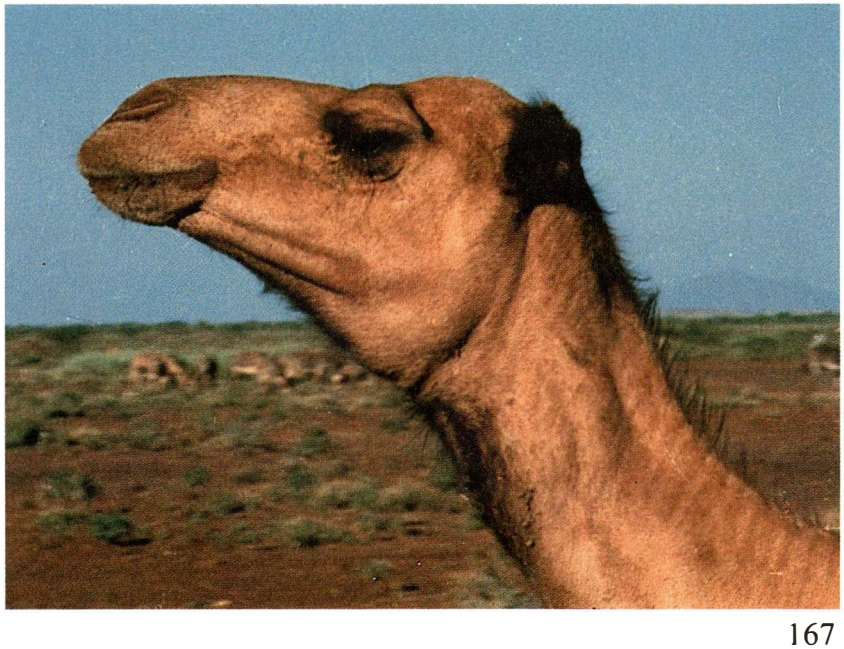


Plate IV,11: Final stage of acute pasteurellosis. The characteristic opisthotonus is an early and highly reliable sign that the camel is in agony. The agonal neck movement has left circular traces in the sand. The anal region is soiled with tarry feces produced by the enteric bleeding.

Plate IV,12: On post mortem the major finding was a severe hemorrhagic enteritis and generalized petechiation under the serosa affecting the whole gastro-intestinal tract.

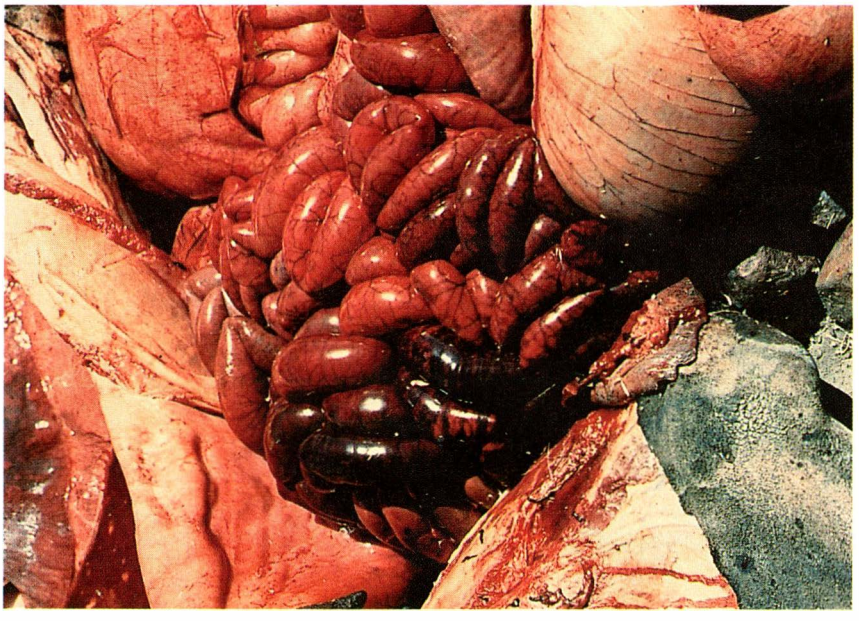
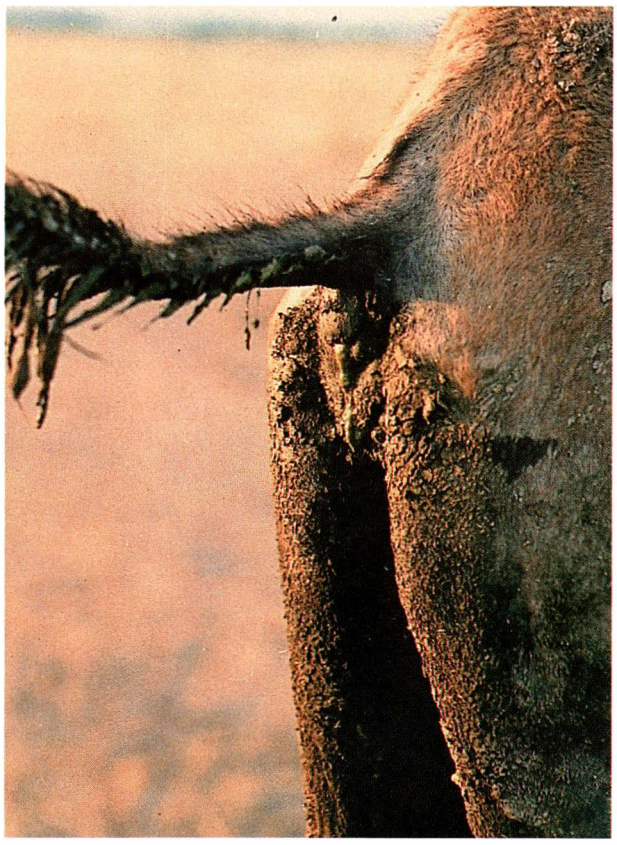


Plate IV,13: Another post mortem finding were multiple petechia on the heart.

Plate IV,14: An immature animal three years of age with acute non hemorrhagic watery diarrhoea. The hindlegs are soiled. The diarrhoea lasted over a week and the animal lost condition gradually , however during this period the animal kept on grazing and had no temperature. The diarrhoea was caused by endoparasites.



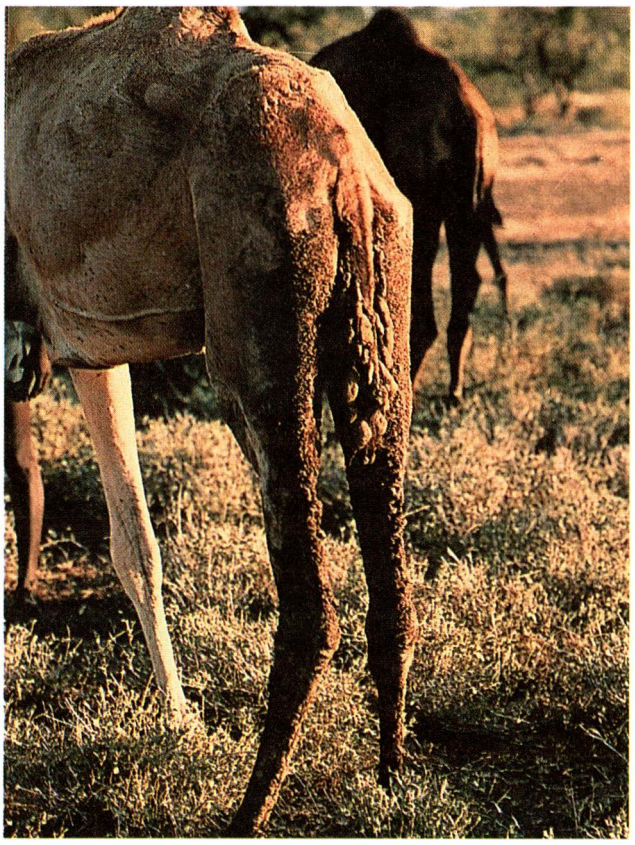


Plate IV,15: This adult female had diarrhoea over a longer period of time. The tail hairs are completely matted by dried old feces. However, it was feeding normally and the loss of condition was minimal.

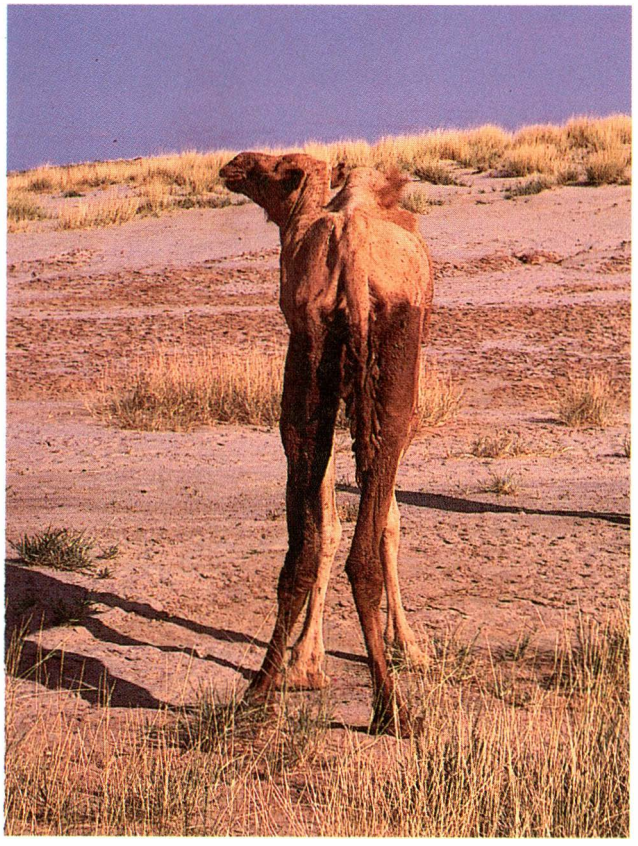
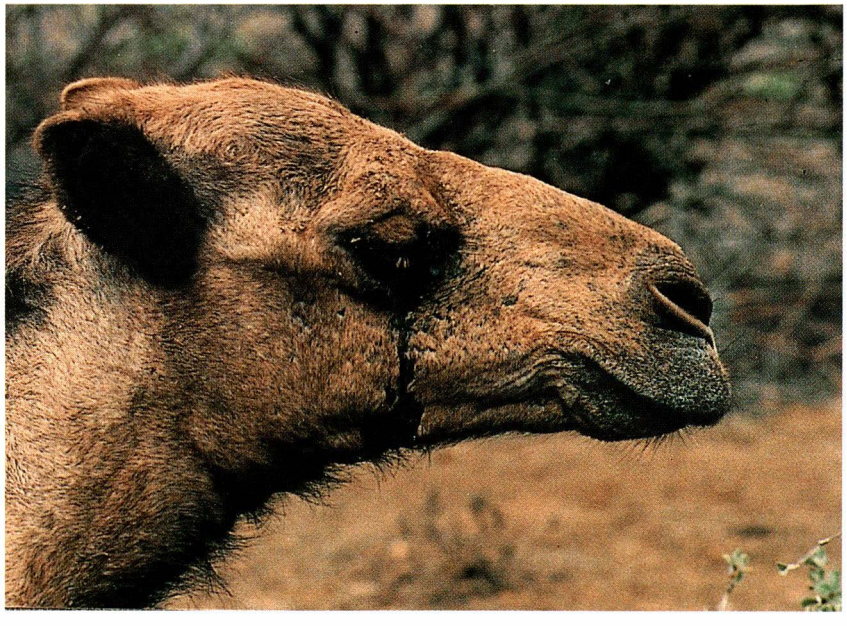


Plate IV,16: This case shows the final stage after prolonged diarrhoea. The animal has no hump, the ribs are prominent, there is general muscular atrophy and the hindlegs are soiled with feces. This animal did not recover and died.

Plate IV,17: This is the same animal as in Plate IV,16 in lateral view.

Plate IV,18: This immature animal showed signs of pneumonia shortly after the onset of the rain season. The animal had fever, indicated by hyperlacrimation, was listless and anorectic. Respiration was laboured, nostrils are visibly dilated.



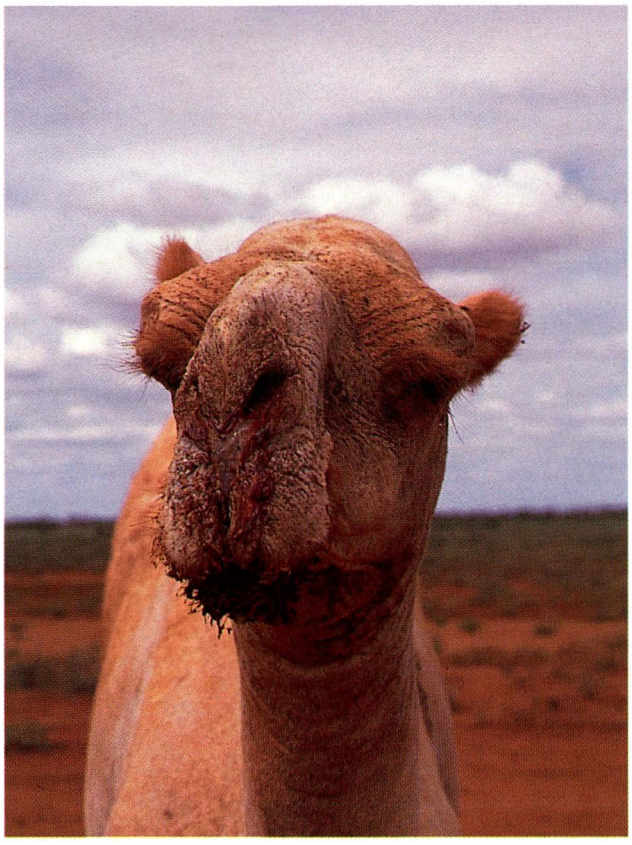


Plate IV,19: An adult animal with a bilateral nasal discharge of purulent nature. The eyes are half closed and the general appearance is dull. This animal showed respiratory distress and died shortly after.

Plate IV,20: Initial stage of sinusitis in an adult camel. The camel carries the head slightly elevated and more forward. The head to neck angle is wider than usual. There is a noticeable swelling right above the frontal sinus.

Plate IV,21: The same animal a couple of days later. There is a slightly purulent discharge from one nostril. Unilateral discharge is highly indicative for sinusitis. Again the swelling above the sinus frontalis is visible. The animal was later on slaughtered for other reasons and the diagnosis of sinusitis was confirmed by necropsy.

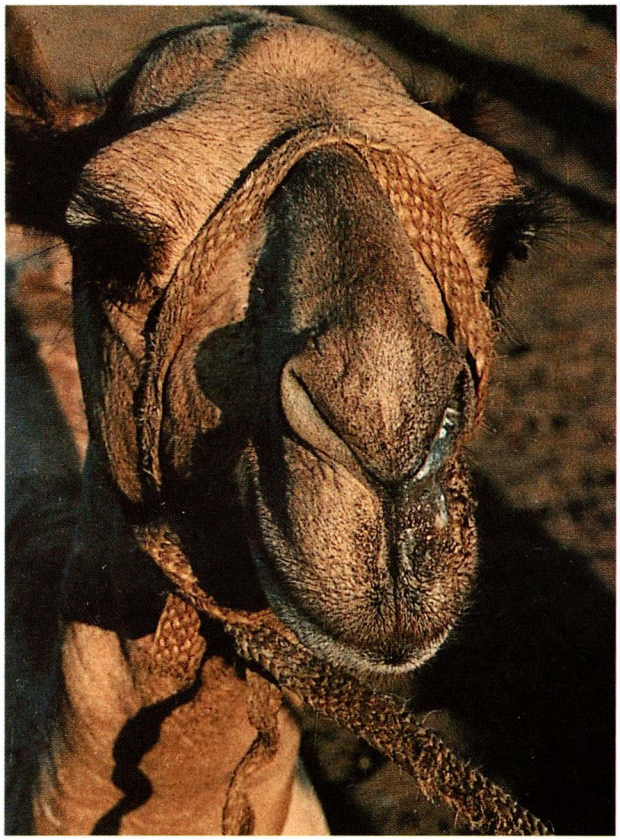
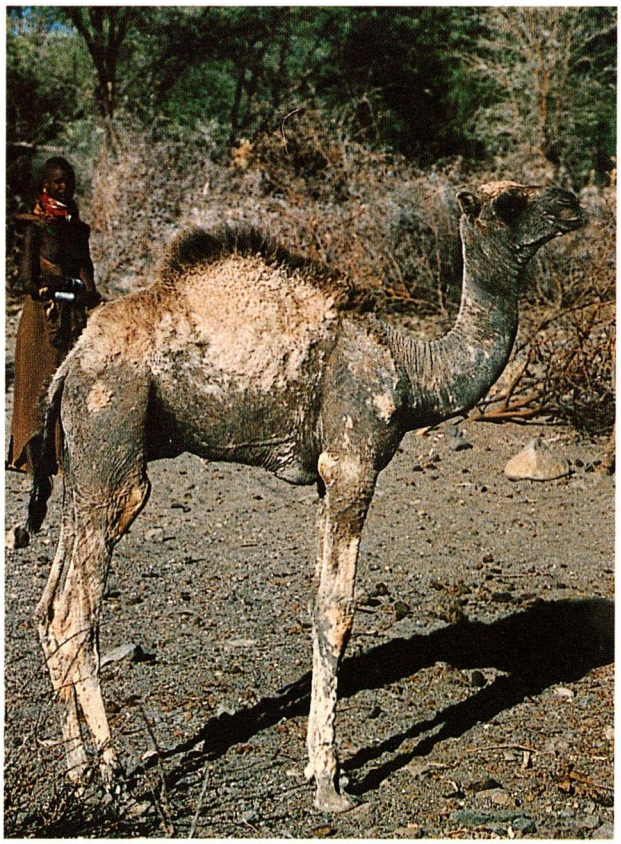


Plate IV,22: Case of acute generalized mange in a young calf four months old. There is a marked hair loss. The long hair on the rump is still present. This region is rarely affected. The animal showed marked pruritus.



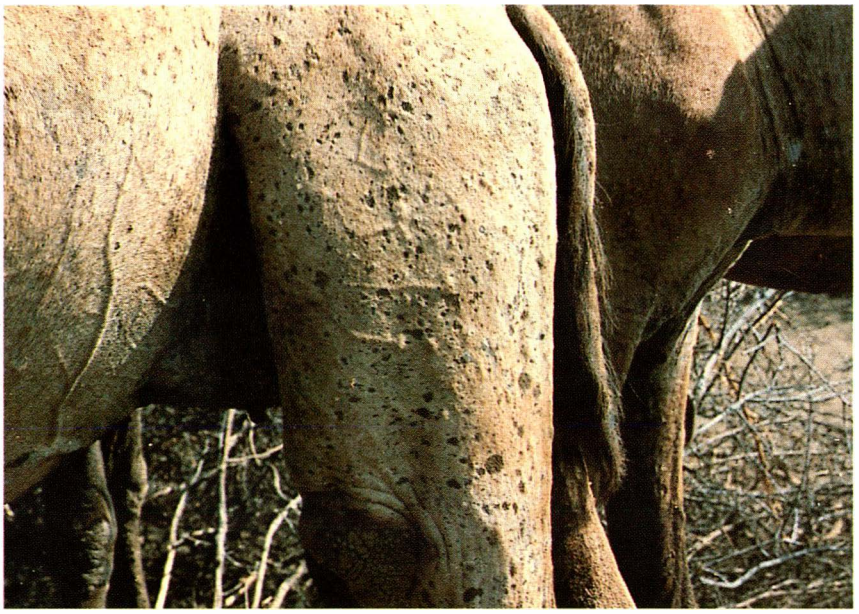


Plate IV,23: A case of controlled generalized mange in adult animals. Only small patches of hair loss are visible. Characteristic site and typical clinical signs of chronic mange infection. Pruritus is only mild. This form of mange is typical for adult animals.

Plate IV,24: Axillary region of the same animal.

Plate IV,25: Inguinal region of the same animal. In this animal the infection had been present over a year. There was no pruritus. There is marked hyperkeratosis, excessive skin folding and grey discolouration of the affected skin. In severe cases like this even after successful Ivomec treatment the skin folds do not disappear and stay as a permanent mark.

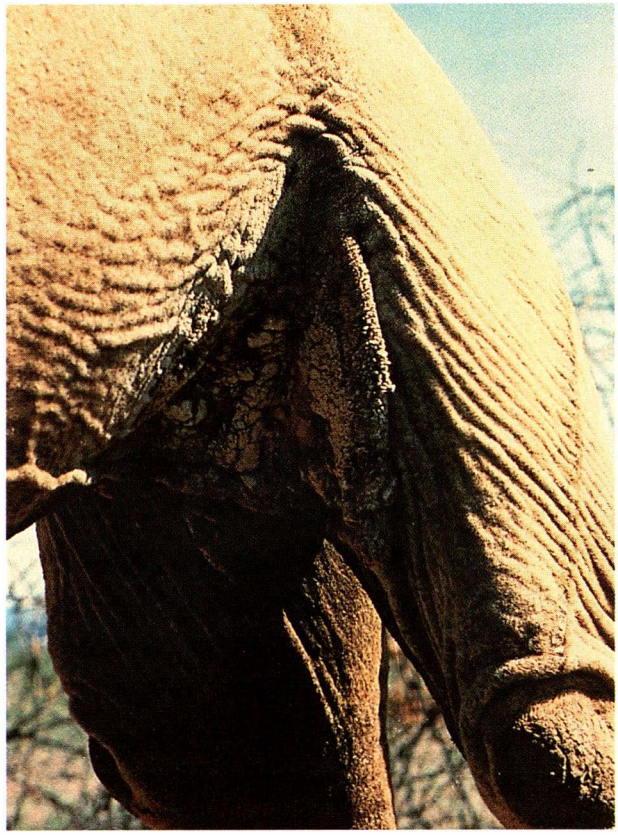


Plate IV,26: A case of ringworm in a young camel. Typical hair loss patches of varying diameter from a few centimetres over ten centimetres. There are no obvious lesions on the skin.

Plate IV,27: A typical case of acute skin necrosis in an adult animal. The lesion is 5.5 cm in diameter. The lesion is exudative and granulation tissue is present in the centre of the lesion.

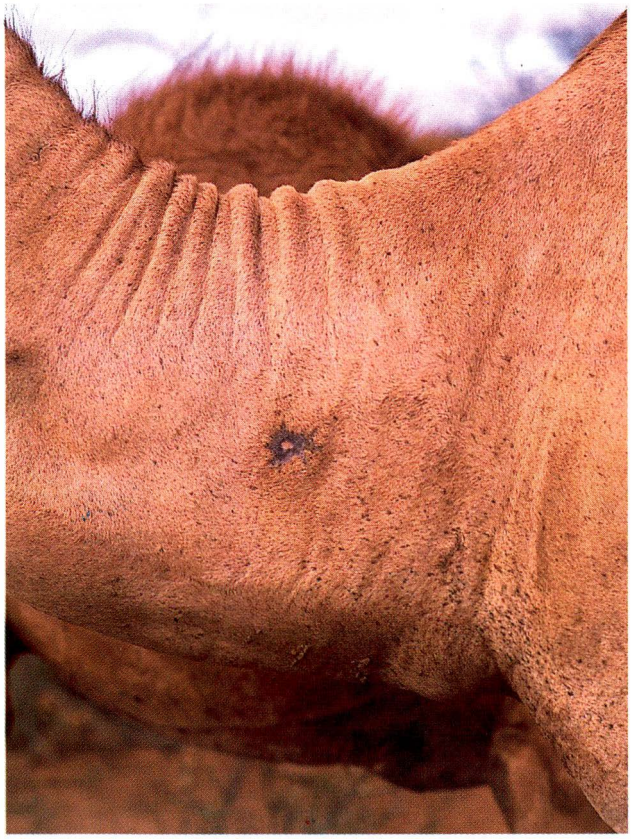


Plate IV,28: Typical appearance of a healed skin necrosis lesion. The scar is star shaped.

Plate IV,29: This is a massive infestation with Hyalomma dromedarii ticks. The preferred attachment site of adult dromedarii ticks are the nostrils. In severe cases over 100 ticks per nostrils have been collected. A common sequela to massive infestation is tissue necrosis.

Plate IV,30: Several ticks of the Rhipicephalus sanguineous group at their preferred attachment site, the eyelid. Infection of the micro-lesions can lead to eye infections.

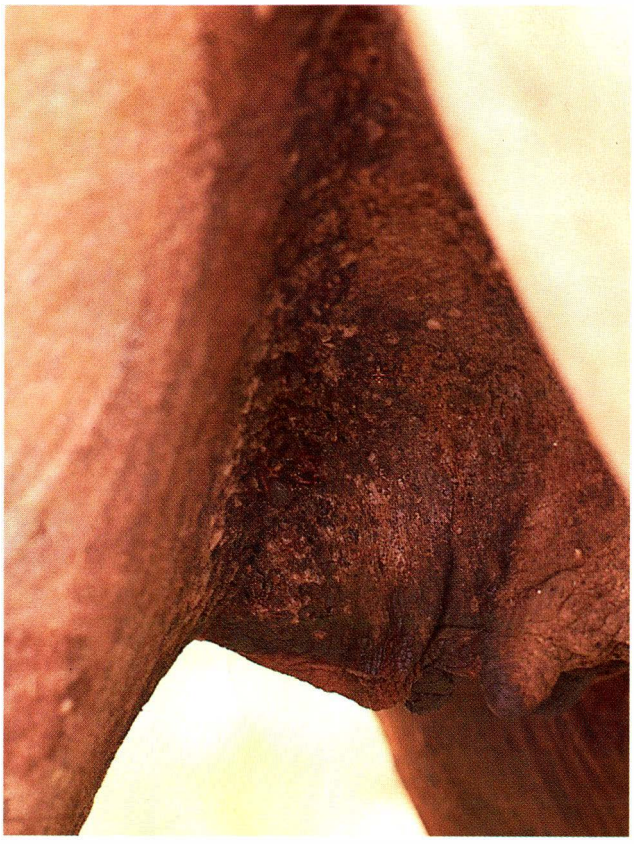
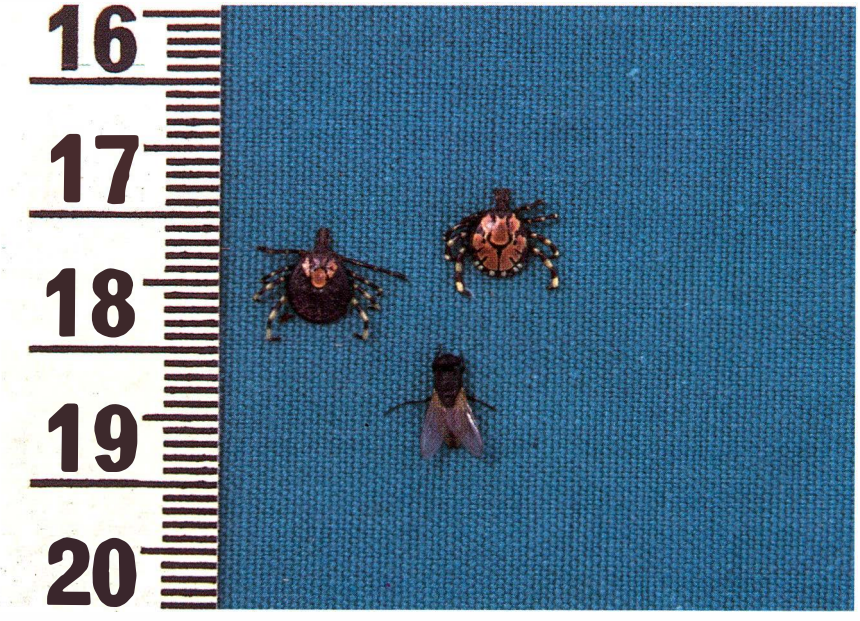


Plate IV,31: Typical thickening of skin as a result to massive Amblyomma spp. infestation in the inguinal region. Amblyomma spp. have a very long mouth parts. Infection and abscessation of micro-lesions is a common sequela.

Plate IV,32: Amblyomma spp. specimens. On the left is the female and on the right is the male. The long mouthpart is visible. To compare size a normal stable fly is presented.



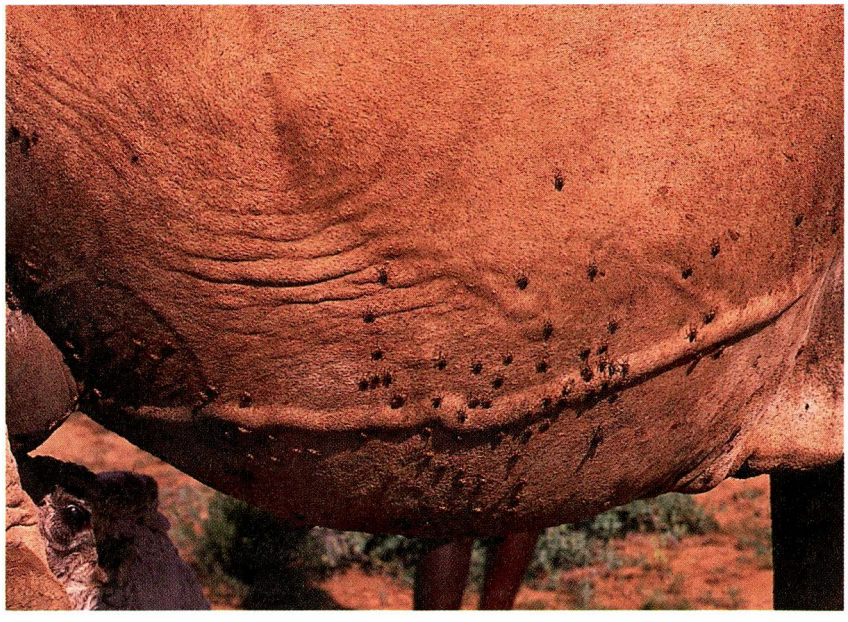


Plate IV,33: A group of Hippobosca camelina flies clustering on the ventral abdomen. Their bite, but especially their flying activity close to the camels severely irritates the animals and can present a real problem when camels are milked.

Plate IV,34: The Hippobosca fly is a large and sturdy fly. In comparison to normal stable flies they are less easy to kill by slapping or squashing.

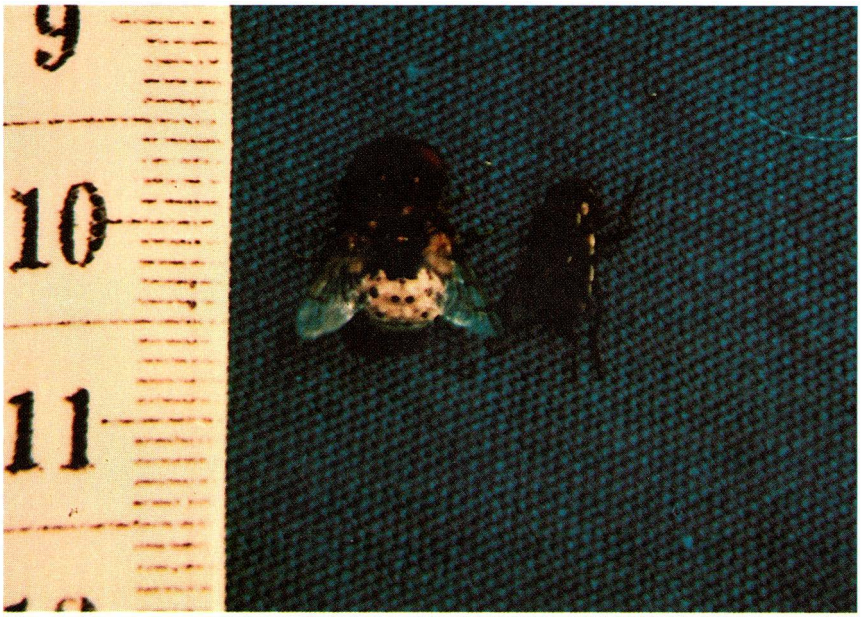


Plate IV,35: An adult Cephalopina titillator specimen. They have a big head and whitish abdomen. To compare size a normal stable fly is presented.

Plate IV,36: These are larvae of Cephalopina titillator. Average size of fully grown larvae just before pupating is 3 centimetres. They were collected from the naso-pharynx, their typical attachment site.

Plate IV,37: Draining the superficial ventral cervical lymph node.

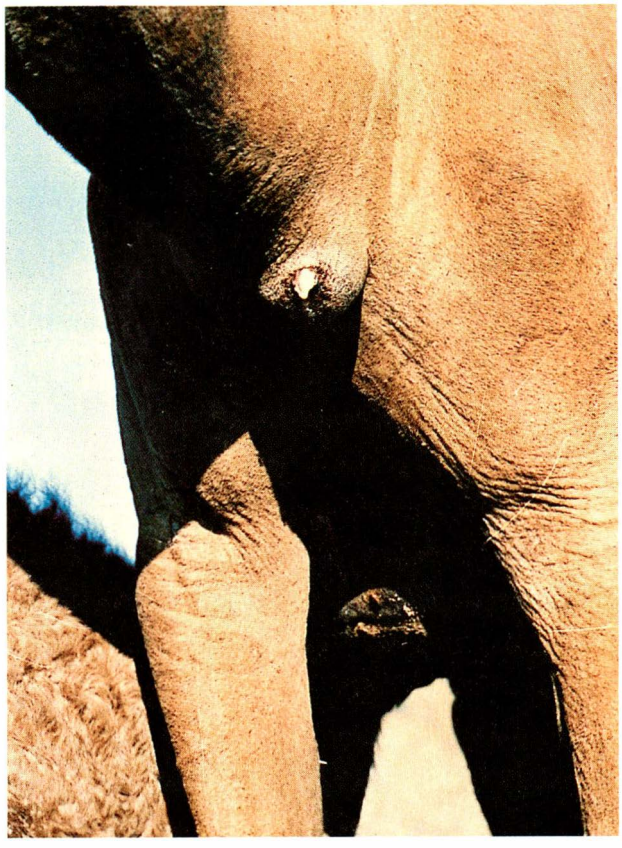


Plate IV,38: Draining the iliofemoral lymph node.

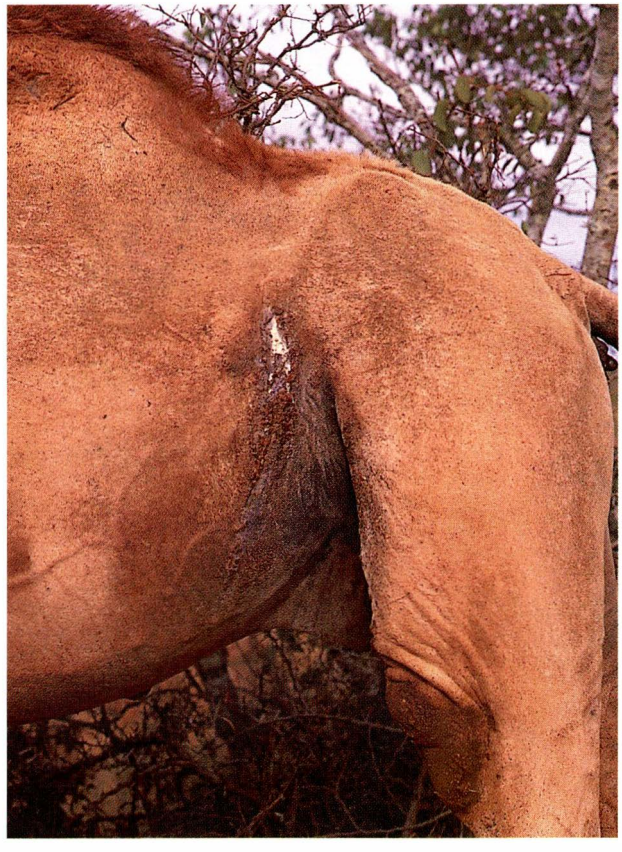


Plate IV,39: Drained mammary lymph node. The thick capsule is visible. Milking was very painful for this animal; however, the glandular tissues of the quarter were not infected and normal milk was obtained.

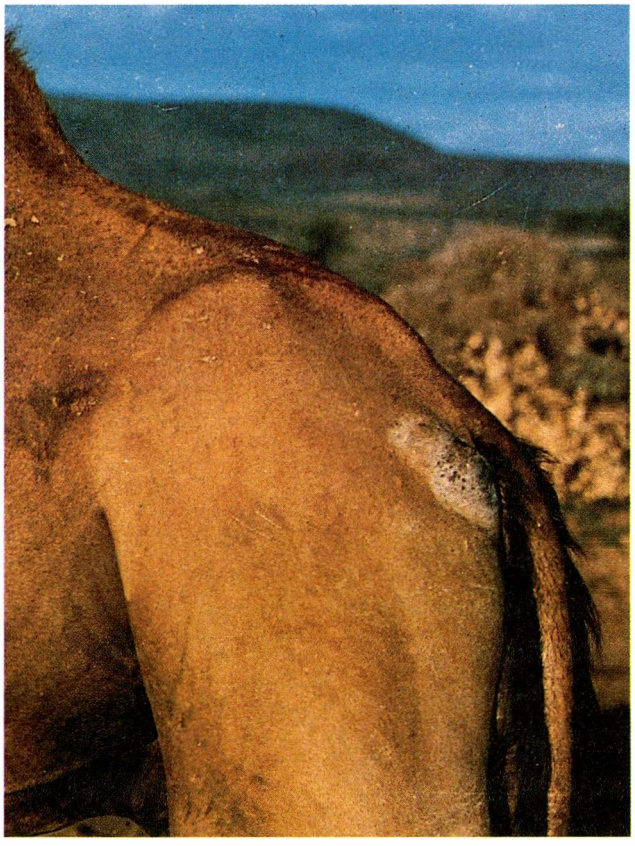


Plate IV,40: Draining a tuberal lymph node.

Plate IV,41: A markedly enlarged popliteal lymph node. This animal did not show any signs of lameness.

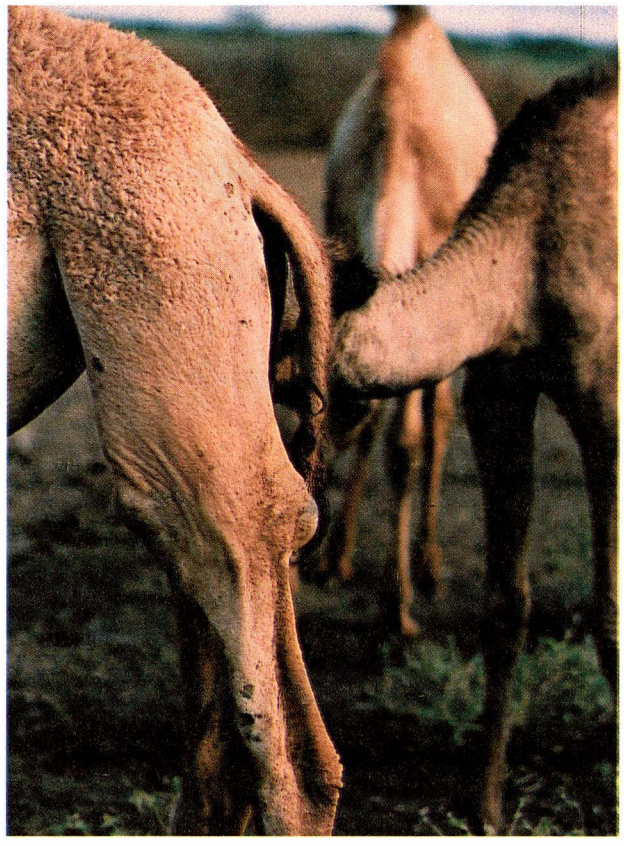


Plate IV,42: Multiple huge abscesses from faulty Naganol administration. The one on the hind leg is due to intramuscular injection, the cervical one due to paravenous injection. The cervical lymph nodes are also enlarged.

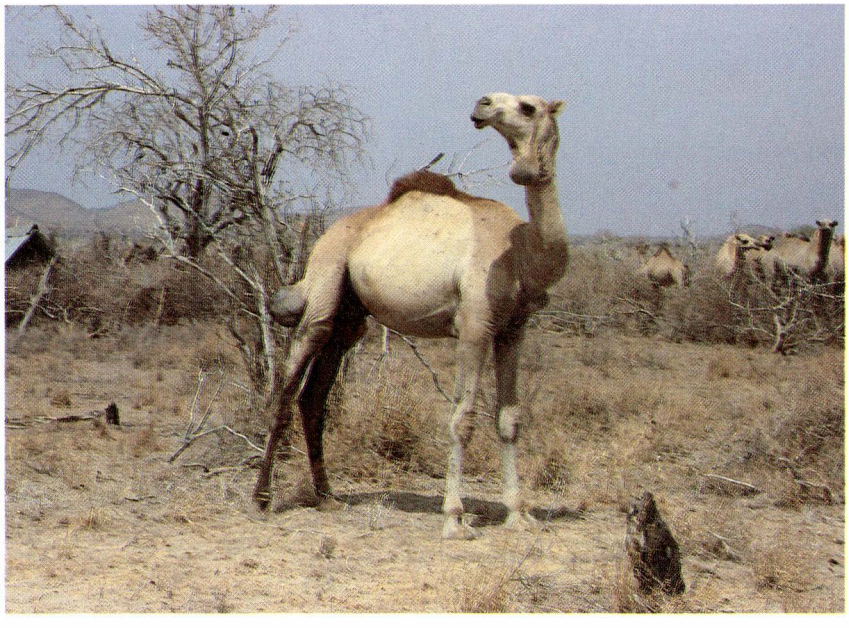


Plate IV,43: This is the abscess surgically removed from the hind leg of the same animal. The abscess is solid organised fatty tissue and surrounded by a thick capsule. Both features are characteristic for abscessation in camels.

Plate IV,44: Abscessation of one mammary gland resulted in general fibrosis of this quarter. The rest of the udder atrophied completely.

Plate IV,45: A case of joint ill in a calf. This is a common problem due to umbilical cord infection. The tarsal joint is most frequently affected. The animal was lame on this leg. The muscles of this leg were atrophied due to prolonged inactivity.

Plate IV,46: A case of purulent arthritis in an adult bull. The bull was lame and received branding treatment. On incision the joint was full of pus. This bull was eventually killed. On post mortem multiple internal abscesses were found.

Plate IV,47: A deep circular solar wound in an adult bull. There was a pronounced lameness. The healing was prolonged. Deep wounds due to foreign bodies are more likely during the rainy season when the solar pad gets softened.

Plate IV,48: A deep fresh pedestal wound in an adult female due to a foreign body penetration. Again the healing was very prolonged. Pedestal wounds are very difficult due to constant contamination and irritation when the animals lay down.

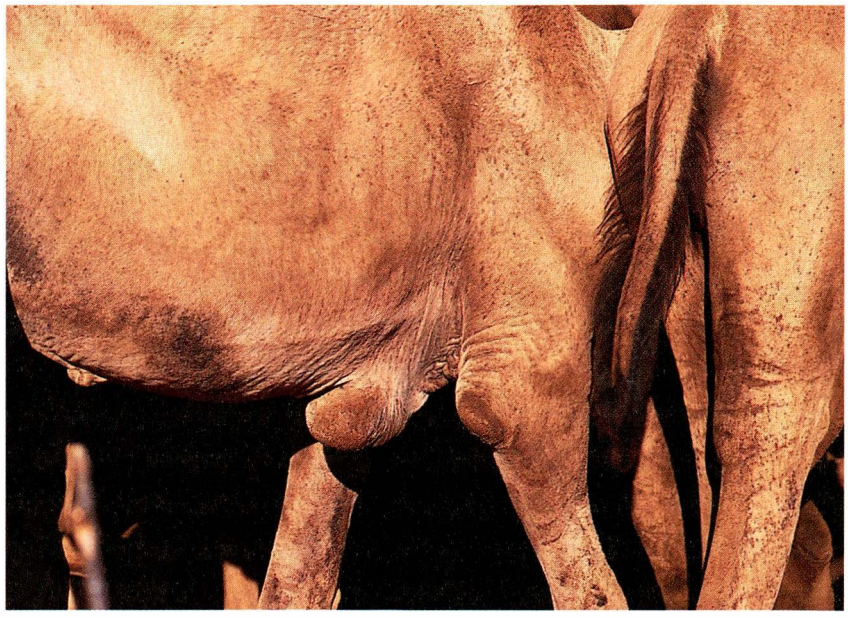
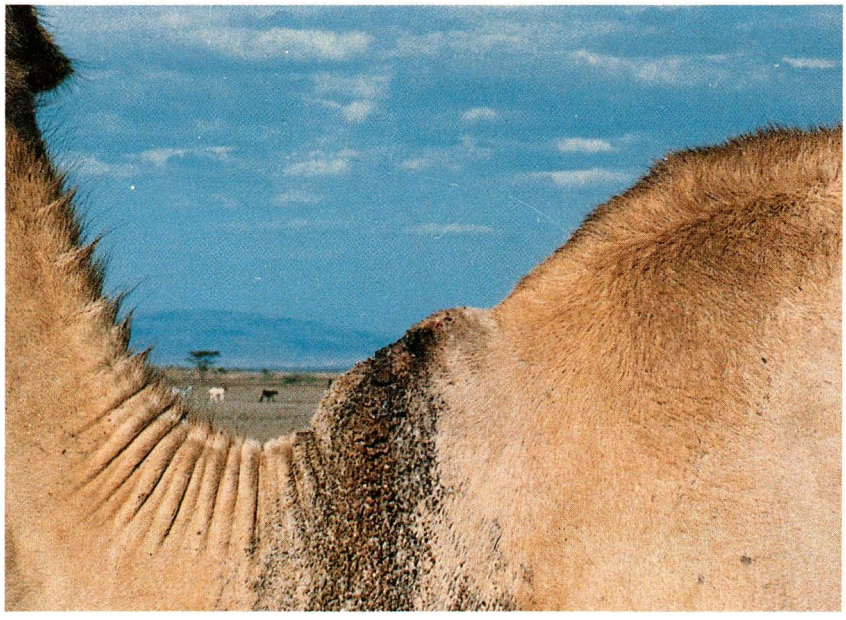


Plate IV,49: Excessive growth of the pedestal pad. This is a common sequela of neglected pedestal wounds. Very large pedestal pads can become a mechanical problem, constant friction with the elbows can cause new lesions and result in more growth. This cycle can only be interrupted if the excessive growth is surgically removed.

Plate IV,50: A deep exudating wither wound in an adult female. Wither wounds have a slow healing tendency. Reopening of the wound by birds or branches is a common problem. Infections of the nuchal ligament are difficult to treat due to the excessive amount of connective tissue and bad vascularisation there.



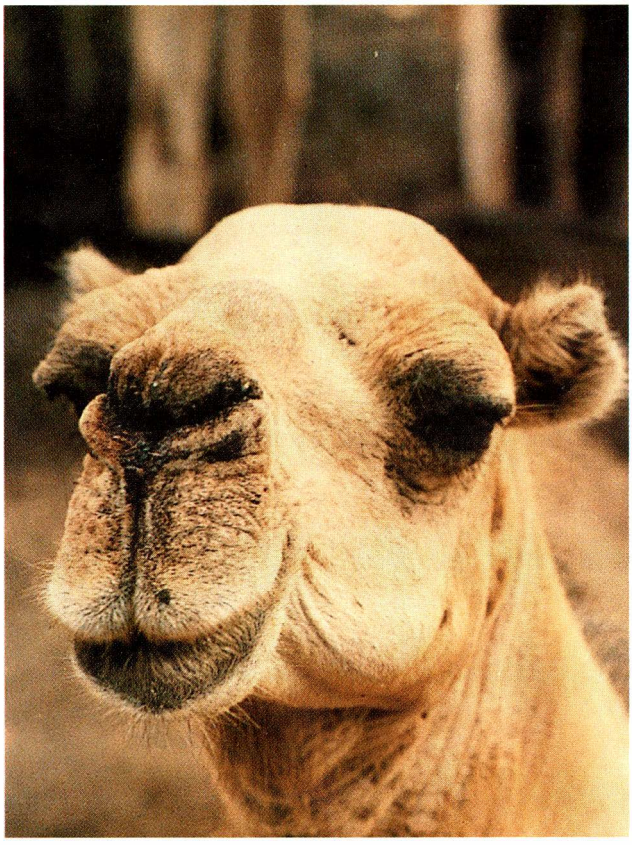


Plate IV,51: Necrosis of the nostrils in an adult animal. A common sequela to massive tick infestation.

Plate IV,52: A rare case of snake bite in the udder. This female camel sat down on a puff udder. Several days after the bite the necrotic udder tissue started sloughing off. This camel survived without treatment. It lost two quarters of the udder completely.

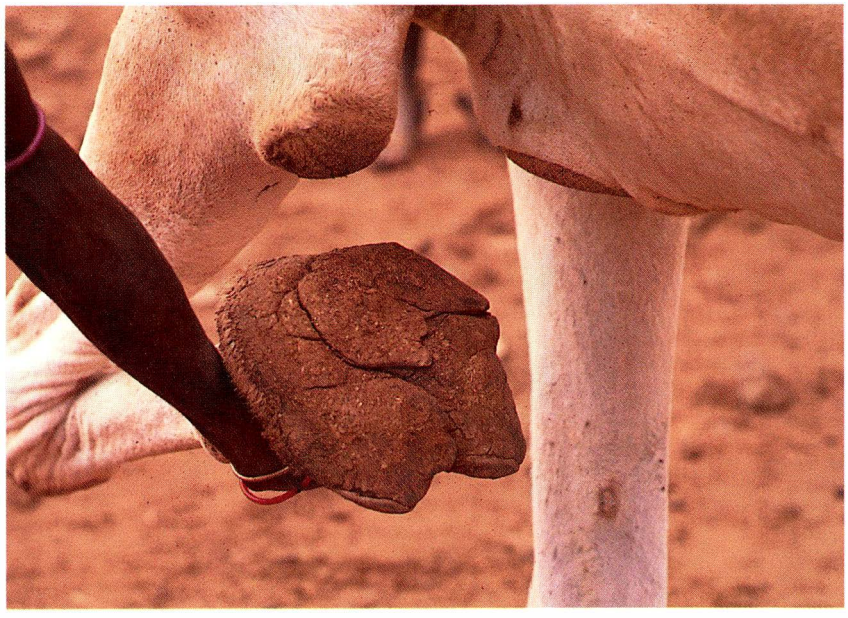


Plate IV,53: Excessive growth of the solar pad. This is a common sequela when animals are kept for a long period on extremely soft soil.

Plate IV,54: Bilateral superficial idiopathic skin lesion. Commonly found on the rear legs, due to constant urine soiling of the hindlegs. When scabs fall off the underlying skin is grey and hairless.

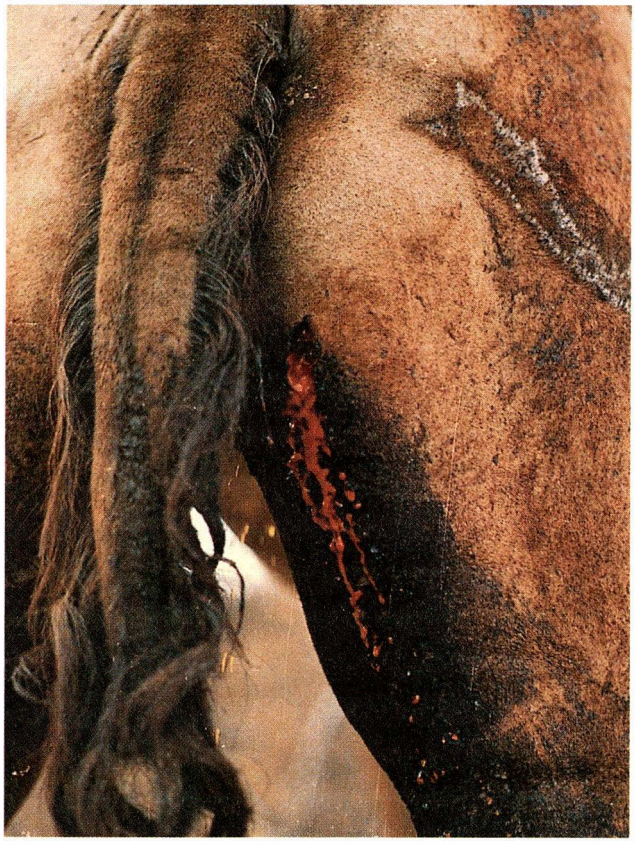
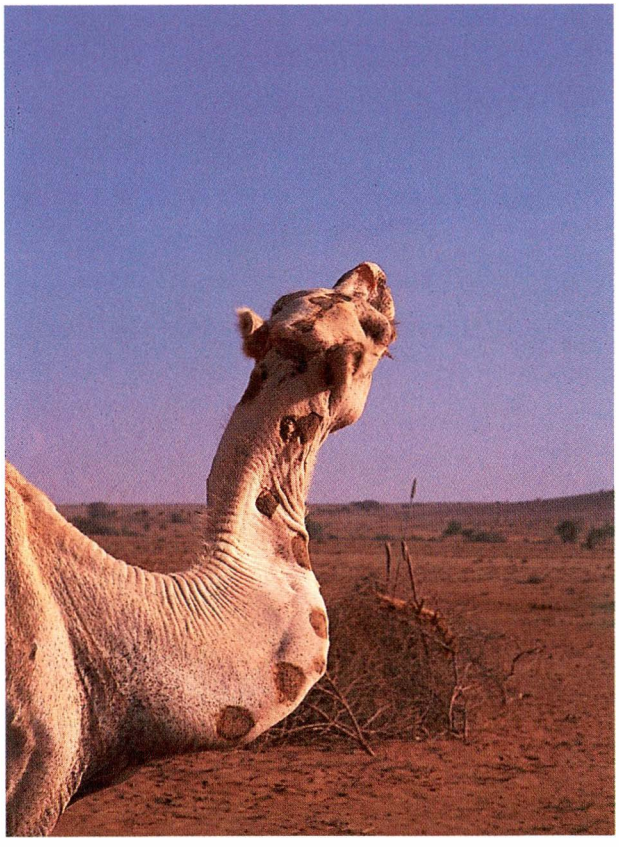


Plate IV,55: An adult bull was wounded by a spear during intertribal raids at the Sudan Kenya border. The bull recovered.

Plate IV,56: A small abdominal hernia in an adult bull. Presumably of traumatic origin during adolescence.

Plate IV,57: A case of wry neck in an immature animal one year and three months old. The condition developed over night. The animal showed no other signs and behaved otherwise normal. Over a period of two month the animal spontaneously recovered.

Plate IV,58: A severe case of wry neck in an adult gelding. The problem did not resolve and the animal lost condition continuously. Due to the severe deformity of the neck the animal could not graze properly. Branding along the neck was tried but not effective. The animal was finally slaughtered.



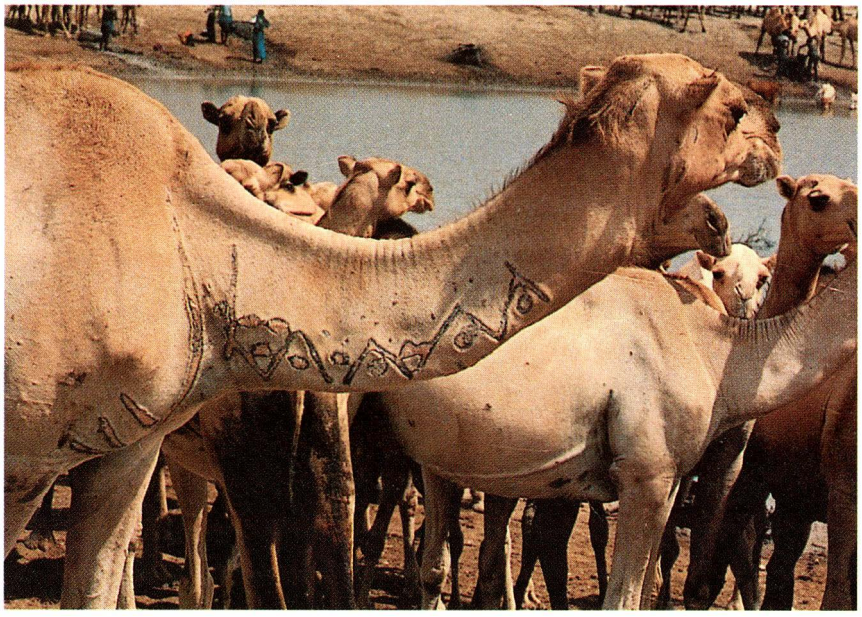


Plate IV,59: This animal is an example of a completely recovered case of wry neck syndrome. It was extensively branded on both sides of the neck.

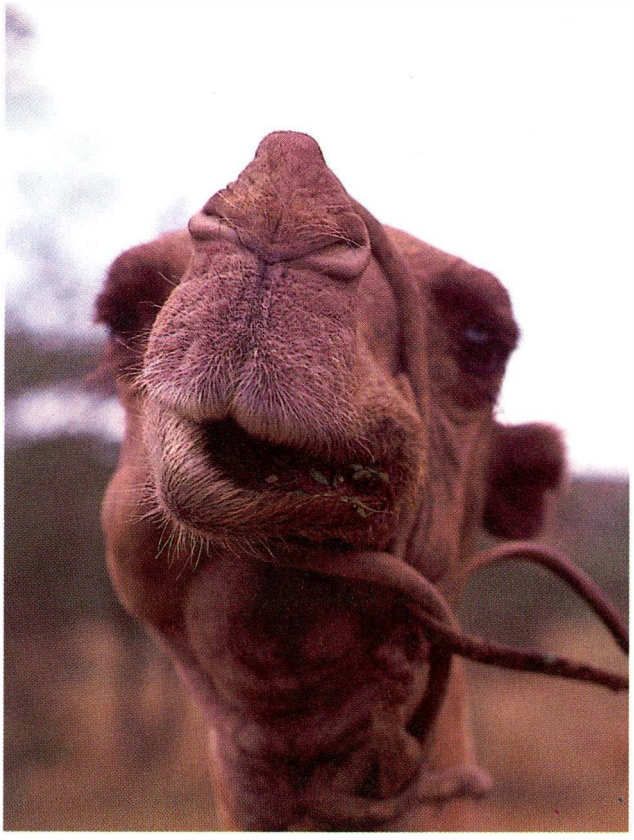


Plate IV,60: A case of a permanent unilateral paralysis of the facial nerve. The upper and lower lip plus the ear on the right paralysed side are hanging down loosely. Grazing was slightly impaired, note the food particles in the mouth.

Plate IV,61: A case of Capparis tomentosa poisoning in an adult female camel. The camel had several weeks before grazed on this plant. In the beginning the animal was unable to rise. Finally walking was possible again but very slow and stiff. the animal lost condition dramatically. Both stifle joints were very painful. The animal had a general weakness in the rear legs.

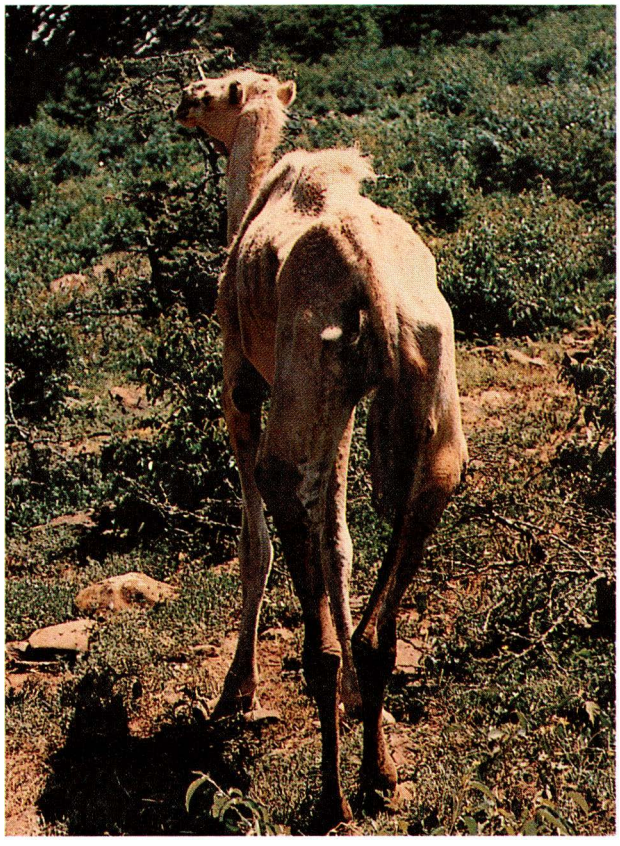


Plate IV,62: Oblique frontal view of the same animal.

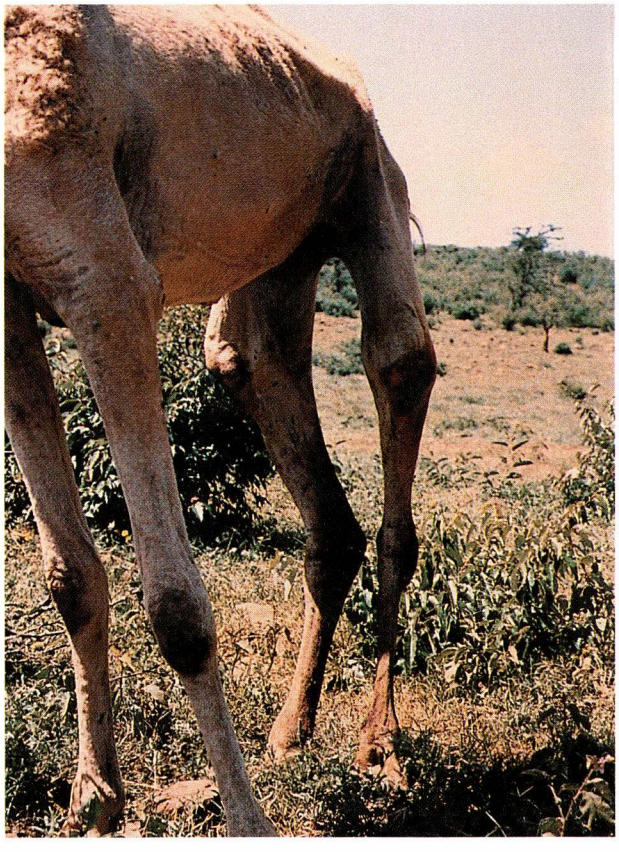


Plate IV,63: Severe unilateral eye infection in an adult animal. Presumably due to trauma. There is marked hyperlacrimation. The animal had no vision on this side.

Plate IV,64: A case of purulent ocular discharge.

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Diseases of the gastro-intestinal system

Gastro-intestinal disorders; (= diarrhoea) khurag (Ko), har, hardik (So), harr (Re), diggheharr (Re), albati (Ga), colera (Tu), Loleo (Tu); (colour plates IV,14; IV,15; IV,16; IV,17)

Etiology and epidemiology: Under nomadic conditions the most commonly encountered diseases of the gastro-intestinal tract in adult camels are predominantly related to severe endo-parasitism, sudden diet changes and some specific diseases such as chronic trypanosomiasis, hemorrhagic septicemia and plant poisoning. The mayor clinical finding is diarrhoea. Most cases of diarrhoea related to endo-parasitism and diet are seen at the beginning of the rainy season. The onset is acute and 20-30 % of the adult animals of a herd are affected. Mortality is usually very low. Prevalence of a number of common pathogens such as salmonella ssp., escherichia coli, coccidia ssp., clostridium perfringens and mycobacterium paratuberculosis, causing severe alimentary diseases in which diarrhoea is a major clinical finding is not known. Neonatal calf diarrhoea is mainly caused by bacterial infection including escherichia coli enterotoxemia and salmonellosis. Morbidity can be up to 30 %. Without immediate and proper treatment mortality rate can reach 100 percent. Poor management practices such as unsanitary feeding, fecal contamination of watering sites and inadequate colostrum intake by the calf post partum facilitate disease outbreaks. Dietary diarrhoea caused by ingestion of excessive quantities of milk is rarely seen in immature and young calves, since suckling intervals are strictly controlled by herdsmen.

Clinical findings and pathogenesis: In diarrhoea, fecal water content is increased resulting in the frequent passage of loose feces. On gross examination faeces may also show alterations regarding to odour, colour and presence of parasites, blood, mucus and undigested feed or sand. Underlying mechanisms for increased fecal water content can be hypersecretion, exudation, altered motility, malabsorption and osmotic retention of water. In acute diarrhoea excessive amounts of fluid and minerals are lost as indicated by sunken eyeballs, decreased skin turgor and sticky

mucous membranes. Persistent diarrhea also results in continuous soiling of rear quarter and a progressive loss in condition. In acute bacterial diarrhoea affected animals are usually debilitated and show additional clinical signs such as fever, abdominal pain, anorexia and general depression. An etiological diagnosis is usually difficult, but affected age groups, seasonal incidence and type of diarrhoea might be helpful to identify the underlying cause. Cases of chronic diarrhoea show a persistent loss of condition, weight loss, decreased productivity, but normal grazing activity and feed intake.

Necropsy findings: Depending on the involved infective agent localized or generalized pathological lesions of the gastro-intestinal tract are found. If definitive etiological diagnosis is needed samples must be submitted for laboratory analysis.

Treatment and control: Dietary induced diarrhoea usually resolves itself, if diet change is corrected and does not require any specific treatment. In diarrhoea caused by endo-parasitism, treatment with a broad spectrum anthelmintic and general improvement of sanitation regarding clean watering holes and clean night enclosures will limit spread and reinfection. In diarrhoea caused by bacterial or viral infection treatment with long acting antibiotics should be accompanied by oral replacement of fluids, supplemental feeding, good sanitation and, to limit spread, isolation of the affected animal. Despite the prevalence of dietary and parasitic induced diarrhoea the importance of a clinical work-up and at least the consideration of the different possible causes should not be overlooked before and during treatment. Careful monitoring of response to treatment, condition of the animal, spread of the disease etc. is mandatory and will aid in making and confirming the diagnosis.

Other clinical findings related to underlying gastro-intestinal disease processes and their most likely cause in camels include:

- impaired grazing/drinking: paralysis of tongue or dulaa; rabies; malocclusion; painful oral lesions caused by camel pox, FMD, BVD, contagious ecthyma, foreign bodies; decayed teeth; fractured mandibula;

- anorexia: high ambient temperature; prolonged dehydration; fever;

- constipation: impaction of forestomachs, bloat; obstruction of large intestines; complete recto-vaginal tear; prolonged dehydration;

- vomiting: behavioural display of stressed or furious camels when restrained;

- tenesmus: endo-parasitism; genital tract diseases such as vaginal prolapse; vaginitis; recto-vaginal tear; urethral obstruction;

- abdominal distension: bloat due to diet; ingestion of excessive quantities of sand; obstruction of large intestines; watered camels; late term pregnancy;

- pain: bloat; peritonitis; enteritis; poisoning; abdominal hernia;

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The respiratory diseases complex

Pneumonia, influenza (various agents); ghudda (Ko), al fahada (Ko), habub (Ko), dugub (So), erghib (So), yaharr (Re), kufa' (Ga), nkorroget (Sa), loukoi (Tu); (colour plates IV,18; IV,19; IV,20; IV,21)

Etiology and epidemiology: Various lower respiratory tract disease conditions of camels have been reported. With the exception of respiratory diseases secondary to trauma or chronic generalisation of secondary infections after perforating wounds of the sternal pad, rib fractures, foot lesions and sinus infection, which are quite common, the definitive etiology of most respiratory diseases is not determined. A variety of viral, fungal, bacterial and parasitic microorganisms have been associated with outbreaks of respiratory disease problems among camels (see table). The most important predisposing factors for respiratory disease outbreaks among camels are sudden climatic changes, poor management practices, low level herd health status and bad nutrition. Disease outbreaks are usually observed during the change from the dry to the rainy season. Draft, cold and rain are highly favourable for disease outbreak. Stressed, diseased, or weaning animals are primarily affected. Mode of infection and spread depends solely on the infectious agent. Crowding and unsanitary conditions can increase

the morbidity rate quite dramatically. Despite usually low morbidity and mortality rates the recovery period of affected animals is quite long. The negative impact on overall productivity should not be underestimated due to the long recovery period. In pregnant animals, particularly during mid-pregnancy (5-6 months), abortion can occur.

Clinical findings and pathogenesis: Pathogenic mechanisms are not well established. Typical clinical signs of acute onset of lower respiratory disease are a change in respiratory rate and depth, respiratory noise such as wheezing, coughing, unilateral or bilateral nasal discharge either serous, purulent or hemorrhagic, increased temperature, anorexia and usually general depression with reluctance to move or work. Hyperlacrimation and other clinical signs may be present such as changes in behaviour, abnormal posture such as abduction of the elbows, extended neck, deviated carriage of the head with apparent swelling of the temporal region or above the sinus frontalis. On percussion the pus filled sinus will sound full or solid. Chronic cases of respiratory disease are characterized by weight loss despite normal grazing and intermittent fever. General immuno-depression also makes the affected animals more prone to other infections.

Table VI,2: Pathogenic agents associated with respiratory disease outbreaks in camels.

Agent	Prevalence	Disease	Reference
Parainfluenza Type1;2;3	widespread regional very common	influenza pneumonia	Bornstein 1988; Burgemeister 1975 Bohrmann et al. 1988 Hedger et al.1980 Olaleye et al. 1989.
Influenza virus A/B	regional	influenza	Richard 1979 Olaleye et al.1989. El-amin et al. 1985.
Adenovirus	regional	influenza	Olaleye et al.1989.
Respiratory syncytial virus	regional	influenza	Olaleye et al.1989.
Infectious bovine rhino-tracheitis	regional	influenza pneumonia	Burgemeister 1975.

Table VI,2 (continued): Pathogenic agents associated with respiratory disease outbreaks in camels.

Agent	Prevalence	Disease	Reference
Pasteurella multocida Type A	widespread very common	broncho-pneumonia	Fassi-Fehri 1987.
Mycobacterium bovis	regional uncommon	miliary/nodular tuberculosis	Fassi-Fehri1987 Mossalami et al. 1971 Higgins 1986
bacterial agents Streptococcus ssp Corynebacterium ssp Actinomyces spp Klebsiella pneumonia	widespread very common	pulmonary abscessation	Leese 1927 Richard 1979. Vitovec et al.1983. Arora et al.1973
Mycoplasma mycoides	regional	pleuro-pneumonia	Richard 1979.
Rickettsia ssp	widespread	pneumonia	Richard 1979
Trypanosoma ssp	widespread very common	pneumonia	Leese 1927; Cross 1917; Rathore 1986
Dictyocaulus vivipara filaria	widespread common	verminous pneumonia	Rathore 1986 Leese 1927
Echinoccocus granulosus Cysticercus dromedarii	widespread very common	hydatid disease	Leese 1927 Cankovic 1982 El Badawi et al. 1980 Macchioni et al.1984. Abdurahman 1987. Pandey et.al.1986. Saad 1982
Dipetalonema evansi	regional	pneumonia pleuritis	FAO 1986

Table VI,2 (continued): Pathogenic agents associated with respiratory disease outbreaks in camels.

Fly larvae (nasal-Myaisis)	widespread very common	rhinitis	Rathore 1986 Higgins 1986 Elias et al.1982
Leeches	regional common	rhinitis	Rathore 1986

Necropsy findings: Depending on the involved infectious agent localized or generalized pathological lesions of the respiratory tract are found. Typical signs of respiratory diseases of viral origin are often masked by secondary bacterial invasion. Bacteriological and histological examination should be performed if definitive etiological diagnosis are needed.

Treatment and control: Principle treatment of affected animals includes anti-microbial therapy, improved management practices eg. housing, hygiene and good nursing care. In case of bacterial infections high doses of long-acting broadspectrum antibiotics should be used. If treated early, the prognosis can be good. Fistula formation between the sinus and the nasal cavity is a common finding in most cases of sinus infection. Drainage is usually sufficient. In case of nasal airway obstruction due to purulent discharge relief can be achieved by regular cleaning and flushing of the nasal cavity with saline. Prognosis is usually good.

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Ectoparasites

Sarcoptic mange (scabies); gerrrab (Ko), addha (So), hado (Re), chito (Ga, Bo), lepepedo (Sa); emitina (Tu); (colour plates IV,22; IV,23; IV,24; IV,25)

Etiology and epidemiology: Sarcoptic mange ranges among the most important camel diseases of East Africa. Mange is caused by Sarcoptes scabiei var. cameli, a minute burrowing mite. The disease is widespread and highly contagious. Main mode of transmission is through close physical contact at watering holes, dust-bath areas and housing enclosures. Contaminated objects such as grooming tools,

blankets and saddles also act as fomites. Young, immature, stressed adult and otherwise debilitated animals are generally affected and usually develop the chronic generalized form of mange. Healthy animals may be affected as well, but usually lesions remain localized. Morbidity is usually moderate, but poor management and inclement weather can increase morbidity and mortality rates quite dramatically.

Clinical finding and pathogenesis: Female mites deposit their eggs in the horny, outer layer of the skin. Four developmental stages eggs, larvae, nymphs and adults are present on the host. Completion of development from egg to adult takes approximately 17-21 days. Host reactions are caused by burrowing (mechanical damage) and allergic reaction to mite excretions (saliva; feces). Intense pruritus, evolving small vesicles and inflammatory reaction of the skin characterize the beginning of the disease. Subsequently affected skin areas show loss of hair and become moist and exudative. Pruritus is severe and affected animals exhibit extensive rubbing and scratching behaviour. Fully developed mange is characterized by scab formation and thickening of the skin due to hyperkeratosis. Most commonly affected sites are the head, axillary, inguinal and perineal area. Mild cases of mange show localized or generalized small patches, 1-2 cm in diameter of hair loss. Chronic cases of mange typically show grey-coloured and folded hyperkeratotic skin. Pruritus is still present, but less apparent than in the early stages of the disease. Affected animals show a general loss in condition, decrease in milk production and poor reproductive performance.

Treatment and control: Improving management practices and sanitation is a necessary prerequisite to successful treatment. Overcrowding, mingling of affected animals with healthy animals and contact with contaminated tools should be avoided. It should be kept in mind that camel herders can also serve as fomites and are occasionally themselves infected by mange especially on the palms and between the fingers. Therefore it is recommended, whenever feasible, that affected animals should be treated and handled by only one person, who is not involved with handling unaffected animals. Improved management practices can reduce the risk of spread among a herd and hasten recovery by limiting reinfections. Topical application of acaricides present an effective, but rather labour intensive treatment. Vigorous brushing of affected areas with dip solutions is necessary. This treatment must be repeated at ten day intervals until healing is complete. Application of motor oil plus acaracida mixture to affected sites is effective too, however, systemic poisoning from percutaneous absorption is possible. Therefore its use can only be recommended in treatment of singular lesions. Systemic treatment with Ivermectin, an injectable antiparasitic drug, has recently become a frequently used drug in controlling and treating camel mange. The recommended dosage for cattle 1 ml/50 kg body weight is effective in camels. Subcutaneous administration appears to be safe. Occasionally local tissue reactions such as swelling or abscessation can be observed. Despite of efficacy and convenience of treatment it has to be kept in mind that clinical response takes time and treated camels can still be a source of infection for other animals until

clinical response has fully taken place. In addition spraying with an acaracide to kill mites present on the skin surface is advisable. Traditional practice is to supplement salt. It is thought to have a general positive effect on disease outcome. No other treatments are applied.

Dermatomycosis; robi (So), ropi (Ga, Bo), ngammyeni (Sa), akiserit (Tu); (colour plate IV,26)

Etiology and epidemiology: This disease condition is caused by dermatophytic fungi belonging to three genera Trychophyton sp., Microsporum sp. and Epidermaphyton sp.. Among camel herds Trychophyton sp. appears to be the main causative agent. It is known from other livestock species that high humidity, crowding and nutritional deficiency (vitamin A ?) seem to be important predisposing factors for disease outbreaks. Whether this holds true for camels as well has not been investigated. Calves are primarily affected, and morbidity can be up to 80% depending on herd health status and sanitary conditions. However it appears that the disease does not spread fast among a herd. Mortality rate is nil. In general disease is mainly spread by direct contact with infected animals, but grooming tools, blankets, enclosures and man can also act as fomites. In kids typical ringworm lesions are quite often seen on the head. The importance of so called "carrier animals" without clinical signs for spread of infection is not known. Another disease condition, which may be confused with dermatomycosis has been reported from Kenya; the causative agent involved was dermatophilus congongolensis.

Clinical findings and pathogenesis: The fungi invade and multiply in dead keratinized tissue such as the growing hair shaft and the stratum corneum. There are 2 distinctive clinical pictures described. The more common one is characterized by circumscribed grey-white slightly raised hairless lesions which are typical for ringworm. Lesions 1-2 cm in diameter are mainly found on the head, neck and legs. The other clinical picture is characterized by a more generalized condition which can be easily confused with mange. The incubation period is thought to be between 8 and 30 days. Pruritus is absent and spontaneous recovery is normal. Development of immunity after recovery from infection seems to be likely, since ringworm infection of animals older than two years are seldom seen. Disease diagnosis is usually based on finding of the characteristic lesions. Direct microscopical examination or culture on Dermatophyte Test Medium may be used to confirm diagnosis. Ringworm fungi as strict aerobes do not survive under the thickly crusted centre of the lesions. Therefore to collect useful samples such as skin scrapings and hair samples it is essential to obtain these from the edge of active lesions. For direct microscopical examination samples are placed on a glass slide, then covered with 20% Potassium hydroxide or Sodium hydroxide, briefly heated up and then examined for presence of fungal mycelia and spores.

Treatment and control: Commonly, treatment is not applied, however a variety of medications for treating ringworm in other livestock species are available. Topical application of solutions are quite useful in the beginning of the disease when only a few lesions are present. Lesions are first scrubbed with soapy water, scabs and crusts are removed and the dried lesions then covered with medications. To avoid contamination of the area the removed scabs and crusts, being infective, should be properly disposed of burning them. Whole body treatment using sprays and washes are recommended when an entire herd is affected. In general, prognosis is good and treatment is usually successful. In cases with severe secondary bacterial infection of lesions the additional use of broad spectrum antibiotics is advisable. Vaccination against ringworm as an alternative method for treatment has been investigated in the USSR, apparently with great success.

Table VI,3: Some common medications used to treat Dermatomycosis in other livestock species (Source: Blood, Radostits & Henderson 1989)

Dispension/drugname	directions
Ointments/	
Whitfields ointment	
2-4% thiabendazole ointment	b.i.d/q.i.d every 5 days
proprionic ointments	
Solutions/	
Lugols' iodine sol.	s.i.d every 2nd day
1:200-1:1000 quaternary ammonium compounds	s.i.d.every 2nd day
0.25% hexadecamethylene-1:16-bis	b.i.d/t.i.d every 4.day
Hexetidine	s.i.d once
0.01%-0.1%Natamycin	b.i.d. every 4rth day
Sprays/washes	
agricultural Bordeaux mixture	s.i.d for 5 days,then
weekly	
0.5% lime sulphur	
0.5% sodium hypochlorite	
1:300 Captan	
0.5% chlorhexidine	
Systemic	
10% sodium iodide 1g/14kg Bwt	intravenous. s.i.d, repeat after one week.

griseofulvin causes side effects in camels such as nausea and diarrhoea, therefore it is not recommended to use it.

Skin necrosis; na'eita (Ko), maha (So), kharfat (Re, Ga), lomgoi (Sa), dulla (Bo); (colour plates IV,27; IV,28)

Etiology and epidemiology: A variety of infectious agents have been isolated from necrotic skin lesions, including actinomyces cameli, streptococcus spp.,

staphylococcus aureus, corynebacterium spp.. Dietary salt deficiency has been associated with outbreaks of the disease, however no conclusive diagnosis is available. Moderate spread of the disease occurs through close physical contact such as crowding at watering sites and night enclosures. Another mode of spread is through contaminated fences and trees. The disease causes pruritus and intensive rubbing and scratching is seen. All age groups are susceptible, but morbidity appears to be slightly higher among immature animals. Mortality is usually low.

Clinical findings and pathogenesis: The disease is characterized by a single, flat ulcerative lesion though multiple lesions occur occasionally. Most commonly affected sites are the head, neck and shoulder region. Painful swellings of small skin areas mark the beginning of the disease. Skin necrosis starts in the centre and spreads outward, followed by sloughing of the necrotic skin. Circular ulcers of varying diameter usually 2-10 cm remain and are clearly demarcated from surrounding healthy tissue. Secondary bacterial infection results in purulent discharge. Due to the intensive rubbing and scratching behaviour fences, trees and holding pens become contaminated and facilitate spread among the herd. The draining lymph nodes are enlarged and painful. Healing is usually rather slow (3-4 weeks) and scar formation is common. Risk of septicemia is high when lesions develop on top of regional lymph nodes.

Treatment and control: Recommended treatment of septicemic animals includes immediate systemic administration of broad-spectrum antibiotics and good nursing care. Treatment of lesions consists of good debridement, flushing with iodine and topical dressing with anti-bacterial and insecticide preparations. Regular supplemental feeding of salt may reduce the incidence of skin necrosis.

Tick infestation; adult tick: gurad (Ko), shilin (So), shilim (Re), shilmi (Ga), shelem (Bo), ilmangeri (Sa); nymph: yakhel (So), turdach (Re), yakhal (Ga), shini (Bo); emadang (Tu); (colour plates IV,29; IV,30; IV,31; IV,32)

Tick infestation is a common finding throughout the year. Ticks commonly found on camels belong to the family Ixodidae, so called true ticks. Female ticks deposit their eggs in sheltered spots. The newly hatched larvae, called seed ticks, wait on vegetation such as grass and scrubs for a suitable host. After attachment they feed on blood and or lymph until they are fully engorged. They detach after having engorged. Male ticks usually remain on the host longer than females. Commonly found ticks on dromedaries are Hyalomma ssp, Rhipicephalus ssp and Amblyomma ssp. These are two or three host ticks. In three host ticks each developmental stage (larvae, nymph and imago) requires a new host after feeding. These ticks are adapted to warm climate and their process of development is greatly influenced by ambient temperature. Inclement weather has a negative influence on hatching and moulting time. Immediately after the rainy season there is a marked seasonal decrease in tick burdens on camels. Apart from very heavy infestations average tick burden in dromedaries kept under nomadic conditions is around 50-100 ticks per animal during the dry season. Long lasting grazing

periods in areas heavily infested with seed ticks and temporary crowding at watering wells will facilitate spread and increase infestation rate. Ticks from the genus Rhipicephalus ssp. and Hyalomma ssp. are known to be important disease vectors for domestic livestock. The importance of tick transmitted pathogenic agents for dromedaries has not been thoroughly investigated. However, outbreaks of hemorrhagic septicemia appear to be related to heavy Hyalomma dromedarii infestations. The main harm caused by ticks and their developmental stages, especially nymphs, is through blood sucking. An adult female tick can remove 2 ml of blood, in heavily infested calves with nymphs the blood loss therefore can be marked and lead to anaemia. Tick bites and subsequent attachment produce skin irritation and a localized allergic or inflammatory skin response. Secondary bacterial infection of these microlesions is possible. Heavily infested animals show general loss of productivity and body weight.

Table VI,4: Commonly found tick species and preferred attachment sites.

	attachment site		
genus	nostrils	eye/ear	perineal
H.dromedarii	(+++)	(+)	(+)
H.rufipes	(-)	(-)	(+++)
H.truncatum	(-)	(-)	(+++)
R.sanguineous	(-)	(+++)	(+)
R.pulchellus	(-)	(-)	(+)
R.evertsi	(-)	(-)	(+)
R.simus	(-)	(-)	(+)
A.gemma*	(-)	(-)	(+)
A. lepidum*	(-)	(-)	(+)

* Amblyomma ssp. causes severe skin lesions due to very long mouthparts.

Treatment and control: Commonly affected body regions are summarized in table 1 and tick infestation there can be easily appreciated. However, nymphs commonly hide in body regions with longer hair, like the withers, neck, shoulders, hump and ribs. A thorough examination is necessary to diagnose tick infestation. Heavily infested animals should be treated with pour-on acaricides or sprayed. In adult animals, regular application of tick grease to common sites is recommended. Immature animals especially suckling calves should be regularly treated in the first few months with pour on acaricide to reduce preweaning mortality due to heavy nymph infestation. Altering management strategies by avoiding heavily tick infested grazing areas, overcrowding at watering holes and holding sites will also help to control tick infestations.

Fly infestation; Cephalopina titillator: senghel (So), senghelel (Re), rhamu (Ga); (colour plates IV,33; IV,34; IV,35; IV,36)

Fly infestation can present several problems in camel management. According to their genus flies can cause myaisis, transmit diseases, or produce simple disturbance and irritation resulting in handling difficulties and significant loss of productivity. Hippobosca camelina, a biting fly belonging to the group of camel flies is commonly found in the presence of camels. They are not easily disturbed and cluster in the abdominal and inguinal region. They can serve as a disease vector, the importance as a tryps vector is not fully assessed, but the significance as a disease vector is thought to be neglegible, since it has been observed that the fly stays in close proximity to the camel and rarely leaves its chosen host. Cephalopina titillator, a myiasis producing fly, is rarely observed, being rather short lived. However the extremely common larval stages causing nasal myiasis demonstrate their continuous presence The female deposits egg clusters on the nostrils, later the emerging larva migrate to the naso-pharynx and attach. After completing their development the larvae are usually removed by sneezing. Characteristic clinical findings in affected animals are occasionally bleeding from the nose, usually presence of nasal discharge due to swelling and infection of the upper respiratory tract and respiratory distress. If larvae penetrate the ethmoturbinate bones fatalities may ensue. Diagnosis is based on presence of neurological signs. Rabies should be kept in mind as a differential diagnosis. Drug treatment is seldom applied, but if necessary several injectable antiparasitic drugs seem to be effective.

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Abscesses, wounds and lesions

Abscesses; waglal (So), malah (Re), ngemek (Sa), abus (Tu); (colour plates IV,37; IV,38; IV,39; IV,40; IV,41; IV,41; IV,42; IV,43; IV,44; IV,45; IV,46)

Etiology and epidemiology: Singular or multiple external and internal abscesses are a very common health problem in camels. Several organisms have been isolated from abscesses such as corynebacterium spp., streptococcus spp., staphylococcus spp., pseudomonas spp. and actinomyces spp.. In adult animals abscessation is usually a common sequel to traumatic skin penetration. Infected fighting wounds, puncture wounds caused by thorns, wounds from predators, saddle sores, microlesions caused by ectoparasites and faulty or nonsterile administration of veterinary drugs can lead to single or multiple subcutaneous abscess formation. Abscessation of singular lymph nodes is a common feature in camels. Furthermore a disease condition resembling caseous lymphadenitis occurs mainly in camels over 3 years. Hereby abscessation is mainly restricted to the external lymph nodes such as prescapular or cervical lymph nodes. The condition is chronic and benign. Characteristic cold, painless and closed abscesses are present commonly stabilizing at about the size of an orange. A variety of microorganism have been isolated, however the etiology remains nuclear. In neonate camels multiple subcutaneous abscess formation and joint ill is a common sequel to neglected umbilical cord infections. Joint-ill is an important disease of neonatal camels, in which bacteria colonize joint spaces. Tarsal and carpal joints are most commonly affected. Suppuration and tissue reaction produces acute pain, heat and swelling. Chronically evolving bony changes cause arthritis. Calves affected by chronic arthritis show less activity and usually do not thrive well. Onchocerca gutturosa, a helminth living in the skin, is a wide spread finding in camels especially in the nuchal ligament. It is not known if fistulous whither wounds can be associated directly with the presence of the larvae. In view of the

general importance of these conditions. an in-depth investigation would be advisable.

Clinical findings and pathogenesis: By definition an abscess is a circumscribed collection of pus surrounded by a wall of fibrous tissue. Abscess formation is usually a slow process. At the site of injury a hot and painful swelling develops indicating inflammatory tissue reaction. The presence of pyogenic bacteria or an irritant solution leads to various amounts of pus formation resulting in gradual enlargement of the abscess. The abscess is initially firm and gradually softens during the maturation process. At this time spontaneous rupture may occur discharging a thick and viscous pus. Due to the excessive formation of fibrous tissue a characteristic feature in camels and the thick consistency of the pus, drainage is usually insufficient and reoccurrence of the abscess and prolonged healing is common. Invasion of the organism into the blood or lymphatic system can result in internal abscessation, septic polyarthritis, joint-ill and life-threatening septicemia.

Treatment and control: Improved management and sanitation are mandatory. Affected animals should be treated by surgically excising the abscesses. Treatment includes proper drainage, irrigation with antiseptic solution such as diluted iodine and application of insecticidal preparations to prevent myaisis. Hydrogen peroxide solutions can be used in the initial treatment to disolve and break up the the abscess core. Application of petroleum jelly on the skin below the incision is helpful to prevent seepage induced excoriation. In addition systemic application of broad-spectrum antibiotics in cases of joint-ill and septicemia are necessary. Prognosis is guarded in all cases of joint-ill and septicemia. Surgically incised simple abscesses usually show good healing.

Wounds and Lesions (colour plates IV,47; IV,48; IV,49; IV,50; IV,51; IV,52; IV,53; IV,54; IV,55;; IV,56)

Injuries of varying degrees of severity are a common problem in camel management. In habitats which are characterized mainly by shrub, acacia tree vegetation and stony ground, occurrence of skin, foot pad and sternal pad wounds is quite high. Apart from that locally abundant predators such as hyenas and lions or venomous snakes and tribal raids can also contribute to a higher incidence of wounds. During the rutting season fighting wounds among male camels are a common problem. Common sites for bite wounds are the withers, hump, frontlegs and scrotum. Occasionally female camels are accidentally injured by rutting males during courtship. The food pad and the pedestal pad are predisposed by their function to penetration by foreign bodies such as thorns, branches and sharp pebbles. Humid and wet weather increase the liability by softening the horn.

Clinical findings and pathogenesis: There is a great variation in appearance of soft tissue wounds. Lesions can be simply superficial or involve deep tissue. Factors such as time lapse since injury, further contamination with soil, blood supply, presence of necrotic tissue, foreign bodies and flystruck greatly influence physical appearance of wounds. Skin lacerations caused by branches and/or thorns are usually superficial and of limited extent. Wounds caused by penetrating foreign

bodies are usually small and deep. They can be easily overlooked especially in the case of foot and pedestal pad lesions. Lesions of the foot pad usually result in various degrees of lameness, hot and painful swelling and reluctance to move. Grunting in the act of rising or sitting down is suggestive for presence of a pedestal wound. Furthermore, pedestal wounds may also alter reproductive performance, since copulation takes place in a crouched position. Affected male camels show a decreased libido, since weight bearing during copulation is done mainly by the pedestal pad. Biting Wounds can either appear as small puncture wounds, extensive lacerations or even amputation of soft tissue. A bite from a venomous snake is characterized by two small puncture wounds. Bleeding is minimal. Extensive tissue swelling develops and followed by local tissue necrosis.

Treatment and control: It is important to assess the time lapsed since injury, the extent of lesions and the status of blood supply. Primary closure should not be undertaken in the case of grossly contaminated wounds, where excessive tension will result from closure, e.i. wounds close to joints, where tissue is either necrotic or of questionable viability and where dead spaces are present. These wounds are left open, debrided, a drain placed, broad spectrum antibiotics systemically administered and allowed to heal by secondary intention. Since all wounds are predisposed to fly-struck, application of insecticidal preparations should always be included in the treatment protocol. Biting wounds must be opened and the wound cavity explored, since biting wounds usually result in extensive trauma and contamination of deep tissue. They are flushed with diluted iodine or a sterile saline solution. Prognosis is usually good.

Successful treatment of wither wounds presents a problem. Recurrent contamination, reopening of the wound by birds or brushing branches and insufficient drainage are common. Vigorous treatment is necessary. Bite wounds caused by venomous snakes are not treated. In case of local tissue necrosis caused by the venom general wound management is applied. Superficial food pad lesions usually heal in a couple of days, if the camel is rested. Dressing the lesions with antibiotic wound powder is usually enough. In the case of deep solar wounds, vigorous debridement, flushing of the wound canal, removal of any foreign bodies and use of a protective bandage is recommended. Proper treatment is necessary. Neglected cases can result in loss of the animal.

Treatment of an injured pedestal pad presents a serious challenge. Position and function lead to continuous soiling and irritation of the wound. To prevent this a doughnut shaped bandage can be applied. Hereby the pedestal pad no longer comes in contact with the soil when the animal lays down. Abscessation of the pedestal pad is a common sequel of deep pedestal pad lesions and has to be treated vigorously, since secondary infection of the chest cavity is possible from fistulas of migrating foreign bodies. Good drainage of infected pedestal pad wounds is rarely achieved. Prognosis is guarded, but good nursing care and rest have yielded successful results. In neglected cases excessive formation of fibrous tissue can result in an enormously enlarged pedestal pad. Such cases require surgical amputation.

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Diseases and disorders of the nervous system

Rabies; yudle (So), sugeri kaare (Re), nkwang (Sa), siribo (Bo), nyanye (Ga), ingerep (Tu)

Etiology and epidemiology: Rabies is one of the most important zoonotic viral diseases. It is widespread throughout Africa. All animals apart from reptiles and birds are susceptible to the disease. Important vectors are domestic canines and wild carnivores such as jackals, hyenas and spotted wild dogs. The main mode of transmission is by bite wounds. Incubation period can vary between one month up to several months. Rabies is considered a fatal disease, however recovery has occurred. Outbreaks of rabies in camels have been related to attacks by stray dogs or other predators.

Clinical findings and pathogenesis: Upon introduction of infectious saliva into body tissue, the virus replicates, then travels to the brain and from there to the salivary glands. Apart from the observed progressive paralysis tentative diagnosis is quite often based on the behavioural changes in rabid animals, which are quite typical. Commonly observed behavioural changes in rabid animals are viciousness, increased activity or excitation and pica. In camels as described in other animals two forms can be distinguished the dumb and furious rabies. The furious rabies form seems to be more common. Rabid camels show profuse salivation, due to inability to swallow caused by paralysis of the throat, aimless running off from the herd and coming back, increased aggressiveness and progressive paralysis. However it must be kept in mind that in most diseases affecting the brain changes in animal behaviour do occur. Normal ingestion, body care, locomotion, rest and sleep behaviour can be modified with regards to increased or diminished intensity. Changes in social behaviour towards other animals or man can also evolve. Increased aggressiveness and activity in camels have been also noted in case of coenuris and bacterial meningitis caused by listeria ssp and nasal myaisis.

Treatment and control: Since rabies presents a high zoonotic risk for human beings, animals with rabies-like symptoms should be immediately isolated and killed if evaluation of history is suggestive of rabies, such as previously attacked by wild carnivores or stray dogs. Controlling rabies in endemic areas is only possible through mass vaccination of stray dogs and immediate elimination of suspected rabid animals. It is strongly recommended that all persons who frequently handle domestic livestock or wildlife should receive a pre-exposure immunization. Titres should be checked every year.

Stiff neck; hattal (Ko), tagou (So), rekigerri (Re)

According to camel herders there is a distinctive disease condition known to them as stiff neck syndrome. Both acute and chronic forms exist. Clinical findings in the acute form has striking similarity to tetanus. However the described chronic form does not fit the clinical picture of tetanus. It seems more likely that two different diseases exist, which are apparently not distinguished by the camel herders. Characteristic clinical findings in the acute form are a stiff neck, general rigidity of muscles and inability to open the mouth. The acute form, quite often fatal, can last 10-15 days with progressing signs. All age groups appear to be susceptible. Again the disease does not appear to be contagious since only single animals are usually affected. The condition appears to be very painful. Spontaneous recovery is not uncommon, however convalescence period is quite long. The chronic form is characterized by permanent stiffness of the neck. Affected animals are holding the head and neck extended and are in severe pain. The chronic form lasts about 3 to 12 month and the animal looses condition quite dramatically and eventually die. Traditional treatment includes extensive branding of the neck region. With regards to the clinical findings in the chronic form suggested differential diagnosis has included rheumatism and muscular affection during surra. Subluxation of the atlantoccipital articulation or other musculo-skeletal injuries to the cervical column have to be included in the differential diagnosis.

Etiology and epidemiology of tetanus: Tetanus is a widespread disease in tropical regions. It is caused by Clostridium tetani an anaerobic bacteria, which is commonly present in soil or the intestinal tract. The susceptibility to the neurotoxin released by Clostridium tetani varies within animal species. Mortality is usually quite high. Recovered animals apparently do not develop an immunity.

Clinical findings and pathogenesis: Tetanus is caused by a neurotoxin, which stimulates nerve endings. In wounds contaminated with soil containing clostridial spores, especially deep puncture wounds or wounds covered by dirt or scabs a favourable anaerobic condition is created in which clostridium tetani can multiply and grow. Upon stagnation of growth, autolysis of bacterial cell membranes occurs and the neurotoxin is released. Incubation period is thought to be between 10-14 days. Characteristic clinical findings are localized stiffness of head and neck muscles, generalized muscle rigidity, lock jaw and erect ears. External stimulation including noise, sudden movement and sensation of contact will provoke sudden general spasms. Respiratory rate and body temperature are markedly increased. Severity of general spasms and outcome of the disease depends on the amount of released toxin and animal susceptibility to the neurotoxin. In mild cases recovery is possible. The convalescent period is quite long. In severe cases fatal outcome is common.

Treatment and control: Affected animals should be put in a quiet and dark environment. If no suitable facility is available the animal should be sedated. Application of dark eye patches and ear plugs will be helpful to reduce exposure to external stimulation. The area must be inspected for potentially dangerous objects such as rocks and branches which should be removed to reduce the risk of injury during general spasms. Furthermore clean and soft bedding should be provided. The animal is inspected for presence of suspected wounds and these are cleaned. Tetanus antitoxin and antibiotics are systemically administered. Beware of possible anaphylactic shock due to antitoxin. Animals responding to the treatment should receive good nursing care throughout the recovery period. This treatment protocol commonly used for other livestock has been successfully used in the early stages of tetanus in camels.

Wry neck syndrome; kasara (Ko), shimper (So), dahasi (Re); (colour plates IV,57; IV,58; IV,59)

In wry neck syndrome the characteristic clinical finding is a S-shaped deformation of the neck. The onset of the disease is acute and spontaneous recovery without treatment is not uncommon. The condition does not appear to be painful and otherwise the animals behave normally. In severe cases grazing might be impaired and animals loose condition progressively. Most commonly affected age group are weaning animals. The disease does not seem to be contagious since only single animals among a herd are affected. Systemic treatment with vitamin B complexes seems to be curative and hasten recovery. Whether the disease is related to a general deficiency in Vitamin B complexes is not known. Traditional treatment in case of wry neck syndrome is extensive bilateral branding of the neck.

Facial paralysis and other nerve dysfunctions; (colour plate IV,60)

Nerve damage is commonly related to trauma or inflammatory processes. The onset is usually acute and clinical findings such as partial or complete malfunction are quite obvious. Restoration of normal function depends on the extent and nature of damage. Prognosis is guarded if no improvement can be observed during the first 4-6 weeks, however good nursing care and persistence in treatment have yielded unexpected success. Common causes for facial paralysis are direct trauma to facial branches, otitis media or interna and skull fractures into the petrous temporal bone. Paralysis is usually unilateral. Characteristic clinical findings are immobility and dropping of the ear and deviation of the nose to the unaffected side. In permanent facial paralysis there is an obvious atrophy of muscles on the affected side. Treatment for acute cases includes administration of anti-inflammatory drugs, application of hot packs and good nursing care. Other nerve dysfunctions observed or reported have involved paralysis of the radial nerve after prolonged lateral recumbency, inability to get up after prolonged restraint with ropes in sternal recumbency, post partum posterior ataxia in heifers with dystocia and transient paralysis of the tongue presumably related to vigorous manipulation of tongue or resulting from trauma (Somali weaning technique cutting tongue).

Table VI,5: Common neurological disorders in the camel

Clinical signs	Vernacular name	Etiology	Reference
Wry neck-syndrom	kasara shimbir gudaan	Vit B ?	Sudan/Köhler et al. 1990 Somalia/Gulleed et al.1986 Kenya*
stiff neck	grun goudaneki	tetanus	Sudan/Köhler et al.1990 Ethiopia/Richard 1979 Kenya*
facial paralysis		trauma	Kenya*
agressive-ness & increased activity	shimbir haad shimbirr folie	myaisis coenurosis myaisis listeriosis rabies	Somalia/Moallin 1990 Ethiopia/Richard 1979 Ethiopia/Richard 1979 Marocco/Burgemeister 1974 Peck 1966 Mauritania/Bah 1981 Somalia/Leese 1927
Progressive ataxia		Cu deficiency plant poisoning	Palmer et al. 1980
Swaying disease		Se defficiency	China/Zhang et al.1988
Posterior paralysis	 kraff	plant poisoning Ca deficiency P deficiency	Marocco/Burgemeister 1974. Kenya* Idris et al.1984 Marocco/Burgemeister 1974 Somalia/Moallin 1990 pers. comm.
Irritability, convulsions		Mg deficiency	India/Chandel et al. 1989

Kenya* Dioli & Stimmelmayr 1990

Plant poisoning; loturudei (Sa), bosoto (Tu), hada (Ga), arda (Bo), gedak (So); (colour plates IV,61; IV,62)

Throughout Africa the presence of Capparis tomentosa, a medicinal plant, has been recurrently associated with plant poisoning in camels. Without previous experience camels will readily eat the palatable plant. The chemical nature of the toxic agent has yet to be investigated. Ingestion of leaves or fruits from the plant

result in toxicosis characterized by a variety of neurological disorders such as twisting of the neck, progressive loss of coordination, hind limb paralysis and convulsions. Time elapse between onset of clinical signs and death is usually less than 24 hours. Mortality is close to a 100%. In case of survival, the affected animal appears to be in severe pain and recovery is usually slow. Anorexia and severe stiffness of stifle and hip joints are common clinical findings. There is no antidote available. Efficacy of symptomatic treatment such as oral administration of activated charcoal to adsorb toxicants, sedation to counteract the central nervous signs and prevent self inflicted injuries, administration of large quantities of oral fluids and the use of purgatives such as magnesium salts is unknown. Introducing camels to new grazing areas, where Capparis tomentosa plants are present should be avoided, but if this is not feasible close monitoring of animals during browsing is recommended to prevent accidental ingestion.

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Ocular diseases

Etiology and epidemiology: Ocular diseases are quite common among herded camels. Most of these are of traumatic origin including blows, thorns and other foreign bodies. Commonly only one eye is affected. On pastures where vegetation consists mainly of shrubs and Acacia trees the incidence of trauma is quite high. Injuries also occur during the night, when the animals are confined in small enclosures, which are traditionally built of acacia branches. Excessive rubbing due to irritation of the eye lid caused by fly or tick infestation can also lead to eye injuries and secondary bacterial infections. During the fly season, infestation with Thelazia leesei, a regionally common nematode can be seen. The eyeworm is found in the conjunctival sac. Large numbers may cause mild conjunctivitis and hyperlacrimation. Eyelid inflammation is also seen with camel pox and contagious ecthyma infections. Occasionally eye infections result in impaired vision or complete blindness caused by corneal opacity and scars. Opacity of the lens is a common clinical finding among older camels. The etiology is not clear. Depending on the degree of cloudiness vision can be partly or completely impaired. Without supportive help these animals usually lose condition quite rapidly since grazing ability is seriously hindered. They are also at a higher risk of predation if not thoroughly guarded. Cases of temporary blindness in adult camels

have been observed. There were no lesions present and the animals recovered full eyesight after a month. Clinical findings were photophobia and apparent blindness as indicated by insecure gait and walking into objects. This idiopathic blindness was thought to be related to a previous severe outbreak of camel pox in the herd. Night blindness apparently also occurs in camels at a very low incidence. It has been seen in both sexes. The animals are otherwise completely normal.

Clinical findings and pathogenesis: Most eye diseases are quite painful and cause a lot of discomfort and may result in reduced feed intake. Beside obvious clinical signs such as hyperlacrimation, ocular discharge, head tilt, wounds and swelling of periocular tissue, behavioural changes such as separation from the herd, seeking shade, extensive rubbing of the head and squinting, insecure gait and bumping into obstacles are also indicative of eye problems.

Treatment and control: Examination of the eye might require rope restraint or slight sedation. Thorough examination of the eye will often reveal the cause. Superficial wounds of the eyelid and the periorbital region usually do not require any specific treatment beside wound cleaning, removal of present ticks and prevention of fly struck.

Treatment of swelling and inflammation of the eyelids and secondary bacterial conjunctivitis caused by camel pox or contagious ecthyma lesions includes careful cleaning of the eye and repeated application of topical antibiotic ointment into the conjunctival sac. Treatment of inflammation of the conjunctiva or keratitis due to foreign bodies such as sand, grit, thorns consists of careful removal of the foreign body and repeated application of topical antibiotic ointments. Furthermore the following management practices are recommended. The animal should be kept in the shade or a temporary eye patch placed over the affected eye. In case of severe pain as indicated by obvious loss of condition the short term use of analgesics is recommended. Feeding and watering of animals with temporary or permanent impaired vision should be done separately from the herd to prevent food being taken by other camels. Furthermore the animals should be confined in an enclosure to reduce the risk of self inflicted injuries.

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Chapter V

Field guide to post-mortem examination

R.Stimmelmayr, M.Dioli and H.J.Schwartz

Brief introduction to the anatomy of the camel

Knowledge of the basic anatomy of the camel is a precondition for the understanding of all its physiological and productive functions. However, in the context of this chapter only those aspects will be introduced, in the briefest manner, which have a bearing on conducting post-mortem examinations under field conditions.

The skull of the camel resembles more that of a horse than that of any domestic ruminant. The most striking feature is a prominent projection of the occipital bone to which the powerful nuchal ligament is attached, which largely supports the weight of the head and the neck. The vertebral skeleton of the dromedary is characterized by a kyphotic vertebral column with 7 cervical, 12 thoracic, 7 lumbar, 5 fused sacral and 15 to 21 caudal vertebrae. The transverse process of cervical vertebrae project ventrally from the arch forming groove. The sternum consists of seven sternebrae. There are 12 pairs of ribs, four of these are asternal (Figure V,1). The asternal ribs are bent backwards, the last one at an angle of approximately 45ł, thus enclosing a larger portion of the abdominal cavity. This makes surgical placement of forestomach fistulas more difficult than in domestic ruminants.

The limbs are long and slender. Radius and ulna as well as fibula and tibia are completely fused. There are only 2 toes with distinctive nails and no vestigial digits. The distal phalanges of each toe are supported by digital cushions consisting of adipose tissue encapsulated in connective tissue. These in turn are supported by thick layers of connective tissue and the thick, undivided sole.

The skin is thick, tight and relatively immobile. There are only few subcutaneous elastic connective tissue patches, situated at the withers, the cranial medial foreleg, the abdomen, the caudal lateral hindleg, where subcutaneous injections can be applied (see Chapter III). There are 4 modified epidermal structures, the so called callosities, situated at carpal, elbow and stifle joints, and at the sternum. They occur where the camel in contact with the ground when couched and consist of a dark horny substance. The skin over the hump is quite elastic it contracts or expands easily with the hump, but remains rather tight at all times. The hump itself consists mostly of fat and fibrous connective tissue, its size depends mainly on the nutritional status of the animal. The camel has no other subcutaneous fat deposits of any importance.

The topography of the viscera is shown in the Figures V,2 and V,3. The lungs are occupying the major portion of the thorax. To view the heart properly the cranial

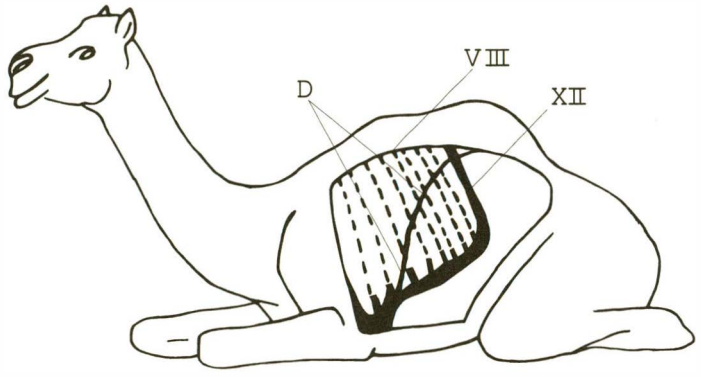

Figure V,1: Topography of ribs and diaphragm, left side (D = diaphragm; VIII = 8th rib; XII = last rib)

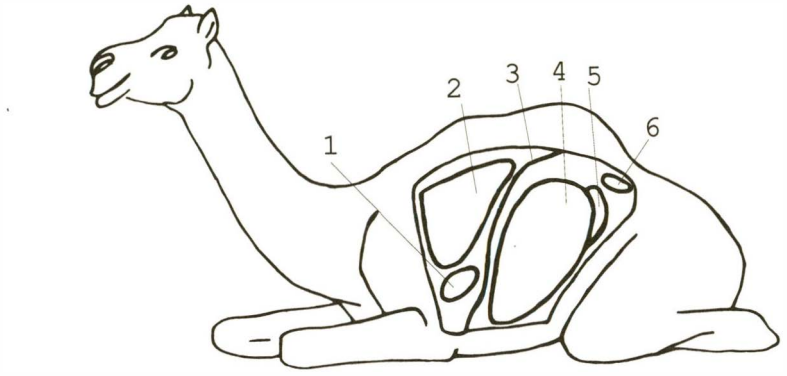

Figure V,2: Topographic anatomy of organs in situ, left side (1 = heart; 2 = lungs; 3 = diaphragm; 4 = compartmented stomach; 5 = spleen; 6 = kidney)

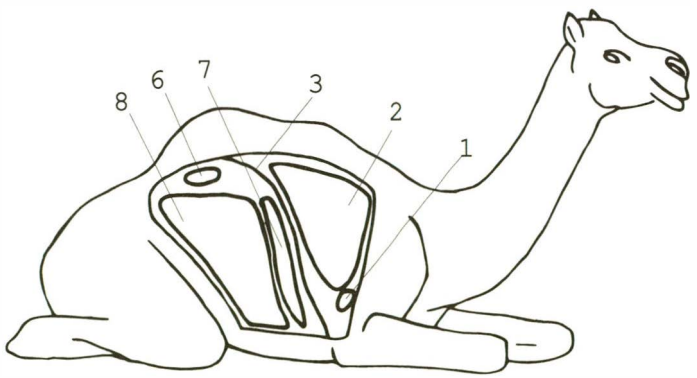

Figure V,3: Topographic anatomy of organs in situ right side (7 = liver; 8 = coiled intestines)

lung lobe has to be removed (Colour Plates V,1 and V,2). The compartmented stomach plus spleen are the prominent organs on the left side upon opening the abdomen. On the right side the heart is only visible when the lung is removed. Upon opening the abdomen the small intestines are the dominant organ. To see the liver properly the last three ribs have to removed. The right kidney is more cranially situated then the left one.

The respiratory system: The nostrils are slit like and can be voluntarily closed completely. The trachea is wholly cartilaginous and up to 150 m long in adult animals. It divides into 3 bronchi the B.trachealis, the B.principalis dexter and B.p.sinister. The pleural cavities are completely separated. On the right side the pleural cupola projects beyond first rib. The lungs have no fissures and lobulation is not distinct (Colour Plates V,3 and V,4). The right lung, extending from the first to the eleventh intercostal space, consists of 3 lobes, the cranial, the caudal and the accessory lobe. The left lung consists of 2 lobes. In the left lung the accessory lobe is missing. The caudal border of the lungs has a distinctive ruffled visceral pleura. In most animals a small diaphragmatic bone is found in the centre of the diaphragm.

The heart has a pointed shape (Colour Plates V,6 and V,7). On the left side it is situated between the fourth and the fifth intercostal space. On the right side it is situated between the fourth and the sixth intercostal space. The sulci and coronary grooves are completely filled with white fat. The colour of the intima of major arteries is white and the surface is smooth. The pericard is quite thick (2 to 4 mm) and not transparent. The colour is white. The pericardic fluid is clear, odourless with the viscosity of water. The total amount is 3 to 10 cc.

The digestive system: The camel has a slightly prehensile, split upper lip; the lower lip is slack, often pendulous. The upper jaw has a tough dental pad. The oral mucosa are pigmented. Large conical and buccal papillae are present. The soft palate (dulaa) in males has an expandable diverticulum. Protrusion of the inflated dulaa is part of the rutting behaviour (see Chapter III). The tongue is quite long and spatulate in shape. The oesophagus runs left of the trachea. The compartmented stomach (Colour Plate V,10) has already been described in Chapter I. The small intestines have a total length of 40 meters (Colour Plate V,9). The large intestines are about 19.5 meters long. The colon is coiled.

The spleen is crescent shaped (Colour Plates V,8; V,11; V,12). It is of firm and elastic texture. The proportion of interlobular connective tissue is quite high. The malphigian corpuscles are visible on gross inspection. The spleen is situated in the left flank in close proximity to the left kidney. It is attached on its full length to the compartmented stomach (Colour Plate V;8). The pancreas has one pancreatic duct. The left body is usually larger and longer.

The liver is divided into three lobes. There is a distinct lobulation on gross inspection. The caudal borders are characteristically fimbriated. The liver has a high proportion of inter-lobular and intra-lobular connective tissue, therefore the texture is very firm. The liver lies mainly on the right side, extending from the fifth to the twelfth rib. There is no gall bladder.

Both kidneys are bean shaped. The kidney capsule is very strong, thick and completely adhesive to the kidney surface (Colour Plates V,19 to V,21). The cortex and medulla are distinctive. The ratio is 1:1. The left kidney is situated between the fifth and seventh lumbar vertebra. The right kidney is placed slightly forward between the second and fourth lumbar vertebra. Table V,1 summarises morphometric values of the inner organs which are typical for a healthy adult camel.

Table V,1: Some morphometric values of organs of a healthy adult camel

organ	colour	weight [kg]	length [cm]	width [cm]	diameter [cm]
heart	d.brown	1.5 - 2.0	22	19	
lungs	pink	5 - 6			
spleen	g.pink	0.3 - 1.0	30 - 40	8 - 10	1.5 - 2.5
liver	d.brown	6 - 10	60 - 70	35 - 50	
pancreas	pink	0.4 - 0.5	42		
kidney	l.brown	1.0	19	10	
adrenal		[g]			
right	g.pink	15 - 37	5 - 8	3 - 5	1 - 5
left	g.pink	15 - 33	4	3.5	2
thyroid	r.brown	fluctuation	3 - 8	1.0 - 4.0	0.5 - 1.5
pituitary	grey	3 - 4	0.8 - 1.2		

g. = grey; d. = dark; l. = light; r. = reddish

Endocrine glands: The thyroid gland shows a marked seasonal fluctuation in size and weight. In most animals an isthmus is present. It is situated a few centimetres from the base of mandibula. The adrenal glands show a great variation in size and shape. Right and left can be easily distinguished. The right adrenal is an elongated, flat, triangular shaped organ, covered by a strong capsule. The cortex is light brown and the medulla brownish yellow. It lies adjacent to the right crus of diaphragm and is attached to vena cava. The left adrenal is a flat, discoidal shaped organ, covered by thin capsule. It lies 8 to 10 cm in front of the left kidney. In immature and young camels they are much smaller, have a smooth surface and are of reddish brown colour. Females tend to have heavier glands than males. The pituitary is a pea shaped organ.

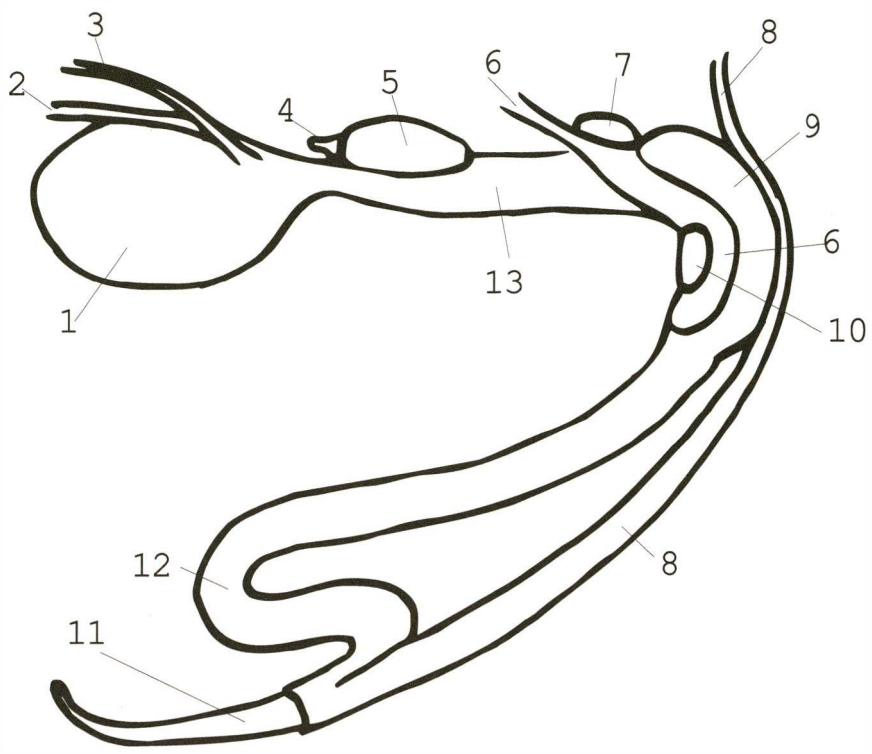

Figure V,4: Schematic rendering of the male genital organs: 1 = Vescia urinaria; 2 = Ductus deferens; 3 = Ureter; 4 = Uterus masculinus; 5 = Prostata; 6 = M.ischiocavernosus; 7 = Gl.bulbourethralis; 8 = M.retractor penis; 9 = M.bulbospongiosus; 10 = Crus penis; 11 = Pars libera penis; 12 = Flexura sigmoidea penis; 13 = M.urethralis. (redrawn after Smuts & Bezuidenhout, 1987)

Figure V,4 gives a schematic rendering of the male reproductive system. The praeputium is triangular shaped and caudally directed. The penis is of the fibro-elastic type. There is a distinct urethral process at the tip of the penis. The urethra is small in diameter and an urethral recess is present at the ischiatic arch. The testicles show a marked seasonal fluctuation in size, weight and texture. They are situated high up in the ischiatic arch. One testicle tends to be smaller and softer. There are two accessory glands, the prostate and the bulbourethral gland. Cryptorchism is not uncommon.

The female reproductive system is presented in Figure V,5. The uterus is a short bicornuate type. It has a distinct T-shape. In the adult female it weighs between 0.2 and 0.4 kg. The horns are asymmetric. This distinctive feature is already present in the neonate and not related to calvings. The left horn is always longer. Its length is 8 to 22 cm. In comparison the right horn is 5 to 12 cm long. The uterine body is quite short (3 to 14 cm). The cervix has longitudinal folds and is about 3 to 6 cm long. The cervical os never closes tight. The ovaries are small and resemble porcine ovaries.

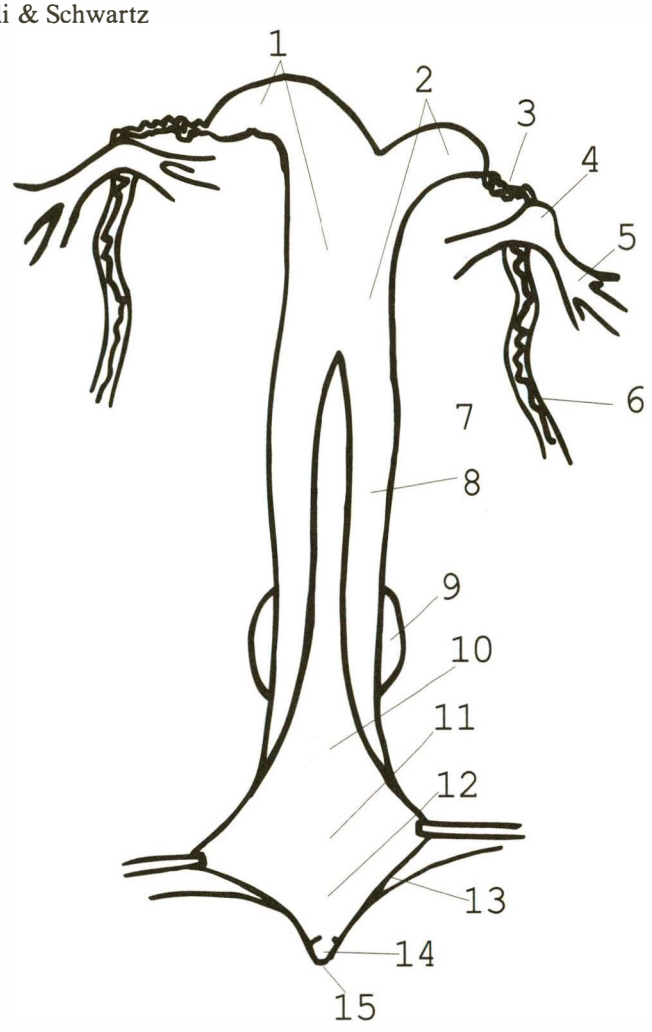

Figure V,5: Schematic rendering of the female genital tract: 1 = Cornu uteri sinistrum; 2 = Cornu uteri dextrum; 3 = Tuba uterina; 4 = Ovarium in bursa ovarica; 5 = Mesovarium; 6 = A.and V.ovarica; 7 = Mesometrium; 8 = Corpus uteri; 9 = Vesica urinaria; 10 = Vagina (opened); 11 = Opening of urethra, 12 = Vestibulum vaginae; 13 = Labium pudendi; 14 = Clitoris; 15 = Commissura labiorum ventralis. (redrawn after Smuts & Bezuidenhout, 1987)

The udder is divided into four glandular quarters. The right and left udder halves are distinctly separated by the laminae mediales. The separation of front and rear quarter within each half is indistinct. Usually the front quarter are considerably larger than the rear quarters. Each quarter has one teat. There are two ducts per teat. Presence of accessory teats is not an uncommon finding. The udder size varies greatly with the stage of lactation.

Table V,2 compares anatomical characteristics of the camel to those of bovines and horses. The list is not exhaustive, but mentions only those characteristics which show distinctive differences between the three species.

Table V,2: Comparative anatomical chart of camel, bovine and equine species

Organ	Camel	Cow	Horse
vertebral/ column	C7;T12;L7; S5;CD15-20	C7;T13;L6 S4;CD18-20	C7;T18;L6 S4;CD15-21
No.of ribs	12 8:4	13 8:5	18 8:10
heart	pointed	round	pointed
pericard fluid	3-10 cc		
lungs	no fissures weight 5-6kg	fissures	no fissures
	pink	pink	red
diaphragmatic bone	yes	no	no
stomach	3-compartment stomach	3 forestomachs + 1 true stomach	1 true stomach
small intestines	40 meters	27-49 meters	
large intestines	19.5 meters	14 meters	
colon	coiled	coiled	horseshoe shaped
liver	6-10kg dark brown	4.5-10kg light brown	5kg brown red
gallbladder	none	yes	none
spleen	crescent 0.8-1kg dark purple	long oval 0.7-1.2kg grey purple	crescent 1.0-2.0kg steel blue
kidney	bean shaped	lobulated	r/heart shaped l/bean shaped
capsule	v.adhesive	none adhesive	none adhesive
pancreas	0.5 kg 1 pancreatic duct	0.6kg 1 pancreatic duct	0.3-0.5kg 2 pancreatic ducts

Table V,2 (continued):

Organ	Camel	Cow	Horse
male genitals			
praeputium	caudally	cranial	cranial
penis	fibro-elastic	fibro-elastic	musculo-cavernous
location	ischiatic arch	pendulant	pendulant
female genitals			
uterus	bicornuate T-shaped	bicornuate	bicornuate Y-shaped
horns		35-45 cm	22-25 cm
body		3 cm	3o cm
oviduct	25-28 cm	20-28 cm	20-30 cm
accessory vesicular gland	none	yes	yes
udder			
quarters	4	4	2
teats	4	4	2
ducts/teat	2	1	2
integumentum			
callosities	yes carpal;elbow; stifle;sternal	no	no
lymphnodes	lobulated		

Sources: Smuts and Bezuidenhout, Anatomy of the dromedary, 1987; Nickel, Schummer and Seiferle; Lehrbuch der Anatomie der Haustiere I-IV, 1960.

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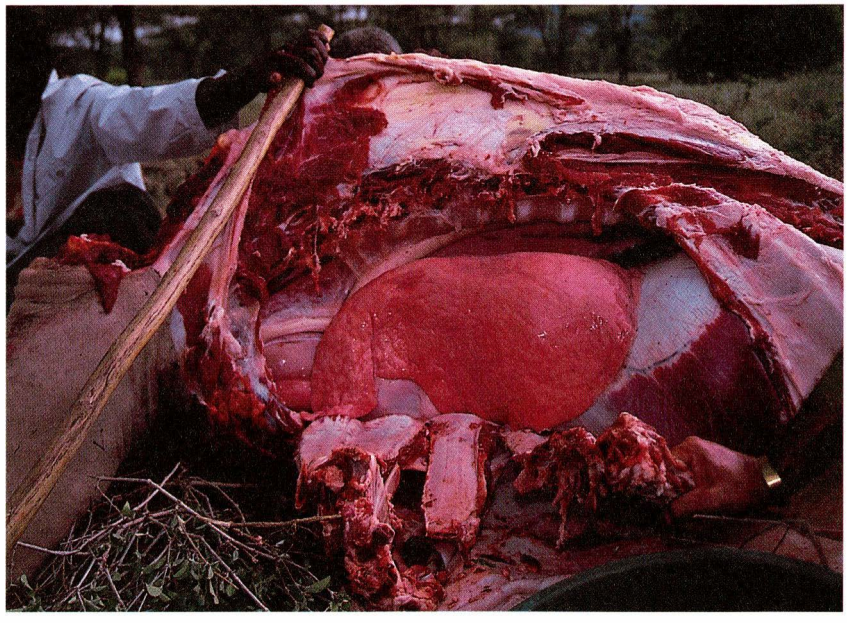
Plate V,1: Thorax opened, right view, lungs, diaphragm and and liver in situ.

Plate V,2: Thorax opened, lungs, heart and diaphragm in situ.



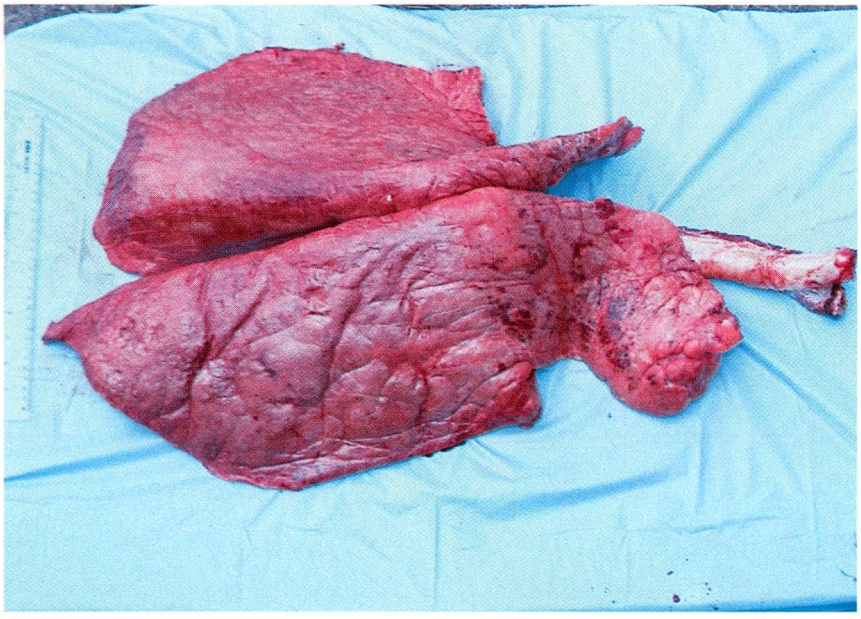
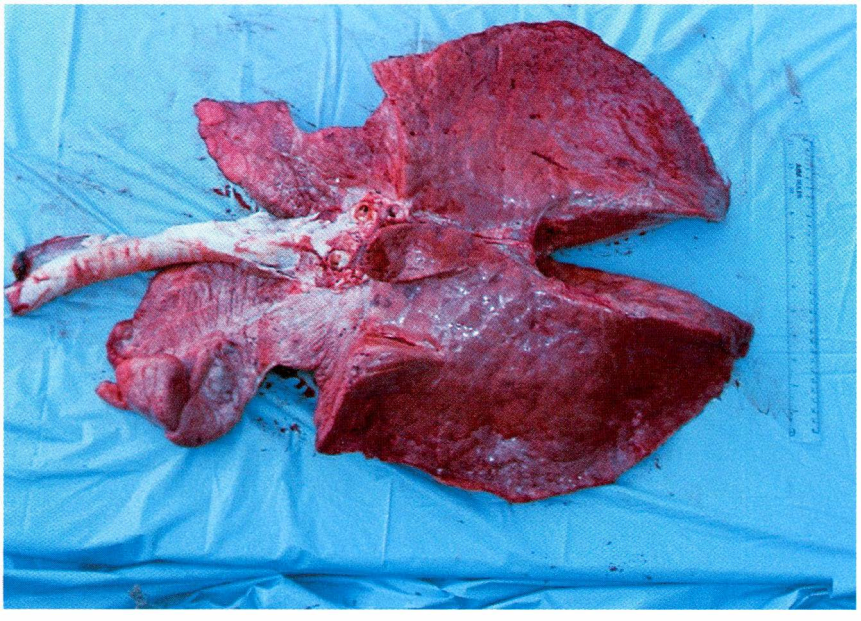


Plate V,3: Lungs in toto, costal view.

Plate V,4: Lungs in toto, visceral view.



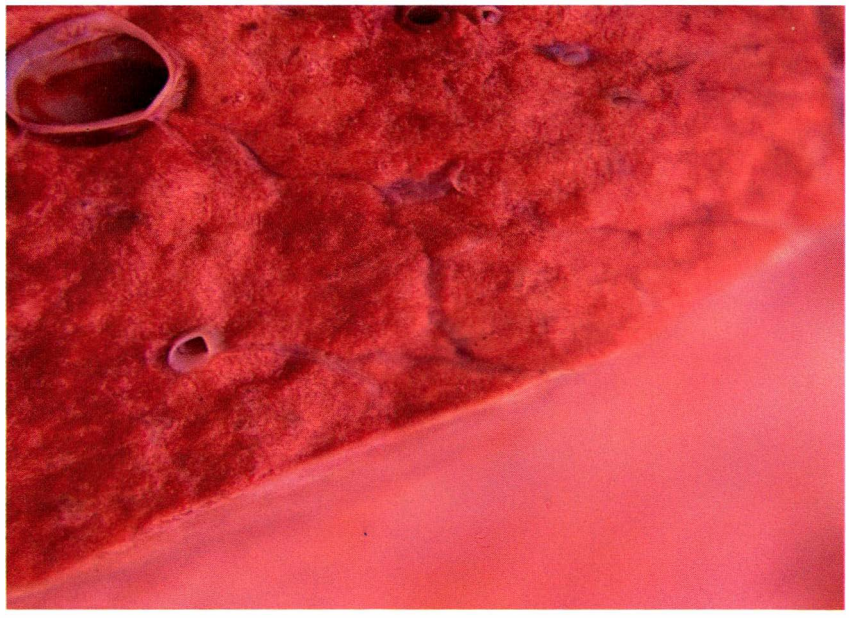
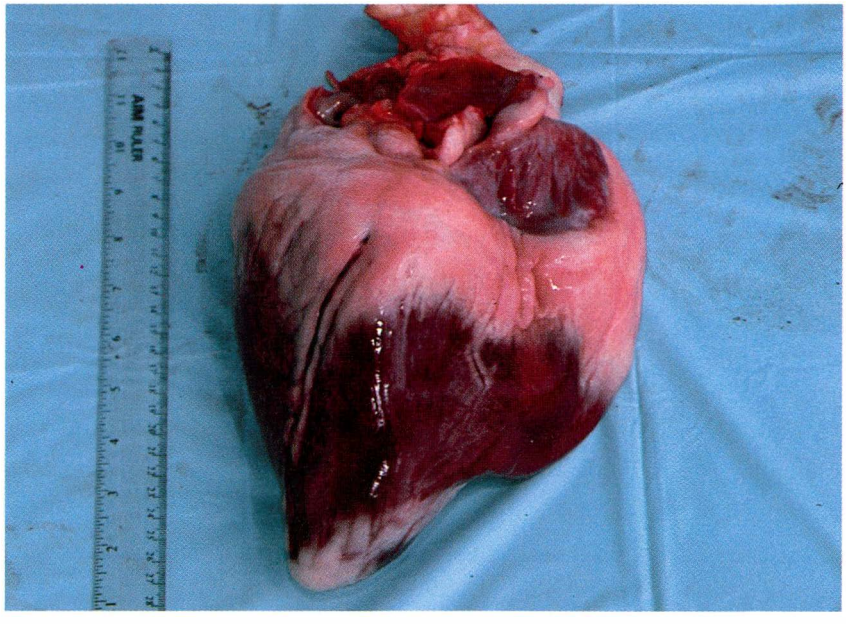


Plate V,5: Close up of a cross section of a healthy lung.

Plate V,6: The heart



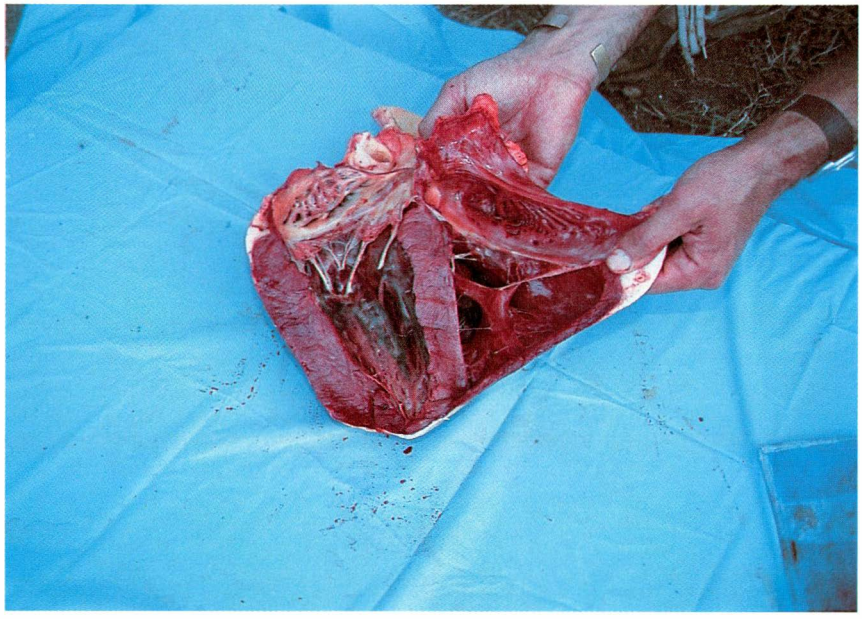
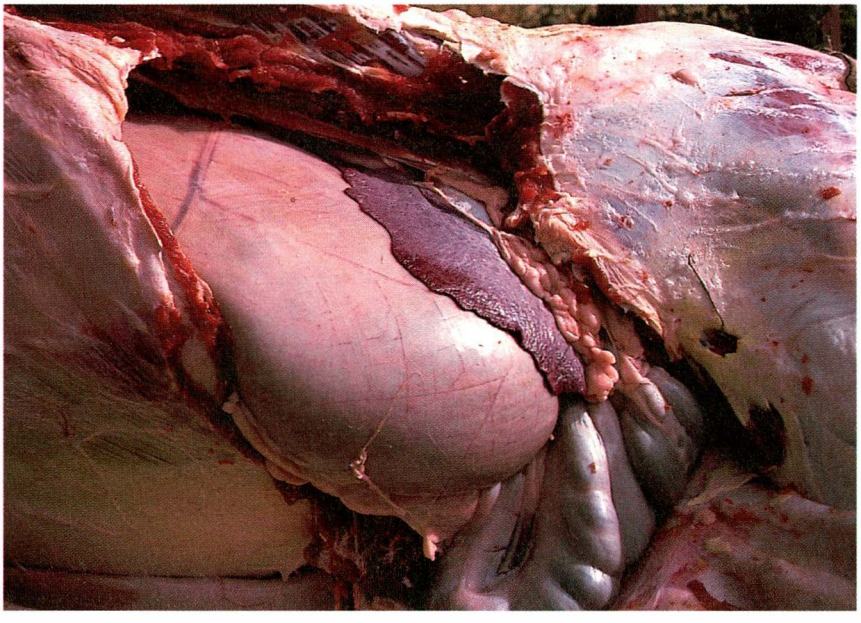


Plate V,7: Interior of a healthy heart.

Plate V,8: Abdomen opened, left view: stomach compartment 1, spleen, loop of coiled colon.



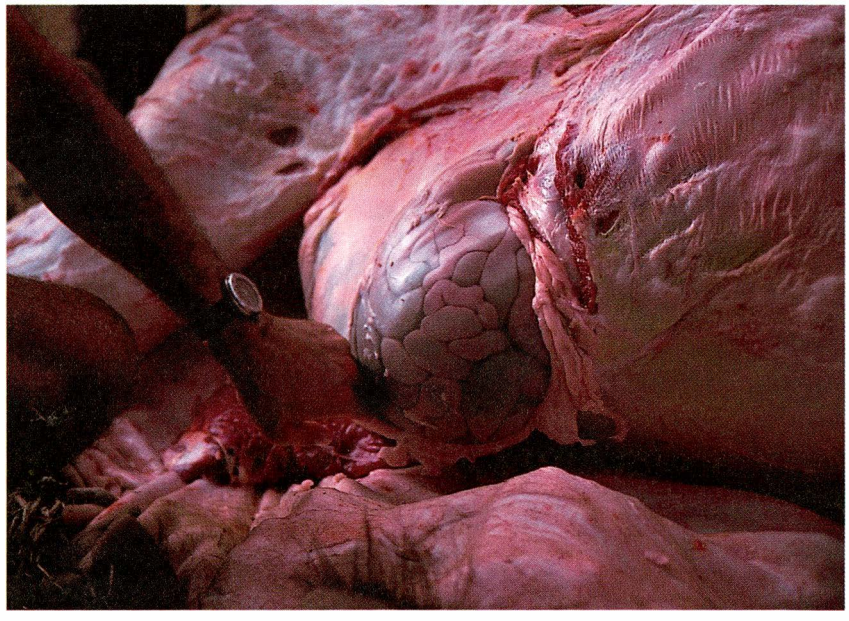
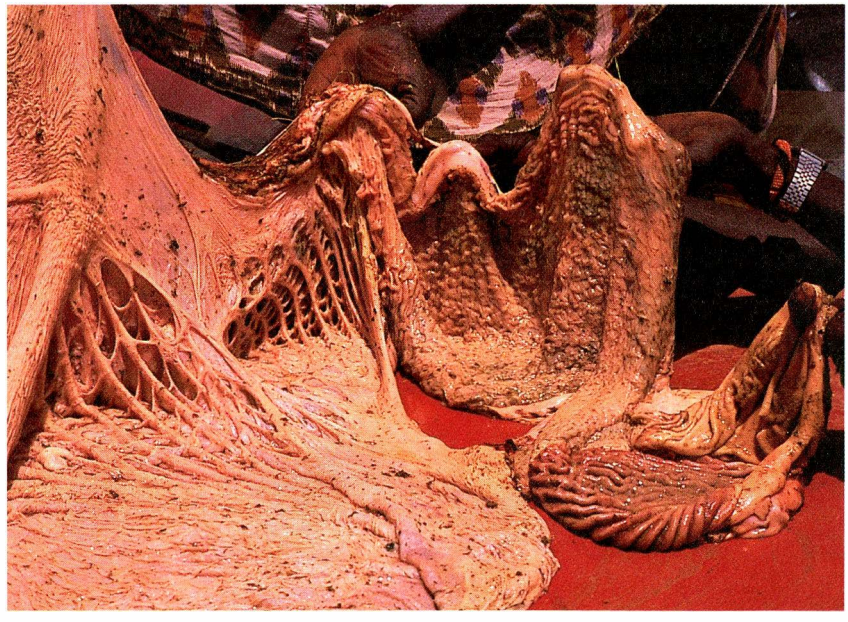


Plate V,9: Adomen partially opened, right view, coiled small intestines.

Plate V,10: Interior of compartmented stomach, note glandular sacs, longitudinal skin folds of compartment 3 and absence of papillae.



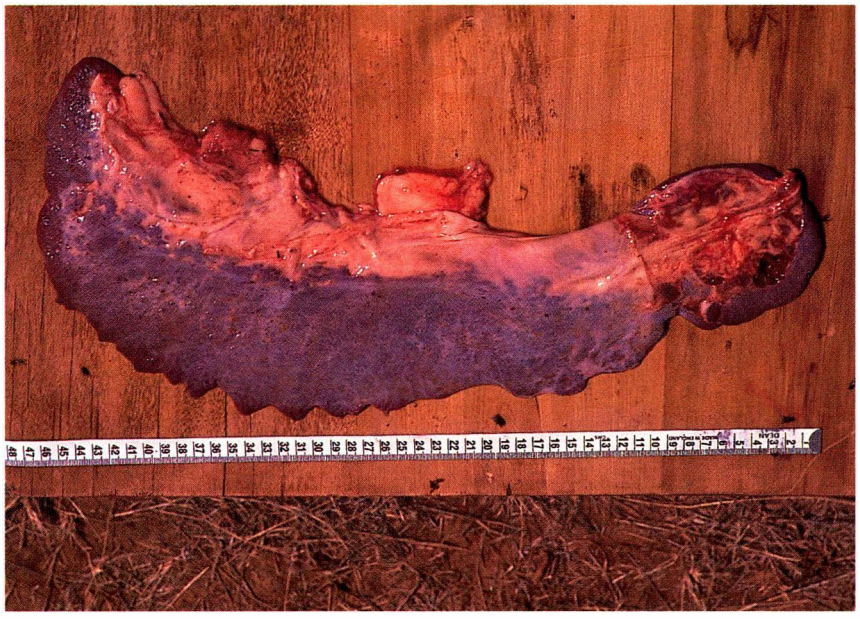
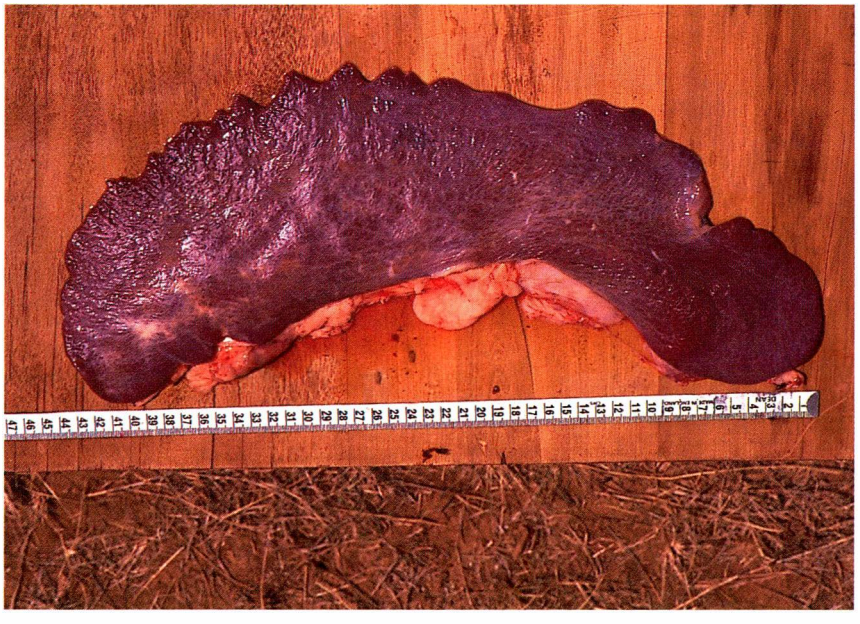


Plate V,11: Visceral view of the spleen.

Plate V,12: Costal view of the spleen.



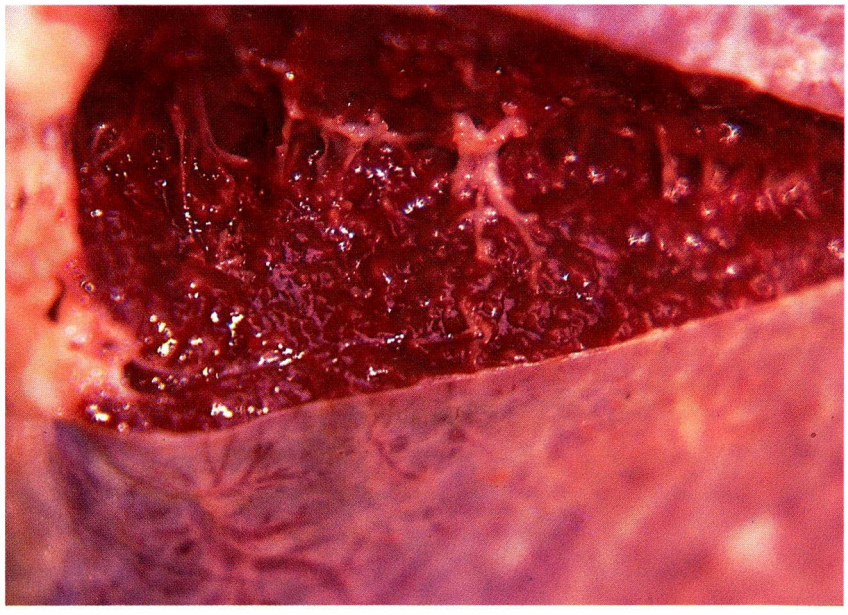
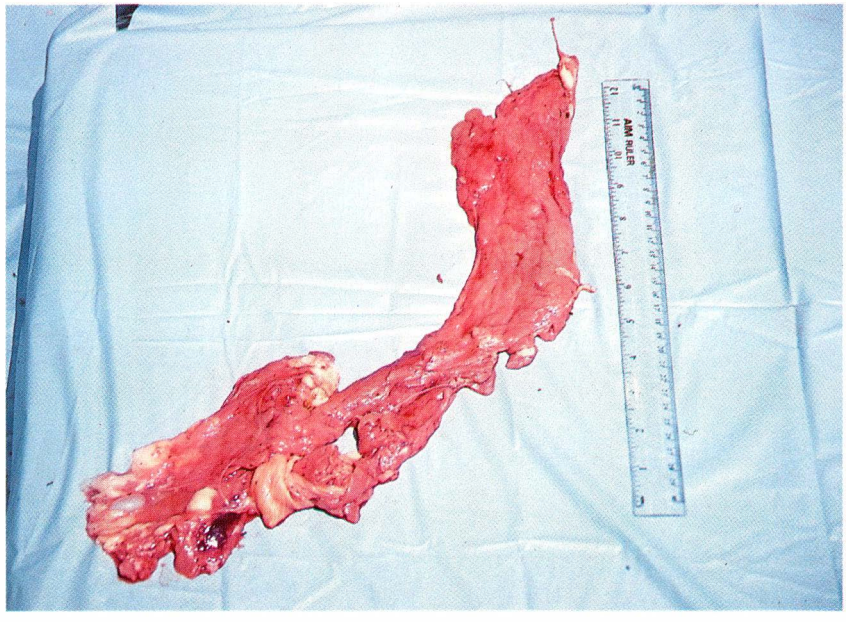


Plate V,13: Close up of a cross section of the spleen.

Plate V,14: The pancreas.



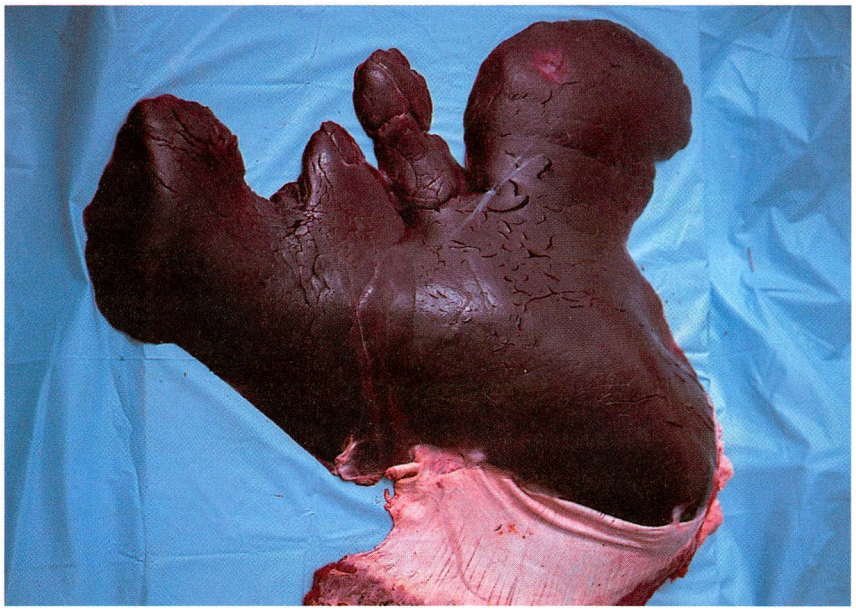
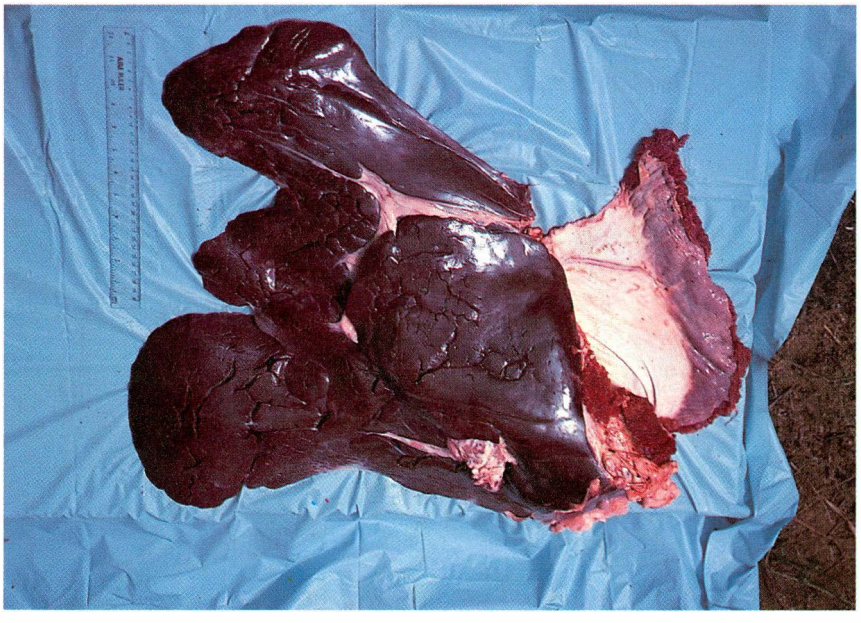


Plate V,15: Parietal view of the liver.

Plate V,16: Visceral view of the liver.



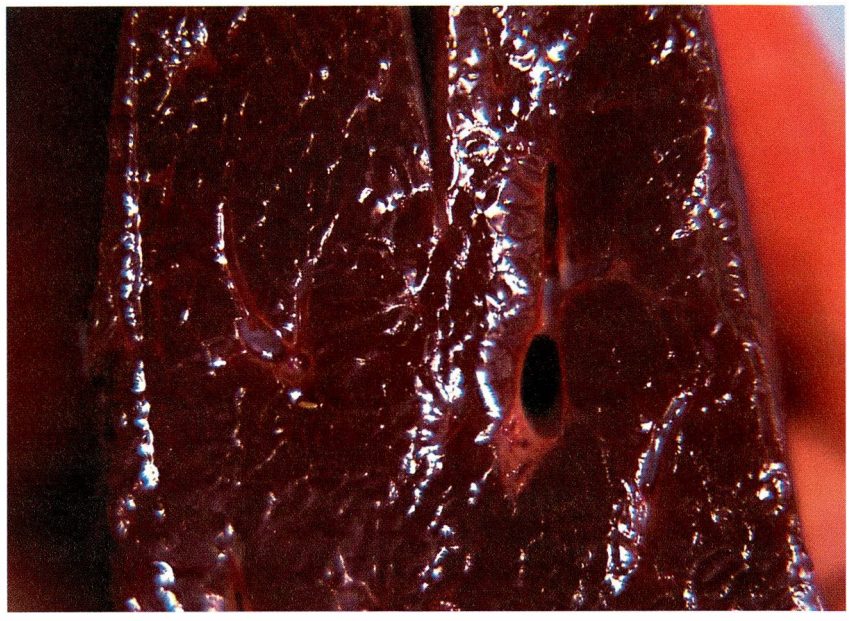


Plate V,17: Close up of a cross section of the liver.

Plate V,18: Topography of the left and right kidney, spleen, stomachs and intestines.

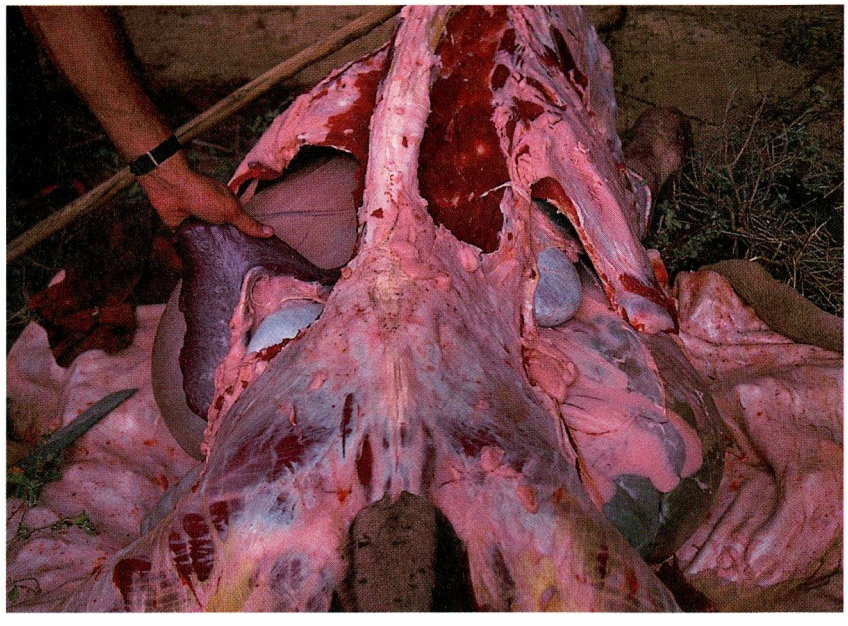
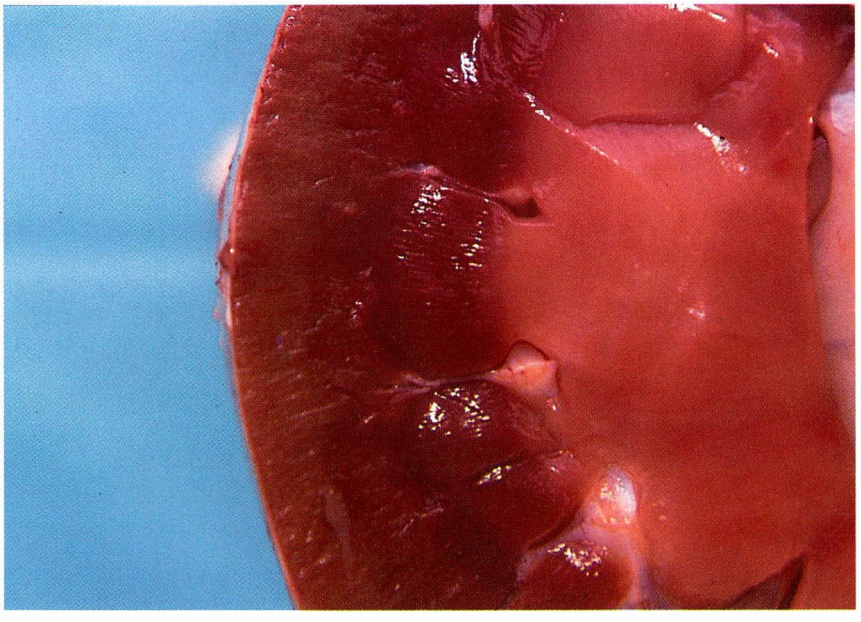


Plate V,19: Right and left kidney. The capsule is partly removed.

Plate V,20: Close up of a cross section of the kidney



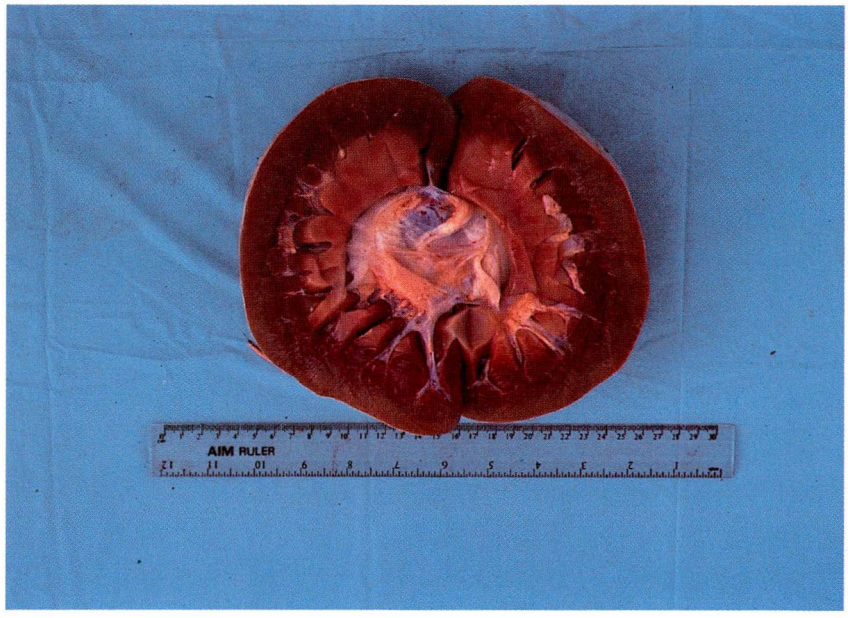


Plate V,21: Longitudinal section of the kidney

Plate V, 22: Superficial lymph nodes.

Plate V,23: Haemorrhagic stripes on the hump, probably caused by beating with a stick.

Plate V,24: Multiple hydatic cysts in the lungs caused by Echinococcus. In adult animaös this is a very common finding. Most animals, however, show no obvious symptoms even with the most massive infestations.

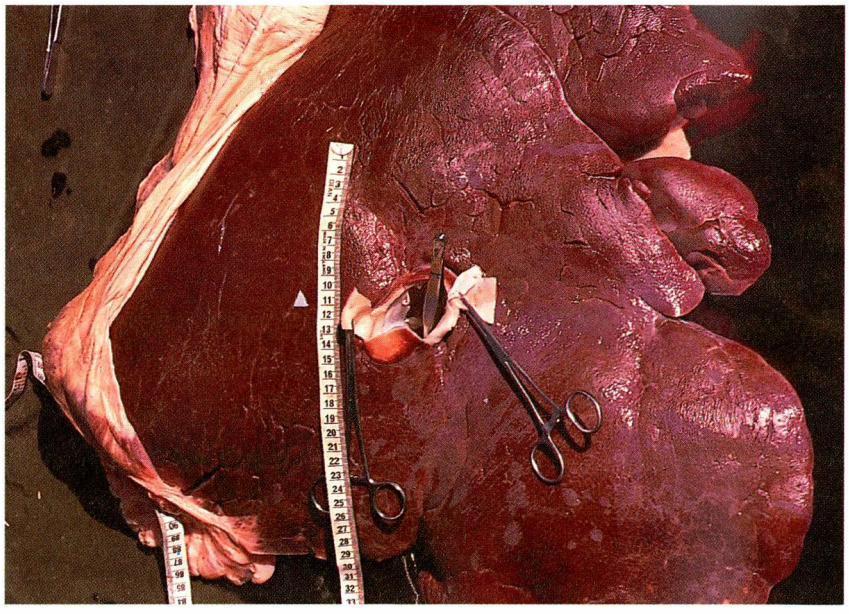
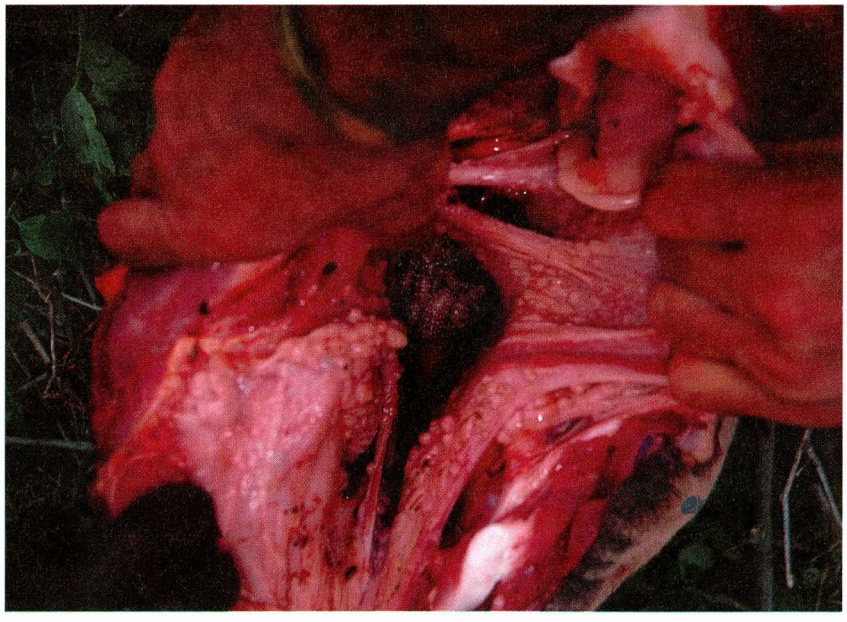


Plate V,25: An opened single hydatic cyst in the liver of an adult animal.

Plate V,26: Massive Cephalopina titillator infestation of the naso-pharynx in an adult bull.



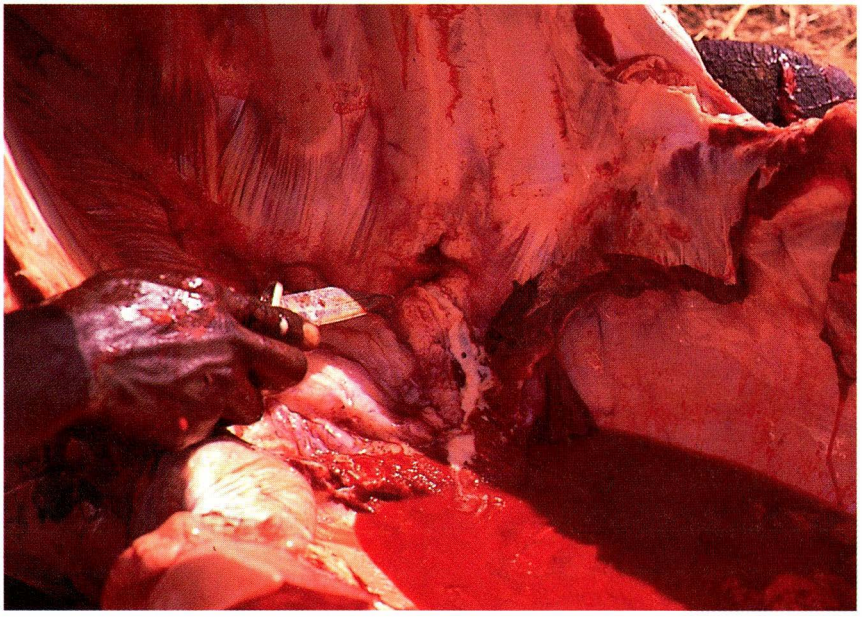


Plate V,27: Male adult animal which was slaughtered because of a chronic suppurating pedestal wound. On post-mortem examination multiple adhesions between pericard and thoracic wall were found, The pedestal wound was connected by a fistula to an abscess near the heart.

Plate V,28: Large haematoma behind one kidney. This animal was castrated 24 hours before. Apparently one artery kept bleeding. The animal died the following morning. No external bleeding had been observed. On opening the abdomen was filled with blood.

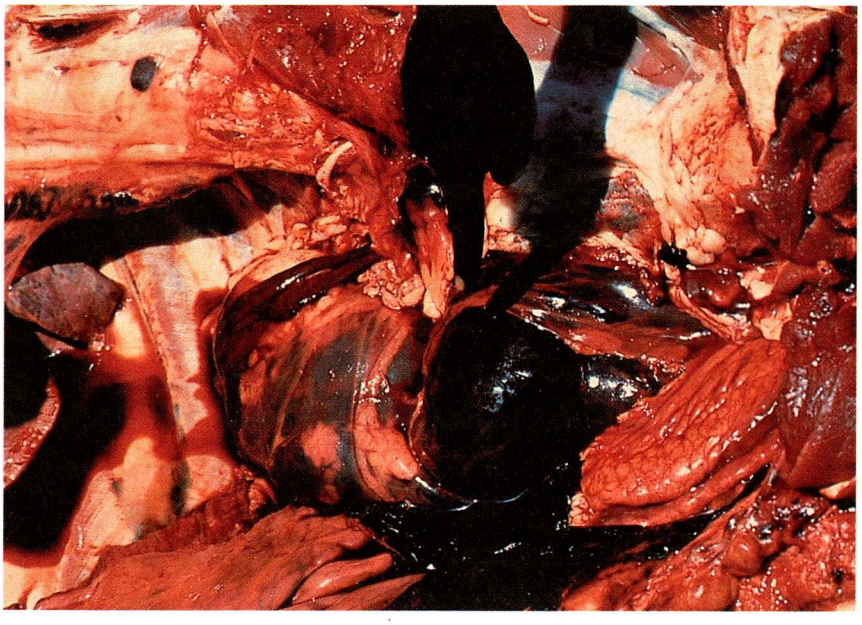
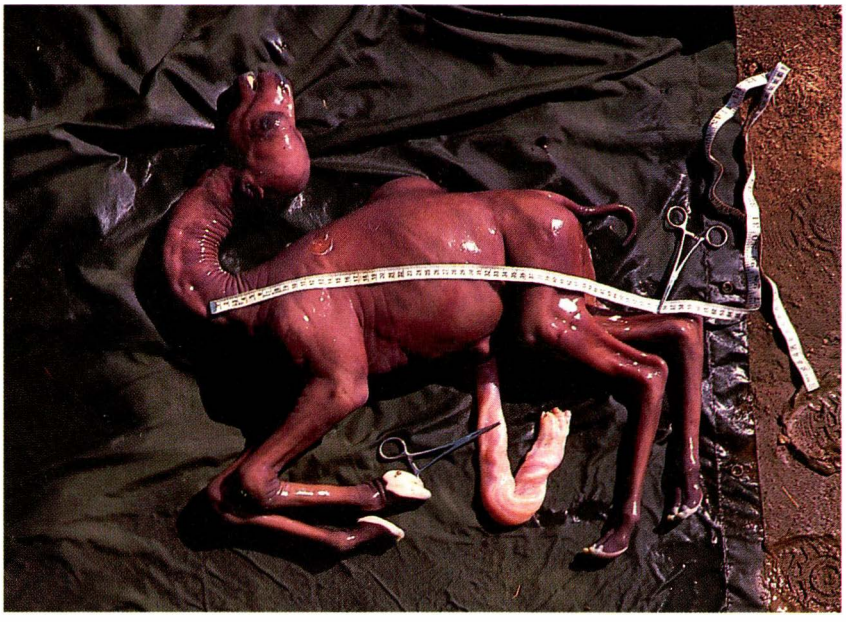
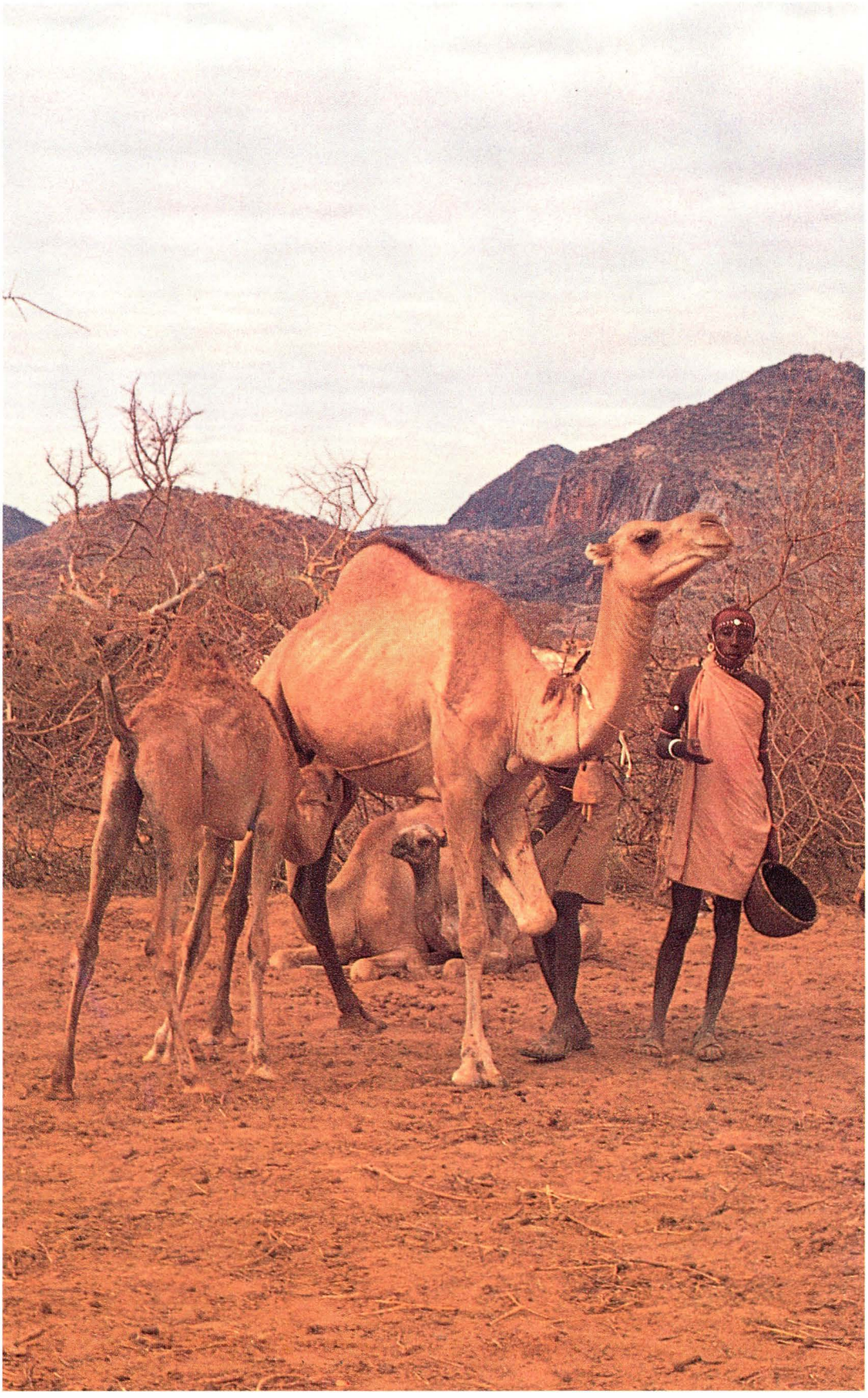


Plate V,29: Swollen and haemorrhagic mandibular lymph nodes in a young animal. Most likely an acute case of septicemia.

Plate V,30: It is not uncommon to find on slaughter, that a female, believed to be barren, is pregnant. This fetus is approximately six months old.





Necropsy performance

Necropsy inspection serves two important purposes in veterinary medicine, firstly disease diagnosis and disease control, secondly the hygienic aspect, i.e the assessment whether a carcass is safe for human consumption or not. Conduction of a routine post-mortem examination requires basic knowledge of anatomy and physiology, knowledge of pathology to determine character and extent of disease and systems involved and an organized dissection protocol to ensure a complete and careful examination. Table V,3 summarises in form of a check list all important aspects of a post-mortem examination in the field. Where laboratory facilities are at hand, the check list can be much more extensive.

Time of death and time of post-mortem examination

The time lapse between death and beginning of the necropsy procedure should be as brief as possible. Post-mortem carcass deterioration is especially rapid under high ambient temperature, in case of septicemia and clostridial infections such as tetanus and blackleg. Among the first organs to show signs of post-mortem deterioration are the gastro-intestinal tract, adrenal glands and the central nervous system. Characteristic signs of beginning post-mortem deterioration hereby are desquamation of epithelium (gastro-intestinal tract), liquidisation (adrenal medulla and central nervous system) and general friability of organs (gastro-intestinal tract, liver and kidneys). Pale, watery and cooked appearance of muscles are a sign of advanced post-mortem deterioration. Valuable indicators to estimate time of death are rigor mortis, blood clotting and imbibition. Viability of endoparasites can also be a valuable indicator, e.g. cephalopina titillator larvae die a few hours after their host has died. Rigor mortis starts usually about one hour after death and lasts 24 to 72 hours depending on ambient temperature. Rigor mortis is best assessed upon opening the heart. Prior to rigor mortis the left ventricle appears dilated and contains various amounts of red unclotted blood. During rigor mortis the left ventricle is contracted and nearly empty of blood. After rigor mortis has passed by the left ventricle contains dark haemolised blood, which originated from the left atrium. In prior to death stressed or emaciated animals rigor mortis takes place and subsides more rapid due to depleted glycogene storage depots of muscles. Characteristic signs of emaciation versus poorness of carcass are lack of hump, lack of renal fat depot and heart fat or presence of gelatinous yellow fat. Based on presence of inflammatory reaction around structural changes differentiation is possible between post-mortem autolysis and necrosis. In ruminants a similar condition to bloat can be mimicked by post-mortem bacterial fermentation of ingesta.

Necropsy procedure

Necropsy examination itself and obtained results are based on visual examination, palpation and concise description of tissues, organs and their cut surfaces. A method to assess organs on gross inspection are morphometric measurements.

Table V,3: Check list for necropsy performance and gross inspection in the field

Whole animal	(1)	body condition, e.g. obese, thin, emaciated
Skeleton	(1)	abnormalities, fractures,
Skin and membranes	(1)	colour
	(2)	hair coat, e.g. complete, length, clean,
Muscles and fat	(1)	colour
	(2)	consistency
Organs[1)]	(1)	colour
	(2)	weight
	(3)	length, width, diameter
	(4)	consistency
	(5)	topography (only if displaced)
	(6)	adhesions
	(7)	ratio of cortex-medulla[2)]
	(8)	ratio of ventricles to septum
	(9)	foreign bodies[3)]
	(10)	float[4)]
Fluid[5)]	(1)	colour
	(2)	amount
	(3)	viscosity
	(4)	foreign particles
	(5)	odour
Structural change:	(1a)	type of lesion, e.g. abscess, ulcer, tumour, hemorrhage, scar, wound, cyst,
	(1b)	depth of lesion, e.g. superficial, deep,
	(2)	distribution, e.g. localized, generalized,
	(3)	size and shape
	(4)	amount or number, e.g. single, multiple
	(5a)	consistency, e.g. firm, soft, liquid,
	(5b)	texture, e.g. smooth, rough
	(6)	odour
	(7)	colour
parasites	(1)	type, e.g. tick, maggot, worm, hydatid cyst
	(2)	amount or number
	(3)	location
	(4)	alive, dead

[1)] heart; lungs; kidneys; spleen; liver, endocrine glands; [2)] kidneys; adrenal; thyroid; parathyroid; [3)] gastro-intestinal tract; [4)] lung tissue in neonates; [5)] all body cavities, all capsules

Variations from expected parameters such as size and weight provide helpful information to assess hypertrophia versus hypoplasia versus aplasia. However, it should be kept in mind that age, sex and environmental factors such as nutrition are known to influence physiologically size and shape of some organs. Description of structural changes includes data about the type of change observed, location, colour, size, shape, consistency, extent and severity, quantity, age and presence of other abnormalities. Description of fluid includes information about estimated quantity, colour, viscosity, odour and presence of particles. Description of parasites should include location, type, quantity and whether they are alive or dead. International standard units such as millilitre, litre, centimetre and kilogram should be used for morphometric measurements.

Body orifices, hair coat, foot pads and callosities are examined for colour, odour, presence of foreign bodies, discharges and structural changes. Examination of the body cavities thorax and abdomen includes inspection of cavity lining (pleura, peritoneum), topography of organs, adhesions and presence of fluid. All important superficial lymphnodes are incised and size and colour evaluated. An accurate morphological description of organs such as heart, lungs, liver, spleen, kidneys, genitals and endocrine glands includes information about colour, weight, length, width, diameter, shape, consistency and presence of structural changes or other abnormalities such as fluid, parasites, odour and foreign bodies.

Dissection procedure

A complete history is taken including data about owner, patient, previous and present medical history and management. Numerous methods for dissection procedures exist. The following dissection protocol has been tried with camels under field conditions and could be used as a guide-line:

(1) placement of animal on its left side,
(2) ventral mid line skin incision along the length of the body, beware of pedestal pad and male genitals or udder,
(3) skin animal towards the dorsal mid line, reflect limbs by severing attachment between scapula and thorax and splitting the pelvic symphysis,
(4) split lower jaw and dissect ventral neck to get access to cervical structures,
(6) open abdominal cavity by a ventral mid line incision, beware of unintentionally cutting intestines, reflect abdominal wall,
(5) break ribs just below the spine and along the sternum, remove ribs,
(6) eviscerate respiratory tract plus heart in toto,
(7) eviscerate gastro-intestinal tract (plus liver, spleen) in toto,
(8) remove kidneys, genital tract and adrenal glands,
(9) skin limbs and open joints,
(10) disarticulate atlanto-occipital joint and open skull to remove brain.

In case of necropsy inspection of animals slaughtered by traditional method the protocol has to be disregarded and necropsy examination is performed along with slaughter sequence. In animals slaughtered by Muslim method (cutting of major cervical vessels) the carcass appears overall paler and blood storage organs such as spleen will appear contracted and empty.

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Necropsy examination sheet

In most cases when the necessity arises to perform a post-mortem examination in a camel, neither a trained veterinarian is available nor are any laboratory facilities within reasonable reach. It is therefore necessary to recruit other persons, such as the camel owners, if they can read and write, veterinary scouts, agricultural extension personnel, nurses, dispensary attendant and maybe even school teachers for this task, to get a better insight into the epidemiology in camel populations and, maybe even more important, to evaluate the risks to public health arising from the camel as a domestic livestock. If the afore mentioned groups are to participate in this task they need precise, unambiguous and simple instructions and routine procedures. The necropsy examination sheet presented below was designed to fulfil this particular purpose.

The examination sheet provides in a simple sequence sets of questions which require standard answers. Some of those should be provided with the examination sheet like a multiple choice code, where descriptive terms for colour, size, shape, consistency and quantity are needed. Others are simple measurements of weight, volume, length or diameter. Other, medical terms like lesion, abscess, ulcer, wound, necrosis, scab, scar etc. need to used in a standardised way. This would probably require a small illustrated glossary to go with the examination sheet. In an exercise with local school leavers in the Districts of Marsabit and Isiolo, using an examination sheet modified for sheep and goats the authors found a high proportion of unmistakable diagnoses provided by persons which had only minimal training.

Necropsy examination sheet Part 1: gross inspection before dissection

Recorder	Name
Owner	Name, Location
Death **Post-mortem**	Date, time Date, Time
Animal	Breed: body weight: sex: age: branding:
Condition	body: hump: haircoat: udder: teats: pads:
Body openings	nostrils: mouth: ears: eyes: anus: vulva:
History	symptoms: onset: duration: herd: treatment:

Part 2: inspection of internal organs

Thorax	serosa pericard heart valves trachea thymus lungs
Abdomen	serosa oesophagus stomach small intestines large intestines liver pancreas spleen kidney adrenal bladder
Genital organs	ovaries horns body cervix vagina penis testicles
Lymphnodes	
Nervous system	
Skeleton	
Muscles	
Diagnosis	

Common necropsy findings

Diseases and health problems in camels, as in other livestock, can be of parasitic origin, due to infectious diseases, nutritional deficiencies or caused by toxic substances. Various reports indicate that parasitism combined with malnutrition is the most common post-mortem finding. 50 to 60 % of camel mortality in Eastern Africa might be attributable to some form of parasitism.

The most important one is probably trypanosomiasis. where post-mortem findings are usually non specific. Only a known history and findings such as generalized muscular waste, pale and watery muscles, serous atrophy of fat, swollen lymph nodes, presence of edema and evidence of anaemia are suggestive of trypanosomiasis, but not necessarily conclusive.

Another parasite of great importance is Echinococcus, which appears to be endemic in camels in the whole of Eastern Africa. In some areas in Northern Kenya and in Sudan hydatid cysts can be found in almost any animal which is slaughtered. Hydatidosis is rarely detected in live animals, many may be massively infected without showing any symptoms. Success of immunological diagnosis, by IHA or immunoelectrophoresis, of hydatidosis is still limited. Post-mortem inspection combined with safe destruction of infected organs and/or carcasses in the only way to control this severe health hazard.

Gastro-intestinal parasites, particularly Haemonchus ssp., are frequently found in slaughtered camels. Counting of the worms can be done using the method described by Eysker (1978). Total burdens of more than 20,000 worms in an adult animal are not uncommon.

Nasal myiasis caused by the larvae of Cephalopina titillator is another common problem in all of Eastern Africa. Although infestation is often easily noticeable in the live animal, since the camel expel some larvae by sneezing, it is often only the post-mortem examination which shows the extent of the problem. Musa et al. (1989) found all of 44 inspected camels at a slaughter house in Sudan to be heavily infested with C. titillator larvae, which had caused severe deterioration of the naso-pharyngeal mucosa, thus favouring secondary infections with bacteria like Pasteurella, Corynebacterium and Klebsiella.

Many of the previously described findings are made at slaughter or at post-slaughter inspection. However, on many other occasion necropsy helps to diagnose the cause of mortality. In Example 1 of a post-mortem examination which was carried out using the procedure described before an unmistakable diagnosis could be made. The animal was bought on the market, was obviously sick, and was slaughtered to test the described procedure.

The diagnosis was haemorrhagic septicemia. The most obvious findings were generalized internal petechiation especially under the serosa of the intestines, the heart and the lymph nodes. In other cases gelatinous fluid may be present around the lymph nodes.

Post-mortem examination EXAMPLE 1

Part 1: gross inspection before dissection

Recorder	Dioli	
Owner	unknown, animal bought in Lodwar market, obviously sick	
Death	slaughtered, 10 a.m.	
Post-mortem	immediate, during butchering	
Animal	Breed:	Somali
	body weight:	550 kg
	sex:	female
	age:	not known, estimated 8 years
	branding:	straight line bilateral on lower jaw
Condition	body:	good, well muscled
	hump:	well developed, firm consistency, round shape
	haircoat:	complete, hindlegs soiled with feces
	udder:	small, non active, usual shape, firm consistency
	teats:	right cranial teat old healed wound close to orifice, other teats usual shape,
	pads:	small spherical deep pedestal wound, necrotic tissue at the edges, and small amount of pus
Body openings	nostrils:	clean, dilated, no lesions
	mouth:	pigmented mucosa, no lesions
	ears:	normal
	eyes:	eye balls sunken in, cornea surface wrinkled and slightly traumatized (small abrasions)
	anus:	slightly dilated, dark tarry feces around sphincter
	vulva:	disfigured, healed perineal wound,
History	symptoms:	fever, diarrhoea, swollen glands, loss of appetite
	onset:	acute
	duration:	2 days
	herd:	no other animals affected
	treatment:	none

Part 2: inspection of internal organs

Thorax	serosa	transparent, adhesions between pleura and heart, multiple small haemorrhagic spots, 3 small abscesses close to adhesions
	pericard	white, one adhesion to body wall, 5 cc transparent, watery fluid
	heart	dark brown, 1.5 kg, firm, dark haemolised blood in left chamber, multiple petechia on surface
	valves	triscupidal and mitral slightly thickened
	trachea	inner mucosa lining red
	thyroid	normal
	thymus	normal
	lungs	red, puffy consistency, 4 small hydatic cysts
Abdomen	serosa	transparent
	oesophagus	inner lining reddened
	stomach	very small amount of feed, several small, superficial ulcers in compartment 3
	small intestines	dilated, liquid faeces
	large intestines	dilated, multiple haemorrhagic spots no formed faeces in rectum
	liver	dark brown, 10 kg, one small abscess
	pancreas	multiple haemorrhagic spots
	spleen	red, swollen, 1.5 kg, multiple haemorrhagic spots
	kidney	normal
	adrenal	multiple haemorrhagic spots
	bladder	medium filled, haemorrhagic spots on mucosa
Genital organs	ovaries	non active, no follicles, several old corpora lutea
	horns	no remark
	body	no remark
	cervix	dilated
	vagina	no remark
	penis	n.a.
	testicles	n.a.

Lymphnodes	all internal and external lymph nodes swollen, surface dark red
Nervous system	no remarks
Skeleton	no remarks
Muscles	no remarks
Diagnosis	Acute haemorrhagic septicemia, probably Pasteurella or Salmonella infection
Additional findings	One narrow, but deep and suppurating pedestal wound, connected by a fistula to the thoracic cavity, adhesions between serosa and pericard, 3 abscesses in close vicinity to the fistula channel, 3 hydatic cysts in the thoracic cavity

The picture may be complicated by signs of hemorrhagic enteritis and lesions of early pneumonia. In many cases the clinical and necropsy findings may not be so conclusive and differentiation from anthrax, blackleg, septicemic salmonellosis and acute leptospirosis has to be done by bacteriological examination. The absence of bloody discharge from the natural body orifices and a normal appearing spleen on post-mortem can be used to initially differentiate hemorrhagic septicaemia from anthrax. In this particular case the picture was complicated by the suppurating wound in the pedestal and the associated abscesses. What had caused the wound could not be ascertained. It had been noted by the owner for several months before.

Infections of the gastro-intestinal tract are not easily diagnosed by necropsy procedures alone. Depending on the involved infective agent localized or generalized pathological lesions of the gastro-intestinal tract are found. If definitive etiological diagnosis is needed samples must be submitted for laboratory analysis.

Infections of the respiratory tract present a similar problem in post-mortem diagnosis. Depending on the involved infectious agent localized or generalized pathological lesions of the respiratory tract are found. However, typical signs of respiratory diseases of viral origin are often masked by secondary bacterial invasion. Bacteriological and histological examination should be performed if definitive etiological diagnosis are needed.

In Example 2 of a post-mortem the rare case of a slaughter animal, a young male, was recorded which had no pathological observation whatsoever and could be considered of no interest in the context of this chapter, except for the very singularity of such finding.

Post-mortem examination EXAMPLE 2, Part 1: gross inspection before dissection

Recorder	Stimmelmayr	
Owner	Ehrat, herdsman, Ngurunit, Kenya	
Death	slaughtered, 6 a.m.	
Post-mortem	7 a.m., during butchering	
Animal	Breed:	Somali
	body weight:	450 kg
	sex:	male
	age:	4.5 years
Condition	body:	fair
	hump:	no remark
	haircoat:	complete, no lesion, clean
	udder:	n.a.
	teats:	n.a
	pads:	no remark
Body openings	nostrils:	normal
	mouth:	normal
	ears:	normal
	eyes:	normal
	anus:	normal
	penis:	no remark
History	symptoms:	none
	onset:	
	duration:	
	herd:	
	treatment:	

Part 2: inspection of internal organs

Thorax	no remarks
Abdomen	no remarks
Genital organs	no remarks
Lymphnodes	no remarks
Nervous system	no remarks
Skeleton	no remarks
Muscles	no remarks

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Annex 1

A Study of Tick Infestation in Four Nomadic Camel Herds in Northern Kenya

M.Dioli

There is only little information on tick infestation in camels kept under nomadic conditions in arid areas. The aim of this study was to identify:

- the prevalent species of ticks infesting the camel,
- the seasonal population fluctuation related to rainfall,
- their sex ratio and
- species composition at preferred three attachment sites.

The study was carried out over a period of 34 months on four camel herds in the North of Turkana District (Lokitaung Division). Most of the study area is at altitudes under 600 m a.s.l. with two mountain ranges of about 1500 m a.s.l. The annual rainfall is 300 to 500 mm, the prevalent vegetation types are woodland and wooded or bushed grassland.

The four camel herds studied belonged to Turkana pastoralists. Their management was left completely under the responsibility of their owners. Herd 1, 2, 3 and 4 consisted of 51, 29, 54 and 37 adult animals respectively. The study was carried out over a period of 34 months. The four herds were sampled at monthly intervals: herd 1, 2, 3 and 4 were sampled 28, 19, 26 and 24 times respectively. One individual, each time a different one, was selected and a total tick count carried out on one side of the body. Total tick load was estimated doubling the number of ticks counted from on each animal at three defined attachment sites, i.e. the nostril, eye and ear and the perineal area. All ticks counted were subsequently removed and identified by species and sex using the key of Matthysse and Colbo (1987). Data of the monthly rainfall were obtained from the Kenya Meteorological Department in Lodwar.

The seasonal fluctuation of tick loads in herd 1 is represented in Figure 1. All other herds show a similar pattern with tick loads fluctuating between 30 and 150 per camel. The highest number of ticks per camel was regularly found at the peak of the dry season immediately before the onset of the rains. Since the main rains occur prevalently in April and May it is possible to predict accurately the season of maximum tick challenge from November to February. High monthly rainfall has immediate negative effects on tick loads, confirming the xerophilous adaptation of tick species commonly infesting the camel. Tick number decrease drastically immediately after a period with heavy rainfall, i.e. mean monthly rainfalls of 100 mm and over.

Figure 2 gives the percentages of the different species of ticks found in the four herds. Nine tick species of three genera have been identified. In the herd 1, 2 and

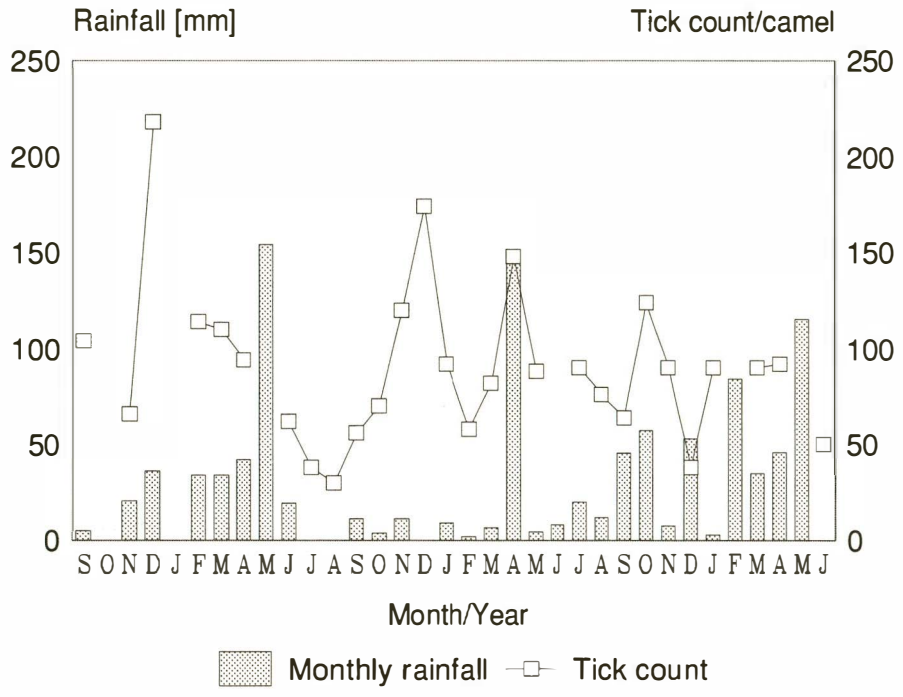

Figure 1: Seasonal fluctuation of tick loads in herd 1 in relation to mean monthly rainfall [mm]

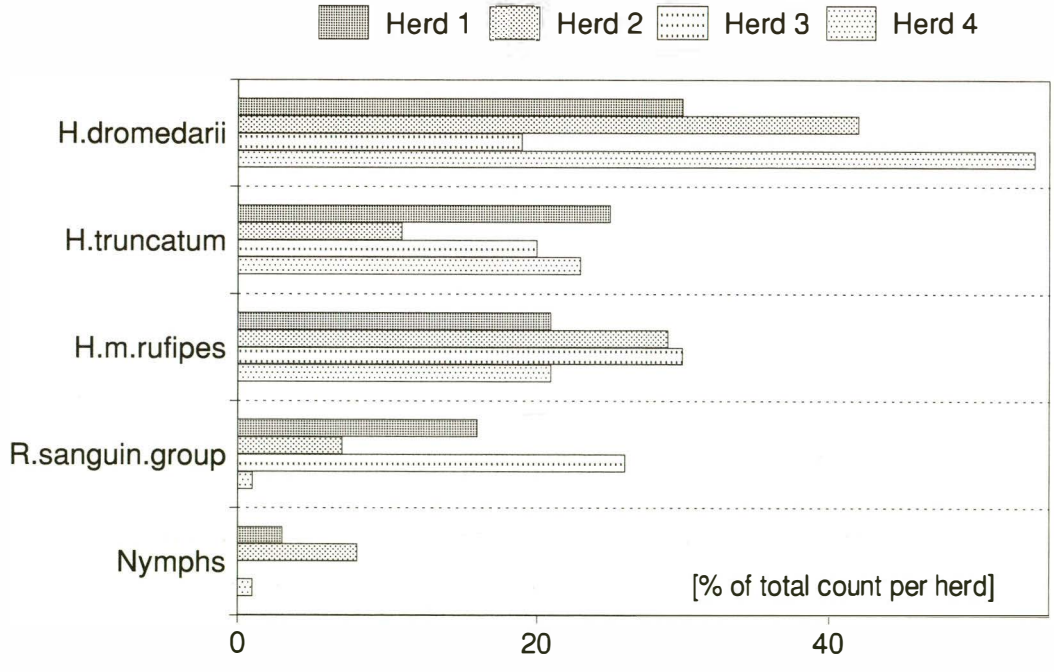

Figure 2: Composition of tick populations by species in four herds of camels

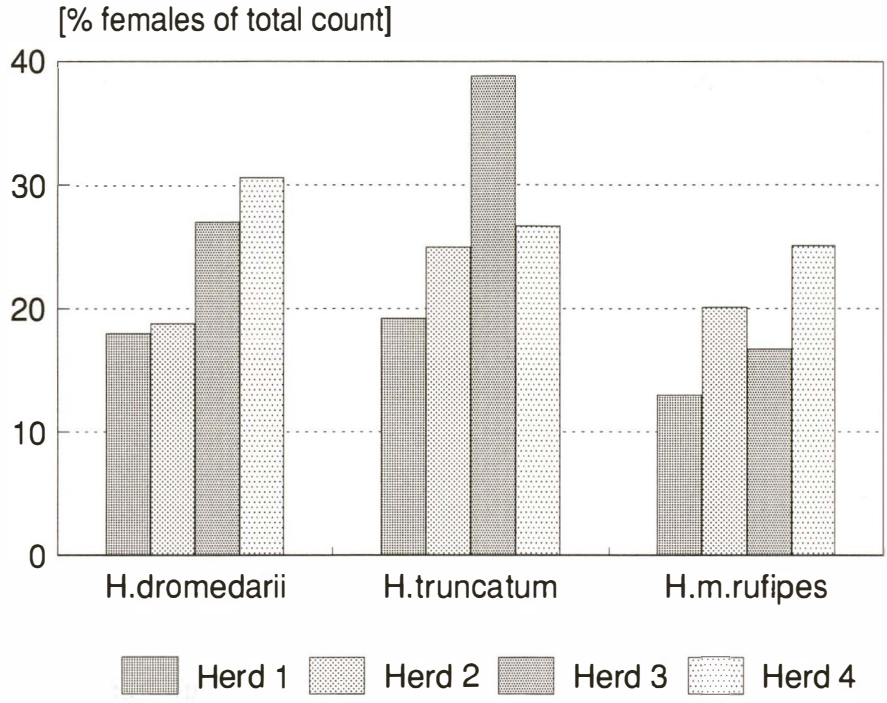

Figure 3: Mean proportion of female ticks in four camel herds during 34 consecutive months

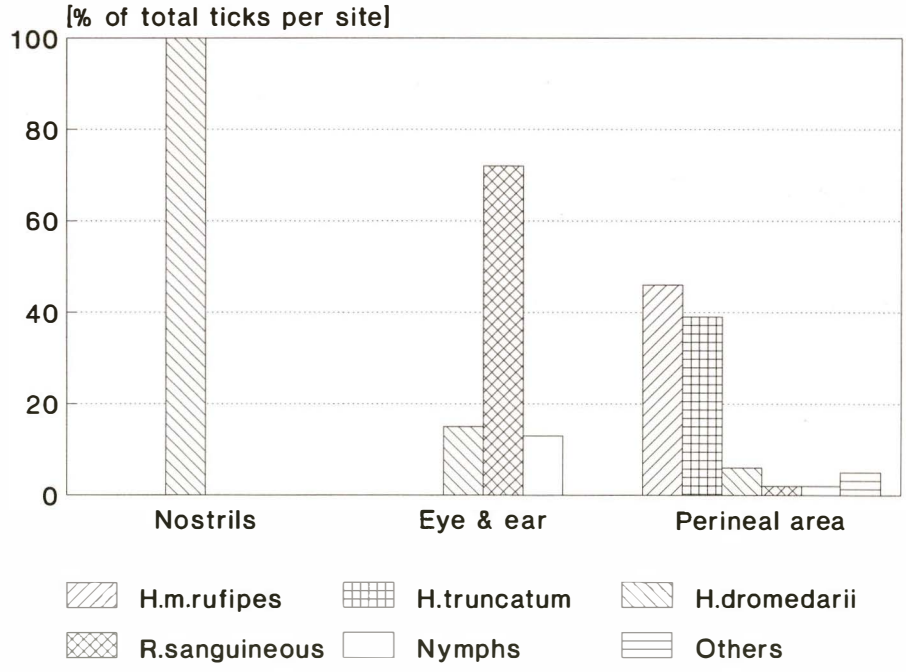

Figure 4: Composition of tick population by species at three different attachment sites in four camel herds during 34 consecutive months

3 the prevalent tick species were *Hyalomma dromedarii, Hyalomma marginatum rufipes, Hyalomma truncatum* and *Rhipicephalus sanguineous* group. Some other species of ticks have been collected in small number in herds 1, 2 and 3, i.e. *Rhipicephalus simus, Rhipicephalus pulchellus, Rhipicephalus evertsi, Amblyomma lepidum, Amblyomma gemma*. In herd 4 only three species were found, the most common one (54%) was *H.dromedarii* followed by *H.truncatum* and *H.m.rufipes*, *R.sanguineous* group was present only in very small number.

Of the nine tick species recorded in the study only four were found in significant numbers: *H.dromedarii, H.m.rufipes, H.truncatum* and *R.sanguineous* group. The differences in the prevalence of these species in the four herds were most likely determined by differences in management and environment of the four study herds. Herd 1 and 2 were moderately mobile with 43 and 41 household movements during the study period and had only limited contacts with cattle. Herd 3 was highly mobile (55 household movements during the study period) and had regular close contacts with cattle. Herd 4 was almost sedentary (only 20 household movements during the study period) and had virtually no contacts with cattle. In particular the frequency and intensity of contact with cattle appear to affect the occurrence Rhipicephalus spp. and Amblyomma spp. on camels.

Figure 3 shows the proportion of males and females of the dominant tick species combined for all herds observed the whole of the study period. In all the four herds more males were collected than females, *H.dromedarii, H.m.rufipes* and *H.truncatum* the difference between male and female numbers was pronounced. They were balanced in the *R.sanguineous* group. Temporal fluctuations in the sex ratio were extreme; there was, however, no distinct seasonal pattern.

Figure 4 shows the tick species composition at three attachment sites, the nostrils, eyelid and ear and the perineal area. As for the sex ratios the presentation refers to all herds and the whole period of study. At the nostril site only *H.dromedarii* was found. At the eyelid and ear site the *R.sanguineous* group was the most abundant species (72%) followed by *H.dromedarii* (15%) and few nymphs (13%). At the perineal area the predominant species were *H.m.rufipes* (46%) and *H.truncatum* (39%); some other species were present in limited number, *H.dromedarii* (6%) and *R.sanguineous* group (2%), few nymphs (2%) were collected together with some specimen of *R.evertsi, R.pulchellus, R.simus, A.gemma* and *A.lepidum*.

Attachment site preferences observed on camels in this study for *the R.sanguineous* group, *H.m.rufipes* and *H.truncatum* are similar to those observed with cattle. *H.dromedarii* was found at all sites with a clear preference for the nostrils, where it was the only species present, thus clearly confirming the assumed single host specialisation of this species.

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Annex 2

Common range forage species preferred by camels, and their nutritional value

H.J.Schwartz

If given a choice camels prefer to feed on bushes and trees and other dicotyledon species and avoid grasses completely. In a study carried out over three years on a semi-arid thornbush savannah in Northern Kenya feeding behaviour of camels was monitored in comparison to that of other domestic herbivores. Out of approximately 320 plant species which had been identified on the experimental pastures, camels were regularly feeding on 44 species of trees and large bushes, 25 species of dwarf shrubs and 8 species of soft forbs. Another 70 to 80 species of all classes, including grasses, occurred occasionally in their diet. Table 1 lists all those species which, averaged over all three years of recording, contributed to more than 2 % of the total recorded feeding time.

Table 1: Range forage species preferred by camels

	Feeding time [% of total]	Feeding stations [% of total]
Trees and large bushes		
Acacia mellifera	2.7	1.8
Acacia tortilis	5.7	4.6
Balanites pedicellaris	2.5	1.1
Boscia angustifolia	2.0	1.0
Cadaba farinosa	7.6	3.2
Commiphora africana	4.2	2.2
Commiphora spec.	2.8	1.4
Cordia sinensis	4.4	2.2
Grewia bicolor	4.9	2.9
Grewia tenax	2.9	2.7
Grewia villosa	3.3	3.5
Maerua endlichii	8.8	4.5
Opilia campestris	4.6	2.5
Dwarf shrubs		
Baleria acanthoides	4.6	9.5
Indigofera spinosa	6.7	13.8
Sericocomopsis pallida	4.4	7.2
Vernonia cinerascens	6.4	8.7
Soft forbs		
Blepharis linariifolia	2.8	4.8

These included 13 trees and large bushes, 4 dwarf shrubs and one soft forb which accounted for 81.3 % of the total observed feeding time. The camels were mainly harvesting leaves, but also flowers, fruits and, during the dry season, the tips of twigs and branches, i.e. last seasons woody growth. After one exceptionally long dry spell, when green forage was very scarce they were occasionally debarking trees.

Forage quality was regularly monitored during the feeding behaviour observations. For each observation date, i.e. every two weeks, the five most preferred species were sampled and analysed. Forage quality fluctuated considerably with the season. The various parts of the same species showed likewise a great variation in quality. Figure 1 shows the differences in fibre, lignin and crude protein content of various parts of Acacia tortilis including also young and old leaves.

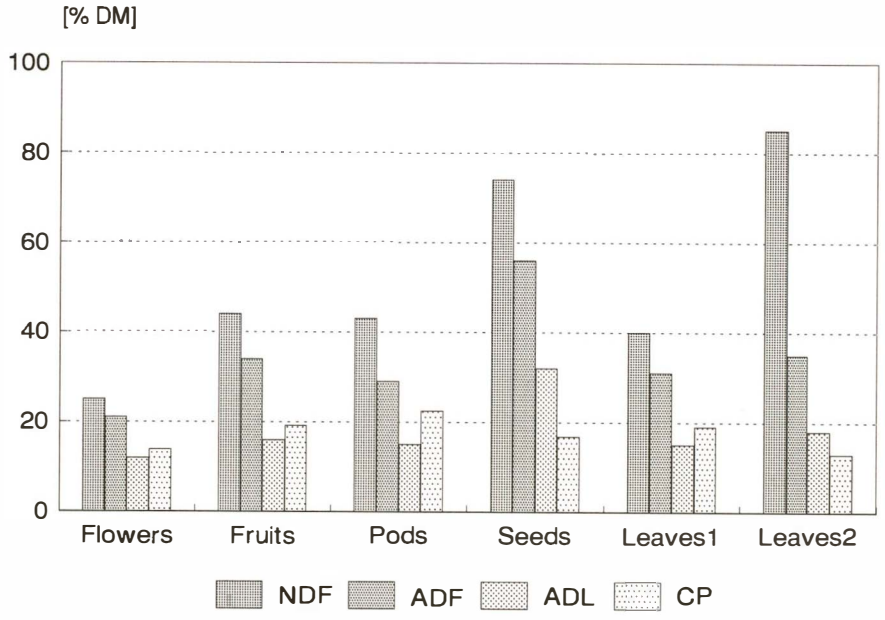

Figure 1: Mean gross composition (Neutral Detergent Fibre, Acid Detergent Fibre, Acid Detergent Lignin and Crude Protein) of various parts of Acacia tortilis sampled over three years in one location in Northern Kenya (Leaves 1 = fresh growth during the rainy season; Leaves 2 = green leaves approx. 4 months old).

The results of the chemical analysis of the most preferred forages are compiled in Table 2. Means, standard deviations, minima and maxima are listed, to give an impression of the seasonal changes which were observed. Highest fibre and lignin contents were reached at the end of the dry seasons, highest crude protein contents with the beginning of the rainy seasons. Generally, due to the fact that camels were selected mostly green material from deep rooted bushes and trees throughout the year, forage quality did not change as much as in the herblayer and there particularly in the grasses.

Table 2: Nutritive quality of forages preferred by camels

		NDF	ADF	ADL	Ash	CP
Bushes and trees						
Acacia mellifera						
	Mean	36.84	24.40	7.11	10.00	20.76
	S.D.	8.00	5.68	1.86	6.09	6.38
	Maximum	53.37	38.61	12.63	29.79	29.68
	Minimum	21.59	12.95	5.19	4.66	8.10
Acacia tortilis						
	Mean	34.89	26.70	8.37	5.41	16.23
	S.D.	7.33	8.78	4.07	1.10	3.44
	Maximum	49.64	59.58	17.59	8.10	23.11
	Minimum	24.81	19.45	3.35	4.43	10.83
Balanites pedicellaris						
	Mean	26.48	16.30	10.81	15.89	23.87
	S.D.	3.63	2.55	1.21	1.41	4.27
	Maximum	30.43	19.24	11.57	16.89	28.67
	Minimum	23.28	14.73	9.41	14.89	20.49
Boscia angustifolia						
	Mean	57.47	38.01	11.08	8.03	13.31
	S.D.	6.63	3.34	2.09	2.15	1.65
	Maximum	65.00	41.54	14.76	11.65	15.16
	Minimum	46.57	32.42	9.34	5.38	10.19
Cadaba farinosa						
	Mean	30.91	19.06	8.19	14.87	25.55
	S.D.	8.93	6.91	3.11	3.02	4.69
	Maximum	42.20	27.34	14.91	19.09	31.58
	Minimum	17.61	10.33	5.37	10.66	17.28
Commiphora africana						
	Mean	41.51	28.63	12.21	6.34	17.76
	S.D.	8.53	9.51	7.63	1.85	3.63
	Maximum	52.53	45.91	27.23	9.89	22.55
	Minimum	30.99	17.91	6.33	4.36	12.94
Commiphora spec.						
	Mean	45.54	30.18	12.88	7.22	15.82
	S.D.	11.90	14.04	8.43	1.51	7.74
	Maximum	68.76	58.58	31.48	10.04	22.77
	Minimum	34.78	19.91	6.50	5.51	3.12

Table 2 (continued)

		NDF	ADF	ADL	Ash	CP
Cordia sinensis						
	Mean	39.76	35.78	14.71	13.92	17.59
	S.D.	5.71	8.01	4.75	2.17	4.19
	Maximum	47.94	46.02	20.96	18.80	24.20
	Minimum	28.55	21.96	7.22	11.90	11.44
Grewia bicolor						
	Mean	44.32	24.75	6.80	8.75	20.71
	S.D.	3.44	3.46	1.20	1.02	2.64
	Maximum	53.62	32.16	10.28	11.46	24.70
	Minimum	37.43	14.37	4.74	7.15	14.82
Grewia tenax						
	Mean	33.07	20.77	4.82	10.50	20.83
	S.D.	4.38	2.22	1.17	1.64	4.66
	Maximum	40.02	23.99	6.56	14.22	31.82
	Minimum	25.44	16.47	3.18	8.26	15.60
Grewia villosa						
	Mean	45.61	27.84	4.98	8.83	18.24
	S.D.	4.57	2.62	1.28	1.08	2.82
	Maximum	52.96	33.90	8.07	11.51	25.15
	Minimum	35.70	24.11	3.00	7.30	11.60
Maerua endlichii						
	Mean	28.84	17.09	5.63	16.34	22.68
	S.D.	13.16	8.65	2.97	6.69	2.38
	Maximum	60.92	37.87	12.74	23.70	25.74
	Minimum	19.76	10.97	3.85	4.48	18.76
Opilia campestris						
	Mean	26.52	17.97	9.50	15.01	29.68
	S.D.	4.24	4.12	1.90	3.90	6.52
	Maximum	37.02	27.28	12.96	20.61	40.12
	Minimum	22.28	13.81	7.28	8.03	20.43
Dwarf shrubs						
Baleria acanthoides						
	Mean	49.69	35.81	10.12	12.42	13.27
	S.D.	8.62	6.72	2.89	4.04	2.91
	Maximum	58.86	44.32	14.01	20.33	18.97
	Minimum	34.28	24.88	5.55	8.38	8.42

Table 2 (continued)

		NDF	ADF	ADL	Ash	CP
Indigofera spinosa						
	Mean	49.67	38.17	9.52	9.41	13.71
	S.D.	10.57	10.08	4.03	1.91	5.00
	Maximum	66.76	53.38	15.81	13.86	31.32
	Minimum	27.91	17.29	2.12	6.27	7.60
Sericocomopsis pallida						
	Mean	45.25	20.12	3.12	13.90	21.55
	S.D.	2.91	2.70	0.84	1.93	5.33
	Maximum	52.98	28.85	5.80	17.32	30.97
	Minimum	39.78	16.19	2.06	9.90	12.94
Vernonia cinerascens						
	Mean	45.01	30.94	9.19	9.16	18.16
	S.D.	14.87	14.58	5.32	3.68	7.44
	Maximum	73.54	60.60	23.41	16.70	34.52
	Minimum	25.46	13.62	2.97	3.02	6.90
Soft forbs						
Blepharis linariifolia						
	Mean	56.96	35.26	7.59	9.87	11.92
	S.D.	8.42	5.41	1.75	1.90	2.89
	Maximum	76.03	44.19	10.46	13.50	15.12
	Minimum	43.48	24.96	4.05	6.61	4.27

In addition to the chemical analysis the most preferred forage species were repeatedly tested for dry matter digestibility using the nylon-bag technique with camels equipped with forestomach fistulas. Samples of the forages were dried, ground, weighed into nylon bags and incubated for 6, 12, 24, 48 and 72 hours in the forestomach of free ranging camels. Dry matter loss from the nylon bag during these incubation periods serves as an indicator for digestibility. In a comparative approach the same was done, again with the respective preferred forages with sheep, goats and zebu cattle. Figure 2 shows the mean dry matter disappearance curves for the most preferred forages of the four species of domestic herbivores, as they were tested at monthly intervals for three years. Camels, sheep and goats show very similar disappearance curves, indicating that they are all able to select feed of similar quality from the same pasture. Cattle, being grazers, consistently select diets of lower quality. Table 3 summarises the values obtained for camels. Means, standard deviations, minima, and maxima again serve to demonstrate seasonal variation of quality.

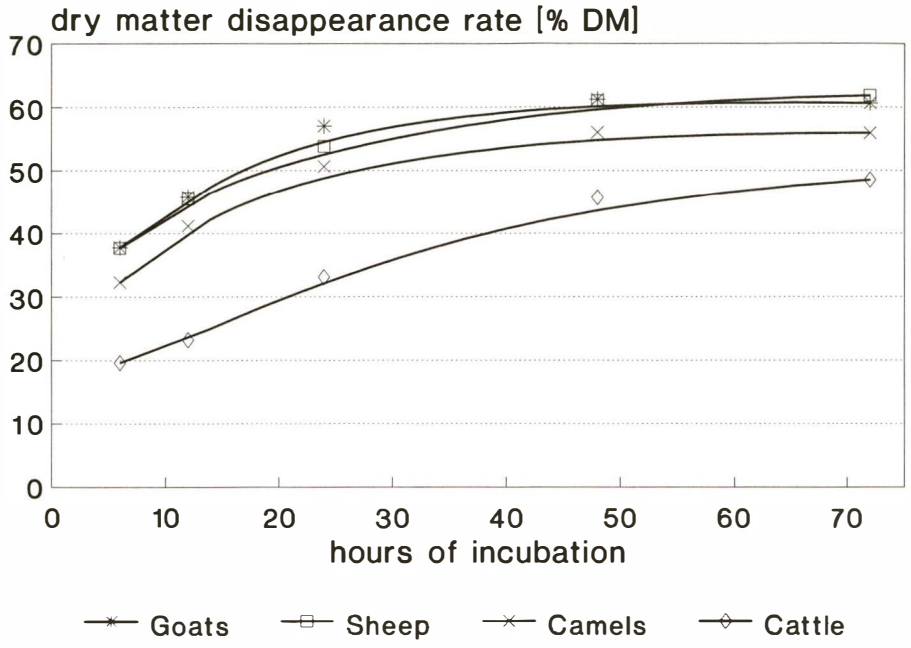

Figure 2: Mean dry matter disappearance rates of preferred forages measured with the nylon-bag technique in free ranging sheep, goats, zebu cattle and camels

Table 3: Dry matter disappearance rates of preferred forages incubated for 12 and 48 hours in nylon bags in the forestomachs of free ranging camels

Bushes and Trees	**12 hrs**	**48 hrs**
Acacia mellifera		
Mean	43.0	55.0
S.D.	4.8	7.1
Maximum	50.2	65.1
Minimum	35.2	44.5
Acacia tortilis (leaves)		
Mean	48.5	63.7
S.D.	11.2	5.6
Maximum	75.0	75.2
Minimum	36.9	57.9
Balanites pedicellaris		
Mean	66.1	67.3
S.D.	4.4	1.5
Maximum	71.7	68.7
Minimum	62.4	65.8

Table 3 (continued)

Boscia angustifolia			
	Mean	45.1	51.7
	S.D.	0.2	0.9
	Maximum	45.3	52.4
	Minimum	44.0	51.1
Cadaba farinosa			
	Mean	54.3	79.9
	S.D.	-	0.2
	Maximum	-	80.1
	Minimum	-	78.9
Commiphora africana			
	Mean	23.3	43.2
	S.D.	2.3	5.3
	Maximum	26.9	50.2
	Minimum	20.9	39.0
Commiphora spec.			
	Mean	30.5	55.2
	S.D.	4.2	6.1
	Maximum	34.2	60.3
	Minimum	25.1	46.3
	Cordia sinensis		
	Mean	33.9	68.8
	S.D.	0.2	2.0
	Maximum	34.0	70.2
	Minimum	33.8	67.4
Grewia bicolor			
	Mean	24.2	42.8
	S.D.	7.0	4.2
	Maximum	30.6	48.2
	Minimum	17.0	38.8
Grewia tenax			
	Mean	53.5	74.0
	S.D.	8.2	5.0
	Maximum	58.0	81.0
	Minimum	41.2	69.1
Grewia villosa			
	Mean	33.3	56.6
	S.D.	3.0	3.0
	Maximum	35.5	58.7
	Minimum	31.2	54.5

Table 3 (continued)

Maerua endlichii			
	Mean	57.3	74.0
	S.D.	20.9	11.5
	Maximum	85.4	87.4
	Minimum	17.5	51.5
Opilia campestris			
	Mean	65.2	68.3
	S.D.	3.4	6.8
	Maximum	69.3	76.4
	Minimum	60.2	61.3
Dwarf shrubs			
Baleria acanthoides			
	Mean	41.4	54.5
	S.D.	6.1	0.8
	Maximum	45.7	55.1
	Minimum	37.1	54.0
Indigofera spinosa			
	Mean	30.3	45.3
	S.D.	8.1	12.1
	Maximum	51.3	64.0
	Minimum	17.0	22.7
Sericocomopsis pallida			
	Mean	37.3	53.8
	S.D.	3.2	9.8
	Maximum	40.5	64.0
	Minimum	31.0	38.3
Vernonia cinerascens			
	Mean	38.2	52.9
	S.D.	4.8	2.1
	Maximum	41.6	54.4
	Minimum	34.8	51.5
Soft forbs			
Blepharis linariifolia			
	Mean	23.9	55.5
	S.D.	4.5	24.9
	Maximum	27.3	82.9
	Minimum	15.6	23.5

Further reading

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Glossary of Terms

Sources: Longman Dictionary of the English Language 1988; Black's Veterinary Dictionary, 1982.

acute	esp. of an illness, disease, etc having a sudden onset, sharp rise, and short course
anaesthesia	loss of sensation, esp sensation of pain, resulting either from injury or a disorder of the nerves or from the action of drugs.
anaemia	a condition in which the blood is deficient in red blood cells, hemoglobin or total volume
anorexia	loss of appetite esp when prolonged
anoestrus	the period of sexual quiescence between two periods of sexual activity in mammals that have breeding cycles
atrophy	decrease in size or wasting away of body part or tissue
blastocyst	early form of an embryo consisting of a hollow ball of cells
carpus	wrist or corresponding structure
chronic	esp. of an illness, disease marked by long duration or frequent recurrence
colostrum	the milk that is secreted for a few days after giving birth and that differs from that secreted later in having a higher protein and antibody content
conformation	the proportionate shape or contour, esp. of an animal
congenital	existing or dating from birth
constipation	abnormally delayed or infrequent passage of dry hardened feces
convulsions	an abnormal violent and involuntary contraction or series of contractions of the muscles
desquamation	to peel off in scales and flakes.
dyspnoea	difficult or laboured breathing
eczema	an inflammatory condition of the skin characterized by redness, itching etc.
edema	abnormal accumulation of fluid beneath the skin causing swelling
epidemiology	a branch of medical science that deals with the occurrence, distribution and control of disease in a population

emaciate	to cause to become excessively thin, to waste away physically
etiology	the study of the causes of anything esp diseases
excoriate	to wear off the skin, abrade
haemorrhage	loss of blood from the blood vessel
idiopathic	arising spontaneously or from an obscure or unknown cause
infertile	not fertile or productive
inflammation	a local reaction to injury or infection that is marked by dilation of the minute blood vessels and infiltration of white blood cells into the affected area, accompanied by redness, heat, pain and swelling
-itis	disease or inflammation of (bronchitis; rhinitis; arthritis, conjunctivitis etc)
lochia	discharge of blood, mucus etc, from the womb following birth and usually lasting several days or weeks
masticate	to chew grind or crush food; mastication
meconium	a dark greenish mass that accumulates in the bowels during foetal life and is discharged shortly after birth
morbidity	the incidence of disease
mortality	the number of death in a given time
myiasis	infestation with fly maggots
necropsy	post-mortem
necrosis	death of living tissue
neonate	a newborn child or animal
opisthotonus	characteristic backward position of head
ovulate	produce or discharge eggs from the ovaries; ovulation
papule	a small solid usually conical projection from the skin
paralysis	(partial) loss of function, esp when involving motion or sensation in a part of the body
parturition	the action or process of giving birth to offspring
peri-	enclosing surround all around e.g periorbital tissue
perineum	the area between the anus and the rear part of the genitals, esp. in the female

petechia	a minute bleeding or blood filled spot that appears in the skin or mucous membranes, esp in some infectious diseases
placenta	the mass of tissue in all mammals except monotremes and marsupials that unites the foetus to the mothers womb, it is formed by the interlocking of the membranes of the foetus with the lining of the womb, and is supplied with a network of blood vessels through which oxygen and nourishment pass from the mothers blood to that of the foetus.
post partum	time after having given birth
prognosis	the prospect of recovery as anticipated from the usual course of disease
purulent	consisting of pus
rectally	relating to, affecting, or near the rectum
respiratory system	system of organs carrying out the function of respiration, which in mammals, reptiles, birds etc, consists typically of the lungs and the channels by which these are connected with the outer air.
rigor mortis	the state occurring some time after death in which the muscles become temporarily rigid, stiffness of death.
sedation	the induction of a relaxed easy state, esp by the use of sedatives, also this state.
septicaemia	invasion of the blood stream by disease causing microorganisms from a local seat of infection accompanied by fever, and collapse
serosa	a thin membrane (lining of bowels; abdominal cavity)
tarsus	ankle or corresponding structure
temporal	the temple or equivalent part of the side of the skull
tenesmus	an uncomfortable but ineffectual urge to defecate or urinate
toxicosis	disorder caused by the action of a poison or toxin
ulcer	an open sore in skin or mucous membranes
ventricle	a chamber of the heart that receives blood from a corresponding atrium (chamber that receives blood from the veins) and pumps it into the arteries.

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Colour plates

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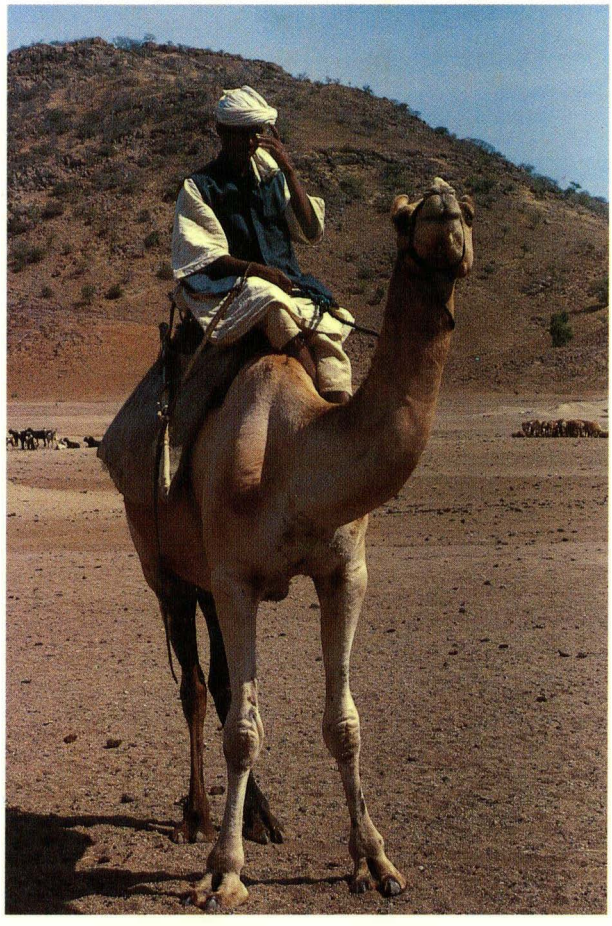
All line drawings, diagrams and maps H.J.Schwartz

With increasing human population pressure and declining per capita production of food in Africa there is an urgent need to develop previously marginal resources, such as the semi-arid and arid rangelands, and optimise their utilisation through appropriate livestock production systems, of which camel production is certainly the most suitable one.

The camel (*Camelus dromedarius*, one-humped camel, dromedary) is an important livestock species uniquely adapted to hot and arid environments. It produces milk, meat, wool, hair and hides, serves for riding, as a beast of burden and as a draft animal for agriculture and short-distance transport. It is most numerous in the arid lowlands of Eastern Africa, i.e. in Somalia, Sudan, Ethiopia, Kenya and Djibouti. Approximately 11.5 million animals in this region represent over 80% of the African and two thirds of the world's population of camels.

This book presents detailed information on the camel in Eastern Africa. Distribution, adaption to arid environments, feeding behaviour and nutritional physiology, products, performances, economic importance, productivity, traditional and modern management practices, diseases, health care and post-mortem procedures are treated with special reference to Eastern Africa.



ISBN 3-8236-1218-2

verlag josef margraf
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