

camels and camel milk

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I. INTRODUCTION

Camel milk: What possible importance can camel milk have in the year 1981 in a world beset with a multitude of problems? The answer to this is clear when we consider that one of the biggest problems confronting mankind today is malnourishment. Camel milk can certainly play a far more important role in the prevention of malnutrition than it does today. Growing and raising foodstuffs for the rapidly increasing human population is especially precarious in the hot and arid zones of the world - the very areas where the camel is one of the few animals not only to survive, but also to benefit man.

Before presenting data on milk production, both quantity and quality, one must consider in detail all the relevant information about the camel in order to ascertain the full value that this animal can play in human nutrition.

Camels, or the family of camels, the Camelidae, are found throughout the world and all camels will be mentioned when possible; however, this report deals mainly with the one-humped dromedary, which is found in the desert and semi-desert areas.

Milk is the main food obtained from a herd of camels, (Dahl, 1979). The one-humped camel was domesticated about 3000 B.C.E. in southern Arabia (Bullet, 1975), mainly for its meat and milk (Epstein, 1971). The camels were, and still are, valued as riding, baggage and work animals, as well as providers of hair and hides. In arid zones the camel is a better provider of food than the cow, which is severely affected by the heat, scarcity of water and feed (Sweet, 1965).

Camels originated in North America when the land masses were still joined (Leuner, 1963). These animals were no larger than hares. Here they remained from the upper Eocene throughout the Tertiary period, into the Pleistocene epoch, a period of 40 million years. Continued evolution produced the very large American camels. From North America, meanwhile, the animals migrated to other parts of the world, finally disappearing from their original area. The various types and breeds in the camel family are probably a result of evolutionary adaptation to the various environments to which the animals were exposed.

Some of the camels migrated to the deserts and semi-deserts of northern Africa and the Middle East. Remains of camels have been found in old Palestine, dating to 1800 B.C.E. Field (1979) considered that further migration of camels in Africa was prevented by their susceptibility to tsetseborne trypanosomiasis. However, the camel has been incriminated as the probable host which became infected with Trypanosoma brucei in the northern tsetse areas and spread the infection which evolved to mechanically-transmitted T. evansi, throughout northern Africa into Asia. These camels have one-hump and long spindly legs.

The two-humped camel, the Bactrian, was domesticated on the border of Iran and Turkmenistan and spread to an area bordered by the Crimea, southern Siberia, Mongolia and China. These animals are stockier than the dromedary and covered by a thicker wool.

The new-world Camelidae are smaller versions of the camels and live in the heights of the mountains in South America.

All the members of the camel family are found in the order of the Artiodactyla (even-toed ungulates); suborder: Tylopoda (pad-footed); family: Camelidae. The old-world genus is the Camelus, having the two species of the Bactrianus (two-humped) and Dromedarius (one-humped). The new-world genus of the Lama has three species, while the genus of Vicugna has only one species.

Although they chew cud, camels differ from true ruminants in a few anatomical features (Cloudley-Thompson, 1969). Adult camels have two incisor teeth in their upper jaws; they lack an omasum, the third stomach division of the ruminants, which is considered the water reabsorbing portion of the stomach; they have no gallbladder; and the hooves have been reduced to claw-like toes, projecting beyond the pads. In India, camel meat is not eaten by the Hindus (Simoons, 1961), nor by the Christian Copts of Egypt, Zoroastrians of Iran, Mandaeans of Iraq and Iran, Nosairis of Syria, Ethiopians of Christian Faith nor in Israel the camel is considered as being unsuitable as a source of meat.

Within the arid regions the camel-breeding tribes have maintained a dominant position over other societies by virtue of their ability to exploit the often poor grazing ranges (Sweet, 1965). Camel-owning tribes are continually on the move, looking for grazing and water for their animals (Elamin, 1979). They can wander over 1 000 km in a season. The distance covered depends on the availability of water and feed. With rapidly expanding urbanization, these wanderings are causing clashes between cultures and destroying the grazing areas of the camels.

Because of its importance as a means of survival for the desert dwellers, the camel often plays an important role in the social and cultural heritage of the tribes. For instance, in various cultures (Hartley, 1979) ownership of a camel begins when a male child is born. He is presented with a female calf. The child's umbilical cord is placed in a sac and tied around the neck of the camel. In other societies the camel is used for attracting wives or paying off "criminal" offences (Dickson, 1951).

Camels have been introduced by man into various parts of the world, mainly as baggage animals for the arid zones of the country. This happened in Australia, where the camels escaped into the wild and are now considered vermin (McKnight, 1969). In Italy, Spain, South Africa and Texas in the USA camels were also introduced as pack animals, but they soon disappeared. Camels were introduced into the Canary Islands from Morocco in 1402 (Buillet, 1975), where they are still in use in agriculture and as beasts of burden.

In Sudan (El-Amin, 1979) there is at present one of the largest populations of one-humped camels in the world. They are found mainly in the arid and semi-arid areas of the country, where the average rainfall is less than 350 mm per year.

In the Horn of Africa (Hartley, 1979) the camel is found in the arid and semi-arid rangelands in Ethiopia, Djibouti, Somalia and Kenya. In these areas water supplies range from abundant in the riverine areas, to extreme aridity. In these areas the inhabitants are mainly pastoral and the camels roam according to the range conditions. In the dry season the camels are watered once every 10–20 days, compared with every 3–8 days for sheep and goats and every 2–3 days for cattle. The movement of the camels away from the living centres is divided primarily into far-moving dry herds and the closer-by milch animals.



Baggage camel
Photo 1



Ploughing with aid of the camel
Photo 2

The Boran of Ethiopia and Somalia rank their animals as follows: lactating caws, dry cows, lactating camels, dry camels, sheep and goats (Lewis, 1974). The pastoral Somali nomads have only two types of herding units. The first consists of the camels herded by the young unmarried men, which sometimes graze hundreds of kilometers from wells. The second group of milch animals are herded by the family unit of husband, wife, unmarried daughters and young sons. During the rainy season, when feed is freely available, the two herding units meet, and with both milk and meat in abundance, collective rituals and feasts take place.

For the Gabbra and Rendille tribes of northern Kenya, the camel is still the most important livestock (Sato, 1976; Torry, 1973). Much of their culture revolves around the camel owing to the animal's ability to survive the extreme aridity and to supply milk, which is the staple diet of these tribes.

In Pakistan, as well, there are areas with extremely arid pastures in which the only livestock that can produce milk, meat, wool and skins is the camel (Knoess, 1979). The camels are also valued as pack animals, carrying up to 600 kg on their backs and are also used for pulling carts.

In China, Mongolia and Russia the two-humped Bactrian camel thrives. (Dong Wei, 1979). They are mainly used as pack, riding and draught animals. The wool is of some importance, reaching 1 500 tons per year. Meat and milk are of lesser importance (Dong Wei, 1981).

In South America the guanaco and vicugna are the wild forms of the camel family (Bustinza Choque, 1979). The llama and alpaca have been domesticated. These Camelidae are utilized mainly as pack animals, but also supply meat, skin and fur. The South American cameloids live in a semidesert habitat that ranges from sea level to the Andean high country, at elevations of 5 000 m or more.

The questions that must be answered are:

1. What makes the camel, particularly the one-humped Arabian camel, so special? Or how is this animal able to adapt so perfectly to his environment?
2. Can the natural traits of the animal be improved upon for man's use?
3. If this animal can be of such benefit to man, why hasn't it been more widely used up to now?
4. What is the composition of camel milk? How much milk can it give? What is its fertility capability?
5. What does the camel eat?

The reason why the camel has not been more widely used is given in the opening remarks of the International Symposium on camels in Sudan, organized by the International Foundation for Science (El-Karouti, 1970). It was stated that "the prejudice against the camel stems from a misconception that it is of low economic value and is synonymous to under-development". It is universally accepted that milk and meat for human consumption in established communities are supplied mainly by cattle, sheep and goats. This applies even to arid zones, although it is actually the dromedary which can survive and let alone producing milk and meat for humans in these areas, while other animals have difficulty in staying alive.

Thus, almost no research as to the capacity of the camel to produce milk and meat under drought conditions, in areas, or under conditions where human nutrition is so precarious, has been done. As former camel owners become sedentary, the camel disappears. No thought is given to the ability of this animal to produce food in severe drought periods. In many places of the world the development of infrastructure, especially roads, has caused the camel to lose its value as a riding animal or beast of burden. Motor transport can now reach most outlying areas. However, in countries such as Afghanistan, Pakistan and India, motor transport is still extremely expensive and in those areas, which are undeveloped and not suited for motor vehicles, the camel is still a prized animal. The trends in camel holding can be seen

in Table 1. Thus it can be seen that in most countries the camel population is declining. The present-day distribution of camels shows that the limit of camel breeding does not pass the 50 cm rain area (Mason, 1979). The Bactrian camel is not found in temperatures over 21°C.

Research in physiology, endocrinology, husbandry, various diseases and their control are among the basic requirements from which further development and reorientation of the camel industry can start. While many aspects of camel anatomy, physiology and diseases are well documented, knowledge of husbandry is lagging far behind. Improved methods of breeding and intensive husbandry have not been systematically examined. The introduction of hardy plants into arid areas for camel fodder is only in its embryo state.

The changes in shape and size of camels from their original small size (Zeuner, 1963) were obviously caused by interactions with their environments. This is also true for the wide changes that have been described for the various physiological mechanism. The changes in normal physiological responses to the environment not only allow the animal to survive, but explain the ability of this animal to supply nutrition for their young. This supply could be used for man, who is attempting to live in these areas. Furthermore, basic knowledge of breeding and lactation is a primary requirement for planning improved husbandry and farming with these animals.

The physiological mechanisms, which allow the camel to survive periods of over two weeks without drinking water and to eat the most unpalatable plants, all have to do with the conservation of water. The appropriate physiological mechanisms will be discussed further. What is of interest now is that severe desiccation is tolerated. Up to 30 percent of its body weight can be lost by loss of water - amounts that would be fatal in the case of other farm animals or even man (Schmidt-Nielsen, 1964). Moreover, this loss can be replenished in a matter of minutes (Yagil *et al.*, 1974). The camel has the lowest water-turnover of all animals (Macfarlane, 1977) and is able to regulate water and salt uptake from the colon and their excretion from the kidneys (Yagil and Etzion, 1979). Camels do not need to sweat to lower body temperature, thus conserving water (Schmidt-Nielsen, 1964). The camel increases its body temperature from 34°C in the early morning to over 41°C in the late afternoon, at which time the environment cools greatly. Thus the camel stores its heat during the day and cools off by conduction and convection in the evening. The water-deprived camel reduces its metabolism (Schmidt-Nielsen *et al.*, 1967; Yagil *et al.*, 1975) which also conserves water.

Together with the examples of physiological adaptation mentioned above, there are also behavioral adaptations. These consist mainly of presenting the smallest possible surface area to the rays of the sun (Ingram and Mount, 1975) and by being less active in the heat of the day. Even the covering of the camel changes from a wool in the winter to a sleek shiny reflecting hair in the summer. Equatorial camels do not shed their hair, but maintain a smooth reflecting coat throughout the year. The hump does not serve as a water reservoir, nor solely as an energy reserve, but its greatest use is that being a concentration of body fat it leaves the subcutaneous tissues virtually fat-free, thus allowing for an efficient cooling to a relatively cooler environment (Cloudley-Thompson, 1969).

The future of the camel lies in the exploitation of the milk and meat producing capabilities in areas where perennial drought conditions cause many human deaths each summer. In addition, the interaction between livestock and vegetation will decide the degree of continued desert encroachment or rehabilitation.

Table 1. World camel population (millions)*

	1978	1969 – 1971	
Bactrian			

China	0.6 – 1.04	1.15	
Mongolia	0.62	0.64	
U.S.S.R.	0.23	0.25	
	0.91 – 1.89		2.04
<u>Dromedaries</u>			
<u>North East Africa:</u>			
Somalia	5.4	2.5	
Sudan	2.9	1.6	
Ethiopia	1.0	0.9	
Kenya	0.6	0.4	
	9.9		5.4
<u>West Africa:</u>			
Mauritania	0.7	0.1	
Chad	0.4	0.1	
Niger	0.4	0.2	
Mali	0.2	0.1	
W. Sahara, Nigeria			
Senegal, Upper Volta	0.1	-	
	1.8		0.5
<u>North Africa:</u>			
Tunisia	0.2	0.2	
Algeria	0.1	0.1	
Egypt	0.1	0.1	
Libya	0.1	0.3	
Morocco	0.02	0.2	
	0.5		1.0
	1978		149 – 1950
<u>Asia:</u>			
India	1.2	0.6	
Pakistan	0.8	0.5	
Afghanistan	0.3	0.3	
Iraq	0.2	0.5	
Saudi Arabia	0.1	0.3	
Iran	0.03	0.6	
S. Arabian & Gulf States	0.2	0.2	
E. Med. countries	0.05	0.2	
	2.9		3.2

* FAO Production Yearbook (No. 16 (1962) and No. 32 (1978)





II. MILK PRODUCTION

When discussing milk and lactation in general, two aspects must be taken into account. The first is the amount of milk produced per day and per lactation period. The other aspect, which is as important, is the type of milk produced. Animals living in cold areas or in the sea need a different quality of milk from those living in hot areas; this applies also to fast-growing animals as compared with slow-growing animals (Yagil & Etzion, 1980).

This section will deal with the lactation, milking and amount of milk produced.

The mainstay of the desert nomad's food is camels' milk, which is consumed fresh or when just soured (Mares, 1954, Gast *et al.*, 1969). Data on the actual amount of milk produced by camels are not very accurate for judging the milk-giving capabilities of camels. Calves must be allowed to drink; therefore, the herder and his family must share with the calf the milk produced by the herd. How much the calf drinks certainly varies with its size, age, and health. The amount of grazing and water available to the camel will also determine the amount suckled, and the total produced.

The camel, like the cow, has a four-quartered udder. It is firmly suspended from the abdomen, without deep cuts (Sharma, 1963) (Photo 4). There are four teats, each having two orifices.

China

The two-humped Bactrian camel is used mostly as a working animal (Dong Wei, 1979). The lactation period is 14–16 months, and the amount of daily milk production averages 5 kg per animal; although some animals can give as much as 15–20 kg per day. Normally, only about 2 kg are milked; the rest is suckled by the calf.



Camel uddr. Punjab, Pakistan.
(Knoess, K.H. milk production in the camel, 1979)
Photo 3

Russia

Milking capabilities of the Bactrian, the dromedary, and the hybrid of these two types of camels were examined (Kheraskov, 1955, 1961, 1965; Lakosa & Shokin, 1964; Dzhumagulov, 1976). The dromedary gave more milk than the Bactrian or the hybrids (Table 2). The hybrid - Kazakh - gave more milk than the hybrid Turmein. The lactation period was 18 months. Most of the milk was produced in the first seven months of lactation, from spring, throughout summer, until Autumn. This was correlated with the availability of fodder. Grazing in Winter is difficult, because of snow. The second lactation yield was far greater than the first, and in each following lactation more milk is produced. The estimated milk yield between the third and sixth months of lactation was 879– 1 572 kg (Kulaeva, 1979). Slightly more milk was received from the back-quarter, 56.4 percent to 43.6 percent from the forward-quarters. From the sixth month of pregnancy the amount of milk declined.

With good stall feeding the same amounts of milk were received as with grazing animals. This would be of great importance if a steady and balanced diet could be supplied to the animals throughout the year.

When the animals are hand-milked the milker stands on one leg and balances the milking bowl on his bent left leg. The left hand holds the bowl, while the camel is milked with the right hand. Another method is to tie the bowl around the milker's neck so it hangs low enough to be held while the camel is being milked. Camels have successfully been machine milked. Liners of 18.56 mm diameter and 56 mm length are recommended for the Bactrian and liners of 20.6 mm diameter and 90 mm length are recommended for

the dromedary (Baimukanov, 1974). The animals were gradually changed from hand to machine milking in the presence of their calves. The cell-count of milk of hand-milked camels was lower than that of machine-milked camels (Kospakov, 1976).

In the vast dry areas between the Caspian Sea and the Balkash Lake the camel is, and can be, of great nutritional importance. In Kazakhstan, milk and milk products account for up to 90 percent of the daily staple diet. The camel is the most important provider of milk. Thirty-seven percent of all milk comes from the camel; 30 percent from sheep; 23 percent from the Yak and only 10 percent from cows.

New World Camels

Little is known about the milk production of these members of the camel family. The alpaca, when kept on good pasture, can produce up to 0.5 kg of milk daily (Novoa, 1970).

Horn of Africa

In the Horn of Africa, milking of camels is not only an act of work, but has become an integral part of the local culture and heritage. Only boys, unmarried women or ritually clean men are allowed to milk the animals (Hartley, 1979). No treatment of the milk is allowed. The milk is either consumed fresh or when just soured. In some tribes the herdboys subsist on camel milk alone. They drink water only after the camels are watered. Two teats are left for the calf, while the other two are milked-out for the tent dwellers. These latter two teats are tied up with soft bark fibres. The colostrum is not drunk, but is either given to the calf although it is thought to be bad for the young camel (Field, 1979), or spilled onto the ground. This certainly represents a bad practice since the colostrum contains large amounts of absorbable antibodies.

The camels are milked twice a day; before dawn and at night. The average milk production is about 1 800 kg, i.e.: 9 kg per day.

Table 2. Milk yields of camels (kg)

Country	Daily		Lactation yield	Lactation length (months)	Calculated yield per 305 day	Reference
	average	maximum				
China-Bactrian	5	15–20	1 254			Dong Wei, 1981
USSR-Bactrian					735	Lakosa & Shokin,
- Hybrid-Kazak					1 305	1964 "
-Hybrid-Turkmen			981			"
Dromedaries						
China	7.5		3 300	16–17	2 288	Ensminger, 1973
USSR					2 003	Lakosa & Shokin,
USSR	8.1	19	4 388			1964 "
Horn of Africa	9		1 800			Hartlet, 1979
N. Kenya	4	12				"
N. Kenya		50	1 897			Field, 1979
Ethiopia	5–13		1 872–2 592	12–18	1 525–3 965	Knoess, 1977
Somalia	5		1 950	13	1 525	Rosetti et al., 1955
Libya	8.3–10		2 700–4 000	9–16	2 532–3 050	C.E.F. Li, 1977
Algeria	4	10				Gast et al., 1969

Tunisia	4			12	1 220	Burgmeister, 1974
India:						
good feeding	6.9	18.2	3 105–8 190	15	2 105–5 551	Rao, 1974
bad feeding			1 360			Yasin <i>et al.</i> , 1957
desert	6.8	9.1	2 430–4 914	18	1 373–2 776	Rao, 1974
Pakistan:	8.0	13.5	13 560–3 660		1 068–4 118	Yasin <i>et al.</i> , 1957
good feeding	9–13.6	20.5	2 727–3 636	16–18	3 150–4 148	" "
bad feeding	4		1 364		1 220	" "
Pakistan:	6.7–10		2 700–3 600	9–18	2 044–3 050	Leupold, 1978
good feeding	15–35		5 475–12 775	12	4 574–10 675	Knoess, 1979
desert	8.10		2 920–3 650	12	2 440–3 050	Knoess, 1979
Egypt	3.5–4.5		1 600–2 000		1 068–1 373	El-Bahay, 1962
Israel						
+ water	6.0					Yagil <i>et al.</i> , 1980b
- water	6.2					" "

Weaning is carried out when the calves are 9–11 months old. A leather band with protruding thorns is placed on the calf's head in such a way that the dam is pricked every time the calf attempts to suckle; the dam thus quickly moves away.

North Kenya

In North Kenya the camels produce far more milk than the local cows. The Sakuye camel produces an average of 4 kg milk daily with a maximum of 12 kg. The cow produces 0.5–1.5 kg per day. Camels lactate for about a year. In areas with only one rainy season lactation finishes at the end of the dry season; this is thought to be caused by the shortage of feed during this period.

In areas of northern Kenya, where the nomads subsist almost entirely on camel milk, there are two rainy periods. Field (1979a and 1979b) reported lactation studies lasting three lactations. The duration of lactation was 47–67 weeks. Lactation ended 4–8 weeks following conception. Daily milk production reached 21 kg in the first week, declining to 4.8 kg in the 16th week of lactation. There was an average daily milk yield of 13 kg for the first 10 weeks (1.8–50.2 kg) and 3 kg for the remainder of the lactation. Total production averaged 1 897 kg per animal. In the lactation studies the lowest milk yields were those given by camels without calves. These animals also had much shorter lactation periods, even though they were milked 5–7 times a day. Four milkings per day yielded more milk than twice a day milkings: seven liters compared with six (Evans and Powys, 1979; Shalash, 1979).

Ethiopia

The camel is known to be capable of producing large quantities of milk under extensive and intensive management (Knoess, 1979). Knoess rightly stresses the fact that as the camels are not intensively milked, but some milk is left for their calves, the exact amount is difficult to assess. Milk trials in the Awash Valley of Ethiopia were carried out for six days in various stages of lactation (Knoess, 1976). As suckling stimulus is an integral part of milk production (Yagil *et al.*, 1975), it is obvious that in the short period of hand-milking the maximum milk producing capabilities were not fully exploited. Even so, eight liters in two milkings, or 2 470 kg over 305 days were obtained. The daily average for twice-a-day milking was estimated at 7 kg. These animals grazed on irrigated pastures. Under rainfed conditions, 13 kg per day can be milked (Knoess, 1979). It was found that some days the camels were milked 6–8 times a day, while other days they were not milked at all. This certainly would make the milk supply lower than if the animals

were milked regularly each day. In the dry season the milk yield was about half that of the rainy season. This could be due to the lack of feed or to advanced stages of pregnancy (Lakosa, 1964).

Somalia

The lactation period is between 8–18 months (Mares, 1954a). The length of lactation depends on when the lactating dam is remated. The average daily yield in milk is 5 kg with a total yield of 1 950 kg. The amount of milk drunk by the calf is regulated by tying up one or more teats (Mares, 1954a). The amount the calf is allowed is determined by its needs and the milking capacity of the mother. Camels are milked twice a day; just after sunrise and at least two hours after sunset. Calves run with their mothers but are penned separately at night. From the age of six weeks they graze. When calves have finished suckling the amount left for consumption by the tent dwellers can vary from 1 to 4 kg (Epstein, 1970).

If a calf dies, the dam dries up if milking is not stimulated (Mares, 1954a). For this a foster calf or conditioning of the mother is necessary. Often arranging for the dam to see the skin of her dead calf is enough to stimulate let-down of milk. Fostering is done in three ways: (1) The foster calf is covered with the skin of the dead calf and allowed to suckle until the milk is flowing and the dam can be hand-milked. (2) The calf is tied down in front of the foster-mother, a rope being tied from the calf to the mother's muzzle. (3) The nostrils, ears or anus of the foster-mother are compressed with a special clamp. When the clamp is released, and the pain thus removed, the calf is presented for suckling. This is usually enough for the dam to allow the foster-calf to suckle.

In all cases the calf drinks from its own mother as well as from the foster-mother.

Algeria

The nomads of the Ahaggar in the Sahara depend on milk to give them a balanced diet (Gast *et al.*, 1969). They have a saying "water is the soul; milk is life", and hungry people say "I've lost the taste of milk". Of course the camel is only one of the providers of milk. Goats, sheep and cows supply milk and milk products. The lactating camel produces 4–5 kg/day, on good pasture, for the first three months. A good milker can even provide up to 10 kg a day. When the udders are full the animals are milked three times a day, otherwise their swaying teats hinder their walking. After the third month of lactation the yield averages about 2 kg per day. The bad milkers dry off very quickly. It is therefore accepted that one camel is necessary to provide the requirements of one family. The camel herders' only source of food is camel milk.

The camels are tied down during the night and the camels' udders are covered with nets to prevent the young from suckling. The first milking takes place before dawn. The young calves are allowed to suckle for about one or two minutes. This is time for the milk to let-down. The calves are pulled away and the dam then milked for the tent dwellers. At twilight the camels are returned to the camp, and milked again after allowing the calves to suckle for a few minutes.

India

The geographical distribution of camels (dromedaries) in India, is in the States of Gujarat, Haryana, Maharashtra, Madhya Pradesh, Punjab, Rajasthan and U.P. (Rao *et al.*, 1970). The females calve for the first time at the age of 4 years. They lactate for 8–18 months. The amount of milk for the calf, and the amount that is milked, is regulated by tying up the teats to prevent the calf from suckling. The camels are milked twice a day. The daily milk production is between 2.5–6 kg, but often 15 kg per day is milked. Lactation yields range from 2 000 kg (Gohl, 1979) to 2 700–3 600 kg (Rao *et al.*, 1970) under good feeding conditions, to about 1 360 kg, when feed supplies are poor (Yasin and Wahid, 1957).

Pakistan

The Arabian camel is found mainly in West Pakistan (Yasin & Wahid, 1957). Length of the lactation varies from 270–540 days; daily milk yields of 15 to 40 litres were recorded (Knoess, 1977). The total milk yield ranges from 1 350–3 600 kg. The lower milk yields were found in the areas where feed supplies are poor and under desert conditions. When the camels were well fed, there was an average milk yield of 10–15 kg per day (Yasin and Wahid, 1957). As much as 22 kg a day were obtained from some camels. In the areas with poor feeding the daily average was 4 kg. The heavy Pakistani camels produced up to 35 kg per day (Knoess, 1979). The desert camels gave more milk than the animals getting poor feed. These animals were milked twice daily.

Egypt

With good feeding a daily milk production of 10–15 kg was obtained (Shalash, 1979) giving a yield of approximately 3 000–4 000 kg per lactation. Daily yields of 22 kg have been recorded. Where feeding was precarious the daily production was only 4 kg, with a total production of 1 500 kg. These later data are similar to those presented by El-Bahay, 1962.

Israel

No actual recordings of milking have been made. Estimates of milk production range from 7 to 15 kg daily. Lactation periods vary from 9–18 months. In order to establish the total amount of milk produced by the lactating camel, the milk yield was measured indirectly (Yagil & Etzion, 1980). This method is based on firsts marking the calves' blood with radioactive water. The calves were not allowed access to any drinking water as this would have made milk determinations impossible. The mothers were allowed drinking water only once a week for an hour, from the beginning of spring until the end of summer. The results show that there was a slight increase in milk yields as lactation progressed (5.7 to 6.2 kg). No decline was found when the animals were dehydrated. These data do not give the full potential of the camel as, in fact, what was measured was the calves' need for water. The calves ate the same feed as their mothers. They started eating within the first month of birth. Not notwithstanding this fact, it is quite clear that the feed demand of the calf is fairly large. In addition, research was carried out using the same diet throughout the year to eliminate nutritional factors affecting quantity and quality of milk. The natural grazing available to camels changes from winter to spring and in the summer the changes are even more drastic, in quantity and quality. With a decline in quantity the calves would tend to take more from their mothers than when the feeding is plentiful.

The milk production of camels in general was reviewed. Only in the USSR and in Saudi Arabia were any attempts made to milk camels by machine (Baimukanov, 1974). In the main the same milking methods are still in use as were probably used for the first domesticated camels. Milk is still shared with the calf (Photo 4) and many superstitions and ritual customs accompany the milking of camels. The dromedary gives more milk than the Bactrian. The milk yield of dromedaries does not vary so greatly between the various countries; the maximum daily milk yields are relatively large; and the length of lactation varies greatly, not only between countries, but also within a country. It is clear that status of feed and water will determine the amounts of milk for human consumption. Improving the feed is of prime importance in planning for better husbandry. Intensive farming will also allow for better husbandry and for easier implementation of selective breeding for high milk production. These aspects will be discussed in detail in other sections.

A most interesting phenomenon was discovered when research was carried out on intestinal lactase concentrations in various ethnic groups in Saudi Arabia (Cook & Al-Torki, 1975). Adult Arabs were found to have the highest lactase levels. This was supposed to demonstrate a selective advantage associated

with the fluid and caloric value of camel milk and indicate the importance of camel milk for the survival of desert nomads.

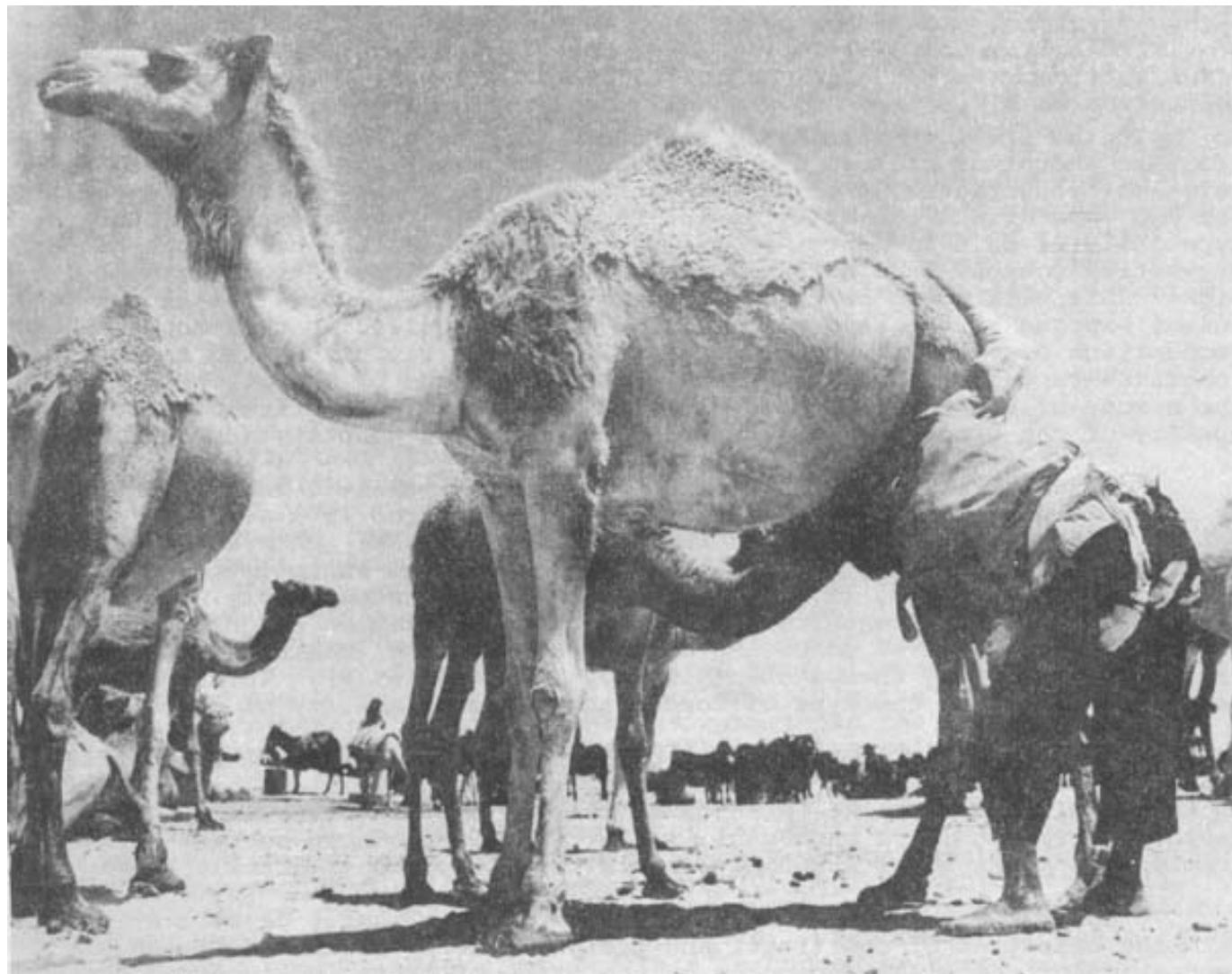


Photo 4: Milk for man and animal





III. COMPOSITION OF CAMEL MILK

In the previous section it was shown that camels can produce an adequate amount of milk in drought areas where other domestic animals have very low production. Of prime importance for the young camel, and especially for man, who drinks the milk, is the composition. Cows exposed to heat, especially if drinking water is scarce, produce milk that has a much higher dry-matter content than normal (Bianca, 1965). The fat content is especially high. This milk would certainly not provide a suitable diet for man or animal exposed to the same climatic and water stresses. Data concerning the composition of milk vary greatly. This can be partly attributed to the inherited capabilities of the animals, but the stage of lactation, age, and the number of calvings also play a role. Of special significance to the quality of the produced milk are the feed and water quantity and quality.

Most camel milk is drunk fresh. It is also consumed when slightly sour or strongly soured. (Milk products will be considered in a separate section). Camels'milk is generally opaque white (Dihanyan, 1959; Heraskov, 1953; Yagil and Etzion, 1980). Normally it has a sweet and sharp taste, but sometimes it is salty (Rao, 1970). At times the milk tastes watery. In certain countries there are prejudices among the urban population concerning camel milk. It is considered as having an unpleasant taste (Yasin and Wahid, 1957). It is frothy when shaken slightly (Shalash, 1979). The changes in taste are caused by the type of fodder and the availability of drinking water.

Fresh camels' milk has a high pH (Grigor'yants, 1954; Ohri and Joshi, 1961a). The pH of milk is between 6.5–6.7 (Shalash, 1979). This is similar to the pH of sheeps' milk. When camel milk is left to stand, the acidity rapidly increases (Ohri and Joshi, 1961). The lactic acid content increases from 0.03 percent after standing 2 hours to 0.14 percent after 6 hours.

The first milk, the colostrum, is white and slightly diluted as compared with the colostrum of cow (Yagil and Etzion, 1980). Other studies on the composition of the milk, depending on the stage of lactation, confirm these data (Sestuzheva, 1958). It was found that 3 hours post-partum total solids (T.S.) averaged 30.4 percent. The T.S. declined to 18.4 percent during the first 2 days of lactation. This decline in T.S. was not caused by a variation in fat content, as initially the fat percentage was low, at 0.2 percent, and then greatly increased to 5.8 percent; rather the decline in total proteins and minerals was

responsible. Ohri and Joshi (1961b) made a detailed study of camel colostrum. The range and average values for colostrum were:

<u>Specific gravity (15.5°C)</u>	<u>Range %</u>	<u>Average %</u>
Fat	0.1 – 0.4	1.079
Protein	15.79–19.52	0.15
Lactose	3.98–5.13	17.78
Ash	1.44–2.80	2.60
Acidity (percent) (lactic acid)		0.38

In Somalia the colostrum (dumbar) is used by some as a food, but is generally only taken as a laxative (Mares, 1954). However, in most countries where camels are kept, the colostrum is considered unsuitable for drinking (Shalash, 1979). It is even considered as unsuitable for the calf and is milked onto the ground. However, as colostrum contains large amounts of antibodies and is beneficial for digestion in the newborn calves, it is advisable to use it for the calves, if it is not palatable for human consumption.

The general composition of camels' milk in various parts of the world is given in Table 3. Milk analysed at monthly intervals until the 6th month of lactation, then analysed in the 12th month, and at the end of the 14–17 months total lactation period, showed that the average composition observed during the first month of lactation remained constant for the first 6 months (Sestuzheva, 1958).

The specific gravity of camel milk is less than that of cow, sheep or buffalo milk (Shalash, 1979).

The most important factor in camel milk is water content. Young camels, and especially the humans living in drought areas, are in need of fluid to maintain homeostasis and thermoneutrality. The water content of camel milk fluctuates from 84 percent (Knoess, 1976) to 90 percent (Ohri and Joshi, 1961). When examining only the effects of the lack of drinking water on camel milk, the diet remaining unchanged throughout the year, great changes in water content of milk were found (Yagil and Etzion, 1980). The camels were allowed ad libitum drinking water only during the winter. From spring until the end of summer the mothers and calves were allowed to drink only once a week for one hour. With water freely accessible the water content of the milk was 86 percent, but when water was restricted the water content of milk rose to 91 percent. These changes reflect the range presented in the literature and thus makes it important as to when the milk was sampled by the various investigators. Water content of fodder would also affect water content of milk. Thus, it would appear that the lactating camel loses water to the milk in times of drought. This could be a natural adaptation in order to provide not only nutrients,

but necessary fluid to the dehydrated calf. Another explanation can be found when examining the mechanism of sweating in man when exposed to heat (Ingram and Mount, 1975). Adaptation to heat causes secretion of a profuse watery sweat. This is caused by secretion of endogenous ADH (anti-diuretic hormone, secreted from the neurohypophysis) because man produces the same water sweat when injected with ADH. Thus man loses water from his sweat glands, allowing him to maintain thermoneutrality. As the mammary glands have the same embryonic origin as the sweat glands (Strauss, 1974), and as ADH secretion is elevated in the dehydrated camel (Yagil and Etzion, 1979), it could happen that the loss of water into the milk is due to the action of this hormone. Injections of ADH into lactating laboratory rats exposed to heat for 8 hours a day also caused increased water content in milk (Etzion and Yagil, 1981). Even the milk of slightly dehydrated cows, not under desert conditions, shows such an increase (Aschaffenburg and Rowland, 1950). It is also of importance to note that the other hormone of the neurohypophysis is oxytocin, the hormone that is essential for the letdown of milk. Stimulation of suckling and milking could possibly influence the neurohypophysis and induce secretion of both hormones and so lead to a dilution of the milk. Whatever the explanation, the diluted milk at times of water deprivation makes an excellent food for man. It also explains the Bedouin tales of taking a lactating camel along on long trips through the desert (Abu-Rabuja, personal communication).

Table 3. General composition of camel milk

Country	Fat %	SNF * %	Protein	Lactose %	Ash %	Density %	Water %	Reference
General	5.38	7.01	3.01	3.36	0.7			Barthe, 1905
	2.9		3.7	5.8	0.6			Leese, 1927
	3.07	10.36	4.0	5.6	0.8		86.5	Davies, 1939
	2.87		3.9	5.4				Davies, 1939
	3.02	9.31	3.5	5.2	0.7			Lampert, 1947
USSR:								
Dromedary	4.47	9.15	3.5	5.0	0.7	1.1	86.38	Kheraskov, 1953
Bactrian	5.39	9.59	3.8	5.2	0.7	1.03	85.02	Kheraskov, 1961a+b
	4.3	8.2	-	2.8	0.9			Grigor' yants, 1950
Pakistan	2.9	10.1	3.7	5.8	0.7			Yasin & Wahid, 1957
	4.2	8.7	3.7	4.1	0.8			Kon & Cowsie, 1961

<u>India</u>	3.78	9.59	4.0	4.9	0.95	1.03–1.04		Ohri & Joshi, 1961
	3.08	9.92	3.8	5.4	0.7	1.04		Khan & Appora, 1964
	2.9	10.1	3.9	5.4	0.8		87.6	Harbars Singh, 1962
	4.1		2.0	4.7	0.7		88.5	Harbars Singh, 1962
<u>Egypt</u>	3.8	8.2	3.5	3.9	0.8	1.03	87.9	El-Bahay, 1962
	3.0	9.92	3.9	5.5	.8			Davis, 1963
<u>Ethiopia</u>	5.5	8.9	4.5	3.4	0.9		85.6	Knoess, 1976
<u>Israel:</u>								
plentiful-drinking water	4.3	14.3	4.6	4.6	0.6	1.01	85.7	Yagil & Etzion, 1980
scarce-drinking water	1.1	8.8	2.5	2.9	0.35	0.96	91.2	Yagil & Etzion, 1980

* Non-fat solids

With the increase in water content of milk produced by thirsty camels, there was a decrease in the fat content, from 4.3 to 1.1 percent (Yagil and Etzion, 1980). In the literature, the percentage of milk fat of camels varies from 2.6 (Yasin and Wahid, 1957) to 5.5 (Knoess, 1976). Again, the hydration status of the animals would determine the fat content of the milk, as well as the type of forage eaten.

The milk fat is also different from that of other animals. When left standing, fat is distributed as small globules throughout the milk (Yagil and Etzion, 1980). The fat globules are very small 1.2–4.2 microns in diameter (Dong Wei, 1981). The ratio of fat to total solids averages 31.6 percent (Shalash, 1979). This is much lower than that of the buffalo, which is 40.9 percent. The fat appears to be bound to the protein (Khan and Appara, 1967). This would explain why it is difficult to extract fat by the usual method of churning sour milk (Rao *et al.*, 1970). This difference in milk fat necessitated saponification of camel milk in order to extract vitamin A and carotene (Khan and Appara, 1967). Petroleum ether extraction, as used in milk of other animals, was not efficient enough for camel milk.

Camel milk fat has a low Reichert value of 16.4 (Dhingra, 1934). The fatty acid composition of camel milk fat was found to be as follows (in weight percentage):

Butyric acid	2.1
Caproic acid	0.9
Caprylic acid	0.6

Capric acid	1.4
Lauric acid	4.6
Myristic acid	7.3
Palmitic acid	29.3
Stearic acid	11.1
Oleic acid	38.9
Linoleic acid	3.8

Compared to cow, buffalo and ewe milk fat, camel milk fat contains less short-chained fatty acids, but the same long-chained fatty acids can be found. (Dhingra, 1934). Gast *et al.*, (1969) claim that the value of camel milk is to be found in the high concentrations of volatile acids and, especially, linoleic acid and the polyunsaturated acids, which are essential for human nutrition.

The molar percentage distribution of the glycerides in camel milk fat is as follows (Dhingra, 1933).

Fully saturated glycerides	25.6
mono-oleo unsaturated glycerides	37.8

The total saturated acids in whole fat was 62.6 percent mole.

The distribution of phospholipids in camel milk (expressed in mole percent of phospholipids) was as follows Morrison, 1968 a and b):

phosphatidyl ethanolamine	35.9
phosphatidyl choline	24.0
phosphatidyl serine	4.9
phosphatidyl inositol	5.9
sphingomyelin	28.3
lysophosphatidyl ethanolamine	1.0
lysophosphatidyl choline	0.0
total choline phospholipids	52.3
ethanolamine plasmalogen	15%

Milk protein content of camel milk ranges from 2 to 5.5 percent (Yasin and Wahid, 1957). The total protein in camel milk is similar to that of cow milk. Dilanyan (1959) reported the casein content of dromedary and Bactrian milk as 2.7 and 0.89 percent respectively and that of albumin as 3.8 and 0.97 percent respectively. Kherashov (1961) examined four breeds of camels and found the value for total protein to vary from 3.5 to 3.8 percent and casein from 2.7 to 2.9 percent. Egyptian camels had low casein, 2.6 percent (El-Bahay, 1962). Camel milk casein and their fractions were found to be poor in crude protein when

compared with cow milk (Pant and Chandra, 1980).

Milk from the dehydrated camel has a severely decreased protein percentage. (Yagil and Etzion, 1980). Again, this demonstrates the direct effect of drinking water on the composition of milk. It must be stressed that protein content of the feed will also directly affect that of milk.

The amino acid composition of Bactrian milk declines as lactation advances (Kudabaer *et al.*, 1972). The contents of methionine, valine, phenylalanine, arginine and leucine are greater than in cow milk. The nitrogen content of camel milk was found to be 15.6 gr/100 gr. The following amino acids were present: alanine 3.05; arginine 3.15; asparagine 7.65; glycine 1.57; glutamine 23.4; histidine 2.5; isoleucine 6.4; leucine 10.4; lysine 7.6; methionine 3.5; phenylalanine 5.7; proline 13.3; serine 5.9; threonine 6.9; tyrosine 5.8; valine 7.4; ammonia 1.72. (Hoeller and Hassa, 1965).

Sestuwheva (1958) found that the lactose content of camel milk remained unchanged from the first months up to the end of lactation. The concentrations in milk vary from 2.8 percent (Grigor'yants, 1950) to 5.8 percent (Yasin and Wahid, 1957). These were approximately the same range as found between the hydrated and dehydrated animals (Yagil and Etzion, 1980). The changes in lactose concentration would account for the milk being described as sometimes sweet, and other times bitter.

The mineral content of milk is expressed as total ash in Table 3 and will be discussed further. The total ash content of camel milk varies greatly, and the lowest percentage of ash was found in the milk produced by dehydrated camel (Yagil and Etzion, 1980). Camel milk is rich in chloride (El-Bahay, 1962). Although milk from the dehydrated camel showed decrease of fat, protein and lactose content, that of sodium and chloride increased (Yagil and Etzion, 1980). This would account for the salty taste.

Both concentrations of calcium phosphate and magnesium decline in the milk of dehydrated camel. (Yagil and Etzion, 1980). However, these concentrations are still adequate for human nutrition and are similar to the values presented by Kulier (1959).

Camel milk is rich in vitamin C (Kno, 1959, Knoess, 1979). This is important from the nutritional stand point in areas where fruit and vegetables containing vitamin C are scarce. Kheraskov (1961) found the vitamin C content of camel milk to vary between 5.7 and 9.8 mg percent. As lactation progresses, the vitamin C content increases (Bestuzheva, 1964). The vitamin C levels are three times that of cow milk and one-and-a-half that of human milk (Gast *et al.*, 1969). Vitamin B₁₂ in camel milk declined from 3.9 ug/l at 1.5 months lactation to 2.3 ug/l at the fourth month of lactation (Bestuzheva, 1964). Vitamin B₁ and Vitamin B₂ concentrations are adequate and are higher than those of Afar sheep (Knoess, 1976). Vitamin B₂ content in camel milk is also higher than

in Afar goat milk, but the vitamin B₁ is lower in camel milk. Carotene concentrations in the milk declined from 0.46 mg/kg at 1.5 months lactation to 0.16 mg/kg at 4 months lactation (Bestuzheva, 1964). The vitamin A content has been reported as being as little as 0.037 mg percent (Kheraskov, 1961) to 1.264 mg/l (Anderson *et al.*, 1940). Khan and Appona (1967) found an average of 7.57 ug/ml of vitamin A and 9.4 ug/ml of carotene. The latter used the method of saponification to extract the vitamin A and carotene.

The milk of all four quarters appears to have the same composition (Ohri and Joshi, 1961). Camel milk is very similar to goat milk and compares very favourably with human milk (Davis and McDonald, 1953). This again stresses the importance of camel milk for human nutrition. Camel herders living only on milk in Kenya (Fields, 1979) and in the Ahaggar region of the Sahara (Gast *et al.*, 1969) are healthy and vigorous. Camel milk is renowned for its health-giving qualities, which includes good bone growth. Some camel herders living on camel milk only show a change in the colour of their hair to red (Gast *et al.*, 1969), but this returns to normal when a more balanced diet is resumed.

From all the data presented it is clear that the camel produces a nutritious milk for human consumption. It is also evident that the taste and quality of milk is directly affected by the amount of water drunk, and the amount and quality of feed eaten. The fluctuations in fat, protein, fat and salt are determined by the amount of water drunk (Yagil and Etzion, 1980) and by changes in pasture. Grazing on Atriplex halimus gives a salty taste to the milk, and grazing on Schouwia purpurea gives a cabbage smell to the milk (Gast *et al.*, 1969).





IV. MILK PRODUCTS AND THEIR USES

As milk from the lactating camel must provide nourishment for her young calf as well as for human, not a great deal will be left for milk products. Moreover, the composition of camel milk does not allow for making some of the accepted products that are made from cow, sheep and goat milk. Nevertheless, milk products are made from camel milk, and the milk itself is used for purposes other than simply nutrition.

As in most pastoral communities, where milk for human consumption is obtained from more than one domesticated species of animal, milk products are made after milk of various animals in mixed. It is often unclear therefore if some of the products can be made from camel milk alone (Dhal and Hjort, 1976) or if the milk used is a mixture. This is often the case when camel milk is mixed with fresh or churned goat milk (Gast *et al.*, 1969). This mixture is made with certain quantities of camel milk added until the required taste is obtained.

Not all communities use camel milk for making products. The milk of the Afar camels in Ethiopia, for instance, is not allowed to be processed or sold (Dahl, 1979).

When camel milk is not consumed fresh it must be processed as soon as possible both because its keeping quality seems to be poor and as it is further adversely affected by the climate it soon goes bad if not treated.

Many superstitions and beliefs have evolved around camel milk and milking. Only specific members of the family can graze the animals (Hartley, 1979) and the milk is considered as having medicinal as well as mystical properties.

Fermented milk products

Under warm conditions raw milk does not keep for long and actually its fermentation appears to be a means to preserve it not only for a limited period of time. Fermented products have various names in various parts of the world (Aggarwala and Sharma, 1961). In the Caucasus it is called kefir; in Armenia, matzoon; in India, dahi; in Sardinia, gioddu; in Bulgaria, yoghurt; and in Syria, Israel and Egypt, lehben. The method of preparation of fermented milk consist in heating the milk to the boiling point (Aggarwala and Sharma, 1961) so as to kill bacteria. Subsequently it is cooled to body temperature

and a small quantity of previously fermented milk is added which will work as a starter. The milk is well stirred and kept overnight at ambient temperature. By next morning it has curdled. At that stage it has acquired a sour taste and the typical flavour of fermented milk has developed. Pathogenic bacteria were killed when the milk was boiled and conditions have developed which will make it difficult for them to develop, assuring that a re-infection took place at a later stage. Therefore, fermented milk products are edible for some time. Kheraskov (1964) described the method for commercial manufacture of kefir from camels' milk: milk is flash pasteurized at 85°C, getting rid by this means of pathogenic bacteria. The milk is then cooled to 26–30°C and then inoculated with a 3 to 6 percent of kefir culture. It is then bottled. After incubation at 20–26°C for 8 to 12 hours, a soft coagulum is formed and its acidity reaches 60°–70°T. The product is then allowed to ripen for 24–28 hours at 6 to 8°C. The end product has a refreshing flavour and a thick creamy consistency. It is white and without gas. The acidity of one-day old kefir is in the region of 95°T and its alcohol content is about 4 percent. "Chal", or shubat, is a white sparkling beverage that has a sour flavour (Lakosa and Shokir, 1964). The "chal" is prepared by first souring it in a skin bag or ceramic jar, normally with a capacity of 30 kg. Previously soured milk is added to the fresh milk. It is well mixed and each day, for 3 to 4 days, fresh milk is added to the mixture. Eventually the end product must have 3 to 5 times the original volume of "chal" that was initially added. This is the best ratio for the "chal". It was found that camel milk does not sour at temperatures below 10°C and this for up to 72 hours. At 30°C the milk sours in approximately 8 hours, compared with cow milk, which sours within 3 hours at a temperature of 30°C. The comparison between the composition of camel milk and camel "chal" is as follows (Grigor'yants, 1954):

	<u>Camel milk</u>	<u>"Chal"</u>
acidity	18°	28°
fat	4.3%	4.3%
lactose	2.75%	1.32%
non-fat solids	8.2%	6.6%
ash	0.86%	0.75%
ethyl alcohol	0	1.1%
ascorbic acid	5.6 mg%	4.8 mg%

The "chal" contains Lactobacilli lactic; streptococci and yeast (Kieselev, 1956). "Chal" was successfully prepared by using cultures of Lactobacillus casei, Streptococcus thermophilus and lactose fermenting yeasts and incubating inoculated milk for 8 hours at 25°C and subsequently for 16 hours at 20°C. Holder pasteurization did not affect the quality of the milk, but pasteurization at 85°C for 5 minutes caused the milk to have a bad flavour. "Chal" made from pure cultures of Lactobacillus casei, Streptococcus thermophilus and species of Torula had markedly less non-fat solids and lactose than the milk from which it was made (Kuliev, 1959). It contained 0.05 to 1.2 percent of CO₂.

In Mongolia “Tarag” is a cultured milk product similar to yohurt, while “Unda” is a product produced by lactic and alcohol fermentation of camel and other animals' milk (Accolas *et al.*, 1975).

In the Ahaggar region of the Sahara milk is fermented in a manner similar to that mentioned above (Gast *et al.*, 1969). The animals are milked into special jars, made of Tamari wood, which can hold 2 to 3 litres of milk. The milk is mixed in the jars, and if not immediately drunk, it is stored in containers made of animal skin. In these skin containers the milk sours. The milk of the previous day is mixed with fresh milk until sour. There are great changes in the fat percentages of the milk products. As it is a practice to water the animals only once every 4 to 5 days, and as the lack of drinking water can cause a decrease in fat percentage (Yagil and Etzion, 1980) the fluctuating fat content is understandable. A lehben is also made by sweetening fresh milk (Gast *et al.*, 1969). If water is added to this mixture a longer storage time is achieved. This lehben can be kept for 5–6 days in the summer, and up to 10 days in the winter.

The methods of making butter and butter milk products can be summarized as follows (Gast *et al.*, 1969):

- fresh milk is poured into a goat skin and allowed to ferment for 12 to 24 hours at 25°C–30°C. Then fermented milk churned for 15–20 minutes at 12–18°C. Butter and butter-milk are obtained;
- butter is mixed with clarifying agent and heated at 100–120°C for 30 minutes so as to obtain preserved butter fat;
- butter-milk is used to make dried cheese, or to prepare soup, or after sauce or water has been added is consumed immediately.

The fermented milk is sometimes churned with a little water and is called “Mattha” (Aggarwala and Sharma, 1961). When more water is added and the butter is removed it is called “Lagsi”. These make pleasant and nutritious drinks in the heat of summer. The lactose is converted into lactic acid by bacteria and into alcohol by the yeasts. There is normally no alcohol in yoghurt because of the rapid development of the lactic acid forming bacteria, which depress the growth of the yeasts.

“Khoa” and other non-fermented whole milk products (Yasin and Wahid, 1959).

“Khoa” is made by evaporating small amounts of milk over a hot, steady fire. (Aggarwala and Sharma, 1961). The milk is continuously stirred to prevent scorching. At first the mass left over has a buttery consistency, but after cooling, it turns into a semi-solid dough with a sweet taste. “Khoa” can be kept for about 200 days. If sugar is added it keeps for longer periods.

“Rabbri” is also made by heating milk in a shallow iron pan over a hot fire. The difference

with "Khoa" is that the solids are removed successively from the thin layer of coagulated milk on the surface. Then the product is allowed to cool. When the milk reaches a fifth to an eighth of the original volume, it is removed from the fire. The mass is now gently mixed, without damaging the flakes that have formed. Sugar is added and it is then allowed to cool.

"Malai" is made by allowing large quantities of milk to simmer gently over a steady fire until a thick layer of milk fat and coagulated proteins forms on the surface. This is then removed and allowed to cool.

Butter and derived products

Some authors describe butter being made from camel milk (Shalash, 1979) while others categorically state that butter cannot be made from camel milk (Dickson, 1951). The preparation of butter from camel milk is not as easy as from milk of other animals owing to its unique milk-fat properties. The fat is distributed as small micelle-like globules in the milk (Dong-Wei, 1981); Yagil and Etzion, 1980). In addition, the fat is apparently bound to protein and there is a great difference in fatty acid composition. (Gast *et al.*, 1969). Samples of camel butter are characteristically rich in polyunsaturated fatty acids. There are only traces of fatty acids with chains shorter than C-12 lauric acid. The butter does contain normal amounts of C-16 palmitic acid, and has very high content of the polyunsaturated C-18 oleic and linoleic acids, when compared with butter obtained from milk of other animals (Gast *et al.*, 1969). The Turags' belief that camel milk is especially healthy for sick, young and old people probably because of its fat composition and vitamin content. Nevertheless, butter can be made from camel milk. Knoess observed that butter can be obtained after 15 to 20 minutes churning, whereas according to Shalash (1979) it can take up to about four hours. Butter can be made by churning fresh camel milk at 24–25°C in a special blender (Lakosa and Rakin, 1964). At lower temperatures the cream of the camel milk will not churn. Water content of butter was found to be about 13 percent and its acidity 3.3°T. Specific gravity was 0.923 and it melted at 44.5°C. This butter is used for cooking and is not eaten as butter *per se*. It is sometimes used by women as a cosmetic (Gast *et al.*, 1969).

In the Sahara, butter is made by placing camel milk into a thin, hairless, goat-skin for 12 hours. This skin is never washed with water. Inside the temperature rises to 28°C, a temperature very similar to that used in the blender (Lakosa and Rakin, 1964). In winter the goat-skin is often placed into the ground near a warm fire to obtain the optimum temperature before making butter. This aids in the fermentation. Churning is done when the container is half filled with sour milk. Air is blown into the container and the top is tied off. It is hung on a tent pole and rapidly swung to and fro. This is done in the early morning and the amount of butter obtained is determined by the skill of the man doing the churning. No churning is done during the day as solar heat apparently impedes proper separation. Some cold water is added into the goat-skin before the end of

churning. This aids in solidifying the butter. It is then placed in a wooden bowl or kettle. Fresh butter is not eaten, but is often used as a base for medicines. The fresh butter is difficult to preserve. It is not limpid and becomes rancid rapidly. Most of the butter is thus melted down to make Shmen or "Semma". The butter is melted at 100–120°C for 30 minutes. A clarifying agent is added to hot butter and it is stirred with a wooden spoon. This agent can be crushed dates or a grated, roasted piece of ram horn, or leaves of certain plants or seeds. Heating destroys the bacteria and the clarification agent collects the dirt and floats to the top, where it can be skimmed off. If dates are used as clarifying agent it is then given to children. If not, it is thrown away. The leaves give the specific colouring and aroma to the butter.

The Bedouin in the Sinai Peninsula place the camel milk that is left over in a big clay jar, were it allowed to partially ferment. Then they place the milk into a leather container and shake it for about 4 hours and subsequently extract butter. Milk from quite a few camels is normally required to obtain enough butter for the requirements of the herder families. Camel butter has a harder consistency than the butter of sheep milk. The butter has a greasy appearance and taste, so only little is eaten and it is used mainly for cooking.

Cheeses

Soft cheese can be made from camel milk. The fat is bound to the milk proteins and the casein is also different from that of other animals (Ottogalli and Resmini, 1976). The alpha and beta caseins were found to react much more slowly on electrophoresis. Nevertheless, several plants that make rennet coagulated cheese from camel milk exist in the USSR (Dilanyan, 1959; Mihaine, 1962). The Tourag nomads on the other hand say that cheeses cannot be made from camel milk, as it does not curdle, and so discussion on cheese making in the Sahara is restricted to cheeses made from milk of other animals (Gast *et al.*, 1969). However, cheeses can also be made by mixing camel milk with milk of other animals (Kheraskov, 1962; Rao *et al.*, 1970). The cheeses made are often spiced cheeses or made without salt or sugar. The difficulty in making cheeses in the Sahara most probably refers to the technique which is being used. This is apparent as the addition of the peptic enzyme, that is collected from rabbit stomach, or from the abomasum of young goats, to camel milk causes the formation of a coagulum. This coagulated mass is soft like cotton wool (Gast *et al.*, 1969).

As previously mentioned, in summer the lack of proper amenities in many countries to keep milk at low temperature does not allow for storing milk. The left-over camel milk is thus curdled and soured. Casein can be prepared from this milk and the product is known as "industrial casein" (Pant and Chandra, 1980), because the product is considered unfit for human consumption. It is used for making glue and gums. Whereas industrial casein and its fractions made from cow milk were found to be rich in crude proteins, the industrial casein and its fractions when made from camel milk are poor in crude proteins. Simple and effective methods were standardized for obtaining proteins

from milk whey. The proteins of camel milk whey have a relatively higher percentage of nitrogen than those obtained from the whey of cow milk (Pant and Chandra, 1980). The high percentage of proteins and the amino acid composition of camel milk industrial casein suggest that it could make a satisfactory dietary supplement to the human diet. The unpleasant odour and taste however, make it unsuitable for consumption by man or animals. It is thought that it would be possible to purify the camel industrial casein and so make it fit for human consumption.

The Bedouin of the Sinai Peninsula and the Tourag nomads (Gast *et al.*, 1969) make a dry cheese called "Afig". These are balls of cheese that are made from butter milk, after the butter has been made, as mentioned previously. The Afig cheese balls are placed on the sides of the tents to dry out. No other kinds of cheeses are made. The reason for this is said to be that the camel spoke to the Prophet Mohammed and it was agreed that no cheeses would be made from her milk and that her wool would not be dyed. Thus, there is a prohibition against making cheeses from camel milk, except following the making of butter.

By French standards the nutritional value of camel milk is considered to be the lowest after the ewe, goat and cow milk (Gast *et al.*, 1969). But it is also stated that 4–5 kg of milk and milk products are enough to cover all the requirements for a man so far as calories, lipids, proteins and calcium are concerned.

No mention is made of the fact that in times of drought the ewe, goat and cow have difficulty in surviving, while the camel goes on producing; in addition, the water in the milk is an invaluable source of liquid for man; yet the camel is neglected despite the fact that it is an invaluable source of food for man in arid and semi-arid areas. Better techniques, adapted to local conditions, are required to increase the quantity and improve the quality of products obtained from camel milk.

Butter milk that is left over following churning is also used to make soup (Gast *et al.*, 1969). Dates, pepper, water and other ingredients are added to make a tasty meal. This cold soup is prepared just before it is eaten and it is highly nutritious.

Miscellaneous uses of camel milk

Medicinal properties

In India camel milk is used therapeutically against dropsy, Jaundice, problems of the spleen, tuberculosis, asthma, anaemia, and piles (Rao *et al.*, 1970). The "chal" and other lung ailments (Gast *et al.*, 1963) has proven beneficial in the treatment of tuberculosis (Akundov *et al.*, 1972). A clinic has been established in which milk is used for treatment (Urazakov and Bainazarov, 1974). Patients with chronic hepatitis had improved liver function after being treated with camel milk (Sharmanov *et al.*, 1978). In fact, camel milk

was as effective as ass milk and superior to treatment with only medication or a diet consisting of cow milk proteins.

The camel milk works as a laxative on people unaccustomed to drinking this milk (Rao et al., 1970). Apparently stomach upsets only occur when the milk is drunk while still warm. When it is cool, no ill effects have been noted (Gast et al., 1969). The milk also apparently has slimming properties (Yasin and Wahid, 1957).

Camel milk is given to the sick, the elderly and the very young because of the belief that it is not only healthier, but works especially well in bone formation (Gast et al., 1969). The belief among the Bedouin of the Sinai Peninsula, is that any internal disease can be cured by drinking camel milk. The milk is said to be of such a strength, and to have such health-giving properties, that all the bacteria are driven from the body. This said to be true only for camels that eat certain shrubs and bushes. The shrubs and bushes are, themselves, used in the preparation of medicines. However, camels which eat straw are said to lose this ability.

Mystical properties

In Ethiopia camel milk is considered as having aphrodisiac powers (Rao et al., 1970). In Somalia, among the pastoral tribes, it is believed that milk drunk on the night when the camels first drink water, following a long period of thirst, has magical powers (Mares, 1954). "He who drinks milk on this night from a thirst-quenched camel will lose the thorns that have penetrated his feet, even from childhood".

In the Sahara there is a superstition that when camel milk is given to a certain guest, only the milk of one particular camel is given to him. (Gast et al., 1969). Therefore, if the guest casts an evil eye on the herd, only the camel, whose milk he has drunk, will be affected and will stop lactating.





V. REPRODUCTION

Although this report will not deal in depth with camel fertility, the reproductive characteristics of both male and female camels must be examined before the importance of camel milk for human nutrition in drought areas can fully be assessed. It is often stated that the most negative argument against camel breeding is their slow and uncertain reproductive rate (Novoa, 1970). In some areas camel breeding is even considered to be too hazardous to be undertaken systematically (Gast *et al.*, 1969).

Puberty

The camels are sexually mature at 4 to 5 years of age (Evans and Powys, 1979; Mares, 1954; Yasin and Wahid, 1957), although a 3-year old camel can be used for reproduction (Leonard, 1894; Novoa, 1970; Williamson and Payne, 1959). In the male, full reproductive prowess is not developed until six years (Novoa, 1970) or even seven years (Hartley, 1979) of age. Domesticated vicugnas could reproduce at one year of age (Romero, 1927), but the fertility of both males and females at this age was low (Koford, 1957). Alpacas and vicugnas are not normally bred until they are at least two years old (Novoa, 1970).

Breeding season

Aristotle reported that breeding time of camels is in November and December (Leonard, 1894). However, camels, both male and female, are seasonal breeders (Yasin and Wahid, 1957), mating during the rainy, or cold season (Yagil and Etzion, 1980). Longer hours of daylight initiate the breeding season (Chen and Yuang, 1979). Must (1969) described an all-year-round oestrus in the female camel, but this was not found in any other publication.

The pattern of the reproductive cycle appears to relate to the harsh environment in which the camels live (Novoa, 1970). The calves are born in the months most suitable to guarantee their survival. The breeding season differs in various countries. In the region of Pakistan (Yasin and Wahid, 1957), China (Chen and Yuan, 1979), Egypt (Shalash, 1965) and Israel (Yagil and Etzion, 1980), the breeding season is from December to April. This is the period in which both males and females are fertile. In Somalia the male camel ruts in the spring from April to May, (Mares, 1954). In India the breeding period is from November to February (Singh and Prakash, 1964). In Morocco the rutting season occurs in winter and spring. Both rutting season and consequent births coincide with adequate water and feed supplies. In Russia the domesticated Bactrian was found to be polyoestrous, having oestrus cycles all the year round (Bosaev, 1938). The wild camel in the Gobi desert, however was a seasonal breeder (Bannikov, 1945). The rut occurring between January and February. In the Sudan, Musa and Abusinea (1978) report the season as being from March to August.

Oestrus cycle and ovulation

As previously mentioned, the female camel is a seasonal polyoestrous animal. The period of oestrus is easily recognizable by the animal's general restlessness, often aggressiveness in manner, and by swelling and discharge from the vulva (Yasin and Wahid, 1957; Yagil and Etzion, 1980). The length of the oestrus

cycle is normally 2–3 weeks (Bodenheimer, 1954; Leonard, 1894), although in the Bactrian camel the period can extend to 30–40 days (Bosaev, 1938). The actual heat lasts for 3–4 days (Bodenheimer, 1954; Leonard, 1894), although 21 days was considered by Yasin and Wahid (1957) as being the period of heat.

Ovarian cycle activity was fully described by Musa (1979). He reports a 28-day cycles in which follicles mature in 6 days maintaining their size for 13 days, then regress in 8 days. There is no spontaneous ovulation in the camel (Chen and Yuan, 1979; Musa, 1979; Shalash, 1965), so that without mating there is no luteal phase. Manual stimulation of the cervix for 15 minutes did not induce ovulation, although luteinization of the mature Graafian follicle occurred (Musa and Abusina, 1978). Ovulation occurs 30–48 hours following copulation (Chen and Yuan, 1979). Shalash (1965) stated that without pregnancy there is no formation of a corpus luteum. The size of the corpus luteum depends on the ovarian activity (Musa and Abusinea, 1978). The corpus luteum was larger and lasted longer when mating occurred at the time of maximum follicular development. When mating took place later, the corpus luteum was smaller and disappeared in a short period of time. In Beersheva (Israel) research was carried out using radio-immuno assay of sexual hormones in the blood of the female. There was an increase in oestradiol activity from the beginning of December which ended toward the beginning of April. Surprisingly enough, there were also peaks of progesterone activity, although no male was present. The peaks in hormone activity were 23 days apart. From the middle of January there were peaks of oestradiol accompanied by peaks of progesterone 2 days later, every 7 days. Twenty-four to 48 hours following mating, the luteinizing hormone (LH) appeared. The LH then declined steadily for 6 days and a second period peak even greater than the first, was found almost two weeks later. At that time, the progesterone levels were extremely high. The oestrogen levels were low, but both hormones showed peaks in activity every 4 days. LH activity was non-existent. These 4-day fluctuations continued almost right through the pregnancy. While undertaking physiological research on body fluids and renal function, two camels aborted. In these camels the hormone activity declined to base-line levels.

Oestrus has been known to re-occur a day after calving (Barmicev, 1939). If the camel is well fed, oestrus can occur within one month post partum (Mares, 1954; Yasin and Wahid, 1957). If the camel has no milk, then oestrus occurs within 28 days (Evans and Powys, 1979). This means that with good feeding conditions camels can be mated as soon as the young calves start grazing.

The Lama pacos have prolonged periods of oestrus interrupted by short periods of an oestrus (San Martin, 1961). Ovulation occurs 26 hours after copulation. Injections of HCG lead to ovulation 24 hours later.

Sexual cycle of the male camel

The male camel is a seasonal breeder, the season corresponding with that of the female (El Amin, 1979; Yagil and Etzion, 1980). The male undergoes behavioral and hormonal changes during the rutting season (Chen and Yung, 1979; Yagil and Etzion, 1980).

The male is normally docile and easily controlled, however, in the rutting season he can become so aggressive that he is dangerous and cannot be handled. He is extremely restless. He blows a balloon-like flap out of the side of his mouth which is called a palatal flap (Charnot, 1963; Yagil and Etzion, 1981) (Photo 5). Its appearance is accompanied by a roaring-gurgling sound. The lips are often covered with saliva. The glands between the ears secrete a dark, bad-smelling, watery secretion. This area is constantly rubbed against all objects in the surroundings, including grass mounds. The back legs are spread, and the tail is then beaten against the penis. Drops of urine are deposited on the tail and spread over the back. Eventually, the hindquarters have a strong urine odor.

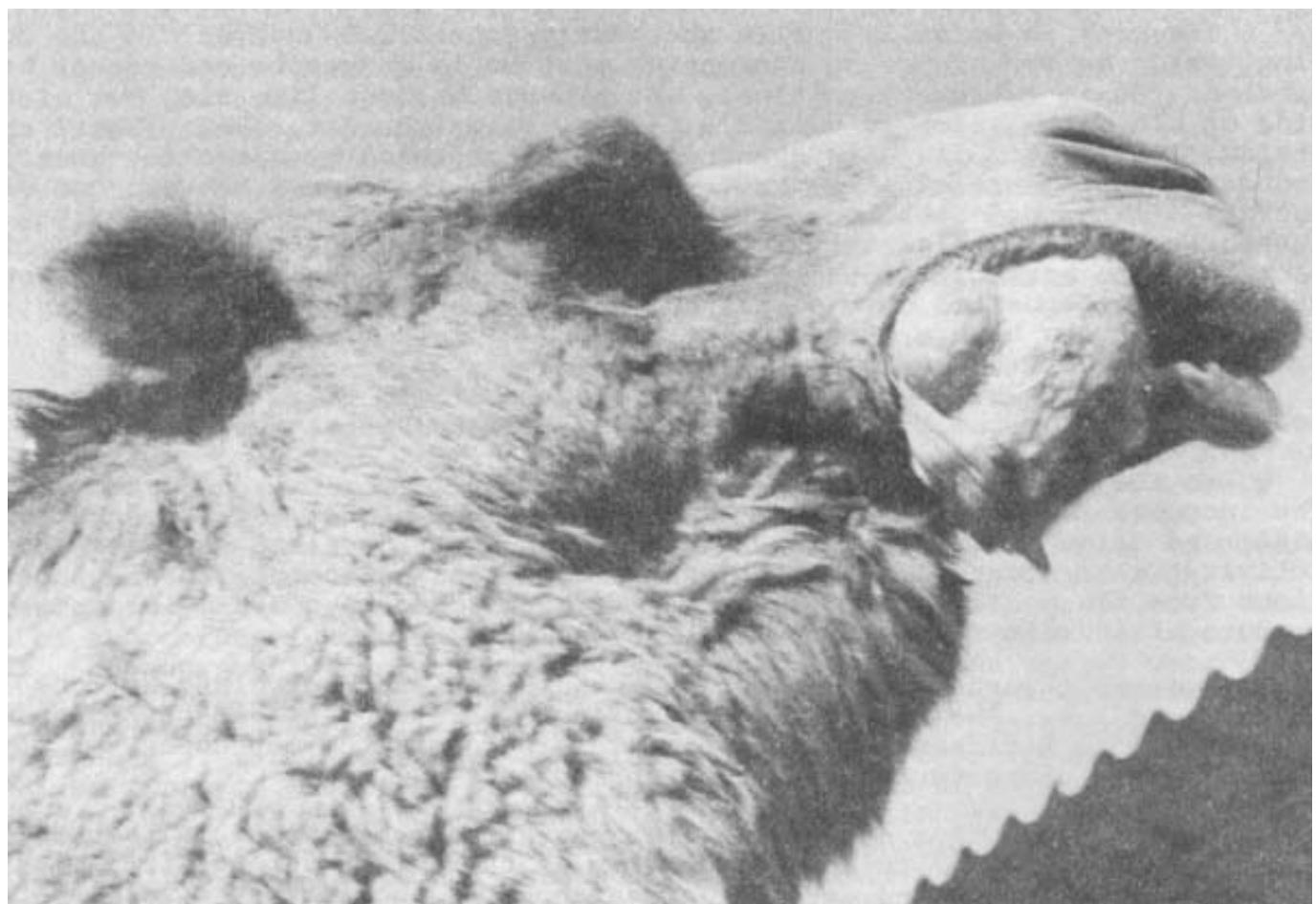
The rutting males readily attack each other and timid males soon learn to keep away from the territory staked out by more aggressive males.

In the rutting periods there was increased secretion of androgens. The increase in hormone secretion was found in the blood (Yagil and Etzion, 1980) and urine (Charnot, 1958). Adenohypophysis (increased neurosecretory activity) also occurred (Charnot and Racadot, 1963; Santini, 1964). Secretions from the neck, poll and glands were also found to contain large amounts of androgens (Yagil and Etzion, 1980).

There were no changes in behaviour when the blood and neck gland hormone levels were low. The female camel also has a palatal flap and neck glands (Leese, 1927), but these are dormant. This suggests the dependency of secondary sex characteristics on the androgens.

Male alpacas have no changes in appearance or behaviour in the breeding season (Novoa, 1970). This is surprising as there is a strong similarity between the behaviour and external appearances of the rutting camel and the in-musth Asiatic elephant (Jairudeen, *et al.*, 1972). The latter also becomes extremely aggressive, secretes from the head glands, plays with his penis and urinates onto the ground.

The male camel can mate at 3 years of age, but the optimal age to begin is between 4–5 years (Hartley, 1979; Mares, 1954; Yasin and Wahid, 1957). At 6 years of age they are in full reproductive vigour. The best males are selected for breeding: the rest are castrated or used as baggage camels (Mares, 1954). The male can breed for 7 years (Hartley, 1979). The male dromedary can mate with 50 to 80 females a season, when he is in good condition (Leese, 1927; Yasin and Wahid, 1957). The Bactrian male mates with 10 females per season (Terentjev, 1951).



Male camel in rut - palatal flap
Photo 5

Breeding habits

In Somalia the calving interval is 24 months. As a female can live up to 30 years, she can produce about 8 calves in a life-time (Yasin and Wahid, 1957). With good feed and management the inter-calving time can be reduced to one every two years (Evans and Powys, 1979). This would mean two calves every 4 years and a total of 13 calves in a lifetime. Even two calves in 2 ½ years can be attained and this would greatly improve the fertility of these animals.

At 4 or 4 ½ years of age the animals are first used for breeding (Hartley, 1979). The best male is chosen on the basis of his vigour and judged by the performance of his parents. The females should also be culled for defects, such as slow breeding, poor milk yield, bad mothering and weak offspring (Hartley, 1979). Herds are normally too few in number, for culling to be undertaken and all females are mated.

Copulation

There are many reports concerning the copulation of camels. These vary from being rarely observed (Mares, 1954) to the act being screened from humans by other members of the herd (Yasin and Wahid, 1957). The author has not only watched a male serving various females in a herd, but has assisted him in the act. If not aided, courting and mating can be very violent. If the male selects a female and she is not willing to go down quietly when he approaches her, he will bite at her neck and eventually roughly force her to the ground. There the female utters her guttural protest, while the male first straddles her and then gently slides down until he is squatting on his back legs (Photo 6). Copulation lasts for about 15 minutes. This is accompanied by much gurgling and grunting. The male pushes forward continuously with many pelvic thrusts. The male gives about 7 ml of semen with an average of 615 million sperm per mm (Chen and Yuang, 1979).

Pregnancy diagnosis

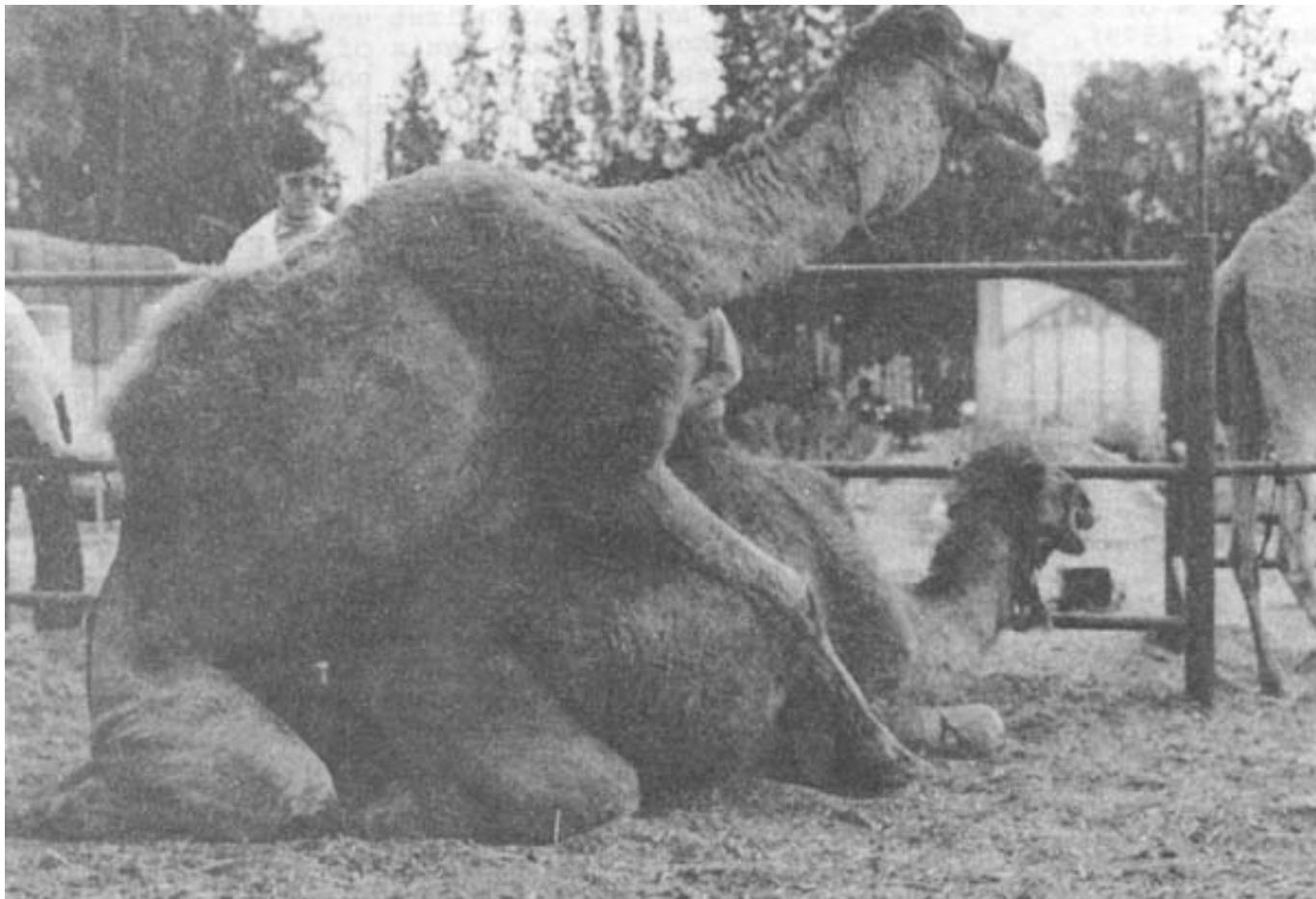
In order to improve the efficiency and increase the economical viability of camel breeding, it is important to know if and when the females are pregnant. This can be done by rectal palpation (Chen and Yuang, 1979; Musa, 1979) and by biological assay using infantile mice (Musa, 1979). The latter method is only feasible at certain stages of pregnancy. The surest method is by radio-immuno assay. Pregnancy determination is important in the care of the females, the selection of males and in long-term planning.

Gestation

Yasin and Wahid, (1957) report a gestation of 365 to 395 days whereas Evans and Powys (1979) record a gestation period of 373 to 393 days. The gestation period of the Bactrian camel is 402 days (Chen and Yuang, 1979).

Calving

Signs of approaching parturition are restlessness and leaving the herd (Chen and Yuang, 1979), if in a paddock, the pregnant camel pushes against the railings and gazes off into the distance. In the first stage of parturition the cervix gradually relaxes, the forefeet of the calf, with the amnion, are forced into the vagina. In the second stage the animal increases straining. The feet become visible, still enclosed in the amnion. The head then appears and the rest of the body quickly follows. The first two stages average 27–30 minutes. In the third stage the placenta is expelled. This



Copulation of camels
Photo 6

takes about 50 minutes, but can take much longer. The calves stand within 20 minutes of birth and in a short while start suckling.

Fertilization rate and infertility

The fertilization rate of camels is considered very low (Novoa, 1970). Fifty percent fertility, or even less, has been recorded (Keikin, 1976; Yuzlikaev and Akhmedier, 1965). Repeated matings were often due to improper development of follicles (Barmintsev, 1951). Injections of Pregnant Mare Serum Gonadotropin (PMSG) with an interval of 48–72 hours led to 100 percent calving rate (Yuzlikaev and Akhmediev, 1965). Anatomical abnormalities of the females are the main causes of infertility (Shalash and Nawito, 1963). Another cause of infertility is foetal death (Shalash, 1965; Tayeb, 1953). This was suspected when a single foetus was born, but more than one corpus luteum was found.

Infertility and slow breeding habits of the camel can be associated with poor feeding and management. Better selection, disease control, and improved husbandry could not only improve the standard of milk production, but could shorten the time for first calving, intercalving intervals and quality of the herds in general.



VI. CAMEL PRODUCTS OTHER THAN MILK

In order to produce milk, the female must be successfully mated and a calf must be born alive. The young calves can be a source of meat, especially those young males which are considered unsuitable for breeding. Old males and unproductive females are also a source of meat. Wool is produced as a natural insulation against the cold, being discarded in the heat, and hides can be tanned.

Meat

Camel meat is not universally eaten. In the pastoral communities camel meat is only eaten on special occasions. These include festive gatherings following the return of the herd from grazing (Hartley, 1979), and ritual celebrations (Dahl and Hjört, 1979; Dickson, 1951). In some cases animals belonging to a certain tribe will not normally be slaughtered as they have been named and are considered to be an integral part of the tribe (Gast, *et al.*, 1969). This does not prevent people from such tribes from stealing and eating camels from neighbouring tribes.

The camel is a good source of meat in areas where the climate adversely affects other animals. The male dromedary carcass can weigh 400 kg or more (Knoess, 1977). The carcass of a male Bactrian can weigh up to 650 kg. The carcass of a female camel weighs between 250 and 350 kg.

Data collected from a herd numbering about 4 300 animals showed that the body weight of slaughtered animals averaged between 439–484 kg (Keikin, 1976). This was more than the weight of 400 kg previously given (Knoess, 1977). The total meat production of the herd was 530–650 metric tons. It is obvious that the meat yields depends on the age, sex, feeding condition and general health of the animal (El-Amin, 1979). Not only the yield, but also the taste of the meat is determined by these parameters. Camel meat tastes like coarse beef (Cloudley-Thompson, 1969; Dickson, 1951). In old animals the meat is tough and not tasty (El-Amin, 1979). The cut of meat also determines its tenderness (Abdal-Baki, *et al.*, 1957), the hump being considered a delicacy (Dickson, 1951). It is eaten raw, while still warm, but after it cools down it is boiled before it is eaten (Hartley, 1979). The hump, together with the fat of the prenephric and premesenteric areas are an important supplement to the human diet. As the animals get older, so the moisture and ash content of the hump fat and around the kidneys increases, while the

crude fat content decreases (Shalash, 1979). It was found that there was more crude fat in the fat tissue around the kidneys than in the hump. The brisket, ribs and loin are other preferred parts of the carcass (Hartley, 1979).

The dressing percentage of the carcass varies between 52 percent and 77 percent; the fat between 0 and 4.8 percent; and the bones between 15.9 and 38.1 percent (Shalash, 1979; Kutznekov, *et al.*, 1972). There is a difference in the percentages of protein, water, fat and ash of meat from various parts of the body (Shalash, 1979). The age of the animal also affects the components of the meat. Camels younger than 5 years have less protein, fat and ash than older camels. Nevertheless, these relatively small amounts of protein are comparable with the protein content of beef whether it is from bull, cow, or steer. The fat and ash content of camel meat is lower than that of beef.

Meat of the llama, alpaca and guanaco is of high quality and is a highly prized commodity (Bustinza, 1979). Meat production by far surpasses the utilization of milk of these animals. The meat is high in protein and low in fat, as in the case of old-world camels (Parades and Bustinza, 1978).

Sadek (1966) showed that the use of camel meat for sausage making eliminated its toughness. The meat is easily cured, and the high protein content provides good caloric value. They are also cheaper than sausages made from other meat. Camel meat can be preserved by cutting it into strips and allowing it to dry. It is then preserved by putting the dried strips in clarified butter fat (Hartley, 1979).

In northern Kenya camel blood is consumed as it supplies necessary iron, salts and other essential nutrients (Dahl and Hjörts, 1979). The high vitamin D content of camel blood is invaluable in aiding bone formation (Shany *et al.*, 1978).

At present, more camels are being slaughtered in those areas where there is less output from other livestock to guarantee dietary protein intake (Wilson, 1978). As pastoral societies disappear with the conversion of the nomad to a sedentary way of life, the camels are being sold and slaughtered (Gohl, 1979). In Libya there is a brisk meat market (Bulliet, 1975). In Sudan, although there are legal restrictions concerning camel meat, there is a large export market to Egypt (Asad, 1970). Camel meat from Sudan is also exported to Libya and Saudi Arabia (El-Amin, 1979). In Egypt camel meat makes up an important part of the dietary proteins especially for the lower income groups (Shalash, 1979).

Hair and wool

Camelidae living in the high-altitude regions of Peru, Bolivia and Argentine have wool of excellent quality (Bustinza, 1979). The wool of the vicugna is especially highly prized. This wild species, living in the high Andes, has very short wool, 2 to 3 cm long with an

average yield of only 150 gr per animal. The fine internal fibres are brown-yellow, and the coarser external fibers are brick red giving an overall red appearance. The vicugna also has a large hank of fibres growing on the chest which are longer and stronger than the fibres on the rest of the body. These chestfibres are light-yellow to white in colour. The ponchos and shawls made from vicugna wool are highly prized and very costly.

The guanaco is found in the valleys of Patagonia. The body is covered with two types of wool; very fine internal fibres which are light brown, and coarser and longer external fibres which are red-brown in colour. The head is covered with short black hair. The young have an especially fine pelt.

The llama also lives in the heights of the Andes. These animals give about 2 kg of wool per animal per year. The fibre is long and coarse. It has a variety of colours, black, brown and white, often all appearing on one animal. The wool is used for making string bags or sacks, blankets and clothing.

The alpaca is an animal of great economic importance. The wool is an important item of this animal. There are two types of alpacas, the Huacaya and the Suri which are easily differentiated by their wool. The wool fibres of the Huacaya are rough with a well-defined crimp. This wool is very similar to sheep wool and is easy to dye. The wool grows perpendicular to the body and forms compact staples. The wool of the Suri, on the other hand, is completely different and is of coarser quality. The fibres are shiny and smooth and have no crimp formation. The wool is not easily dyed. The wool grows parallel to the body, forming lank, round staples that fall from the body leaving a line down the middle of the back.

Much research has been done concerning the fibres of the various animals. This has been well presented by Bustinza (1979). The fibres are affected by age and sex as well as by nutrition and diseases.

The production of wool and hair of adult animals ranges between 1 kg (El-Amin, 1979) and to 5 kg (Keikin, 1976). The wool and hair of the oldworld camels is of lesser quality and value than that of the new-world camels. The Bactrian gives more wool than the dromedary and its wool is also of a higher quality (Dong Wei, 1979). Wool is shed at the end of winter, and if not gathered, the animal rubs itself against trees and bushes until the wool is discarded. In China about 1 500 tons of wool are collected per year. This wool is used for making padded cloth, quilts and mattresses. In addition to the wool, there is long hair that can also be sheared. This is used for making rope. The hair from the dromedary is used for making clothes, tents, carpets (Cloudley-Thompson, 1965), robes, saddle-girths and blankets (El-Amin, 1979).

Skins

Camel hides are used for making shoes and sandals. The hide of the dromedary is not good quality, and is mainly used for making whips and saddles (El-Amin, 1979). Hide is used to make a gourdlike container for water and milk. The skin of the vicugna is highly prized and can bring in US\$ 1 000 per skin (Bustinza, 1979). The guanaco has a skin of good quality and, among other things, is used for making bed covers, coats and mantels. Llama hide is used for making shoes, sandals and bags.

The meat, skins and furs of the new-world camels are thus far more important for man than the milk and haulage ability of the old-world camels. Nevertheless, the food producing characteristics of the desert-living camel, in respect of both milk and meat, are complemented by accompanying yields of wool, hides, skins and bones, which all help to provide man with clothing, shelter and other useful products. When breeding for the ideal milk producer, the meat, as provided by the calves, and the wool can supplement local industry. As with beef, the most economical age for slaughter, and the age of the animal having the best-tasting meat must be determined. This will quickly reverse the misconceptions regarding camel meat which are mainly due to the slaughter of aged animals that have outgrown their usefulness.





VII. FEED AND DIGESTION

The yield and quality of milk produced by an animal depend on the composition of the feed available, including liquids. The lactating camel in an arid area must not only overcome the shortage of drinking water, but also the shortage of forage. The fodder that is available can also affect the composition and taste of the milk. When camels subsist mainly on *Atriplex*, the milk acquires a salty taste, while feeding on *Schowia purpurea* gives the milk an odour similar to that of cabbage (Gast, *et al.*, 1969). Fodder composition also directly affects the fat and protein content of the milk. The availability of drinking water was shown to have a direct affect on milk fat content, with limited drinking water causing a decrease in milk fat and protein content (Yagil and Etzion, 1980a).

One of the most advantageous attributes of the camel in drought areas is its ability to utilize plants that grow well under arid conditions and are in the main unacceptable to other grazing animals (Knoess, 1977; Sharma and Bhargava, 1963; Williamson and Payne, 1965). Examples of such plants are the camel thorn, Acacia and salt bushes (Newman, 1979). The utilization of available fodder is also much higher in the camel than in any other domestic animal in the same areas (Farid, *et al.*, 1979). The camel's ability to utilize the scanty fodder resources of the arid zones of the world for body maintenance, growth and production makes this animal a potentially important source of food. An understanding of the anatomy and physiology of the digestive tract and of feed utilization is therefore, important before consideration is given to the value of these animals as a source of human nutrition.

The digestive tract

Although camels ruminate they are not true ruminants, as they lack the four well-defined stomachs of the ruminants; the rumen, reticulum, omasum and abomasum. The anatomy of all members of the Camelidae is considered to be similar but most of the available data on the anatomy of the alimentary canal have been obtained mainly from the llama.

Lesbre (1903) and Leese (1927) stated that the camel has only three stomachs, compared with the bovine's four compartments (Phillipson, 1979) a.i. the missing compartment being the omasum, or third stomach. Hegazi (1950) describes the camel as having the same four compartments as other ruminants, but with the external constrictions between the omasum and abomasum being less well defined in the camel.

Vallenás, *et al.*, (1972), state that the llama and guagnaco stomachs consist of only three compartments. The anatomy of the stomachs will be discussed in detail later.

The salivary glands of the camel have the same grouping as in cattle, but are slightly darker in colour (Leese, 1927). The arrangement of the glands, however, is different. The parotid glands are in the same position in camels as in cattle, but in camels the maxillary gland is located under the parotid gland and jugular vein and over the pharyngeal lymph glands (Leese, 1927). The gland does not extend under the throat as it does in cattle. The sublingual glands are smaller than those of cattle and are situated along the root of the tongue. The buccal glands are well developed, and have dorsal and ventral portions.

When comparing the mouth of the camel with that of cattle, the outstanding differences are the very supple lips of the camel, the long prominent papillae, and canine teeth.

Much has been written about the internal anatomy of the camel stomachs. The stories of camels being slaughtered for water in the stomach (Bohlken, 1960) led to the belief that the rumen, contained water cells (Leese, 1927). It was assumed that these water cells were able to store water (Colbert, 1955; Hegazi, 1955; Leese, 1927). This theory was disputed by Schmidt-Nielse, *et al.* (1956). The saclike compartments are found in the caudal part of the first compartment, the rumen (Vallenás, *et al.*, 1972). It has been suggested that the main function of this glandular region of the fore-stomach is the rapid absorption of solutes and water (Engelhardt and Rubsamen, 1979).

The suggestion that the glandular areas of the rumen are accessory salivary glands (Schmidt-Nielsen, *et al.*, 1964) has not been substantiated. The mucous layer which covers the surface epithelium may have a mainly protective function (Bubsamen and Engelhardt, 1979). The bicarbonate secretion of these glands (Eckerlin and Stevens, 1972) was not substantiated in later experiments (Rubsamen and Engelhardt, 1978).

The oesophagus enters the rumen (Vallenás, *et al.*, 1972). This compartment is divided by a transverse muscle pillar into a cranial and caudal sac. The second compartment, the reticulum is small and only partially separated from the first compartment. The reticulum is separated from the third compartment by a tubular sphincter. The third compartment is an elongated tubiform organ, slightly dilated at its proximal end where it enters the fourth chamber, which its fundic and pyloric glands. The mucous membrane of the third compartment contains long folds and no laminae, as found in the typical bovine omasum (Bohlken, 1960). The fourth compartment, the abomasum, is small. In adult animals no folds are found (Bohlken, 1960).

The surface of most of the first and second compartments is lined with a non-papillated stratified, squamous epithelium (Vallenás, *et al.*, 1972). Glandular epithelia can be found in the ventral portions of the first two compartments and covering all of the third compartment. The glandular area in the first compartment is restricted to the bottom of

the saccules, and this may be the reason for this area being smaller in camels than in llamas. In addition, the pouches in the camel's rumen are smaller than those in the llamas.

In the adult llama the contents of the first two compartments account for 10–15 percent of the animal's body weight, and the third compartment for a further 1–2 percent. It is therefore clear that the intestines must contain at least an additional 5 percent of the body weight. Then the total contents of the camel's alimentary canal will account for 25 percent or more of the animal's body weight. The liquid contents in the alimentary canal is the source of water for the thirsty camel (Yagil and Etzion, 1979).

The function of the numerous endocrine cells in the stomach wall (Engelhardt and Rubsamen, 1979) is unknown but it is possible that these cells play an important role in the control of the water and electrolyte balance of the camel during dehydration (Yagil and Etzion, 1979).

From the anatomical differences between the Camelidae and Bovidae it was hypothesized that the physiological processes in the alimentary canal would also differ (Bohlken, 1960). This is further emphasized by the difference in rumen protozoal population between the camel and the sheep (Farid, *et al.*, 1979). Entodinium comprises 70 percent of the rumen protozoal population in both animals, while Holotricha accounts for 10 percent of the population in sheep, but was absent in camels.

Epidinium is present in camels, but absent in sheep rumen. The interesting fact was that during water restriction the Entodinium population and total protozoal count decreased in sheep, but in camels the Entodinium population increased and the total count remained virtually unchanged.

Physiology of the digestive tract

The extremely mobile lips of the camel and the tough mucosa of the mouth enable the animals to graze thorn bushes. The branches are stripped of their leaves and the thorns present no problem.

In the mouth the feed is mixed with saliva. The size and structure of the salivary glands and the composition and flow of saliva from the glands, are all comparable with what is found in cattle (Engelhardt and Rubsamen, 1979). Camel saliva is slightly hypotonic and the bicarbonate content is high (Engelhardt and Rubsamen, 1979). When the animal is dehydrated a quarter of body weight is lost. The parotid gland secretions then decline to a fifth of the normal flow (Hoppe, *et al.*, 1974). In the camel, as in all ruminants, the urea formed from the protein metabolism is recycled to the stomach via the saliva. In addition, the camel also obtains urea via the rumen epithelium itself (Houpt and Houpt, 1968; Nolan and Leng, 1972). The urea nitrogen is important as it is assimilated into microbial

protein which is a source of protein for the animal following hydrolysis in the small intestines (Emmanuel, 1979).

Camel saliva was collected by allowing the animals to chew a clean dry sponge and then examined for amylase content (Nasr, 1959). It was found that the saliva has less amylase than that of man, pig or rat. This, however, is different from cattle saliva which has no amylase (Schwartz and Steinmetzer, 1924) whereas it is present in buffalo saliva (Nasr, 1959). Of all the glands, the parotid glands have the most amylolytic activity, the submaxillary glands the least and the sublingual glands none being mucous glands.

The contractions of the first and second compartments begin with a contraction of the second compartment (Engelhardt and Rubsamen, 1979). This is similar to the relationship of reticulum and rumen in cattle. In camels the contents of the dorsal portion of the rumen are relatively dry. The ventral portion of the cranial and glandular sacs in the reticulum, contain semifluid and watery ingesta (Ehrlein and Engelhardt, 1968; Ehrlein and Engelhardt, 1971; Vallenás and Stevens, 1972).

Following the first, single contraction of the reticulum there is an immediate contraction of the caudo-ventral region of the rumen and the glandular sacs (Engelhardt and Rubsamen, 1979). The caudo-dorsal rumen contracts, followed by the cranial sacs. This first set of contractions is followed by additional contractions. The duration of a cycle is 1–2 minutes in the resting llama. The rate increases when the animal feeds. The contractions and movements of each cycle begins with a contraction of the reticulum. During contraction of this compartment contents are moved from the reticulum to the caudal sac of the rumen. From here part of the contents re-enter the reticulum and part goes into the cranial sac, when the caudal sac contracts. When the cranial sac contracts, its contents move back into the caudal sac (Ehrlein and Engelhardt, 1968). The motility of camel's fore-stomach is radically different from that of cattle.

The contents of the third compartment, the omasum, are fairly dry. This strongly suggests a significant absorption of water (Engelhardt, Ali and Wipper, 1979) although water is also squeezed into the abomasum when the omasum contracts. Stomach contents enter the third compartment, when the canal between this compartment and the first compartments, dilates. This occurs when there is a maximum contraction of the reticulum. At this stage the proximal portion of the canal contracts, while the distal part dilates. The whole canal contracts, pushing the contents through to the third compartment. As water is absorbed in this compartment, it functions in a manner similar to the bovine omasum (Ehrlein and Hill, 1969; Stevens, *et al.*, 1960). In the third compartment weak circular contractions occur in the proximal portion with pronounced contractions in the distal portion (Ehrlein and Engelhardt, 1971).

Rumination and eructation occur three to four times during every cycle (Ehrlein and Engelhardt, 1971; Engelhardt and Rubsamen, 1979). Rumination begins after the

maximal contraction of the cranial rumen sac. Eruption takes place near the peak of the caudal sac contraction.

In the camel's fore-stomachs the volatile fatty acids (VFA) produced are efficiently neutralized, probably by the glandular secretions (Vallanas and Stevens, 1972). A high concentration of VFA is found in the Camelidae rumen (Maloiy, 1972; Vallanas and Stevens, 1972; Williams, 1963). The various proportions of VFA are similar to those found in the rumen of cattle (Maloiy, 1972). This suggests a great similarity in metabolism in the forestomachs of camels as compared with other ruminants. Motility studies, however, indicate that there is no precise similarity between the species (Vallanas and Stevens, 1972) and was verified in comparison studies between the camel and the Zebu (Maloiy, 1972). It was found that the camel has a lower digestive efficiency of low quality hay, assumed to be caused by a more rapid passage of food through the stomachs. Camels fed on straw (Yagil and Etzion, 1980), however, not only grow better but digest the food better than milch cows (Personal observation). Digestibility of medium quality hay was no different in the llama and in sheep (Engelhardt and Schneider, 1977). In the digestive studies the most important finding was that the fluid volume of the fore-stomach and the rate of outflow of fluid from the stomachs to the intestines was far greater in the camel than in the Zebu (Maloiy, 1972). Water-deprived sheep lost far more rumen water than camels (Farid, *et al.*, 1979). Water dynamics in the alimentary canal of the camel allow it to survive and produce during dry periods. The alimentary water provides a reservoir that is tapped slowly in order to maintain a relatively unchanged extracellular volume and provides the fluid which dilutes the milk. (Yagil and Etzion, 1979; Yagil and Etzion, 1980a and b). The anatomical differences between camels and other ruminants could account for the much slower water turnover in the camel (Macfarlane, 1977).

Sodium chloride, and VFA were found to be rapidly absorbed from the rumen of the llama (Engelhardt and Sallman, 1972; Rubsamen and Engelhardt, 1979). The absorption rates in the llama were three times greater than the absorption in sheep and goats. Absorption occurs mainly in glandular areas of the fore-stomach. In the third compartment solubles and water are absorbed (Engelhardt, Ali and Wipper, 1979). The absorption rates of sodium, VFA and water in this tubiform compartment were found to be far greater than the absorption rate in the omasum of sheep and goats.

The pH is very low in the abomasum (Engelhardt, Ali and Wipper, 1979). An estimated secretion of water occurs reaching 15 percent of the amount that was absorbed in the omasum.

Comparative experiments carried out at the Desert Research Institute in Egypt (Farid, *et al.*, 1979) showed that the camel managed far better than sheep on a low-protein, roughage diet and restricted drinking water regimen. The sheep were allowed to drink every three days, the camels every twelve days. The camels needed less water than the

sheep for every unit of dry matter consumed or per unit body mass. The camels also had a lower water intake than Zebu cattle (Maloiy, 1972). During deprivation studies, camels lost far less water in urine and feces than did sheep (Farid, *et al.*, 1979). The camels digested dry matter and crude fibers better than the sheep. The sheep, however, utilized crude protein better than the camels. The sheep increased their feed intake during dehydration. The nitrogen metabolism of the camel was superior, and this was even more apparent during water restriction owing to the reduced nitrogen excretion in both faeces and urine. The sheep were only able to reduce the nitrogen excretion in urine. The endocrine cells and secretory cells in the rumen of the camel could account for the added nitrogen retention capabilities (Engelhardt and Rubsamen, 1979). These data also reinforce the theory of endocrine control of the alimentary canal, kidneys and mammary glands affecting the water, salt and nitrogen metabolism (Yagil and Etzion, 1979; Yagil and Etzion, 1980a and b), the ADH being responsible for the flux of water and urea-nitrogen, the aldosterone for the flux of sodium. The decline of nitrogen in both faeces and urine and the renal loss of sodium allow the camel to maintain a relatively unchanged extracellular volume. The flow of water in the same direction with the urea-nitrogen accounts for the lower amount of faecal and urinary water in the camel, when compared to the Zebu steer (Maloiy, 1972) or sheep (Farid, *et al.*, 1979). The camel has thus a far more efficient nitrogen conservation mechanism than other ruminants (Emmanuel, 1979). Even on a low-protein diet, nitrogen fixation in the rumen and constant recycling of urea contribute significantly to a steady protein synthesis. Twelve days of dehydration in the camel were equal to two days of dehydration in sheep, as far as recycling of urea was concerned (Farid, *et al.*, 1979). The most pertinent result of the experiment was that the sheep did not survive the experiments while the camels were unaffected.

Another important difference with other ruminants is that camels have a significantly higher blood glucose level (Emmanuel, 1979; Yagil and Berlyne, 1977). This may be caused, in part, to the anatomical differences in alimentary canals (Engelhardt and Rubsamen, 1979), although VFA production was high in the camel's fore-stomachs (Engelhardt and Rubsamen, 1979; Maloiy, 1972). Other metabolic factors may play a role in the glucose handling by the camel as well as the hygroscopic properties of glucose may play a significant role as was demonstrated in glucose-loading trials (Yagil and Berlyne, 1977).

Salt makes up a very important part of the camel's diet (Hartley, 1979). Nomadic tribes are especially careful to ensure that the camel obtains sufficient salty plants to eat. Salt is an important factor in the passage of water and urea in the gut and the kidneys (Yagil and Etzion, 1979). Inadequate salt diet will lead to less milk production in camels (Hjort and Dahl, 1979; Mares, 1954) which becomes even more important when drinking water is restricted (Yagil and Etzion, 1980).

Feeding habits

The camel covers large areas while browsing and grazing, and is continually on the move, even if food is plentiful. Distance of 50–70 kilometers a day can be covered (Newman, 1979). Camels in the Horn of Africa still range for their food even though they are brought to graze on crop residues, such as sorghum stover, cotton stalks and sesame waste (Hartley, 1979).

The main forage is obtained from trees and shrubs. The diet is made up of species of Acacia, Indigofera, Dispera, and Tribulus. The Acacia, Salsola and Atriplex plants which contain the highest content of moisture, electrolytes and oxalates are preferred (Newman, 1979). It is noteworthy that most of the preferred plants are not readily eaten by other animals because they are thorny and bitter. In Australia (Newman, 1979) sbrubs and forbs make up 70 percent of the diet in winter and 90 percent in the summer.

In northern Kenya some of the plants browsed by camels are (Maloiy, 1972):

Botanical name	Water content (g/100 g)	Crude protein (g/100 gDm)	Caloric value (cal/ gDm)
<u>Acacia brevispica</u> (flower)	58	17.8	3 958
<u>Acacia brevispica</u> (fruit)	74	23.5	5 720
<u>Acacia mellifera</u>	65	18.4	4 472
<u>Acacia senegalensis</u>	67	13.0	4 027
<u>Acacia tortilis</u>	64	13.6	4 550
<u>Capitanya</u> sp.	88	16.3	4 007
<u>Duosperma eremophilus</u>	73	16.6	2 746
<u>Kleinia</u> sp.	78	7.3	4 385

The camels graze in the early morning and late afternoon which are the coolest times of the day for feeding. Analysis of the fodder indicated that the plants had a high water and protein content.

Raedike (1980) gave a detailed account of the food habits of the guagnaco in Chile. The average diet consisted of 61.5 percent grass-like forage; 15.4 percent browse; 6.9 percent epiphytes; 2.4 percent lichens; 2.6 percent fungi; 11.2 percent forbs. Browse was the least preferred forage, while euphorbs, lichens, epiphytes and fungi were the most preferred. The availability of the plants also determined their degree of intake. Essentially the South American Camelidae prefer succulent forage (Newman, 1979). Whereas camels prefer shrubs and forbs, cattle and buffaloes prefer grasses (Newman, 1979). Thus, the cattle and camels complement each other and do not compete for food when grasses, shrubs and forbs grow in the same region. This is not the case with sheep and goats, which have more or less the same preferences as the camels. Even then, a certain symbiosis can be obtained. Feeding trials with Atriplex sp. grown densely were

not a success with sheep (Budda, personal communication). Sheep ate only around the perimeter of the trial area. Any attempt to penetrate the bushes resulted in the wool being caught on twigs and thorns. When camels grazed the field, their natural habit of wandering while eating opened up paths for the sheep to follow and benefit from the abundant food. This trial showed the possibility of growing fodder in large amounts in small areas, and showed the benefits of raising sheep with camels. This combination of communal grazing was also demonstrated in Kenya (Evans and Powys, 1979). Between the years 1974–1978, camels were introduced into sheep and cattle grazing areas. The Productivity of the land was increased as camels ate vegetation ignored by other animals. The pasture was also improve when the plants, which competed with the grass, were removed.

Camels have been successfully grazed on pure Alfalfa and overmature Panicum maximum in Ethiopia (Knoess, 1976; Knoess, 1977). It is not practical to consider these species as forage for camels in dry areas. When camels and sheep were presented with a mixture of chopped hay and straw, the sheep chose the hay, while the camel ate both without showing preference (Farid, *et al.*, 1979).

Camels manage to store sufficient energy in hump fat during the season when food is plentiful, to enable them to survive the times of poor forage (Hira, 1947). The problem of ranching animals in arid and semi-arid areas is the seasonal low availability of forage and water (Payne, 1966). The distances covered by grazing camels is one of the reasons for the decline in their numbers. Not only is family life disrupted by separation of the herders from the family, but encroaching urbanization is causing conflict between camel herders and settlers. Urbanization is also causing the destruction of the natural grazing. In critical areas the camel was accused of causing severe damage to slow-growing trees and shrubs, although sheep and goats are either the culprits or are at least partially to blame (Warrent and Maisels, 1977). Newman (1977) suggests that the feeding habits of the camel are such that they actually preserve their environment. Competition with other grazing animals presents a danger to the camel (Raedeke, 1980). In addition, various native ranges in Africa are being depleted of natural forage (Le Houerou, 1974) as a result of the inhabitants giving up or replacing camel raising with quick-return cash crops, industrial crops, grains and vegetables. Not only does this lead to famine in time of drought, but natural drought-resistant plants and shrubs have disappeared, and so there are no animals to supplement human diet.

To summarize, not enough is known about the anatomy and physiology of the one-humped camel, especially its activity during periods of drought. The camel can subsist on forage rejected by other animals and are unaffected by long periods without drinking water. Milk production is relatively unaffected by the lack of water (Yagil and Etzion, 1980b), but the smell, taste and content is affected by the type of forage as well as by lack of water (Gast, *et al.*, 1969; Yagil and Etzion, 1980a). The camel's grazing habits and its preferred native ranges are bringing it into confrontation with the changing

manner of living and the striving for quick-profit farming. This is disastrous in arid areas, where these quick-turnover crops have an adverse affect on the human population when the lack of rainfall precludes agriculture activities. When famine becomes widespread and people are starving, the camels although not being a rapidly reproducing animal, would provide a suitable and continuous supply of food during periods of drought.





VIII. MANAGEMENT

Animal husbandry covers a variety of subjects which have direct or indirect impact on the final product. Breeding, feeding, housing, disease control and care all affect the growth and production of animals. Husbandry has been based on superstition and practices handed down by father to son over the ages. Customs regarding the ownership of camels; who is allowed to graze them; and even watering have been ingrained in the culture of the various nomadic people (Gast, *et al.*, 1969; Hartley, 1970; Mares, 1954).

"The maintenance of the fragile ecological balance in the desert requires extreme mobility and endurance of the men and the herds". These words of Hilde Gauthier Pilters (1979) sum up the difficulties of camel raising under present conditions. The search for food, the attractions offered by encroaching urbanization, and a more sedentary life are causing people to abandon camel holding and turn to easier ways of living (Cole, 1975) that is, until times of drought, when the so-called easier living and rapid turnover of crops and other food animals, die leaving thousands starving. In 1973, during the worst drought for over fifty years, camels suffered the least. An FAO census (1977) taken in Niger, showed a 100 percent loss for cattle, 50 percent loss for sheep and goats and only 20 percent loss for camels.

Traditional camel raising has no future. Camel husbandry must be revolutionized, and camel raising must be shown to be not only socially acceptable, but economically viable. Like the old cultural values, the traditional role of the camel is disappearing, so new and improved methods of camel raising must be initiated that will enable man to utilize the natural ability of the camel to produce milk, meat, fiber, hides, skins and energy in areas where other animals cannot produce, or produce only with difficulty.

Milk and meat yields can also be increased by better husbandry. Planned breeding programmes, increasing the amount of feed, better utilization of feed and a good health programme are as important as understanding the physiology of reproduction, gastro-enterology and endocrinology.

There is often little or no cooperation between the animal scientist and the botanist in trying to achieve the common goal of improving fodder that would improve animal husbandry and provide food for people. Modern technology and changing society can aid camel raising as a source of food in those parts of the world where water and fodder are scarce.

Camel raising must not be abandoned; it is often the only way to utilize vast desert areas (Gauthier-Pilters, 1979). Although considered a highrisk animal, because of its slow reproduction rate (Dahl and Hjort, 1979) the camel is often the only defence against starvation during the perennial periods of drought.

There is a direct relationship between the cultural habits of man and camel holding (Mares, 1954). The nomadic life is a consequence of the need to search for grazing. With the decline in this way of life the social structure of the nomadic community is changing. In traditional camel raising the entire community is together during the cool season, but much time is spent with the camels in aiding mating and calving (Dahl and Hjort, 1979). This is the time when meat and milk are plentiful and access to water and pastures for the animals is easy. During the hot season the families disperse according to their tasks with the various groups of camels. Almost every able-bodied person, from seven years old to the aged, is needed in the search for pasture (Torry, 1973). The pastoral societies thus feel deprived of society's benefits and

experience a much lower standard of living (Squires, 1978).

Three alternatives for housing and feeding camels can therefore be considered: (1) The age-old method of wandering great distances looking for feed. But the camels' way of feeding is entirely different from that of sheep and goats, which graze intensively, and cattle, which move slowly and demand large amounts of fluid. Camels never overgraze (Gauthier-Pilters, 1979); they are constantly on the move and take only small portions of each plant. In contrast, sheep and goats graze down to the roots, and goats often climb into trees to obtain feed. In the summer of 1973 in the interior part of middle Mauritania not a single blade of grass was left because of the grazing sheep and goats. (Gauthier-Pilters, 1979). Even in extremely poor vegetation areas the camels did not consume all the feed. Mixed ranching or breeding in the traditional camel areas is virtually impossible because the vegetation is not only dispersed and irregular, but is often unpalatable to other animals. These areas are not suitable for agriculture.

Wandering with camels can be made more profitable by introducing plants into the grazing areas. This can be done by keeping sheep or goats with the camels in order to increase production. The camel, however, shows preference for some plants. In western Sahara in a pasture of forty plants the camel's diet consisted of Diplotaxis pitardiana (Gauthier-Pilters, 1979) forming one third of total feed intake. In western Erg, Cornulaca monocantha made up 65 percent of feed intake, although seven other fodder plants were available. One of the plants readily eaten by the camel is Anabasis artemoidea, which is a hardy, dry plant that supposedly wears down the teeth. Another plant that is preferred in Aristida purgens. This plant is a hardy grower, but dries up quickly in the spring. It covers vast dune areas in Mauritania and western Algeria. For up to five months of the year it is the only fodder available. The dry stalks, leaves and flowers are all nutritious and more succulent pastures are ignored in favor of these plants. Aristida plumosa and Panicum turgidum are also favourites of the camel. Even spiny plants are liked and do not hamper the camel from eating them.

In Israel, experiments were carried out in growing various species of the salt bushes, Atriplex, and of Cassia, Acacia and Kochia as shrubs and as reapable fodder and as a by-product grown on municipal waste (Forti, 1971; Forti, et al., 1980; Pasternak, 1981). The salt bushes can be grown intensively and are easily introduced into arid and semi-arid areas. In areas, where the average annual rainfall was between 160 to 200 mm, yields in deep loessial soils were generally good to outstanding. In sandy soils and overlaying loessial soils natural selection was severe and only a few species could survive. Atriplex canescens and ssp. linearis seemed to thrive the best. No species survived in deep sand dunes. The extremely rapid development and great density and height of Atriplex breweri and Atriplex lentiformis made it difficult for sheep to graze conditions which would not hamper the camels, but would be preferred by them. This enables camels and sheep to graze together, one complementing the other. Even following heavy grazing the shrubs recovered rapidly, and in the areas harvested by tractor the yields were 2 ton per dunam with three crops per year. As camels and sheeps have a liking for these plants, their introduction into the camel's grazing areas, or grown in pure stands, would allow an increase in herds of camels, and the combined grazing of sheep and camels.

The grazing camel has low feed requirements (Gauthier-Pilters, 1979). They eat 8–12 kg of dry matter a day, about 30–40 kg of fresh pasture with 80 percent water content. But normal daily feed intake averages 10–20 kg fresh feed, i.e. 5–10 kg dry matter a day. The amount most frequently eaten was 6–7 kg of dry matter a day. This is a most important observation when discussing other methods of housing and feeding. In addition, the feed intake observation applies to an animal understanding standard work consisting of carrying 120 kg for 6 hours a day at 5 kg per hour. Camels can thrive for months by eating only 5 kg of dry fodder a day. The minimum ration is about 2 kg a day, recorded in the drought of 1973.

Although water is an essential part of an animal's diet, the camel can survive long periods without drinking, and then replenish the loss in a very short time (Schmidt-Nielsen, 1964; Yagil, et al., 1974). Nevertheless,

water needs are dictated nor only by the climate, but also by feed (Gauthier-Pilters, 1979). (In autumn, when grazing on Acacia, the camels requires 4 ½ liters of water per day.) This increases to 13 liters in the spring and reaches 30 liters a day when grazing on salty pastures. In southern Algeria, during the summer season, eating evergreen bushes supplies the equivalent of 15–20 liters of water a day. Even on dry food, straw and concentrated feed, the camel is unaffected by a lack of water for up to ten days or more (Yagil, *et al.*, 1974). From October to May there is so much fluid in the vegetation that the camel does not require drinking water (Gauthier-Pilters, 1979; Macfarlane, 1977; Schmidt-Nielsen, 1956).

The mechanisms that enable the camel to go long periods without water are those which allow for a low rate of water loss and a high tolerance to dehydration (Gauthier-Pilters, 1979). Even though body weight losses of 40 percent can be found, camels only stop eating after more than a third of the body weight is lost. The rapid replenishment of losses (Yagil, *et al.*, 1974) and the fact that the camels do not muddy water supplies mean a far more efficient utilization of water (Dahl and Hjort, 1979). The same mechanisms allow the dehydrated, lactating camel to produce diluted milk (Yagil and Etzion, 1980). However, water supplies must be readily available as a herd of camels will drink large amounts in a very short time, so that slowly drawing buckets of water from a well will not suffice.

Water is an essential element for lactating animals, both for drinking and for the growth of vegetation. Both sheep (Stephenson, *et al.*, 1980) and cattle (Bianca, 1965) need free access to water for adequate lactation. Lactating sheep and cattle have a much higher obligatory water turnover. Water is also essential to the camel, even though the milk production is unaffected by seven days of dehydration (Yagil and Etzion, 1980). When introducing plants into the camel's grazing areas, vegetation which is drought resistant and requires minimal water must be chosen. When referring to the radius of grazing for various animals (Schmidt-Nielsen, 1965, it appears that the camels has, by far, the greatest grazing radius. This can also be used in planning a better exploitation of the water resources and introduction of plants.

(ii) A second method of feeding camels is to allow them to graze off the remains of cash-crops (Evans and Howys, 1979). This is commonly adopted, but is a very hazardous method and does not allow for long-term planning. Drought will not only wipe out the crop, but may also present a problem in feeding the camels.

(iii) The third method, which has not yet been the subject of research, is raising and breeding the animals in a stall system. The other two methods are cheaper and easier so far as housing is concerned. In the stall system, simple, mobile fencing can be erected that would restrain the animals in the evening (Evans and Powys, 1979). Before discussing the feedlot system an adequate supply of feed must be guaranteed. It is not enough to supply feed for maintenance, but production must also be taken into account. Very detailed tables are available for cattle, swine and sheep holders which supply the energy value of each feed and the amounts necessary for each age and each stage of production. If little feed is available, it may be necessary to maintain fewer animals to guarantee maximum production per animal. This fact is often overlooked by the pastoral tribes and over-grazing often leads to severe damage at vegetation and to smaller and weaker animal.

Introduction of hardy, nutritious plants, such as the Atriplex (Forti, *et al.*, 1980) which can be reaped (Pasternak, 1981) will enable maintenance of camels in a closed area. No problems were encountered, either in fertility or in production, when camels were restrained in a relatively small area (Yagil and Etzion, 1980a and b). Research in plant introduction is at present unconnected with the plants palatability, digestability and utilization by the animal. Housing the animals will not necessarily cost a great deal.

A shaded area is all that is necessary in the enclosed space. This method of holding camels will enable the population to enjoy the benefits of sedentary life such as education and health services, but especially it will allow for greater improvement of the growth and production of camels.

Better production of animal protein can be attained by better use of grasslands, improved pasture and fodder production, and also the improved production capacity of the animals themselves.

The breeding of camels, as carried out today is a high risk because of the slow reproduction rate (Dahl, 1979). Females are six years old when they first give birth, then only calve once every two years. Building up a herd is thus not only expensive, but is a long-term undertaking. This can be remedied by improved breeding techniques. The calving interval can be brought down to eighteen months, similar to that of cows (Knoess, 1976). Shortening of the calving interval can also be achieved by separating the calves from the mothers at an early age and milking the mothers as is done in the case of cows. Calves can already browse at one month of age (Evans and Powys, 1979). The problem of the female camel not giving milk when her calf is not present (Gast, *et al.*, 1969) was also inherent in the Arabian cow (Jonas, 1952), but this can be overcome. Twice-a-day milking will probably allow the camel to transfer her bond to the milker. Bactrian camels are milked without any such problems (Kuchabaev, 1972).

Animal breeding began as an art many thousands of years ago (Rice, *et al.*, 1957). Among camel-herding tribes the best male was selected as the breeding animal, while the other males were castrated or kept separated from the females (Hartley, 1979). However, the selection of the male was not based on production parameters. Livestock improvement depends primarily on the breeder's ability to select the animals in his herd which have received from their parents a genetic make-up which is an improvement on the herd average. But genetic choice for production is not enough; the docility and temperament of the animals must be considered as a factor when building the herd. Culling of females is also essential for herd improvement. The rate of selection depends on the availability of younger and better animals. In choosing animals for breeding the education and training of the pastoral (now semi-rural) community are necessary. Performance records of both males and females are essential.

Records must be kept of body type, growth rate, udder conformation, milk production and fertility the biggest problem in implementing improved breeding is the long time-gap involved on progeny testing. To meet today's standards a female will need to mature at 5 years of age, be pregnant almost a year, then have a further year of lactation before she can be judged. This is a minimum of seven years for a female. Judging a male for breeding will take about the same time. It is therefore of vital importance (a) to obtain earlier sexual maturity. This can probably be attained with improved feeding and management; (b) to use artificial insemination and semen banks at central stations; and (c) to decrease inter-calving intervals. All this can only be attained if advisors and extension workers are able to move among the mostly nomadic tribes. Better housing and feeding will, to a large extent, increase growth rate of the herd. The growth rate of young calves is far greater in the wet season than the dry season (Field, 1979). The heat itself does not depress growth, but poor quality fodder does. Nutritional and environmental restrictions on milk production are countered by mechanisms controlling lactation (Stephenson, *et al.*, 1980). In hot areas, with poor fodder, the balance is tilted to restricting milk production in sheep and cows. In camels, probably in order to guarantee survival of the species, the balance was tilted toward maintaining lactation. Young lambs in the heat must drink water (Stephenson, *et al.*, 1980), while young camels derive enough liquid from their mothers' milk (Yagil and Etzion, 1980). This genetic benefit is important and should be retained when selecting animals for milk production.

Therefore, the third option of management, i.e. stallfeeding, introduction of plants, selection of breeding stock and education and training will give the best opportunity for improving the production of camels. The intensive holding of camels will also decrease the risk run in herding of camels escaping in order to return to the area where they were born, even if this occurs years later and hundreds of kilometres away (Denis, 1970).

Another benefit of stall holding is that disease prevention and control can easily be carried out and this will

also greatly improve productivity. Internal and external diseases cause a high mortality rate among young camels, and are the cause of abortions and reduced milk and meat production (Evans and Powys, 1979; Mustafa, 1978; Richard, 1979). Feed would be better utilized by healthy and parasite-free animals. The diseases or health hazards of camels are as follows:

Viral diseases

Camel pox is the main viral disease. There are regular outbreaks among the young camels. It is mainly a benign ailment seen mostly on the lips, head and other soft parts of the skin.

Rinderpest. In the open, camels are fairly resistant to outbreaks of rinderpest. Experimental injections with the virus give a relatively small increase in body temperature and an immunological response.

Foot-and-mouth disease is sporadically found, but on the whole the animals are unaffected. Even in widespread cases of the disease among cattle, no antibodies were found in the camels. A virulent outbreak of foot-and-mouth disease, which greatly affected sheep, goats and cattle did not affect the camels, although they were in close contact (Evans and Powys, 1979).

Bacterial diseases

Anthrax which causes a swelling of the superficial lymph glands and almonellosis are two acute bacterial infections found in camels. Camels with severe symptoms of anthrax have been killed for food without causing an outbreak of the disease.

Brucellosis is not a well-identified clinical entity. Abortions are frequent but have not been found to be caused by brucellosis. Although tests have not been conclusive, brucellosis appears to be a bigger problem than previously considered. More intensive husbandry will increase incidence of this disease if no proper preventive measures are taken.

Corynebacteriosis is widespread. On slaughter, lung abcesses caused by Corynebacterium are often found. Pericarditis and pleurisy are complications which are often observed.

Pulmonary-affection-complex or, as it is known, dromedary respiratory disease complex can be caused by rickettsia, virus and pasteurella infections.

Rickettsiosis: could be an important zoonotic disease. This was determined serologically because, as yet, it has not been demonstrated clinically.

Parasitic diseases are dominant in camels, both internally and externally. Trypanosomiasis can cause deaths, but is manifested as a chronic, periodically febrile disease. It leads to abortions, premature births, and inability to feed the young. Reproduction is thus greatly reduced. The causative organism is Trypanosoma evansi.

Helminthiasis hydatidosis is endemic in certain areas of the world. Large cysts are found in lungs, liver and spleen. It is a zoonotic problem of proportions far greater than has been documented and further research is needed. Prevention and treatment are simple.

Myiasis is a seasonal problem, as are camel bots, which are found in the nasopharynx.

Mange is caused mainly by Sarcoptes scabiei and was mentioned in the first literature available on camels.

Ticks are a great problem. They can be found on the entire body, but usually concentrated under the tail and in the ears. Adult Hyaloma can be found deep in the ears. Spraying kills the ticks and prevents further spreading.

The main actions to prevent these ailments are:

- Systemic treatment against trypanosomiasis
- Anthelmintic treatment
- Vaccination against pyogenic diseases
- Vaccination against camel pox
- Vaccination against anthrax

From what has so far been said in this chapter it is clear that the main reason for the decline in camel pastoralism - the long period of time needed to build the herd and the slow improvement of the herd can be countered. Either controlled grazing or stall-feeding makes it possible to improve holding, feeding, selection and the control of parasites and diseases. All these factors will increase the value of the camel and reverse the trend of giving up camel herding in favour of growing cash crops or sheep raising. Sheep, goat and even cattle rearing can be undertaken in conjunction with camel raising. This will offer the benefits of quick-growing and rapidly reproducing animals that are very susceptible to drought and relatively slower developing animals that can continue producing food for man even under severe dry conditions.

The price of camels is comparable to that of cows (Evans and Powys, 1979), although scarcity of camels is raising this price. The direct upkeep of camels is far less than cattle, as they subsist on inferior quality fodder. However when conditions are acceptable cattle are preferred because of camels' slower maturing rate. There is no question that in areas where both feed and water are readily available cattle are more profitable, but no comparative study has been done on production of cattle when feed quality or water quantity is low. When drought exists cattle are soon annihilated (Rice, *et al.*, 1957). Sheep and goats are also far more susceptible to drought than camels (FAO, 1977). The holding of camels, in addition to cattle, sheep and goats will, therefore, increase the utilization of plants grown on meager water resources, while in times of drought, when other animals must be slaughtered, the camel will continue to provide milk and meat for man. This will prevent the high rate of human mortality associated with the loss of livestock (Seaman, *et al.*, 1978).

It is possible that intensive holding of camels will give rise to new problems. Veterinary and agricultural supervision of the herds will provide advice and assistance in overcoming any cause that could affect the growth, health and production of the animals. Education and training are the keystones to establishing a self-sufficient source of animal protein for human nutrition.



Water hole for camels in the desert
Photo 7





IX. DISCUSSION

The one-humped Bedouin camel, either alone or together with sheep and goat husbandry, offers one possibility to combat malnutrition in perennial drought areas.

The members of the Camelidae are to be found in various areas of the world. The value of the smaller members of the family and the two-humped Bactrian camel is to be found in wool, hides and transport. Milk does not play a significant role in the economic importance of these animals. Nevertheless, the Bactrian camel is of importance in parts of Russia, where they are kept fairly intensively and are even machine milked (Knoess), (Kuchabean, *et al.*, 1972). The Arabian camel was domesticated because of its potential value as a source of milk (Epstein, 1971).

What makes the camel so special in the deserts and semi-deserts is its ability to survive the severe drought conditions by many, and varied, physiological mechanisms. Although other ruminants have large quantities of water in their digestive tracts, as is needed for normal digestive processes, their water turnover is far greater than that of the camel (Macfarlane, 1964; Macfarlane and Howard, 1972). This low water turnover enables the camel to graze relatively far from water sources (Schmidt-Nielsen, 1958) and to replenish losses in a very short time (Yagil, *et al.*, 1974). Whereas lambs and calves must have drinking water, even during the period before weaning (Stephenson, *et al.*, 1980), the young camels can subsist on their mothers milk alone (Yagil and Etzion, 1980a, b). Therefore, water resources when limited, can be utilized far better by camels than by other animals.

Camels do not need to enter the water to cool down, and well-planned stalls can keep the animals out of direct sunlight without increasing the heat load. In stall feeding, feed will be used for production and not burned off as energy in the long treks searching for food. In hot and dry areas buildings do not have to be necessarily solid brick, but should have suitable roofing, enclosed by a solid fence to prevent animals being stolen or breaking out a water and feed trough and an area for milking, examination and treatment.

Milk production of camels in drought areas can be a valuable source of food for the human population. In severe drought sheep, cattle and goats die, while the camel remains relatively unaffected (Seaman, Holt and Rivers, 1978). It often is the only provider of food (Sweet, 1965). The inability to recognize the value of this animal to date

is due to a number of factors. The notion that camel raising is a primitive occupation and not socially acceptable is the main reason for the decline in camel raising (Knoess, 1979). Quick-return crops or grazing, quick-reproducing sheep and goats appears to be a better value than maintaining camels for long periods (Dahl and Hjort, 1975). Grazing land is becoming scarce and is of poor quality for efficient production (personal communication). Camel raising is on the decline because it is considered a high-risk proposition (Dahl and Hjort, 1979) as well as uneconomical. In addition, the importance of the camel as a riding animal or a beast of burden is declining from year to year, as nomads turn to mechanized transport.

In all the arguments against camel raising, the most important fact has been overlooked by the planners, and even by the owners of the camels themselves: in times of severe drought the camel can be the only animal that will digest the remaining flora, and on it can produce milk and meat for human nutrition (Sweet, 1965). There is much truth in the quotation from the Koran that "the camel was given to man as a gift from God".

When faced with a lack of drinking water the milk production of the camel is unaffected (Yagil and Etzion, 1980b), unlike that of most other milk-giving animals (Bianca, 1965; Konar and Thomas, 1970). The quality of milk produced is what makes the camel of immense value for human nutrition in times of water shortage. The milk of the dehydrated camel appears to be diluted (Yagil and Etzion, 1980a). The water content is one of the highest known and there is an accompanying decline in fat content, however, salt content is increased. The feed that is eaten will directly affect the final taste of the milk (Shalash, 1979). As the nutritional value is high, the camel therefore provides a nutritious and diluted food, supplying calories, minerals and water, which are greatly needed. It has long been known that desert travellers take a milch camel with them when wandering through the desert. This was always considered as being done to provide a source of food, but it is now clear that as a reserve of liquid they are of extreme importance. The Bedouin confirm that on their trips the milk was very watery (Personal communication).

The various ways of preserving camel milk, as acidified products or butter (Gast, *et al.*, 1969; Grigoryants, 1954; Nemekh and Accolas, 1978) are primitive, but efficient, methods of preserving the milk. What is known to date concerning Bedouin camels' milk production has been gathered from camels which have not been genetically selected for milk production or raised to increase milk production. Nevertheless, relatively large amounts of milk can be produced, ranging from 5 to 13 kg a day (Knoess, 1979). A herd of camels producing such amounts of milk would be sufficient to keep numerous people alive in times of drought. If methods are found to increase shelf-life of milk, or if the population is trained to acidify and store milk, the danger of malnutrition in times of drought would be greatly lessened.

In rainfed agriculture the camel is a better producer of milk than any other domestic

animal (Knoess, 1979).

Cows at an environmental temperature of 32°C have a reduced dry matter intake, which limits not only milk production, but also body-weight (Bianca, 1965). An environmental temperature of 40°C depresses the appetite of Holstein and Jersey cows almost completely but not that of Zebu heifers. Animals devote more time to shade seeking and less to grazing. Dehydrated camels look for shade; stalls would provide adequate protection. In cows the high production of milk increases total heat load and thus increases susceptibility to heat stress. The changes in milk yield and milk composition resulting from a hot environment are thus a combination of the direct effect on milk yield and voluntary starvation (Bianca, 1965).

The small black Bedouin goats, however, are not only able to go 2–4 days without drinking water, but are able to produce around 2 kg of milk a day (Shkolnik, Maltz and Gardin, 1980). This opens up the possibility of combined grazing of camels with this type of hardy, high producing goat. More research needs to be carried out on such animals and on various sheep breeds, that, with better husbandry, could produce both milk and meat in drought areas and not only in the rainy periods. Providing shade and stall-feeding would decrease the heat-stress on these animals and allow them to lose less water for cooling and so continue producing for longer periods. When the drought becomes too severe, these animals can be sold or slaughtered. In the following rainy period these herds of sheep and goats can easily be rebuilt. In the meantime, the camel will continue to produce during severe drought. This will make a high-risk economical venture a venture of survival.

The four conditions that must be met before pastoral industry in least developed area can be undertaken, are (Squires, 1976):

- Availability of free land, producing suitable forage
- Demand for animal products
- Low labour requirement
- Suitable animals for breeding and herd improvement

The limited availability of free land is slowly becoming a pressing problem with increasing urbanization. Nevertheless, there are still enough arid and semi-arid areas which are fairly barren, but can be readily grazed by camels. They are often the only animals that can survive in those areas. But the land is not sufficient, and there must be suitable forage (Squires, 1976; 1978, 1979). Here the introduction of hardy forage plants will greatly increase the grazing capabilities, which not only will increase the production of the animals, but will allow more animals to graze intensively in a defined area which will alleviate the squabbles between home-steaders and nomads. It is also possible to go over, partially or wholly, to stall keeping. Forage can be grown as shrubs (Forti, 1971), as fields that can be harvested, even mechanically (Pasternak, 1981) or close to the

encroaching townships using municipal rubbish dumps, (Forti, *et al.*, 1971). The hardy plants are readily eaten by the camel as they are mainly salty plants with a high protein content. Trials on the introduction of various species of Atriplex, Acacia and Cassia have been a great success in semi-arid zones, and the improved grazing land with increased carrying capacity has given good results.

The second condition for pastoral industry, the demand for animal products, needs no further comment. The alleviation of malnutrition is the quest of the coming years. Even today there is a big market for camel meat in various parts of the world, where drought is of limited importance. Exporting meat, of the young males that are not used for breeding, would provide a good income for camel breeders. If relatively bare areas can be covered with fodder not only camels, but sheep and goats can be kept at the same time, which will greatly increase the production of animal protein and provide a fall-back to the slower-producing camels in times of drought. The extremely rapid development of Atriplex, combined with its density and height, present grazing sheep and goats with problems, but camels grazing at the same time open up paths between the bushes. The camels graze at different levels than the sheep or goats thus forming a perfect symbiosis in grazing. Land use can thus be more productive than agriculture based on cultivated crops, as this can lead to soil erosion (Knoess, 1979).

The third condition for pastoral industry, a low requirement of labour, is especially applicable in the case of the grazing camel. Herding is not labour intensive, even though during the mating and calving periods more help is needed. Stall-raising would increase the labour, because of the need to bring food to the animals, but the introduction of mechanization would elevate the level of farming and greatly reduce the labour requirements. Families would not have to be separated, and so the community as a whole would enjoy the benefits of social services, without breaking their link with tradition.

The most important condition for pastoral industry is choosing the breeding stock. This is of vital importance and will probably need a lot of persuasion and education before suitable progress can be achieved. Building up a suitable herd is not an easy matter. It is easier to choose a good male than to choose good females and cull the bad ones.

At the moment the main reason against raising camels is the long periods without production: six years to wait for sexual maturity and then a long calving interval of two years (Dahl, 1979), however the calving interval can be shortened to 18 months (Knoess, 1976). With good management this interval could be reduced to a year, or 15 months. If the calves are separated from their mothers within the breeding season, a month or so after birth, the female camel will quickly come on heat. This would then allow for breeding in the same season as calving. Although climate as well as feeding have considerable effects on the fertility of the animals, improved nutrition would increase the health and so the fertility of the animals. The combination of balanced nutrition and education in the selection of both males and females will shorten the period

before maturity and improve the birth weight and calving intervals. Disease control will also lessen abortions and perinatal deaths. It is quite clear that the increase in milk and meat production will be determined by all of the above factors. Selection, on its own, will not have a great effect on undernourished animals. Well-fed animals will show no improvement if ill or worm infested. The goal of a healthy, well-fed and high-producing animal can be achieved even in a drought area with good planning, control, education and aid.

Increasing camel production will not take place rapidly, nor will it be easy to convince populations that have not previously owned camels or have left camel raising for easier and "more modern" businesses. Camel raising in feed-lots need not to be left to people who have previously managed camels, but it can be a self-sufficient industry close to an urban centre, utilizing unskilled man-power which is creating a labour problem in the towns. The photography of the camel providing milk for both man and animal is a vivid expression of the ties between the camel and man in drought areas of the world.

In conclusion no more appropriate words can be used to sum up the situation described in the foregoing than those written by Knoess in 1977: "Countries in the arid zones of the world should reconsider the role of the camel and camel breeding, if they are to capitalize on the unique potential of these animals to produce protein and other animal products at relatively low cost from desert and steppe lands and from farm wastes".





X. RECOMMENDATIONS

The potential of camel production in the arid and semi-arid areas of the world should be utilized. The existing situation must be improved, and this can be achieved in a number of ways, each adding to successful production in times of drought.

- Hardy shrubs or grasses should be introduced into areas where other vegetation can only be grown with difficulty or not at all. Research should be carried out to compare grazing with harvesting of these areas. This will help guarantee an ample and nutritious diet for the animals.
- Wells need to be sunk or improved in order to make it easier to draw water.
- Breeding management should be improved. Proper records should be kept of births, matings and possibly of production. Where the local population is incapable of doing this, outside inspection and help should be given.
- Breeding practices should be modernized and improved. Collection, storage and transport of semen should be subjects for further investigation. It would be of value to have a central sperm bank to serve a large area, if transport is available to reach the various herds. At the time of insemination, examinations, of the animals can be carried out and information can be collected. The local population must be educated to recognize signs of "heat" in the female.
- Hand milking, without the presence of the calves, must be introduced. Where possible, milking machines must be used. This will also entail research into the suitability of the various milking techniques.
- Stall-feeding should be introduced, as far as possible. This will guarantee more efficient use of feed and water, improved chances of introducing selection techniques, better health control and easier observation and control.
- An efficient system of marketing of meat, milk, wool and hides should be established to ensure effective operations both during peak production periods and during periods of drought when the milk becomes vitally important.
- A veterinary advisory programme should be drawn up to decide how to control and prevent prevalent diseases. Deworming and spraying or dipping are essential. Regional laboratories for serological research should be set up.
- Camel raising can be combined with sheep and goat raising. Actually, if camels are stall-fed, sheep and goat breeding will be much easier and will increase the profitability of the herds. The different habits and often different preferences in feed make the combined husbandry an attractive proposition. Also in this case

disease and parasite control are of importance.

Research into various fields of interest is imperative. It is a challenge to our society that we can combine our knowledge and skills to help make the camel a popular animal to breed; an animal which is such an obvious solution to improving human nutrition in the arid zones of the world, where hunger is endemic, and strikes millions of people every year. The main objective is to help the local populations become independent of foreign aid and capable of providing their own food sources in times of drought.





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