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**THE CAMEL (*CAMELUS DROMEDARIUS*):
A BIBLIOGRAPHICAL REVIEW**



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**THE CAMEL (*CAMELUS DROMEDARIUS*):
A BIBLIOGRAPHICAL REVIEW**

**BY
E. MUKASA-MUGERWA**

**PUBLISHED BY
INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA 1981
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ABSTRACT

Available literature on the dromedary in Africa and Asia is reviewed in order to assess the current performance and productive potential of this species. The origins, distribution and classification of camel breeds are briefly discussed. The reproductive anatomy is described, and is followed by an account of breeding behaviour and performance, with special attention to fertility. The digestive anatomy of the dromedary and its feed and water requirements are then analysed, with a discussion of water metabolism, before the animal's major and minor diseases are identified. The camel's ability to produce milk and meat is assessed in detail, together with its suitability for transport and other purposes, such as ploughing, milling and the production of hides and skins. Management and socio-economic factors are also briefly discussed. Finally, the information presented is summarized, some proposals for future research are put forward, and a bibliography is given.

KEY WORDS

/Bibliography/ /Africa/ /Asia/ /camel/ /animal population/ /breed/ /animal performance/ /reproduction/ /fertility/ /feed intake/ /water intake/ /animal disease/ /milk yield/ /meat yield/ /work animal/ /livestock management/ /research/ /recommendation/.

RESUME

La littérature disponible sur le dromadaire en Afrique et en Asie est examinée afin d'évaluer les performances et le potentiel de production actuels de cette espèce. Les origines, la distribution et la classification des races camelines sont brièvement discutées. L'anatomie reproductive est décrite, suivi d'un exposé sur le comportement et les performances de reproduction avec référence spéciale à la fertilité. L'anatomie digestive du dromadaire ainsi que ses besoins alimentaires et en eau sont alors analysés, avec discussion sur le métabolisme hydrique, avant d'identifier les maladies principales et secondaires de l'animal. La capacité de production laitière et bouchère du chameau est évaluée en détail, ainsi que son aptitude pour le transport et autres fins tels que le labour, le moulage et la production de cuirs et de peaux. Les facteurs socio-économiques relatifs à la gestion sont aussi brièvement discutés. Finalement, l'information présentée est résumée et quelques propositions pour la recherche ultérieure sont formulées, accompagnées d'une liste bibliographique.

MOTS-CLES

/Bibliographie/ /Afrique/ /Asie/ /chameau/ /population animale/ /race/ /performance animale/ /reproduction/ /fertilité/ /consommation animale/ /consommation d'eau/ /maladie animale/ /rendement laitier/ /rendement boucher/ /animal de trait/ /exploitation du bétail/ /recherche/ /recommandation/.


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PREFACE

The role of the camel in the modern world is changing. As pastoral societies evolve or decline, traditional uses of the camel, for example as transport, diminish. Yet the productive potential of this species and the manifold purposes which it may serve, combined with its ability to perform efficiently in harsh environments, are compelling reasons for understanding how to make better and more systematic use of this animal resource.

Although a number of significant studies on the one-humped camel or dromedary have been carried out in several African and Asian countries, there has been little integrated research or interdisciplinary evaluation of the state of knowledge on this species. The present review was therefore undertaken in order to summarize current knowledge of the animal and its productivity, to identify gaps in that knowledge, and to suggest avenues for future research. Although the literature on the dromedary is scanty compared with other domestic animals, it has not been possible to consult it all. Nor has it been possible to incorporate all the findings of the 150 works or more cited. However, it is hoped that most of the salient facts for the purposes of designing future research have been identified and included.

This monograph is the fruit of several years of preparation. Study was initiated by Dr. A. Ortiz, animal scientist, and Mr. B. McClure, sociologist, who together laid its foundations by collecting and analysing much of the basic material. Their substantial input at this early stage is gratefully acknowledged, while the comments and information later provided by other workers in the field have also been most helpful. The monograph was continued and completed in its present form by Dr. E. Mukasa-Mugerwa, veterinarian, with editorial and secretarial assistance by Mr. S. Chater and Wzro. Salome Gerima. It was typeset and printed at ILCA by Wzro. Mekwanent, Wt. Tenagne and Ato Mahmoud Saleh. The photographs of the Afar people of Ethiopia with their camels, including the ploughing scene photographed during trials in the irrigated Awash River valley and reproduced on the front cover, were taken by M.D. Gérard, specialist with the French Technical Cooperation Programme in Ethiopia, who most kindly permitted their use in this report. The remaining photographs were taken in Sudan by the author. The Bibliography is divided into two sections: under References the works cited by the author are listed chapter by chapter, while a classified list of additional works has been attempted under the heading Further Reading. The latter is far from exhaustive, but for much of the material included the author is indebted to IEMVT (Institut d'Élevage et de Médecine Vétérinaire des Pays Tropicaux).



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1. ORIGINS AND DISTRIBUTION

1.1 EVOLUTION OF THE DROMEDARY

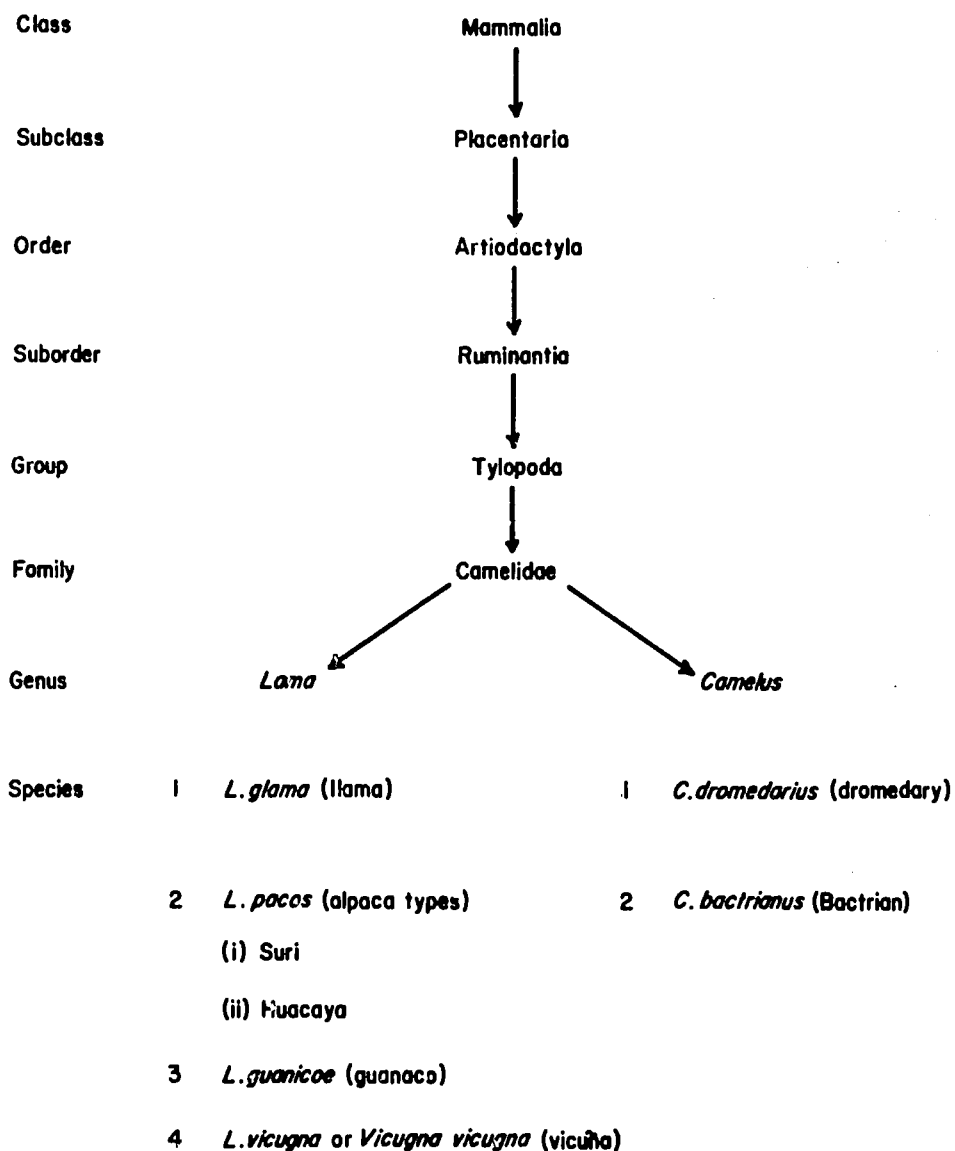
The dromedary or one-humped camel (*Camelus dromedarius*) is one of two species within the genus *Camelus*, the other being the Bactrian or two-humped camel (*C. bactrianus*). Camels and llamas are the two genera comprising the Camelidae family. The Camelidae belong to the ruminant suborder within the placental subclass of mammalian vertebrates. Among the living artiodactyls the Camelidae family is the only one within the Tylopoda group (see Figure 1).

Mikesell (1955) indicates that the origin of camels can be traced to the *Protylopus*, an animal that occupied the North American continent during the Eocene period. That the Camelidae eventually disappeared from the mother continent is part of the enigma surrounding the extinction of North American Pleistocene mammals. However, by this time Camelidae had already migrated across the Bering Straits to Asia during the late Pliocene or early Glacial epochs (Novoa, 1970; Williamson and Payne, 1978; Drosandi, 1915). Others migrated to South America and evolved into the wild guanaco, the vicuña and later the domesticated llama and alpaca - the humpless cameloids of the New World. Fossil evidence indicates that Camelidae were present in China, Siberia, and Russia during the Pliocene and Pleistocene periods. During the latter they were also found in Rumania, Palestine and North Africa. In Africa, the wild camel extended as far west as the Atlantic coast and as far south as northern Tanzania, according to Mason (1979).

Fernandez-Baca (1978) indicates that while both camels and llamas evolved from common North American ancestors over 1 million years ago, no significant karyotypic differences exist between the various species, except for sex differences. Work by Taylor et al (1968) showed that the guanaco, the Bactrian camel and the dromedary each have 74 chromosomes, similar to the number found in the llama, alpaca, guanaco and vicuña by Benirschke (1967). Taylor et al therefore conclude that the evolutionary changes that occurred were due to single gene mutations or minor chromosome rearrangements.

Williamson and Payne (1978) indicate that the earliest Old World camels, which probably reached North Africa, were more closely related to the two-humped camel

Figure 1. Representation of the classification of the dromedary and other Camelidae.



Source: Compiled by author, from Cauvet (1925), Leese (1927), Curzon (1947), Fernandez-Baca (1978) and Mason (1979).

(*Camelus bactrianus*). This North African stock, however, became extinct, and the subsequent reintroduction of the camel to the continent involved the dromedary instead.

The modern one-humped camel or dromedary (the latter name derives from the Greek *dromados*, meaning "running") is generally thought to have evolved from the two-humped Bactrian species. This theory is partly based on embryological evidence showing that during prenatal development the dromedary foetus actually has two humps (Dennler de ia Tour, 1971), while a vestigial anterior hump is present in the adult. Williamson and Payne (1978) speculate that the one-humped species probably evolved in one of the hotter and more arid areas of western Asia. Today the two species can and often do interbreed, and on the basis of the fertility of the hybrids some authors have advocated amalgamating them into one species with two varieties. In areas of bordering distribution, such as north Punjab, Persia and Afghanistan, the phenotypic differences between the two types tend to diminish as a result of the crossbreeding between them.

The Bactrian or two-humped camel (*C. bactrianus*) is generally a long-haired sturdy animal, powerfully built and adapted to rigorous, cold climates. It is capable of marching in snow-covered mountains. The two-humped camel is found in Turkestan and throughout central Asia (War Office, 1908) and in the extremely cold northern deserts (Fazil, 1977). Leese (1927) suggests that the species developed in the Bactriana part of Afghanistan, whence it spread through Asia, China, Turkestan and Russia. Bulliet (1975) concludes that the first homeland of the Bactrian was the border of Iran (Khorasan) and the USSR (Turkemanistan). Tracing the story of its domestication, he estimated that the date of domestication probably reaches back to before 2,500 B.C. From this early focus of domestication, the Bactrian spread far and wide. It still exists today in central Asia and Mongolia, but has receded from other areas, e.g. the Indus valley.

Bulliet also makes the significant observation that in areas where the Bactrian has disappeared, the dromedary exists in substantial numbers. Similarly, the dromedary is rare in those areas where the Bactrian still exists. He suggests that substitution occurred because the nomads of the Syrian and Arabian deserts valued the one-humped camel both as an animal and also on account of its products. The Bactrian, on the other hand, was raised by Asiatic peoples who already had alternative sources for milk, meat and wool (cattle, sheep and goats). Whenever the two cultures came into contact, the Arabic pattern seemed to predominate, with the result that the one-humped camel gradually replaced the Bactrian, as it did for instance on the famous caravan trade route through central Asia to China, the silk route.

The dromedary is sometimes referred to as the Arabian camel, after the area in which it is thought to have been domesticated and probably most extensively employed. Mason (1979) suggests that the dromedary was domesticated in southern Arabia around 3000 B.C. However, the evidence as to where, when and why these animals were first domesticated remains inconclusive.

1.2 THE DROMEDARY IN AFRICA

1.2.1 Distribution

Curasson (1947) and Epstein (1971) indicate that the dromedary was introduced into North Africa (Egypt) from southwest Asia (Arabia and Persia). The former indicates that occasional shipments were also made to Spain, Italy, Turkey, France, the Canaries, North America and Australia. The latter country still contains a small feral herd of around 20,000. The present world habitat of the camel is shown in Figure 2. Leese (1927) and Fazil (1977) also mention attempts to introduce camels into various parts of southern Africa. Today camels are still used as mounts by police patrols in the Kalahari desert of Botswana (von Kaufmann, personal communication), as well as by the Game Department in northern Kenya.

Once in Africa, Mikesell (1955) suggests that the camel spread west and southwards from Egypt, although Bulliet (1975) is of the view that the camels of the Horn of Africa are more likely to have come across the sea from the Arabian Peninsula than spread southwards from Egypt and Sudan.

According to FAO (1979) statistics (see Table 1), there are about 17 million camels in the world, of which 12 million are found in Africa and 4.9 million in Asia. Of this estimated world population, 15.1 million are believed to be one-humped camels and 1.9 two-humped. The world population of camels is not increasing very rapidly, mainly owing to the decrease in numbers in the non-tropical areas (Williamson and Payne, 1978). However, 70% of the world's camels are still found within the tropics and over 90% of the African herd are present in this region. The African population is thought to be increasing slightly, especially within the tropics.

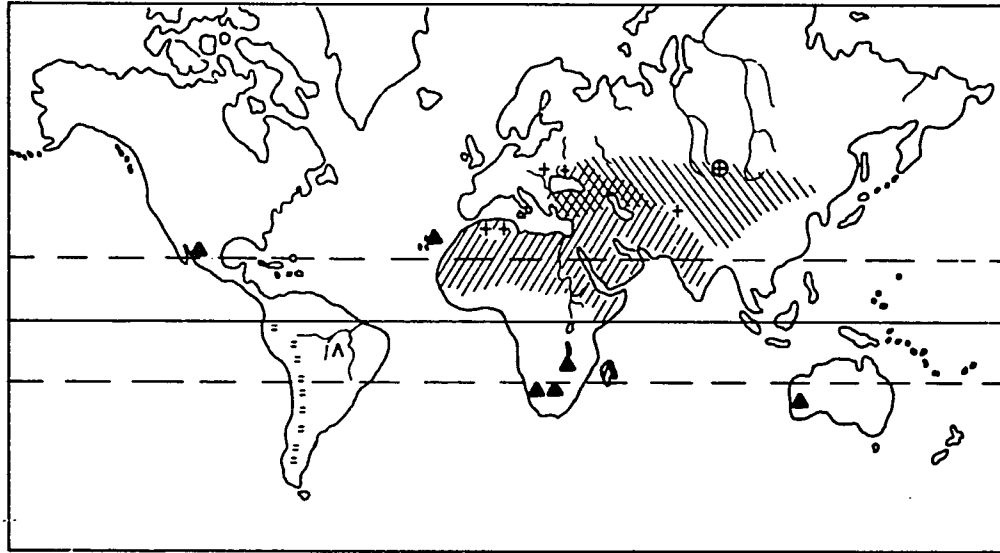
Today the dromedary is found in substantial numbers in the following African countries: Algeria, Chad, Djibouti, Egypt, Ethiopia, Kenya, Libya, Mali, Mauritania, Morocco, Niger, Nigeria, Senegal, Somalia, Sudan, Tunisia, Upper Volta and West Sahara. It is noteworthy that the five neighbouring countries of Somalia, Ethiopia, Sudan, Kenya and Djibouti together contain 84% of African camels and over half (60.1%) the world's camel population, while Africa as a whole contains 72%. In northern Kenya as in some other areas, however, numbers are declining, since the camel is being replaced by other domestic species.







1.2.2 Classification

Leese (1927) classified dromedaries according to their natural breeding areas into (i) hill camels, small compact muscular animals fit for work as baggagers, and (ii) plains camels, larger animals subdivided into riverine and desert types. The riverine camels are heavy baggagers with slow movements, while the desert types are light and typical of most riding animals. He also identifies a third group, intermediate between hill and plains animals.

It has been shown (IAO, n.d.) that dromedaries can also be classified into three groups according to their morphology: (i) the brachymorphic dromedary, a large and heavy animal typified by the Egyptian caravan camels; (ii) the mesomorphic dromedary, a

Figure 2. *Habitat of the camel.*



- | | |
|--|--|
|  Habitat of dromedary |  Area where the dromedary has been introduced |
|  Habitat of two-humped camel |  Habitat of the American camelidae |
|  Area where fossil deposits have been found |  Area of the wild camel |

Source: Adapted from Cauvet, 1925.

Table 1. *Estimated camel populations of Africa and the world, 1978.*

Country	Population (x10 ³)	As % of world population ^{1/}	As % of African population ^{2/}
Africa			
Algeria	147	0.87	1.21
Chad	26	0.15	0.21
Djibouti	405	2.38	3.32
Egypt	95	0.56	0.78
Ethiopia	960	5.65	7.88
Kenya	574	3.38	4.71
Libya	75	0.44	0.62
Mali	198	1.17	1.62
Mauritania	718	4.23	5.89
Morocco	20	0.12	0.16
Niger	350	2.06	2.87
Nigeria	18	0.10	0.15
Senegal	6	0.03	0.05
Somalia	5400	31.78	44.30
Sudan	2904	17.09	23.82
Tunisia	205	1.20	1.68
Upper Volta	5	0.03	0.04
West Sahara	86	0.51	0.71
Other Regions			
Afghanistan	290	1.70	-
China	1040	6.50	-
India	1174	6.58	-
Iraq	232	1.37	-
Mongolia	615	3.62	-
Pakistan	819	4.82	-
Saudi Arabia	108	0.54	-
USSR	230	1.35	-

^{1/} Based on the world population of 16.99 millions.

^{2/} Based on the African population of 12.19 millions.

Source: FAO, 1979.

lighter animal illustrated by the Libyan camel and (iii) the dolichomorphic dromedary, to which group belong the lean, swift Mehara animals common among the Saharan peoples. The first two groups comprise what is generally called the 'beast of burden' camel when a broad classification based on the ability to work is applied.

Cole (1975), writing about the Murrah of Arabia, distinguishes three types: the beast of burden (baggage), the riding and the milking camel. Within each of these broad classes there are numerous breeds and types of dromedary, which have been bred and raised by man to suit local conditions. Man's role in evolving these various types has, however, been secondary to the genetic and environmental pressures on both the dromedary and the Bactrian camel.

The names of the dromedary breeds and types found in Africa often reflect the locality or country where the animals are raised, the people who breed them or simply the animals' colour, rather than any division into work, riding or milking breeds. It is thus possible for the same camel types, with a common ancestry but occupying different geographical areas, to be labelled as two separate types or breeds. A comprehensive and systematic classification of camel breeds remains to be achieved. For the purposes of the present report, the major African camel types for each country are briefly described below, primarily on the basis of presentations by Mason and Maule (1960), Leese (1927), Gillespie (1962) and Epstein (1971).

Somalia

Somalia, with over five million camels (FAO, 1979), has the largest herd in the world. Descriptive accounts of the various Somali camels are, however, contradictory, with that of Hartley (personal communication) probably being the most consistent. He indicates several types. The camels of the Esa people (the Esa Madobe and Esa Ad), who graze the Zelia plain in the winter and migrate westwards up the Awash in spring, are small active animals; any male of 5 years or more may be employed for light pack work and no special baggages are raised. The camels of the Hargeisa region are also fairly small; in this region are found the Gadurbusi and Harb Awal camels. The tribal confederation of the Rer Ogaden has large numbers of excellent camels which are fawn and red in colour (some may be almost white). The Dolbahanta camels are raised by the tribe of that name in the Nogal valley and are related to the Ogaden types. The Mudug camels are owned by the Mijerteen, Merehan (Darod) and Habr Jiddan (Hawiye) tribes and tend to be dark in colour, of medium size and renowned equally as pack or milk animals, similarly to those of the Ogaden, where they usually enter to graze. The animals of the Benadir region, with more than 400 mm of rainfall, are very large compared to the more northerly animals of Somalia. In areas between rivers (e.g. the Scebeli and the Juba) large and even outstanding camels are common among the Gel Jaal (Rahanwein) and Garre tribes. These are the results of favourable environment and management.

Sudan

With almost three million camels, Sudan has the second largest herd in Africa. The numbers decrease from the north towards the south, where more sheep and cattle are raised. Sudanese camels are divided broadly into two categories: pack and riding camels. Pack camels are represented by the Rashaidi, a very good baggage camel, and the Arab camel, a collective name referring to the remaining baggages of Sudan. Within the Arab classification are found the baggages of the Kordofan, Darfur and Kababish regions. The Rashaidi (Zebedi) is a short-legged, small, light animal of pinkish-red colour. It is graceful and capable of carrying moderate loads at a quick pace, though probably not as useful

as the Kababish baggager. Riding camels of the Sudan are more common in the northeastern part of the country and include two major types, the Anafi and the Bishari pure breeds, as well as a cross between the two (Acland, 1932).

Ethiopia

In Ethiopia camel types are commonly referred to by the colour of their coat. Thus the Grain is a tawny coloured baggage camel of the Habab, Ad Shekh, Ad Temeryam, Ad Moalim and Ad Saora tribes. The Cajeh is a reddish animal of the Beni Amer from the Khor Baraka region. It is intermediate between the Bishari of Sudan and the Grain, and is used more as a pack animal. The Danakil is a native of the desert of the same name. Other camel types of mixed breeding (especially Arab blood) are found in small numbers in the country.

Kenya

The camels of Kenya may broadly be divided into three types according to habitat. The Somali camel is found in the northeastern province and is probably the same as the Benadir type found in Somalia, which also shows some affinity with the Anafi of Sudan. It is suitable only for light work, e.g. water carriage and transportation of camp equipment, but is little used as a riding animal. The Rendille or Gabbra is bred by the Rendille people, who are extensively discussed by Spencer (1973). It is a smaller but more robust animal of the semi-desert areas. The Turkana is a small breed adapted to the bush and stony hill areas west of Lake Turkana (Rudolf). Besides the Somali, Rendille and Gabbra peoples, who raise camels in large numbers, the Turkana, Samburu, Borana and Pokot also keep them to a lesser extent.

Egypt

While camels are extensively used in the densely settled areas of Egypt, camel raising is not a major occupation in this country. Four camel breeds are found, the Sudani, the Maghrabi, the Fellahi and Mowalled, a cross between the Maghrabi and the Fellahi. The Sudani and Maghrabi are imported into Egypt from neighbouring countries. The Fellahi is a large baggager bred in Upper Egypt but mostly used in the Nile delta region. Coming from areas where feed supplies are more plentiful, the Fellahi is generally not fit for desert work. The Mowalled, on the other hand, is a much more suitable farm and desert animal, probably because of its heterozygous ancestry. There is a wide variation both in colour and conformation within this type.

Libya

The camel is a very important domestic animal in Libya, where the broad categories of baggage and riding camels are recognized. Sturdy pack animals are bred in the northeastern region. These fine baggagers are collectively called the Maghrabi (from the Maghreb) and are not a purebred type but rather the result of crosses between Sudanese, Egyptian, Tunisian and Moroccan breeds. Their coats consist of long, soft, reddish-brown hair. The remaining Libyan camels vary in conformation and colour. The camels from the

nutritionally poor Fezzan region are small to medium-sized animals with short smooth hair and light colour. By contrast, the camels from Ghadames, an important centre on the caravan route, are short-legged, long-wooled, reddish-brown animals. The Bedouin Urfilla and Oulad Busaif Arabs of western Libya raise much heavier riding camels than those from the Jebel Tarhuna and Charyan areas, which are in turn superior to the riding camels from the Tripoli and Cussabat areas.

Tunisia, Algeria and Morocco

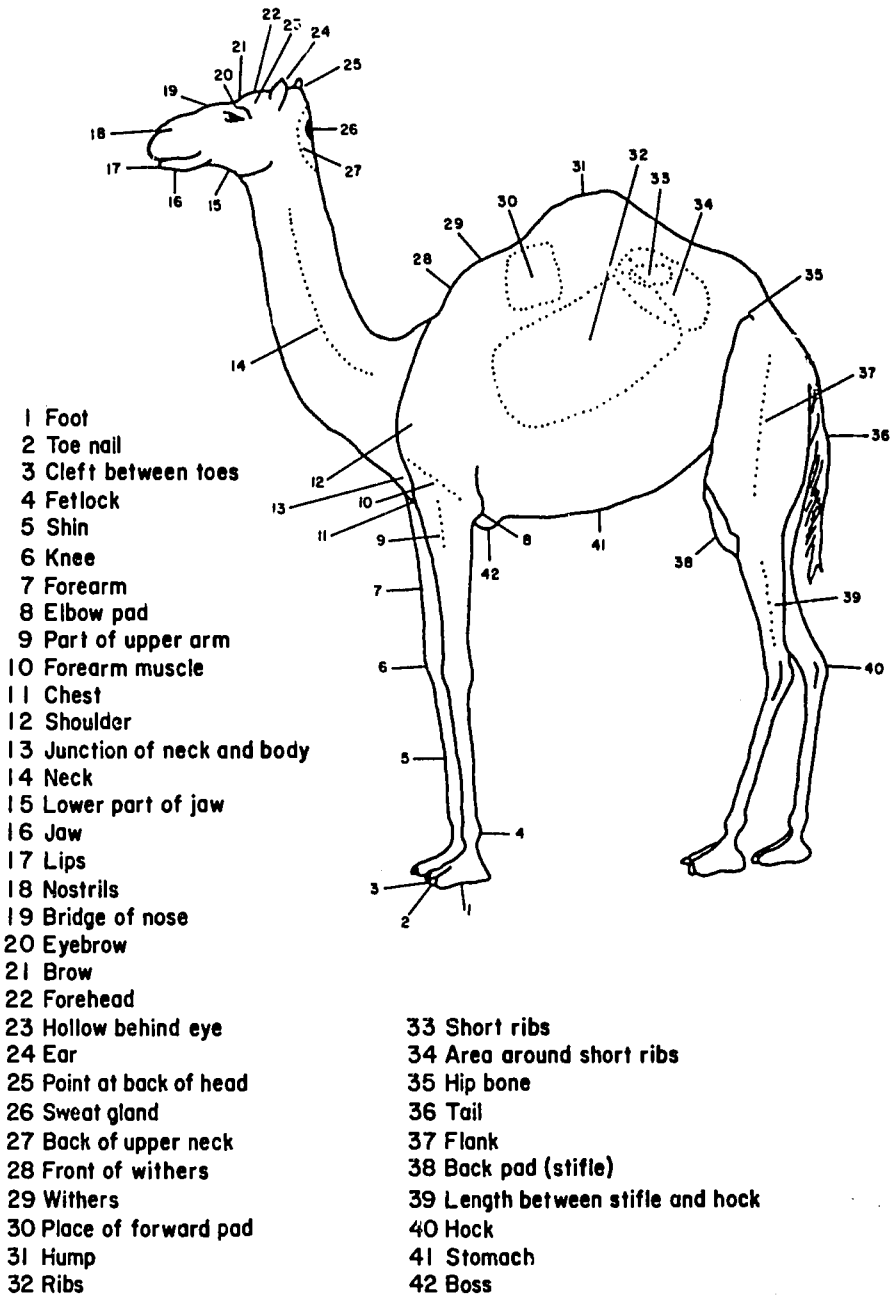
As in Libya, camels are a very important species in northwest Africa, where they are extensively used as baggagers even in the rugged mountainous areas. Two broad categories of animals are raised in the Tell region of Tunisia and Algeria, the riverine and desert types (Leese, 1927; Epstein, 1971). Epstein indicates that Tunisian camels closely resemble the Maghrabi and are ranked as the finest camels of the Atlas region. They are generally dark in colour, but a few are white. He observes that although Algerian camels are similar to the Tunisian animals, they are of inferior conformation. However, Moroccan camels have been bred and used for mountainous areas to such an extent that they are unfit for desert work. In the region bordering northern Mauritania, a strong breed suitable for heavy baggage work is raised by the Tajakant, a Bedouin tribe.

Saharan and West African Camels

Camels in West Africa are classified as plains or mountain types and as pack or riding animals. The variations in nutrition and terrain encountered across the region have resulted in the development of three distinct kinds of camel, the northern Saharan, the Haggar or central Saharan and the southern Saharan. Within these three, various subtypes are identifiable. The Tiberti, for example, is one of the smallest riding camels of Africa, bred by the Ted and Daza tribes. It is well adapted to stony and sandy terrain and has a coat that grows very long in winter. The Manga, bred by the Bideyet tribe, is found north of Lake Chad and is a heavy pack camel more suited to the southern regions and not to the desert proper. The Aür camel is raised by the Tuareg tribes, i.e. the Asben, Kel Owi, Kel Tadele and Kel Ferwan in the Aür region. It is a tall, slender, desert riding camel of great speed. Further south the Aür camel tends to grow bigger and heavier owing to increased feed availability, and consequently becomes more sluggish. The Berabish is found in the region of the Niger River and is also called the River Niger camel. It is better adapted to humid conditions and is thought to be capable of withstanding trypanosomiasis. The Adrar is a dual purpose (pack and riding) breed raised by the Tuareg people. It is greyish with light coloured extremities. The Saharan (or Sahel) camel is bred in the Sudanian and Mauritanian Sahel, extending from Ahaggar in the north to 100 km north of the Niger and Senegal valleys in the south. This breed includes the famous Mehara type of the Sahara, the largest camel breed of West Africa. The fastest Mehara are raised by the Tuareg; generally they are animals of immense perseverance, a quality common to most of the Saharan camels and probably surpassed by no other camel type. The Gandiol of Senegal is of Mauritanian descent. Enjoying good nutritional levels for most of the year, it is usually a heavy baggage camel. A more complete account of the camels of the western Sahara is given by Boué (1948).

Before reviewing the performance of the dromedary the points of the animal's body should be presented (Figure 3). Robertson (1938) cited the common Arab saying that the camel's body is made up of parts taken from other species.

Figure 3. *The points of the camel.*



Source: Acland, 1932.

2. REPRODUCTIVE PERFORMANCE

The level of fertility in domestic animals results from a number of interacting factors, some of which have a genetic basis while others are environmental in origin. In most domesticated species much research has been undertaken to discover how these factors operate, but unfortunately thorough investigations of this kind have not so far been carried out for the dromedary. Based on the available literature, an attempt is made here to explain some aspects of the reproductive anatomy, physiology and performance of the dromedary.

2.1 ANATOMY OF THE REPRODUCTIVE SYSTEM

2.1.1 The Male Reproductive System

Early accounts of the anatomy of the reproductive system of the male camel (Cauvet, 1925; Leese, 1927; Tayeb, 1948) continue to serve as reference works on the subject. In this section the testes, tubular and copulatory organs of the male genital tract are described.

The testes of the camel are located in the perineal region, in a position similar to that of the dog (Leese, 1927) or boar. Each is contained in its own scrotum. Tayeb (1948) observed that the scrotum of the camel is generally covered by the tail but could be seen in the standing position. The scrotum is oval and sparsely covered with hair. A faint median raphe divides the two testicles. The camel testes have been described as being broadly similar to those of the horse, although differences become obvious on careful dissection.

The testes are oval in shape and in an animal of 3 years measure 7-10 cm in length, weighing 80-100 gm each. El-Wishy and Omar (1975) found the average length, breadth and thickness in 6- to 10- year-old camels to be 9.07, 5.08 and 4.43 cm respectively, with an average weight of 91.71 gm. They observed that the right testicle was often slightly smaller than the left one.

The internal structure of camel testes has been studied by Adel-Raouf et al (1975), who calculated the average diameter of the seminiferous tubules to be 210μ . While the diameter did not significantly differ between the right and left testes, it varied significantly ($P < 0.005$) according to season, being smallest during the summer ($189.40-203.26\mu$) and largest in spring ($209.68-226.20\mu$). Williamson and Payne (1978) also confirm that camel testes increase in size during the breeding season.

Abdel-Raouf et al also discovered a seasonal influence on the number of germinal cells, spermatogonia, spermatids and sperm cells, implying that the non-breeding season of the camel is characterized by reduced spermatogenesis rather than complete aspermatogenesis, as is found in some non-domestic ungulates. In this respect the Arabian camel studied was found to be very similar to the ram. The fluctuation in sperm cell numbers was confirmed in the quantitative studies of Osman and El-Azab (1974). They found that the testes of the camel are not only small for the size of the animal compared with other species, but also contain fewer cells per gram of testicular tissue when compared with the bull, buffalo, ram and boar. Estimated daily spermatozoa production rates in Egyptian and Sudanese camels were 8.1 and 5.6 ($\times 10^9$) cells during the spring, while in the autumn they were 4.2 and 3.2 ($\times 10^9$) cells. These values are much lower than the figure of 13.1 ($\times 10^9$) cells quoted for the bull.

Leese (1927) described camel sperm cells as resembling those of the ram. Khan and Kholi (1973a) studied the physical characteristics of camel spermatozoa and gave the following data: head length, 5.35μ (5.08-6.35); head width, 3.42μ (3.17-3.81); tail length, 35.62μ (34.2-37.5); and overall length of the sperm, 48.37μ (46.9-50.8).

The posterior border of the camel testis is convex and free. The anterior surface is flattened, except where the epididymis attaches to the anterior-dorsal point. Here the efferent ducts emerge from the gonadal interior. The tail of the epididymis is very closely apposed to the testicular surface by means of the epididymal ligament. Like most domestic species, except the horse, the camel testis has a well-defined mediastinum, and rudimentary testes have also sometimes been described in a ventral-anterior position in relation to the true testes. The vas deferens of the camel is remarkably twisted for much of its initial course, but becomes fairly straight towards the end portion. This peculiarity results in a thickened spermatic cord, which is relatively long and houses the vas deferens, the pampiniform plexus, spermatic artery, nerves, lymphatics and the internal cremaster muscle. The internal inguinal ring of the camel is very narrow.

Regarding the accessory glands of the male reproductive tract, both Leese (1927) and Tayeb (1948) described the presence of the prostate gland and the absence of seminal vesicles. The prostate gland is a discoid structure made of two lobes joined by one isthmus and located on the dorsal aspect of the pelvic urethra. It averages 3-7 x 5 cm and is dark yellow in colour. Tayeb also described a dilated end of the vas deferens in an area generally occupied by the ampulla, which is usually described in a similar manner. There is no confirmation as to whether the dilation was in fact the ampulla or not. He also notes the additional presence of the bulbo-urethral (Cowper's) gland. The two units of the gland are located on either side of the terminal portion of the pelvic urethra. They are whitish, almond-shaped organs measuring 2.5 x 1.2 cm.

An interesting aspect of the copulatory organ of the male camel is the shape of its penile sheath. Early accounts of the structure present it as a voluminous, conical organ

hanging from the abdomen like a large mammary gland. The point of the penile sheath is directed posteriorly and carries a very narrow orifice about 1.84 cm in diameter (Mobarak et al, 1972). Leese (1927) commented that this posterior orientation of the orifice results in the urine being directed backwards during micturition. Tayeb (1948) confirmed the above observations and added that the sheath has two pockets, one internal and one external. The sheath is dark in colour and, like the scrotum, sparsely covered with short hair. Its muscles are arranged in three groups (anterior, posterior and lateral), and their coordinated contraction and relaxation results in the forward and backward movement of the structure, or the constriction and dilatation of the preputial orifice. The anterior group of muscles is the largest and the lateral one the weakest. All insert into the inner surface of the skin covering the free part of the penis (Mobarak et al, 1972).

Within this massive casing the penis is hidden in its non-erectile state. It is a firm, cylindrical organ whose diameter generally decreases from the root towards the free end (glans penis). The average diameters of the root, middle and glans penis parts are given as 2.23, 1.64 and 0.42 cm by Mobarak et al (1972). A prescrotal sigmoid flexure is characteristic of the camel penis, dividing the organ into pre-, post- and intra-sigmoid portions. The average lengths of the three were estimated by Tayeb (1948) as 17.5, 17.5 and 25 cm, giving a total length of 60 cm. Leese (1927), and more recently Mobarak et al (1972), give average total lengths of 67.5 cm and 59.6 cm respectively. The penis originates in the region of the ischiatic arch via three cavernous bodies. The three are surrounded by a thick tunica albuginea which has a ventral urethral groove. The urethra proper is ventrally and laterally covered by the corpus cavernosum urethrae and dorsally by the tunica albuginea. Trabeculae from these outer layers penetrate the penile bodies in increasing amounts from the root end towards the glans penis. The caverns and cavities characteristic of the initial portion are therefore progressively replaced by fibrous tissue from the tunica albuginea. The septum between the two dorsal penile bodies tends to become ill defined towards the free end of the penis, which is elliptical caudally and ovoid cranially, where the cavernous nature of the caudal part of the penis is again more prominent. The urethra at this level is surrounded by the urethral body and assumes a left-sided rather than a middle position. At this level too, the urethral body is characterized by large blood vessels. The glans penis of the camel is shaped like a hook (Mobarak et al, 1972), curved along the vertical plane. Its features are a well-defined neck and a urethral process measuring 4 - 6 x 2 mm. This terminal portion of the penis feels cartilagenous to the touch and on cross-section a complete ring of hyaline cartilage filled with blood vessels may be revealed. On the outside of this ring there are many elastic fibres and caverns.

Muscles of the camel penis include the ischiocavernosi and the retractor penis. The blood supply of the male camel genitalia is similar to that of the bull and its nerve supply is typical of most domestic species. The camel penis is in general of the fibrous type, though some vascular elements are observed at the root and terminal parts. Mobarak et al (1972) classify the camel penis as intermediate between the fibrous and vascular types. The urethral body, however, consists primarily of vascularized tissue.

2.1.2 The Female Reproductive System

In this section the ovaries, tubular and copulatory portions of the female genital tract are described. Joshi et al (1978) noted that although the camel is a ruminant the reproductive tract of the female has some affinity with that of the horse.

The ovaries of the Iranian dromedary were found to have an average size of 13 x 29 x 33 mm and an average weight of 10 gm (Chahrasbi et al, 1975). The weight estimate is slightly higher than the range of 3.66 ± 1.49 - 8.51 ± 2.66 gm given by Shalash (1965), but the size is in agreement with the figures of 3 - 6 cm for length x 2.5 - 4 cm for thickness of Abdo et al (1968). The size and weight of the gonads are influenced by the stage of the reproductive cycle, i.e. by ovarian activity.

Shalash (1965) described the gonads as fairly flattened organs with numerous ovisacs, giving them the appearance of a bunch of grapes. The lateral surfaces, however, tend towards convexity. They are reddish in colour and each is enclosed in an ovarian bursa which ends blindly laterally but has a medially located opening where the fimbria are situated. Their suspensory ligament is a cord-like modification of the broad ligament.

Abdo et al (1968) studied both the micro- and macroscopic properties of the camel ovary. They concluded that though the shape, size and weight may differ from those of other species like the cow, ewe, sow and mare, the microscopic properties of both the Graffian follicles and the corpora lutea (CL) show no clear differences.

The Graffian follicles are randomly distributed on the ovarian surface and may sometimes (4.82%) be found even in pregnant animals. Those of the left ovary tend to be slightly larger than those of the right (1.24 as against 1.20 cm) (Shalash, 1965). While Musa and Sineina (1976) also describe follicular activity in pregnant camels, they assert that it decreases with advanced gestation. The endocrinology of pregnancy in the camel warrants further investigation.

Musa and Abusineina (1978a) estimated that follicles generally take about 6 days to grow to maximum size (range 2 - 14 days) and range from 1.5 to 3 cm in diameter, although sizes of 8 - 9 cm were also recorded. The grown follicle remains constant for 5 - 19 days (average 13 days) before regressing over a 7- to 10-day period. The growth of follicles to maturity alternates between the two gonads, but smaller follicles can always be palpated alongside them.

Abdo et al (1968) refer to the presence of CL during the luteal phase of the oestrous cycle of Iranian dromedaries. However, in the more recent study by Musa and Abusineina (1978a) involving 35 cycles over a 15-month period, no luteal phase was demonstrated, ovarian activity being mainly follicular.

The CL is thus normally observed only during pregnancy in the camel. Its shape varies between spherical, elongated and oval, and in early gestation it has a flabby consistency, becoming larger and firmer as pregnancy advances. A neck-like constriction is observed at the point where it attaches to the main ovarian body. The CL of pregnancy is light brown with a greyish central cavity, and variable numbers (one to three) of CL may be found on the same ovary, their size varying from 1.85 to 1.88 cm and their weight from 4.15 to 4.68 gm (Shalash, 1965).

Both Shalash (1965) and Musa and Sineina (1976), who examined 787 and 416 reproductive tracts respectively, agree that there is more (12.98%) ovulation from the left than the right ovary and that pregnancy in the camel is almost exclusively left-sided (99%). Cross pregnancy, where the pregnancy is maintained by a CL on the opposite side, is very common (37.73%). The explanation is probably that early embryonic migration is frequent

among dromedaries. That more CL than viable embryos are seen in the camel also suggests a high rate of early embryonic mortality. Both twins and triplets are very rare in the species, an observation born out by the Arab saying that one is more likely to see the moon on earth than the birth of live twins in the camel.

Since most CL in the camel are observed only during pregnancy or in the few cases where the uterine opening is patent, it would appear that some type of stimulation, e.g. copulation, is necessary for ovulation to occur (Shalash, 1965). Musa and Abusineina (1978a) confirm that ovulation among Sudanese dromedaries is non-spontaneous, requiring copulation beforehand. However, even 15 minutes of experimental cervical stimulation by palpation failed to induce ovulation, although leutinization of the Graffian follicle was produced. The camel is thus an induced ovulator like the cat and the rabbit. Copulation apparently triggers the release of the gonadotrophins essential for ovulation to occur, approximately 36 hours later (Williamson and Payne, 1978).

An account of the anatomy and histology of the female dromedary gonads is given by Tayeb (1950a) and this work is recommended for further details.

The oviducts of the camel are small in diameter (1 - 2 mm), but become larger at the ovarian end where the fimbria are located.

The dromedary has a bicornuate type of uterus. It is a large organ whose weight may vary from 193.7 to 376.4 gm (Shalash, 1965) depending on the phase of the oestrous cycle. Generally it is located in the abdominal cavity, but Musa and Abusineina (1978b) observed that open uteri and those with early pregnancies are sometimes located intra-peivically. However, these observations were based on per rectum examinations of recumbent camels. The uterus is reddish white, shiny and smooth with a short body. Its two horns are closely apposed externally but clearly separated by a median septum internally. Their anterior end is marked by what is almost a T-junction, and generally the left horn is the larger (Joshi et al, 1978). The camel has a diffuse placenta, the mucous membranes of the uterine body and horns being smooth and devoid of cotyledons. Histologically, the pregnant camel has an epithelial-chorial placenta similar to that of the horse (Novoa 1970).

The camel cervix, like that of the cow, has a number of mucosal folds arranged in three or four rows. The cervical canal is short (3.5 cm), with a diameter of about 5.5 cm, while the external opening is relatively large (3.5 cm). Like the cervix of the zebu cow (*Bos indicus*), that of the dromedary tends to hypertrophy and protrude some distance into the vagina, resulting in the formation of two blind sacs (one dorsal and one ventral). Anteriorly, the mucosal folds of the cervical canal form a prominent crest which marks the cranial opening of the cervix.

The vagina is an elastic organ of reddish colour measuring 30 - 35 cm and lined with mucosal folds posterior to the external cervical opening. Both longitudinal and circular folds have been demonstrated, although the latter are the more pronounced. With advanced pregnancy there is a tendency for the uterine weight to stretch out these folds.

Leese (1927) described the canals of Gartner and the glands of Bartholin in the camel. Tayeb (1953) indicated that these canals are located in the vaginal wall. They originate in the region of the external cervical opening. He also gave an account of the blood and nerve supplies of the reproductive tract.

The camel vulva is about 8 cm long. On its ventral floor it has a suburethral diverticulum, on top of which is located the true urethral orifice. The demarcation between the vagina and the vulva is marked by the hymen or its remnants.

2.2 BREEDING

2.2.1 Puberty and Sexual Maturity

Puberty is the age at which an animal first becomes capable of reproduction, while at sexual maturity this capability is increased to the optimum level.

Wiltbank (1974) stressed that the attainment of puberty in cattle is influenced by the age and weight of the animal. A heifer may reach puberty earlier if she is of the right weight. This principle is well understood and applied for many domestic species. Unfortunately the camel has a slow rate of growth (Chatty, 1972) and this genetic handicap, in addition to the general lack of feed supplementation under pastoral management systems, results in advanced ages at puberty for the dromedary.

Williamson and Payne (1978) and Matharu (1966) estimated that the sexual maturity of dromedaries occurs at 3 years. Spencer (1973) observed that the Rendille camel of northern Kenya may reach 6 years before getting her first calf. Allowing for a year's gestation period, this would give an age of 5 years at first conception. Singh (1966) wrote that the age of first sexual desire among male camels in India was 2 years but that full musth was delayed until 8 years, although the animals could be sparingly used for service at 6 years. Leupold (1968a) is of the view that both sexes attain sexual maturity at 3 years. However, Khatami (1970) indicated that both the Iranian female and male camel reach sexual maturity at the age of 5 years.

It is common practice to withhold female camels from breeding until they are 4 - 6 years old (Williamson and Payne, 1978; Matharu, 1966). This practice doubtless results from the fact that fecundity continues to increase with age, even after sexual maturity, and only starts to decline with senility. Since the gestation period is about a year, age at first calving therefore averages between 5 and 7 years, a much later age than in cows. However, this disadvantage is largely offset by the camel's longer breeding life.

The length of the camel's reproductive life varies, but some females continue to breed until 20 years old. Cossins (1971) reports a camel cow of 30 that had had 15 calves. When well fed and managed some camels live up to 40 years, and in spite of a calving interval approaching 2 years the camel is still capable of producing as many progeny as most pastoral cattle. Spencer (1973) indicates that the Rendille camels of northern Kenya can produce as many calves as the Samburu cattle.

The calving interval in camels is prolonged not only by their limited breeding season but also by the suppression of oestrus for a long time after parturition. Postpartum oestrus is normally delayed for about 1 year, although a few females come back into heat as early as 1 month after parturition (Williamson and Payne, 1978). The level of nutrition is a factor here, since when feed supplies are inadequate, maintenance, growth and lactation take priority over reproductive performance, which becomes a physiological luxury. At any

rate camels usually calve only every other year, or at best twice in 2 years. The theoretical maximum annual calving rate is thus 50 - 80%.

2.2.2 Rutting

Among male camels, which are often not put to full service until they reach 6 - 8 years, rutting or musth is generally limited to particular periods of the year, as it is in the female. It is partly influenced by age and level of nutrition. The breeding season, which often coincides with the rains, lasts about 3 - 5 months on average, but for some animals, especially older ones, the period may extend throughout the year (Williamson and Payne, 1978). The latter authors further observed that there was no specific rutting season for animals on or near the equator (probably within the tropics), where rutting may take place throughout the year.

During the rutting period the usefulness of the male as a work animal is diminished; he loses his appetite, develops occasional diarrhoea and displays abnormal behaviour patterns.

Mimram (1962) has reviewed in detail the occipital glands of female, male and castrated dromedaries. Among rutting males the occipital glands tend to secrete more profusely (Matharu, 1966; Fraser, 1968). Rutting males constantly protrude the mucosa of their buccal cavity, which expands into a balloon-like structure. They become irritable and rarely tolerate rivals. Wind sucking and belching also occur continuously in rutting stallions, which attempt to mate with most females, even those not in oestrus. Their increased activity and lack of appetite often result in a loss of condition at the end of the breeding season.

When many males are herded together, usually only one (the strongest) will "develop the rut". If more than one develop the rut a fight will often build up until the weaker submits and suppresses his sexual desire (Singh, 1966). Fraser (1968) also considered the voluntary suppression of breeding instincts to be related to the male's status in the hierarchy of the herd. Sexual desire can be quelled if rutting males are driven hard at work.

A number of studies have been performed on the haematological characteristics of camels before, during and after the breeding season, but the results so far obtained lack consistency, even as regards the average values of the major blood constituents. However, Khan and Kholi (1978) obtained a statistically significant ($P < 0.01$) drop in blood haemoglobin and an increase in total leucocytes during the breeding season.

There is considerable divergence as to the ideal ratio of males to females during the breeding season. Estimates vary from as low as 1 male per 5 - 7 females (Watson, 1969), through medium levels of 1:10 - 30 (Asad, 1970; Gauthier-Pilters, 1959) to as high as 1:50 - 80 (Williamson and Payne, 1978; Singh, 1963 and 1966; Leupold, 1968a). Major determining factors include the management practices of pastoralists, the condition and stamina of the male, his libido and the fertility level of the females. Demand on the part of herders for service by particular sires as well as the fee which may be charged by the owner of the male could also adjust the ratio upwards. Droandi (1936) and Burgemeister (1975) indicate that a camel stallion can breed three females per day at the peak of the breeding season, although higher levels are possible.

2.2.3 Castration

Males not reserved for breeding are often castrated. Castrates are more manageable and make better working animals. Cossins (1971) indicated that castration may also be carried out for meat production purposes. The ideal age at which to castrate camels is 4 - 6 years. Droandi (1936) gives a detailed description of castration methods used by the Arabs. The operation may be carried out in any season, provided the animals are healthy enough to withstand the stress involved.

The animal is first hobbled and turned on its side or back, with all its limbs immobilized. The open castration method involves the use of a razor, a palm branch, two iron cauterizers and a small rope. Healing following open castration usually takes 30 - 40 days, and there may be extensive swelling or discharge from the wound. A simpler castration method consists of merely twisting the spermatic cord, and in this case healing occurs more rapidly, often requiring only 2 weeks.

2.2.4 Oestrus

After reaching sexual maturity the female dromedary exhibits regular oestrous cycles, which nevertheless seem to be limited to particular periods of the year. However, Nawito et al (1975), cited by Williamson and Payne (1978), imply that the Egyptian dromedary may conceive at any time of the year, although there is still considerable variation in conception between seasons. In India and much of the northern hemisphere the breeding season extends from November to March. It is influenced by the level of nutrition and changes in daylight length, among other factors. Altitude and atmospheric humidity may also play a part (Dahl and Hjort, 1976). The findings of Shalash (1965) clearly illustrate a breeding periodicity of this kind (see Table 2). According to Novoa (1970), Bosaev

Table 2. *Monthly variation of ovarian activity in the camel.*

Month	Ovaries with:			Total functioning ovaries	
	No Activity	Graffian follicles	CL of pregnancy	Number	%
January	76	30	113	143	8.28
February	38	20	33	53	3.07
March	34	24	99	123	7.12
April	40	48	173	221	12.79
May	50	24	107	131	7.58
June	88	20	51	71	4.11
July	90	18	18	36	2.08
August	22	6	2	8	0.47
September	48	10	23	33	1.91
October	46	4	13	17	0.98
November	39	25	44	69	4.00
December	113	29	116	139	8.05

Source: Shalash, 1965.

(1938) indicated that while the domestic Bactrian camels of Russia are polyoestrous throughout the year, the wild Bactrian camels are only seasonally so. Novoa states that sexual activity among Camelidae in general appears to be very variable, and that the factors influencing its nature and duration are still largely unknown.

Once the breeding season has started the female camel will come into heat every 20 - 25 days (average 23.4 days; Joshi et al, 1978). Longer durations, e.g. 28 days (Musa and Abusineina, 1978a), have also been observed. In cattle, these extended oestrous cycles are often associated with silent or unobserved heat periods and the same may well be true of dromedaries also.

The oestrous period itself generally lasts 4 - 6 days (Joshi et al, 1978) although a range of 1 - 7 days is given by Parkes (1969). Both these findings are slightly shorter than the range of 6 - 8 days given for the Bactrian camel by Williamson and Payne (1978).

In a well organized study Gupta et al (1978) showed that female camels in India usually come into oestrus five times in a breeding season. They remain in oestrus for 4 - 5 days, but the chances of conception decrease as the period progresses. The results of these authors, based on only a small number of animals, are shown in Table 3. Skillful

Table 3. *Effect of service at different stages of the oestrus period on conception rates in the camel.*

	Group of animals and day of oestrus when exposed to the male									
	1		2		3		4		5	
No. of animals in group	8		8		8		8		7	
No. of animals conceiving during:	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
1st cycle	4	4	4	4	2	2	3	3	1	1
2nd cycle	1	5	2	6	1	3	2	5	3	4
3rd cycle	3	8	2	8	2	5	-	5	1	5
4th cycle	-	-	-	-	2	7	3	8	1	6
5th cycle	-	-	-	-	-	7	-	-	1	7
No. of services per conception	1.87		1.75		2.75		2.12		2.71	

(a) Number of animals bred during each cycle.

(b) Cumulative number of animals bred.

Source: Adapted from Gupta et al, 1978.

management could become important here, since if hand mating were used in the early stages of the oestrous period to obtain the best conception rates, overall fertility would be improved.

During the oestrous period the female dromedary shows both anatomical and nervous signs of heat. She is generally restless, seeking the company of the male and tending to bleat continuously. She develops a swollen vulva, often associated with a discharge (Singh, 1963 and 1966). Droandi (1915) observed that oestral camel cows emitted a penetrating, foul smell from the vulva that could be smelt over long distances, but which had an excitative effect on the males. He noted that the vulvar lips contracted and swelled at intervals and that the animals tended to raise their tails and micturate more frequently during oestrus. Females at this time are generally capricious, and when forced to work are excited by weights applied to their flanks.

Joshi et al (1978) have studied the oestrous cycle of the Bikaneri camels of India in detail. They observed that the vagina appeared moist and light pink in colour during pro-oestrus. It became moist and red during oestrus itself, though the moistness decreased as oestrus drew to an end. Similar changes were observed in the vestibular mucosa. Superficial flat cells with eosinophilic cytoplasm and pyknotic nuclei were found to be characteristic of vaginal smears during oestrus, while intermediate cells were predominant in smears from pregnant animals. Vaginal examination showed that the cervix was moist and relaxed during oestrus. On per rectum examination the uterine horns were turgid at the beginning of oestrus, but turgidity was not as marked as in cattle. Numerous Graffian follicles were palpable on both ovaries but no CL could be felt during any part of the oestrous period.

2.2.5 Mating

Leese (1927), Fraser (1968) and Burgemeister (1975) described copulation among camels, a process labelled as secretive by Matharu (1966). Fraser (1968) noted that mating behaviour among camels differs from that of other ruminants, and indicated the essential relationship between conformation and mating behaviour.

Copulation often starts with courtship involving a necking exercise. Khan and Kholi (1973b) indicate that in courtship the male may not only smell the female genitalia but may even bite her in this region, or around the hump. Bleeding due to severe bites is not uncommon.

Often the strong male may simply round up the female and crouch her after exhaustion for service (Hartley, 1979). Usually the male induces the female into a sitting position, and those in oestrus, especially those in season for the first time, will readily assume this position. The male then grasps the female with his forelegs, while most of his weight rests on his buttocks, with all the joints in his back legs flexed. The animals thus face in the same direction. During a single mating session the male may ejaculate three or four times, each service being preceded by fresh penile penetration.

It is common for camelmens to aid the entrance of the male penis into the female genitalia, although males are also believed capable of locating the vulvar opening by themselves by rotating the erect penis on its longitudinal axis. In Somalia, Hartley (1979) noted that hand service by herdsmen well known to the male camel is common. The method is used to select a female for service and she is usually served twice. However, there is a

lack of agreement as to whether the male camel is always assisted to effect penetration. Those who accept the argument of assistance use it to justify the lack of wild camels, allegedly caused by an inability to copulate. The Australian feral herd, however, continues to expand in the wild. Another explanation might lie in seasonality, combined with the fact that generally only one male develops the rut during the breeding season. It is possible that the male becomes overworked as the season progresses, resulting in a drop in sexual drive.

Copulation among camels may last for a short time - 12 - 30 minutes, according to Rakhimzhanov (1975), Leese (1927) and Burgemeister (1975) - or for an hour (Droandi, 1915). Leonard (1894) suggested that mating could last the whole day, with breaks for the male to ward off any external disturbances. Other camels often gather around the copulating couple. At the end of the mating act the male tends to gurgle and froth at the mouth, while the female is inclined to bleat excessively.

Using the artificial vagina method, Khan and Kholi (1973b and c) estimated the volume of Bikaneri camel ejaculates to average 3.1 ml (range 1 - 10 ml). Though subject to individual variations the trait was unaffected by age. Semen appeared white in colour with a thick viscid consistency and had an average pH of 7.8 (range 7.2 - 8.8). The mass motility and the percentage of spermatozoa showing progressive motility improved with subsequent ejaculates.

2.3 GESTATION

The gestation period of the dromedary is often quoted as about 1 year, with a range of 355 - 389 days being given by Burgemeister (1975), Williamson and Payne (1978), Leonard (1894) and Leupold (1968a). The breeding season thus occurs at the same time of year as the calving or foaling period. The gestation period of the Bactrian camel is slightly longer, averaging 13.5 months (Dahl and Hjort, 1976).

Various methods have been developed for determining pregnancy and estimating its duration in the camel. Mares (1954) observed that female camels tend to dry off naturally after conception. Field (1979a) reported that lactation ceased 4 - 8 weeks after pregnancy in female camels of northern Kenya. However, there are also reports of camels continuing to lactate for 12- to 18- month periods. Whether the latter category of animals were empty or pregnant is unclear, but Kloess (1976) referred to a pregnant camel that was still giving a considerable amount of milk. Until it can be established whether or not the camel exhibits lactational anoestrus, the observation cannot be relied upon as an efficient means of pregnancy diagnosis.

Camels are known to reject further breeding after conception, and oestrous cycles are normally discontinued. In cattle, however, 5% of animals tend to come back into oestrus in spite of positive conception, and in camels Shalash (1965) observed Graffian follicles in 4.82% of pregnant uteri. The rejection of breeding cannot therefore be used as a conclusive indicator of pregnancy.

Mares (1954) concluded that the pregnant camel has a characteristic way of lifting her tail when approached by a male or handled by a man, an observation which Singh (1966) considered a reliable sign of pregnancy. Musa and Abusineina (1978b) have nevertheless cast doubt on its accuracy. They observed that female camels "cocked" their tails

during anoestrus, oestrus or pregnancy. On the other hand, they reported the successful use of rectal palpation to diagnose pregnancy in the camel. As it does in cows, the method involves palpation of the uterus, its contents and blood supply. The authors found that the presence of one or more well-developed CL was highly suggestive of pregnancy. They also described the position and characteristics of the uterine arteries in six camels throughout the gestation period, comparing their findings with those for the cow.

Other methods for diagnosing pregnancy in the camel include the ballotement of the foetus through the right flank, a method limited to the later stages of gestation. Mammary gland hypertrophy may indicate pregnancy in the camel, but like abdominal enlargement and ballotement this indication becomes reliable only in the last trimester. In primiparous females, however, abdominal enlargement may be observed as early as 6 months, but caution should always be exercised in using this method since other conditions (e.g. ascites and flatus) may also cause abdominal enlargement and thus simulate pregnancy. Recently, Schels and Mostafawi (1979) have reported good results using the ultrasonic method for pregnancy diagnosis in 15 Iranian camels. Twelve out of 15 5- to 11-year-old females were positively diagnosed.

2.4 PARTURITION

Signs of imminent birth in the camel include a relaxation of the sacrosciatic ligaments resulting in two grooves, one on either side of the tail. The animals become lethargic and develop an oedematous swelling of the vulva. Colostrum can be drawn from the teats, which are engorged during the last days of gestation.

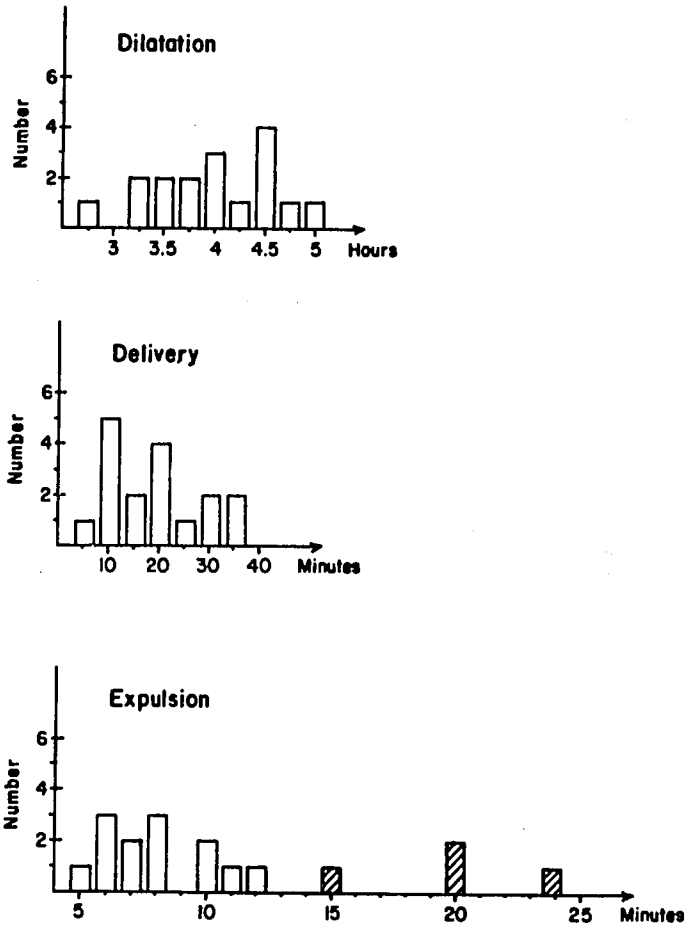
In a study of 17 pregnant camels, Burgemeister (1975) found that the external signs of imminent parturition in the camel were not very pronounced. He noted that the abdominal pains usually associated with the onset of dilation were not very severe in the camel. However, he also observed that 3 - 5 hours before delivery females tended to show agitated behaviour. They lie down more frequently and their feeding becomes disturbed. Leese (1927) had noted similar behaviour to that observed by Burgemeister, but concluded on the contrary that labour pains are more pronounced in the camel than in the cow or mare, and added that sometimes it may be advisable to tie down timid (and especially primiparous) females.

The onset of abdominal pains was taken to indicate the beginning of the first of the three stages of parturition observed by Burgemeister (1975). The three stages, dilation, delivery and expulsion are reproduced in Figure 4, where the duration of each is shown.

Parturition generally occurs with the dam in a lying position, although delivery in the standing position is also possible (Gauthier-Pilters, 1959). Most females will deliver unaided, but camelmen are willing to provide extra help when necessary. The anterior longitudinal presentation (forelegs of the foetus being presented first), dorsal position (the back of the foetus being directed towards that of the dam) and extended posture (all the limb joints being fully extended) were the norms encountered in the camels noted by Burgemeister.

There is little significant difference between the pelvic measurements of the dromedary and the Bactrian camel. However, while the delivery process on average takes

Figure 4. Duration of stages of parturition in 17 camels studied.



Note: The hatched bars indicate parturitions where abnormal deliveries were involved

Source: Adapted from Burgemeister, 1975.

24 ± 2.34 minutes in the former, it is longer (40 ± 2.63 minutes) in the latter, probably because the Bactrian calf is larger (Moldagaliev, 1976). The duration for the dromedary is slightly higher than the average of 19 minutes calculated from the data given by Burgemeister for the Tunisian camel (Figure 4).

Of the 17 animals studied by Burgemeister only 4 migrated from the main herd during calving, despite the opinion of Richard (1976) that one reason why brucellosis was not prevalent among camels was the tendency of females to stray away during calving.

The third stage of parturition (expulsion of the foetal membranes) lasts about 15 minutes but it is also common for the placenta, which is diffuse, to be shed together with the newborn (Singh, 1966). It should be noted that there is an extra foetal membrane in the dromedary (Musa, 1979). This membrane is epidermal in origin and surrounds the entire foetus except at the lips, vulva, prepuce, anus, umbilicus, teat orifices and hooves. All body orifices are therefore open to the foetal (amniotic) fluids, while the rest of the body is separated from them. The same author observed that the average volume of foetal fluids in the dromedary was 9 litres at parturition, the allantoic fluid averaging 80 - 90 % throughout gestation.

Burgemeister indicated that females stand up soon after delivery. It is by standing up that the umbilical cord is severed (Leese, 1927). The camel does not generally lick its young as do the sow and the mare (Fraser, 1968), but it is an excellent mother (Matharu, 1966 and Droandi, 1915).

After delivery camel herders often dry the calf with a sack or straw and shelter it away from cold draughts and wind.

Williamson and Payne (1978) report that some camelmen work their pregnant animals up to the time of delivery, and return them to work soon after. Other camelmen, however, carefully look after their pregnant stock, dividing those about to deliver into a separate group which may sometimes receive extra feed and care. Pregnant camels should be maintained on good pasture during the last 2 months of gestation and for a minimum of 3 weeks after delivery.

2.5 PERINATAL GROWTH AND MORTALITY

2.5.1 Birth Weight and Early Growth

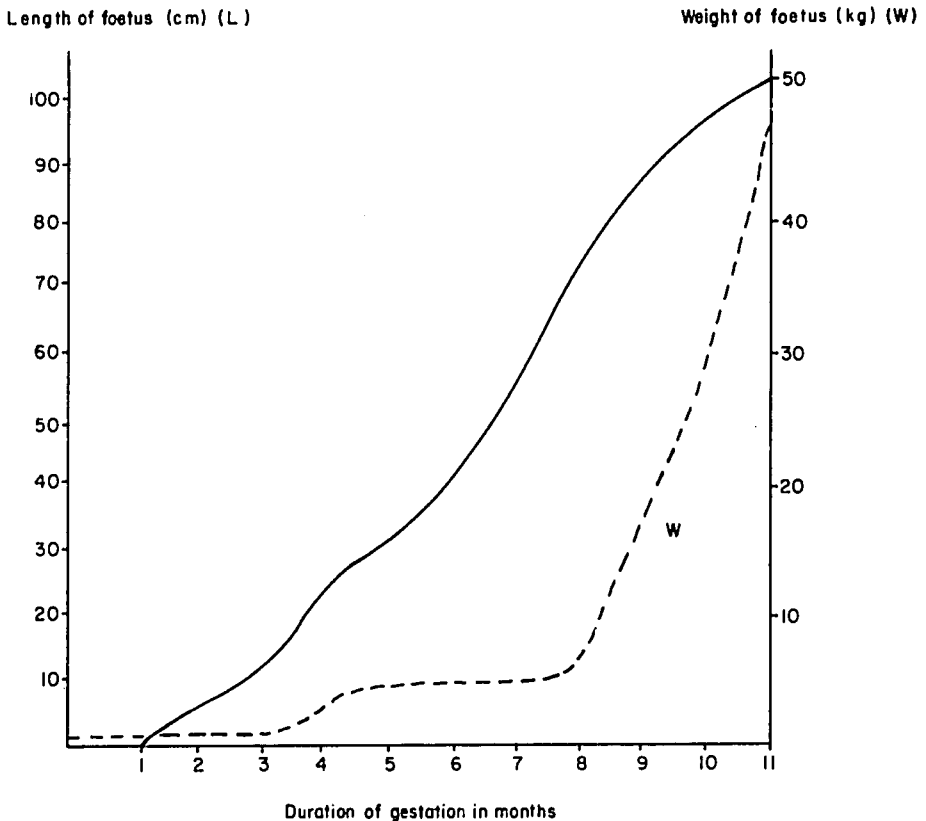
In a study carried out at a government camel breeding farm in India, Bhargava et al (1965) reported on the birth weight of Bikaneri camels. The smallest calf weighed 26.3 kg, half the weight of the heaviest calf, which was 52.15 kg. The average birth weight for males was 38.19 kg and for females 37.19 kg, with a pooled average of 37.23 kg. In this study, which involved 134 records over a 3-year period, the sex of the calf, the calving sequences and the month of calving apparently had no statistically significant effect on birth weight. The sex of the calf has, however, often been found significant for other domestic species. Brinks et al (1961) are among the many authors who have shown it to be a significant source of variation in bovine birth weights, irrespective of the age of the dam. Heifer calves weigh 7% less than bull calves. In pigs Johanson and Rendel (1968) indicated that male piglets outweighed females by 50 gm, while in sheep ram lambs outweighed ewe lambs by approximately 5%.

Burgemeister (1975) recorded the birth weight of Tunisian camel calves as 25.81 ± 2.14 kg, lower than the average weights of 37.23 kg given for the Indian dromedary and 30.9 kg recorded by Field (1979a) for Rendille and Gabbra calves in Kenya. Burgemeister further recorded the shoulder height of the calves as 95.4 ± 2.34 cm, taller than the estimate of 75 cm given by Leonard (1894) for the Arabian camel. Such differences reveal the variations in camel calf performance attributable to breed, strain, environment and management.

Heredity is another factor affecting prenatal growth, directly via the genotype of the foetus and indirectly through the genotype of the dam. A positive correlation exists between maternal body size and age and the prenatal growth rate of the foetus. According to Johansson and Rendel (1968) birth weight is influenced by the sum total of factors contributing to the nourishment of the foetus in the uterus. Hansard and Berry (1969) summarized the factors influencing the birth weight of animals and estimated that the largest component of variation (36%) is attributable to the combined genotypes of the dam (20%) and foetus (16%), followed by intra-uterine foetal environment (30%), maternal environment (18%), parity (7%), nutrition (6%), sex (2%) and maternal age (1%). The exact role of these factors in the camel has not been investigated.

The nutritional status of the dam may also have a direct bearing on foetal growth, a factor which would seem to be important in the camel: poor nutritional levels during gestation may lead to increased perinatal mortality. Nevertheless, Musa (1979) studied the development of the camel foetus and its associated growth curve, concluding that there was a striking similarity to the pattern for cattle. The growth curve of the dromedary foetus is shown in Figure 5.

Figure 5. Prenatal growth of the camel foetus.

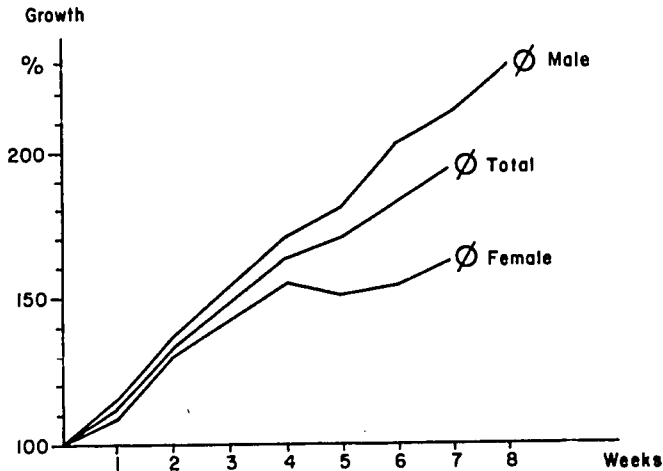


Source: Adapted from Musa, 1979.

Pre- and postnatal body growth is also affected by a number of hormones. Dickson (1933) indicated that somatotropin and other pituitary hormones are responsible for growth, but that the role and extent of each varies between species and is not yet known for camels. The same author also indicates that although the thyroid gland hormone (thyroxine) is essential for prenatal growth, it only comes into play during the terminal stages of gestation.

Burgemeister (1975) studied the weekly postnatal growth performance of young dromedaries. The results of his observations are given in Figure 6. They show that male calves tend to grow faster than female ones. Field (1979b) observed the growth patterns of camel calves in northern Kenya. Two groups of animals were studied, one under Rendille pastoralist conditions and another under special project conditions whereby the young received at least 75% of their dam's milk. The former group showed average daily gains of 222 gm and 255 gm during the dry and wet seasons, while gains ranged from 378 gm to 655 gm for the latter group. These figures reflect the important influence of dam milk on growth and indicate the negative effects of competition for milk between calf and man under the pastoralist management system. The postnatal calf growth curves given by Field also show a better performance by calves born during the wet season, irrespective of the breed of camel. However, their advantage is not a permanent one, since calves born in the dry season appear to catch up after 9 - 12 months by means of compensatory growth.

Figure 6. *The postnatal growth performance of young dromedaries.*



Source: Burgemeister, 1975.

Although the lactation period of the female camel may last up to 2 years, the suckling young are generally weaned much earlier, at any time between 3 and 18 months under traditional pastoral systems, the average being 12 months. Camel calves begin to graze when they are only a few weeks old, the change from milk to more solid food occurring gradually and with few effects on growth (Williamson and Payne, 1978). Field, on the other hand, observed in his study that weaning results in a check on camel calf growth, citing one case where the liveweight gain dropped from a preweaning level of 410 g per day to 317 g per day during the 6-month period after weaning.

2.5.2 Losses

Prenatal losses seem to occur more frequently in the camel than in other domestic species. Embryonic mortality, often associated with genetic causes, has been cited as a significant factor. Musa and Sineina (1976) found two or three CL in 13.65 % and 1.22 % of 491 single births, whereas the twinning rate was only 0.4 %. Leonard (1894) wrote that only one calf is produced by the camel and Leese (1927) stated that he had never seen nor heard of twins or triplets being born alive to a camel. These observations, together with the histological evidence of Shalash (1965), clearly indicate the early occurrence of embryonic mortality, although the latter author found conclusive evidence of mortality in only a few of the camel tracts examined.

The causes of embryonic deaths include various pathological conditions such as metritis and pyometra, as well as genetic abnormalities resulting from inbreeding, hormonal disturbances and so on. Burgemeister (1974) points out that in Tunisia it was customary to service females with a sire from the herder's own colony, thereby increasing the level of inbreeding. One of the detrimental effects of inbreeding is the depression of low-heritable characters such as fertility, reflected in increased abnormal germ cells and the early degeneration of zygotes and embryos. This abnormality is well known in bulls (Mukasa, 1974) and other domestic animals, and there is little reason to doubt its occurrence in camels also.

Prenatal deaths in many species are frequently followed by embryonic resorption and a return to oestrus. However, since the camel has limited annual breeding period, the repeat-breeder camel would be unlikely to come back into season before the following year. The death of larger embryos may be followed by the invasion of suppurative bacteria leading to maceration. Alternatively, bacterial invasion may fail to occur, the dead organism being retained in a sterile state as a mummified foetus.

Abortions and stillbirths both occur in the dromedary. Droandi (1936) observed that abortion in camels was by no means rare, and that a major cause was probably that pregnant females are frequently overworked. He noted a practice common among the Arabs, whereby females were even denied rest while in labour, in order to avoid falling behind on long marches. Delivery was speeded up by pulling out the head and legs of the calf, which was then wrapped in a bag and carried with the rest of the baggage. Practices of this kind may well lead to subsequent reproductive problems. Richard (1976), Fazil (1977) and Curasson (1947) attributed abortions in the dromedary to trypanosomiasis. Other causes include febrile conditions such as pneumonia and camel pox, or nervous excitement (Leese, 1927). Pasteurellosis and salmonellosis have also been cited.

Spencer (1973) reported a low growth rate of Rendille herds in northern Kenya and attributed it partly to the high incidence of diseases affecting reproductive performance. Shalash (1965) found indications of infection in nearly half the female genital abnormalities examined. One of the infectious conditions observed by the latter was pyometra, sometimes associated with maceration of the foetus. Bursal and ovarian adhesions are often subsequent complications of this condition. Infections of the genital tract usually follow difficult parturition, retention of foetal membranes or trauma (Roberts, 1971). Paraphimosis and phimosis were described in camels by Leese (1969). They are mainly the result of inflammation of the prepuce. He also described orchitis due to trauma, followed by infection of the wounds on the scrotum.

It is not infrequent for deaths to occur during delivery itself. Losses are caused by difficult calving, sometimes compounded by the unskilled intervention of the herdsman. Leese (1927) indicated that human assistance during delivery is rare under normal conditions, but added that newborn calves can be lost through umbilical haemorrhage, the incidence of which can be reduced by the proper ligation of the cord.

Williamson and Payne (1978) stated that the newborn camel is a very delicate creature and that losses are high in the first 3 weeks of life, a view also shared by Singh (1966).

Fazil (1977) wrote that a female camel in good condition may produce too much milk for the calf's needs. Overfeeding may result in diarrhoe, indigestion and sometimes death. Colostrum, in spite of its laxative and immunological advantages, is considered dangerous by most camel herders and is commonly fed only in minimal amounts (Williamson and Payne, 1978). However, when colostrum is withheld to a substantial degree the calf may be deprived of the protection provided by the antibodies it contains, which are essential for body defence and resistance mechanisms during early life. Most calves become unthrifty and many die if deprived in this way. Calf mortality among camels was estimated at 50 % by Leonard (1894), 30 - 50 % by Bremaud (1969) and 31 - 59 % by Cossins (1971).

In addition to overfeeding or lack of colostrum other causes of early calf mortality have been observed. In a study of three camel raising clans of the Jijiga area of Ethiopia, Cossins (1971) recorded mortality rates of 31, 49 and 59 %. He attributed the latter two high values to the fact that the herds were maintained all the year in tick-, fly- and predator-infested areas. Bremaud (1969) attributed calf mortality in the camel herds of Kenya to poor nutrition, diseases and predators. He noted that owners did not consider the 30 - 50 % calf losses as a serious problem. Field (1979a) surveyed 204 deaths among the camels of northern Kenya and found that 92 (45 %) occurred at under 2 years. Major causes included drought (35 %), ticks (22 %) and camel pox (16 %). Leonard (1894) was of the view that the premature weaning of suckling calves and the early age at which the young are made to begin work also contribute to mortality within the first 4 years of life.

Curasson (1947) quoted Droandi, who considered polyarthritis as a common ailment in young camels following infection through the umbilical cord, with symptoms and lesions similar to those observed in the horse. In a study of young camels in Tunisia, Burgemeister (1975) observed that of 26 pathological conditions diagnosed at or soon after birth, the commonest was 'arthrogryposis' (16.4 % of the 73 animals examined), followed by asthenia (12.3 %), polyarthritis (2.74 %), traumatic arthritis (1.37 %), congenital abnormalities of the stomach (1.37 %) and fractures (1.37 %). Overall, he concluded that 26 % of young camels are lost before the age of 6 weeks.

2.6 FERTILITY

2.6.1 Fertility Rates

Fertility has been defined as the ability of the male and female to produce viable germ cells, mate and conceive, and subsequently give rise to living young (Ensmiger, 1969). Many factors, including perinatal losses, influence the overall fertility rate of dom-

estic animals, with the result that rates are difficult to define. A significant aid in establishing precise figures is the keeping of proper breeding records, a management practice entirely lacking among camel herders under traditional systems. However, it is generally believed that fertility rates in the camel, especially under traditional systems, are low.

Dahl and Hjort (1976) have noted that even under improved management the fertility rate of camels is very unlikely to be much higher than 50 % in pastoral herds. The authors, however, quote Russian work in which the fertility level of the Bactrian camel was found to be 65 % under ranch conditions, although Keikin (1976) reports the calving rate at a large Soviet camel ranch (4,300 head) as averaging only 40 %.

Contrasting methods of estimating fertility in camels were used by Bremaud (1969) and Wilson (1978). The former used direct interviews with the pastoralists, while the latter employed aerial surveys of the various age groups to determine fertility indices. Bremaud, whose results are partly reproduced in Table 4, estimated the fertility rate of Gabbra and Somali camel herds in Kenya as 34 % and 52.25 % and quoted Watson's (1969) figure of 41 %. The results indicate that 80 % of animals had a calving interval of at least 2 years, that 73 % did not rebreed within 12 months of calving and that 74 % of young are weaned at 12 or more months of age. However, the data base was very limited, and in the absence of proper breeding records results based on interviews with nomads should in any case be accepted with reservation. Bremaud himself confesses a bias in his own results, since calf mortalities remained unaccounted for, and also nomads probably tended to report only on their best-performing females. His figures for fertility rates should therefore probably be scaled down. Wilson (1978) gave the calving rate of Darfur camels in southern Sudan as 70 %, which seems a very high estimate under pastoral conditions.

2.6.2 Causes of Low Fertility

As the previous sections have indicated, the factors contributing to low fertility in the camel are many and complex. They may briefly be summarized as follows:

Late Age at First Calving

Puberty occurs late in the camel, and animals may be 3 - 5 years or more at sexual maturity. Inadequate weight, resulting from a low plane of nutrition, may well be a cause of delay. Females are commonly withheld from breeding until 4 - 6 years old. Gestation accounts for a further year, with the result that calving frequently occurs for the first time at 5 - 7 years, considerably later than in cows. This factor is partially offset by the camel's longer breeding life.

Limited Rutting Potential

Full male musth may in some cases occur only at 8 years, and animals are often not put to full service before 6 - 8 years. In addition it is reported that only one male in the herd develops the rut, while the others suppress their sexual desire. This situation, together with a loss of appetite and increased activity noted in males during the breeding season, may lead to a loss of condition and subsequent drop in libido. Difficulties in male penetration may also play a part.

Table 4. *Fertility characteristics of camels of northern Kenya.*

Characteristic	Number (and %) of animals
Calving interval (months)	
12	1 (3.8)
14	1 (3.8)
15	1 (3.8)
16	1 (3.8)
24	14 (53.8)
30	1 (3.8)
36	1 (26.9)
Time between calving and rebreeding (months)	
1 - 3	1 (3.8)
3	2 (7.7)
6	2 (7.7)
7 - 11	19 (73.0)
Age of calf at weaning (months)	
3	1 (3.7)
6 - 11	6 (22.2)
12	17 (63.0)
24	3 (11.1)

Source: Adapted from Bremaud, 1969.

Limited Breeding Opportunities

Although animals near the equator are reported to breed all the year round, the breeding season elsewhere generally appears limited (November to March in the northern hemisphere). Length of the breeding season is probably affected by nutrition levels and daylight length, and possibly by other factors such as altitude and air humidity. Since gestation usually lasts a year, the breeding season tends to occur at the same time as calving, limiting the number of females able to conceive. When prenatal deaths occur, rebreeding is usually delayed until the following year.

Prolonged Calving Interval

Camels calve once every other year, or at best twice in 2 years. The result is a low annual calving rate of 50 - 80 %. The calving interval is prolonged by (i) the lengthy gestation period, (ii) the limited breeding season and (iii) late postpartum oestrus (frequently 1 year after parturition).

Inadequate Nutrition

Low feed availability, especially in times of drought, may affect overall fertility in a variety of ways, ranging from delayed sexual maturity and a curtailed breeding season to threatened calf viability. When feed is scarce, growth and lactation take priority over reproduction, which becomes a physiological luxury. Under pastoral systems, competition for milk between calf and man becomes an additional factor. Again, colostrum is commonly withheld from calves, depriving them of essential antibodies, while early weaning may check calf growth, increasing susceptibility to disease. Conversely, overfeeding may also be a problem in times of plenty, leading to diarrhoea, indigestion and in some cases death.

Management Practices and Perinatal Calf Losses

Management practices, as well as disease, emerge clearly as a crucial factor in the high calf mortality rate of 30 - 60 %, and doubtless also affect embryonic and foetal losses as well as other aspects of fertility. Better and more widespread knowledge of the most favourable time during the oestrous period at which to practise hand mating (the first 1 - 2 days) might improve conception rates. In some herds inbreeding results in genetic abnormalities, especially the decline of low-heritable characters, of which fertility is one. Again, animals with reproductive abnormalities such as cryptorchidism, intersexuality and gonadal hypoplasia are not culled as they would be under more sophisticated production systems. There is little knowledge of appropriate breeding ratios, and the herding of males together probably has a negative effect on libido. Sexual desire may also be quelled if rutting males are driven hard at work. In some cases pregnant females are worked up until delivery, and occasionally they may not even be allowed to rest while in labour, leading to an increased risk of abortions and stillbirths, and subsequent reproductive problems. At parturition itself, the unskilled intervention of the herdsman can again lead to calf losses. The newborn are delicate and losses in the first 3 weeks of life may be high, especially when nutritional and disease problems arise. Premature weaning and the early age at which camels are expected to begin work lead to high mortality within the first 4 years of life.

Disease and Other Factors

Disease is a major influence on calf losses. Trypanosomiasis, leading to abortions and general debility, is an important contributory factor. Pasteurellosis and salmonellosis are also cited as causes of abortions, while camel pox particularly affects the young once the immunity obtained from colostrum has worn off after the first few months of life. Infections such as pyometra, phimosis and paraphimosis, orchitis and filiarasis directly affect the reproductive tract, as also do abnormalities such as cysts, and all of these may occur with some frequency. There is a high rate of early embryonic mortality, and twins or triplets occur only with the utmost rarity. Endocrine factors, including insufficient gonadotropins to enhance follicular development and subsequent ovulation, may also contribute to infertility. Again, cystic ovarian degeneration is often associated with hormonal disturbances. Finally, ticks, flies and predators, as well as other infectious diseases, such as anthrax, may play a major role in carrying off the young.

To sum up, low fertility is clearly one of the major constraints to camel production. It is a problem that must be overcome if herd offtake is to be increased with a view to marketing good quality camel meat. At present, what little meat reaches the market is often of low quality, since herdsman are unwilling to trade off young animals.

3. NUTRITIONAL CHARACTERISTICS

The one-humped camel possesses remarkable abilities to exploit the scanty feed and water supplies found in its natural habitat, the arid and semi-arid areas. However, exaggerated and erroneous claims have sometimes been made regarding the digestive tract of this species, especially with respect to its ability to store and use water efficiently. Nevertheless, the many features peculiar to the camel's digestive system have sometimes led authors to describe the camel not as a "true" but as a "pseudo" ruminant.

3.1 ANATOMY OF THE DIGESTIVE SYSTEM

Early reports on the digestive system of the dromedary, e.g. by Cauvet (1925), Leese (1927), Droandi (1936) and Tayeb (1950b and c), continue to serve as reference works on this topic. Recently, Schmidt-Nielsen (1964) has confirmed many of these original observations and the present summary, in which the parts of the digestive tract are briefly described one by one, is mainly based on the findings of these investigators.

The lips of the camel are extremely mobile. The upper lip is bifid, a feature thought to aid the consumption of thorny plant material, while the lower one, especially in adults, tends to be pendulous. The upper lip is also sensitive enough to pick up small pieces of vegetation, according to Hafez (1968), who added that the nostrils are surrounded by sphincteric muscles which keep them closed most of the time, thus reducing evaporation from the nose and preventing the entrance of sand and flies. The mouth is often open and gurgling or bellowing sounds are frequently emitted. During this process, a pink bladder-like membrane (part of the soft palate) may be seen to protrude beyond the lips, especially among rutting males. This mucous membrane is protracted less in females than in males. Nevertheless, in both sexes it may appear as a balloon-like structure, although in fact it has no central cavity. It is made of loose connective tissue according to Leese (1927), who concludes that its protrusion is associated with the eructation of rumenal gases. A report by the British Military Administration in Eritrea (BMA, n.d.) indicates, however, that protrusion of the soft palate mucosa may be a mechanism providing for the moistening of the throat, and thus a form of protection against excessive thirst. The camel has a very hard dental pad and a long hard palate.

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The cheeks are densely lined by pigmented papillae, long conical protuberances (up to 2 cm) which can easily be mistaken for pathological growths, even by the experienced camelman. The tongue of the dromedary is a small but highly mobile structure supplied with five to seven papillae on each side, each of which can be up to 1 cm in diameter.

The adult dromedary generally has 34 teeth. Sudanese breeds are reputed to have 36. A peculiarity of the dentition is the presence of incisor teeth in the upper jaw and canines in both jaws (Leese, 1927). In this respect the Camelidae differ from other ruminants. The dental formula of the dromedary is:

Milk teeth

$$\frac{1 \ . \ i \ . \ 1 \quad 1 \ . \ c \ . \ 1 \quad 3 \ . \ pm \ 3}{3 \ . \ . \ . \ 3, \ 1 \ . \ . \ . \ 1, \ 2 \ . \ . \ . \ 2} = 22$$

Permanent teeth

$$\frac{1 \ . \ i \ . \ 1 \quad 1 \ . \ c \ . \ 1 \quad 3 \ . \ pm \ 3 \quad 3 \ . \ m \ . \ 3}{3 \ . \ . \ . \ 3, \ 1 \ . \ . \ . \ 1, \ 2 \ . \ . \ . \ 2, \ 3 \ . \ . \ . \ 3} = 34$$

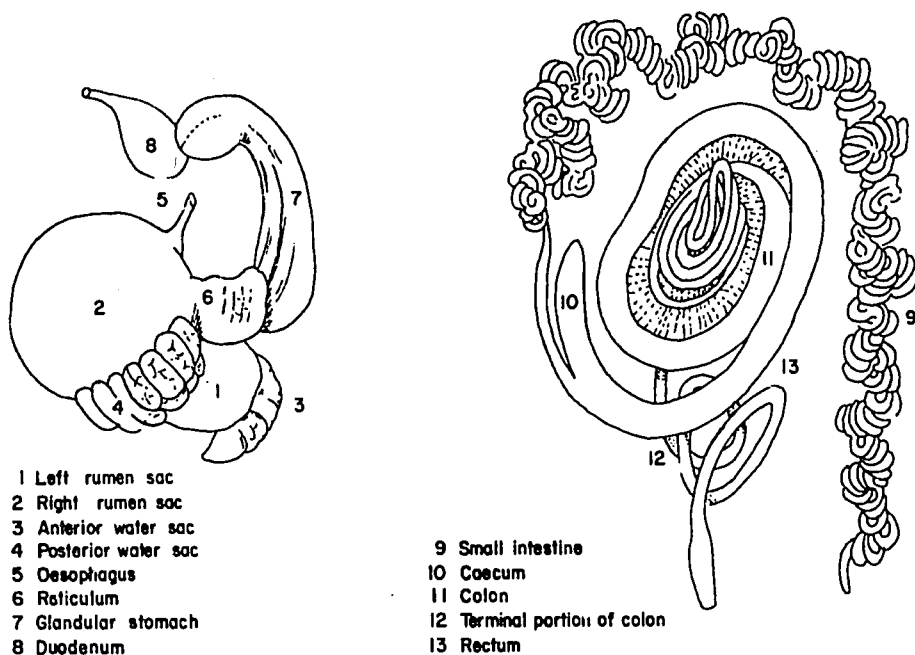
Leese (1927), Acland (1932), Boué (1950) and Williamson and Payne (1978) discuss the use of dentition in determining the age of camels. Both Acland and Williamson and Payne show that at birth the central pair of teeth has already erupted, at 1 month the laterals appear and by 2 months the third pair erupts through the gum. These teeth are crowded and begin to wear down at 1 year. At 2 years they are so worn that they are no longer crowded or touching each other. By 4 years they are completely worn out, with square or irregular tables, and are loose. At 5 years the central pair of permanent teeth erupts, followed by the second at 6 years, and all three pairs are visible at 7 years.

Although there are minor anatomical differences, the camel's salivary glands resemble those of other ruminants. They include well developed parotid, maxillary and molar glands, and insignificant sublinguals (Leese, 1927). Leese also described minute salivary glands at the base of the cheek papillae. An extensive account of these glands and the associated ganglionic and lymphatic supplies is given by Tayeb (1959b).

The camel pharynx is a long, narrow cavity divided into two chambers (anterior and posterior) by a transverse mucosal fold. The anterior chamber is a favourite site for camel bots (*Cephalomyia larvae*). Unlike the horse, the camel has no guttural pouches. Its oesophagus is a long tube of large capacity, and while in the horse this tube is often half the size of the trachea, in the camel it can be 1 - 2 m long. It is lined by glands which secrete a mucus helping to lubricate the often rough forage consumed by the camel.

As a ruminant, the camel has a stomach with four chambers, although there are some reservations as to whether the last two chambers should be classified as separate entities. The rumen or first compartment continues to be a source of controversy owing to its additional anterior and posterior sacs (Figure 7). These sacs are divided into smaller chambers and subchambers by well developed mucosal folds (Schmidt-Nielsen, 1964), the edges of which are made of strong muscular bands. On postmortem examination the rumen often contains a mixture of food, mucus and water. The extra chambers usually hold a smelly, slimy fluid, probably the reason why such names as "water chambers", "water sacs" and "water compartments" have sometimes been applied to them. Their role as major water storage facilities has, however, long been refuted (e.g. Leonard, 1894).

Figure 7. Schematic representation of the alimentary tract of the dromedary.



Source: Adapted from Droandi, 1936.

Their capacity is hardly more than 7 litres, and it is very doubtful whether such a meagre amount could meet the needs of a large animal like the camel. The rumen occupies much of the left side of the abdominal cavity, and may contain ingesta amounting to approximately 11 - 15 % of the animal's body weight, an estimated capacity comparable to that of the cow. These contents are rich (83 %) in the water necessary for digestion in ruminants. The extra rumenal compartments contain numerous glands which secrete a product very similar to saliva.

A large opening connects the rumen to the reticulum, otherwise called the honey-comb, second stomach or second compartment. The mucosal surface of the reticulum is fairly similar to that of other ruminants but differs in being glandular. It has a small capacity and its contents are more fluid than those of the rumen. The oesophageal groove of the camel stomach has only one well developed lip.

The omasum (third stomach or third compartment) of the camel does not have the extensive mucosal folds characteristic of the bovine. It is difficult to distinguish the omasum externally from the abomasum (fourth, glandular or hind stomach). The abomasum is lined by 15 -20 mucosal folds which are a favourite site for *Haemonchus longistipes*. It has a well developed pyloric sphincter.

Leese (1927) estimated that the small intestines of the camel are about 40 m long. The common secretory duct of the liver and pancreas is located in the duodenal portion, about 53 cm from the pyloric sphincter. The jejunum occupies much of the right abdominal cavity. Associated with this middle portion are a chain of mesenteric lymph nodes and a further group around the anterior mesenteric artery. The lymphatic supply of the last portion, the ileum, is closely associated with that of the large intestine. The latter is approximately 19.5 m long with a caecum similar to that of the cow, except that its blind end is attached to the mesentery. The colon is larger in its first portion and is coiled in a manner similar to that of the pig (Figure 7). It is enclosed in its own mesenteric fold. Much water is absorbed in this region, where the fluidy luminal contents suddenly change into hard faecal pellets of dung. The rectum forms the terminal portion of the large intestine.

The camel liver is highly lobulated, especially on its ventral-posterior surface. Extensive interlobular connective tissue gives the organ a similar appearance to that of the pig (Leese, 1927). The camel has no gallbladder and the bile duct fuses with the pancreatic duct to discharge by a common opening into the duodenum. The spleen of the camel weighs about 5.5 - 6.6 kg.

3.2 NUTRITIONAL REQUIREMENTS AND FEEDING

3.2.1 Feed Resources

Most camels are raised in arid areas with scanty and unreliable rainfall. These areas are for the most part considered unsuitable for raising crops (Gauthier-Pilters, 1977). Forage growth is usually very sparse and large grazing areas are therefore needed per animal. Great distances often have to be covered in search of drinking water. The fodder grasses and herbs found here grow, flower, fruit and lignify extremely quickly, providing adequate protein and carbohydrates for only a month or so in a year. Thorn and fodder bushes, which utilize more water owing to their larger root systems (Kuthe, 1977), are thus nutritionally more valuable.

The grazing pastures of the desert (northwestern Sahara) have been divided into three ecological types by Gauthier-Pilters (1972). They consist of (i) the *ergs*, or areas of shifting sands (dunes), (ii) the *hammada*, or rock-floored desert areas, and (iii) the *wadi*, or areas of desert streams, usually dry except during the rainy season.

By necessity therefore, most African camels are raised and must survive under harsh conditions of limited natural vegetation, although in a few areas they are also raised on irrigated pastures. Fortunately the food requirements of the African dromedary are modest, and under extreme drought conditions the animal can decrease not only its food intake (Gauthier-Pilters, 1977), but also its metabolism (Ingram and Mount, 1975). Under these conditions the camel adjusts by adopting highly extensive, dispersed and continuous grazing habits even during the heat of the day, and will also consume more thorny and woody plants.

Field (1979a) reported on the ecology and management practices of the Gabbra and Rendille tribesmen of northern Kenya. Using 17,500 records of plant availability collected over 10,000 feeding minutes, he found that the average diet of camels consisted of dwarf shrubs (47.5%), trees (29.9%), grasses (11.2%), other herbs (10.2%) and vines (1.1%).

There was, however, considerable variation in plant types, and between wet and dry seasons within each type. The camel is thus predominantly a browser, although it also grazes on tall, succulent young grasses. The Somali camel is an exception, reputed to be more of a grazer than a browser.

Camels consume many different kinds of plant: Knoess (1976) noted the advantage of the camel over other livestock in the Awash valley of Ethiopia, in that it could utilize a wider variety of local plants, while Matharu (1966) indicated that Indian camels were able to consume many types of feed sometimes considered unsuitable for other herbivores and could live on hard, thorny plants like acacia, which are alleged to be among their favourite species. Camels are capable of ingesting thorns up to 1 cm long. When such plant types are consumed the amount of green matter drops to about 5 kg per day from the normal 30 - 40 kg associated with young succulent forages, according to Gauthier-Pilters (1974). In a study lasting $2\frac{1}{2}$ years in the Sahara the latter author estimated that a desert camel consumed 2 - 4 tonnes of DM annually. She also identified some 200 different types of plants consumed by the camel, although no more than 15 - 20 could be found on any one grazing pasture. Maxwell-Darling (1938) confirmed the wide variety of plants consumed by the Sudanese camel and further noted that the camel was slow in adapting to new plants, although animals used to being handled could easily be introduced to strange forages if hand fed by the owner. Leese (1927) observed in addition that while local camels could avoid the native poisonous plants, it was easy for newcomers to consume and be poisoned by them. Further information on the species consumed by camels may be found in the ecological publications of Le Hou  rou (1972 and 1974) and Newman (1979).

The carrying capacity of western and northern Sahara pastures was reviewed by Gauthier-Pilters (1974). She found that a 10% cover of *Aristida*, with an average production of 2.2 t of DM per ha, was enough to support 300 camels for 5 months. With the less productive *Panicum turgidum* however, only 0.8 t of DM was present, enough for only 80 animals over the same period. These calculations reflect ideal stocking rates, whereas in practice camels are generally raised on less productive pastures and forages, entailing lower stocking rates. Leese (1927) suggested a stocking rate of one animal per 4 ha. When bushes were close together, 2 ha were considered sufficient, even for a nursing animal.

Bremaud and Pagot (1962) studied the physical, nutritional and botanical characteristics of Sahelian pastures together with their carrying capacity. The nutritive values they obtained are shown in Table 5. They found that the protein content of DM varied from 0.86% in the dry season to 6.32% in the rainy season, while that of cellulose was more consistent at 33.67% and 32.92% respectively. The nitrogen-free extracts were calculated as 54.74% and 47.32% respectively.

3.2.2 Grazing and Supplementation

Given the general absence of digestibility trials for the plants consumed by camels - although some values can be derived from FAO data compiled by Gohl (1975) - it is hard to establish the exact minimum requirements of the dromedary under varying age, sex, pregnancy and working conditions. Rough estimates only can be obtained by using the results of Bremaud and Pagot (1962), Gauthier-Pilters (1974 and 1977) and the general formulae for estimating the crude protein digestibility (CP_2) and total digestible nutrients (TDN) of fresh tropical forage, given by Butterworth and Diaz (1970) as:

$$CP_2 = -18.88 + 39.07 \text{ Log}_e CP$$

and

$$TDN = 51.65 + 3.66 \text{ Log}_e CP - 0.25 CF + 6.85 \text{ Log}_e EE.$$

Table 5. *The nutritive value of Saharan vegetation in different seasons of the year.*

	End of dry season		Mid rainy season		Start of dry season	
	Mar. %	Apr. %	Aug. %	Sept. %	Nov. %	Dec. %
Water	9.50	8.20	75.00	74.00	51.00	48.00
Protein	1.27	0.70	1.58	1.47	1.70	1.80
Fat	0.68	0.55	0.42	0.45	0.71	0.69
N-free extract	48.60	50.26	11.83	13.24	24.00	25.60
Cellulose	31.90	31.00	8.23	9.64	16.50	18.50
Minerals	7.30	9.20	2.29	2.54	4.60	5.40

Source: Bremaud and Pagot, 1962.

Alternatively, the nutrient requirements for cattle have sometimes been adopted as standards for use in camel studies. Thus Farid et al (1979) observed that under stress the Egyptian camel needed less water per unit DM intake or per unit body mass ($\text{kg}^{0.75}$) than sheep. Camels digested DM and crude fibre better than sheep, but CP was less well digested. Camels recycled more urea per day than sheep.

Thompson (1978) stated that the quantification of feed requirements for animals is a complex matter because of the variety of factors that influence requirements, the criteria for nutritive adequacy, and the variability between and within animal species. Changes in breeding, management, feedstuffs and methods of feed processing constantly influence feed requirements, which as a result should be frequently reevaluated. Regarding supplementary feeding, Childs (1978) discussed some of the factors affecting nutrient requirements, the major ones being:

- (a) already existing feed consumption, which is in turn influenced by energy level of the feed and ambient temperature;
- (b) inherent differences between male and female animals in given species;
- (c) disease conditions and
- (d) management conditions.

It is difficult to draw any general conclusions concerning the adequacy of the feed resources discussed above, and for the camel much work remains to be done in this field. However, Gauthier-Pilters (1974 and 1979) indicated that the Saharan camel can derive enough nutritional value for its daily requirements, if given ample grazing time. She noted that free-grazing camels, being hardier, consume less feed than their fellows from the richer semi-arid areas. The animals used in her own work retained their working capacities in spite of consuming only 10 kg of forage per day. Adopting a 2.5 % DM intake level, Field (1979a) obtained a similar estimate of 9.1 kg per day for Kenyan work camel averaging 363 kg liveweight.

Leonard (1894), Acland (1932) and the British Military Administration in Eritrea (BMA, n.d.) agree that camels are able to derive enough nutrition by grazing and browsing provided they are used for light work only, but that whenever they perform heavy tasks or when forage is not available or is inadequate, extra feeding is imperative. If the animal is being worked the nourishment derived or the time allowed for foraging is often insufficient. In such cases additional feeding is essential, often demanding more organization on the part of the herders or camelmen. The nutritional management of the dromedary thus varies according to location, nature of work and management system.

In Somalia, the experience of Hartley (1979) was that hand feeding of camels is almost unknown, although animals are sometimes brought to agricultural areas to feed on crop residues such as sorghum, cotton stalks, sesame waste and pulse haulms. The amount of work extracted from baggage camels is adjusted (in terms of weight and duration) to feed availability, without any hand feeding.

Ideally camels should be allowed to feed for 6 - 8 hours a day, with a further 6 hours being allowed for rumination (Williamson and Payne, 1978; Matharu, 1966). Matharu indicates that camels should be grazed in the morning hours and the late afternoon, and be given grain in the evening. Theoretically this would be the ideal arrangement, but it is not practicable for animals in service, which are often working during the cool parts of the day and are only allowed to utilize the hot periods for grazing or browsing. It is nonetheless highly advantageous to allow the camel to forage as much as possible, since it is not only more economical but, as stated earlier, the animal is also able to utilize a wider variety of forage than other domestic species in similar environments.

Whenever salt is not provided, animals benefit from being allowed to spend part of their grazing time on salt-rich pastures, e.g. *Atriplex*, *Salsola* and *Suaeda* spp. (Williamson and Payne, 1978). Often, however, salt is provided in salt pans, or by salting the drinking wells or even feeding salt earth.

Nanda (1957) recommends that a good camelman should be prepared to march 24 - 32 km per day with his animals, allowing them to graze for 6 - 8 hours in the process. When long journeys are undertaken, halts should be made in places with good forage. He observes that it is good management to rest dromedaries during the rainy season, allowing them to graze and recuperate. Forages tend to sprout and become plentiful during the rains, a period during which the camel hump (a form of food reserve) also tends to develop and become restored (Leese, 1927).

When forage is sparse camels have to be mobile so as to derive enough nutrients, and should accordingly be allowed longer grazing and browsing times. Gauthier-Pilters (1974) observed that Saharan camels spent 8 - 10 hours a day grazing, irrespective of whether the pasture was good or bad. The grazing habits of the dromedary allow it to utilize plants within a radius of 20 km of the camp, taking small bites from each plant, a nibbling tendency which also preserves the desert vegetation. Naturally they prefer plant material high in moisture and oxalate. The amount of forage per bite tends to be fairly constant, allowing a rough estimate of green matter consumed by the camel to be made from the number of bites.

Spencer (1973) noted that camels sometimes trot to their daily browse, giving them more time to feed when they reach the spot. During feeding they should be under the strict control of the herdsman, since it is hard to assemble dispersed camels.

Dahl and Hjort (1976) observed that the grazing patterns of camels form a circle made up of a series of smaller loops (Figure 8), rather than the solid circular or elliptical shapes characteristic of cattle grazing. In the case of camels it is the availability of vegetation rather than water which determines for how long camelmen will set up camp. The duration of a camp may vary from 1 day to a few weeks. Torry, cited by Pratt and Gwynne (1977), also confirms that compared to other livestock the camels of the Gabbra travel great distances to and from water. The maximum distances the various kinds of stock may travel to wells, depending on the quality of pasture between the camp and well, are given in Table 6, while Table 7 depicts the typical limits for a *damar* (a camp with its surrounding grazing area) for camels, sheep and goats owned by the Kababish in Sudan.

Table 6. *Maximum distances covered by livestock to wells.*

	Good surrounding pasture	Poor surrounding pasture
Camels	80 km	30 - 50 km
Cattle	40 km	10 - 15 km
Smallstock	50 km	10 - 15 km

Source: Torry, in Pratt and Gwynne, 1977.

Table 7. *Typical damar limits for camels, sheep and goats.*

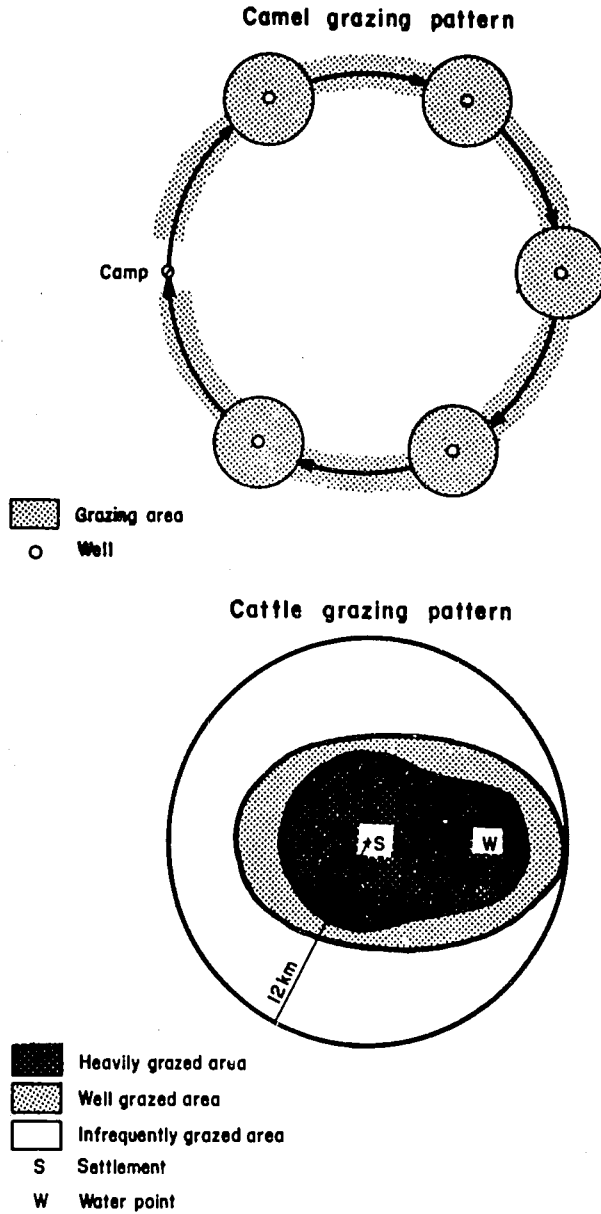
	Days interval between watering	Normal year		Bad year	
		Radius grazed (km)	Area grazed (km ²)	Radius grazed (km)	Area grazed (km ²)
Camels	9 - 10	56	9,842	96	28,490
Sheep and goats	4 - 5	29	2,590	48	7,252

Source: Asad, 1970.

Although supplementary feeding is rare, it is not altogether unknown. Nanda (1957) indicated that while green fodder or chop could be fed to camels at any time of the day, grain is best fed in the evening. The biting habit of camels makes it necessary not to feed more than one animal in the same manger, which also avoids waste from spillage and ensures that even the young and sick get their fair share. Leese (1927) confirmed that green feed was beneficial to sick and debilitated animals, and when fed to animals in service allowed longer working hours. Some of the supplementary rations recommended by Leese (1927) and Acland (1932) are given in Table 8.

Camels have also been raised exclusively on supplementary feeds or under feedlot conditions. Khatami (1970) reported on the favourable performance of Iranian

Figure 8. *The grazing patterns of cattle and camels.*



Source: Dahl and Hjort, 1976.

camels in the latter environment. In one trial animals were given 15 - 20 kg of a low-priced ration made up of straw, beet, pulp, molasses and barley (with the barley not exceeding 10 - 15 % of the ration). According to another trial the animals were raised on a sugar

Table 8. *Some recommended feeding rations for the camel.*

Camel type	Grazing conditions	Supplementation
Working Indian or Egyptian baggager	Fair	3.6 kg millet.
	Poor	8.9 kg straw; 1.8 kg gram; 42 gm salt.
	None	13.3 kg straw, 2.7 kg gram; 42 gm salt.
Working Somali or Aden camel	Poor or none	8.9 kg hay; 1.8 kg <i>Sorghum bicolor</i> ; 42 gm salt.
Riding camel in Aden	Variable	11.1 kg karbi; 2.2 kg cottonseed or other oil cake; 10 gal water.
Walking camel	Good	No grain, but some salt.
Trotting camel	Good	4.5 kg grain every watering day, with some salt.
	Poor	2.27 kg grain every day, with some salt.
Trekking camel	Variable	2.27 - 4.5 kg grain every day, with some salt.
Riding camels At rest Working	Available	2.27 kg grain per day.
	Available	3.6 kg grain per day.
	None	4.5 - 6.8 kg grain per day, with some salt.

Source: Adapted from Leese (1927) and Acland (1932).

beet farm. They were ready for slaughter within a short time, females and males having gained 0.95 kg and 1.4 kg per day respectively.

Evans and Powys (1979), ranching in Kenya, have succeeded in raising camels alongside other livestock under ranch conditions. Here the different feeding habits (browsing and grazing) of the various species are exploited to allow two separate stocking rates, while the camel's browse tendencies are additionally beneficial to bush control.

The experience of Leonard (1894) with camels in military service was that:

- (a) camels thrive best in their indigenous environment;
- (b) their appetites are uncontrolled in lush pastures and they may bloat to death in clover fields;
- (c) under very poor pasture conditions their feed should be supplemented with grain, chopped straw, hay or other available forage.

When no forage was available the animals were given 4.5 kg of barley and 9 - 11.3 kg of chopped straw. Leonard recommended that when grazing is available the amount of supplementary grain should not exceed 3.6 kg, which even then should be fed only when the work load

was at its heaviest. This last opinion would confirm the observation cited earlier that camels can derive adequate nutrition from grazing or foraging alone, when the work load is light. If on the other hand neither grazing nor grain was available, then 31.7 kg of chopped straw was fed along with 85 gm of salt three times a week.

How camels survive under harsh conditions is partly explained by Engalhardat and RübSamen (1979). They indicated that camels do not secrete large quantities of urea. They are capable of recycling 92 - 97% of the urea formed in the first and second stomachs, as also are llamas on low protein diets. This process is effected in two ways: through the permeability of the rumenal mucosa, and through resorption in the kidney.

3.3 WATER REQUIREMENTS

3.3.1 Watering Frequency

The camel's ability to survive long periods without drinking water is legendary, and is fundamental for its survival in arid areas. Leese (1927) observed that this ability to withstand water deprivation varies between breeds and according to the type of herbage consumed, although it can be induced by the judicious training of the animals. He observed that while the large Delta camel of Egypt required water every day, the Somali camel could survive with only one drink in 4 days. Mares (1959) also reported the astonishing ability of Somali camels to abstain from water, concluding that they were able to go for 30 days without a drink, provided the grazing was good. This breed is also capable of spending as little as 1 week a month on good pasture, while the other 3 weeks are spent trekking to and from wells. In a good year the animals may even last from April to December without visiting drinking wells, surviving only on succulent plants and standing pools. Leese (1927) found that Indian camels needed water every other day, while Cole (1975) noted that the Arabian camel drank once a week in the summer, every 7 to 10 days in the autumn and spring, and every 4 to 6 weeks in the winter. Certain types of desert sheep and goats also possess the ability to abstain from water for some time, but their resistance is nowhere near that of the camel.

The period of abstinence is influenced by climatic factors, the quality and quantity of forage and its water content, the age of the animals and the type of work to which they are subjected, according to Gauthier-Pilters (1974) and Schmidt-Nielsen (1964). The former quoted Monod (1955) as indicating that working animals in the Sahara were able to trek 1000 km, i.e. for 20 - 30 days without drinking water. When air temperatures reached 30 - 35° C the animals started visiting drinking places, but it was not until temperatures reached 40° C that their drinking rhythm accelerated and became regular. At this temperature the animals drank every 3 to 7 days, depending on the quality of vegetation. When air temperatures fell below 40° C, forage usually remained fairly green, so that camels could manage with only one drink every 10 to 15 days. Camels used to being watered frequently do not withstand dehydration as well as those used to long spells without water.

The ability of the camel to refrain from water for long spells should not, however, be overexploited. Animals should be watered whenever possible, and the more work they are required to do, the more drinking water they need. Hassan (1971) carried out a

dehydration experiment on dromedaries from Sudan. A 5-year-old animal was kept in an open enclosure for 51 days (November - December) without water. Although it survived on dry grass throughout the experiment, its appetite became capricious near the end. Blood sample analyses revealed a rise in erythrocytes and a drop in leucocytes and haemoglobin, but the packed cell volume (PCV) remained fairly constant. The animal tolerated a loss of 37% of its body weight, a water deprivation level excelled only by the oryx and the addax antelope.

3.3.2 Drinking Capacity and Sources

Just as camels can easily go without water for long periods, so also do they find it easy to drink water when it is available. Gauthier-Pilters (1974) observed that when the animal's water loss did not exceed 90 - 100 litres (which may correspond to 20% of its weight), it regained its original weight within a few minutes of drinking. Furthermore, a strong healthy camel may consume water equivalent to one third of its body weight in 10 minutes. The highest drinking rates observed were 135 litres in 13 minutes and 200 litres consumed over two to three drinking sessions. On average the Saharan camel was capable of drinking 15 litres per minute, not far from the estimate of 100 litres in 10 minutes given by the Institut für Tropische Veterinärmedizin (Leupold, 1968b). Schmidt-Nielsen (1964) concluded that the camel has enormous drinking capacities and could consume 30% of its body weight in water in a single session. Leese (1927) gave the average daily water consumption of the Indian camel as 13.6 - 36.4 litres, which may rise to 90.9 litres for animals which have been deprived for some time. These figures agree with the range of 30 - 100 litres given for the East African camel by Pratt and Gwynne (1977). Gauthier-Pilters (1974) estimated the daily consumption of the North African camel to be 20 - 30 litres. In an extensive discussion (1977) of the drinking habits of this camel type, she found that water consumption was closely correlated with feed intake and that the camel's drinking speed is lowered by malnutrition.

The sources of water for the camel are varied. Usually animals are watered from wells dug and maintained by the camel herders. In desert areas during the rainy season, animals may water from the temporary streams, ponds or oases that develop during this time. For housed camels on farms, piped water may occasionally be available. Nevertheless, a major source for the animal is the water content in forage, a source often overlooked but instrumental in enabling the camel to survive long spells without watering per se. Gauthier-Pilters (1974) noted that the water content of desert forage is more than is generally believed, and estimated that Saharan camels may derive 3 - 30 litres per day from foraging, depending on the state and locality of the vegetation. Different plants provide different quantities of water, but even in summer desert camels may obtain up to 15 litres of water with their daily food. The water content of shrubs tends to remain fairly constant throughout the year.

3.3.3 Water Conservation and Utilization

Cole (1975) concluded that the camel's ability to abstain from drinking water was not due to its proverbial ability to store it, but rather to its "cooling system". Bulliet (1975) stated simply that camels do not store water, they conserve it. While these assertions are confirmed by the anatomical description given earlier, they indicate only part of an intricate mechanism which has attracted much research in recent years. Schmidt-Nielsen (1959

1961, 1964 and 1975), Bartha (1971), Richards (1973) and Hardy (1972) provide descriptions of the physiological mechanisms behind water utilization and conservation in the dromedary. Recently, the subject has been reviewed by Ingram and Mount (1975) and the present account is based on their discussion.

Ingram and Mount suggest that the rate of heat loss (H) in an animal is proportional to the rate of heat production (M) and the rate at which heat is being lost from or stored in the body (S), in a relationship designated as:

$$M = H + S$$

They indicate that M is always positive but that H and S may be negative or positive, although H is more often positive. The relationship between the production, loss and storage of heat indicates the manner in which the heat from metabolic processes is dissipated.

Heat can be stored in the body without loss to the environment, but only up to a certain point, since a rise in body temperature results. When the organism is exposed to high environmental temperatures which change heat loss into heat gain, i.e. when H becomes negative, S will become positive, owing to the combined effects of metabolic heat production and heat gain from the environment.

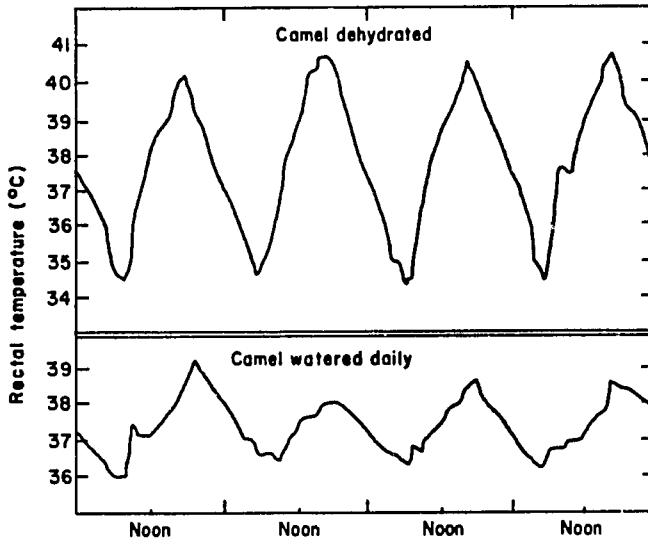
Heat storage occurs in the dromedary during the daytime, when it is exposed to high temperatures. The animal's body temperature rises several degrees during the day and falls slowly during the night. The camel has sweat glands, but uses them very economically. Thus, according to Schmidt-Nielsen (1964), instead of dissipating all its heat during the hot part of the day by sweating valuable water, the camel stores heat, allowing its body temperature to rise as high as 40.7°C. For example, a rise of 6°C in the body temperature of a 500 kg animal is equivalent to approximately 2,500 kcal (sp. heat = approx 0.8), the dissipation of which via evaporation would require almost 5 litres of water (sweat). Instead, this heat is lost at night by radiation and conduction.

If the morning temperature falls to a low level, the leeway for heat storage during the following day will be correspondingly greater, postponing the moment at which sweat must be used to prevent a rise above the tolerance threshold of 40.7°C. During periods of dehydration the fluctuation in body temperature becomes marked, falling to as low as 34°C before rising to the 41°C mark, whereas when the animal is watered daily the fluctuations are much smaller (see Figure 9).

A further factor is that the sweat lost after the upper limit is reached evaporates on the skin rather than the tip of the hair, so that the latent heat of vaporization is drawn from the skin rather than from the atmosphere. A similar mechanism is found in the donkey, although here the upper limit before sweating is not as high as in the camel. Different species develop different ways of avoiding dehydration, some becoming nocturnal while others, like the camel, fluctuate their body temperatures. Desert man adopts loose clothing, which protects him from radiation during the day and from the cold at night. Some additional characteristics which help camels to survive in the arid areas of low water supply are shown in Table 9.

Other adaptive mechanisms of the camel include its metabolic activity, which is sensitive to temperature fluctuations, and its kidney structure. The kidney is made of short and long Henle loops, but the proportions of each vary between different species. The more

Figure 9. Fluctuation of the rectal temperature of the camel under different watering frequencies.



Source: Schmidt-Nielsen, 1964.

Table 9. Some morphological and behavioural characteristics enabling the camel to survive in various environments.

Environmental stress	Adaptive mechanism
1. Solar radiation/reflection	Long limbs (increasing height from ground)
2. High temperatures	Hair shedding in summer
3. Seasonality of feed availability	Adipose tissue reserves (hump)
4. Deserts - thorny vegetation	Thick skin, hard tissue around mouth, thick mouth lined with long papillae
- water scarcity	Increased drinking capacity, conservation of metabolic water, ability to survive dehydration (metabolism lowered)
5. Low temperatures	Low renal flow during dehydration, renal resorption of urea, can feed without water, thick coat in winter
6. Evaporative cooling	Apocrine sweating

Source: Adapted from Ingram and Mount, 1975.

long loops there are the higher the water resorption potential and the ability to concentrate urine. Cattle have more short loops than long, while sheep have more long ones, with the result that the upper concentration limit of cattle urine is only 2.6 osmoles/litre, while that of sheep is 3.5 - 3.8 osmoles/litre (Macfarlane, 1968). However, these are concentrations during water deprivation, whereas normal values rarely rise above 1.5 osmoles/litre. Thus, while cattle tend to produce a diuresis after drinking, sheep require a considerable intake (3% of their body weight) before increased urine excretion occurs. Camels, however, can retain water without a diuresis. They have a low initial glomerular filtration rate of about $60 \text{ ml kg}^{-1} \text{ min}^{-1}$, falling to $15 \text{ ml kg}^{-1} \text{ min}^{-1}$ when water is restricted, whereas in cattle, filtration rates of $90 - 150 \text{ ml kg}^{-1} \text{ min}^{-1}$ are found, falling to one third of this value during water deprivation. Sheep are intermediate between the above values.

The camel's ability to concentrate its urine enables it to tolerate water and plants with a high salt content. Richards (1973) notes that the camel is capable of secreting urine with a salt content higher than that of sea water. The urinary bladder of the camel is small. A 300 kg camel watered daily excretes an average of 3 or 4 litres of urine per day, but under half a litre when deprived of water, according to Schmidt-Nielsen (1964). The latter author noted that the volume could be increased to 1 litre by feeding sodium chloride (common salt). With a urine (U) osmotic concentration of 2.760 osmolar, and a normal plasma (P) level of 0.34, camel urine has a total concentration value eight times that of plasma. In other words, the U/P ratio is 8, whereas in man it is 4.

The low rate of faecal dehydration in the camel is also worth noting. The amount of faeces varies with feed composition and digestibility. Generally camel faeces consist of a large number of small, oblong pellets (about 3 cm long). They are very light in weight and their outside is shiny and almost black (Schmidt-Nielsen, 1964). They are so dry that in treeless areas they can rapidly be used for fuel. They burn readily, owing to their abundant cellulose content.

The role of the camel's hump in water storage is not as great as was once believed. Schmidt-Nielsen (1964) argues that while the camel hump contains fat which is convertible to about 40 litres of water, optimum utilization of this source would necessitate the use of oxygen. The oxygen inhaled would lead to a loss of water on the outbreath greater than the water storage capacity of the hump, so that he doubts the use of the hump reserve as a major source of water for the animal.

There are a number of behavioural factors which are thought to contribute to the conservation of water. For example, Gauthier-Pilters (1979) observed that camels tend to remain lying down in the same spot from early morning, when the ground is still cold. They tuck in their legs while lying down, while other animals tend to spread out. Camels often align themselves with the sun's rays, only shifting position to maintain this orientation. They also tend to huddle together in one large group, as if in an effort to form a single organism with only its dorsal surface exposed.

However, it is the animal's ability to fluctuate its body temperature and withstand high dehydration levels which are the main factors in its tolerance of water deprivation. The camel can withstand body weight losses of 30 - 40% (Hassan, 1971; Gauthier-Pilters, 1975; Matharu, 1966; Schmidt-Nielsen, 1964). When water is available the camel will quickly drink to replace losses, showing few signs of stress. According to Leupold (1968b), no haemolysis of the blood occurs after heavy drinking of this kind. The erythrocytes of the

camel were able to increase to over 200 times their normal size. The camel also possesses the ability to maintain a constant plasma volume throughout periods of fluctuation in drinking water availability. Leese (1927) noted, however, that camels can sometimes die of distension after long and heavy drinks.

4. CAMEL DISEASES

The diseases of the African camel have not been very extensively researched in comparison with those of other domesticated species, probably owing partly to the non-sedentary nature of the herds, constantly moving in search of grazing and water. It is only in a few places, where the animals are found in favourable environments, often alongside other species, that attempts have been made to study camel pathology. In such areas, e.g. Borana, Bale and Harar in Ethiopia, the camel herders may even request veterinary attention for their dromedaries. Available literature indicates that dromedaries suffer from fewer diseases than other domestic livestock (Leupold, 1968a) and epidemic are rare. For further details on disease the reader should consult the works of Leese (1927 and 1969), Gatt-Rutter (1967), Curasson (1947), Castagnera (1957), Bares (1968), Cauvet (1925), Burgemeister (1975), Burgemeister et al (1975), Blaizot-Bouvier (1975), Ferry (1961) and Richard (1979). The present review is by no means exhaustive.

4.1 NORMAL CONDITION

Fluctuations are commonly observed in the body temperature of the camel, which is able to adjust its own body temperature. Leese (1969) indicates that the temperature is lowest at dawn and gradually increases until sunset before dropping during the night. It may vary from day to day. He gives the normal temperature at 6 a.m. as 36.4°C and at 6 p.m. as 38.1°C. Schmidt-Nielsen (1959) gives a morning temperature of 33.9°C and asserts that the higher limit is never above 40.5°C. Altman and Ditmer (1968) give the intramuscular neck temperature of the dromedary as 35.1 - 39.1°C and the rectal temperature as 34.5 - 38.5°C. Mason (1917) gave a range of 35 - 38.6°C.

Leese (1927 and 1969) showed that the pulse of the camel can be taken from the posterior tibial artery, with the animal in a sitting position. The medial sacral artery, near the root of the tail, could also be used. He estimated the pulse rate of a resting camel as 45 - 50. He observed that the normal respiration rate of the camel at rest is 5 - 12 per

minute. A higher respiration rate is often indicative of a febrile reaction. Like the pulse rate, respiratory rates tend to be higher at noon than in the early morning.

The camel is capable of closing its nostrils and breathing through its mouth. At such times the lower lip tends to become pendulous. Occasionally the animal will puff out its cheeks during mouth breathing.

Vomiting occasionally occurs in the dromedary and is not necessarily a sign of disease. Camels are nervous animals and may vomit and spit when handled. When vomiting occurs in an undisturbed animal, however, it should be regarded as a symptom of disease.

4.2 MAJOR DISEASES

4.2.1 Protozoal Diseases

Trypanosomiasis

Among camels, trypanosomiasis is sometimes also referred to as *surra*. It has received much attention, being extensively discussed or investigated by almost everyone involved in camel medicine. It is caused by *Trypanosoma evansi*, present in most areas where camels are found. Bremaud (1969) also lists *T. congolense* as a possible cause of the disease. The organism is transmitted by *Tabanus*, *Stomoxys*, *Lyperosia* and *Haematobia* flies (Scott, 1973), which are prevalent around river banks and watering points in the arid zones. Tsetse flies, the main vectors of bovine trypanosomiasis, are not involved in the transmission of *T. evansi* to camels.

Through blood samples and smear examination it was estimated by Richard (1976) that about 15% of camels in Borana (Ethiopia) were infected. An extensive account of the disease is given by Curasson (1947), but it would appear that trypanosomiasis mainly occurs as a chronic (subacute) debilitating ailment. The acute form is rare.

Fazil (1977) confirmed that camel trypanosomiasis is a slow, wasting disease. The animal becomes thin, weak, prostrate and eventually dies. The first signs of the disease are a drop in production (milk yield) and the tendency of pregnant females to abort. There is loss of appetite and the animals become very emaciated. Leese (1969) discusses the acute and subacute forms of camel trypanosomiasis at some length, indicating that the latter form may last 3 to 4 years before the animal finally succumbs. Recovery may occur in 20% of animals which are well fed, rested and managed. These animals subsequently become immune. The death of chronically affected animals is often triggered off by secondary infections, e.g. bronchopneumonia.

A tentative diagnosis of trypanosomiasis may be made on the basis of clinical signs, after which camel herders are often able to summon help or rest the affected animals. Thick blood smears taken from the tip of the ear to detect the organisms are useful in confirming the disease.

The best way of controlling the disease is by treatment with drugs. Two drugs have proved useful: Naganol (Suramin, Moranyl) and Anthrycide. It is necessary to give the correct dosage since underdosing may create resistant trypanosomes. Scott (1973) reported strains of *T. evansi* which were resistant to Suramin in Ethiopia and recommended the use of Anthrycide sulphate. Fazil (1977) reported good results with Anthrycide sulphate injected subcutaneously at a dosage of 4.4 mg/kg body weight, 2 g being sufficient for a 500 kg animal. He cautions against the use of Berenil, however, which may be toxic to camels. Other drugs have also been employed, but with less efficiency. Balis and Richard (1977) used 0.5 - 1 mg/kg of Isometamidium chloride hydrochlorate (intravenous or intramuscular) and recommended its use only in the absence of the more effective drugs. Dosages higher than 1 mg/kg are very poorly tolerated by the camel, according to Balis (1977).

Other Protozoal Diseases

Gatt-Rutter (1967) discussed the prevalence of protozoal infections in the camel. In some cases, however, the mere demonstration of an organism in the blood or faeces was used to establish the presence of a disease. Typical of the uncertainty surrounding these diseases are the results of Sharma and Gautam (1974), who found that 13.08% of 191 camels randomly sampled were serologically positive when tested for *Toxoplasma gondii* in the Hissar area of India. The animals were otherwise healthy, showing no clinical signs of the disease. No extensive accounts of protozoal diseases are available and only a brief list of the diseases treated by various authors (Gatt-Rutter, 1967; Richard, 1979, etc) is given here: leishmaniasis, coccidiosis, theileriosis, anaplasmosis, sarcosporidiosis and toxoplasmosis.

4.2.2 Parasitic Diseases

Internal Parasites

On the basis of faecal (1,500 samples) and postmortem examination, Richard (1976) estimated that 92% of the animals examined in various parts of Ethiopia were to some degree infested with internal parasites (80% with *Strongyloides* ova, 10% with *Strongyloides* larvae and 16% with *Trichuris* ova). Fourteen helminth species were identified on postmortem examination, the main ones being *Monezia* spp., *Stilesia vittata*, *Avitellina centripunctata*, *Trichuris globosus*, *Haemonchus contortus*, *Trichostrongylus* spp. and *Impalalia somaliensis*. Cysticercosis and hydatidiosis were also found in a few cases. Additionally, Leese (1969) listed the frequent occurrence of *Oestrus cameli* (the camel bot), *Haemonchus longistipes*, *Nematodirus spathiger* and *Ostertagia mentulata*, while *Trichocephalus echinophyllus*, *T. centripunctata*, *T. globipunctata*, *Distoma hepaticum*, *D. lanceolatum* and *Taenia expansa* were found in smaller numbers. He added that echinococcosis was common among camels but is of little consequence, and recorded the presence of *Linguata* larvae cysts in the mesenteric glands of camels in India. Leese also went on to describe *busk* as a disease of camels in the Nile delta caused by *Strongylus filaria*. Blaizot-Bouvier (1975) found, on the basis of faecal sample examinations, that Ethiopian camels were infected with parasites such as *Monezia expansa*, *Stilesia vittata*, *Avitellina centripunctata*, *Strongyloides papillosus*, *Trichuris ovis* and *T. globosus*. In a survey of camels at a government camel breeding farm in India, Lodha et al (1977) found that

64.7% of the faecal samples examined contained *Trichuris globosa*, while 13% contained *Haemonchus longistipes*.

Richard (1976) wrote that acute helminthiasis in dromedaries (gastro-intestinal parasitism) is generally associated with diarrhoea and weakness. The frequently encountered form is the chronic one with sporadic bouts of diarrhoea, constipation and emaciation. There is disturbed absorption of nutrients with a resultant drop in production. Animals with chronic gastro-intestinal parasites also tend to succumb very easily to other diseases.

The presence of echinococcosis (caused by *Echinococcus granulosus*) in Nigerian camels was established and investigated by Dada (1978): Out of 3,410 slaughtered animals examined, 1,952 (57.2%) were found to be infected with the disease. Hydatid cysts were found in the lungs, liver and spleen of infected animals (but not in the heart), and losses of what would otherwise have been parts for human consumption were considerable. El-Khawad et al (1979) found recently that 35% of the camels surveyed in central Sudan were infected with hydatidosis.

Magzoub and Kasim (1978) reported *Fasciola gigantica* and *F. hepatica* among camels in Saudi Arabia. They found a higher incidence of fascioliasis (liver fluke) in animals from the eastern region and associated this with the higher rainfall and irrigation schemes in the area, conditions which are conducive to the survival of the intermediate snail hosts. A very high percentage (14.2%) of camels imported for slaughter from Sudan were infected with fascioliasis.

Filariasis has recently attracted attention as an important camel disease caused by *Dipetalonema evansi*, which inhabits the arteries, especially the spermatic artery, but sometimes also the pulmonary and diaphragmatic arteries. Michael and Saleh (1977) developed a slide agglutination test for the diagnosis of camel filariasis, a method found to be 86% accurate.

It is clear that the helminth parasites and the extent of infestation vary with location and management system. As with helminthic infestations in other domestic species, the disease picture varies with the burden. An individual account of the disease picture for each of the above-named parasites is beyond the scope of this review. Suffice it to say that good management practices should be coupled with regular deworming of the camels.

A few chemotherapeutic agents have been evaluated for the treatment and control of camel helminths. Recently, Lodha et al (1977) found that a 90% Methyridine injectable solution at 1 ml/4.5 kg and 4% Morantel tartrate at 1 ml/4 kg liveweight were very effective in the treatment of mixed infestations of *Trichuris*, *Haemonchus*, *Nematodirus* and *Strongyloides* in camels. Tetramisole hydrochloride (Nilverm) 3% w/v oral drench at 0.5 ml/kg liveweight was the next best treatment, whereas Thiabendazole, even at 90 mg/kg liveweight, did not produce encouraging results.

External Parasites

Camel mange is sometimes considered the most important disease of dromedaries after trypanosomiasis. The only mite that infects camels is *Sarcoptes scabiei* var.

cameli (Richard, 1976). Mange is a highly contagious disease which can spread to herdsmen or others associated with infected animals. The mite may be transmitted directly by contact or indirectly through objects such as saddles, harnesses, utensils, bedding and even tree trunks. It tends to spread more quickly during cold weather, when animal coats usually grow long and the animals huddle together more often.

Sarcoptic mange affects animals of all ages and sexes and is certainly more common and severe than was previously thought (Lodha, 1966). The organism, which is just visible to the naked eye, requires 2 or 3 weeks to multiply, after which the population explodes, spreading very rapidly all over the animal body and through the herd. Infection generally starts in the head region, extending through the neck to other areas with thin skin, such as the penile sheath and the udder. The whole body may become infested within a month. Affected areas become swollen, hardened, hairless and wrinkled, especially in the hindquarter, thigh and hock joint areas. Infected foci are highly irritating, forcing the animals to scratch themselves and rub against one another, or against other objects such as trees, thereby spreading the infection even further. The infection leads to a loss in feeding and grazing time, with a subsequent loss in condition and productivity. Seriously affected animals are often unsightly and blood may be seen oozing out of areas traumatized by scratching and rubbing.

Once the disease has been diagnosed (which should not be difficult since sarcoptic mange is the only type affecting camels), the infected animals should be isolated. Their living quarters should be disinfected with 5 - 10 % phenol and then exposed to the sun for 2 weeks. Treatment should aim at killing the mites, promoting healing of affected areas and restoring the normal health and productivity of the animals. Thus it is common practice to clip around the infected areas, which are then scrubbed, preferably with a brush, and washed with soap.

After drying an acaricidal dressing is applied, e.g. Gammexane or any of the hydrocarbon or organophosphorous insecticides. Dipping is the most efficient method of application, but the camel's large size limits its extensive use, and hand dressing and spraying are the more commonly employed methods. Lodha (1966) studied the efficacy of DDT, Lindane, and Co-Ral, and concluded that Lindane at 0.05% concentration was the most effective. Three applications at weekly intervals are generally used, irrespective of the acaricide. A power sprayer was used in this particular study and with a pressure of about 500 g/cm² it took approximately 3 minutes to cover one animal completely, requiring 9 litres of the solution.

Camels do not suffer greatly from tick-borne diseases. Nonetheless, a few species of ticks have been isolated, including *Amblyomma gemma*, *A. variegatum*, *Hyalomma truncatum*, *H. excavatum*, *Ripecephalus pulchellus*, *R. pravus* and *R. simus* (Bremaud, 1969; Richard, 1979). Spraying by hand pump with any of the dipping or spraying compounds usually used for cattle or sheep appears to be effective.

Leese (1969) recommended that riding camels should be deticked as a matter of normal routine and observed that camels tend to accumulate ticks just below the anus, which if unattended may result in severe ulceration. Ticks generally cause consistent irritation, leading to rubbing. When located around the eyelids they may force the animal to rub against trees or other objects, often resulting in conjunctivitis.

Skin Diseases

Camel pox is an ailment mainly of young camels (6 months to 2 years) caused by a virus closely related to other variola poxes (Fazil, 1977), which was only recently isolated in Iran (Richard, 1976). Camel pox is an infection of the skin which can also infect man. It is a typical pox disease showing the four usual stages of pox lesions: papules, vesicles, pustules and crusts. These lesions are commonly observed on the head and other areas of the body with fine skin. The incubation period of the disease is about 2 weeks. In young camels there may be associated diarrhoea and subsequent death of the animals. Animals recovering are immune for life, and nursing calves attain some degree of immunity through colostrum for the first few months of life.

Adult camels are generally resistant. Those that become infected usually develop a benign form manifesting as oedema of the head, associated with swollen lips that may become blistered. However, Leese (1969) indicated that camel pox may become inalignant, its lesions spreading to any part of the body, especially the areas with thin skin. Occasionally the disease is fatal.

Saddles which are not well fitted or loads which are improperly balanced are often associated with skin bruises and saddle burns. Such areas become infected, ulcerate and may lead to skin necrosis. Raw areas of flesh may be seen on the back or hump after the loss of the top skin, and Richard (1976) isolated a wide variety of pyogenic organisms from these necrotic areas.

Fazil (1977) indicates that skin necrosis among camels may be associated with salt deficiency. Once established, the ulcers spread to surrounding areas, and there is little spontaneous healing. Fazil suggests that cleaning with antiseptic solutions, e.g. 1:100 Acriflavine, together with the supplementary feeding of salt should be able to control the lesions.

Domenech et al (1977) studied the various pyogenic skin conditions of the dromedary in Ethiopia. Besides the type of skin necrosis described above (locally known as *maha*) they found that camel skins could also be affected by localized abscesses known as *mala*. *Mala* is a typical infection of the lymph nodes, caused by *Corynebacterium pseudotuberculosis* and *Streptococcus* of the Lancefield type B group. A mixed infection may occur and sometimes the abscesses may be due to *Staphylococcus* or *C. pyogenes* organisms. It is a chronic infection which often affects the lymph nodes at the base of the neck and around the rump. The abscesses are usually closed, cold and painless.

4 . 2 . 3 Bacterial Diseases

Anthrax

Camel herders do not generally slaughter their animals for meat, but sometimes consume the meat of those that die of disease. Anthrax is thus a disease of major public health importance, although its incidence in the camel may not be very high.

Camel anthrax is an acute or peracute disease caused by *Bacillus anthracis*. In Ethiopia, Richard (1976) reported serious outbreaks of anthrax in camels, with some grazing areas being notorious for the disease. *Bacillus anthracis* spores may remain alive

in the ground for 60 years. Fazil (1977) indicated that the disease in camels is similar to that in other species but Leese (1969) is more specific, observing that camel anthrax is similar to the form observed in horses and pigs. Bremaud (1909) wrote that anthrax was particularly rampant in the Wajir camel herding area of eastern Kenya.

Major signs observed include oedematous swelling of the head, throat, neck and body. Involvement of the throat may lead to difficult breathing and swallowing. It is possible for death to occur without septicaemia, and apoplectic and diarrhoeic forms may also be observed.

The diagnosis and treatment of the disease should follow the lines recommended for other species, and it is possible to protect camels with the same type of vaccine as used for cattle, e.g. Blanthax, which also protects against blackquarter.

Salmonellosis

Salmonellosis among camels of the Sudan has been reported by Curasson (1947). Cheyne et al (1977) also described an outbreak of the disease in Somalia.

The disease is caused by *Salmonella choleraesuis* bacteria and may be peracute with death occurring in a few days. It may also become protracted. In the acute form, affected animals have a high temperature (39° C) and a pulse rate of 50 per minute. In the observations made by Cheyne et al (1977), the prescapular and submaxillary lymph nodes were swollen, muscle twitches were observed on the head and neck regions, and there was diarrhoea. Protracted cases (5 to 6 days) exhibited a thready pulse, congested mucous membranes and black, liquid, foul-smelling faeces. The mortality rate in this particular outbreak was under 10%.

Like anthrax, salmonellosis is of great public health importance. Cheyne et al reported salmonella food poisoning caused by the consumption of infected camel meat. They also quoted work which showed the presence of *Salmonella* spp. in the faeces of healthy animals, and that up to 3% of the carcasses at one camel abattoir in Egypt contained *Salmonella typhimurium* in their viscera.

As regards treatment, favourable results have been obtained by combining antibiotics with sulfonamides.

Tuberculosis

Camel tuberculosis is generally sporadic. Leese (1969) reported that it is frequently found in Egyptian camels, while Mason (1917) indicated that at one Cairo abattoir the incidence of tuberculous carcasses was 2.8%. Tubercular lesions were found to affect the liver and lungs, or the lungs alone, or were sometimes generalized throughout the body. Mason concluded that camel tuberculosis was caused by the same bacilli as cause the bovine type (*Mycobacterium bovis*). He indicated that the close confinement of camels and cattle together may be the source of cross-infection, since no lesions were found in the carcasses of animals originating from purely camel herding regions. Although the camel is thus susceptible to bovine tuberculosis, it would appear that the disease is not an important one. In spite of their susceptibility to infection, camels are very resistant to the

effects of the disease, and a long period elapses before they become cachectic and emaciated. Trypanosomiasis, with which this disease can be confused, is a far more common and debilitating illness.

4.3 MINOR DISEASES

4.3.1 Bacterial Diseases

A number of minor bacterial organisms have been isolated from camel tissues. Further bacterial diseases have been suspected on the basis of personal interviews with camel herders. The list of such diseases includes pneumococcosis (Kamel, 1939), pasteurellosis, brucellosis, blackquarter, paratuberculosis (John's disease), pneumonia and tetanus (Leese, 1969). Burgemeister et al (1975) demonstrated antibodies against *Brucella abortus*, *B. melitensis*, *Listeria monocytogenes* type 1, *Mycobacterium tuberculosis* and *Leptospira* from the sera of 52 camels from southern Tunisia. Richard (1979) also lists rickettsiosis, tetanus, plague, glanders and infectious pustulo-dermatitis.

4.3.2 Viral Diseases

Rabies

Leese (1969) indicated that rabies is not infrequently found in African camels. Infection often follows attacks and bites from wild animals. Affected camels become violent and aggressive and should be restrained or destroyed to avoid spreading the disease to other animals. Sometimes, sick animals simply become noisy and terror-stricken. They may also develop paralysis of the tongue.

Rinderpest and Foot-and-Mouth Disease (FMD)

Rinderpest and FMD are two diseases which are suspected to occur in camels, but as yet no classical cases have been recorded. The suspicion probably arises from the prevalence of the diseases among cattle.

Fazil (1977) comments that camels are slightly susceptible to rinderpest and that there might be an occasional death. Curasson (1947) reported outbreaks of rinderpest among camels in West Africa. Richard (1976), while reporting rare occurrences of FMD in Ethiopian camels, confessed that his attempts to detect the virus (types A, O and C) in camels herded with cattle experiencing a severe outbreak of FMD were negative. The current problem is to establish whether the dromedary is capable of acting as a carrier for the rinderpest and FMD viruses.

Other Viral Diseases

Burgemeister et al (1975) isolated antibodies against infectious bovine rhinotracheitis, bovine virus diarrhoea and para-influenza type 3 virus in Tunisian camels. Both *Chlamydia* and *Coxiella burnetti* were also demonstrated.

4 . 3 . 3 **Miscellaneous Diseases**

Nosepeg Tears

Traumatic wounds may result from the use of nosepegs or rings. If the tears are observed fresh, they should be stitched or handled like fresh wounds. Caution should be taken against subsequent fly infestation of the wounds.

Inflammation of the Soft Palate

The camel is capable of protruding its soft palate beyond the lips. This balloon-like structure may sometimes be traumatized by sharp objects or during fighting, and infections may result. The throat of affected animals becomes swollen and the camel may be unable to swallow. Breathing becomes laboured and the neck may be extended. Palatal inflammations of the camel tend to be chronic and often ulcerative. Leese (1969) recommended that the best corrective measure is to amputate the inflamed portion of the palate at the level of the first grinders. Little haemorrhage is encountered and the animals show almost instantaneous relief.

Bloat

Bloat or gas tympany occurs in camels under similar circumstances as in cattle, and is handled in a similar manner. However, when a trocar is used to relieve the gas, a finer type than the cattle trocar is recommended. It is often unnecessary to use a trocar, since drugs may be just as effective. Fazil (1977) shows that the use of 0.85 - 1.14 litres of linseed oil or any of the commercial anti-bloat drugs is effective.

Impaction of the Third and Fourth Stomachs

The camel differs from the cow in that its third and fourth stomachs are not clearly demarcated. The common opening between these two chambers is also very patent. The contents of these stomachs are always more fluid than in cattle. It is thus rare for impaction to occur in camels, but when it does so it often involves both stomachs. Common causes of impaction include extreme dehydration and chemical poisoning. A lack of faeces is observed. Vomiting may occur, rumenal movements become suppressed, while excitement and other nervous signs may also be exhibited. If untreated, the camel may die in 2 to 3 weeks, most of which time is spent in a recumbent position.

Treatment of impaction in camels consists of giving 2.27 litres of linseed oil or 0.68 - 1.38 kg of magnesium sulphate (the exact amount being proportional to size and age), with the subsequent administration of plenty of water. If the treatment is repeated the dosage has to be reduced.

Ingestion of Sand

Mason (1920) reported a high rate of mortality in the Indian Camel Corps. Indian camels, which are not used to working in a sandy terrain, failed to adopt proper

grazing habits and consumed too much sand. The Sudanese and Egyptian animals in the group, which were accustomed to the habitat, were not affected. Signs before death included profuse vomiting, diarrhoea, tympany, colic and pain, although the temperature generally remained normal. Mason recommended the administration of oil to affected camels, the application of muzzles when animals were not grazing, and feeding 42.53 gm of salt per day. It would, however, appear dangerous to use animals which are unaccustomed to sand on work in the desert.

For a review of surgical diseases, lameness and other sporadic diseases of the camel, the reader is recommended to consult the work of Leese (1969). Curasson (1947) continues to serve as a standard reference work on camel helminthology and general medicine.

5. PRODUCTION AND UTILIZATION

The versatility of the camel and its ability to survive and perform in the harsh arid and semi-arid areas of the world have earned it names such as "ship of the desert", while its strength and docility have been exploited for agricultural, transport and riding purposes. It is, however, the animal's unparalleled ability to convert the scanty resources of the desert into milk, meat and fibre for the pastoralists of tropical Africa and Asia that have gained it the most reputation. Camel herders give deserved recognition to their animals and Sweet (1965) wrote that the camel is the basic resource among the Bedouin camel herding tribes of northern Arabia, such as the Rwala, Shammar and Mutair. The wide array of functions and products which the camel can provide is probably best summarized by Bulliet (1975), who wrote that the camel can be milked, ridden, loaded with baggage, eaten, harnessed to a plough or wagon, traded for goods or wives, exhibited in a zoo or turned into sandals and camel hair coats.

Unfortunately there are few data available on camel productivity under pastoral conditions. The present review is based on the limited existing information for the dromedary, and on results obtained using the Bactrian camel of the Asiatic regions.

5.1 MILK PRODUCTION

5.1.1 Yields

It is difficult to estimate the daily milk yield of the dromedary under pastoralist conditions owing to the inconsistency of milking frequency. Camels may be milked once a day among the Murrah of Arabia (Cole, 1975), from two to four times among the Somali (Bremaud, 1969; Hartley, 1979) and the Rendille of Kenya (Spencer, 1973), and as many as six or seven times among the Afar of Ethiopia (Knoess, 1977). The latter may also leave their animals unmilked for a whole day, which may account for sporadic very high estimates of up to 13 kg of milk per day.

For an unspecified type of camel Williamson and Payne (1978) stated that a good dam could yield 9 kg of milk per day at the peak of her lactation. Bremaud (1969) and Knoess (1976) gave the maximum daily production of the Somali and Adal camels as 12 and 10.4 kg respectively. According to Dahl and Hjort (1976), Yasin and Wahid (1957) estimated that the Pakistan dromedary (bigger and reputed to be a better milker) can produce 9.1 - 14.1 kg of milk when well fed. Leese (1927) said that the amount of daily milk recovered during the first 2 weeks postpartum may vary from 4 to 9 litres in addition to the share of the young calf. The dromedary, like most other species, gives most milk near the beginning of the lactation period. In a study of the camels of northern Kenya, Field (1979b) estimated their daily yield at 21 litres in the 2nd week of lactation, falling to 4.8 litres by the 16th week. One dam that had lost her calf at birth only gave 2.2 and 3.7 litres at the two respective times.

The average length of lactation in the camel is 12 months, but it may vary from 9 to 18 months (Bremaud, 1969; Leese, 1927; Field, 1979b; Mares, 1954). The variations for this trait depend mostly on management and environment (season, temperature and feed supply). Leese (1927) described 8-month lactation periods which extended to 18 months after an improvement in grazing. The common practice of breeding camels to calve every 2 years, together with their limited breeding period, are conducive to extended lactation periods, especially under good nutritional levels. Dahl and Hjort (1976) quote Russian data showing that on the rare occasions when camels calve every year a lactation period of 7 months is normal.

In general lactational yield will vary with species, breed, individual, region, feeding and management conditions, stage of lactation (Dina and Klinteberg, 1977), type of work and milking frequency. Leupold (1968a) gave the average lactational production of Pakistan camels as 2,700 - 3,600 kg under poor nutrition, not far from the estimates of 1,700 and 3000 kg given by ITV (1973a) for the same camel type under desert and favourable conditions (Table 10). The potential lactation yield of Adal camels in Ethiopia maintained on irrigated pastures was calculated as 2,847 kg from results given by Knoess (1976). Williamson and Payne (1978) wrote that the lactation yield (over 16 - 18 months) of a good unspecified dam under favourable tropical conditions could reach 2,722 kg or more. Dahl and Hjort (1976) gave the average daily milk production of the East and North African camel as 3.5 - 4 kg, i.e. a 9- to 18-month yield of 945 - 1,080 to 1,890 - 2,160 kg.

All these estimates indicate that the camel is potentially a better milker than many African zebu breeds of cattle. The lactation period and yield of the latter average 239 days (8 months) and 1,195 kg (based on data from Mahadevan, 1966, and Kiwuya, 1973a and b). Spencer (1973) confirmed that the amount of milk produced by one Rendille camel in Kenya far exceeds that of a zebu cow, estimating that 20 camels give as much milk as 80 Samburu cattle in the wet season. The average lactational yield of the Bactrian camel is about 800 - 1,200 kg, although it can reach 5000 kg (Williamson and Payne, 1978).

With regard to annual milk production, the haphazard management systems characteristic of nomadic pastoralists make it difficult to evolve any strict methods for obtaining records. Probably the best estimate of annual production is $(LY \div DL) \times 365$, where LY is the lactational yield and DL is the duration of lactation in days. Estimates are bound to be biased by factors such as variations in lactation periods and milking frequencies. Moreover, no adjustment can be made for any of the possible sources of variation in camel milk production since little work has been carried out on the effects of physiological factors on

Table 10. *Characteristics of camel milk production potential.*

Location or nutritional status	Daily milk production (litres)	Length of lactation (months)	Lactation yield (litres) ^{1/}	Source
Good animal	9	9 - 18	2,500	Leese (1927)
Pakistan (good feed)	-	9 - 18	2,700 - 3,600	Leupold (1968a)
Pakistan (poor feed)	-	9 - 18	1,350	Leupold (1968a)
Good feed	-	18	3000	ITV (1973a)
Desert		9	1,700	ITV (1973a)
Sahara	2.8 - 5.11	12	1,022 - 1,865	Capot-Rey (1962)
Eritrea	5 - 6	12	1,825 - 2 190	Mason and Maule (1960)
Ethiopia (irrigated pasture)	7.8	12	2,847	Knoess (1976)
Kenya	4.55	12	1616	Spencer (1973)
Unspecified	9.0	-	2,722	Williamson and Payne (1978)
Kenya	2.2 - 21	11 - 16	1,897	Field (1979b)
Well fed	9.1 - 14.1	16 - 18	2,722 - 3,629	Yasin and Wahid (1957)
Poorly fed	3.6	9	1,134 - 1,588	Yasin and Wahid (1957)
Tuareg camel	10	-	-	Nicolaisen, 1963
Sudan	5 - 10	10 -12	1,200 - 2,600	El Amin (1979)
Somalia	9	12	1,800	Hartley (1979)
East Africa	3.5 - 4	9 - 18	945 - 2,160	Dahl and Hjort (1976)

^{1/} All measures given in litres on the basis of 1 litre = 1 kg .

Source: Compiled by author.

lactation in the camel. Indications are, however, that the species, breed or type, age, stage and persistency of lactation, lactation number and length of the dry period all make some contribution to the variations in milk production.

The effect of oestrus and pregnancy on lactation is not very clear, but Knoess (1976) refers to a 3-month pregnant camel that was still giving 7.6 kg of milk per day in its 14th month of lactation. Field (1979b) observed a female which was still lactating 74 weeks after calving. He commented that probably she had failed to conceive in spite of having been mated. Hartley (1979) also observed that while a 365-day lactation was the rule for Somali camels, they would milk for a 2nd year if not put in calf. If the above formula is applied to present data, the annual milk yield of the camel can be estimated to range from 1,905 to 3,744 kg.

5.1.2 Milking and Milk Consumption

Milking the dromedary is a process which varies according to the different groups of pastoralists. It becomes less complex as the number of milkings per day increases, which is usual when maximum yields are required. Cole (1975) gives a good account of the procedure among the Murrah of Saudi Arabia, who generally milk their animals once a day. The animals are herded home soon after sunset, following a full day's grazing. They are bedded and allowed to rest, during which they start ruminating. After an hour's rest the lactating females are individually roused for milking. The woollen protector which prevents the calves from suckling while at pasture is removed and the dams are allowed to nurse. Milking is done by the men, although on occasion the help of the women is sought, and the milk is collected in large enamel bowls.

In his review of milking procedures among the Somali, who often milk their animals twice a day, Mares (1954) confirmed that a resting period after grazing is allowed. Milking times are about 2 hours after sunset and at early dawn. The Somali prevent calves from suckling while at pasture by ligating two or more of the teats (Cossins, 1971), the number depending on the strength of the calf and the milking ability of the dam. Hartley (personal communication) noted that they use a special string made from soft bark called *mark*. Cossins further observed that a dummy calf or even the skin of a dead calf may be used to stimulate milk let-down. Sometimes a clamp called the *quolob*, which is fixed over the vulvar lips, is also used. The animal is tied up short (head to tail) and kept under this restraint for some time. On release of the rope and *quolob* it will usually let down milk (Hartley, personal communication). Sometimes the same calf may be used to induce milk let-down in two lactating camels. In Kenya, Spencer (1973) reported that the Rendille milk their camels three times in 24 hours: once during the day and twice at night. Torry (1971) also gave an account of the organization of milking among these people.

Many pastoralists keep mixed herds with varying milking capabilities, thus assuring a continuous supply of milk throughout the year. Others, however, depend exclusively on the milk supply provided by their camels in an environment where other species would not survive, or if they did, would not give sufficient milk. Camel milk is thus a very important element in the diet of most camel herders. It is also the only source of nutrition for newborn calves in the first few weeks of life. Most pastoralists are experienced at striking a balance between the amount of milk taken out and that left for the calf, but in pastoral societies in which dependence on camel milk is high, competition may arise between the needs of man

and those of the young calf, with detrimental effects on calf viability. Occasionally, male calves are slaughtered in order to conserve for human consumption the milk they would otherwise have consumed. Bremaud (1969) observed that the practice among the Somali was to leave half the dam's milk for the calves, while Williamson and Payne (1978) noted that for heavy-milking dams only one quarter of the milk is left for the young during the first 3 weeks, the allowance being increased thereafter. Leese (1927) and Lewis (1969) indicated that camel milk may occasionally be diluted with water to sustain horses and rear their foals in waterless countries.

The general practice is to consume the milk soon after milking, since it is difficult to keep fresh. Dahl and Hjort (1976) state that camel milk goes sour very rapidly. The itinerant life of the nomads also encourages direct consumption of the product, but some reports show that camel milk can be processed into other by-products. Mares (1959) noted that surplus milk among the Somali is soured and stored as a curd or made into cheese. Other reports indicate that camel milk can be made into tallowy white butter and ghee. Further reports from Somalia by Hartley (1979) indicate that customs regarding the handling of camel milk vary across the country. In some areas it is soured, in others it is sugared and sold at market. The Afar of Ethiopia, on the other hand, are known to be reluctant to allow the milk to pass away from the camel's presence (Knoess, 1976). Mares (1959) observed that the Somali herders are not very market conscious, but would be willing to sell some milk if there was a market at hand. Camel milk in the Sudan is not commercially exploited, according to El Amin (1979). Cole (1975) stated that the Murrah Bedouin do not depend on the sale of their animals or animal products to secure the additional foods they may need.

5.1.3 Nutritive Value

With regard to the nutritive value of camel milk, Mares (1954) observed that colostrum or *dumbar* is often consumed by the Somali, who regard it as a laxative. Camel milk compares favourably with cattle and goat milk but not with that of sheep (Tables 11 and 12). It is very rich in vitamin C (5 mg per 100 ml, according to Leupold, 1968a), a vital ingredient when fruits and greens are scarce (Knoess, 1976), and contains 70 calories per 100 gm. It is also high in water and mineral contents (El Amin, 1979). Dahl and Hjort (1976) calculated that 4 kg of camel milk would be needed to satisfy the daily calory requirements of one adult human being, while a consumption of 1.8 kg would meet his protein needs. It is estimated that 18 - 20 camels are required to meet the needs of a nomadic family throughout the year (Sweet, 1965; Lundholm, 1976), assuming that half the animals are in calf. Sometimes, however, a rich stockowner may have as many as 100 or even 1000 camels in his herd, as observed by Lewis (1969), who additionally points out that 10 - 20 animals will suffice to support and transport an average family in the Horn of Africa. These estimates were based on the fertility rate of the camel, the length of its lactation period, its daily milk production, and the nutritive value of the milk plus any other sources of food.

A detailed account of nutritive requirements is also given by Field (1979a). He observed that among the Rendille of Kenya the average family consisted of 12 members. Adopting daily calory and protein requirement levels of 13,800 kcal and 318 gm, as recommended by Dahl and Hjort (1976) for a family of 5, he calculated that a Rendille family of 12 would need 39 kg of camel milk to meet its daily calory requirements and 17 kg to meet its protein needs. Rendille camels give about 1,300 litres of milk per year or 3.5 litres per day. A family of 12 would thus need 11 and 5 camels to meet its daily calory and protein requirements respectively. However, the average herd only includes 8 lactating females, and the

Table 11. *Composition of milk from various species.*

Species	Water (%)	Total Solids (%)	Fat (%)	Protein (%)	Lactose (%)	Ash (%)	Source
Camel	85.6	14.3	5.5	4.5	3.4	0.9	Knoess (1977)
Camel	86.96	13.04	3.3	3.87	5.15	0.72	Dahl and Hjort (1976)
Camel	87.24	12.76	4.2	3.7	4.1	0.76	ITV (1973a)
Camel	86-90	-	4-5.5	3.6-4.7	-	0.8-1.0	El Amin (1979)
Pooled average for camel	86.6	13.36	4.33	4.02	4.21	0.79	Author
Cow	86.2	13.8	4.4	3.8	4.9	0.7	Ensminger (1969)
Goat	87.0	12.9	4.1	3.7	4.2	0.8	Ensminger (1969)
Horse	90.1	9.9	1.0	2.6	6.9	0.35	Ensminger (1969)
Pig	82.8	17.2	5.1	7.1	3.7	1.1	Ensminger (1969)
Sheep	82.0	18.0	6.4	5.6	4.7	0.91	Ensminger (1969)
Human being	88.0	12.0	3.8	1.2	7.0	0.21	Ensminger (1969)

Source: Compiled by author.

Table 12. *Chemical composition of casein in camel, cow and goat milk (in g amino acid per 5.6 g N).*

Constituents	Camel	Cow	Goat
Amino Acids			
Alanine	3.05-.20	3.41	3.55
Arginine	3.15-.26	4.14	2.10
Aspartic acid	7.65-.56	7.47	7.38
Glycine	1.57-.14	2.08	2.10
Glutamic acid	23.40-.78	23.16	20.32
Histidine	2.51-.20	3.02	4.99
Isoleucine	6.40-.28	6.60	4.31
Leucine	10.44-.52	10.00	9.94
Lysine	7.58-.28	8.06	8.23
Methionine	3.47-.19	3.19	3.54
Phenylalanine	5.64-.29	5.41	6.00
Proline	13.28-.82	11.83	14.59
Serine	5.88-.26	6.60	5.16
Threonine	6.31-.19	4.30	5.73
Tyrosine	5.76-.42	5.80	4.77
Valine	7.40-.35	7.47	5.69
Other			
Ammonia	1.72-.15	1.81	2.16

Source: Adapted from Hoeller and Hassan, 1965.

deficit usually has to be met from the milking of smallstock. The Rendille raise an average of 120 sheep and goats per family, the lactating females of which yield about 17,500 kcal per day, producing an overall surplus of almost 10,000 kcal.

5.2 MEAT PRODUCTION

5.2.1 Supplies

Camel meat is rarely consumed among the camel herders of Africa. It is only eaten in critical periods of food shortage, or when entertaining guests, or for ritual and sacrificial purposes (Dahl and Hjort, 1976). Camels may sometimes be slaughtered in case of imminent death, or even after death (Spencer, 1973). The consumption of camel meat is considered a luxury among pastoralists.

Non-camel herding societies have only recently begun to awaken to the meat producing potential of the camel. There are few reports of efforts to breed and select the camel for meat characteristics in Africa. Nonetheless, Chatty (1972) stated that since the role of the camel as a beast of burden was fast becoming obsolete, the camel nomad has tended to respond by breeding for meat production. He quoted Coon (1952) as observing that the Rwalas are now raising more camels than ever before. Leupold (1968a) stated that the only safe future for the dromedary was as a meat animal.

There is one major area of Africa in which trade in camels for slaughter appears relatively well developed. Williamson and Payne (1978) wrote that in Kenya, Ethiopia, Sudan and Somalia, which together contain almost half the camel population of Africa, a considerable number of camels are managed and bred specially for slaughter. The area is undoubtedly a net exporter of camel meat. Bremaud (1969) pointed to a clandestine trade in slaughter animals over the Kenya - Somalia border, involving 600 - 1000 camels per month. He estimated that 25 - 30 animals were presented per day at Bulahaji market, and referred to a specially constructed camel abattoir at Archer's Post, where a total of 60,000 animals had been slaughtered over several years. At this facility products such as meat powder, bone meal, meat extract, fat, hides and manure had been produced. Leupold (1968a) estimated that 15,000 animals were slaughtered in Somalia every year, although the figure given by UNECA/FAO (1972) is almost 10 times higher. In Ethiopia, Knoess (1976) wrote that a large number of animals were exported for slaughter to Libya and Saudi Arabia yearly, and that the average price paid was about US \$ 0.35 per kg liveweight. In Sudan, which has the largest camel population in Africa, camels account for 5.4% of the national meat and milk producing stock (Wilson, 1978). Official slaughter figures for that country varied between 15,477 and 30,385 from 1970 to 1974 (El Amin, 1979). Besides meeting domestic demand, Sudan exports camels to Libya, Egypt and the Gulf States.

In a review of the meat industry of Egypt, Alim (1976) indicated that the indigenous camel population had declined by 37.7% from 175,000 to 109,000 between 1967 and 1974. The decline coincided with an increase in slaughter figures from 53,000 to 64,000 camels in 1973 and 1974, during which time the contribution of camel meat to domestic meat supplies rose from 14,000 to 17,000 t.

The only other area of Africa in which camels are thought to be fairly extensively used for meat is northern Nigeria, where Dada (1978) estimated that 3,410 animals were slaughtered between September and December at one abattoir in Kano.

Some governments, e.g. the Indian Government (Bhargava et al, 1965), now maintain extensive camel breeding farms. Large breeding farms are found in Russia, where the Bactrian camel is raised (Keikin, 1976). Commercial operations of this kind are, however, almost non-existent in Africa, where most pastoralist breeding and selection efforts have tended to emphasize baggage and riding characteristics more than meat production. This kind of selection has often resulted in distinct riding and baggage camel types and breeds, and these are the varieties which are generally marketed. The animals presented for meat are often worn out, incurably injured or barren (Williamson and Payne, 1978).

Knoess (1977) hinted that camel production is sometimes regarded as a primitive practice and is discouraged by certain governments in favour of cattle, sheep and goats.

5.2.2 Dressing Percentage

Writing generally about the indigenous livestock of eastern and southern Africa, Mason and Maule (1960) estimated that the average liveweight of the Kababish baggage camel was 450 kg and 350 - 400 kg for the Somali camel. Pratt and Gwynne (1977) estimated the average weight of the East African camel to be 400 kg, although mature males and females may attain weights of 550 and 500 kg, with a height (including the hump) of just above 2 m. Bremaud (1969) gave figures which yield an average weight of 450 kg for the Somali camels of northern Kenya. Dina and Klinteberg (1977) quoted the results of a French team which calculated the average liveweight of Somali camels in the Ogaden region at 554 kg and 309 kg for males and females respectively. Wither height varied from 165 to 215 cm. All recent figures are consistent with the range of 453.5 - 557.9 kg earlier given by Leese (1927).

In a recent study by Knoess (1976), who proposed a modified formula for estimating the liveweight of camels, the liveweight of mature Afar animals in the Awash valley of Ethiopia rarely reached 500 kg. The wither height was calculated as 1.75 m and the heart girth and abdominal circumference of three stallions averaged 1.85 and 2.12 m respectively.

The shoulder height of Darfur camels in southern Sudan ranged from 180 to 200 cm in females (Wilson, 1978). Wilson also found that girth circumference was not a very good indicator of individual weights, although it gave a fair estimate of group averages. Field (1979b), on the other hand, demonstrated a very high correlation between the three body measurements of shoulder height, heart girth and hump girth. The sum of these could be used to predict body weight, using a regression equation.

Williamson and Payne (1978) concluded that the average dromedary weighs 454 - 590 kg, while the average Bactrian camel is slightly heavier.

There is thus considerable phenotypic variation in the liveweight of mature dromedaries, whose age at full growth ranges from 6 to 7 years for males and 7 to 8 for females. As regards daily weight gain, Khatami (1970) refers to the results of feeding trials in Iran: in one case a ration of 15 - 20 kg of straw, beet pulp silage, molasses and barley was used, the barley not exceeding 10 - 15% of the ration, while in another the feeding experiment was carried out at a sugar beet farm where some animals were allowed to graze the sugar

beet tops. Female and male animals gained about 0.95 and 1.4 kg per day respectively. By comparison, zebu cattle gain 0.11 kg when poorly managed, and 0.34 kg when well managed from weaning to maturity (Ledger et al, 1967).

Khatami (1970) gave the average carcass weight of the Iranian dromedary as 300 - 400 kg, with that of the females being 250 - 350 kg. The same author further gave a figure of 650 kg as a possible carcass weight for the male Bactrian camel. Bremaud (1969) gave figures from which the average carcass of Somali camels in northern Kenya can be estimated to weigh 286 kg. He reported that the limbs are severed at the femero-tibial and humero-radial joints, and that these appendages could weigh up to 44 kg, yielding a further 22 - 26 kg of meat. The majority of the animals presented for slaughter were females. In a slaughterhouse study involving 60 camels, Wilson (1978) derived some very useful results which are reproduced in Table 13. The average liveweight of Darfur camels was 426.2 kg while the carcass weight was 208.5 kg, yielding a dressing percentage of almost 49%. His results also indicated that males generally have a higher dressing percentage than females.

Table 13. *Liveweight, carcass weight and dressing percentage of Darfur camels.*

	Males	Females	Total
Number of Animals	21	29	50
Liveweight (kg)			
Mean	447.9	414.4	426.2
SD ±	84.10	50.83	65.74
Range	305.5-581.0	307.5-522.5	305.5-581.0
Carcass weight			
Mean	231.3	196.3	208.5
SD ±	49.18	24.94	38.78
Range	104.0-310	141.0-248.8	141.0-310.0
Dressing percentage			
Mean	51.4	47.4	48.8
SD ±	2.88	3.25	3.65
Range	46.2-55.6	41.3-53.5	41.3-55.6

Source: Wilson, 1978.

The dressing characteristics of the camel are summarized in Tables 14 and 15. On the basis of the review by Dahl and Hjort (1976), it is evident that in general the dromedary has a higher dressing percentage than pastoralist cattle. It is not clear, however, whether the dromedary is capable of sustaining these high percentages under all management and ecological systems.

Assuming an average offtake of 4% for slaughter and a dressing percentage of around 50%, camels probably contribute about 100,000 t per year to African meat supplies, most of which are consumed on the continent.

Table 14. *Dressing percentage in camels and pastoralist cattle.*

Animal type	Dressing percentage	Source
Dromedary camel	41.3 - 55.6	Wilson (1978)
	54 - 57	Congui (1953)
	56 - 57	Dina and Klinteberg (1977)
	57	ITV (1973b)
	52.8 - 76.6	Kuznetsov and Tretyakov (1972)
Bactrian camel	50 - 63	ITV (1973b)
	56 - 70	Williamson and Payne (1978)
	48 - 50	Dahl and Hjort (1976)
Pastoralist cattle	45 - 50	Dahl and Hjort (1976)

Source: Compiled by author.

Table 15. *Weight of camel carcass, organs and appendages as percentage of liveweight.*

	Weight (kg)			As % of liveweight		
	Mean	SD±	Range	Mean	SD±	Range
Carcass						
Forequarter	120.2	22.21	79 -183.5	35.0	1.51	31.42-38.15
Hindquarter	84.5	14.53	59.5-124.5	24.7	1.38	20.98-28.53
Hump	4.0	4.3	0 - 20.0	1.1	1.04	0 - 4.45
Total	208.5	38.78	141 -310	60.7	2.09	55.75-65.11
Organs						
Heart and lungs	8.4	1.13	6.5- 10.5	2.5	0.33	1.78- 3.36
Liver	7.5	1.45	4.5- 11.0	2.2	0.41	1.47- 3.45
Appendages						
Head (skinned)	12.1	1.81	8.5- 16.5	3.6	0.32	2.8 - 4.49
Feet	14.6	2.25	10.5- 19.5	4.3	0.37	3.31- 5.16
Hide	34.8	6.11	22.5- 47.0	10.2	0.81	8.50-11.76

Source: Adapted from Wilson, 1978.

5.2.3 Meat Quality

Chatty (1972) and El Amin (1979) stated that camels mature comparatively slowly. Dahl and Hjort (1976) wrote that camels can be slaughtered at between 4 and 10 years. With increased age, however, there is an increase in meat toughness; the meat also becomes less tasty and of inferior quality. Quoting Russian work, the latter authors suggested that the best age for slaughter is 2.5 years, a figure consistent with the 3 years given by Dina and Klinteberg (1977). At this age the animals average about 300 kg and are not yet fully grown. Their meat is young and tender.

Most pastoralists prefer the meat of young camels aged 4 to 6 months, often associating indigestion with the consumption of meat from calves of 3 months or less (Dahl and Hjort, 1976). Leupold (1968a), Fischer (1975) and Knoess (1977) all assert that the meat of young camels is comparable in taste and texture to beef. Leupold (1968a) described the meat of the camel as palatable, coarser than beef, varying in colour from raspberry red to brown-red and having white fat. It contained a lot of glycogen and was therefore sweet in taste, like horse meat. Khatami (1970) indicated that in appearance and colour, texture and palatability, camel meat is very similar to beef, adding that the carcass of a well fed camel is uniformly covered with a thin layer of good quality fat.

Nasr et al (1965) indicated that the meat of young camels (below 5 years) has a higher moisture content (78.27%) than that of older animals (76.24%) and estimated the protein, crude fat and ash contents of the two age groups as 20.07 and 22%, 0.92 and 1.01%, and 0.76 and 0.86% respectively, with no significant difference between the sexes. Despite the higher moisture content, meat extract output was 1.5 - 2.5 times higher than for beef, owing to the high creatinine content. Little marbling was associated with camel meat. Comparative meat composition figures for the various animal types given by Nasr et al (1965) are shown in Table 16. Dahl and Hjort (1976) adopted figures of 21% protein and 1% fat as standards for camel meat in their calculations.

Table 16. Mean values of different meat components in bulls, cows, steers and camels.

Type of Animal	Water %	Protein %	Fat %	Ash %
Bull	76.41	20.95	1.20	1.05
Cow	75.52	21.19	3.99	1.02
Steer	72.98	20.41	4.88	0.97
Camel 5 yr or more	76.24	22.02	1.01	0.86
Camel under 5 yr	78.27	20.07	0.92	0.76

Source: Nasr et al, 1965.

Unfortunately, in spite of all the indications of the superior quality of meat from younger animals, there is a great reluctance on the part of camel herders to sell off their stock at this age. Most trade therefore consists of meat from much older animals, the low quality of which has a direct bearing on the extent of demand for camel meat outside the camel herding societies. A typical example is given in the study by Bremaud (1969) in northern Kenya, in which data collected at Wajir market showed that the average age of 26 animals slaughtered was 14.5 years. It is therefore hardly surprising that camel meat is often labelled inferior in urban societies, and its consumption is considered fit only for the poor (Cole, 1975). Nevertheless, evidence is emerging that when certain standards are set and adhered to, camel meat can be successfully marketed alongside that of cattle, sheep and goats.

Some nomadic peoples consume the blood of camels. There is no indication as to how much blood can be recovered at slaughter, but Wilson (1978) has estimated that the amount of blood and fluids lost at slaughter is equivalent to 9.1% of the final carcass weight. In the case of Sudanese camels, losses ranged from 31 to 53 kg for 14 mature males.

Pratt and Gwynne (1977) indicated that in Turkana camels are extensively used to provide blood for human consumption. An adult camel will yield 5.5 litres per bleeding and may be bled twice a month.

5.3 RIDING CAMELS

While the role of the camel as a major means of transport is diminishing with the advent of more modern methods, the riding camel is still an efficient means of communication in remote areas. It is used by police patrols, extension agents and the nomadic people themselves, and is unlikely to become wholly redundant in the foreseeable future. In fact it is conceivable that as world fuel reserves run down, the role of the camel as a means of transport will be maintained. The function of the riding camel in times of peace and war in the past is well documented (e.g. Robertson, 1938; Green, 1885/86). Green indicated that mounted camels were probably used in warfare as far back as 190 B.C. Nowadays, camel racing is still a popular sport throughout the Arab world.

The riding camels of Arabia, Egypt and the Sahara are known as the Dilool, the Hageen and the Mehara respectively (Leese, 1927). Within this broad classification many local riding types are found.

5.3.1 Conformation and Performance

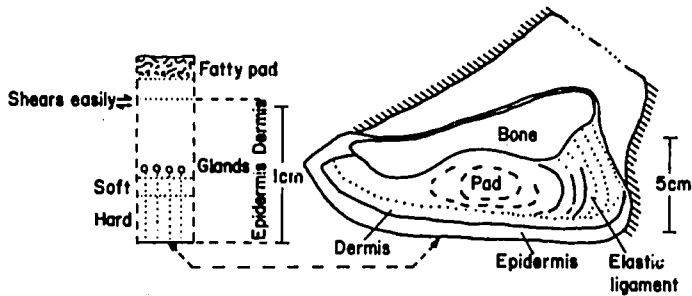
There are few indications as to the qualities expected of the ideal riding camel, but there is some agreement that the Beja types of the Sudan come nearest to the ideal. The best descriptions of Sudanese riding camels are given by Gillespie (1962) and Epstein (1971). They refer to the Beja camels of the Bishar, used by the Amarar, Hodendowa, Benir Amir and Habaab tribes of the Red Sea coast and Eritrean hills, and also to the Anafi or Shukria camel found east of the River Nile in Sudan. Unless otherwise stated, the following account is based mainly on the observations of these authors.

The riding camel should be slender and long-legged, with a strong but not coarse bone structure. A mature riding bull should display the signs of masculine strength, boldness and symmetry. A short head with a high domed forehead, a roman nose and a fairly deep muzzle with firm, even lips are expected, combined with large prominent eyes and small pointed ears well pricked forward to give an alert expression. The neck should be slender, short, muscular, high set and blending evenly into the shoulders. The general line from the chest should be straight forward for two fifths to a half of its length, before it makes an abrupt upward turn. The set of the head in relation to the vertical neck portion should simulate an inverted L and the head should be maintained almost level with the hump. The shoulders should be deep, strong and well covered. The animal should show strong chest and upper arm muscles, the elbow being carried clear of the lower chest. The chest proper should be wide with deep, well sprung ribs. A short back and symmetrical hump are characteristic of animals in good working condition, and full, well muscled loins are also normally expected. A dropping rump of medium length is characteristic of riding camels. The animal's thighs should be broad, thick and full, such that when viewed from the back the animal should not appear too "split up". The second thighs should be broad and muscular. Muscular forearms and strong, heavy knee joints, combined with moderately straight,

closely set hocks are considered the ideal. The cannon bone should be clean and flat. The front feet are expected to be fairly straight while the back ones should be slightly turned out. Tough, horny soles showing even wear are considered ideal, camels from hilly terrain being often recognized by the hypertrophy of the soles and the uneven wear of their nails.

Bligh et al (1976) gave an account of the special adaptive mechanisms and anatomy of the camel foot, which help the animal to travel and work in the sandy and often rough terrains in which it lives. The elaborate design of the foot is shown in Figure 10. It resembles a tyre, but is filled with fat rather than air. The fat is arranged in a series of fatty pads separated by cartilaginous septae and surrounded by a strong collagenous wall, except at the rear end where elastin is the major component. Above and below the fatty pads, there is a 1 cm layer of thick, rubbery epidermis, which is constantly moistened by the sweat glands running through it. These fatty pads are mainly composed of neutral triglyceride, consisting of 75% unsaturated fatty acids. This type of fat becomes fairly liquid at low temperatures, thus enabling the camel to walk on cold surfaces without the pads becoming solidified.

Figure 10. Longitudinal section through the foot of the camel (*C. dromedarius*) with (on left) the sole shown in greater detail.



Source: Bligh et al, 1976.

In general a thin, supple skin is the expected norm for riding camels. The hair of the Beja camels is short and closely set, but they may carry a full growth around their shoulders and throat, especially during the winter. Young and female camels often have more hair than the males, while castrates develop more curly hair, especially round the hump. Colours vary between breeds. The Bishari camel may be sandy, grey or white in colour, the latter being the most highly prized.

Turning to the Anafi camel, this breed is also said to be a good riding animal, although not of outstanding quality since it is bred for speed rather than for stamina. It is less robust than the Bishari, but fast and smooth, having no rival for distances of up to 40 km.

With regard to the performance of riding camels, Dina and Klinteberg (1977) refer to some outstanding feats of speed and endurance. When only one rider is carried

with about 54 kg of baggage, the camel is capable of 10 km per hour and may cover 48 km a day for long periods. If no baggage is carried the animal may move at 15 - 19 km per hour, covering 80 km a day for 2 weeks (Leese, 1927).

Leese described four speeds or paces for riding camels: walk, jog, fast run and canter. He indicated that the normal walking speed is 4 km per hour, while that of the jog, the pace most frequently used, is around 8 - 12 km per hour on level ground. During the fast run, which he described only for the North African and Arabian camels, speeds of 14 - 19 km per hour may be recorded. This speed should not be maintained for longer than 1 hour, and camels should never be made to canter, since both the animal and the rider quickly become exhausted. Gillespie (1962) recommended that the canter should be used only for short periods, e.g. for shows or races. He observed that every riding camel has an optimum speed for comfortable riding. For the Beja camel (reputed to be the best riding type) it is 8 km per hour. He categorizes the riding paces as the "jog" or "slow trot" (8 km per hour) and the "fast run" (16 - 32 km per hour). Figure 11 depicts some of these paces, as described by Cauvet (1925).

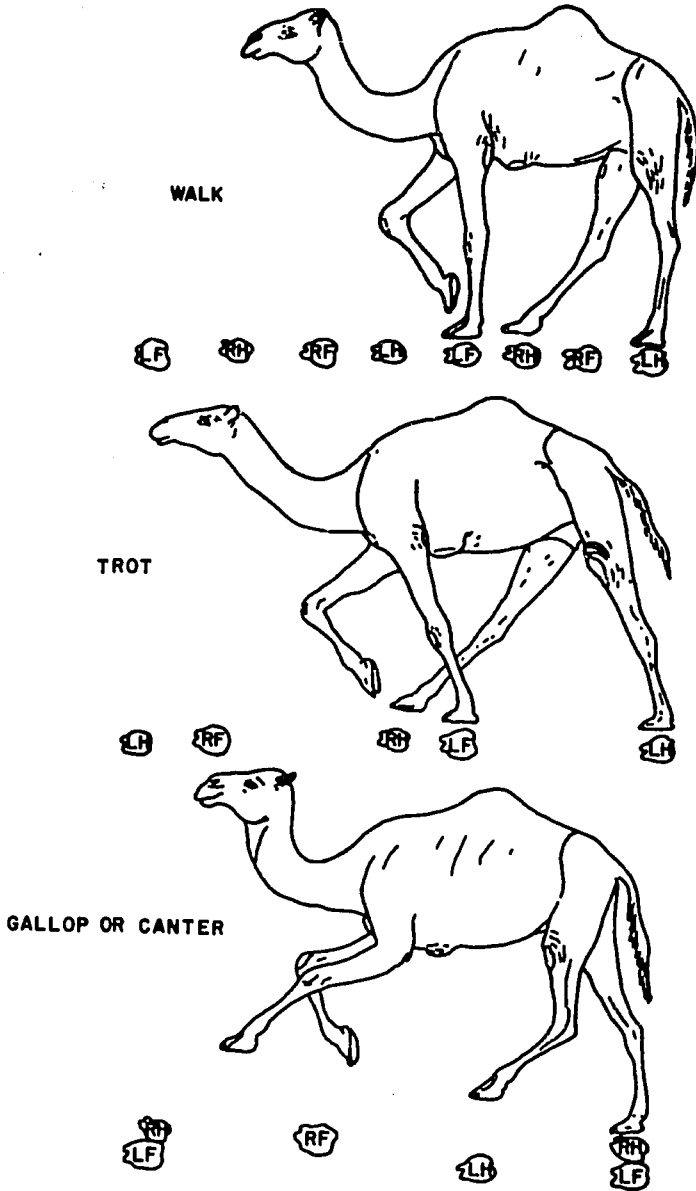
5.3.2 Training and Equipment

Indian authors offer some extensive descriptions of the raising and breaking in of riding camels. Singh (1963) and Matharu (1966) recommended that the best age for breaking in a riding camel is about 3 years. Waiting until after this time may result in stubborn and troublesome animals (Nanda, 1957). Knoess (1976) reported an incident in Ethiopia where a 7-year-old Adal camel had to be roped and starved for 3 days to break him in. Initial obedience training consists of head control, which is achieved with a head-roped in conjunction with a nosepeg made of wood, bone or metal. Next the camel is taught to sit and stand on command, and to submit to mounting in the sitting position (Leese, 1927). Camels often tend to take off when the rider is only half mounted and special care has to be paid to this shortcoming during initial training. The animal is then taught how to respond to reins, before being subjected to the various paces. Before the age of six, the animal should never be given an adult load. Amounts of luggage are gradually built up in proportion to the animal's age and strength. Singh (1963) warned that riding camels should never be struck on the back of their necks, recommending that the best point to "tickle" a camel was behind the right leg of the rider.

The riding camel may be driven by means of a nosepeg, nosering, bridle or halter. Singh (1963) recommends piercing the camel's nose at an early age when the nosepeg or ring is to be employed for riding. Different peoples prefer different instruments for riding, e.g. the nosepeg or ring in India, bridles in Egypt and the halter in Sudan (Leese, 1927). Leese observed that the nosepeg is often used in association with one or two strings, depending on how many nostrils are pierced. The same type of nosepeg may be used to drive both riding and baggage camels. Noserings are usually small (about 1 cm in diameter), made of silver or silver plated, avoiding iron which leads to heat and rust problems. Bridles used for riding are like those of pack camels but smaller, and are used with leather straps and nosebands. Halters are only considered suitable for riding docile animals of placid temperament, used to handling from an early age.

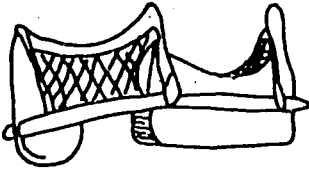
Some of the various types of riding saddle are illustrated in Figure 12. Two types are described by Leese (1927): the Arab *markloofa* used by single riders, and the Indian *pakra* employed when two riders mount the same animal (Figure 12.1). The former

Figure 11. *The three common paces of the dromedary.*

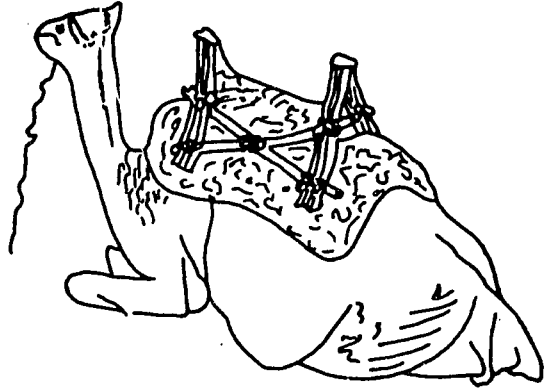


Key: RF = Right front, LF = Left front, RH = Right hind, LH = Left hind

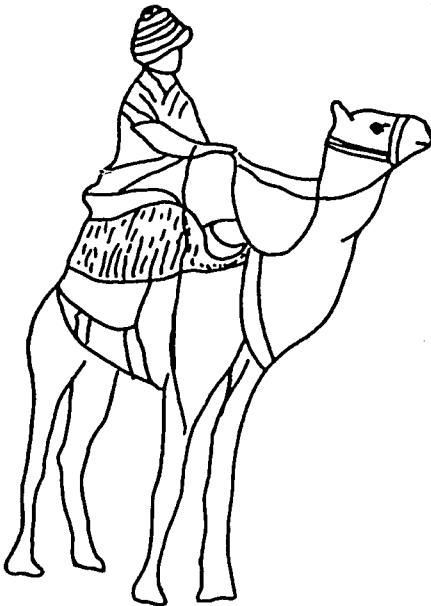
Figure 12. Riding and baggage saddles of the dromedary.



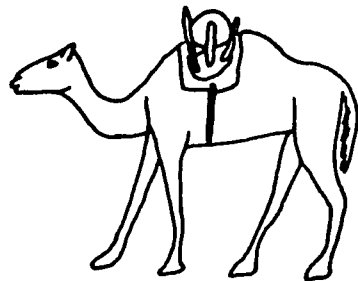
12.1. The Indian *pakra* saddle for two riders.



12.2. The North Arabian saddle used in the Sahara.

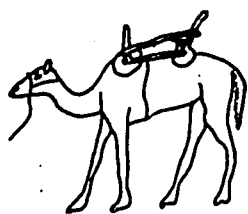


12.3. Typical sitting position with the North Arabian saddle.

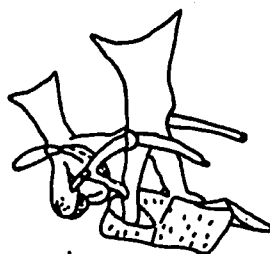


12.4. The Mauritanian *rahla* saddle.

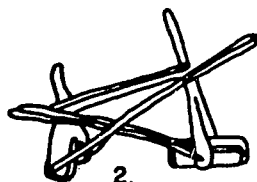
Figure 12. (Continued).



12.5. The Teda *terke* saddle.



1.

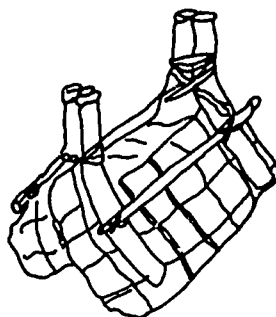
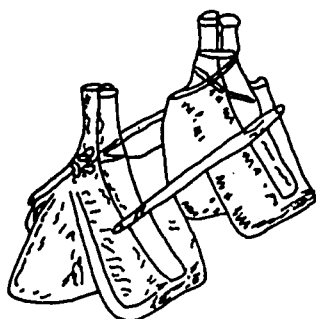


2.



3.

12.6. 1 and 2 from Mauritania;
3: used amongst the Tede.



12.7. Baggage saddles or *hawia*, from Sudan.

Source: Adapted from Bulliet (1975) and Acland (1932).

is a general term for a lighter saddle designed for more rapid paces, typified by the North or South Arabian and Saharan saddles (Figures 12.2 - 12.6). A sheepskin is sometimes used on top of the saddle. Bulliet (1975) gave an extensive account of the North Arabian saddle (Figures 12.2 and 12.3), invented around 500 to 100 B.C. In this type the rider is located on top of the hump, whereas with the South Arabian saddle he is seated behind the hump.

Variations of these two basic types are found in most camel herding societies. The North Arabian saddle primarily consists of two arches (saddlebows), shaped like an inverted V. The two arches are attached to one another by straight or crossed horizontal bars or sticks on each side, to give a rigid, square structure with a hole in the middle. One arch is located in front of the hump and the other behind it. The open space in the middle is filled with cushioning, e.g. a blanket or sheepskin. The saddle is designed so that the rider's weight is distributed evenly over the rib cage, rather than directly over the hump. Bulliet noted that in the Middle East variants of the North and South Arabian saddle constitute the entire range of saddle designs.

Three types of saddle are found in the Sahara, all designed so that they rest on the camel's shoulders, in front of the hump. The Saharan shoulder saddles offer many advantages, one of which is better animal control, since the rider rests his feet on the animal's neck. Examples are the *terik* and *tabyast* saddles of the Tuareg. Other advantages of shoulder saddles over the Arabian saddles are their light weight, simple, single-girth attachment to animals and the need for fewer alterations to padding to accommodate changes in the size of the hump. Although a shoulder saddle, the *rabla* saddle from Mauritania and the western Sahara (Figure 12.4) does not allow foot control, owing to the presence of an arch located in front of the rider. The *terke* saddle (Figure 12.5), common among the Teda people of the southern Sahara, is an intermediate type between the North Arabian saddle and the shoulder saddle. Although for the most part it resembles the former, its back arch slants backwards, with the side bars attached higher and closer together, making the front end broader. The rider perches at the very front, often in front of the hump (Bulliet, 1975).

Bulliet (1975) indicates that in spite of the recognized superiority of the Saharan shoulder type, saddles for the women of the Sahara region (Figure 12.6) are usually constructed along the lines of the North Arabian saddle. Paradoxically, however, in northern Arabia saddles for women are based on the South Arabian design.

5.4 BAGGAGE CAMELS

5.4.1 Conformation and Performance

There is no general agreement on the ideal physique of the baggage camel. Acland (1932) suggested that the first consideration in selecting a baggage camel is whether the animal is to be used for walking or for trotting. It should be robust, heavy and well furnished with bone and muscle. Acland (1932), Leese (1927) and Mason and Maule (1960) also indicated that either a small or a large head with a narrow roman nose, prominent eyes and large lips may be favoured. The neck should be medium to long, resulting in the head being carried high, and should be set low down the chest. The chest should be deep, with ribs that are neither too flat nor too round. The last three ribs should be well developed. The hump should be firm and well developed. There should be plenty of space behind the hump for the saddle. The forelegs should be straight but may be wide apart. Turned-out toes tend to predispose to "brushing" at the elbow. The leg bones should be heavy. Fairly large and flat hooves are also indicators of good baggagers. The hindlegs should be heavy and well muscled so that the animal is not too "split up". Straight hocks are also preferred. The tail should be high.

Major determining factors of the loads carried by both riding and baggage camels include the breed, size and age of the camel, and the distance to be covered. Additional influences are the terrain, the pace and the amount of available grazing on the route (Singh, 1966). Baggage and pack camels should not be driven for longer than 8 hours a day, and not longer than 6 hours without rest. If an average speed of 3 - 5 km per hour is maintained, then 30 km or more can be covered per day, which is considered adequate. Higher speeds may result in shifting loads and sore backs, which may damage animal performance. A single camel or a group of three moves faster than a column or caravan.

Williamson and Payne (1978) estimate that a load of 159 - 295 kg can be carried by a baggage camel for 24 km per day over an indefinite period, while 544 kg may be carried over a shorter distance. They also cite the work of Podberezkin (1951), who noted that the Bactrian camel can pull a load of up to 1,500 kg. Green (1885/86) reported that some Egyptian camels were able to carry 160 - 180 kg and two riders without showing distress. These estimates compare favourably with reports on the Turkana camel, estimated to carry 100 kg without stress (Pratt and Gwynne, 1977) and the Bactrian camel in Mongolia alleged to carry 130 kg for long journeys covering 35 - 50 km per day, or 275 kg for shorter trips of 85 km (ITV, 1973b).

Leonard (1894) recommended that the hours of 10 a.m. to 4 p.m. should be left for grazing, since it was preferable to move during the cooler parts of the day. On the rare occasions when camels have to be driven for 12 hours a day (a practice which is difficult to justify), the animals should be rested for a full day in every four of such extended marches. It is advisable to rest the animals in a kneeling position, as standing with a full load is conducive to rapid exhaustion. At the end of the day's march the pack saddle should not be removed immediately after the baggage, in order to avoid rapid chilling and possible blood vessel congestion, which will damage the back skin.

Camels are poor climbers, and shorter stretches are recommended on uphill terrain. They are almost helpless under muddy conditions because of constant slipping, and although they are good swimmers they may have to be forced into the water.

The baggage camel is introduced to work at 5 years but should not be given full loads until 6 years old (Matharu, 1966). However, it can be broken in at any time after 2 years (Leese, 1927). Various ways of managing young camels between 2 and 5 years old are given. Generally, the young are taught how to stay in the line of trek by having a rope or halter tied round their necks and attached to a quiet adult. This part of the training is considered complete when the young camel can be led by a rope tied to the tail of the adult in front. When the nosepeg is used for driving, the nostrils have to be pierced at least 1 month before the instrument is inserted. During this time the young camel is taught how to sit in response to noserope commands during halts, carrying a baggage saddle which is loaded with increasingly heavy weights. Only when it is fully grown should it be given a full load, which is always proportional to its strength. A travelling column of camels is usually led by the finest and strongest bull. The animals are usually connected by a noserope to the tail of the animal in front. It is also possible to drive camels without these leads, a practice which is discouraged wherever motor traffic might be encountered. If camels in desert conditions can be led unattached, the advantage of allowing some limited and vital grazing en route is gained, although this will undoubtedly slow down the pace.

5.4.2 Training and Equipment

Different types (Indian, Arab and Somali) of pack saddle were described by Leese (1927). A typical baggage or pack saddle from Sudan, called the *bawia*, was illustrated by Acland (1932). It is made of two arches joined by side bars, like the North Arabian riding saddle (Figure 12.7). The structure is then fitted, either by means of two pads stuffed with grass or on four *bedids* (leather pads) kept in position by leather loops, which also allow for easy detachment. When pads are used, their inner sides should be made of canvas. It is always important to ensure that the saddle fits the camel properly, especially after the rainy season when the conformation of the animal generally changes. Poorly fitted saddles result in sore backs. For this reason, extra grass is always carried to adjust the shape of the pads, which should also be emptied frequently to avoid their becoming too hard and nobbly. Acland also noted that some native saddle pads are made entirely of grass, with no canvas bag.

Although commercial saddles are available, it is generally felt that each camel should have its own specifically designed pack saddle. A well fitting saddle to a great extent determines the output of baggage and pack camels. Pack camels are loaded by balance, and the best system is thus to have all items divided into two equal halves which are then slung on either side of the hump. Flattened packages of uniform size and weight are always preferred. In case of rain all the ropes should be adjusted, as they tend to contract and can cause pressure sores.

In addition to the head gear and saddles, other items which are used or carried while riding include loading ropes, leg-ropes or hobbles, a feeding bag, a saddle repair kit and a blanket for the night. Further equipment might include breast pieces, a crupper and tarpaulins. Nets have also been used for loading, but loading ropes are usually preferred.

5.5 DRAUGHT CAMELS

The draught camel may be used for a variety of functions, including pulling carts, drawing wheels, ploughing, and conveying water. It is also used in processing plants, e.g. sugar cane crushers and oil mills (Matharu, 1966). The physical conformation of the camel is not considered very conducive to these tasks, although some encouraging results have nonetheless been achieved. There is no available description of the ideal draught camel, but the main qualities utilized are the brute strength of the animal, its ability to go without water for long spells, and its flat feet, which are considered ideal for treading on sandy surfaces. It is often used singly or in pairs, and sometimes in a combined team with a bullock or buffalo (Leese, 1927). The use of the camel for draught is thought to be increasing in both Africa and Asia.

The draught camel is capable of ploughing at a pace of approximately 2.5 km an hour. It is recommended not to work camels for longer than 6 hours a day, 4 hours in the morning and 2 in the afternoon (Nanda, 1957). In Ethiopia experiments have shown that one Adal camel performs work equivalent to two Harar oxen. In a ploughing experiment, Knoess (1976) reported coverage of 500 m² per hour or 1 ha per 20 hours, ploughing at 16 cm depth. He found camels better for work than cattle, since they were easier to train and maintain, more hardy under heat and radiation, could be locally purchased and required

lower feed costs as they utilize a wide variety of local herbage. Reporting on draught camels in Sudan, Wilson (1978) estimated that the dromedary could exert the equivalent of 1 hp of energy during ploughing, covering 1 ha in 11.25 hours. The energy output was slightly higher during oil milling, at about 1.2 hp. In both respects the camel was better than most other domestic species except the horse. A major difference between using oxen and camels for ploughing is that the labour requirement is generally higher for camels : one person is usually required to lead the animal, while the second works the plough from behind. Camel-operated wells have also proved efficient along the northern fringes of the Sahara, where they provide water for many artificially irrigated plots.

The wide range of uses to which the camel can be put has resulted in considerable variation in the implements used to exploit the animal's abilities and strength. Knoess (1976) reported on the modification of the ox-plough to fit the camel. Leese (1927) reported that more than one camel can be harnessed together, and the equipment used in such cases is also described in detail. The type of cart and harness used is a major factor in determining output: with ordinary harnesses Indian camels drew 326 kg, but by using a specially harnessed cart the weight could be increased to 816 kg (Singh, 1963).

The temperament of the camel has been described as passive (Leonard, 1894). Williamson and Payne (1978) described the camel as an amenable, patient animal easily trained for work. Singh (1963), however, cautioned that in spite of this docility the camel can be savage and violent when improperly handled. It is capable of sudden fits of rage, pronounced among males during the rutting season, for which reason it is always advisable to separate the sexes during work (War Office, 1908). Leonard (1894) described a few unfortunate experiences, ranging from simple kicking to severe injury. Geldings are always easier to handle than entires. Reports have been made (BMA, n.d.) that certain breeds become timid in the presence of Europeans, while others, like the Somali camel, become nervous and panic at night.

The camel possesses tremendous powers of endurance and hardiness. It is recorded that pain is borne by these animals with unusual stoicism. They will continue to labour without showing marked symptoms until they are completely exhausted by disease or privation (War Office, 1908). It is therefore imperative for camelmen to keep a constant watch on their animals, since they may easily be overworked to death (Nanda, 1957). It is this capacity to work under difficult conditions, and its ability to go without water for long spells, that differentiate the camel from other transport or draught animals. It is noted that after reaching the limits of its endurance the camel will either die or take a very long time to recover. Immature animals should not be given excess loads and very old animals should not be forced to overwork. The fact that castrates work better than entires and are more docile should not be overexploited. When properly handled and looked after camels may live up to 45 years.

5.6 CAMEL HAIR AND HIDES

In hot climates camels do not develop long coats, with the result that there are very few data on camel hair in Africa and Arabia. However, given below is a brief summary mainly using data from India, Russia and other areas where production is more common.

Camel hair is light and durable and has low conductivity. It is thus considered excellent for making blankets and other warm garments. The best hair is supposed to come from young animals or those in the wild state (Singh, 1966). In India it is common practice to clip the camels in spring, when 1 - 1.5 kg of hair may be recovered, but animals from colder areas may yield up to 5.4 kg per clipping (Nanda, 1957; Singh, 1966). Leupold (1968a) observed that the annual wool production of the Bactrian camel ranges from 5 to 12 kg per animal, with a yield of 76 - 83 % after cleaning. The best quality came from 1-year-old animals, where 85% of the hair was pure wool with a diameter of 16 - 18 μ . He noted that by contrast most dromedaries give only 1 kg of wool per year. Hartley (1979) estimated that Somali camels are capable of providing 0.5 kg of hair per year. The hair could be clipped or simply pulled.

Keikin (1976) reported on wool production from a herd of 4,300 camels in Russia. Annual wool production in 1970 and 1974 was 557 kg and 576 kg respectively. Williamson and Payne (1978) quoted Russian data indicating that the Bactrian camel is capable of providing 4.5 kg of hair per yield, the quality depending on the age, sex and breed of the camel. Young Bactrian camels are reported to yield higher quality hair than older animals. Knoess (1976) observed that dromedary foals under 2 years old have a very fine undercoat that tends to fall off and should be cropped by hand. Asad (1970) reported that camel hair was excellent for weaving tents and rugs.

Camels are clipped with hand shears. Efforts are made to shear as close as possible, taking care not to injure the skin. On working animals the saddle seat is left unclipped in order to guard against galls. Young calves are not clipped in India since their hair protects them against the hot monsoon winds. In the cold season, clipped animals should be covered with a blanket at night.

Animal care after clipping often includes oiling the body. The animal is shaded for some time to avoid blistering when exposed to the sun. Two days after oiling the camels' bodies are covered with mud which is removed by stripping three days later. This practice is an attempt to minimize parasites, and has been found satisfactory (Nanda, 1957; Singh, 1966).

Camel hides are little used for leather making since yields are alleged to be poor. Almost no data are available on this subject.



A traditional function of the camel: moving camp in the Afar area of Ethiopia.



Balancing the load correctly is an important skill when using the camel as a baggager.

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Fetching water in the dry Afar country of Ethiopia; once trained, camels can be easily led in a column.

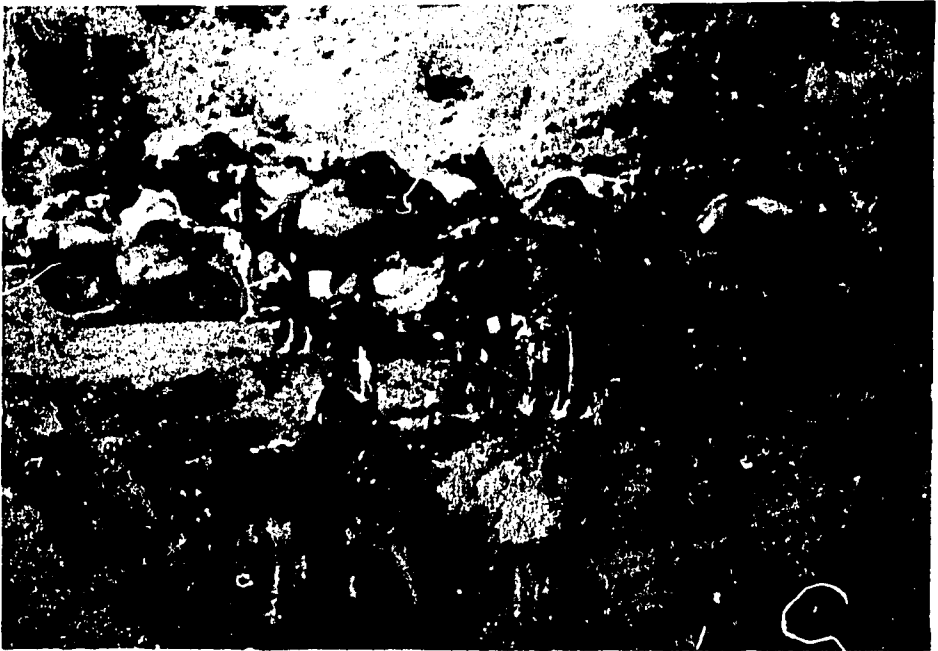


Mature male harnessed for ploughing trials in the irrigated Awash Valley of Ethiopia.

SOC

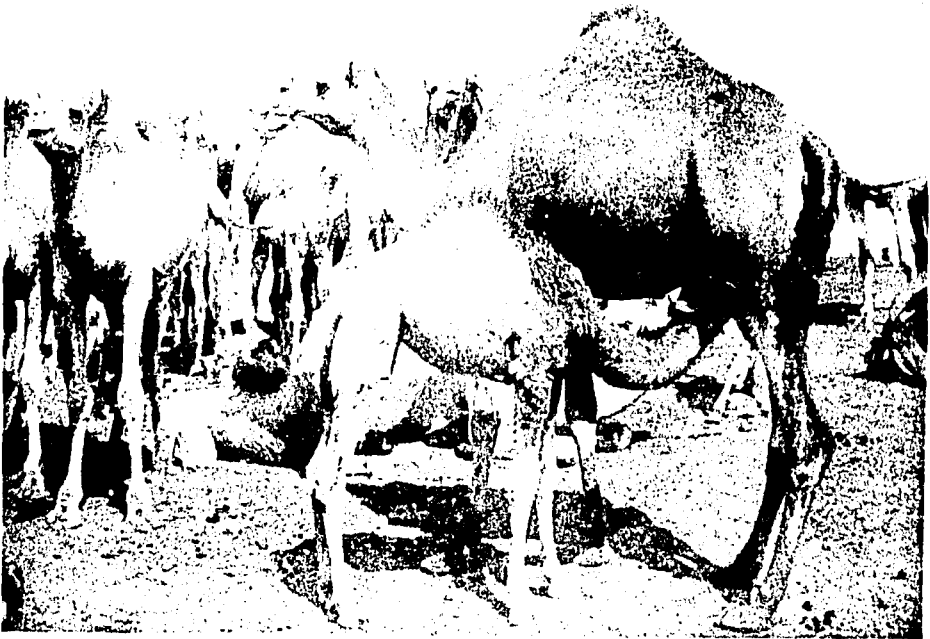


A Sudanese riding camel, equipped with the north Arabian saddle, positioned over the hump.



Watering a large herd in southern Sudan: the need to add salt in a watering trough considerably lengthens the task.

sod

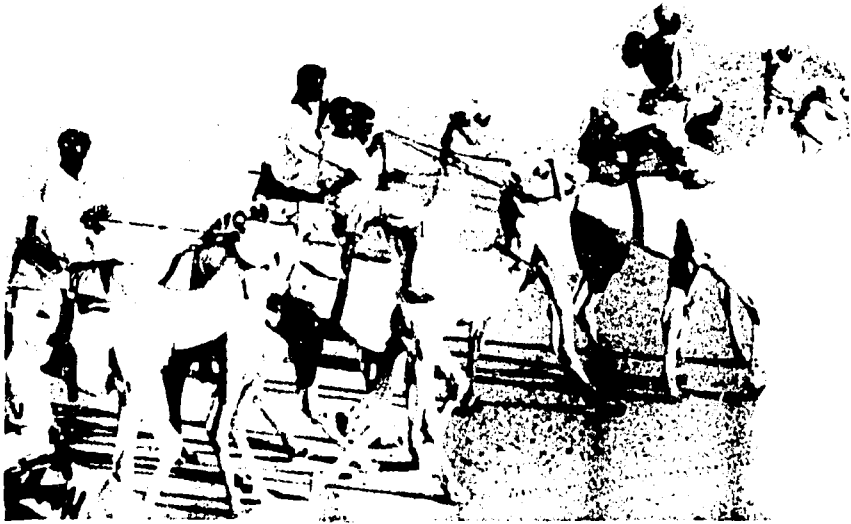


The best camel wool comes from young animals: a suckling calf at Omdurman market, near Khartoum.



Conserving water by reducing exposure to heat: while resting, camels huddle together facing the sun to reduce sweat loss.

426



Walking to the start of a camel race, a popular sporting attraction in Khartoum and throughout the Arab world.



The winner, in the traditional sidesaddle riding position combining comfort with easy animal control, even while racing.

6. MANAGEMENT AND SOCIO-ECONOMIC FACTORS

6.1 GENERAL

Social and economic factors have a great influence on camel herd management and production, yet most of these factors are poorly understood and almost none have been rigorously quantified.

The camels of Africa and Arabia are exploited in various ways and to varying degrees by different pastoral groups. The management system depends on many factors, including the environmental conditions and the composition and size of the herd in relation to those of the family (which determine what the herd is expected to contribute and what labour is available for herding), but one of the most fundamental factors is the degree to which the herders are dependent on their camels. Three broad categories emerge here: The first is exemplified by the Murrah Bedouin of Arabia, who depend almost entirely on their camels. They raise virtually no other livestock (Cole, 1975) and as a result they owe their survival to their camel herds. Inevitably they accord their animals great care and respect.

In Africa, on the other hand, other types of livestock are usually raised in addition to camels, especially sheep and goats and sometimes cattle. Camels are then part of a mixed livestock economy, as in the case of the Gabbra people of northern Kenya, who regard camel husbandry as the mainstay of their subsistence and a basic component of their cosmological order, but who also raise large flocks of smallstock (sometimes numbering 200 - 400 animals) as well as some cattle. Several societies other than the Gabbra utilize camels within a mixed livestock economy but generally rely less on their camels and more on their other stock to meet subsistence requirements, as in the case of the Afar of Ethiopia. Both the Gabbra and the Afar may be broadly regarded as belonging to the second category of camel raisers.

The third category of camel herders is illustrated by the Kababish Arabs of the Sudan and the Jawabis of the western desert area of Egypt. Although these people are often regarded as camel herders, they in fact raise more sheep and goats and maintain settled villages where crop production is possible, providing a further addition to the subsistence

base (Awad, 1962). In this third category there is not only reduced dependence on camels for subsistence, but also potential for the use of camels for draught purposes, which does not arise in the first two categories.

For all three of these categories the camel herd is a source of prestige, capital and wealth which is built up during favourable periods and which is often saved by its greater mobility during times of hardship. The camel is therefore a basic resource for many pastoral groups in the arid areas of Africa and Arabia. When droughts occur (as they often do) camels prove to be the primary source of subsistence and mobility, and hence the key to survival (Hartley, 1979).

6.2 SOCIAL ORGANIZATION AND OWNERSHIP

Capot-Rey (1962) has suggested that nomadic societies flourish in a climate of liberty bordering on anarchy. Awad (1962) has further suggested that nomadism is a way of life characterized by simplicity and frugality, and that those who practise it acquire the habit of freedom and the dislike of controls and limitations imposed by authority of any kind. In fact, however, the individualism of the pastoralist and his taste for independence are always tempered by a second major factor affecting social organization, namely the need to provide for collective security. Groups of camel herders come together not only to exploit natural resources better, but also to provide protection against misfortune or insecurity. Exchange of livestock within and between groups is a common practice to spread risk and build supportive relationships, and structures of some sort exist in all pastoralist societies to arbitrate in disputes and supervise compensation to injured parties. Only rarely, however, do such controls apply to the allocation of grazing. An indication of how different forms of social and territorial organization affect camel management can be obtained by considering briefly the situation of the few societies cited in the introductory section above.

The Murrah Bedouin are a camel-raising pastoral group in southeastern Arabia. In this harsh environment survival depends on the symbiotic relationship between man and animal. Camels are raised for milk and only very rarely slaughtered for meat. The diet of camel milk is supplemented with rice, dates and bread, but the camel remains the kingpin of survival. Most of the Murrah raise no sheep and goats, and the few that do own small ruminants usually entrust them to others specializing in smallstock husbandry.

Cole (1975) reported that the Murrah clans (of which there are seven) are residual units with no active role in the economic organization of society. They are vested with no authority over wells or pasture, their functions being mainly political. They are not involved in decisions relating to migration or the ownership and disposal of animals. Instead the household is the basic social and economic unit, comprising an elderly couple and the children and grandchildren. Households tend to operate independently and may be widely dispersed, but they also join other households when conditions are more favourable. Herds are mainly built up through the inheritance of animals from the paternal grandfather. Other animals are acquired through the dowry system, or through inheritance by women who marry into the family. The head of the household owns the core of the herd, but he cannot sell or give away stock without the consent of its other members. The division of the herd signifies the splitting up of the family or household.

According to Torry (1971), the Gabbra of northern Kenya regard themselves as derived from many different tribes. Gabbra camps consist of 4 - 10 households, between which livestock may be given away, exchanged or lent out. The Gabbra may borrow milking animals when their own are in calf and dry. They manage borrowed animals independently but do not own them. A common type of exchange, useful in building up a herd, occurs when a man lends a young male camel to another man, who looks after it and castrates it. He continues to work the camel until it is mature, and when he returns it to its original owner an additional young female camel is given as a gift in return for the loan. Such livestock exchanges or substitutions provide mutual assistance and security over the long term. Debts or obligations may remain dormant for a long period, until the time of need arises and the animals are recovered. Exchanges also afford an opportunity to spread animals over a large area, reducing losses from localized disasters. The Gabbra sell sheep and goat skin, or live animals, including cattle, to pay for subsistence purchases, but camels are never sold.

The Afar of Ethiopia raise sheep, goats and cattle as well as camels. Herding tasks are divided among the various family members. Every Afar starts to build up his or her own herd at birth, when the newborn child is given *budubta* (navel string) stock, preferably one female animal of each species. However, herd ownership is strongly biased in favour of men, and although women own animals the disposal rights are vested in the head of the management unit in which they are herded. The property rights of children are also circumscribed in the same way by the disposal rights of their father.

Viability is threatened when a management unit dissolves into several new units on the death of the head of the family. These new units often experience problems owing to a shortage of animals. If the new units fail to regain viability, they are temporarily dissolved and their members attach themselves with their animals to other units, to their father's or mother's brother or to their wife's father or brother. Whereas animals are owned individually, access to natural resources is communal. However, stock may be divided between two or three different territories, for example with the husband in his own territory, with a wife in another territory and with a sister's husband in a third. In the Afar area, where resources are unevenly distributed, these arrangements appear to have ecologically sound implications, opening up access to wider areas and providing possibilities for moving resources from surplus to deficit parts of the system.

The Kababish Arabs of Sudan raise a variety of domestic species, but camels, sheep and goats are considered the most important. Any species can be sold for cash. For sentimental reasons the Kababish regard themselves as camel herders, but in fact they raise far more small ruminants than camels. As a group, the Kababish are not wholly dependent on their livestock, supplementing their diet with crops such as millet, rice and maize.

Among the Kababish, animals can be acquired as gifts, through inheritance or by contract. A boy acquires animals from his father at birth, on circumcision and at various other stages of his life, so that sufficient numbers are often owned by the time a man is ready to marry. Marriage is marked by the payment of bridewealth (animals, money and other commodities) to the bride's family. On marriage, a man will seek to set up his own household, and his father gives him as large a number of animals as possible. Women can also receive livestock gifts from their fathers, but these are almost never camels. A married couple, however, cannot manage their livestock independently until they have children of

sufficient age, so that until then they must either join forces with another household or else hire herdsmen. The minimum labour requirement for an average herd is considered to be six, a level found in only 65% of households. Acute labour shortages are found mainly among the newly married and the very old. Ideally a household should have at least three sons, one each for the camels, sheep and goats.

6.3 HERD MANAGEMENT

As already stated, management practices are influenced by factors such as herd structure, watering requirements and labour availability, but primarily by the purpose for which the camels are kept and the degree of dependence on them. The Azab Bedouin of southeastern Arabia raise baggage, riding and milk camels, but their dependence on camel milk means that milking camels are the most highly valued (Cole, 1975). So important is camel milk among these people that male calves are sometimes slaughtered so that all the milk produced by the dam can be consumed by the household.

Typical camel herd composition figures are hard to derive, but often more animals are raised than are needed for family subsistence. In part this is an attempt to guard against theft and natural disasters such as droughts, epidemics and predators, etc. Building up a camel herd can be risky and expensive in terms of both time and money, partly due to the animal's low reproductive performance. Furthermore, under the harsh conditions in which many camels are raised, growth rates are slow. Age at first calving is 6 or 7 years, with a 2-year calving interval thereafter. If balanced sex ratios and a calf mortality rate of about 30% are assumed, a mature female can be expected to produce only 0.175 female calves annually, or 3 over a 20-year reproductive span. Camel herds are thus bound to increase only very slowly, and the hardship caused by losses is considerable.

Females require extra attention during breeding and calving periods, which tend to coincide. The lactation and gestation periods are both about 1 year. Unless special care is taken it is thus possible for all the cycles to coincide, so that all the fertile females breed, conceive, calve and lactate at the same time. It may be as a result of this pattern and the special risks entailed in raising camels that pastoralists in Africa usually maintain additional species, especially goats and sheep, for better all-round protection. Due to their higher reproduction and prolificacy rates, small ruminant flocks can be built up more quickly, affording a better springboard for recovery after disasters (Dahl and Hjort, 1979). Sheep and goats are also more readily sold than camels and are a more convenient size for household consumption.

Hartley (1979) observed that in the Horn of Africa female camels are often culled for such weaknesses as poor mothering, poor milking, slow breeding or the production of unthrifty young. This applied selection process combines with natural selection to ensure the survival of only the fittest and most productive animals.

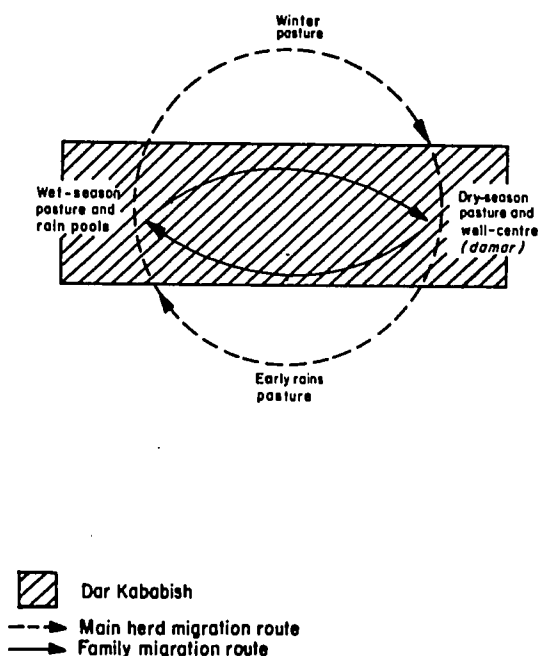
Just as social and economic factors influence the basic pattern of management, so also do the needs of the animals themselves. Survival, for the pastoralist, depends largely on the survival of his animals. To maintain his animals safely, providing them with adequate feed and water and protecting them against disease, the pastoralist must make subtle and complex calculations. Should his animals be herded together, or divided among his

relatives? What proportion of large to small stock should be kept? How soon should the herd be moved to the dry-season grazing area? Where animals represent the key to survival, the most fundamental adaptation, to balance and maintain the needs of both man and animals, is migration.

6.3.1 Migration

The camel herders of Africa and Arabia practise either transhumance, moving according to a regular seasonal pattern, or nomadism, migrating more freely in order to take advantage of widely dispersed and erratic grazing and water resources. Although nomadic movements may be subject to fluctuation, they are almost never entirely random (Williamson and Payne, 1978). Both types of movement are subject to considerable variation between the different groups, making generalizations difficult. For instance, El-Amir (1979) indicates that while camel herders in western Sudan may cover up to 1000 km in the course of migration from north to south, in the eastern part of the country, where conditions are better, shorter migratory distances are travelled. In Arabia, Cole (1975) found that on average the Azab (the most wide ranging of the Murrah Bedouin) covered almost 2000 km during migration, in addition to extra journeys made in search of pastures or lost animals, and visits to cities and towns. Nomadic migration in Africa is exemplified by the Tuareg, Reguibat and Chaamba herdsmen of the Sahara, while the seasonal migratory pattern practised by the Kababish Arabs is depicted in Figure 13, and their corresponding activities are shown in Table 17.

Figure 13. Annual migration cycles of the Kababish camel herders.



Source: Asad, 1970.

Table 17. Annual cycle of major movements and activities of the Kababish Arabs.

Summer (<i>sdyf</i>) hot, dry season February-June	Rainy Season (<i>kbarif</i>) cool, wet season July-September	Post Rains (<i>daral</i>) warm, dry season October	Winter (<i>shital</i>) cold, dry season November-January
Families			
At dry-season well-centres	Move to west or northwest after first showers; contact with main herds	Separation from main herds	Digging of shallow water holes
Redigging and relining of wells		Exploitation of larger rain-pools, with extended stops	Movement back to dry-season well-centres (speed depending on intensity of rainfall)
Heavy work watering main herds	Fairly rapid movement between rain pools		Move to different dry-season well-centres if rainfall has been poor
Main herds			
Return from northwest early summer to dry-season well-centres	Rapid move north to exploit wet-season pastures in Dar Kababish	Move northwest	Move farther northwest to exploit winter grazing in desert (camel herds further than sheep flocks)
Circulating in dry-season pasture around well-centres	Contact with families Circulating in wet-season pastures		
Move to south or southwest late summer to exploit early pastures in central Kordofan and Darfur (camel herds further than sheep flocks)			

Source: Asad, 1970

Although camel herders usually move in search of grazing there are exceptions to this rule. Other climatic factors, and particularly disease, also play an important part. Hartley (1979) referred to annual livestock movements from the interior of Somalia towards the coastal areas during the cooler months, as these areas are considered unbearable during the hot periods of the year, and also to migratory movements away from areas prone to flooding during the rainy season. In addition, Torry (1971) observed that among the Gabbra the location and duration of camel camps was influenced not only by water and forage supplies but also by tick infestation, to which camel calves are particularly susceptible.

The main seasons distinguished in camel-raising areas generally include a rainy season (cool and wet), a winter season (cool and dry), and a summer season (hot and dry). The summer is often spent around the home base, as there are usually reliable wells and the animals require more frequent watering at this time of year. During this season wells, with their high labour requirement, play a crucial role in herd management strategies. With the return of the rainy season the herds begin to disperse. These departures relieve the pressure on grazing and water for those who remain behind. As surface water becomes available, it offers a less labour-intensive alternative to watering from wells, making it particularly attractive to owners of large herds. Members of the same lineage or social group usually migrate in the same direction. At first, owing to limited water and forage supplies, halts are short, but as the rains become heavier supplies increase and settlements are established for longer periods. Nevertheless it is often necessary to move camel camps once every week or fortnight, whereas cattle camps are usually moved only once in 4 or 5 months, provided ample water and forage are available. Owners of small herds may then combine their camels in a single large herd, which may include several hundred animals. Where mixed herds are maintained, camels move over a wider radius than the other species since they can travel longer distances and survive longer without water. Their better mobility also ensures more variation in diet and improved chances of finding salt bushes, if salt is not available from licks or salt wells.

Where national governments have moved to introduce watering points and other improvements, the migratory system has been modified. However, water points are often established without adequate consideration of grazing availability. Overstocking frequently occurs around new water supplies, and agriculturists may also be attracted to settle on former grazing areas.

6.3.2 Herding

Herding practices differ among the various groups, according to migration patterns, labour availability, the degree of dependence on the camel and other factors.

According to Cole (1975), the Murrah Bedouin generally divide their camel herds into four groups. One group comprises females with their newborn calves, which need more attention due to their restricted mobility. This group gives the best milk. It is watered almost every week and is usually herded by the eldest son. In the course of the day the latter may be visited by his father or other family members, with whom the milk is shared. The second group is made up of the females with calves of 8 - 18 months. They may be herded by another son, a young man or an unmarried woman. Due to the greater mobility

of this group it is often sent further from the camp, and may be gone for several weeks at a time. During these extended periods of absence the herd is generally managed by two youths, who also consume the milk provided, which is of lower quality than that of the former group. The third group consists of pregnant females, often left to fend for themselves during the day but brought back to the camp at night. The last group is made up of baggage and riding males. The baggage camels (often including the stud bull) are used for moving camps, when they are ridden by the women, while the riding camels are used by the men and boys. When not in use these animals are hobbled and left to feed by themselves, and are only fetched when needed, by a woman or young girl.

Camel herding among the Murrah is thus generally the work of young boys and girls. The men do the milking, although occasional help from young women may be sought. The common practice is to gather all the animals together for the night and divide them up in the morning, whether camps are stationary or on the move.

The Murrah Bedouin are highly skilled in herd management. They can recognize the footprints of their animals and tell the age and weight of an animal from its footprint, as well as how long it stayed in one place. They are thus able to trace lost animals, and the direction taken by their kinsmen if they are left behind.

As already stated, complete dependence on camels is rare in Africa, but some groups of the Rendille and Gabbra live almost exclusively on the products of their camels and smallstock (Dahl and Hjort, 1979). In most camel herding areas of Africa the sheep and goats are usually maintained closer to the homestead or camp. The camels (and cattle where present) are divided into dry and milking groups, and the group containing the dry camels roams the furthest, sometimes up to 100 km from water. Besides the dry females this group also comprises older females, sexually immature females, weaners and males. The milking herd is maintained closer to home, the calves being kept closest to the camp, which is often surrounded by thorny bush enclosures for protection against theft and predators.

The division of labour among the Gabbra is described by Torry (1971). A young child of 6 years or so tends the camels, helped by an older child to bring them to the camp in the evening. An older girl or woman brings water to the camp every 3 to 5 days, while two people are required to take the camels to water every 11 to 15 days. A small child helps gather firewood while an older girl or woman is responsible for preparing meals and repairing household articles. One child is left in charge of the sheep or goats. In order to have access to grazing over a wider area the Gabbra usually attempt to send some of their livestock to satellite camps in spite of the additional labour requirements.

Among the Somali, Hartley (1979) observed that herding is mainly the responsibility of boys and men. Somali women tend the smallstock at the camp, sometimes augmented by a few baggage and milk camels. Although Somali herds may be amalgamated for herding, night enclosures are usually divided into separate compartments (*kadin*) one for each of the members comprising the group. A single *kadin* may house 60 - 100 animals. No permanent huts are built during migration, however, and the herders often sleep on grass mats in the middle of the animals, taking shelter beneath them in case of rain.

Among the Afar, each married woman usually has her own sheep and goats (which may be split into two different flocks) which she tends with her young children, while cattle and camels are herded separately by older boys and young men. In daily herding operations, these herds or flocks may be combined in different ways. For example, two wives may combine their goats in one flock and their sheep in another, during the day, instead of each grazing mixed flocks, while reclaiming their own animals at night and keeping them in separate enclosures. Similarly, camels and cattle may be combined into herds of dry and lactating animals. The head of the household management unit, either a father or an older brother, decides on strategic issues such as the movement of camps, the deployment of family members in different camps, the allocation of lactating animals to different wives and the borrowing, lending, exchange or slaughter of animals. Some husbandry decisions, however, are made by wives, particularly those relating to milk production, for example the slaughter of young male animals to increase the milk available for human consumption. Camel calves, which become valuable pack animals, are not slaughtered.

Like most pastoralists, the Afar prefer to herd the various livestock species separately. This strategy has a sound ecological basis, but it means that more labour is required. Labour requirements depend on the type of terrain on which the animals are kept, but the relationship between the number of animals in a herd and the amount of labour required is non-linear. One herdsman is required for 10 camels, but he can also look after 100. In watering operations, in contrast, the amount of labour required increases proportionally with herd size, and also with watering frequency. The overall labour requirement for watering camels is lower than for other species, since their watering frequency is lower, but the household management unit must nevertheless provide enough labour for all routine operations while maintaining a herd large enough to provide subsistence for all the household members. This problem is central to any pastoral production system. Moreover, the viability of the management unit is affected by unpredictable factors such as seasonal variations in range and herd productivity, and by losses and gains as animals and household members leave or are born into the unit.

Imbalances in the relationship between livestock and human numbers may be corrected in several ways. If there are too few animals, a management unit may appeal to friends and kinsmen for loans of productive animals, whose milk and offspring are then kept by the borrower. Sheep and goats are readily exchanged in this way, while more valuable cattle and camels are usually only exchanged between owners who have entered into a formal relationship. Food shortages may also be relieved by participation in a meat feast, when a steer or camel provided by one of the participants is repaid in cash or in young stock in instalments over a period of 2 to 3 years. Again, a household may send some of its members to stay with another household for a period of time. Wives frequently return to their father's or brother's household, and as a result consumption from the herd is temporarily reduced. A labour shortage, on the other hand, may be corrected by borrowing extra herders or hiring herders on a contractual basis. A typical camel-herding contract would entail responsibility for a manageable herd (less than 100 animals), and would allocate all the milk and one male calf per year to the herder. If the herder is a relative, he may also receive female animals.

Another kind of herding system, described by Asad (1970), is found among the Kababish of Kordofan and northern Sudan. Under this system camel herds numbering up to 150 animals are brought together from different households, camps or groups and herded by one, two or three herdsmen. They may stay away from the household for long periods, since the staple food is millet and the family is far less dependent on camels. Camel herds are divided into a group of females with their young, and a male group used mainly for transportation. Animals sold are usually from the latter group. Goats, regarded as good milkers, are normally kept nearer the main camp. Herding under this system is the responsibility of the men, who also build and maintain the wells in addition to visiting the urban centres to sell animals and buy household items and clothing. When labour becomes a major constraint, the Kababish women also help with herding, although the men rarely perform female tasks.

Management under ranch conditions poses different problems, but the inclusion of camels on cattle ranches may bring advantages in some environments. In Kenya. Evans and Powys (1979) have recently introduced camels into their cattle ranching enterprise to complement the cattle component. The browsing habits of camels are exploited to control bush encroachment. At the same time the camels provide milk for the staff, releasing more cattle milk for the growing calves. The experience of such ventures should indicate whether or not camel ranching might be commercially viable.

6.4 TRADE AND OTHER FACTORS

Pastoral societies never function in isolation. Traditional links with the outside world include trade, involving the exchange of livestock for crop or other products, and other forms of cooperation with sedentary farming communities, such as agreements to allow animals to graze stubble fields after the harvest in return for the manure provided, which fertilizes the cultivated land. Increasingly, however, the pace of change in non-pastoral Africa is bringing new pressures to bear on the traditional pastoral societies. In some areas, with the development of water supplies and improved animal health care, former restraints on herd size have been reduced, with the result that animal populations have expanded rapidly, at a time when increasing amounts of grazing land are being taken into cultivation by settled farmers. More recently, rural and industrial development schemes have accelerated change, bringing both problems and benefits.

An important aspect of trade in arid areas in the past was the use of the camel as a baggage animal. The expansion of modern transport facilities has reduced this role, and the famous caravans of the past, which enabled camel owners to earn extra income from the hire of their animals, have almost disappeared. The distances covered by baggage camels in Africa today are therefore much shorter than they once were, and among pastoralists their use is more or less limited to moving camps, drawing water and performing other work around the camp.

Generally speaking, the more a pastoralist society is dependent on its camels for subsistence, the less willing the pastoralist will be to sell animals or their products. With the exception of small amounts of camel hair, the Murrah Bedouin almost never sell camels or their products, while amongst the Gabbra the sale of animals is regarded with scorn. Other

societies are somewhat more market-oriented, however. Asad (1970) found that the few Kababish Arabs inclined to sell camels usually do so before or after the rainy season. They may take time to recognized market points, or else wait for the town traders to make the journey out into the countryside. Animals may be bought for cash or in exchange for food commodities or other items such as clothing, which the traders bring with them. In the latter case the terms of trade are not as favourable as in the former, and the camelmen do not make as much profit. It is not uncommon for traders to purchase animals and leave them in the care of the herders, for collection at a later date.

El-Amin (1979) indicates that in Sudan camels are marketed fairly widely. Animals are sold near Port Sudan for export to the Gulf States, others are sent north to Libya and Egypt, while still more are sold on the domestic market. The country's largest market is at Omdurman, near Khartoum. Slaughter figures for Sudan varied from 15,477 to 30,385 animals per year between 1970 and 1974. In 1979 the average price paid for a good 4-year-old camel was about US \$ 550, but a bull in top condition could fetch up to US \$ 1,200. Similar prices were also recorded in the Kassala Province east of Khartoum. The better organization of trade and higher prices paid have often attracted herdsmen into Sudan from neighbouring countries. However, government regulations in Sudan, as in Somalia, restrict export to male animals. When females are culled, usually for infertility, they are consumed locally. The meat of young females is the most highly prized and is often eaten by the herders themselves.

African camels are therefore sold primarily for meat, although sporadic attempts have also been made to establish camel milk marketing systems. The potential of camels for hair production is rarely mentioned, and there are no reports of successful marketing operations for these commodities in Africa and Arabia.

When the minimum output required from camels (meat, milk, transport) cannot be achieved, camel herders resort to one or more of the following alternatives:

- (a) acquiring more animals through the mutual aid network or through raids;
- (b) migrating to areas of better pasture and water supplies;
- (c) amalgamating small herds with larger ones for better protection;
- (d) seizing new grazing areas;
- (e) becoming sedentary or semi-nomadic farmers;
- (f) abandoning camel pastoralism in favour of another species, or
- (g) abandoning pastoralism altogether.

It is clear that the extent to which redistribution through mutual aid systems can guard against catastrophe is limited, especially when disasters occur on a regional or national scale. Dahl and Hjort (1979) cite the case of the Subuye Borana of Kenya, who lost virtually all their camels during border wars, so that not enough were left to re-establish viability through redistribution alone. Their pastoral way of life was radically disrupted, and some resorted to other livelihoods. The Sahel drought of the early 1970s was another example of catastrophe on a wide scale, claiming the lives of people and animals and forcing many others to change their life style.

In other cases however, adaptation may not result from stress factors alone. For example, camel herders who are more conscious of marketing systems and values may

become aware that there is generally greater demand for beef than for camel meat, and as a result they may replace their camels with cattle. Others, who live on the fringes of modern civilization, may have seen the advantages of sending their children to schools, visiting hospitals and, as in Arabia, using motorized transport rather than camels.

In conclusion it can be said that camel raising within pastoral systems is an arduous occupation, the viability of which becomes increasingly fragile or is destroyed altogether as the systems themselves are subjected to increasing pressure. However, it may prove that traditional camel pastoralism constitutes the only efficient way of exploiting many areas where cultivation is impossible and grazing resources are poor. It is therefore to be hoped that the more successful components of camel pastoralism can be identified and preserved, so that they may become the basis of future development. Any improvement, however, will require detailed integrated research, in which the customs, life style and internal logic (both social and economic) of the pastoralist system will have to be taken into account.

7. SUMMARY AND PROPOSALS FOR FUTURE RESEARCH

7.1 SUMMARY

The one-humped camel (*Camelus dromedarius*), and the two-humped camel (*C. bactrianus*) from which it is thought to have evolved, are the two species comprising the genus *Camelus*. Together with the llamoids of South America they are members of the Camelidae family, believed to have evolved from the *Prottylopus* which occupied the North American continent over 1 million years ago. The dromedary was probably first domesticated in southern Arabia around 3000 B.C.

Of the estimated 17 million camels of the world, 15 million are one-humped, and the vast majority of these (12 million) are found in Africa, especially in the five neighbouring East African countries of Somalia (5.4 million), Sudan (2.9 million), Djibouti (0.4 million), Ethiopia (0.9 million) and Kenya (0.5 million). The rest are mainly found in Asia. Camel populations are increasing only slightly, and in a few areas, such as northern Kenya, the numbers are actually declining, since camels in pastoral herds are being replaced by other livestock species.

Various classifications of the camel have been made according to different types or uses (e.g. baggage, riding and milking camels), but no systematic classification of breeds has yet been carried out. Breeds in each country are usually designated by the name of the area in which they are raised or that of the people who keep them, or simply by the coat colour of the animal.

The anatomy and physiology of the male and female reproductive systems have attracted considerable research, although certain aspects of reproductive performance, especially fertility, are inadequately understood. It is known that the female is an induced ovulator, and that early embryonic mortality is high. The female has a diffuse epithelio-chorial placenta similar to that of the horse. The male has an intermediate type of penis, between the vascular and fibrous types. Multiple births are almost unknown in the camel.

Camels grow slowly, reaching puberty at a later age than other livestock species. Sexual maturity is probably reached at 3 - 5 years. The gestation period is about a year, with the result that age at first calving is generally 5 - 7 years. The camel has a longer breeding life than other domestic species and fecundity increases with age, declining only

with the onset of senility. The calving interval is prolonged by the camel's limited breeding season, among other factors. When males are herded together, usually only one develops the rut. Hand service by herdsmen is common, and if practised at the opportune moment in the oestrous cycle, may improve conception rates. Occasionally, camels in calf are worked up to the time of parturition, a practice alleged to be a major cause of abortion. Perinatal losses are considerable, with young calves appearing highly susceptible to disease. Fertility levels appear low and herd growth rates are consequently slow. Improved fertility will have to be achieved if herd offtake for meat production is to be increased.

The camel is raised in the arid and semi-arid zones where feed resources are frequently scarce. It possesses remarkable abilities to exploit these limited resources, and the special features of its digestive system have led some authors to describe it as a «pseudo» ruminant. Its feed requirements are modest, and under drought conditions it can decrease both food intake and metabolism. Camels are primarily browsers, consuming a very wide variety of plants. One animal probably consumes on average around 2 - 4 tonnes of DM annually, and a stocking rate of one camel per 2 - 4 ha has been suggested. Camels should be allowed to feed for 6 - 8 hours a day. They may travel considerable distances to obtain both food and water. Supplementary feeding is rare, but under very poor pasture conditions animals should be given supplementary grain, chopped straw, hay or other forages and crop by-products. They should also have access to salt.

Camels can survive without visiting wells and pools for long periods, even when traveling, and can tolerate the loss of 30 - 40% of their body weight. The relatively high water content of the browse plants on which they feed plays a significant part in their ability to abstain from drinking water, and it is estimated that camels may obtain up to 30 litres of water per day from green forage alone. When they reach water camels are able to consume large amounts, sometimes equivalent to one third of their body weight, over a very short period (10 minutes). Their ability to conserve water and use it efficiently is linked with a highly efficient renal system, together with a capacity to withstand fluctuations in body temperature of up to 6°C. Contrary to previous beliefs, camels do not store much water in their hump and stomach compartments.

Camels seem to suffer from fewer diseases than other domestic animals and epidemics are rare. Major diseases include trypanosomiasis, occurring mostly in subacute form, helminthiasis, with an estimated infestation rate of 92% in Ethiopia for instance, mange, which is highly contagious and spreads rapidly, and camel pox, particularly affecting young animals. Anthrax and salmonellosis have public health importance, while less common diseases include brucellosis, blackquarter, pneumonia, tetanus and rabies. Camels may also be susceptible to rinderpest and FMD.

Available reports suggest that camels are potentially better milkers than many zebu cattle breeds. However, it is difficult to estimate actual milk yields under pastoral conditions because milking is irregular. Yield levels are also affected by breed, stage of lactation and especially feeding and management conditions. The lactation period apparently averages 12 months, and recorded yields vary from 1,134 litres under poor feeding conditions to 3000 litres or more under good conditions. Camels are usually milked between once and three times a day. Competition may arise between human and calf milk requirements, but most pastoralists are skilled at striking a balance between the two. The milk is usually consumed fresh, although it can also be processed into curd, cheese, butter or ghee. It is seldom marketed. In terms of nutritive value camel milk compares favourably with cow and goat milk and is rich in vitamin C.

In Africa camels are bred and selected for baggage and riding characteristics rather than for meat, which is only rarely consumed by pastoralists. However, breeding for slaughter is reported to be more common in Kenya, Ethiopia, Sudan and Somalia, where there are substantial camel populations. Slaughter figures in Sudan alone varied between 15,477 and 30,385 from 1970 to 1974. Sudan not only meets domestic demand but also exports camels to Libya, Egypt and the Gulf States, while Ethiopia too exports to Libya and Saudi Arabia. Slaughter figures in Somalia are also reported to be high, with extensive unofficial trade across the Kenya - Somalia border. Camels have low growth rates, taking 6 - 8 years to attain mature liveweights of 350 - 600 kg. Dressing percentages, at around 50%, are higher than for pastoralist cattle. The meat of older animals is tough, but young camel meat (under 5 years old) is tender and similar to beef, although less marbled. Young camel meat is preferred by pastoralists, who rarely sell their younger animals. The meat marketed is therefore usually from older, culled animals of low quality, and is often considered inferior by urban consumers. Some pastoralists periodically consume the blood of their camels.

Riding camels are still an efficient means of communication in remote areas and are used not only by pastoralists but also by police patrols and extension agents in some areas. The Beja types from the Sudan are reputed to be the best riding camels. Speeds of 10 - 19 km per hour have been recorded and the distance covered may be up to 80 km per day. Baggage camels, on the other hand, are slower and should be rested more frequently, averaging 3 - 5 km per hour and covering 30 km in a day. Loads are estimated at approximately 150 - 300 kg. The performance of both baggage and riding camels varies according to the load carried, the age and breed of the animal, and the ruggedness of the terrain. Various training methods and types of equipment are used.

Camels are increasingly being used for draught in Africa and Asia. Performances of 1 hp for ploughing and 1.2 hp for oil milling have been recorded. Performance is strongly influenced by the implements employed. When camels are used for ploughing there is generally a higher labour requirement than for oxen.

Herd management in pastoral societies varies according to the degree to which the herdsmen depend on their camels for survival. Dependence on camels may be almost total, but in Africa it is more common for mixed herds to be raised, and camel production may even be combined with both smallstock and crop production. Nonetheless, the camel remains a prestige animal in all pastoral groups. Social organization and ownership patterns vary among pastoral societies, but the basic component is usually the individual household, which retains a high measure of independence. The redistribution of animals as loans, gifts and exchanges is a key factor in the provision of collective security.

The migration pattern adopted, whether transhumant or nomadic, is another major factor in herd management, and is shaped primarily by climatic and disease factors. The different species may be herded together or separately, but herd division more usually results in groups of dry and lactating animals, with sheep and goats kept nearer the camp or settlement, while the camels, with their greater powers of survival, are sent furthest. Labour availability in relation to the subsistence requirements of the management unit is a delicate balance and various mechanisms exist to correct deficiencies.

Trade and other factors may also affect herd management. The use of the baggage camel for trading purposes is now limited, while the sale of meat and milk remains generally at a low level except in Sudan and eastern Africa, where slaughter figures are much higher than elsewhere and an export market has developed. Other factors include the impact of development schemes, and the various kinds of stress produced by rising population pressure and shrinking land resources. Pastoral societies adapt to stress in various ways, ranging from changes in the species or number of animals raised to the complete abandonment of the pastoral way of life. Camel pastoralism, however, may prove ultimately to be the only viable production system in some arid areas, and consequently research is needed to identify favourable production components for use in future development.

7.2 PROPOSALS FOR FUTURE RESEARCH

The aim of the present review has been to bring together as much information on the one-humped camel as possible from both conventional and non-conventional sources. This information has been summarized and some of the gaps and contradictions in the existing state of knowledge pointed out. In this final section an attempt is made to outline an appropriate strategy for future research in this area.

The camel has until now received less attention than other domestic species. Much of the work so far has been carried out by individuals, with little institutional support. Some topics, such as anatomy and disease, have attracted considerable attention, while others have been largely neglected, and research has tended to remain isolated and unrelated to production systems as a whole. There has therefore been little impact on development efforts.

The role of camels for transport in Africa and Asia seems to be declining, so that emphasis in the future should probably be placed on their potential for meat and milk production and their possible use for traction. Nevertheless, the importance of the camel as the traditional means of transport for pastoral groups should not be overlooked. Camels also enable transport costs to be kept low by walking themselves or other products to market, sometimes travelling considerable distances in remote areas.

Before specific topics for further research are outlined, an attempt will be made to assess the magnitude of supply and demand for camel meat and milk. From the data supplied by Alim (1976), El-Amin (1979), UNECA/FAO (1972) and FAO (1975) it is estimated that over 160,000 camels are sold for meat every year in Somalia and 103,000 in Sudan, which implies an average offtake rate of just over 4%. Additional animals also enter these two countries from neighbouring Kenya and Ethiopia. The four countries together account for 80% of the camel population of Africa. Of the total offtake, 60% are slaughtered for local markets, especially in Somalia (136,000). The remaining 40% are exported, mainly to Egypt, Saudi Arabia, the Gulf States and Libya. The extent of trade in these areas suggests that camel meat production, if developed, might significantly alleviate the shortage of meat products in other areas of Africa and the developing world. The daily average per capita consumption of animal protein is only 10.6 gm in Africa, well below the minimum requirement of 29.0 gm (Alim, 1976) and the world average of 24.4 gm (FAO, 1979). Potential demand is therefore high.

Information on supply and demand for camel milk is scarce, but it would seem that pastoralists often keep more animals than are required to meet their subsistence needs, which implies a surplus of milk which could be marketed. For example, Field (1979a) estimated that on average a Rendille family in northern Kenya raises 4 camels and 65 small ruminants more than the number needed to meet its daily requirements. At an average price of US \$ 0.20 per litre, such a family might derive an annual income of US \$ 1000 from the sale of surplus milk. It is possible that even larger herds are raised by other pastoral groups in Africa, so that the overall continental opportunities could be much higher.

Since there have been few efforts to improve camel productivity in Africa, supplies of both meat and milk will continue to develop in line with herd numbers. Moreover, unless efforts are made to expand existing local and export markets and to introduce camel products to areas where they are as yet unknown, market demand will tend to remain at the present level. Subsistence demand, on the other hand, will probably rise in line with population growth in arid rural areas.

Research and development work on camel production is carried out by institutions in several countries with substantial national herds, for example by the national veterinary schools of Sudan, Egypt, Somalia, Saudi Arabia, Iran, Iraq, Pakistan, India and Senegal. Other research institutes, such as the Desert Centre in Egypt, the Arid Zones Research Institute at Alice Springs in Australia, and the Bikaner Institute at Rajasthan in India, are also working on camels, and further research is sponsored by international organizations, such as the Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux in France and the United Nations Environmental Programme.

This work should focus on the characteristics of camels, their environment, available technology, marketing possibilities and relevant economic and social factors. Since work is being carried out in many different countries it will be important to coordinate efforts in order to avoid duplication and ensure the better use of limited funds. The need for proper coordination may well justify the setting up of a Camel Production Research Institute (CAPRI) in one of the countries with a large camel population or in affiliation with one of the already existing livestock research organizations. It will also be important for governments to adopt a multidisciplinary approach to the design and implementation of development projects based on research findings.

With regard to specific research topics, there is a need to develop a standard procedure for classifying the numerous types of camel in Africa. Many breeds in the different (often neighbouring) countries are probably the same, differing only in name and in minor characteristics. Accurate population estimates are also needed, as estimates now available fluctuate widely.

Slow herd growth rates are in part attributable to the low reproductive performance of the camel. Its physiology of reproduction, including oestrus, gestation and parturition, is only partly understood. The role of such factors as climate, nutrition, pathology, endocrinology and inbreeding need to be further investigated. Is it true, for example, that the presence of excess males and sterile females tends to lower reproductive performance? As the camel appears to be an induced ovulator and a seasonal breeder, the potential of oestrus synchronisation procedures for increasing fertility might usefully be investigated.

The causes of high calf mortality rates should also be investigated, and the best methods for reducing them identified. Improved survival rates will result in faster herd growth, releasing more animals for slaughter at an earlier age to meet consumer preferences. The current practice of marketing old and culled animals only may be due to the risk of high calf losses.

Nutritional investigations should continue to focus on the capacity of the camel to survive under stress. The relationships between anatomical peculiarities, such as those of the digestive system, and the camel's physiology are still not fully understood. The roles of trace elements, sodium balance and vitamins need special attention, especially in pregnant females and newborn calves.

To return to milk production, the existence of the surplus resources alluded to above needs to be confirmed and their extent in different countries or areas assessed. It will then be important to find out why camelmenn have so far been reluctant or unable to sell surplus milk. Would higher prices lead pastoralists to increase their sales of camel milk and milk products? These questions should be addressed in the context of a broader examination of the social, cultural and economic factors which may limit milk production under current pastoral systems. The situation calls for a concerted intergovernmental effort, since almost every country in Africa shows a deficit in dairy products (ILCA, 1979a).

The wide dispersal of pastoralists in the arid zone would make a formal milk collection, processing and marketing system difficult to establish and maintain. However, small marketing systems might be possible in areas where camel owners have settled. Reports of the poor keeping quality of camel milk have been made alongside those to the contrary. Research is needed to clarify this question and identify not only the best form in which the commodity could be collected from often remote producers, but also the most acceptable form for its potential consumers. Conversion into butter, cheese or ghee are alternatives which should be investigated before a marketing strategy is selected.

Efforts to encourage the marketing of camel meat must address similar constraints. The arid zones of Africa (with under 500 mm rainfall) comprise one third of the continental land area (approximately 7.026 million km²). Most of the 12 million camels of Africa are found in these areas, in addition to 31 million cattle, 26 million sheep and 35 million goats. Whether it is advisable to increase or to decrease the livestock numbers in this zone is difficult to ascertain. Both stocking rates and carrying capacities vary considerably from one area to the next, and also from year to year. Nevertheless, in Africa, as in most of the developing world, there is an urgent need for increased animal production to overcome the large protein deficiencies referred to earlier. Cattle have been raised on ranches and under feedlot conditions utilizing agro-industrial products. The performance of most tropical breeds under these conditions has in the main been disappointing, since they often require more than 15 feed units (FU) per kg of weight gain compared with only 6 FU for most temperate breeds (ILCA, 1979b). The camel has a slow rate of growth and has not been selected for meat production in Africa, so that it is very unlikely to fare any better than tropical breeds of cattle under intensive or semi-intensive conditions. Extensive methods, based on the improved utilization of those rangelands on which its ability to survive is hard to surpass, might pay better dividends. However, pastoralists raise their camels as a means of transport and a source of milk, so that any attempt to increase herd offtake for meat would have to ensure the continued supply of milk within the system. In addition, the general resistance of urban consumers to camel meat would have to be overcome. As pre-

viously advocated for milk, work is required to find out whether camel meat can be turned into other products, such as canned meat and sausages, and to gauge the acceptability of these on local and foreign markets. Attempts to process camel meat into animal feeds for other species should also be undertaken.

Should research confirm the existence of a large potential market for camel milk and meat products, major efforts to improve range management and utilization by the traditional herders will have to be made. Research on browse plants for cattle and small ruminants is developing fast in some parts of Africa, but little work has yet been carried out on the feed value and palatability of these species for camels. Such work is clearly needed, since of all the domestic species raised in the arid zones, camels are the major users of browse. Work on pastoral infrastructure (water points, roads, fencing, milk collection points) needs to be accelerated, with due regard to social, economic and environmental constraints. Better grazing controls are also needed, to protect both the environment and the pastoral societies themselves.

In the longer term a stratified production system might be envisaged in some areas, in which young animals could be purchased from pastoralists and finished on camel or mixed species ranches in ecologically more favourable areas. At such facilities, whether private or government owned, efforts could be made to breed and select for better performance. Stratification of this kind, however, requires heavy expenditure and is little suited to the current needs of the pastoralist. It should therefore be approached with caution. In the shorter term it would probably be more advisable to concentrate on improving the subsistence base provided by camels in traditional systems. Often the breeding and calving periods coincide and the pastoralist is confronted with a situation in which all his animals breed, calve and milk at the same time. As a result, a period of plenty may be followed by one of scarcity. The need to determine the minimum herd structure and size to meet the needs of the pastoral family on a continuous basis, will therefore be of particular concern.

Where camels have been used for traction, for example on the north coast of Africa, the output from one animal is alleged to exceed that of a pair of mature zebu oxen. If this performance level can be confirmed, it would seem appropriate to extend the use of camels for ploughing in areas where they are raised but are not as yet used for this purpose. Such development efforts should begin with a survey of the local acceptability of introducing new roles for the camel. The cost and efficiency of implements, i.e. yokes, carts, ploughs, harnesses and saddles, should be investigated. Existing techniques in the training and management of camels for traction should be observed and evaluated for possible transfer into new areas. Finally, research should continue to compare the performance of the camel with that of other species, especially cattle and equines, for all the various functions which it can perform.

7.3 CONCLUSIONS

This review has led to the identification of a number of areas in which research is urgently needed. However, improved understanding of existing production systems is a prerequisite to the planning of effective pastoral development projects. Once production systems have been thoroughly understood, packages of innovations should be designed and introduced in the field under management conditions appropriate to the

pastoral group concerned. Given the high value attached to independence by the pastoralist, the freedom to accept or reject innovations should probably be left largely in his hands. At any rate it is important to note that research should probably not be carried out on experimental stations, in isolation from the realities of pastoral conditions, but should reach the field as soon as possible, albeit on a small scale. The packages should then be adapted in the light of initial experience, while more intensive research on specific components offering favourable prospects for improvement is also launched. This approach is the one already adopted by ILCA for other domestic species throughout the ecological zones of tropical Africa. Once a promising improvement package has been identified, it can be recommended for extension on a wider scale, with due regard to transferability.

In any effort aiming to improve camel productivity and the welfare of camel pastoralists, while at the same time seeking to protect the ever-threatened arid ecosystems in which most camels are raised, a coordinated multidisciplinary approach appears necessary. In the words of Pratt and Gwynne (1977), «Success depends on a balance between ecology, sociology and economics, and the availability of administrative personnel capable of achieving this balance».

BIBLIOGRAPHY

REFERENCES

1. ORIGINS AND DISTRIBUTION

- Acland, P.B.E. 1932. Notes on the camel in eastern Sudan. *Sudan Notes Rec.* 15 (1): pp. 119-149.
- Benirschke, K. (ed.) 1967. *Sterility and fertility of interspecific mammalian hybrids: Comparative aspects of reproduction failures.* New York, Springer Verlag.
- Boué, A. 1948. Les chameaux de l'ouest saharien. *Rev. Elev. Méd. Vét. Pays Trop.* 2 (4): pp. 193-201.
- Bulliet, R.W. 1975. *The camel and the wheel.* Cambridge (Mass.), Harvard University Press, 327 pp.
- Cauvet, Commandant 1925. *Le chameau: Anatomie, physiologie, race, extérieur, vie et moeurs, élevage, alimentation, maladies, rôle économique.* Paris, J.B. Baillièrre et fils, 947 pp.
- Cole, D.P. 1975. *Nomads of the nomads: The Al Murrab Bedouin of the Empty Quarter.* Chicago, Aldine Publishing Co., 179 pp.
- Curasson, G. 1947. *Le chameau et ses maladies.* Paris, Vigot Frères, 464 pp.
- Dennler, de la Tour, G. 1971. Inheritance of the hump in the camel, dromedary and camel x dromedary cross. *Anim. Breed. Abstr.* 40: p. 364
- Droandi, I. 1915. *Notizie sul cammello.* Tripoli, Governo della Tripolitania, 307 pp.
- Epstein, H. 1971. *The origin of the domestic animals of Africa.* Vol. 2. London, African Publishing Corporation, 719 pp.

- FAO (Food and Agriculture Organization) 1979. *Production yearbook, 1978*. Rome.
- Fazil, M.A. 1977. The camel. *Bull. Anim. Health Prod. Afr.* 25 (4): pp. 454-462.
- Fernandez-Baca, S. 1978. Llamoids or New World Camelidae. In *An introduction to animal husbandry in the tropics*, eds Williamson, G. and Payne, W.J.A. 3rd ed. London, Longman, 755 pp.
- Gillespie, I.A. 1962. Riding camels of the Sudan. *Sudan J. Vet. Sci. Anim. Husband.* 3 (1): pp. 37-42.
- IAO (Istituto Agronomico per Oltremare) n.d. Presentazione del dromedario. Offprint from *Natura* 1938 (11): pp. 19-23.
- Leese, A.S. 1927. *A treatise on the one-humped camel in health and disease*. Stamford (Lincs.), Haynes and Son, 382 pp.
- Mason, I.L. 1979. Origin, history and distribution of domestic camels. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IAS (International Foundation for Science), Provisional Report 6: pp. 21-33.
- Mason, I.L. and Maule, J.P. 1960. *The indigenous livestock of eastern and southern Africa*. Technical Communication 14, Farnham Royal (Bucks), CAB (Commonwealth Agricultural Bureaux), 248 pp.
- Mikesell, M.K. 1955. Notes on the dispersal of the dromedary. *South-west J. Anthropol.*, 1955: pp. 231-245.
- Novoa, C. 1970. Reproduction in Camelidae: A review. *J. Reprod. Fertil.* 22: pp. 3-20.
- Robertson, J. 1938. The camel. In *With the cameliers in Palestine*. Reed (Mich.), Marshall Press, pp. 35-44.
- Spencer, P. 1973. *Nomads in alliance: Symbiosis and growth among the Rendille and Samburu of Kenya*. London, Oxford University Press, 230 pp.
- Taylor, K.M., Hungerford, D.A., Snyder, R.L. and Ulmer, F.A. (Jr.) 1968. Uniformity of karyotypes in the Camelidae. *Cytogenetics* 7: pp. 7-15.
- War Office 1908. The camel. In *Animal management*. London, H.M. Stationery Office, pp. 277-295.
- Williamson, G. and Payne, W.J.A. (eds) 1978. *An introduction to animal husbandry in the tropics*. 3rd ed. London, Longman, 755 pp.

2. REPRODUCTIVE PERFORMANCE

- Abdel Raouf, M., Faith, M.R. and Owaida, M.M. 1975. Studies on reproduction in the camel (*C. dromedarius*). 5: Morphology of the testes in relation to age and season. *J. Reprod. Fertil.* 43: pp. 109-116.
- Abdo, M.S., Al-Janabi, A.S. and Al-Kawafi, A.A. 1968. Studies on the ovaries of the female camel during the reproductive cycle and in condition affected by cysts. *Cornell Vet.* 59: pp. 418-425.
- Asad, T. 1970. *The Kababish Arabs: Power, authority and consent in a nomadic tribe*. London, C. Hurst and Co., 263 pp.
- Bhargava, K.K., Sharma, V.D. and Singh, M. 1965. A study of the birthweight and body measurement of camels (*Camelus dromedarius*). *Ind. J. Vet. Sci. and Anim. Husb.* 35 (1): pp. 358-362.
- Bosaev, J. 1938. Sexual activity of camels and organization of service. *Konevodstvo* 8-9: p. 26.
- Bremaud, O. 1969. Trans. ILCA. Notes on camel production in the northern districts of the Republic of Kenya. Maisons-Alfort, IEMVT (Institut d'Élevage et de Médecine Vétérinaire des Pays Tropicaux), 105 pp.
- Brinks, J.S., Clark, R.T., Rice, F.J. and Kieffer, N.M. 1961. Adjusting birthweight, weaning weight and preweaning gain for sex of calf in range Hereford cattle. *J. Anim. Sci.* 20 (2): pp. 363-367.
- Burgemeister, R. 1974. *Probleme der Dromedarhaltung und Zucht in Sudtunesien*. Giessen, ITV (Institut für Tropische Veterinärmedizin), 95 pp.
- Burgemeister, R. 1975. *Élevage de chameaux en Afrique du Nord*. Eschborn, GTZ (Gesellschaft für Technische Zusammenarbeit), 86 pp.
- Cauvet, Commandant 1925. *Le chameau: Anatomie, physiologie, race, extérieur, vie et moeurs, élevage, alimentation, maladies, rôle économique*. Paris, J.B. Baillière et fils, 947 pp.
- Chahrasbi, H., Radmehr, B. and Goulbazhagh, F. 1975. Anatomy and histology of the reproductive organs of the Iranian camel (*C. dromedarius*). 1: Ovary. *J. Vet. Fac. Univ. Tebran* 30 (4): pp. 42-50.
- Chatty, D. 1972. Structural forces of pastoral nomadism with special reference to camel pastoral nomadism. Occasional paper, The Hague, Institute of Social Studies, 96 pp.
- Cossins, N.J. 1971. Pastoralism under pressure: A study of the Somali clans in the Jijiga area of Ethiopia. Mimeo, Addis Ababa, LMB (Livestock and Meat Board), 101 pp.
- Curasson, G. 1947. *Le chameau et ses maladies*. Paris, Vigot Frères, 464 pp.

- Dahl, G. and Hjort, A. 1976. *Having herds: Pastoral herds growth and household economy*. University of Stockholm, Department of Social Anthropology, 335 pp.
- Dickson, W.M. 1933. Endocrine glands. In *Duke's physiology of domestic animals*, ed. Swenson, M.J. 8th ed. London, Cornell University Press, 1463 pp.
- Droandi, I. 1915. *Notizie sul cammello*. Tripoli, Governo della Tripolitania, 307 pp.
- Droandi, I. 1936. *Il cammello: Storia naturale, anatomia, fisiologia, zootecnica, patologia*. Florence, Istituto Agricolo Coloniale Italiano, 856 pp.
- El-wishy, A.B. and Omar, A.M. 1975. On the relation between testes size and sperm reserves in the one humped camel (*C. dromedarius*). *Beitr. Trop. Landwirtschaft. Veterinärmed.* 13 (4): pp. 391-398.
- Ensminger, M.E. 1969. *Animal science*. 6th ed. Danville (Illinois), Interstate Printers and Publishers, 1253 pp.
- Fazil, M.A. 1977. The camel. *Bull. Anim. Health Prod. Afr.* 25 (4): pp. 454-462.
- Field, C.R. 1979a. Ecology and management of camels, sheep and goats in northern Kenya. Mimeo, Nairobi, UNEP/MAB - IPAL (United Nations Environment Programme/ Man and Biosphere - Integrated Project in Arid Lands), 18 pp.
- Field, C.R. 1979b. Camel growth and milk production in Marsabit district, northern Kenya: Preliminary report. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 215-240.
- Fraser, A.F. 1968. *Reproductive behaviour in ungulates*. London and New York, Academic Press, 202 pp.
- Gauthier-Pilters, H. 1959. Einige Beobachtungen zum Droh-, Angriffs- und Kampfverhalten des Dromedarhengstes, sowie über Geburt und Verhaltensentwicklung des Jungtieres, in der nordwestlichen Sahara. *Z. Tierpsychol.* 16(5): pp. 593-604.
- Gupta, A.K., Chowdhary, M.S. and Barhat, N.K. 1978. A note on the optimum time for service in camels (*C. dromedarius*). *Ind. J. Anim. Sci.* 48 (4): pp. 324-325.
- Hansard, S.L. and Berry, R.K. 1969. Fetal nutrition. In *Animal growth and nutrition*, eds Halez, E.S.E. and Dyer, I.A. Philadelphia, Lea and Febiger, 402 pp.
- Hartley, B.J. 1979. Camels in the Horn of Africa. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 109-123.
- Johanson, I. and Rendei, J. 1968. Trans. Taylor, M. *Genetics and animal breeding*. Edinburgh, Oliver and Boyd Ltd, 489 pp.

- Joshi, C.K., Vyas, K.K. and Pareek, P.K. 1978. Studies on estrus cycle in Bikaneri she-camel (*C. dromedarius*). *Ind. J. Anim. Sci.* 48 (2): pp. 141-144.
- Keikin, D. 1976. Camel breeding can be economical. *Anim. Breed. Abstr.* 44 (11): p. 597.
- Khan, A.K. and Kholi, I.S. 1973a. A note on biometrics of the camels' spermatozoa (*C. dromedarius*). *Ind. J. Anim. Sci.* 43 (8): pp. 792-793.
- Khan, A.K. and Kholi, I.S. 1973b. A note on the sexual behaviour of male camels (*C. dromedarius*). *Ind. J. Anim. Sci.* 43 (12): pp. 1092-1094.
- Khan, A.K. and Kholi, I.S. 1973c. A note on collection of semen of camel with the help of an artificial vagina. *Ind. J. Anim. Sci.* 43 (5): pp. 454-455.
- Khan, A.K. and Kholi, I.S. 1978. A note on some haematological studies on male camels (*C. dromedarius*) before and during rut. *Ind. J. Anim. Sci.* 48 (4): pp. 325-326.
- Khatami, K. 1970. Camel meat: A new promising approach to the solution of meat and protein in the arid and semi-arid countries of the world. Mimeo, Tehran, Ministry of Agriculture, 4 pp.
- Knoess, K.H. 1976. *Assignment report on animal production in the middle Awash valley*. Rome, FAO (Food and Agriculture Organization), 57 pp.
- Leese, A.S. 1927. *A treatise on the one-humped camel in health and disease*. Stamford (Lincs.), Haynes and son, 382 pp.
- Leese, A.S. 1969. *Tips on camels for veterinary surgeons on active service*. Rome, FAO (Food and Agriculture Organization), 56 pp.
- Leonard, A.G. 1894. *The camel: Its uses and management*. London, Longman, Green and Co., 335 pp.
- Leupold, J. 1968a. Le chameau: Important animal domestique des pays sub-tropicaux. *Les cahiers bleus vétérinaires* 1968 (15): pp. 1-6.
- Mares, R.G. 1954. Animal husbandry, animal industry and animal disease in the Somaliland Protectorate. Parts 1 and 2. *Brit. Vet.* 110 (7): pp. 422-423, 470-481.
- Matharu, B.S. 1966. Animal management: Camel care. Offprint from *Indian Farming*, October 1966: pp. 19-22.
- Mimram, R. 1962. Les glandes occipitales du dromadaire. *Cahiers de la Faculté des Sciences, Séries Biologie Animale* 1. Rabat, 42 pp.
- Mobarak, A.M., El-Wishy, A.B. and Samira, M.F. 1972. The penis and prepuce of the one-humped camel (*C. dromedarius*). *Zentralbl. Veterinarmed.* 19: pp. 787-795.
- Moldagaliev, T.M. 1976. The effect of fetal size and pelvic measurements on parturition in different species of camel. *Anim. Breed. Abstr.* 44: p. 653.

- Mukasa, E.M. 1974. Genetics of bovine spermatozoan morphology. Ph. D. thesis, Colorado State University, 150 pp.
- Musa, B.E. 1979. Reproductive patterns in the female camel (*C. dromedarius*). Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 279-284.
- Musa, B.E. and Abusineina, M.E. 1978a. The oestrous cycle of the camel (*C. dromedarius*). *Vet. Rec.* 103 (25): pp. 556-557.
- Musa, B.E. and Abusineina, M.E. 1978b. Clinical pregnancy diagnosis in the camel and a comparison with bovine pregnancy. *Vet. Rec.* 102: pp. 7-10.
- Musa, B.E. and Sineina, M.E.A. 1976. Some observations on reproduction in the female camel (*C. dromedarius*). *Acta. Vet.* 26 (2): pp. 63-67.
- Nawito, M.F., Shalash, M.R., Hoppe, R. and Rakha, A.M. 1967. *Reproduction in the female camel*. Bulletin 2, Cairo, Animal Science Research Institute, National Research Centre, 82 pp.
- Novoa, C. 1970. Reproduction in Camelidae: A review. *J. Reprod. Fertil.* 22: pp. 3-20.
- Osman, A.M. and El-Azab, E.A. 1974. Gonadal and epididymal sperm reserves in the camel (*C. dromedarius*). *J. Reprod. Fertil.* 38: pp. 425-430.
- Parkes, A.S. 1969. *Marshall's physiology and reproduction*. 3rd ed. London, Longman, 688 pp.
- Rakhimzhanov, G.R. 1975. The evaluation of sexual reflexes in male Bactrian camels. *Anim. Abstr.* 44 (351): p. 36.
- Richard, D. 1976. The diseases of the dromedary in Ethiopia. *Ethiop. Vet. Bull.* 2: pp. 46-67.
- Roberts, S.J. 1971. *Veterinary obstetrics and genital diseases*. Ithaca (New York), Edwards Bros. Inc.
- Schels, H.F. and Mostafawi, D.J. 1978. Ultrasonic pregnancy diagnosis in the camel. *Ann. Reprod. Sci.* 1: pp. 19-23.
- Shalash, R.R. 1965. Some reproductive aspects in the female camel. *World Rev. Anim. Prod.* 1965 (4): p. 103.
- Singh, H. 1963. *Handbook of animal husbandry for extension workers*. New Delhi, Ministry of Food and Agriculture, Directorate of Extension, 162 pp.
- Singh, H. 1966. Camel care. *Intensive Agric.* January 1966: pp. 9-12.
- Spencer, P. 1973. *Nomads in alliance: Symbiosis and growth among the Rendille and Samburu of Kenya*. London, Oxford University Press, 230 pp.

- Tayeb, M.A.F. 1948. Trans. Blin, P.C. L'appareil génital mâle du chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 4 (3): pp. 157-160.
- Tayeb, M.A.F. 1950a. Trans. Blin, P.C. Etude sur l'anatomie de l'ovaire et du corps jaune de la chamelle. *Rev. Elev. Méd. Vét. Pays Trop.* 1950 (4): pp. 177-182.
- Tayeb, M.A.F. 1953. Trans. Blin, P.C. Les organes génitaux de la chamelle. *Rev. Elev. Méd. Vét. Pays Trop.* 1953 (6): pp. 17-21.
- Watson, R.M. 1969. A census of the domestic stock of North Eastern Province, Kenya. Mimeo, Nairobi, 135 pp.
- Williamson, G. and Payne, W.J.A. 1978. *An introduction to animal husbandry in the tropics.* 3rd ed. London, Longman, 755 pp.
- Wilson, R.T. 1978. Studies on the livestock of Southern Darfur, Sudan. 5: Notes on camels. *Trop. Anim. Health Prod.* 10: pp. 19-25.
- Wiltbank, J. 1974. Animal reproduction: Class notes for the animal science course. Course No. AN 428, Fort Collins, Colorado State University, 148 pp.

3. NUTRITIONAL CHARACTERISTICS

- Acland, P.B.E. 1932. Notes on the camel in eastern Sudan. *Sudan Notes Rec.* 15 (1): pp. 119-149.
- Asad, T. 1970. *The Kababish Arabs: Power, authority and consent in a nomadic tribe.* London, C. Hurst and Co., 263 pp.
- Bartha, V.R. 1971. The physiological adaptability of camels to the environmental conditions of the vast arid zones. *Tropenlandwirt* 72 (October 1971): pp. 138-148.
- BMA (British Military Administration), Veterinary Department, n.d. *Camel.* Eritrea, 17 pp.
- Boué, A. 1950. La remonte d'une unité méhariste: Son caractère polymorphe. Conditions d'une homogénéité moyenne. *Rev. Elev. Méd. Vét. Pays Trop.* 14: pp. 139-144.
- Bremaud, O. and Pagot, J. 1962. Grazing lands, nomadism and transhumance in the Sahara. In *Problems of the arid zones.* Proceedings of UNESCO Symposium, Paris, 11-18 May 1960. 528 pp.
- Bulliet, R.W. 1975. *The camel and the wheel.* Cambridge (Mass.), Harvard University Press, 327 pp.
- Butterworth, M.H. and Diaz, J.A. 1970. Use of equations to predict the nutritive value of tropical grasses. *J. Range Manage.* 23 (1): pp. 55-58.
- Cauvet, Commandant 1925. *Le chameau: Anatomie, physiologie, race, extérieur, vie et moeurs, élevage, alimentation, maladies, rôle économique.* Paris, J.B. Baillière et fils, 947 pp.

- Childs, G.R. 1978. Establishing nutrient guidelines for animal diets: Role of the feed industry nutritionist. *J. Anim. Sci.* 47 (4): pp. 992-994.
- Cole, D.P. 1975. *Nomads of the romads: The Al Murrab Bedouin of the Empty Quarter*. Chicago, Aldine Publishing Co., 179 pp.
- Dahl, G. and Hjort, A. 1976. *Having herds: Pastoral herd growth and household economy*. University of Stockholm, Department of Social Anthropology, 335 pp.
- Droandi, I. 1936. *Il cammello: Storia naturale, anatomia, fisiologia, zootecnica, patologia*. Florence, Istituto Agricolo Coloniale Italiano, 856 pp.
- Engalhardat, W. and Rüksamen, K. 1979. Review of the digestive physiology in camelides. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 307-319.
- Evans, J.O. and Powys, J.G. 1979. Camel husbandry to increase the productivity of ranchland. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. ITS (International Foundation for Science) Provisional Report 6: pp. 241-250.
- Zarid, M.F.A., Shwaket, S.M. and Abdel Rahman, M.H.A. 1979. Observations on the nutrition of camels and sheep under stress. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 125-170.
- Field, C.R. 1979a. Ecology and management of camels, sheep and goats in northern Kenya. Mimeo, Nairobi, UNEP/MAB/IPAL (United Nations Environmental Programme/Man and Biosphere - Integrated Project in Arid Lands), 18 pp.
- Gauthier-Pilters, H. 1972. Observations sur la consommation d'eau du dromadaire en été dans la région de Beni-Abbes (Sahara nord-occidental). *Bull. Inst. Fondam. Afr. Noire* 34 (1): pp. 219-259.
- Gauthier-Pilters, H. 1974. The behaviour and ecology of camels in the Sahara with special reference to nomadism and water management. In *Symposium on The Behaviour of Ungulates and its Relation to Management*, Calgary, 2-5 November 1971, pp. 542-551.
- Gauthier-Pilters, H. 1975. Nomadenleben, um zu wandern. *Kosmos* 71 (1): pp. 34-40.
- Gauthier-Pilters, H. 1977. Contribution à l'étude de l'écophysiologie du dromadaire en été dans son milieu naturel (moyenne et haute Mauritanie). *Bull. Inst. Fondam. Afr. Noire*. 39 A (2): pp. 385-459.
- Gauthier-Pilters, H. 1979. Some ecological aspects of the camel in the western Sahara. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 387-398.

- Gohl, B. 1975. *Tropical feeds: Feeds information summaries and nutritive values*. Rome, FAO (Food and Agriculture Organization), 661 pp.
- Hafez, E.S.E. (ed.) 1968. *Adaptation of domestic animals*. Philadelphia, Lea and Febiger, 415 pp.
- Hardy, R.N. 1972. The camel. In *Temperature and animal life*. London, Edward Arnold, pp. 44-46.
- Hartley, B.J. 1979. Camels in the Horn of Africa. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1978. IFS (International Foundation for Science) Provisional Report 6: pp. 109-123.
- Hassan, Y.M. 1971. A note on the effect of dehydration on a camel. *Sudan J. Vet. Anim. Husb.* 12 (2): pp. 111-112.
- Ingram, D.L. and Mount, L.C. 1975. *Man and animals in hot environments*. Berlin, Springer Verlag, 185 pp.
- Khatami, K. 1970. Camel meat: A new promising approach to the solution of meat and protein in the arid and semi-arid countries of the world. Mimeo, Tehran, Ministry of Agriculture, 4 pp.
- Knoess, K.H. 1976. *Assignment report on animal production in the middle Awash valley*. Rome, FAO (Food and Agriculture Organization), 57 pp.
- Kuthe, G. 1977. Physiological and nutritional requirements of foraging livestock in arid climatic regions. *Anim. Res. Dev.* 3: pp. 112-119.
- Leese, A.S. 1927. *A treatise on the one-humped camel in health and disease*. Stamford (Lincs.), Haynes and Son, 382 pp.
- Le Houérou, H.N. 1972. *An assessment of the primary and secondary production of the arid grazing lands ecosystems of North Africa*. Rome, FAO (Food and Agriculture Organization), 25 pp.
- Le Houérou, H.N. 1974. *The useful shrubs of the Mediterranean basin and arid tropical belt south of the Sahara*. Rome, FAO (Food and Agriculture Organization), 20 pp.
- Leonard, A.C. 1894. *The camel: Its uses and management*. London, Longman, Green and Co., 335 pp.
- Leupold, J. 1968b. Die wirtschaftliche Bedeutung des Dromedars. In *Kongressbericht über die dritte Tagung der Deutschen Tropenmedizinischen Gesellschaft e.V.*, Hamburg, 20-22 April 1967. Munich, Urban und Schwarzenberg, pp. 130-134.
- MacFarlane, W.V. 1968. Comparative functions of ruminants in hot environments. In *Adaptation of domestic animals*, ed. Hafez, E.S.C. Philadelphia, Lea and Febiger, pp. 264-276.

- Mares, R.G. 1959. The African nomad: East Africa. In *Introduction to animal husbandry in the tropics*, eds Williamson, G. and Payne, W.S.A. 2nd ed. London, Longman, pp. 424-430.
- Matharu, B.S. 1966. Animal management: Camel care. Offprint from *Indian Farming*, October 1966: pp. 19-22.
- Maxwell-Darling, R.C. 1938. Notes on the food of camels on the Red Sea coast and in north-eastern Kordofan. *Sudan Notes Rec.* 21: pp. 189-195.
- Monod, T. 1955. Longs trajets chameliers. *Bull. Liaison Sab.* 6 (20): pp. 38-42.
- Nanda, P.N. 1957. Camels and their management. Delhi, ICAR (Indian Council of Agricultural Research) (1963), 17 pp.
- Newman, D.M.R. 1979. The feeding habits of Old and New World camels as related to their future role as productive animals. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 171-200.
- Pratt, D.J. and Gwynne, M.D. (eds) 1977. *Rangeland management and ecology in East Africa*. London, Hodder and Stoughton, 310 pp.
- Richards, S.A. 1973. Adaptation to heat. In *Temperature regulation*. London, Wykeham Publications, pp. 191-197.
- Schmidt-Nielsen, K. 1959. The physiology of the camel. *Scientific American* 201 (6): pp. 140-151.
- Schmidt-Nielsen, K. 1961. The camel and the desert heat. In *Animal physiology*. 3rd ed. New Jersey, Prentice-Hall.
- Schmidt-Nielsen, K. 1964. The camel. In *Desert animals: Physiological problems of heat and water*. Oxford, Clarendon Press, 277 pp.
- Schmidt-Nielsen, K. 1975. Temperature regulation: The importance of body size. In *Animal physiology: Adaptation and environment*. Cambridge University Press, pp. 334-339.
- Spencer, P. 1973. *Nomads in alliance: Symbiosis and growth among the Rendille and Samburu of Kenya*. London, Oxford University Press, 230 pp.
- Tayeb, M.A.F. 1950b. Trans. Blin, P.C. L'Appareil glandulaire de la tête du chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 4 (3): pp. 151-155.
- Tayeb, M.A.F. 1950c. Trans. Blin, P.C. La cavité buccale du chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 4 (3): pp. 157-160.
- Thompson, D.J. 1978. Introductory remarks for the symposium on establishing nutrient (mineral and vitamins) guidelines for animal diets. *J. Anim. Sci.* 47 (4): pp. 977-978.

Torry, W.I. 1971. Animal husbandry and social organization among the Gabbra, with notes on the Rendille tribe. In *Rangeland management and ecology in East Africa*, eds Pratt, D.J. and Gwynne, M.D. London, Hodder and Stoughton (1977), pp. 156-159.

Williamson, G. and Payne, W.J.A. 1978. *An introduction to animal husbandry in the tropics*. 3rd ed. London, Longman, 755 pp.

4. CAMEL DISEASES

Altman, P.L. and Ditner, D.S. (eds) 1968. Animal energy exchange. In *Metabolism*. Bethesda (Maryland), Federal American Society for Experimental Biology, p. 327.

Balis, J. 1977. Note sur la toxicité de l'Isometamidium par injection intraveineuse chez quelques mammifères domestiques et spécialement chez le dromadaire. *Rev. Elev. Méd. Vét. Pays Trop.* 30 (4): pp. 373-375.

Balis, J. and Richard, D. 1977. Action trypanocide du chlorohydrate de chlorure d'Isometamidium sur *Trypanosoma evansi* et essai de traitement de la trypanosomiase du dromadaire. *Rev. Elev. Méd. Vét. Pays Trop.* 30 (4): pp. 369-372.

Bares, J.F. 1968. Contribution à l'étude de la pathologie infectieuse du dromadaire au Tchad. Thèse doct. vét. Toulouse, ENV (Ecole Nationale Vétérinaire), 92 pp.

Blaizot-Bouvier, C. 1975. Etude des parasitoses gastrointestinales du dromadaire dans la région de Dire-Dawa (sud-est Ethiopie) et essais thérapeutiques. Thèse doct. vét. No. 9, Alfort, ENVA (Ecole Nationale Vétérinaire d'Alfort), 62 pp.

Bremaud, O. 1969. Trans. ILCA. Notes on camel production in the northern districts of the Republic of Kenya. Maisons-Alfort, IEMVT (Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux), 105 pp.

Burgemeister, R. 1975. *Elevage de chameaux en Afrique du Nord*. Eschborn, GTZ (Gesellschaft für Technische Zusammenarbeit), 86 pp.

Burgemeister, R., Leyk, W. and Grossley, R. 1975. Untersuchungen über Vorkommen von Parasitosen, Bakteriellen und viralen Infektionskrankheiten bei Dromedaren in Sudtunesien. *Dtsch Tierärztl. Wochenschr.* 82 (9): pp. 352-354.

Castagnera, H. 1957. *Le chameau, manuel technique*. Dakar, Service Vétérinaire des Troupes de l'AOF (Afrique Occidentale Française), 137 pp.

Cauvet, Commandant 1925. *Le chameau: Anatomie, physiologie, race, extérieur, vie et mœurs, élevage, alimentation, maladies, rôle économique*. Paris, J.B. Baillière et fils, 947 pp.

Cheyne, I.A., Pegram, R.G. and Cartwright, C.F. 1977. An outbreak of salmonellosis in camels in the north-east of the Somalia Democratic Republic. *Trop. Anim. Health Prod.* 9 (4): pp. 238-240.

- Curasson, G. 1947. *Le chameau et ses maladies*. Paris, Vigot Frères, 464 pp.
- Dada, B.J.O. 1978. Incidence of hydatid disease in camels slaughtered at Kano abattoir. *Trop. Anim. Health Prod.* 10 (4): p. 204.
- Domenech, J., Guido, G. and Richard, D. 1977. Les maladies pyogènes du dromadaire en Ethiopie: Symptomatologie, étiologie. *Rev. Elev. Méd. Vét. Pays Trop.* 30 (3): pp. 251-258.
- El-Khawad, S.E., Elisa, A.M., Slepener, N.K. and Saad, M.B.A. 1979. Hydatidosis of domestic animals in the central region of the Sudan. *Bull. Anim. Health Prod. Afr.* 27: pp. 249-251.
- Fazil, M.A. 1977. The camel. *Bull. Anim. Health Prod. Afr.* 25 (4): pp. 454-462.
- Ferry, R. 1961. Parasitisme gastro-intestinal du dromadaire au Niger. Thèse doct. vét. No. 100. Alfort, ENVA (Ecole Nationale Vétérinaire d'Alfort), 41 pp.
- Gatt-Rutter, T.E. 1967. Diseases of camels 2: Protozoal diseases. *Vet. Bull.* 37 (9): pp. 611-618.
- Kamel, H. 1939. *Pneumococcosis in camels*. Bulletin No. 226, Cairo, Ministry of Agriculture Technical and Scientific Service, Government Press, 11 pp.
- Leese, A.S. 1927. *A treatise on the one-humped camel in health and disease*. Stamford (Lincs.), Haynes and Son, 382 pp.
- Leese, A.S. 1969. *Tips on camels for veterinary surgeons on active service*. Rome, FAO (Food and Agriculture Organization), 56 pp.
- Leupold, J. 1968a. Le chameau: Important animal domestique des pays sub-tropicaux. *Les cahiers bleus vétérinaires* 1968 (15): pp. 1-6.
- Lodha, K.R. 1966. Getting rid of camel mange. *Indian Farming*, May 1966: pp. 33-34.
- Lodha, K.R., Raisinghani, P.M. and Karwasra, R.S. 1977. Chemotherapeutic trials of some anthelmintics against helminth parasites in camels. *Ind. J. Anim. Sci.* 47(10): pp. 677-682.
- Magzoub, M. and Kasim, A.A. 1978. The prevalence of fascioliasis in Saudi Arabia. *Trop. Anim. Health Prod.* 10 (4): pp. 205-206.
- Mason, F.E. 1917. Tuberculosis in camels. *Agric. J. Egypt* 7: pp. 1-11.
- Mason, F.E. 1920. Mortality in camels caused by ingestion of sand. *Agric. J. Egypt* 9: pp. 1-6.
- Michael, S.A. and Saleh, S.M. 1977. The slide agglutination test for the diagnosis of filariasis in camels. *Trop. Anim. Health Prod.* 9 (4): pp. 241-244.

- Richard, D. 1976. The diseases of the dromedary in Ethiopia. *Ethiop. Vet. Bull.* 2: pp. 46-67.
- Richard, D. 1979. Study of the pathology of the dromedary in Borana Awraja (Ethiopia). Thesis for doct. vét. Maisons-Alfort, IEMVT (Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux), 221 pp.
- Schmidt-Nielsen, K. 1959. The physiology of the camel. *Scientific American* 201 (6): pp. 140-151.
- Scott, J.M. 1973. An interim report on the bovine and camel situation in the Negele (Borana) region, Sidamo. Addis Ababa, Ministry of Agriculture, Veterinary Department, 7 pp.
- Sharma, S.P. and Gautam, O.P. 1974. A note on the prevalence of toxoplasma antibodies among camels and pigs in Hissar. *Ind. J. Anim. Sci.* 44 (3): pp. 214-215.
5. PRODUCTION AND UTILIZATION
- Acland, P.B.E. 1932. Notes on the camel in eastern Sudan. *Sudan Notes Rec.* 15 (1): pp. 119-149.
- Alim, K.A. 1976. The livestock and meat industry of Egypt. *World Rev. Anim. Prod.* 12 (4): pp. 59-67.
- Asad, T. 1970. *The Kababish Arabs: Power, authority and consent in a nomadic tribe.* London, C. Hurst and Co., 263 pp.
- Bhargava, K.K., Sharma, V.D. and Singh, M. 1965. A study of the birthweight and body measurement of camels (*Camelus dromedarius*). *Ind. J. Vet. Sci. and Anim. Husb.* 35 (1): pp. 358-362.
- Bligh, J., Thomson, J.L.C. and MacDonald, A.G. 1976. Surface contact structures. In *Environmental physiology of animals*. Oxford, Blackwell Scientific Publications, pp. 142-145.
- BMA (British Military Administration), Veterinary Department, n.d. *Camel*. Eritrea, 17 pp.
- Bremaud, O. 1969. Trans. ILCA. Notes on camel production in the northern districts of the Republic of Kenya. Maisons-Alfort, IEMVT (Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux), 105 pp.
- Bulliet, R.W. 1975. *The camel and the wheel*. Cambridge (Mass.), Harvard University Press, 327 pp.
- Capot-Rey, R. 1962. The present state of nomadism in the Sahara. In *Problems of the arid zones*. Proceedings of UNESCO Symposium, Paris, 11-18 May 1960. 528 pp.

- Cauvet, Commandant 1925. *Le chameau: Anatomie, physiologie, race, extérieur, vie et mœurs, élevage, alimentation, maladies, rôle économique*. Paris, J.B. Baillière et fils, 947 pp.
- Chatty, D. 1972. Structural forces of pastoral nomadism with special reference to camel pastoral nomadism. Occasional paper. The Hague, Institute of Social Studies, 96 pp.
- Cole, D.P. 1975. *Nomads of the nomads: The Al Murrah Bedouin of the Empty Quarter*. Chicago, Aldine Publishing Co., 179 pp.
- Cengui, S. 1953. Indagini sul macello, sulla distribuzione ponderate e sulla correlazione fra le diverse parte del corpo del dromedario somalo. *Zootec. e Vet.* 8: pp. 188-191.
- Coon, C. 1952. *Caravan: The story of the Middle East*. London, Jonathan Cape, 365 pp.
- Cossins, N.J. 1971. Pastoralism under pressure: A study of the Somali clans in the Jijiga area of Ethiopia. Mimeo, Addis Ababa, LMB (Livestock and Meat Board), 101 pp.
- Dada, B.J.O. 1978. Incidence of hydatid disease in camels slaughtered at Kano abattoir. *Trop. Anim. Health Prod.* 10 (4): p. 204.
- Dahl, G. and Hjört, A. 1976. *Having herds: Pastoral herd growth and household economy*. University of Stockholm, Department of Social Anthropology, 335 pp.
- Dina, D. and Klinteberg, R. 1977. Proposal for a rural development training project and study concerned with camel utilization in arid lands in Ethiopia. Mimeo, Addis Ababa, Relief and Rehabilitation Commission, 11 pp.
- El-Amin, F.M. 1979. The dromedary camel of the Sudan. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 35-53.
- Ensminger, M.E. 1969. *Animal Science*. 6th ed. Danville (Illinois), Interstate Printers and Publishers, 1250 pp.
- Epstein, H. 1971. *The origin of the domestic animals of Africa*. Vol. 2. London, African Publishing Corporation, 719 pp.
- Field, C.R. 1979a. Ecology and management of camels, sheep and goats in northern Kenya. Mimeo, Nairobi, UNEP/IPAL (United Nations Environmental Programme/Man and Biosphere - Integrated Project in Arid Lands), 18 pp.
- Field, C.R. 1979b. Camel growth and milk production in Marsabit district, Northern Kenya. Preliminary report. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 215-240.

- Fischer, H. 1975. Schaf-, Zeigen- Wasserbüffel- und Dromedarhaltung: Bedeutung, Stellenwert und Entwicklungsmöglichkeiten sowie ihre Haltungsbedürfnisse in der Konkurrenz zur Rinderhaltung. Beiträge zur III Veterinärtagung, Ouagadougou, 16 pp.
- Gillepsie, I.A. 1962. Riding camels of the Sudan. *Sudan J. Vet. Sci. Anim. Husb.* 3 (1): pp. 37-42.
- Green, G.W. 1885/86. The organisation and employment of camel corps in warfare. *J. R. United Serv. Inst.* 1885/86: pp. 521-537.
- Hartley, B.J. 1979. Camels in the Horn of Africa. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 109-123.
- Hoeller, H. and Hassan, Y.M. 1965. The amino-acid composition of camel milk casein. *Sudan J. Vet. Sci. Anim. Husb.* 6 (1): pp. 60-63.
- ITV (Institut für Tropische Veterinärmedizin) 1973a. Kamelmilch. Mimeo, Giessen, ITV Information Sheet 21, 2 pp.
- ITV (Institut für Tropische Veterinärmedizin) 1973b. Nutzleistungen des Kamels. Mimeo, Giessen, ITV Information Sheet 20, 3 pp.
- Keikin, D. 1976. Camel breeding can be economical. *Anim. Breed. Abstr.* 44 (11), pp. 597.
- Khatami, K. 1970. Camel meat: A new promising approach to the solution of meat and protein in the arid and semi-arid countries of the world. Mimeo, Tehran, Ministry of Agriculture, 4 pp.
- Kiwuwa, G.H. 1973a. The effects of non-genetic factors on dairy cattle performance in East Africa. *East Afr. Agric. For. J.* 38 (3): pp. 252-281.
- Kiwuwa, G.H. 1973b. Estimation of the effects of season and parity on cumulative and part lactation milk yield of dairy cattle in East Africa. *East Afr. Agric. For. J.* 39 (2): pp. 110-119.
- Knoess, K.H. 1976. *Assignment report on animal production in the middle Awash valley.* Rome, FAO (Food and Agriculture Organization), 57 pp.
- Knoess, K.H. 1977. The camel as a meat and milk animal. *World Anim. Rev.* 22: pp. 139-44.
- Kuznetsov, V.A. and Tretyakov, V.N. 1972. Carcass classification in the Turkmen single-humped camel. *Anim. Breed. Abstr.* 40: p. 361.
- Ledger, H.P., Sachs, R. and Smith, N.S. 1967. Wildlife and food production with special reference to the semi-arid areas of the tropics and sub-tropics. *World Rev. Anim. Prod.* 3 (11): pp. 13-35.

- Leese, A.S. 1927. *A treatise on the one-humped camel in health and disease*. Stamford (Lincs.), Haynes and Son, 382 pp.
- Leonard, A.G. 1894. *The camel: Its uses and management*. London, Longman, Green and Co., 335 pp.
- Leupold, J. 1968a. Le chameau: Important animal domestique des pays sub-tropicaux. In *Les cahiers bleus vétérinaires* 1968 (15): pp. 1-6.
- Lewis, L.M. 1969. *Peoples of the Horn of Africa: Somali, Afar and Sabo*. 2nd ed. London, International African Institute, 204 pp.
- Lundholm, B. 1976. Domestic animals in arid ecosystems. *Ecol. Bull. NFR* 24: pp. 29-42.
- Mahadevan, P. 1966. *Breeding for milk production in tropical cattle*. Technical Communication 17, Farnham Royal (Bucks), CAB (Commonwealth Agricultural Bureaux), 154 pp.
- Mares, R.G. 1954. Animal husbandry, animal industry and animal disease in the Somaliland Protectorate. Parts 1 and 2. *Brit. Vet.* 110 (7): pp. 422-423, 470-481.
- Mares, R.G. 1959. The African nomad. In *Introduction to animal husbandry in the tropics*, eds Williamson, G. and Payne, W.S.A. 3rd ed. London, Longman, 755 pp.
- Mason, I.L. and Maule, J.P. 1960. *The indigenous livestock of eastern and southern Africa*. Technical Communication 14, Farnham Royal (Bucks), CAB (Commonwealth Agricultural Bureaux), 248 pp.
- Matharu, B.S. 1966. Animal management: Camel care. Offprint from *Indian Farming*, October 1966: pp. 19-22.
- Nanda, P.N. 1957. Camels and their management. Delhi, ICAR (Indian Council of Agricultural Research), 1963, 17 pp.
- Nasr, S., El-Bahay, G. and Moursy, A.W. 1965. Studies on camel meat. 1: The effect of age and sex on the components of camel meat. *J. Arab. Vet. Med. Assoc.* 25: pp. 253-258.
- Nicolaisen, J. 1963. Ecology and culture of the pastoral Tuareg. Mimeo, Copenhagen.
- Podberezkin, J.A. 1951. Experience of the work of a better camel-breeding farm. *Anim. Breed. Abstr.* 20: p. 75.
- Pratt, D.J. and Gwynne, M.D. (eds) 1977. *Rangeland management and ecology in East Africa*. London, Hodder and Stoughton, 310 pp.
- Robertson, J. 1938. The camel. In *With the cameliers in Palestine*. Reed (Mich.), Marshall Press, pp. 35-44.

- Singh, H. 1963. *Handbook of animal husbandry for extension workers*. New Delhi, Ministry of Food and Agriculture, Directorate of Extension, 162 pp.
- Singh, H. 1966. Camel care. *Intensive Agric.*, January 1966: pp. 9-12.
- Spencer, P. 1973. *Nomads in alliance: Symbiosis and growth among the Rendille and Samburu of Kenya*. London, Oxford University Press, 230 pp.
- Sweet, L.E. 1965. Camel pastoralism in North Arabia and the minimal camping unit. In *Man, culture and animals*, eds Leeds, A. and Vayds, A. Washington, AAAS (American Association for the Advancement of Science), pp. 124-152.
- Torry, W.I. 1971. Animal husbandry and social organization among the Gabbra, with notes on the Rendille tribe. In *Rangeland management and ecology in East Africa*, eds Pratt, D.J. and Gwynne, M.D. London, Hodder and Stoughton (1977), pp. 156-159.
- UNECA/FAO (United Nations Economic Commission for Africa/Food and Agriculture Organization) 1972. *Prospects for production, marketing and trade in live-stock and livestock products in eastern Africa to 1985. Vol. 2: Country Studies*. Addis Ababa, 276 pp.
- War Office 1908. The camel. In *Animal management*. London, HM Stationery Office, pp. 277-295.
- Williamson, G. and Payne, W.J.A. 1978. *An introduction to animal husbandry in the tropics*. 3rd ed. London, Longman, 755 pp.
- Wilson, R.T. 1978. Studies on the livestock of Southern Darfur, Sudan. 5: Notes on camels. *Trop. Anim. Health Prod.* 10: pp. 19-25.
- Yasin, S.A. and Wahid, A. 1957. Pakistan camels: A preliminary survey. *Agric. Pak.* 1957 (8): pp. 289-297.

6. MANAGEMENT AND SOCIO-ECONOMIC FACTORS

- Asad, T. 1970. *The Kababish Arabs: Power, authority and consent in a nomadic tribe*. London, C. Hurst and Co., 263 pp.
- Awad, M. 1962. Nomadism in the Arab lands of the Middle East. In *Problems of the arid zones*. Proceedings of UNESCO symposium, Paris, 11-18 May 1960. 528 pp.
- Capot-Rey, R. 1962. The present state of nomadism in the Sahara. In *Problems of the arid zones*. Proceedings of UNESCO symposium, Paris, 11-18 May 1960. 528 pp.
- Cole, D.P. 1975. *Nomads of the nomads: The Al Murrab Bedouin of the Empty quarter*. Chicago, Aldine Publishing Co., 179 pp.

- Dahl, G. and Hjort, A. 1979. Dromedary pastoralism in Africa and Arabia. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 448-456.
- El-Amin, F.M. 1979. The dromedary camel of the Sudan. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 35-53.
- Evans, J.O. and Powys, J.G. 1979. Camel husbandry to increase the productivity of ranchland. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 241-250.
- Hartley, B.J. 1979. Camels in the Horn of Africa. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 109-123.
- Torry, W.I. 1971. Animal husbandry and social organization among the Gabbra, with notes on the Rendille tribe. In *Rangeland management and ecology in East Africa*, eds Pratt, D.J. and Gwynne, M.D. London, Hodder and Stoughton (1977), pp. 156-159.
- Williamson, G. and Payne, W.J.A. 1978. *An introduction to animal husbandry in the tropics*. 3rd ed. London, Longman, 755 pp.

7. SUMMARY AND PROPOSALS FOR FUTURE RESEARCH

- Alim, K.A. 1976. The livestock and meat industry of Egypt. *World Rev. Anim. Prod.* 12 (4): pp. 59-67.
- El-Amin, F.M. 1979. The dromedary camel of the Sudan. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6: pp. 35-53.
- FAO (Food and Agriculture Organization) 1975. *The international meat development scheme*. Report to the Government of the Democratic Republic of Sudan. Rome, 169 pp.
- FAO (Food and Agriculture Organization) 1979. Self-sufficiency: Facts and Figures. *Ceres* 12 (1): pp. 19-21.
- Field, C.R. 1979a. Ecology and management of camels, sheep and goats in northern Kenya. Mimeo, Nairobi, UNDP/MAB-IPAL (United Nations Environmental Programme/Man and Biosphere - Integrated Project in Arid Lands), 18 pp.
- ILCA (International Livestock Centre for Africa) 1979a. Milk supply problems in tropical Africa. *Economic trends*, ILCA Bulletin 4: pp. 4-8.
- ILCA (International Livestock Centre for Africa) 1979b. The potential of tropical Africa in by-products for animal feeds. *Economic trends*, ILCA Bulletin 6: pp. 1-10.

Pratt, D.J. and Gwynne, M.D. (eds) 1977. *Rangeland management and ecology in East Africa*. London, Hodder and Stoughton, 310 pp.

UNECA/FAO (United Nations Economic Commission for Africa/Food and Agriculture Organization) 1972. *Prospects for production, marketing and trade in live-stock and livestock products in eastern Africa to 1985. Vol. 2: Country studies*. Addis Ababa, 276 pp.

FURTHER READING

GENERAL

Auby, J.C. 1970. *Mémento élémentaire de biologie et de pathologie du dromadaire d'Afrique du Nord*. Compiègne, CIFV (Centre d'Instruction du Service Vétérinaire de l'Armée).

Bilke, E. and Koppe, J. 1972. Reisereindrücke aus der Tierzucht Aegyptens. *Tierärztl. Umsch.* 27 (5): pp. 230-231.

Boué, A. 1951. L'originalité du chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 5: pp. 109-114.

Boué, A., Castagnera, H. and Daudel, Cmdt. Vet. 1962. *L'initiation au dromadaire*. Compiègne, CISV (Centre d'Instruction du Service Vétérinaire de l'Armée).

El-Fourgi, M. 1950. Le chameau tunisien. Thèse doct. vét. No. 48, Toulouse, ENV (Ecole Nationale Vétérinaire).

Gauthier-Pilters, H. 1959. *Unter Nomaden und Kamelen*. 2nd ed. Kempen, Thomas-Verlag.

Gauthier-Pilters, H. 1970. Tylopodes. In *Elsevier's animal encyclopedia*. London, Elsevier.

Gauthier-Pilters, H. 1970. Le dromadaire: Fables et réalités. *MIFERMA (Mines de Fer de Mauritanie) Informations* 19: pp. 47-52.

Gauthier-Pilters, H. 1976. Trans. Baskin, L. The camel: Wonder of the desert. *Priroda (Moscow)* 3: pp. 128-137.

Gleichen, C. 1975. *With the camel corps up the Nile*. 2nd ed., Wakefield (Yorks), EP Publishing Ltd.

IFS (International Foundation for Science)/National Council for Research (Sudan) 1980. Provisional Report 6: The Workshop on Camels, Khartoum, 18-20 December 1979. Stockholm.

Krumbiegel, I. 1952. Kamele. *Neue Brehm-Bücherei* 50: p. 36.

- Larrat, R. 1936. L'élevage du dromadaire. In *Conférence consultative de l'Élevage, Dakar, 25-30 March 1936*. Maisons-Alfort, IEMVT (Institut de l'Élevage et de Médecine Vétérinaire des Pays Tropicaux), pp. 101-112.
- Leclercq, P. 1976. *Principales races d'animaux domestiques des zones tropicales*. Maisons-Alfort, IEMVT (Institut de l'Élevage et de Médecine Vétérinaire des Pays Tropicaux).
- Lefebure, E. 1907. Le chameau en Egypte. In *Actes du 14e Congrès International des Orientalistes*, Algiers, 1905. Paris, Editions Leroux, pp. 24-42.
- Lesbre, F.X. 1906. *Précis d'extérieur du cheval et des principaux mammifères domestiques*. Paris, Asselin et Houzeau.
- Lesourd, M. 1963. Le dromadaire au Sahara. *Rev. Serv. Biol. Vét. Armée* 16(2): pp. 50-55.
- Leupold, J. 1971. Kamele. In *Handbuch der Landwirtschaft und Ernährung in den Entwicklungsländern*, pp. 861-882.
- McKnight, T.L. 1969. *The camel in Australia*. Melbourne University Press.
- Michael, E. 1905. Le chameau du Sahara soudanais. *Bull. Soc. Geogr. Alger.* 1905: pp. 368-386.
- Monteil, V. 1952. Essai sur le chameau au Sahara occidental. *Bull. Inst. Fondam. Afr. Noire* 7(9): pp. 25-132.
- Rao, C.K. 1973. A note on the camel. Mimeo, New Delhi, Animal Husbandry Commission.
- Richard, D. 1979. Note sur l'élevage camelin en Ethiopie. Mimeo, Addis Ababa, Ministry of Agriculture.
- Rousseau, R. 1943. Le chameau au Sénégal. *Bull. Inst. Fondam. Afr. Noire* 5(1-4): pp. 67-80.
- Roux, J.P. 1959. Le chameau en Asie Centrale. *Cent. Asiatic J.* 5: pp. 35-76.
- Sharma, V.D. and Bhargava, K.K. 1963. The Bikaneri camel. *Indian Vet. J.* 40: pp. 639-643.
- Surcouf, J.M.R. 1922/23. Note sur le dromadaire. *Bull. Soc. Hist. Nat. Afr. Nord* 1922/23: pp. 13-14.
- Vallon, M. 1856. Mémoire sur l'histoire naturelle du dromadaire. *Rec. Hyg. Méd. Vét. Mil.* 1856(7): pp. 351-614.
- Vitale, M.A. 1928. *Il cammello: E i reparti cammellati*. Rome, Sindacato Italiano Arti Grafiche.

ANATOMY/CYTOLOGY/HISTOLOGY

- Abdalla, O. 1965. Anatomical study of the female genital system of the one-humped camel. 1: Ovaries. *Sudan J. Vet. Sci. Anim. Husb.* 6(1): pp. 41-52.
- Abdalla, O. 1967. Anatomical study of the female genital system of the one-humped camel. 2: The oviducts. *Sudan J. Vet. Sci. Anim. Husb.* 8(2): pp. 67-77.
- Abdalla, O. 1968. Anatomical study of the female genital system of the one-humped camel. 3: The uterus and the placenta. *Sudan J. Vet. Sci. Anim. Husb.* 9(1): pp. 477-503.
- Abdalla, O. and Hassan, A.A. 1970. The male genital system of the one-humped camel. M.V. Sc. thesis, Khartoum University.
- Awkati, A. and Al-Bagdadi, F. 1971. Lacrimal gland of the camel. *Am. J. Vet. Res.* 32(3): pp. 505-510.
- Barmintsev, V. 1951. Rectal examination of the reproductive organs of the camel. *Konevodstvo Konnyj. Sport* 21: p. 38.
- Boué, A. 1949. Quelques anomalies dentaires chez le chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 3(1): pp. 46-47.
- Chahrasbie, H. and Radmehr, B. 1974. Recherches anatomiques sur les différences morphologiques et le caractère spécifique de la circulation artérielle de l'encéphale chez le chameau. *Cab. Méd. Vét.* 43(3): pp. 106-109.
- Chahrasbie, H. and Radmehr, B. 1975. Recherches anatomiques et histologiques sur le 3e réservoir gastrique chez le chameau dromadaire des races d'Iran. *Cab. Méd. Vét.* 44(3): pp. 106-109.
- Curasson, G. 1947. Les tests anatomiques de l'adaptation du chameau en milieu désertique. *Rev. Elev. Méd. Vét. Pays Trop.* 1(1): pp. 29-36.
- Dafalla, I.O. n.d. The morphology and histochemistry of the testes of camel (*C. dromedarius*). M.V.Sc. thesis, Khartoum University.
- Dellman, H.D., Blin, P.C. and Fahmy, M.F.A. 1968. Contribution a l'étude de l'anatomie microscopique du tube digestif chez le chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 21(1): pp. 1-32.
- Dowling, D.F. and Nay, T. 1962. Hair follicles and the sweat glands of the camel (*Camelus dromedarius*). *Nature* 195 (4841): pp. 578-580.
- El-Hagasi, H.A. 1954. Le coeur du chameau. *Brit. Vet. J.* 110: pp. 104-108.

- El-Hagri, M.A.A. and Morcas, M.B. 1954. Etude du systeme artériel du membre thoracique du chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 7(3): pp. 165-169.
- El-Hagri, M.A.A. and Morcas, M.B. 1954. Quelques caractéristiques anatomiques des systèmes nerveux et musculaire du membre thoracique du chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 7(2): pp. 81-85.
- El-Shaieb, M. 1978. The brachial plexus of the camel. *Vet. Med. J.* 3(5): pp. 11-20.
- Elwishy, A.B., Mobarak, M.A. and Fouad, S.M. 1972. The accessory genital organs of the one-humped camel (*C. dromedarius*). *Anat. Anz.* 131(1): pp. 1-2.
- Fouad, S.M., Mobarak, A.M. and Aly, M.A. 1979. Micromorphology of the arteries of the penis of the one-humped camel. *Indian J. Anim. Sci.* 49(5): pp. 377-379.
- Hansen, A. and Schmidt-Nielsen, K. 1957. On the stomach of the camel, with special reference to the structure of its mucous membrane. *Acta Anat.* 31: pp. 353-375.
- Hassan, A.A. 1975. The morphology and histo-chemistry of the accessory male glands of the one-humped camel (*C. dromedarius*). M.V.Sc. thesis, Khartoum University.
- Hegazi, A.E. 1953. The spleen of the camel compared with other domestic animals. *J. Am. Vet. Med. Assoc.* 122(912): pp. 182-184.
- Jamdar, M.N. 1960/61. Comparative anatomy of the bony system of the camel (*C. dromedarius*). *Indian Vet. J.* 73(5): pp. 225-239; 37(6): pp. 279-291; 38(2): pp. 53-64; 38(7): pp. 325-338.
- Kanan, C.U. 1960. Notes on the vertebral column, ribs and sternum of the camel (*Camelus dromedarius*). *Sudan J. Vet. Sci. Anim. Husb.* 1: pp. 84-91.
- Lesbre, M.F.X. 1903. Recherches anatomiques sur les camelidés. Extract from *Arch. Mus. Hist. Nat. Lyon*.
- Lesbre, M.F.X. 1906. *Précis d'extérieur du cheval et des principaux mammifères domestiques*. Paris, Asselin et Houzeau.
- Madan, S.C. 1969. Morphology of spermatozoa from the epididymus of the camel (*C. dromedarius*). M.V.Sc. thesis, Rajasthan, University of Udaipur.
- Morton, W.R. 1961. Observations on the full-term foetal membranes of three members of the Camelidae (*C. dromedarius*, *C. bactrianus* and *Lama glama*). *J. Anat.* 95: p. 200.
- Musa, B.E. 1977. A new epidermal membrane associated with the foetus of the camel. *Zentralbl. Veterinärmed.* 6(4): pp. 355-358.
- Noyan, A. 1970. The microscopic appearance of camel and lama erythrocytes. *Ankara Univ. Vet. Fak. Derg.* 17(4): pp. 518-522.

- Osman, A.M. 1960. Anatomical study of the female genital system of the *C. dromedarius* with special reference to the histology of the mucous membrane. M.V. Sc. thesis, Khartoum University.
- Pilliet, A. 1885. Structure de la portion gaufrée de l'estomac du chameau. *Bull. Soc. Zool. Fr.* 10: pp. 40-41.
- Purohit, M.S. and Rathor, S.S. 1962. Stomach of the camel in relation to that of the ox. *Indian Vet. J.* 39(11): pp. 604-608.
- Purohit, M.S. and Singh, B. 1958. The poll glands in camel. *Indian Vet. J.* 35: pp. 296-298.
- Saleh, M.S. 1971. Radiological, anatomical and histological studies of the mammary gland of the one-humped camel. *Zentralbl. Veterinärmed.* 18(4): pp. 347-352.
- Soliman, M.K. and Shaker, M. 1967. Cytological and biochemical studies on the blood of adult she camels. *Indian Vet. J.* 44(12): pp. 989-995.
- Souteyrand-Boulenger, J.D. 1968. Muscle articulaire de la hanche chez les camelidés. *Rev. Elev. Méd. Vét. Pays Trop.* 21(3): pp. 289-292.
- Tayeb, M. 1948. Urinary system of the camel. *J. Am. Vet. Med. Assoc.* 112(861): pp. 568-572.
- Tayeb, M. 1950. Les muscles de la tête du chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 4(1): pp. 21-24.

DISEASES/DISORDERS/PARASITES

- Abdel-Raouf, M. 1965. Studies on reproduction in camels (*C. dromedarius*). 3: Testicular hypoplasia. In *Proceedings of the Sixth Annual Veterinary Congress, Cairo*, pp. 125-130.
- Adam, S.E.I., Obeid, H.M., Ashour, N. and Tartour, G. 1974. Serum enzyme activities and haematology of normal and diseased ruminants in the Sudan. *Acta Vet. Brno* 43(3): pp. 225-231.
- Afshar, A., Nazarjan, I. and Baghban-Baseer, B. 1971. A survey of the incidence of hydatid cyst in camels in south Iran. *Brit. Vet. J.* 127(11): pp. 544-546.
- Altaif, K.I. 1974. Helminths in camels in Iraq. *Trop. Anim. Health Prod.* 6(1): pp. 55-57.
- Amanschulow, S.A., Samarzew, A.A. and Arbusow, L.N. 1930. Sur la variole du chameau de la région de l'Oural. *Bull. Inst. Pasteur* 29: p. 96.
- Auby, J.C. 1970. *Mémento élémentaire de biologie et de pathologie du dromadaire d'Afrique Nord*. Compiègne, CIFV (Centre d'Instruction du Service Vétérinaire de l'Armée).

- Baxby, D. 1972. Smallpox-like viruses from camels in Iran. *Lancet* 2 (7736): pp. 1063-1065.
- Bedson, H.S. 1972. Camel pox and smallpox. *Lancet* 2 (7789): p. 1253.
- Bhargava, A.K. and Vyas, U.K. 1967. "Chloral mag" anesthesia in the camel (*Camelus dromedarius*). *Vet. Rec.* 80 (10): p. 322.
- Bhatt, P.L., Kohli, R.N. Rathore, U.S. 1960. The normal body temperature, respiratory frequency and heart rate of the camel. *Indian Vet. J.* 37 (9): pp. 456-462.
- Crombe, Capt. Vét. 1957. *Au sujet des pertes de chameaux subies par la campagne méhariste du sud Tunisien au cours des derniers mois*. Paris, DSV (Division du Service Vétérinaire).
- Cross, H.E. 1917. *The camel and its diseases: Being notes for veterinary surgeons and commandants of camel corps*. London, Baillière and Tindall.
- Cross, H.E. 1919. Are camels susceptible to blackquarter, haemorrhagic septicæmia and rinderpest? *Bull. Agric. Res. Inst. Pusa* 1919 (80).
- Curasson, G. 1939. Sur quelques plantes toxiques ou réputées toxiques pour le bétail. *Bull. Serv. Zoot. Epizoot. AOF* 2 (3): pp. 14-16.
- Dagain, R. 1947. Le service vétérinaire du Groupe d'Unités Sahariennes de l'Est, à Quar-gla. *Rev. Vét. Mil.* 2 (1): pp. 43-44.
- Daynes, P. and Richard, D. 1974. Note sur les helminthes (et quelques autres parasites) du dromadaire en Ethiopie. *Rev. Elev. Méd. Vét. Pays Trop.* 27 (1): pp. 53-56.
- Decker, R.A. and McDermid, A.M. 1977. Nutritional myopathy in a young camel. *J. Zoo Anim. Med.* 8 (2): pp. 20-21.
- Dhillon, S.S. 1959. Incidence of rinderpest in camels in Hissar district. *Indian Vet. J.* 36 (12): pp. 603-607.
- Durand, M. 1958. Une ostéopathie astrophique chez le chameau: Le *kraff*. *Bull. Acad. Vét.* 31: pp. 159-160.
- Durand, M. and Khouk, M. 1958. Le *kraff*, une ostéopathie dystrophique du dromadaire. *Arch. Inst. Pasteur Tunis* 35 (2): pp. 107-151.
- Edelstein, R.M. and Pegram, R.G. 1974. Contagious skin necrosis of Somali camels associated with *Streptococcus agalactiae*. *Trop. Anim. Health Prod.* 6 (4): pp. 255-256.
- El-Mossalami, E. and El-Nawawi, F. 1971. Cysticercosis among slaughtered camels. *Egypt. Vet. Med. J.* 19: pp. 477-776.

- Fedorov, V.N. 1960. Plague in camels and its prevention in the USSR. *Bull. OMS* 23 (2-3): pp. 275-281.
- Ferry, R. 1961. Parasitisme gastro-intestinal du dromadaire au Niger. Thèse doct. vét. No. 100, Alfort, ENV (Ecole Nationale Vétérinaire).
- Finlayson, R., Keymer, I.F. and Manton, V.J.A. 1971. Calcific cardiomyopathy in young camels (*Camelus* spp.). *J. Comp. Path.* 81 (1): pp. 71-78.
- Foley, H. and Musso, M. 1925. Les plantes du Sahara toxiques pour les animaux. *Arch. Inst. Pasteur Alger.* 3(12): pp. 349-401.
- Frullini, P.L. 1922. Tripanosomiasi e piroplasmosi nei cammelli della dancalia. *Arch. Ital. Sci. Med. Colon.* 19 (4): pp. 340-343 and new series vol. 16 (1938).
- Gatt-Rutter, T.E. 1963/67. Diseases of camels. 1: Bacterial and fungal diseases; 2: Protozoal diseases. *Vet. Bull.* 33 (3): pp. 119-124; 37 (9): pp. 611-618.
- Gautam, O.P. and Bansal, S.R. 1972. Save your camel from pica - *Mitti khana*. *Indian Farming* 21 (10): pp. 40-47.
- Ghanni, A. 1977. Prevailing diseases in the camel: Bibliography. Mimeo, Toulouse, ENV (Ecole Nationale Vétérinaire).
- Godfrey, D.G. and Killick-Kendrick, R. 1962. *Trypanosoma evansi* of camels in Nigeria: A high incidence demonstrated by the inoculation of blood into rats. *Ann. Trop. Med. Parasitol.* 56: p. 14.
- Graber, M. 1966. Action du thiabendazole sur divers helminthes du dromadaire, en particulier sur les nématodes du tube digestif: Compte rendu d'expérience définitif. Maisons-Alfort, IEMVT (Institut d'Élevage et de Médecine Vétérinaire des Pays Tropicaux).
- Graber, M. 1966. Etude dans certaines conditions africaines de l'action antiparasitaire du thiabendazole sur divers helminthes des animaux domestiques. 2: Dromadaire. *Rev. Elev. Méd. Vét. Pays Trop.* 19 (4): pp. 527-543.
- Graber, M. 1967. Etude préliminaire de la biologie d'*Haemoncus longistipes* (Raillet et Henry, 1909) du dromadaire: Resultats obtenus au laboratoire. *Rev. Elev. Méd. Vét. Pays Trop.* 20 (2): pp. 213-225.
- Graber, M. 1967. Enquêtes sur les helminthes du dromadaire tchadien: Etude des strongyloses gastro-intestinales et de l'haemoncose à *H. longistipes*. *Rev. Elev. Méd. Vét. Pays Trop.* 20 (2): pp. 227-254.
- Graber, M. 1969. Essais de traitement du parasitisme gastro-intestinal du dromadaire au moyen du Tétramisole: Premières observations. *Rev. Elev. Méd. Vét. Pays Trop.* 22 (2): pp. 229-236.

- Gruvel, J. and Balis, J. 1965. La trypanosomiase à *T. evansi* chez le dromadaire au Tchad et ses principaux vecteurs. *Rev. Elev. Méd. Vét. Pays Trop.* 18 (4): pp. 435-439.
- Gruvel, J. and Graber, M. 1965. Quelques résultats d'enquêtes récentes sur la globidiose du dromadaire au Tchad: Note préliminaire. *Rev. Elev. Méd. Vét. Pays Trop.* 18 (4): pp. 423-428.
- Harbi, M.S.M.A. and Awad El Karim, M.H. 1972. Serological investigation into Q fever in Sudanese camels (*Camelus dromedarius*). *Bull. Epizoot. Dis. Afr.* 20 (1): pp. 15-17.
- IFS (International Foundation for Science)/National Council for Research (Sudan) 1980. Provisional Report 6: The workshop on camels, Khartoum, 18-20 December 1979. Stockholm.
- Jashoski, B.J. and Williamson, W.M. 1968. A fatal nematodiosis in the camel. *J. Am. Vet. Med. Assoc.* 132 (12): pp. 35-37.
- Jatkar, P.B. and Singh, M. 1971. Diagnosis of *surra* in camels by the passive haemagglutination test. *Brit. Vet. J.* 127: pp. 283-288.
- Jousselin, N. 1949. Notes sur la pathologie du dromadaire: De quelques traitements indigènes. *Rev. Elev. Méd. Vét. Pays Trop.* 3 (2): pp. 105-108.
- Kulshrestha, R.C., Arora, R.G. and Kalra, D.S. 1975. Brucellosis in camels and horses. *Indian J. Anim. Sci.* 45 (9): pp. 673-675.
- Krupenko, S.S. 1972. Camel pox caused by vaccinal virus. *Veterinariya (Moscow)* 1972 (8): pp. 61-62.
- Leveque, R. 1957. Carences d'origine tellurique chez les dromadaires du sud Tunisien. *Bull. Soc. Sci. Nat. Tunis.* 9 (10): pp. 49-57.
- Leveque, R. 1957. Contribution à l'étude d'une maladie appelée *kruff* chez les chameaux du sud Tunisien. *Rev. Corps Vét. Armée* 12 (3): pp. 115-120.
- Lodha, K.R. 1966. Studies on sarcoptic mange in camels (*Camelus dromedarius*). *Vet. Rec.* 79 (2): pp. 41-43.
- Lodha, K.R., Raisingham, P.M. and Karwasra, R.S. 1977. Chemo-therapeutic trials of some anthelmintics against helminth parasites in camels. *Indian J. Anim. Sci.* 47 (10): pp. 677-682.
- Madadi, H. 1973. Sanitary inspection of camel meat. Mimeo, Tehran Municipality.
- Masia, R. 1953. Les maladies microbiennes du dromadaire et leur importance en Afrique du Nord. Thèse doct. vét. No. 28, Alfort, ENV (Ecole Nationale Vétérinaire).

- Mathur, C.S. 1960. Nutrition in relation to satyriasis in camels. *Indian Vet. J.* 37: pp. 199-201.
- Maurice, Y., Bares, J.F. and Baille, Mme. Enquête sérologique sur les rickettsioses chez les dromadaires au Tchad. *Rev. Elev. Méd. Vét. Pays Trop.* 20 (4): pp. 543-550.
- Maurice, Y., Provost, A. and Borredon, C. 1967. Présence d'anticorps antibovipestique chez le dromadaire du Tchad. *Rev. Elev. Méd. Vét. Pays Trop.* 20 (4): pp. 537-547.
- Maurice, Y., Queval, R. and Bares, J.F. 1968. Enquête sur l'infection à virus para-influenza 3 chez le dromadaire tchadien. *Rev. Elev. Méd. Vét. Pays Trop.* 21 (4): pp. 443-449.
- Metcalf, J. 1968. Cardiodynamics of the dromedary camel during phencyclidine analgesia. *Am. J. Vet. Res.* 29 (10): pp. 2063-2066.
- Mirchamsky, H., Bahrami, B., Amighi, M. and Shafyi, A. 1971. Development of a camel kidney cell strain and its use in virology. *Arch. Inst. Razi* 23 (1): pp. 15-18.
- Mustafa, A.A. and Awad El Karim, M.H. 1971. A preliminary survey for the detection of *Brucella* antibodies in camel sera. *Sudan J. Vet. Sci. Anim. Husb.* 12 (1): pp. 5-8.
- Nair, K.P.D. 1968. Efficacy of methyridine 2 (2- methoxyethyl) pyridine in the treatment of trichuriasis in camel (*Camelus dromedarius*). *Indian Vet. J.* 45 (3): pp. 252-255.
- Peck, E.F. 1939. Salt intake in relation to cutaneous necrosis and arthritis of one-humped camels (*C. dromedarius*) in British Somaliland. *Vet. Rec.* 51: pp. 1355-1360.
- Pegram, R.G. and Scott, J.M. 1976. The prevalence and diagnosis of *Trypanosoma evansi* infection in camel in southern Ethiopia. *Trop. Anim. Health Prod.* 8 (1): pp. 20-27.
- Petureau, P. and Maurice, Y. 1968. Epizootologie de la pasteurellose des chameaux au Tchad: Enquête sérologique. *Rev. Elev. Méd. Vét. Pays Trop.* 21 (4): pp. 451-454.
- Petris, M.A. 1956. Caesarean operation in camels. *Vet. Rec.* 68: pp. 367-386.
- Pringle, R. 1955. Foot-and-mouth diseases in camels. *Brit. Vet. J.* 3 (9): p. 416.
- Provost, A., Haas, P. and Dembelle, M. 1975. Premier cas au Tchad de botulisme animal (type c): Intoxication de dromadaire par l'eau d'un puits. *Rev. Elev. Méd. Vét. Pays Trop.* 28 (1): pp. 9-11.

- Provost, A., Maurice, Y. and Borredon, C. 1968. Note sur la peste bovine expérimentale du dromadaire. *Rev. Elev. Méd. Vét. Pays Trop.* 21 (3): pp. 293-296.
- Queval, R., Graber, M. and Brunet, Mme. 1967. Étude de la protidémie et des constantes hématologiques des camelidés en fonction des helminthes dont ils sont porteurs. *Rev. Elev. Méd. Vét. Pays Trop.* 20 (3): pp. 437-449.
- Ramachandran, P.K., Ramachandran, S. and Joshi, T.P. 1968. An outbreak of haemorrhagic gastro-enteritis in camels (*Camelus dromedarius*). *Ann. Parasitol. Hum. Comp.* 43 (1): pp. 5-14.
- Ramyar, H. and Hessami, M. 1972. Isolation, cultivation and characterization of camel pox virus. *Arch. Inst. Razi* 24 (1): pp. 13-21.
- Rathore, M.S. and Lodha, K.R. 1973/74. Observations on sarcoptic mange in camels in Rajasthan. 1: Incidence and intensity; 2: Trials with some insecticides. *Indian Vet. J.* 50 (11): pp. 1083-1088; 51 (2): pp. 149-153.
- Richard, D. 1979. Study of the pathology of the dromedary in Borana Awraja (Ethiopia). Thesis, Créteil Faculty of Medicine. Maisons-Alfort, IEMVT (Institut d'Élevage et de Médecine Vétérinaire des Pays Tropicaux).
- Rossetti, G. and Congui, S. 1955. *Zootechnical and veterinary investigations on the domestic animals of Somalia*. Mogadishu, Ispettorato Veterinario, Amministrazione Fiducaria Italiana della Somalia.
- Said, A.H. 1964. Quelques aspects de l'anesthésie chez le chameau. *Vet. Rec.* 76 (20): pp. 550-554.
- Scott, G.R. and MacDonald, J. 1962. Kenya camels and rinderpest. *Bull. Epizoot. Dis. Afr.* 10: pp. 495-497.
- Selim, M.K. and Rahman, M.S. 1972. Enteric nematodes of camels in Egypt. *Egypt. J. Vet. Sci.* 9 (1-2): pp. 75-80.
- Shalash, M.R. and Nawito, M. 1963. Sterility in female camels. *Dtsch. Tierärztl. Wochenschr.* 70 (18): p. 522.
- Sharma, S.S. and Vyas, K.K. 1972. Involution of uterus and vulva in camels. *Ceylon Vet. J.* 20 (1-2): pp. 9-10.
- Singh, K.V. and Ata, F. 1967. Experimental rinderpest in camels: A preliminary report. *Bull. Epizoot. Dis. Afr.* 15 (1): pp. 19-23.
- Singh, K.V. and Ata, F. 1967. Presence of antibodies against para-influenza 3 virus in camel and sheep sera. *Vet. Rec.* 81 (3): p. 84.
- Singh, M.P. and Singh, C.M. 1969. Mycotic dermatitis in camels. *Indian Vet. J.* 46 (10): pp. 854-856.

- Steward, J.S. 1950. Notes on some parasites of camels (*Camelus dromedarius*) in the Sudan. *Vet. Rec.* 52 (62): pp. 835-837.
- Steward, J.S. 1950. Trichostrongylosis and haemonchosis in the camel: Their recognition and response to phenothiazine. *Vet. Rec.* 52 (62): pp. 837-839.
- Taylor, W.P. 1968. The susceptibility of the one-humped camel (*Camelus dromedarius*) to infection with rinderpest virus. *Bull. Epizoot. Dis. Afr.* 16 (4): pp. 405-410.
- Zaki, R. 1948. Brucella infection among ewes, camels and pigs in Egypt. *J. Comp. Path.* 58: p. 145.

DISTRIBUTION/CLASSIFICATION/DOMESTICATION/ORIGINS

- Basset, R. 1907. Le nom du chameau chez les berbères. In *Actes du 14e Congrès Internationale des Orientalistes*, Algiers 1905. Paris, Editions Leroux, pp. 69-82.
- Boué, A. 1948. Les chameaux de l'ouest Saharien. *Rev. Elev. Méd. Vét. Pays Trop.* 2: pp. 194-201.
- Demougeot, E. 1960. Le chameau et l'Afrique du Nord romaine *Ann. Econ. Soc. Civilis.* 15: pp. 209-247.
- Droandi, I. n.d. Has the number of camels in the world doubled? Mimeo, Florence, Istituto Agronomico per l'Africa Italiana.
- El-Fourgi, M. 1950. Le chameau tunisien. Thèse doct. vét. No. 48, Toulouse, ENV (Ecole Nationale Vétérinaire).
- FAO (Food and Agriculture Organization) 1981. *Production yearbook, 1980*. Rome.
- Forbes, R.J. 1965. The coming of the camel. In *Studies in ancient technology*. Leiden, Brill.
- Free, J.P. 1944. Abraham's camels. *J. Near Eastern Stud.* 3: pp. 187-193.
- Gentry, A.W. and Gentry, A. 1969. Fossil camels in Kenya and Tanzania. *Nature* 222 (5196): p. 898.
- Gode, P.K. 1958. Notes on the history of the camel in India between B.C. 500 and A.D. 800. *Janus* 47: pp. 133-138.
- IFS (International Foundation for Science)/National Council for Research (Sudan) 1980. Provisional Report 6: The Workshop on Camels, Khartoum, 18-20 December 1979. Stockholm.

- Leclercq, P. 1976. *Principales races d'animaux domestiques des zones tropicales*. Maisons-Alfort, IEMVT (Institut d'Élevage et de Médecine Vétérinaire des Pays Tropicaux).
- Lefebure, E. 1905. Le chameau en Egypte. In *Actes du 14e Congrès Internationale des Orientalistes*, Algiers, 1905. Paris, Editions Leroux, pp. 24-62.
- Lesourd, M. 1963. Le dromadaire au Sahara. *Rev. Serv. Biol. Vét. Armée* 16 (2): pp. 50-55.
- Lhote, H. 1953. Le cheval et le chameau dans les peintures et gravures rupestres du Sahara. *Bull. Inst. Fondam. Afr. Noire* 15: pp. 1138-1228.
- McKnight, T.L. 1969. *The camel in Australia*. Melbourne University Press.
- Michael, E. 1905. Le chameau du Sahara soudanais. *Bull. Soc. Géogr. Alger* 1905: pp. 368-386.
- Monod, T. 1939. Variétés: Dromadaire Arabe et dromadaire Africain. *Bull. Serv. Zoot. Epizoot. AOF* 2 (4): pp. 39-41.
- Montagu, I. 1965. Communication on the current survival in Mongolia of the wild horse (*Equus przewalskii*), wild camel (*Camelus bactrianus ferus*) and the wild ass (*Equus hemionus*). *Proc. Zool. Soc. (London)* 144: pp. 425-428.
- Monteil, V. 1952. Essai sur le chameau au Sahara occidental. *Bull. Inst. Fondam. Afr. Noire* 7 (9): pp. 25-132.
- Murray, G.N. 1952. Early camels in Egypt. *Bull. Inst. Désert Egypte* 2 (1): pp. 105-106.
- Rao, C.K. 1974. Scheme for the improvement of Indian camels: Classification into types or breeds, their numbers in Indian states. Mimeo Item 4, New Delhi, Animal Husbandry Commission.
- Rousseau, R. 1943. Le chameau au Sénégal. *Bull. Inst. Fondam. Afr. Noire* 5 (1-4): pp. 67-80.
- Roux, J.P. 1959. Le chameau en Asie Centrale. *Cent. Asiatic J.* 5: pp. 35-36.
- Schafer, E.H. 1950. The camel in China down to the Mongol Dynasty. *Sinologica* 2: pp. 165-194, 263-290.
- Sharma, V.D. and Bhargava, K.K. 1963. The Bikaneri camel. *Indian Vet. J.* 40: pp. 639-643.
- Walz, R. 1951. Zum Problem des Zeitpunkts der Domestikation der altweltlichen Cameliden. *Z. Dtsch. Morgenländ. Ges.* 26: pp. 29-51.

Walz, R. 1952. Beiträge zur ältesten Geschichte der altweltlichen Kameliden unter besonderer Berücksichtigung des Problems des Domestikationszeitpunktes. In *Actes du 14e Congrès Internationale des Sciences Anthropologiques et Ethnologiques*, Vienna, 1905. Vol. 3, pp. 190-204.

Walz, R. 1954. Neue Untersuchungen zum Domestikationsproblem der altweltlichen Cameliden. *Z. Dtsch. Morgenländ. Ges.* 29: pp. 45-87.

ECOLOGY/ETHOLOGY

Bartha, R. 1971. The physiological adaptability of camels to the environmental conditions of the vast arid zones. *Tropenlandwirt* 72: pp. 138-148.

Charnot, Y. 1959. A propos de l'écologie des camelidés. *Bull. Soc. Sci. Nat. Phys. Maroc* 39 (1): pp. 29-39.

Curasson, G. 1947. Les tests anatomiques de l'adaptation du chameau en milieu désertique. *Rev. Elev. Méd. Vét. Pays Trop.* 1 (1): pp. 29-36.

Dementiev, G.P. and Zevegmid, D. 1962. Bemerkungen über das Wildkamel in der Mongolei. *Zool. Gart.* 26 (3): pp. 298-305.

Denis, P. 1970. Observations sur le comportement du dromadaire. Thesis, Faculté des Sciences, University of Nancy.

Field, C.R. 1978. The food habits of camels. Mimeo, Nairobi, UNESCO/IPAL (United Nations Education, Scientific and Cultural Organization/Integrated Project in Arid Lands).

Gauthier-Pilters, H. 1954. Untersuchungen über angeborene Verhaltensweisen bei Tylopoden unter besonderer Berücksichtigung der neuweltlichen Formen. *Z. Tierpsychol.* 11 (2): pp. 213-303.

Gauthier-Pilters, H. 1955. Quelques observations sur le comportement des dromadaires (*Camelus dromedarius*), relevées dans le Sahara nord-occidental. *Bull. Soc. Vét. Zootec. Algérie* 3 (1): pp. 9-13.

Gauthier-Pilters, H. 1955. Observations éthologiques sur les Tylopodes. *Mammalia* 19 (3): pp. 399-415.

Gauthier-Pilters, H. 1956. Das Verhalten der Tylopoden. *Handb. Zool.* 10 (27): pp. 1-24.

Gauthier-Pilters, H. 1958. Quelques observations sur l'écologie et l'éthologie du dromadaire dans le Sahara nord-occidental (note préliminaire présentée au Congrès des Ongulés, Paris, 1957). *Mammalia* 22 (1): pp. 140-151.

Gauthier-Pilters, H. 1960. Ergänzende Beobachtungen zum aggressiven Verhalten und Kampfspiel bei Tylopoden. *Georg von Pel Freigehege für Tierforschung, Jahrbuch 1959-60*, pp. 104-107.

- Gauthier-Pilters, H. 1961. Observations sur l'écologie du dromadaire dans le Sahara nord-occidental. *Mammalia* 25 (2): pp. 195-280.
- Gauthier-Pilters, H. 1965. Observations sur l'écologie du dromadaire dans l'ouest du Sahara. *Bull. Inst. Fondam. Afr. Noire* 27 (4): pp. 1534-1608.
- Gauthier-Pilters, H. 1969. Observations sur l'écologie du dromadaire en moyenne Mauritanie. *Bull. Inst. Fondam. Afr. Noire* 31 (4): pp. 1259-1380.
- Gauthier-Pilters, H. 1974. The behaviour and ecology of camels in the Sahara with special reference to nomadism and water management. *IUCN (Int. Union Conserv. Nat. Resour.) Publ. New Ser. 2* (24): pp. 542-551.
- Gauthier-Pilters, H. 1977. Contribution à l'étude de l'éco-physiologie du dromadaire en milieu naturel pendant l'été (1970-1973) en moyenne et haute Mauritanie. *Bull. Inst. Fondam. Afr. Noire* 39 (2): pp. 385-459.
- IFS (International Foundation for Science)/National Council for Research (Sudan) 1980. Provisional Report 6: The Workshop on Camels, Khartoum, 18-20 December 1979. Stockholm.
- Khan, A.A. 1971. Sexual behaviour of the male camel (*C. dromedarius*) and some studies on semen. M.Sc. thesis, Rajasthan, University of Udaipur.
- Khan, A.A. and Kholi, I.S. 1972. A study on the sexual behaviour of male camel. *Indian Vet. J.* 42 (6): pp. 1007-1012.
- Marsh, G.P. 1856. *The camel: His organization, habits and uses*. Boston, Gould and Lincoln.
- Monod, T. 1963. Ecosystèmes et productivité biologique: Déserts. In *Ninth Technical Meeting*, Nairobi, 1963, pp. 1-18.
- Rosentiehl, D. 1959. Contribution à l'étude des pâturages camelins dans l'Azaouad. Thèse doct. vét. No. 63, Alfort, ENV (Ecole Nationale Vétérinaire).
- Sato, S. 1976. Population ecology of camels among the Rendille. Mimeo, Kyoto University.
- Singh, V. and Brakash, A. 1964. Mating behaviour in camel. *Indian Vet. J.* 41: p. 475.
- Sweet, L.E. 1965. Camel raiding of North Arabian Bedouin: A mechanism of ecological adaptation. *Am. Anthropol.* 67: pp. 1132-1150.
- MANAGEMENT/SOCIO-ECONOMICS**
- Aueljibekov, K. 1967. Camel breeding: A profitable field. *Konevod. Kounyj. Sport* 5: pp: 6-8.

- Basset, R. 1907. Le nom du chameau chez les berbères. In *Actes du 14e Congrès International des Orientalistes*, Algiers, 1905. Paris, Editions Leroux, pp. 69-82.
- Bataillon, C. 1963. Modernisation du nomadisme pastoral. In *Nomades et nomadisme au Sahara*. Paris, UNESCO (United Nations Education, Scientific and Cultural Organization), pp. 165-175.
- Bisson, J. 1963. Nomadisation chez les Reguibat L'Gouacem. In *Nomades et nomadisme au Sahara*. Paris, UNESCO (United Nations Education, Scientific and Cultural Organization), pp. 51-58.
- Boyer, J.R. 1963. Contribution à l'étude de l'élevage camelin au Sahara occidental: Le Reguibat et son chameau. Thèse doct. vét. No. 3, Alfort, ENV (Ecole Nationale Vétérinaire).
- Bourounoff, Y. 1959. Contribution à l'étude de la castration du chameau. Thèse doct. vét. No. 45, Alfort, ENV (Ecole Nationale Vétérinaire).
- Bremaud, O. and Radier, H. 1954. Les bases de l'hydraulique pastorale dans le Soudan oriental (Cercle de Gao). *Rev. Elev. Méd. Vét. Pays Trop.* 7 (1): pp. 19-36.
- Carbuccia, J.L. 1853. *Le dromadaire comme bête de somme et comme animal de guerre*. Paris, Librairie Dumaine.
- Castagnera, H. and Lebailly, J. 1959. Harnachement et matériel méharistes. *Rev. Corps Vét. Armée* 14 (2): pp. 56-63.
- Cauneille, A. 1968. *Les Chaamba: Leur nomadisme*. Paris, Editions CNRS (Centre National de Recherches Scientifiques).
- Cook, R.A. (ed) 1962. Blood money and the law of homicide in the Sudan: A documentary survey. *Sudan Law Journal and Reports*.
- Cran, H.R. 1979. Castration of camels. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report No. 6.
- Crombe, Capt. Vét. 1957. *Au sujet des pertes de chameaux subies par la compagnie méhariste du sud Tunisien au cours des derniers mois*. Paris, DSV (Division du Service Vétérinaire).
- Encke, W. 1970. Birth and hand rearing of a Bactrian camel at Krefeld Zoo. *Int. Zoo Yearb.* 10: p.90.
- Epstein, H. 1965. Regionalisation and stratification in livestock breeding, with special reference to the Mongolian People's Republic (Outer Mongolia). *Anim. Breed. Abstr.* 33 (2): pp. 169-181.
- Forbes, R.J. 1965. The coming of the camel. In *Studies in ancient technology*. Leiden, Brill.

- Gautam, O.P. and Bansal, S.R. 1972. Save your camel from pica - *Mitti kbama* . *Indian Farming* 21 (10): pp. 40-47.
- Gauthier-Pilters, H. 1962. *Unter Nomaden und Kamelen*. 2nd ed., Kempen, Thomas Verlag.
- Gauthier-Pilters, H. 1972. Le puits pastoral dans le désert. *MIFERMA* (Mines de Fer de Mauritanie) *Informations* 23: pp. 50-56.
- Gauthier-Pilters, H. 1973. Les nomades du désert. *MIFERMA* (Mines de Fer de Mauritanie) *Informations* 25: pp. 51-56.
- Gleichen, C. 1975. *With the camel corps up the Nile*. Wakefield (Yorks), EP Publishing Ltd.
- IFS (International Foundation for Science)/National Council for Research (Sudan) 1980. Provisional Report 6: The Workshop on Camels, Khartoum, 18-20 December 1979. Stockholm.
- Jursz, W. 1970. La gravité des morsures de chameau: A propos de sept cas observés au Niger. *Afr. Méd.* 9: pp. 915-916.
- Kacharov, D.N. and Korovine, E.P. 1942. *La vie dans les déserts*. Paris, Théodore Monod.
- Larrat, R. 1936. L'élevage du dromadaire. In *Conférence consultative de l'élevage*, Dakar. 25-30 March 1936. Maisons-Alfort, IEMVT (Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux), pp. 101-112.
- Le Borgne, Capt. 1953. Vocabulaire technique du chameau en Mauritanie. *Bull. Inst. Fondam. Afr. Noire* 15 (1): pp. 292-380.
- Leitch, I. 1940. *The feeding of camels*. Technical Communication 13, Cairo, Imperial Bureau of Animal Nutrition.
- Marsh, G.P. 1856. *The camel: His organization, habits and uses*. Boston, Gould and Lincoln.
- Mathieu, Capt. 1905. Quelques observations sur l'élevage du méhari chez les Chaanba Mouadhi (El Golea). *Bull. Soc. Geogr. Alger.* 1905: pp. 353-367.
- Meissner, W. 1923. Beitrag zur Dromedarkunde mit bestimmter Berücksichtigung der Aufzucht und Benutzung der Dromedare in SW Afrika. Thesis, Berlin, Tierärztliche Hochschule.
- Monteil, V. 1959. L'évolution et la sédentarisation des nomades sahariens. *UNESCO* (United Nations Education, Scientific and Cultural Organization) *Rev. Int. Sci. Soc.* 11 (4): pp. 599-612.
- Musil, A. 1928. *Manners and customs of the Rwala Bedouins*. New York, American Geographical Society.

- Pastner, S. 1971. Camels, sheep and nomad social organization: A comment on Rubel's model. *Man* (London) 6 (2): pp. 285-288.
- Rao, C.K. 1973. A note on the camel. Mimeo, New Delhi, Animal Husbandry Commission.
- Rao, C.K. 1974. Scheme for the improvement of Indian camels: Breeding and husbandry practices. Mimeo Item 7, New Delhi, Animal Husbandry Commission.
- Rao, C.K. 1974. Scheme for the improvement of Indian camels: Average period of gestation and interval between parturitions. Mimeo Item 10, New Delhi, Animal Husbandry Commission.
- Rao, C.K. 1974. Scheme for the improvement of Indian camels: The age at which young ones are put to work. Mimeo Item 11, New Delhi, Animal Husbandry Commission.
- Rao, C.K. 1974. Scheme for the improvement of Indian camels: To what extent camels are milked and what approximate yield is. Mimeo Item 12, New Delhi, Animal Husbandry Commission.
- Richard, D. 1979. Note sur l'élevage camelin en Ethiopie. Mimeo, Addis Ababa, Ministry of Agriculture.
- Rossetti, G. and Congui, S. 1955. *Zootechnical and veterinary investigations on the domestic animals of Somalia*. Mogadishu, Ispettorato Veterinario, Amministrazione Fiducaria Italiana della Somalia.
- Saïvy, G. 1953. *L'économie pastorale saharienne*. Note documentaire No. 1730, Paris, La Documentation Française.
- Sato, S. 1976. Population ecology of camels among the Rendille. Mimeo, Kyoto University.
- Silberman, L. 1959. Les nomades du Plateau Somali. *UNESCO* (United Nations Education, Scientific and Cultural Organization) *Rev. Int. Sci. Soc.* 11 (4): pp. 582-598.
- Rubel, P.G. 1969. Herd composition and social structure: On building models of nomadic pastoral societies. *Man* (London) 4: pp. 268-273.
- Simonnet, H. 1955. L'eau: Besoins de l'organisme; métabolisme; influence de l'abreuvement sur la production animale. *Rev. Elev. Méd. Vét. Pays Trop.* 8 (2-3): pp. 179-208.
- Simoons, F.J. 1961. Camel flesh. In *Eat not this flesh: Food avoidances in the Old World*. Madison, University of Wisconsin Press, pp. 87-90.
- Sweet, L.E. 1965. Camel raiding of north Arabian Bedouin: A mechanism of ecological adaptation. *Am. Anthropol.* 67: pp. 1132-1150.

- Tawney, A.E. 1927/28. A camel pack battery. *J. Roy. Artill.* 54 (2): pp. 228-232.
- Terentjev, S. 1966. Improvement of the Kalmyh breed of camel. *Konevod. Konnyj. Sport* 36 (12): pp. 19-20.
- Thomson, J.K. 1978. Castration of camels. *Vet. Rec.* 102 (4).
- Toupet, C. 1963. L'évolution de la nomadisation en Mauritanie sahélienne. UNESCO (United Nations Education, Scientific and Cultural Organization) *Rev. Int. Sci. Soc.* 15 (1): pp. 67-79.
- UNESCO (United Nations Education, Scientific and Cultural Organization) 1963. *Nomades et nomadisme au Sahara*. Recherches sur la zone aride 19, Paris.
- Vignier, J.P. 1963. Sur l'élevage du chameau à Tassili-des-Ajjers. Thèse doct. vét. No. 36, Lyon, ENV (Ecole Nationale Vétérinaire).
- Vitale, M.A. 1928. *Il cammello: E i reparti camellati*. Rome, Sindicato Italiano Arti Grafiche.

NUTRITION/WATERING/WATER METABOLISM

- Adam, J. 1966. Composition chimique de quelques herbes mauritaniennes pour dromadaires. *J. Agric. Trop. Bot. Appl.* 13 (6-7).
- Bannerjee, S. and Bhattacharjee, R.C. 1963. Distribution of body water in the camel. *Am. J. Physiol.* 204: pp. 1045-1047.
- Bartha, R. 1974. The physiological adaptability of camels to the environmental conditions of the vast arid zones. *Tropenlandwirt* 72: pp. 138-148.
- Chamot, Y. 1960. Répercussion de la déshydratation sur la biochimie et l'endocrinologie du dromadaire. Thèse No. 20, Rabat, Institut Scientifique Chérifien.
- Chamot, Y. 1967. Régulation endocrinienne du métabolisme de l'eau chez le dromadaire. *Bull. Soc. Sci. Nat. Phys. Maroc* 47 (1-2): pp. 1-7.
- Clair, M. 1962. De la résistance du chameau à la soif. Thèse doct. vét. No. 9, Alfort, ENV (Ecole Nationale Vétérinaire).
- Cross, H.E. 1918. *Some camel feeding experiments*. Bulletin No. 77, New Delhi, Imperial Department of Agriculture.
- Curasson, G. 1939. Sur quelques plantes toxiques ou réputées toxiques pour le bétail. *Bull. Serv. Zoot. Epizoot. AOF* 2 (3): pp. 14-16.
- Curasson, G. 1958. *Etudes sur les aliments des animaux et les pâturages tropicaux et subtropicaux*. Paris, Vigot Frères.
- Decker, R.A. and McDermid, A.M. 1977. Nutritional myopathy in a young camel. *J. Zoo Anim. Med.* 8 (2): pp. 20-21.

- Deller, H.D., Blin, P.C. and Fahmy, M.F.A. 1968. Contribution a l'étude de l'anatomie microscopique du tube digestif chez le chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 21 (1): pp. 1-32.
- Field, C.R. 1978. The food habits of camels. Mimeo, Nairobi, UNESCO/IPAL (United Nations Education, Scientific and Cultural Organization/Integrated Project in Arid Lands).
- Foley, H. and Musso, M. 1925. Les plantes du Sahara toxiques pour les animaux. *Arch. Inst. Pasteur Alger.* 3 (12): pp. 349-401.
- Gautam, O.P. and Bansal, S.R. 1972. Save your camel from pica - *Mitti kbana*. *Indian Farming* 21 (10): pp. 40-47.
- Gauthier-Pilters, H. 1970. *Atschana, das heisst Durst: Forschungsreise ins Nomadenland*. Düsseldorf, Schwann-Verlag.
- Gauthier-Pilters, H. 1972. Le puits pastoral dans le désert. *MIFERMA (Mines de Fer de Mauritanie) Informations* 23: pp. 50-56.
- Ghosal, A.K. 1971. Water metabolism in the camel (*C. dromedarius*). Ph. D. thesis, Rajasthan, University of Udaipur.
- Ghosal, A.K., Appanna, T.C. and Dwaraknath, P.K. 1973. Some observations on water restriction in Indian camels. *Indian Vet. J.* 50 (6): pp. 518-520.
- Ghosal, A.K., Appanna, T.C. and Dwaraknath, P.K. 1974. Seasonal variations in water compartments of the Indian camel. *Brit. Vet. J.* 130 (2): pp. 47-49.
- Ghosal, A.K., Appanna, T.C. and Dwaraknath, P.K. 1975. A note on the effect of short-term water deprivation on certain blood characteristics in the camel (*C. dromedarius*). *Indian J. Anim. Sci.* 45 (2): pp. 105-108.
- Ghosal, A.K., Dwaraknath, P.K. and Patney, J.M.L. 1973. A note on plasma carotene and vitamin A levels in normal camels (*C. dromedarius*) of northwest Rajasthan. *Indian J. Anim. Sci.* 43 (9): pp. 899-900.
- Hoppe, P., Kay, R.N.B. and Maloiy, G.M.O. 1976. The rumen as a reservoir during dehydration and rehydration in the camel. *J. Physiol.* 254 (1): pp. 76-77.
- IFS (International Foundation for Science)/National Council for Research (Sudan) 1980. Provisional Report 6: The Workshop on Camels, Khartoum, 18-20 December 1979. Stockholm.
- Labouche, C. and Mainguy, P. 1954. Aspects physiologiques et nutritionnels de l'alimentation du bétail en Afrique tropicale. *Rev. Elev. Méd. Vét. Pays Trop.* 7 (4): pp. 221-307.
- Leitch, I. 1940. *The feeding of camels*. Technical Communication 13, Cairo, Imperial Bureau of Animal Nutrition.

- Leveque, R. 1957. Carences d'origine tellurique chez les dromadaires du sud Tunisien. *Bull. Soc. Sci. Nat. Tunisie* 9 (10): pp. 49-57.
- Macfarlane, W.V. and Siebert, D.D. 1967. Hydration and dehydration of desert camels. *Austr. J. Exp. Biol. Med. Sci.* 45: p. 29.
- Macfarlane, W.V., Morris, R.J.H. and Howard, B. 1962. Water metabolism of Merino sheep and camels. *Austr. J. Sci.* 25: p. 112.
- Maloiy, G.M.O. 1972. Renal salt and water excretion in the camel (*C. dromedarius*). *Symp. Zool. Soc. London* 1972 (31): pp. 243-259.
- Maloiy, G.M.O. 1972. Comparative studies on digestion and fermentation rate in the fore stomach of the one-humped camel and the zebu steer. *Res. Vet. Sci.* 13 (5): pp. 476-481.
- Mathur, C.S. 1960. Nutrition in relation to satyriasis in camels. *Indian Vet. J.* 37: pp. 199-201.
- Peck, E.F. 1939. Salt intake in relation to cutaneous necrosis and arthritis of one humped camels (*C. dromedarius*) in British Somaliland. *Vet. Rec.* 51: pp. 1355-1360.
- Provost, A., Haas, P. and Dembelle, M. 1975. Premier cas au Tchad de botulisme animal (type c): Intoxication de dromadaire par l'eau d'un puits. *Rev. Elev. Méd. Vét. Pays Trop.* 28 (1): pp. 9-11.
- Purohit, M.S. and Rathor, S.S. 1962. Stomach of the camel in comparison to that of the ox. *Indian Vet. J.* 39 (11): pp. 604-608.
- Rosenstiehl, D.F. 1959. Contribution a l'étude des pâturages camelins dans l'Azaouad. Thèse doct. vét. No. 63, Alfort, ENV (Ecole Nationale Vétérinaire).
- Schmidt-Nielsen, B., Schmidt-Nielsen, K., Houpt, T.R. and Jarnum, S.A. 1956. The water balance of the camel. *Am. J. Physiol.* 185 (1): pp. 185-194.
- Schmidt-Nielsen, B., Schmidt-Nielsen, K., Houpt, T.R. and Jarnum, S.A. 1957. Urea excretion in the camel. *Am. J. Physiol.* 188: pp. 477-484.
- Schmidt-Nielsen, K., Crawford, E.C., Newsome, A.E., Rawson, K.S. and Hammel, H.T. 1967. Metabolic rate of camels: Effect of body temperature and dehydration. *Am. J. Physiol.* 212: pp. 341-346.
- Schmidt-Nielsen, K., Schmidt-Nielsen, B., Jarnum, S.A. and Houpt, T.R. 1957. Body temperature of the camel and its relation to water economy. *Am. J. Physiol.* 188: pp. 103-112.
- Siebert, B.D. and Macfarlane, W.V. 1971. Water turnover and renal function of dromedaries in the desert. *Physiol. Zool.* 44: pp. 225-240.

- Simonnet, H. 1955. L'eau: Besoins de l'organisme; métabolisme; influence sur la production animale. *Rev. Elev. Méd. Vét. Pays Trop.* 8 (2-3): pp. 179-208.
- Tartour, G. 1969. Studies on the metabolism of copper and iron in the camel. *Sudan J. Vet. Sci. Anim. Husb.* 10 (1): pp. 14-20.
- Toofanian, F. and Aliakbari, S. 1977. Studies on the digestion of carbohydrates in the camel (*C. dromedarius*). *Trop. Anim. Health Prod.* 9 (4): pp. 233-237.
- Villachon, M.A. 1962. Aliments et alimentation du dromadaire au Tassili n'Ajjer (Sahara central). Thèse doct. vét. No. 31, Toulouse, ENV (Ecole Nationale Vétérinaire).
- Yagil, R. and Berlyne, G.M. 1977. Renal handling of creatinine in various stages of hydration in the camel. *Comp. Biochem. Physiol.* 56 (1): pp. 15-18.
- Yagil, R. and Berlyne, G.M. 1977. Glucose loading and dehydration in the camel. *J. Appl. Physiol.* 42: pp. 690-693.
- Yagil, R., Etzion, Z. and Ganani, J. 1978. Camel thyroid metabolism: Effect of season and dehydration. *J. Appl. Physiol.* 45 (4): pp. 450-544.

PHYSIOLOGY/BIOCHEMISTRY

- Adam, S.E.I., Obeid, H.M., Ashour, N. and Tartour, G. 1974. Serum enzyme activities and haematology of normal and diseased ruminants in the Sudan. *Acta Vet. Brno* 43 (3): pp. 225-231.
- Awkati, A. and Al Bagdadi, F. 1971. Lacrimal gland of the camel. *Am. J. Vet. Res.* 32 (3): pp. 505-510.
- Bannerjee, S. and Bhattacharjee, R.C. 1963. Distribution of body water in the camel. *Am. J. Physiol.* 204: pp. 1045-1047.
- Barakat, M.Z. and Abdel-Fattah, M. 1970. Biochemical analysis of normal camel blood. *Zbl. Vet. Med. A* 17: pp. 550-557.
- Barakat, M.Z. and Abdel-Fattah, M. 1971. Seasonal and sexual variations of certain constituents of normal camel blood. *Zbl. Vet. Med. A* 18: pp. 174-178.
- Bartha, R. 1971. The physiological adaptability of camels to the environmental conditions of the vast arid zones. *Tropenlandwirt* 72: pp. 138-148.
- Bhatt, P.L. and Kohli, R.N. 1959. A preliminary study on camel's blood sedimentation rate. *Indian Vet. J.* 36 (9): pp. 376-379.
- Bhatt, P.L. and Kohli, R.N. 1962. Quantitative biochemical studies on camel's blood. 2: Inorganic phosphorus and sodium content. *Indian Vet. J.* 39 (4): pp. 201-202.

- Bhatt, P.L., Kohli, R.N. and Rathore, U.S. 1960. The normal body temperature, respiratory frequency and heart rate of the camel. *Indian Vet. J.* 37 (9): pp. 456-462.
- Chandrasena, L.G., Emmanuel, B. and Gilanpour, H. 1979. A comparative study of glucose metabolism between the camel (*Camelus dromedarius*) and the sheep (*Ovis aries*). *Comp. Biochem. Physiol.* A 62: pp. 837-840.
- Chandrasena, L.G., Emmanuel, B., Hamer, D.W. and Howard, B.R. 1979. A comparative study of ketone body metabolism between the camel (*Camelus dromedarius*) and the sheep (*Ovis aries*). *Comp. Biochem. Physiol.* B 64: pp. 109-112.
- Charnot, Y. 1958. Répercussion de la déshydratation sur la biologie et l'endocrinologie du dromadaire. Thèse Sci., Paris.
- Charnot, Y. 1964. Le cycle testiculaire du dromadaire. *Bull. Soc. Sci. Nat. Phys. Maroc* 44: pp. 37-45.
- Charnot, Y. 1967. Régulation endocrinienne du métabolisme de l'eau chez le dromadaire. *Bull. Soc. Sci. Nat. Phys. Maroc* 47 (1-2): pp. 1-7.
- Dafalla, I.O. n.d. The morphology and histochemistry of the testes of camel (*C. dromedarius*). M.V.Sc. thesis, Khartoum University.
- Durand, M. and Kchouk, M. 1958. Quelques dosages chimiques dans le sang des dromadaires en Tunisie. *Arch. Inst. Pasteur Tunis* 35 (7): p. 37.
- El-Hagasi, H.A. 1954. Le coeur du chameau. *Brit. Vet. J.* 110: pp. 104-108.
- El-Hagri, M.A.A. and Morcas, M.B. 1954. Etude du système artériel du membre thoracique du chameau. *Rev. Elev. Méd. Vét. Pays Trop.* 7 (3): pp. 165-169.
- Emmanuel, B., Howard, B.R. and Emady, M. 1976. Urea degradation in the camel. *Can. J. Anim. Sci.* 56 (3): pp. 595-601.
- Gauthier-Pilters, H. 1977. Contribution à l'étude de l'éco-physiologie du dromadaire en milieu naturel pendant l'été (1970-1973) en moyenne et haute Mauritanie. *Bull. Inst. Fondam. Afr. Noire* 39 (2): pp. 385-459.
- Ghosal, A.K., Appanna, T.C. and Dwaraknath, P.K. 1973. Studies on the seasonal variations in the blood constituents of Indian camel. *Indian J. Anim. Sci.* 43 (7): pp. 642-644.
- Ghosal, A.K., Appanna, T.C. and Dwaraknath, P.K. 1974. Seasonal variations in water compartments of the Indian camel. *Brit. Vet. J.* 130 (2): pp. 47-49.
- Ghosal, A.K., Appanna, T.C. and Dwaraknath, P.K. 1975. A note on the effect of short-term water deprivation on certain blood characteristics in the camel (*C. dromedarius*). *Indian J. Anim. Sci.* 45 (2): pp. 105-108.

- Cihosal, A.K., Dwarkanath, P.K. and Patney, J.M.L. 1973. A note on plasma carotene and vitamin A levels in normal camels (*C. dromedarius*) of north-west Rajasthan. *Indian J. Anim. Sci.* 43 (9): pp. 899-900.
- Gudat, E. 1964. Contribution a l'étude des constants du sang des camelidés. *Monatsschr. Vet. Mediz.* 19: pp. 822-826.
- Gunstone, F.D. and Paton, R.P. 1953. Animal fats. 1: The component acids of deer fat and camel fat. *Biochem. J.* 54: pp. 617-621.
- Hassan, A.A. 1975. The morphology and histo-chemistry of the accessory male glands of the one-humped camel (*C. dromedarius*). M.V.Sc. thesis, Khartoum University.
- Hassan, Y.M., Hoeller, H. and Hassan, I.M. 1968. Observations on the blood constituents of camels in the Sudan. *Sudan J. Vet. Sci. Anim. Husb.* 9 (1) suppl. 2: pp. 464-476.
- Hoeller, H. and Hassan, Y.M. 1966. Determination of some blood constituents of camels in Sudan. *Dtsch. Tierärztl. Wochenschr.* 73: pp. 553-556.
- Hoppe, P., Kay, R.N.B. and Maloiy, G.M.O. 1974. Salivary secretion in the camel. *J. Physiol.* 244 (1): pp. 32-33.
- Hoppe, P., Kay, R.N.B. and Maloiy, G.M.O. 1976. The rumen as a reservoir during dehydration and rehydration in the camel. *J. Physiol.* 254 (1): pp. 76-77.
- IFS (International Foundation for Science)/National Council for Research (Sudan) 1980. Provisional Report 6: The Workshop on Camels, Khartoum, 18-20 December 1979. Stockholm.
- Kumar, M. and Bannerjee, S. 1962. Biochemical studies on Indian camel (*Camelus dromedarius*): Plasma insulin-like activity and glucose tolerance. *J. Sci. Ind. Res.* 21: pp. 291-292.
- Labouche, C. and Mainguy, P. 1954. Aspects physiologiques et nutritionnels de l'alimentation du bétail en Afrique tropicale. *Rev. Elev. Méd. Vét. Pays Trop.* 7 (4): pp. 221-307.
- Lal, B.J., Bhatt, P.L. and Kohli, R.N. 1962. Quantitative biochemical studies on camel's blood. *Indian Vet. J.* 39 (1): pp. 64-66.
- Leroux, C. 1960. Aspects de la régulation thermique des animaux du désert: Observations personnelles chez le dromadaire. Thèse doct. vét. No. 27, Lyon, ENV (Ecole Nationale Vétérinaire).
- Maloiy, G.M.O. 1972. Renal salt and water excretion in the camel (*C. dromedarius*). *Symp. Zool. Soc. (London)* 1972 (31): pp. 243-259.
- Maloiy, G.M.O. 1972. Comparative studies on digestion and fermentation rate in the fore stomach of the one-humped camel and the zebu steer. *Res. Vet. Sci.* 13 (5): pp. 476-481.

- Maloiy, G.M.O. (ed). n.d. *Comparative physiology of desert animals*. London, Academic Press.
- Mirgani, T. 1977. Fatty acid composition of hump triglyceride of the camel. *Comp. Biochem. Phys.* 58 (2): pp. 211-213.
- Noyan, A. 1970. The microscopic appearance of camel and lama erythrocytes. *Ankara Univ. Vet. Fak. Derg.* 17 (4): pp. 518-522.
- Pathak, S.P. and Trivedi, B.N. 1958. Component glycerides of camels (*Camelus dromedarius*). *J. Sci. Food Agric.* 9: pp. 533-535.
- Purohit, M.S. and Rathor, S.S. 1962. Stomach of the camel in comparison to that of the ox. *Indian Vet. J.* 39 (11): pp. 604-608.
- Rezakhani, A. 1979. The electrocardiogram of the camel (*C. dromedarius*). *Zentralbl. Veterinärmed.* 24 (4): pp. 277-286.
- Schmidt-Nielsen, B., Schmidt-Nielsen, K., Houpt, T.R. and Jarnum, S.A. 1957. Urea excretion in the camel. *Am. J. Physiol.* 188: pp. 477-484.
- Schmidt-Nielsen, B. and Odell, R. 1961. Structure and concentration mechanism in the mammalian kidney. *Am. J. Physiol.* 200: pp. 1119-1124.
- Schmidt-Nielsen, K., Crawford, E.C., Newsome, A.E., Rawson, K.S. and Hammel, H.J. 1967. Metabolic rate of camels: Effect of body temperature and dehydration. *Am. J. Physiol.* 212: pp. 341-346.
- Schmidt-Nielsen, K., Schmidt-Nielsen, B., Jarnum, S.A. and Houpt, T.R. 1957. Body temperature of the camel and its relation to water economy. *Am. J. Physiol.* 188: pp. 103-112.
- Siebert, B.D. and Macfarlane, W.V. 1971. Water turnover and renal function of dromedaries in the desert. *Physiol. Zool.* 44: pp. 225-240.
- Soliman, M.K. and Shakur, M. 1967. Cytology and biochemical studies on the blood of adult she-camel. *Indian Vet. J.* 44 (12): pp. 989-995.
- Tartour, G. 1969. Studies on the metabolism of copper and iron in the camel. *Sudan J. Vet. Sci. Anim. Husb.* 10 (1): pp. 14-20.
- Toofanian, F. and Aliakbari, S. 1977. Studies on the digestion of carbohydrates in the camel (*C. dromedarius*). *Trop. Anim. Health Prod.* 9 (4): pp. 233-237.
- Williams, V.J. 1963. Rumen function in the camel. *Nature* 197 (4873): p. 1221.
- Yagil, R. and Berlyne, G.M. 1977. Renal handling of creatinine in various stages of hydration in the camel. *Comp. Biochem. Physiol.* 56 (1): pp. 15-18.
- Yagil, R. and Berlyne, G.M. 1977. Glucose loading and dehydration in the camel. *J. Appl. Physiol.* 42: pp. 690-693.

Yagil, R., Etzion, Z. and Ganani, J. 1978. Camel thyroid metabolism: Effect of season and dehydration. *J. Appl. Physiol.* 45 (4): pp. 540-544.

PRODUCTION/UTILIZATION

Auelbekov, K. 1967. Camel breeding: A profitable field. *Konevod. Konnyj. Sport* 5: pp. 6-8.

Bhimasena and Rao, M. 1970. Camel's milk and milk products. *Indian J. Dairy Sci.* 23 (2): pp. 71-78.

Carbuccia, J.L. 1853. *Du dromadaire: Comme bête de somme et comme animal de guerre.* Paris, Librairie Dumaine.

El-Bahay, G.M. 1962. Normal contents of Egyptian camel milk. *Vet. Med. J.* 8: pp. 7-17.

El-Dashlouty, M.S., Foda, Y.H., El-Gharabawi, M.I. and Abdallah, M.A. 1977. Effect of enzymes on camel meat. 3: Histological studies on enzymatic tenderization of camel meat. *Agric. Res. Rev.* 54 (3): pp. 137-146.

El-Samahy, S.K. and Shehata, M.M. 1978. Studies on camel meat tenderization (fresh meat). *Ann. Agric. Sci.* 8: pp. 105-117.

Foda, Y.H., Abdallah, M.A., El-Gharabawi, M.I. and El-Dashlouty, M.S. 1977. Effect of enzymes on camel meat. I: The effect of proteolytic enzymes on the water content of camel meat. *Agric. Res. Rev.* 54 (3): pp. 117-126.

Foda, Y.H., El-Dashlouty, M.S., El-Sanafiry, N. and El-Gharabawi, M.I. 1977. Effect of enzymes on camel meat. 4: Comparative effectiveness of bromelin on microbial load. *Agric. Res. Rev.* 54 (?): pp. 147-151.

Foda, Y.H., El-Gharabawi, M.I., Abdallah, M.A. and El-Dashlouty, M.S. 1977. Effect of enzymes on the tenderness of camel meat. 2: Effect of proteolytic enzymes on the tenderness of camel meat. *Agric. Res. Rev.* 54 (3): pp. 127-136.

Hamman, M.A., Hidik, M.E., Sherif, I.H. and Yousef, M.H. 1962. Studies on camel meat. 1: Chemical composition. *J. Arabian Vet. Med. Assoc.* 22: pp. 391-396.

Heraskov, S.G. 1953. Camel's milk and its products. *Konevod. Konnyj. Sport* 23 (11): pp. 35-37.

Heraskov, S.G. 1965. Camel milk: A valuable food product. *Konevod. Konnyj. Sport* 35 (8): pp. 14-15.

Hira, L.M. 1947. Camel breeding in India. *Indian Farming* 8: pp. 504-507.

IFS (International Foundation for Science)/National Council for Research (Sudan) 1980. Provisional Report 6: The Workshop on Camels, Khartoum, 18-20 December 1979. Stockholm.

- Islamy, A. 1950. Riding camels around Khash and Iranshan. *Rev. Fac. Méd. Vét. (Téhéran)* 12: pp. 87-89.
- Ismail, F.A. 1975. Preparation of meat extract from camel meat. *Fleischwirtschaft* 55 (2): pp. 248-249.
- Kulaeva, V. 1964. The production of the Bactrian camel. *Konevod. Konnyj. Sport* 34: pp. 9-10.
- Kuliev, K. 1959. The utilization of camels' milk. *Molochn. Promst.* 20 (2): p. 28.
- Lakoza, I. 1962. A valuable source for production of meat, milk and wool. *Konevod. Konnyj. Sport* 32 (1): pp. 2-5.
- Madadi, H. 1973. Sanitary inspection of camel meat. Mimeo, Tehran Municipality.
- Marsh, G.P. 1856. *The camel: His organization, habits and uses*. Boston, Gould and Lincoln.
- Meissner, W. 1923. Beitrag zur Dromedarkunde mit bestimmter Berücksichtigung der Aufzucht und Benutzung der Dromedare in SW Afrika. Thesis, Berlin, Tierärztliche Hochschule.
- Newman, D.M.R. 1975. The camel: Its potential as a provider of protein in arid Australia. In *Proceedings of the Third World Conference on Animal Production, Melbourne, Australia, 1973*, ed. Reid, R.L. Sydney University Press, pp. 95-101.
- Ohri, S.P. and Joshi, B.K. 1961. Composition of milk of camel. *Indian Vet. J.* 38: pp. 514-516.
- Ottogalli, G. and Resmini, P. 1976. Dairying problems in Somalia: Data on physico-chemical characteristics of zebu and camel milk. *Ind. Latte* 12 (1): pp. 3-10.
- Purchase, H.S. 1943. Some experiments in the making of butter, ghee and cheese from camel milk. *East Afr. Agric. For. J.* 9: pp. 39-41.
- Rao, C.K. 1974. Scheme for the improvement of Indian camels: To what extent camels are milked and what approximate yield is. Mimeo Item 12, New Delhi, Animal Husbandry Commission.
- Rao, M.B., Gupta, R.C. and Dastur, N.N. 1970. Camel's milk and milk products. *Indian J. Dairy Sci.* 23 (2): pp. 71-78.
- Sakkal, F.B. 1945. Le chameau, animal de boucherie. Thèse doct. vét. No. 15, Alfort, ENV (Ecole Nationale Vétérinaire).
- Simonnet, H. 1955. L'eau: Besoins de l'organisme; métabolisme; influence de l'abreuvement sur la production animale. *Rev. Elev. Méd. Vét. Pays Trop.* 8 (2-3): pp. 179-208.

Simoons, F.J. 1961. Camel flesh. In *Eat not this flesh: Food avoidances in the Old World*. Madison, University of Wisconsin Press, pp. 87-90.

Veisseyre, R. 1965. *Techniques laitières*. 2nd ed., Paris, Maison Rustique.

Vitale, M.A. 1928. *Il cammello: E i reparti cammellati*. Rome, Sindacato Italiano Arti Grafiche.

REPRODUCTION

Abdalla, O. 1965. Anatomical study of the female genital system of the one-humped camel. I: Ovaries. *Sudan J. Vet. Sci. Anim. Husb.* 6 (1): pp. 41-52.

Abdalla, O. 1967. Anatomical study of the female genital system of the one-humped camel. 2: The ovaries. *Sudan J. Vet. Sci. Anim. Husb.* 8 (2): pp. 67-77.

Abdalla, O. 1968. Anatomical study of the female genital system of the one-humped camel. 3: The uterus and the placenta. *Sudan J. Vet. Sci. Anim. Husb.* 9 (1): pp. 477-503.

Abdalla, O. and Hassan, A.A. 1970. The male genital system of the one-humped camel. M.V.Sc. thesis, Khartoum University.

Abdel-Raouf, M. 1965. Studies on reproduction in camels (*C. dromedarius*). 3: Testicular hypoplasia. In *Proceedings of the Sixth Annual Veterinary Congress, Cairo, 1965*, pp. 125-130.

Abdel-Raouf, M. and El-Naggar, M. 1964. Studies on reproduction in camels (*C. dromedarius*). 1: Mating: Technique and collection of semen. *UAR J. Vet. Sci.* 1: pp. 113-119.

Barakat, M.Z. and Abdel-Fattah, M. 1971. Seasonal and sexual variations of certain constituents of normal camel blood. *Zentralbl. Veterinärmed.* A 18: pp. 174-178.

Barhat, N.K. and Chowdhary, M.S. 1980. Note on the inheritance of birthweight in Bikaneri camel (*C. dromedarius*). *Indian J. Anim. Sci.* 50 (8): pp. 665-667.

Barmintsev, V. 1951. Rectal examination of the reproductive organs of the camel. *Konnyod. Konnyj. Sport* 1: p. 38.

Bourounoff, Y. 1959. Contribution a l'étude de la castration du chameau. Thèse doct. vét. No. 45, Alfort, ENV (Ecole Nationale Vétérinaire).

Charnot, Y. 1964. Le cycle testiculaire du dromadaire. *Bull. Soc. Sci. Nat. Phys. Maroc* 44: pp. 37-45.

Cran, H.R. 1979. Castration of camels. Paper presented at the Workshop on Camels, Khartoum, 18-20 December 1979. IFS (International Foundation for Science) Provisional Report 6.

- Dafalla, I.O. (n.d.). The morphology and histo-chemistry of the testes of camel (*C. dromedarius*). M.V.Sc. thesis, Khartoum University.
- El-Azab, E.A. and Musa, B. 1976. Early detection of pregnancy in the camel by using biological methods. *Zuchthygiene* 11 (4): pp. 166-168.
- Elwishy, A.B., Mobarak, M.A. and Fouad, S.M. 1972. The accessory genital organs of the one-humped male camel (*C. dromedarius*). *Anat. Anz.* 131 (1): pp. 1-2.
- Encke, W. 1970. Birth and hand rearing of a Bactrian camel at Krefeld zoo. *Int. Zoo Yearb.* 10: p. 90.
- Fouad, S.M., Mobarak, A.M. and Aly, M.A. 1979. Micromorphology of the arteries of the penis of the one-humped camel. *Indian J. Anim. Sci.* 49 (5): pp. 377-379.
- George, N. 1957. Some observations of the foetal circulation in the camel. *Brit. Vet. J.* 113 (5): pp. 219-220.
- Hassan, A.A. 1975. The morphology and histo-chemistry of the accessory male glands of the one-humped camel (*C. dromedarius*). M.V.Sc. thesis, Khartoum University.
- IFS (International Foundation for Research)/National Council for Research (Sudan) 1980. Provisional Report 6: The Workshop on Camels, Khartoum, 18-20 December 1979. Stockholm.
- Jonch, A. 1970. Thirty-year old camel bred. *International Zoo News* 17: p. 249.
- Joshi, C.K. 1972. Studies on certain aspects of reproduction in she-camel. M.V.Sc. thesis, Rajasthan, University of Udaipur.
- Khan, A.A. 1971. Sexual behaviour of the male camel (*C. dromedarius*) and some studies on semen. M.Sc. thesis, Rajasthan, University of Udaipur.
- Khan, A.A. and Kohli, I.S. 1972. A study on sexual behaviour of male camel. *Indian Vet. J.* 42 (6): pp. 1007-1012.
- Madan, S.C. 1969. Morphology of spermatozoa from the epididymus of the camel (*C. dromedarius*). M.V.Sc. thesis, Rajasthan, University of Udaipur.
- Mehta, U.S., Prakash, A. and Singh, M. 1962. Gestation period in camels. *Indian Vet. J.* 39: p. 387.
- Mobarak, A.M. and Elwishy, A.B. 1971. Uterus of the one-humped camel (*Camelus dromedarius*) with reference to rectal palpation. *Indian J. Anim. Sci.* 41 (9): 846-855.
- Morton, W.R. 1961. Observations on the full-term foetal membranes of three members of the Camelidae (*C. dromedarius*, *C. bactrianus* and *Lama glama*). *J. Anat.* 95: p. 200.

- Musa, B.E. 1969. A study of some aspects of reproduction in the female camel. M.V.Sc. thesis, Khartoum University.
- Musa, B.E. 1977. A new epidermal membrane associated with the foetus of the camel. *Zentralbl. Veterinärmed.* 6 (4): pp. 355-358.
- Osman, A.M. 1960. Anatomical study of the female genital system of the *C. dromedarius* with special reference to the histology of the mucous membrane. M.V. Sc. thesis, Khartoum University.
- Petris, M.A. 1956. Caesarean operation in camels. *Vet. Rec.* 68: pp. 367-386.
- Prakash, A. and Singh, V. 1962. Normal parturition in camels. *Indian Vet. J.* 39 (10): pp. 551-553.
- Ram, S., Singh, B. and Dhanda, O.P. 1977. Genetic study on gestation length, birthweight and intra-uterine development index in Indian camel. *Indian Vet. J.* 54 (12): pp. 953-955.
- Rao, C.K. 1974. Scheme for the improvement of Indian camels: Average period of gestation and interval between parturitions. Mimeo Item 10, New Delhi, Animal Husbandry Commission.
- Rao, C.K. 1974. Scheme for the improvement of Indian camels: Breeding and husbandry practices. Mimeo Item 7, New Delhi, Animal Husbandry Commission.
- Schmidt, C. 1973. Breeding seasons and notes on some other aspects of reproduction in captive camelides. *Int. Zoo Yearb.* 13: pp. 387-390.
- Shalash, M.R. and Nawito, M. 1963. Sterility in female camels. *Dtsch. Tierärztl. Wochenschr.* 70 (18): p. 522.
- Sharma, S.S. and Vyas, K.K. 1970. Parturition in the camel. *Ceylon Vet. J.* 18: pp. 7-8.
- Sharma, S.S. and Vyas, K.K. 1972. Involution of uterus and vulva in camels. *Ceylon Vet. J.* 20 (1-2): pp. 9-10.
- Singh, V. and Brakash, A. 1964. Mating behaviour in camel. *Indian Vet. J.* 41: p. 475.
- Thomson, J.K. 1978. Castration of camels. *Vet. Rec.* 102 (4): p. 92.