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Current Status of Genetic Resources, Recording and Production Systems in African, Asian and American Camelids

Sousse, Tunisia, 30 May 2004

Editors: R. Cardellino, A. Rosati & C. Mosconi

Cover page: 17th century engraving by Pieter Jacobsz van Laer of Haarlem, dit Bamboccio, (1599-1642), representing a livestock farm in the Latium region of Italy

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held in Sousse, Tunisia,
30 May 2004

Editors: R. Cardellino, A. Rosati & C. Mosconi

August 2005

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Introduction

The two major groups of camelids, the species belonging to the genus *Camelus* (dromedary and Bactrian camels) and the species of the genus *Lama* (llama, alpaca, guanaco and vicuña) contribute effectively to the welfare and livelihoods of people in harsh and difficult environments: hot and cold deserts, and highlands. The first group is autochthonous to Asia and Africa and the second group originates in South America. Although frugal in habits and of legendary resistance to long periods without water and feed, they are remarkable producers of milk, meat, hair and work. Improved management could enhance this contribution and improve the livelihoods of communities depending on them.

The workshop that originates the present publication took place during the 34th ICAR Session in Sousse, Tunisia, May 2004. The local organizers suggested that camelids would constitute an appropriate theme for a one-day meeting and this idea was embraced by both ICAR and FAO. The purpose of this workshop was to offer participants the possibility:

- to get acquainted with camelid production systems in Africa, Asia and South America, including environmental, management, health, breeding, reproductive and market aspects;
- to gain insight on the status of camelid genetic resources in several countries of Africa, Asia and South America;
- to discuss actual – if existing – and potential recording systems for camelids with emphasis on milk, meat and fiber production;
- to evaluate the need for research and development in camelids at regional and global level;
- to exchange experiences among participants coming from different world areas.

These objectives were largely met, although much remains to be done. Research on camelids lags behind that of most species used for food and agriculture and it has been said that these species have almost been neglected by science. This may be associated with the fact that they are of limited geographical distribution and remoteness of location, again in comparison with more widely used species. Although in general people closely dependent on camelids have a thorough traditional knowledge of their animals, they lack much information that could be provided by scientific research.

The present proceedings touch on several aspects of camelid production. The first three articles contribute general perspectives on dromedaries, Bactrian camels, llama, guanaco, alpaca and vicuña. Following, camel production systems in Africa and in Asia are considered. The next four articles describe camel genetic resources in North Africa, Morocco, Mongolia and Arabian Gulf countries. Dairy productivity potential in camels is discussed in the next article, while meat and fiber recording systems are the subjects of the two subsequent papers. Two more articles close the proceedings, one on llama production systems in Bolivia and the other on production systems of alpaca and vicuñas.

The Editors wish to express their gratitude to ICAR and FAO for supporting the workshop, including travel of authors and meeting facilities, and to the Tunisian Organizing Committee for their enthusiasm and constant support.

Camels and dromedaries: General perspectives

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Summary

Camels continue to be the preferred livestock species for utilizing extreme dry land areas. They are part of the culture of pastoralists and make up over 30% of the livestock biomass in such areas.
Pastoralists are seeking new systems of using their animals and increasing sales of surplus rather the keeping them to accumulate wealth.
The Camel Applied Research and Development Network succeeded in highlighting the case of the marginalized camel production sector, encouraged the establishment of the camel producers association, supported 17 national research systems and developed may technical packages for improving camel productivity.
Further activities would be focused on strategies and policies, technology transfer, marketing of camels and camel products and capacity building.

Key words: importance of camels, CARDN, Camelus dromedarius, Camelus bactrianus.

Background

The family camelidae is divided into two genera. The genus *Camelus* includes two species: *Camelus dromedarius*, the dromedary, the one humped or the Arabian camel; and the *Camelus bactrianus*, the bactrian or the two humped camel. The second genus is the *Lama* comprising four species: *Lama glama*, the *Llama* and *Lama pacos*, the *Alpaca* which are domesticated; and *Lama guanacoe*, the *guanaco* and *Lama vicugna,* the *vicuna* which are wild.
The habitat of the dromedary is the dry hot zones of Asia and Africa. The Bactrian camel lives in the cold deserts of southern areas of the former Soviet Union, Mongolia, East Central Asia and China. The lamoids are found in the cold heights of Latin America.
Scientists believe that the dromedary was first domesticated in Southern Arabia (Zeuner, 1963) or in Northern steppes of Arabia (Bulliet, 1977; Mikesell, 1955). However, Khanna (1990) reported that the dromedary might have been separately domesticated in India.

The camel plays vital socio economic roles and supports the survival of millions of people in the semi-dry and arid zones of Asia and Africa. Camel milk is the sole nourishment for the pastoralists for prolonged periods each year. The camel proved it is the most fit domestic animal during severe drought periods. The camel not only survived such droughts, but continued producing and reproducing while other animals ceased production or died out.

The camel possesses unique qualities which make it superior to other domesticated animals in the hot and arid desert ecosystems. These attributes of the camel are reinforced by its ability to traverse considerable distances with much less effort than other species, moving from one patch of short lived vegetation to another.

The role of camel as a domestic animal is undergoing fundamental changes as subsistence nomadism shifts towards semi-sedentary cash demanding systems. Problems associated with the lack of knowledge, due to insufficient research in the past, are further compounded to day by the challenge of change. The camels of poor families in arid and semi arid areas should become more productive and competitive if the communities concerned are to survive.

The relative importance of camels

Camel numbers increased from 17.671 to 18.783 million in the world during the period 1993-2002 (FAO, 2003). The African cotenant possesses about 13 million, while Asia and Australia have about 4.5 and 0.3 million, respectively. South America possesses about 6.2 million lamoids. There are 12.4 million camels in the Arab countries and 12.5 million in CARDN countries (Figure 1).

In spite of the fact that camel numbers have increased during the last decade, the relative importance as biomass has slightly decreased due increased numbers (and biomass) of cattle in general during the same period. Camels comprised about 6.5, 0.84, 19.2 and 14.8% of the total animal biomass in Africa, Asia, the Arab countries and CARDN countries in 1993, respectively. These ratios decreased to 6.2, 0.7, (Figure 2) 15.1 and 10.1% (Figure 3) in the related areas in 2002, respectively.

The decline of the role of the camel as a mean for transport and agricultural work due to the rapid socio economics changes during the last few decades, and the exclusion of camels from support (crediting and research) have led to the increase in cattle (dairy and beef) projects and numbers, and hence, the slight decrease in the relative importance of the camel.

Total world milk production from camels increased from 4.8 to 5.1 million tons during the period 1993-2002. Meat, hide and fiber production also increased from 353, 28 and 21 thousand tons, respectively in 1993 to 376, 30, and 23 thousand tons, respectively in 2002 (FAO, 2003).

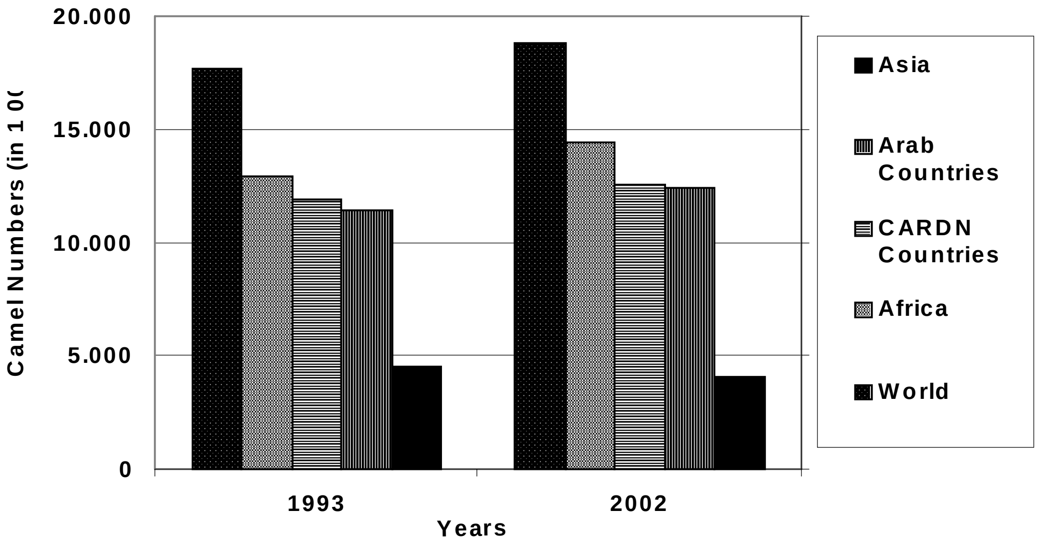


Figure 1. Development of camel heads, in the years 1993 and 2002 in some African and Asian countries.

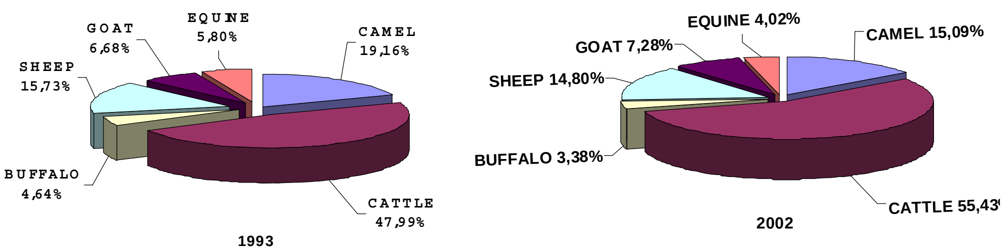


Figure 2. Relative Importance of camels (TLU) in the Arab Countries, in the years 1993 and 2002.

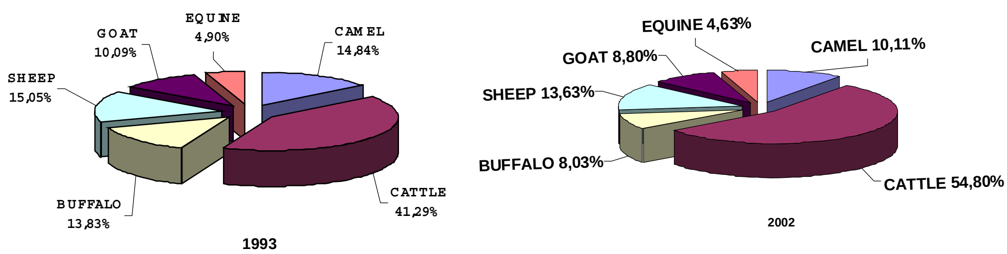


Figure 3. Relative Importance of Camels (TLU) in CARDN Countries, in the years 1993 and 2002.

The Camel Applied Research and Development Network (CARDN)

The virtues of camel include their ability to tolerate several days without access to drinking water without decreasing feed intake and milk yield, which makes it possible to use pasture in areas and at times where there is no water available; and selection of feed which is unpalatable, indigestible or out of reach for other livestock. As there is little overlap with feed selected by other species, increasing the proportion of camels under mixed species stocking allows for higher stocking rate without the risk of long-term damage to the vegetation. Camels have the capacity to travel and to carry loads under these conditions over long distance. Relatively, camels have low susceptibility to certain contagious diseases; and they ensure a decent life of pastoralists on extreme dry lands under non-sedentary livestock systems.

Keeping camels enables people to live in areas which otherwise would not be usable by man. They benefit in particular important pastoral groups, the poor pastoralists in that they:

- provide through their milk daily subsistence needs of food;
- generate income through sales of excess animals;
- ensure security through capital accumulation;
- ensure social links; and
- provide transport, which is a necessary element of the mobility in pastoralist systems as water and feed are not available at one site during all periods of the year.

The unique qualities which make the camel superior to other domestic animals in hot and arid desert ecosystem have attracted the attention of many regional and international organizations. The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) and the International Fund for Agricultural Development (IFAD) with the support of the Islamic Development Bank and the French Government have established the Camel Applied Research and Development Network (CARDN) in 1991.

The scope of CARDN includes countries in Asia and Africa where the camel is of economical or of special importance. The main objectives of CARDN are to:

- assist national research systems to improve and generate (and assist in the adoption of) appropriate technologies in order to ensure sustainable resource use and enable long-term of camel-based production systems;
- assist with the identification of problem areas;
- promote networking where appropriate and seek financial support for its successful operations;
- ensure that results from research are applied where applicable; and
- document and disseminate research results.

The programme is co-ordinated by ACSAD.

Each member country assigned a national Technical/Planning Committee, which is headed by the National Co-ordinator, who oversees the network activities in the country.

A Steering Committee (SC) is the set up for overall governance of the network. The SC is composed of:

- a Senior ACSAD staff (chair);
- one IFAD representative;
- one or two representatives from each of the country groups;
- representatives from donors and potential donors of the network; and
- the network co-ordinator.

The distribution of research work among member countries took into consideration:

1. research priorities for each country;
2. the advancement of research in certain topics;
3. the availability of scientists and facilities; and
4. the tight budget. In certain cases, the same research work was repeated in two countries which have different ecosystems.

CARDN and the case of camel production

CARDN has succeeded in highlighting the case of camel production and the long ignored camel pastoralists. Such a case was brought to the attention of the highest authorities in member countries and elsewhere. Presidents; Prime Ministers; Ministers of Agriculture, Economics, Environments, foreign affairs, and finance; and organizations and NGOS in member countries and elsewhere have considered the camel as one of the key factors for food security in the arid and semi arid zones.

As a result of such activities of CARDN, the concerned parties in member countries have included the camel and camel producers in their plans and started initiating and establishing development projects in the camel producing areas.

Moreover, CARDN has been able to play a very important role in strengthening and help establishing research centers, units and courses in many countries. The intervention of CARDN with authorities has lead to the increase of Camel Research Centers and Units from 5 in the early 1990s to over 35 in member countries, and 10 elsewhere by 2004.

The National Committees for Camel Research and Development

A National Committee for Camel Research and Development was established in each member country of CARDN. The main objectives of the committee are to:

1. coordinate among national research centers;
2. outline the priorities of camel research;
3. form a team of work for each research topic, and
4. conduct the research work within the framework of the programme of CARDN.

The national committee for camel research consistes of well-known scientists in the field and is headed by national coordinator and was officially announced by an order from the Minister of Agriculture in each member country of CARDN.

The initial socio-economic studies of the camel production sector have releavled very important results. Traditional management systems and practices have been studied and experts are exploring means to help improving such systems and practices.

CARDN played an important role in the establishment of the International Camel Pastoral Association in 2001. The main objective of this association is to follow up the development of the camel production in member countries. The Sudan offered to host the association.

CARDN supported NARS in conducting 42 research activities, supported 17 laboratories and established four laboratories for artificial insemination and embryo transfer (a grant for the Islamic Development Bank). Four mobile veterinary units are being purchased to be used in four member countries.

Basic and applied biological research focused on performance, reproduction, nutrition, health, and pre and postnatal mortalities are mainly carried out.

Applied research led to development the following technical packages:

- Colostrom feeding to camel calves to reduce calf mortality.
- Feeding local agricultural by products to reduce grazing pressures and improve reproductive efficiency in camels.
- Utilization of traditional veterinary practices to treat camel diseases.
- Early weaning as a tool for increased herd productivity.
- Camel fattening.
- Camel milk processing.

Studies on marketing of camels and camel products were conducted in 5 member countries were camel production is important (Sudan, Pakistan and Tunisia) and where camel products are highly appreciated (Egypt, Mauritania and Tunisia).

Studies on standardizing camel products are being finalized.

Scientific meetings

CARDN held 38 symposia and workshops, and 13 training course. Experts from CARDN countries participated in 41 conferences, symposia, workshops and training course which were organized by other organizations.

Prizes

A number of collaborating scientists received high national prizes and decoration for their contribution in camel research.

- Mr. Mostapha Gellouze, the national Coordinator of CARDN-Tunisia.
- Mr. Afaf Saad Eddin Fahmy, National Research Center, Molecular Biology Department, Egypt.
- Mr. Saleh Ahmed Mohamad, National Research Center, Molecular Biology Department, Egypt.

The Camel Documentation Unit

The Camel Applied Research and Development Network has established a Camel Documentation Unit (CDU) in order to furnish available research results on camels to scientists, researchers, extension services workers and interested parties. Camel research centers and camel scientists and experts are also surveyed throughout the world in order to coordinate research programmes, and exchange information and experiences.
Over 50 graduate students have been helped and hundreds of scientists have benefited from CDU. Moreover, CDU is publishing the following two important periodicals. The Camel Newsletter (CNL) and the Journal of Camel Science (JCS).

Future themes and activities

This matrix would fit a programme for a third phase of the Camel Applied Research and Development Network (CARDN). However, part of it was included in the programme of CARDN-II during the period July 2003-December 2004 within budget permission. A list of the future themes and activities is summarised in table 1.

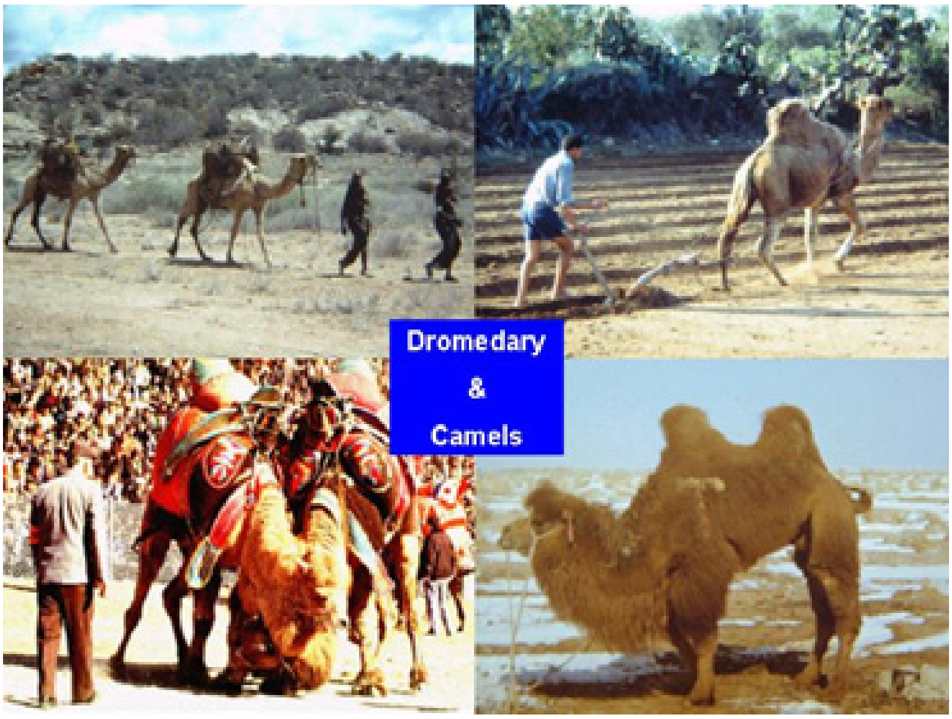
Table 1. Future themes and activities.

Themes	Activities
Strategy and policy	1. Development of Camel production (All countries). 2. Integrated systems for development (Tunisia). 3. Encourage establishment of herders organizations / cooperatives (Most countries). 4. Genetic improvement (Iran and Sudan). 5. NGO's participation (Pakistan). 6. Use of AI (Iran).
Technology Transfer	1. Provide (Developed technologies): 2. AI techniques (Algeria, Iran). 3. Feeding regimes (Egypt, Morocco, Pakistan and Tunisia). 4. Milk processing (Mauritania, Pakistan and Tunisia). 5. Early weaning (Tunisia). 6. Disease control (Egypt, Mauritania, Sudan and Tunisia). 7. Herd book keeping (Tunisia). 8. Camel drawn implements (Pakistan).
	Need: 1. AI techniques (Syria, Tunisia and Yemen). 2. Feeding regimes (Iran, Jordan, Sudan, Syria and Yemen). 3. Milk processing (Jordan, Sudan, Syria and Yemen). 4. Meat processing (Iran, Pakistan, Syria and Yemen). 5. Early weaning (Pakistan, Syria and Yemen). 6. Disease control (Syria, Tunisia and Yemen). 7. Herd Book keeping (Iran and Sudan).

(To be continued in the next page....).

(...to be continued from the previous page).

Themes	Activities
Quality Control of products:	Standards Need: 1. Products (milk, meat, hiders, and fiber) All countrie 2. Value addition (All countries). 3. Grading as per ISO / WTO requirements procedure and implementing tools (Tunisia).
Marketing	1. Marketing live animals (Egypt, Mauritania, Pakistan, Sudan and Yemen). 2. Marketing of camel meat (Algeria, Egypt, Iran, Morocco, Mauritania, Pakistan, Syria, Tunisia and Yemen). 3. Marketing of camel milk (Iran, Jordan, Morocco, Mauritania, Pakistan, Tunisia and Yemen). 4. Marketing of camel hides and fiber (Egypt, Mauritania, Pakistan, Tunisia and Yemen). 5. Legislation (Egypt and Tunisia). 6. Integrated production system (Tunisia). 7. Marketing intelligence (Pakistan, Sudan and Tunisia).
Capacity building	A. for Producers: 1. Organization (Morocco). 2. Range management (Egypt, Iran and Tunisia). 3. Feeding regimes (Egypt, Iran, Jordan, Mauritania and Sudan). 4. Disease control (Iran and Mauritania). 5. Milk processing (Jordan, Pakistan and Sudan). 6. Marketing aspects (Pakistan, Sudan and Tunisia). 7. Decision Making (Tunisia). B. Researchers: 1. Disease control (Algeria, Pakistan, Sudan and Syria). 2. ET and AI Reproduction (Egypt, Iran, Pakistan, Sudan, Syria and Tunisia). 3. 3. Marketing (Egypt). 4. 4. Feeding and Nutrition : Master trainers (Pakistan). C. Extension Officers: 1. Reproduction: (Algeria, Egypt, Tunisia and Yemen). 2. Feeding and Nutrition : (Algeria, Egypt, Jordan, Mauritania, Syria, Tunisia and Yemen). 3. Market skills: (Morocco , Sudan and Yemen). 4. Disease control: (Jordan, Sudan, Syria, Tunisia). 5. Milk processing: (Iran, Jordan, Mauritania, Sudan, Syria and Yemen). 6. Meat processing: (Morocco, Mauritania, Sudan, Syria and Yemen). 7. Camel use for poverty alleviation: (Pakistan).



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Lama (*Lama glama* L.) and Guanaco (*Lama guanicoe* M.): General perspective

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Summary

The highlands of South America form a special ecosystem with an important biodiversity. Since 4 000 or 5 000 years ago, two species of domesticated camelids have developed in this region: the llama and the alpaca, as well as two non-domesticated ones, the guanaco and the vicuña. During the Incas period, these genetic resources played an important role in the development of this ancient culture, but the protagonistic role of Camelids ended abruptly with the Spanish conquest of that South American region five centuries ago. The Spaniards initiated their colonization with the systematic elimination of the camelids and replaced them with their own domestic species, principally sheep and cattle. Along with the Spanish conquest, the mines period begins in these highlands as well; the mines' development requested not only an important quantity of camelids' meat, vegetables and natural energy but also large llama caravans, in order to transport the mines products from highlands to the coast. However, the pastoral communities in those high-risk environments have played a major role in conserving the llama, alpaca, guanaco and vicuña species. The mining activity along with human pressure on the fragile ecosystem resulted not only in an important loss of biodiversity but also, and most importantly, in the reproduction of poverty. Consequently, today like five centuries ago, the highlands of South America are characterized by three elements: poverty, soils of low quality and camelids. And it is through these elements that they try to resolve their main problem, that is poverty. The analysis of market trends, the review of the historical context of the use of native breeds, and the efforts of highlands people suggest that the rational use of South American Camelids, both domestic and wild ones, can be an economic alternative in many production systems in the South American highlands, on the condition that the regional governments in co-operation with the producers are able to find new markets with fair prices and improve the quality of camelids' products.

Keywords: llama, guanaco, highlands of South America ecosystem, poverty and economic alternative.

South America Camelids habitat

The habitat of South American Camelids is located between 2 800 to 5 000 meters of altitude in areas of Peru, Bolivia, Chile and Argentina.

The Highlands of the Andes form a special ecosystem with an important biodiversity. The temperature is usually below 0°C, the fluvial precipitation has an average of 300 mm of rain, and the natural fertility of the soil is low, characterized by Ca and Mg deficiency. Under these conditions biomass production is reduced and located to a rainfall station.

There are two species of domesticated Andean camelids, the llama and the Alpaca, as well as other two, non-domesticated ones, the guanaco and the vicuna. Both domestic and wild camelids use the same pastoral areas. All camelids of the Andes are perfectly adapted to life at altitudes above of 4 000 m, having evolved many physiological adaptations in order to produce in the highlands of South America. For example, they have an unusually high number of small, elliptical red blood cells, which offer them a greater capacity to carry oxygen. The camelids' regional population was estimated at near 5 millions, (Campero, 2004).

In the last centuries, the grazing area has been reduced as a result of the introduction of bovine and sheep. According to the opinion of many researchers, the reduction of the llama populations during the last century was about 80 % of the original population present in the last part of the 18th century.

The presence of sheep and cattle populations in the highlands ecosystem increased the degradation of natural resources. Besides, the irrational management of llamas and the low prices for its products led to the development of a poverty cycle for poor livestock keepers.

The problem

Five centuries ago, the protagonistic role of Camelids ended abruptly with the Spanish conquest of that region of South America. The Spaniards initiated their colonization with the systematic elimination of the llamas and alpacas and replaced them with their own domestic species, mainly sheep and cattle.

The European stock displaced the native camelids from every part of the region save the highest parts of the Puna where the foreign livestock had no chance of survival because of the harsh climate.

The llama and alpaca were exiled to the upper regions of their natural territory, while the sophisticated husbandry and management systems were lost due to Spanish prejudice and lack of understanding.

Along with the Spanish conquest, the mines period begins in the highlands of South America. The mining activities requested not only an important quantity of meat, vegetables and natural energy but also large llama caravans in order to transport the mines products from highlands to the side coast.

During the last two centuries, the mines publishers developed the idea that the llama meat was “Indian meat”, thus it was easy to prohibit its marketing in the urban centers. This idea was associated to the existence of sarcosistiosis in the meat. With such strategies, the miners not only could assure the meat provision but could also buy it in low prices.

Moreover, the pressure on natural resources has increased due to the high rate of human (2.9% per year) and livestock (2%) expansion. Consequently, the ecosystem presents an important rate of degradation of its forests, water and soil resources and cultural values. This process evolved along with the mines development in the highlands.The lost soil was estimated at 14 000 kg per hectare / year.

This erosive process resulted in an important loss of biodiversity and, most importantly, in the reproduction of poverty. People in those regions have only two means of production: soils of low quality and camelids. It is with these that they reproduce poverty. The llama and alpaca became animals of the poor and formed the base of a subsistence culture for the natives of the High Puna.

Bolivia is the country with the largest number of llamas in the world. There are 3 million animals, most of them bred in small family herds and graze on wild pastures. Fifty four thousand poor livestock keepers depend on camelids production.

The socio-economic framework of many people living in the Altiplano region indicates a rather alarming situation which can adversely affect its socio-cultural future. This socio-economic situation is characterized by low education levels, limited access to basic services (health, communication, energy), and soil erosion by overgrazing.

However, the camelid breeding activities and the development of a fair market for its products are the principal opportunity that many Andean people have in order to increase the family income.

Development perspectives

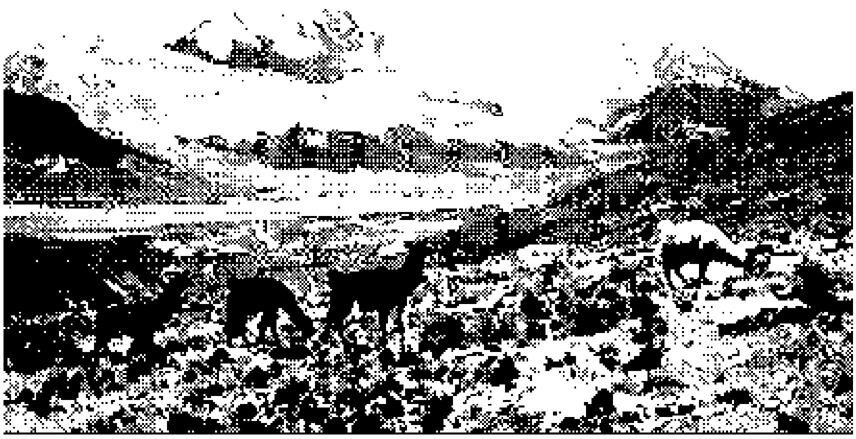
The use and conservation of South American camelids, both domestic and wild animals, is seen optimistically as an economic alternative to many production systems in the highlands of South America.
In this context, the management of natural resources has to take into consideration that important quantities of South-American camelid meat and fiber are sold in both local and international markets at attractive prices. This is the only way for the highlands of South America to cope with their social problems, above all poverty.

Domestic camelids

The pivotal role that llamas and alpacas played in the Incan civilization and its economy naturally elevated their status. In that historical period, very sophisticated ways of management and care were developed for both domestic and wild camelids.
The Alpacas were selected mainly for fiber production. On the contrary, the llamas were selected according to meat and traction criteria. The llama's adaptability and efficiency as a pack animal in the mountainous terrain of the Andes made it possible to link the zones of diverse altitude and to cover the great distances of the region.

The Llama

The *llama* is the most common and also the strongest of the Andean camelids. It has a slender shape and it can be found in up to 16 different colours. The llama has long legs, neck and face, and may reach a hight of 1.9 meters.
As a pack animal, the llama can carry a weight of about 25 kg through long journeys, and up to 40 kg in short ones (Riera *et al.*, 1972). The llama's average weight as an adult varies between 80 to 115 kg. The newborn llamas weigh 12 kg on average. The gestation period lasts about



348 days. The female llama reaches sexual maturity at one year of age, but in South America it is usually not bred until two or three years of age. Males reach sexual maturity at about three years of age.
There are two breeds of llama traditionally recognized - the Q'ara and the Thampulli. Their fiber (technically it is called "fiber" and not "wool") is less dense than that of the alpacas, and averages about 28 microns of diameter (Riera *et al.* 1972).
The llama was selected specifically to produce a large and strong animal for packing. On the other hand, the alpaca was bred to make use of its naturally finer fiber. Today in Bolivia, the harvest of this fine fiber is the base for a significant textile industry whose products are conquesting new markets.

Fiber production

The Andean countries, especially Peru and Bolivia, have lately recognized the importance of native camelid species for their culture and rural development.
Rediscovery of the alpaca's fine wool by the international textile market in the late 1800s led to a higher level of interest in the alpaca, consequently leading to increased management, research, and selective breeding activities. On the contrary, the llama continued its obscure existence until about 30 years ago. (Campero and *et al.*, 2004)
Research into management and breeding of the llama has been instituted and carried on in conjunction with current alpaca research. Obviously, modern transportation has reduced the importance of the llama as a beast of burden. Nevertheless, today the development of industries involved in fiber and meat production is considered pivotal for the rural development of the western regions of Bolivia and Peru.
Today in this country, great emphasis is being laid on this animal as a fiber producer, with meat as a secondary function. In 2003, the production of fiber was 720 tons. This production was 125 % higher than in 1998. The llama fleece has two components: fiber and hair.
The llama fiber is a modulated natural protein with no lanolin or grease, and is classified as a specialty fiber. The llama fiber is characterized as fine, strong, comfortable, warm and lightweight (good warmth to weight ratio), and is available in 16 natural colours, (Campero, 2002). The main negative characteristic of this fiber is its low elasticity.
The characteristics that influence most the commercial value of a fleece are fineness and color. Fineness has always been correlated with higher prices in any type of fiber. Commercial buyers and processors prefer and pay a premium for white fiber because it can be dyed.
The average length of llama fiber is 6.8 ± 1.5 cm, and it is 1.1 cm shorter than its hair. These values are smaller than those reported for llamas selected in the Experimental Station of Patacamaya in Bolivia by Rodriguez (1992), that were 8.3 ± 0.7 cm. Nevertheless, this length is adequate for directing those fibers to industrial processes, and is similar to many sheep breeds of high production of wool as the Merino, that has

a length of 8.1 cm. The general average for “dirty” fleece weight was 1.2 ± 0.2 kg. Howeber, this information does not take into account the age of the fleece or shearing frequency (Cardozo and Choque, 1988).

Llama meat

The consumption of llama meat in the highlands of South America is traditional and in Bolivia it represents near 17 thousand tons per year. In the last years, llama meat has been exported to special markets as exotic or organic meat (Campero, 2004).

The llama meat is similar to beef in taste and texture, but the protein content is higher and its fat level is lower than beef. Moreover, the consumption of llama meat does not cause formation of cholesterol. According to the actual level of meat production quality, the llama meat producers have to improve the quality in order to maintain the new markets.

The amount of cholesterol per 10 ml of llama serum blood varies between 20 to 50 mg while the same in beef is 200 mg and in sheep 300 mg.

Hence, there are many reasons that should permit to increase the presence of this meat in both national and international markets.

Wild camelids

In the last twenty five years, the populations of guanaco and vicuña have increased slowly but constantly. This successful process was only possible thanks to the establishment of natural reserves in Argentina, Bolivia, Chile and Peru. Besides, the control of furtive hunters was important too.

The focal point in this strategy was the role of many rural communities. It is proven that hunters provide illegal markets with animals in other areas far from the natural reserves.

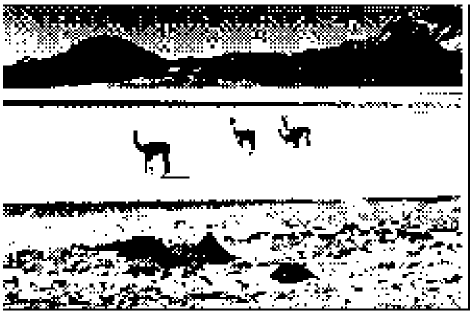
The international markets for guanacos and vicuñas productions were banned by the CITE Convention. Argentina, Bolivia, Chile and Peru have developed plans of rational utilization and have gained the CITES approval. Consequently, these countries can export guanacos and vicuñas products made with fiber shorn of live animals.

In many cities of South America it is possible to find illegal markets of guanaco and vicuñas products. The main illegal markets are found in Buenos Aires, La Paz, Lima and Santiago. But, in some of cases, when the illegal products such as sweaters and shawls were controlled, it was found out that the material was fiber of llama or alpaca. This does not mean that there are no illegal markets in South America.

Guanacos

The guanaco has the widest distribution among all the camelids, ranging from the tip of Tierra del Fuego to the Andes.

The guanaco coat consists of a double layer. One layer is made of relatively short fibers (3.0 cm to 4.5 cm) which are fine and soft, while the other one is formed by long, coarse hairs. The guanaco fiber, with approximately 16 microns average diameter, is not legally traded in international markets unless there is expressed authorization from CITES. Each animal can provide up to 500 g of fiber annually, its colour can be described as a cream tan.



Guanacos are somewhat smaller than llamas, but in general very similar to them. They have a different ear shape from the llama, while both have a similar colour pattern, although the intensity of the pattern varies with the region. They have a brownish upper body and neck, with the front of the limbs coloured brown, and the back of the limbs, chest, belly, and anal region whitish to cream. This white area usually extends quite high to the flanks, as high as the point of the hip. The head is usually greyish to black.

In the last five years, the low demand of the fur industry in Europe has reduced the incentive to hunt newborn animals. In the last years of 70‘s, the exportation of guanaco leather reached nearly 140 000 units. In many countries, the animals are once again viewed as a national treasure to be protected and promoted.

Preservation of wild herds of the nearly extinct guanacos has become a priority, and hunting bans have been imposed and enforced.

Conclusions

Llamas

1. The development of llama fiber and/or meat industrial/handicraft production is vital for many countries in South America in order to accelerate their rural development.
2. New markets situated in Europe, North America and Asia have demonstrated high interest in llama fiber and meat production. If certain problems mainly associated with sanitary standards can be resolved, these areas will be potential markets.
3. Many states have been working in order to develop the necessary conditions to improve the quality of llama products. This includes credits, technology assistance, disease control, market research etc.

Guanacos

1. The guanaco, both a grazer and a browser, is quite adaptable. There are guanacos that live in one of the driest deserts in the world (the Atacama in Chile), while others live in the wet archipelago of Tierra del Fuego, where rain falls all year round.
2. On the basis of the high prices of guanaco fiber in the market, it should be convenient to continue developing an offer of fiber with homogeneous quality since the shearing of live animals. This condition should allow to resolve the problem of hunting of guanacos in order to crop their fibber.

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Camel production systems in Africa

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Summary

Camel breeding had and continues to be of major social and cultural importance in Africa which holds more than 80% of the world camel population. The largest flocks are found in Somalia, Sudan, and Ethiopia. According to FAO statistics, an average of one camel for 20 persons is found in Africa.
Nowadays, camel products are increasingly having advantages compared to other traditional animal products.
In fact, camel products markets (meat, milk, hair, and leather) are expanding because of health problems of the other products of cattle, sheep and poultry.
The meat and milk produced biologically and naturally are becoming substitutes of the traditional products.
This paper analyses the camel production systems in Africa and especially the production machine (number, species, etc), practices and production, profitability (financial and economic aspects), marketing and commercialization.
Finally, the main socioeconomic advantages and constraints will be analyzed.

Key words: camel production, camel breeding, production systems, main constraints.

Camel production potential

It is difficult to give exact estimates of the camel production potential because of the nature of its non controlled breeding system. Table 1 show that the total number of cattle, camels, goats and sheep in the world reached 1 265 540 animal units in 1997 out of which only 1.2% are camels compared to 82% cattle. For Tunisia, camels represent about 11.4% out of the total number of livestock while cattle represent 37.1% which indicates the importance of camels.
According to estimates of FAO, world camel flock is approximately 20 million. It had increased from 18 million heads during the period 1981-1985 to 20 millions by the end of the twentieth century (Alaya, 1999). In Africa, Somalia is ranked first with approximately 6.1 million

Table 1. Cattle, sheep, goats and camel average population in the period 1991-1995 in the world and in 1997 (in thousand heads).

	Cattle		Sheep		Goats		Camels	
	1991-1995	1997	1991-1995	1997	1991-1995	1997	1991-1995	1997
The world	905 219	923 727	22 3908	2102 942	96 586	112 146	18 925	19 373

Source: Alaya, 1990.

heads that is 42.3% of the camel African flock. Sudan occupies the second position with 2 950 million heads (20.5% of the total camel flock in Africa). Mauritania and Ethiopia come in the 3rd and 4th position with 1.1 million heads and 1 million heads, respectively (Table 2).
The North African countries have approximately 900 000 heads including 231 000 heads in Tunisia.

Table 2. The camel African flock (in thousand heads).

Country	Heads
Somalia	6 100
Sudan	2 950
Ethiopia	1 000
Burkina Faso	18
Djibouti	69
Kenya	810
Chad	600
Niger	380
Mali	260
Nigeria	6
Senegal	12
Mauritania	1 100
Tanzania	200
Egypt	135
Libya	129
Tunisia	231
Algeria	125
Morocco	290
Total	14 415

Sources: Alaya, 1999; Faye, 1997; Cheriha, 2000.

Importance of the camel breeding in the agricultural economics in Africa

Faye *et al.* (1997) classified the importance of the camel breeding in the economies of the countries in Africa based on the proportion of the camel production in the Herbivorous Domestic Biomass (HDB). The HDB corresponds to the total weight of the domestic herbivores. Somalia comes at the head with 55% whereas for other countries, like Nigeria, it reaches only 0.15%. Then, the countries are classified into four categories:

- The countries where camel breeding represents only a marginal activity (HDB < 1%): Nigeria, Senegal and Burkina-Faso.
- The countries where the camel breeding represents an average activity (1 < HDB < 8%): Morocco, Algeria, Egypt and Libya.
- The countries where the camel breeding constitutes a significant part of the agricultural economics (8 < HDB < 20%): Tunisia, Niger, Chad and Sudan.
- The countries where the camel breeding is of primary importance in the economy of the country (HDB > 20%): Somalia, Mauritania, Djibouti. Indeed in a country like Somalia, the export of the dromedary constitutes the main source of foreign currency for the country, 60% of dairy consumption is ensured by the camel breeding.

The four countries Somalia, Sudan, Mauritania and Ethiopia total up to 11.5 million heads, that is approximately 77.4% of the African camel flock.

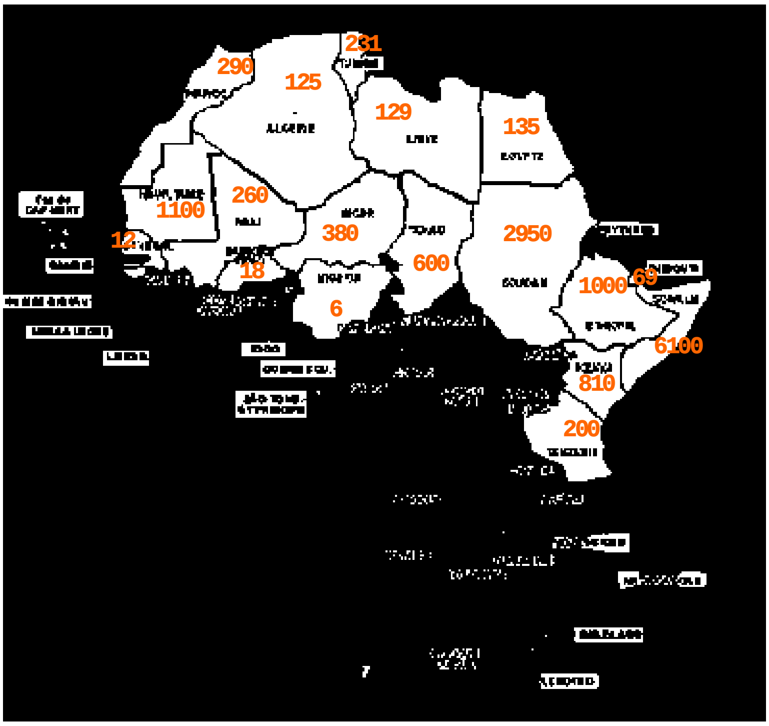

Figure 1. Camel population in Africa (in thousand heads).

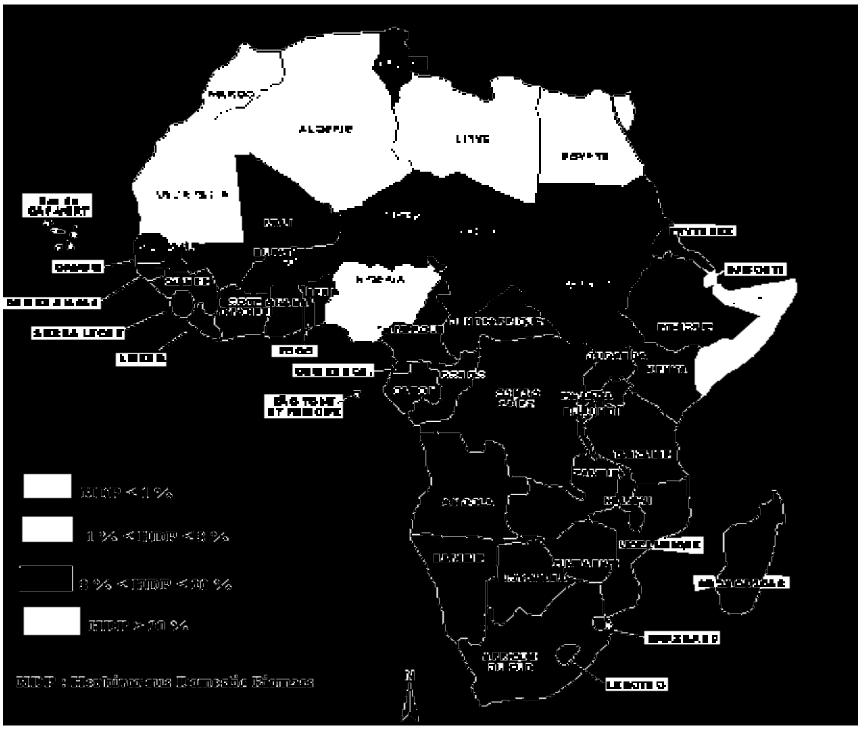

Figure 2. Importance of camels in the agricultural economics in Africa. The HDB corresponds to the total weight of the domestic herbivores.

Camel breeding systems in Africa

Dromedary is known by its preference of open large rangelands since it is able to travel tens of kilometers per day.

In the African countries, two types of camel breeding systems are prevailing:

- The free breeding system.
- The breeding system of accompanied by a shepherd (Controlled breeding system).

The system of breeding in stalling, although it is possible, but almost non practiced.

Free breeding system

It is a traditional breeding system where the herd is left free without guarding.

In general, the stockbreeders attend their herds at long periods (a few months) around the water points. These fixed water points are known by the stockbreeders and the herds.

The periods of frequentation are in general dependent on needs such birth, health control, etc.

It is most widespread in Africa and mainly in the countries of Central Africa and the East Africa. It occupies an important place in North Africa.

For example: the case of “*reguebat*” of the Saharan provinces in Morocco, the case of “*Kel Ewey*” of Niger in the area of Timia which moves up to Nigeria (Faye *et al*., 1997), the case of the “*Mérazzigues*” in the Tunisian Sahara where the camel herds can move hundreds of kilometres in the large Saharan rangelands in Libya and Algeria.
The advantages of this breeding system are :

- The freedom of movement of the animals on large areas and good rangelands.
- More economic efficiency(low costs of breeding).

The most important disadvantages are:

- High risk of animals loss (attacks of predatory, etc.).
- Low productivity.
- can cause damages to thers (cultivated fields, etc.).

Controlled breeding system

In this case, the herd is kept by a shepherd who is in general accompanied by shepherd assistance. The movements and the choice of the grazing lands are controlled by the shepherd. The operations births, health treatments and watering are assisted. The average size of a herd varies from one country to another in Africa (20 to 100 heads per herd). In general, a shepherd controls an average herd of 50 to 80 heads.
This breeding system is practiced in the countries where the grazing areas are limited and the camel breeding is regaining economic interest. It is found more in the countries of North Africa (Tunisia, Libya, and Morocco).
Advantages of this system are:

- Controlled breeding system
- Better range management.
- Reduction of the losses.
- Better productivity.

The disadvantages are:

- High production costs.
- Scarcity of qualified shepherds.
- Needs for means of transport.

Main characteristics of the of camel production systems in Africa

The camel production systems in Africa are diverse enough. The main characteristics of the major geographical areas will be analyzed in the following section (Table 3)
Three main areas are distinguished:

- East Africa: Somalia, Sudan, Ethiopia;
- North Africa: Egypt, Libya, Tunisia, Algeria and Morocco;
- Central Africa: Kenya, Chad, Mali, Mauritania and Nigeria.

Concerning the case of Somalia, Sudan and Ethiopia, the camel production system is marked by the existence of large herds (100-5 000 heads/flock) and of an important diversity of races. The average weight of an animal varies between 400-750 kg and it is around of 650 kg. The big animals size is dominant (Cheriha, 2000; Idriss, 2003).

Table 3. Synoptic table of the main characteristics of the camel production in Africa.

	Average herd (units)	Average weight of adult (kg)	Principal production	Dairy production l/day	Milk Marketing	Other uses	Sector	System	Export/import
North Africa (Egypt, Libya, Tunisia, Morocco)	20-80 heads	400 (250-800)	Meat milk	1.5-6	Not	Transport racing ploughing tourism	Private sector	Extensive semi-extensive	Import from Sudan, Chad, Mauritania
Central Africa (Kenya, Chad, Mali, Mauritania, Nigeria)	-	250-300	Meat milk	1.5-8	Yes	Transport race ploughing	Private sector	Extensive	Export to Gulf countries, Libya, Morocco
East Africa (Somalia, Sudan, Ethiopia)	100-5 000	650 (400-750)	Meat milk (according to the breeds)	5-10	Yes	Transport racing ploughing	Private sector	Extensive	Export to Gulf countries, Egypt, Libya

The objective of the breeding depends on the races. The dairy races exist and produce on average 5 to 10 litres per day. The milk marketing is practiced in Somalia and Ethiopia (Cheriha, 2000; Idriss, 2003).

Animal herders in Sudan lead a nomadic life combined with minor crop production activities for about four months of the year i.e they are agro-pastoralists. The average herd size is around 193 heads, about two thirds of which are females and one third males. Animals depend completely on natural grazing in Darfur province, and mostly on natural grazing with some supplementary feed in Kordofan and the Eastern provinces. Supplementary feeding is composed of sorghum grain, oilseed cakes, sorghum straw and concentrates. It is mainly for weak animals.

Animals and their products form the main source of income for these pastoralists. Income from camels is in the form of animals and milk sales and the other sources of income come from crop sales and transfers from relatives working in Saudi Arabia and the Gulf States. Milk sales are limited in Western Sudan but in Eastern Sudan about 25% of milk production is sold either fresh, in form of yoghurt or liquid butter (Sakr and Abdel Majid, op. cit.). The main problems indicated by the herders include shortage of drinking water, spread of camel diseases, and lack of veterinary services and encroachment of agricultural activities on grazing land. (Idriss, 2003).

The camel breeding is dominated by the private sector. It was reported that stakeholder can own up to 2 million camels in Ethiopia (Faye, 1997). The breeding system is in general extensive. The three countries are among the main exporting countries of camels to Egypt, Libya and the Gulf countries of the Golf. For example, Sudan exports approximately 200 000 heads to Egypt (Idriss, 2003).

In the countries of Central Africa (Kenya, Chad, Mali, Mauritania and Nigeria), the camel production system is characterized by herds of less important size, except some cases in particular Mauritania.

The average weight of the main races is 250-300 kg per animal. The principal objective depends also on races but it is mixed production of meat and milk. The dairy production lies between 1.5 and 8 litres per day (Cheriha, 2000). Milk marketing is practiced but it is not very widespread. Other uses of camels are transport, racing and the agricultural use. The system of breeding is extensive. Exports of camels are practiced to other countries such as Algeria and Libya.

Concerning North Africa (Egypt, Libya, Tunisia, Algeria and Morocco), the camels production systems are marked by very diverse sizes ranging from few heads in the case of agro-pastoral systems to thousands as in the case of Morocco (Faye, 1997; Sghaier, 2003). In general the average size is 50 to 100 heads per herd. The average weight by animal varies according to the races. It is located between 250 and 700 kg/head (Cheriha, 2000).

The main objective of the breeding is the production of meat. The dairy production is secondary and varies from 1.5 to 6 litres/day. The milk marketing is not practiced and the markets are almost missing.

Dromedary is used as means of transport, racing (Mehary race), and draught animal in agriculture. Recently the dromedary starts to be exploited in the tourism sector as it is the case of Kébili and Douz in the south of Tunisia. In this case, the dromedary is used as means of transport in the tourist tours. The average annual income by animal is estimated at 1 160 TND/year (1000 $/year) which represent 400% of the annual income earned from a she camel destined for livestock production (Sghaier, 2003).

Productions

The statistics related to the estimation of camel production in Africa are not precise and are fragmented. The production of camel meat was estimated in 1994 at 248 000 tons that is 82.6% of the world production (approximately 300 000 tons).

The studies carried out by the ACSAD give more precise estimates for the studied countries. According to Idris (2003), the production of camel red meat in Sudan increased from 1 275 000 tons in 1996 to 1 624 000 in 2002. For the case of Tunisia, Sghaier (2003) reported that the camel red meat production evolved from 2 150 tons in 1997 to 3 500 tons in 2003. Meat is the main product of camels and represents about 2.5% of the total red meat production in the country. The average annual camel meat production has increased during the Ninth Economic Development Plan (EDP) from 2 150 ton to nearly 3 000 ton in 2001.

Estimates of the tenth EDP are expected to increase the contribution of camel meat to about 10% of the total red meat production. Planners responsible for the sub sector hope that camel meat production increases from the 3 300 ton per year level at the beginning of the Tenth EDP (2002-2006) to reach 4 050 ton per year by the year 2006.The planned annual increases are shown in table 4.

The evolution of other products in a country like Tunisia is described in table 5. Milk production from the Tunisian camel breeds is rather limited. Quantities produced are therefore intended mainly for consumption by camel herders and shepherds. Beside the fact that quantities produced are limited, whatever is produced is difficult to assemble, store and transport. Having said that, these limitations should not obscure the social and economic value of this promising product because of its nutritive and medicinal value (Some people take it as medicine for diabetes).

The total milk production, as shown in table 5, is expected to increase from 13 750 tons in 1997 to 19 875 tons in 2006.

Table 4. The development of camel production during the Ninth EDP and estimates for the tenth EDP.

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Production (ton pure meat)	2 150	2 280	2 400	2 400	3 000	3 300	3 500	3 650	3 850	4 050

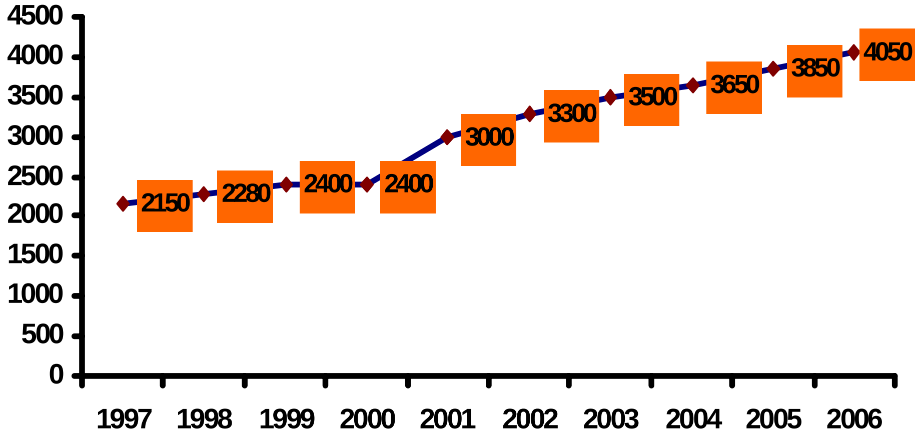

Figure 3. Meat camel production during the Ninth EDP and estimates for the tenth EDP in Tunisia (tons/year)

The products of hair hides, on the other hand, represent the raw materials for the cottage industries in the Southern part of the country. The average hair production per head is estimated at 3 kilograms per year. Table 4 shows the current and estimated future projections:

The figures in table 5 indicate that the average annual production of camel hair is about 220 tons and the average annual production of hides is about 698 tons.

The distribution of these products does not follow a certain established marketing channel but rather a simple rudimentary distribution system that is confined to family members and those involved in cottage industries.

Table 6 shows the estimates of other camel products in the majority of the African countries are given per capita and per race, especially dairy production.

It is noticed that the best performances of dairy production are recorded in Egypt (1 600-4 000 litres/year/lactation) and Libya (1 200-3 500 litres per year/lactation). Countries like Somalia, Ethiopia and Sudan keep high performances but far below the potentialities because of the dominant extensive breeding systems.

Table 5. Estimates of camel milk, hair and hides production

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Hair	181	184	205	205	213	220	231	243	251	262
Hides	577	585	651	651	677	701	734	773	800	835
Milk	13 750	13 925	15 500	15 500	161 125	16 00	17 475	18 400	19 050	19 875

Source: Officer of camel and small animals, 2001.

Table 6. Average production of camel milk in some African countries.

Country	Dairy production	
	Litres / day / head	Litres / year / head
Somalia	9	1 800
Sudan	5-10	1 500-2 500
Tunisia	1.5-5	300-1 200
Egypt	4-15	1 600-4 000
Algeria	4-8	-
Chad	3-5	-
Kenya	4-6	-
Ethiopia	7	2 450
Eritrea	5-6	-
Libya	3-6	1 200-3 500

Source: Cheriha, 2000.

Constraints and advantages

It is not easy to draw up a common and complete diagram of the main constraints and advantages of the camel production systems in Africa because of the specificities of each country and the lack of adequate data. Nevertheless, in a general synthesis will be presented here.

Main constraints

The camel production systems in Africa face several constraints of various importances and in particular:

- Low economic interest of the camel breeding in the economies of the countries with rare exceptions like Somalia.
- The breeding systems and the of control modes of the camel breeding remain traditional.
- The socio-economic and technical difficulties facing the modernization of the camel production systems.
- The absence of well organized markets for camel products in spite of the renewed interest in these products for their biological quality.
- The insufficiency of programs and strategies for the development of the camel sector at various scales: national, regional and international;
- The lack of organization of the camel breeders (associations, co-operatives, etc.) to face the dominating role of the speculators and intermediaries who have major control of the sector.
- In spite of the scientific achievements, the knowledge on camels remains insufficient and do not allow to encourage the sector.
- The insufficiency of the scientific research programs at the various scales (national, regional and international). One can quote here, the example of the regional program implemented by ACSAD, “The Camel Applied Research and Development Network (CARDN)”.
- Low productivity compared to the available potentialities.
- Absence of channel for the main camel products marketing.

Main advantages

The main advantages could be as follow:

- Social importance of the camel breeding which represents the main income activity of most of the pastoral populations in the arid, semi-arid and desert zones of Africa.
- High level of knowledge of the camel breeding production system and the existence of a rich local know-how of this type of breeding,
- Low production costs.
- The natural and biological production conditions would allow the camel products of being substitutes of other livestock products (cattle, etc.).
- The availability of an important productive potential (approximately 80% of the world camel population).
- Existence of a high comparative advantage of the camel products in Africa.
- Beginning of a serious renewed interest in camel breeding in the development strategies of the African countries.

Conclusions

The camel production systems in Africa are very diversified and play an increasingly dominating role in the economies of many countries. Because of its socio-economic and cultural role within a large portion of the pastoral and nomad communities in the African arid and desert regions, this economic activity represents a high local potential solution for poverty alleviation in Africa.

The milk and especially camel meat, which are produced naturally and biologically, would occupy important place on the global market. However, this remains obviously dependent on the implementation of serious national, regional and international strategies for the development of the camel production sector in Africa.

The expansion of the camel use by other sectors, such as tourism and racing, offers new socio-economic opportunities to increase the profitability of the camel production system.

Though the scientific research achievements are modest, they open new horizons for the modernization of the sector in order to improve the productive performances of camels in Africa.

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Alpaca and vicuña: General perspectives

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"Gold of the Andes, riches that dresses the world"

In the landscapes of the high plains at over 4 000 meters above sea level, thousands of years ago the Incas domesticated two species of the South American camelids: Alpaca and Llama, using techniques that are a mystery to these days. The first one would later be used as a source of soft, fine and resistant fibre and the second one as a mean of transportation. From the two species that continued being wild: Guanaco and especially Vicuña, a fantastic and very fine fibre was obtained, which was reserved only for nobility. Its threads were mixed with gold threads to create varied work of art. It was the fibre of the gods.

Key words: South American camelids, domestic camelids, wild camelids, characteristics, population and distribution, fibres, market.

The South American camelids

- The Camelids appeared in North America, about three millions of years ago. A group migrated trough the Bering Strait to Africa and Asia, evolving to form part of the Camelini Tribe (camel and dromedary). An other group migrated to the South trough Central America and expanded in South America, where they formed the Lamini Tribe. Finally, the ancestral Camelids disappeared in North America.
- The South American Camelids belong to the Ariodactyla order, Ruminantia suborder of the Camelidae family.
- Nowadays, the South American Camelids are represented by the domestic camelids: Llama (*Lama glama*) and Alpaca (*Lama pacos*) and the wild ones: Vicuña (*Vicugna vicugna*) and Guanaco *(Lama guanicoe*)

The South American domestic camelids

This group comprises the alpaca (known as the most resistent and light fiber in the world) and the llama, known for its nutritive meat with reduced content in cholesterol.

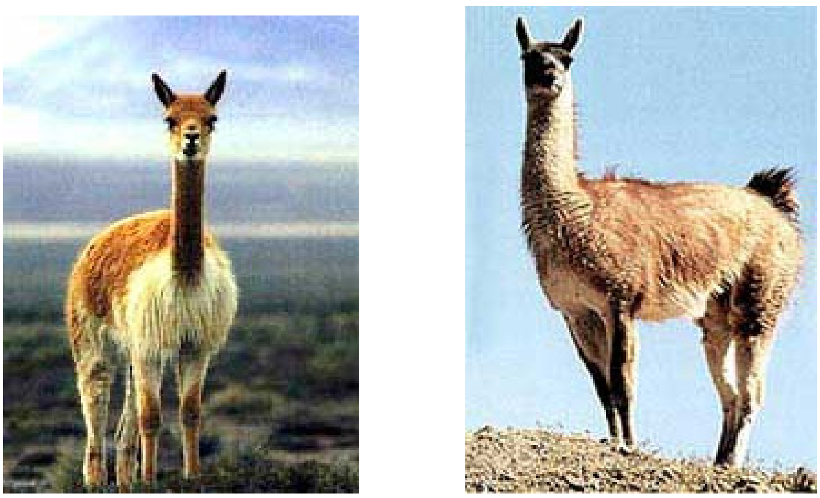
Alpaca (on the left) and llama (on the right).

The South American wild camelids

The South American group of wild camelids comprises vicuña, an animal very well known for the finest fibre in the world and Guanaco that is the most resistant camelid in South America.

The Alpaca: general characteristics

- The alpaca is a pacific animal with a slim body. It is covered with fibre that when it is set together is called *vellón*. It presents steps pads on it's four extremities, which gives it the characteristic of ecological animal, because it does not damage the grass.



Vicuña (on the left) and guanaco (on the right).

- Lives in the Andes zone of Peru, Bolivia, Chile, Argentina and today, by introduction, in United States, Canada, New Zealand, Australia, and in a minor numner in other countries.
- There exists two breeds of Alpaca: Huacaya and Suri.

The Alpaca: population and distribution

Country	Alpacas	Percentage
Peru	3 100 000	87.0%
Bolivia	325 000	9.0%
Chile	30 000	0.8%
United States	30 000	0.8%
Australia	25 000	0.7%
New Zealand	20 000	0.6%
Other countries	30 000	0.8%
Total	3 560 000	100.0%

Source: CONACS - MINAG 2003.

The alpaca fibre

- The Alpaca fibre got a special fibre denomination.

World's special fiber production (in MT).

Mohair	17 000 TM
Cashmere	8 000 TM
Alpaca	6 440 TM

This volume represents less than the 1% of the natural animal fibers.
Source: IPAC-2004

Comparison between alpaca fiber and other main fibers.

Fiber	Production		Refinement	US$/Kg	Comfort	Application	
	Tons.	%	(mic).	(Top)	factor	Punto	Plano
Alpaca baby	515.2	8.0%	22.5	14.0	90.0%	xxxx	xxxx
Alpaca Suri	322.0	5.0%	26.0	13.0	70.0%		xxxx
Alpaca superfine	2 576.0	40.0%	26.5	9.0	70.0%	xxxx	xxxx
Alpaca Huarizo	1 301.8	20.2%	31.0	4.3	55.0%		
Alpaca adult	1 725.0	26.79%	34.0	2.9	25.0%		xxxx
Total	6 440.0	24.1%					
Cashmere	8 000.0	30.0%	16.0	80.0	98.0%	xxxx	xxxx
Mohair kid	3 400.0	20.0%	25.0	27.0	80.0%	xxxx	xxxx
Mohair young G.	10 200.0	60.0%	28/31	21.0	65.0%	xxxx	xxxx
Mohair adult	3 400.0	20.0%	35/37	11.5/6.0	25.0%		xxxx
Total	17 000.0	63.7%					
Angora other types	1 700.0	6.4%					

Source: IPAC-2004.

The alpaca fibre market

In traditional markets of tops and spinning, made of fibre, its reduced volume does not make it competitive and it is exposed to different interests of the producers and industrialists of Peru.

When it is on fashion, approximately each five years, prices become extremely unstable, i.e. they increse very fast due to the effects of the higer demand comparing to the offer; this matter causes relevant internal speculation and a temporal rise of prices in all the chain.

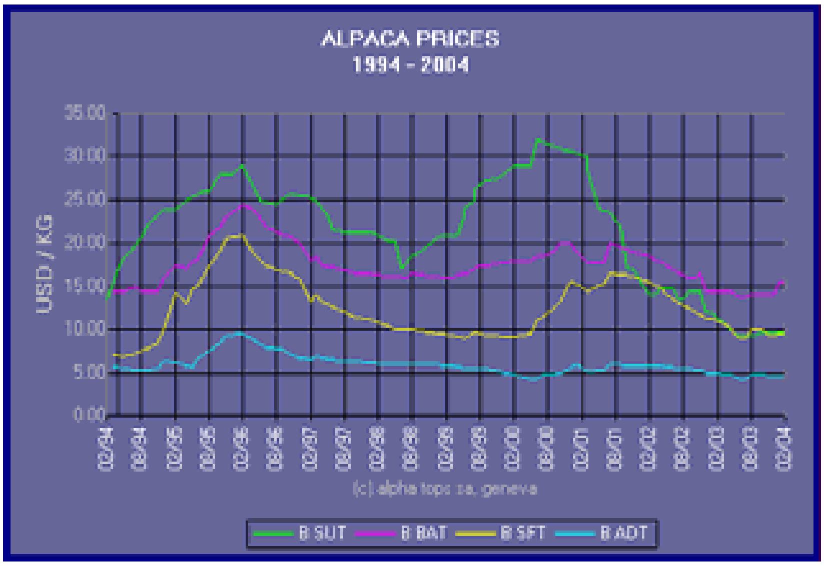
This situation makes the relation very conflictive between the final buyers, which retract from the market, with a consequent replacement of the alpaca with other more stable fibres. As a result, the Alpaca prices go down to sub yield levels of the producers.

Markets and products of the alpaca fibre

- The main exportation markets are: China, Italy, United Kingdom and United States for the tops and spinning, and the United States, Germany, United Kingdom and Japan for the finished alpaca clothes.
- The main exportation products are tops of alpaca and wool combed or rebuke, spinning, fabrics, preparations in plane weave handmade or with special machines, such as sweaters, cardigans and artisan products.
- The 80% of the Alpaca fibre is exported with low added value such as tops, spinning and fabrics and only a 20% as finished clothes.

Development perspectives of the alpaca fibre

- Relating to the productive chain of the fibre, it was established four main objectives:
  - The fibre's refining trough a genetic improvement process.
  - The standardization and normalization of the commerce and transformation process as well as the derived products.
  - The increase of the added value trough the exportation of finished products in a bigger proportion.
  - The international positioning of derived alpaca fibre products in fashion segments more stable and with better prices.
- Relating to the meat productive chain, the development of the sector can be supported through:
  - the improvement of the quality of the carcases: free of parasitic diseases and a better finished.
  - the identification of the markets that appreciate the properties of the alpaca meat, and that are available to pay an higher price.
- Relating to the productive chain of skins and leathers, basically not used, it must be noted that this



Prices of different alpaca fibres (in US$) from 1994 to 2004.

sector has a great potential as soon as some problems linked to the conservation and quality of raw materials will be solved.

- The productive chain with better perspectives in short and medium term is the one associated to the germoplasm: animals on foot, such a reproducers or pets; frozen semen, embryos, ovules, etc.

The vicuña

- The vicuña habitat lays in the high andean ecosystem of the Puna, ranging 4 000 up to the 5 000 a.s.l.. Vicuñas can generaly be found in Peru, Chile, Argentina, Bolivia and Ecuador.
- The vicuña is a wild animal, gregarious and territorial. Socially, they form three kinds of organizations: family groups ruled by a male with five or more female vicuñas, cattle of young male vicuñas rejected by the family groups and the lonely male ones.
- The vicuña is perfectly adapted to the Puna, has cinnamon fibre (mimetic), very fine (10-12 microns of diameter) very warming, particularly adapted to resist low temperatures.

The Vicuña: general characteristics

- The Vicuña produces about 200 grams of this fibre every two or three years.
- Its blood contains around 14 million red globules/cubic millimetre, that facilitate the absorbtion of the small ammount of oxygen in the air. Its feet has very smooth pads that avoids erosion of the lands. It can reach a speed of 45 km/h.

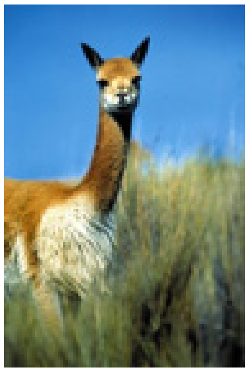
- The vicuña gestation period is of 11 months and produces just one baby vicuña per year, between February and April.

The vicuña: population and distribution

Country	Vicuñas	Percentage
Peru	149 500	61.5
Bolivia	57 905	23.8
Chile	13 528	5.6
Argentina	20 263	8.3
Ecuador	2 058	0.9
Total	243 254	100.00%

The vicuña fibre market and its derived products

- The vicuña fibre is consider the finest animal fibre of the world.
- The price of the partially free of hair vicuña fibre, ranges between 500 and 700 US$ per kilogram.
- The animal products are positioned in a very specific market, because of the very high price of the clothes and their special characteristics.
- More than the 90% of vicuña fibre is exported partially or completely free of hair. Finished products are barely exported.
- The main exportation markets are Italy, United kingdom, Germany and Japan and in the near future United States.



Development perspectives of vicuña fibre

- The vicuña potential is based on the sustainable management of its specie which allow a safety increase of the population and the production of the fibre, improving the safeguard and the control of the population against furtive hunters.
- The Peruvian Government, according to the international agreements (Vicuña Agreement and CITES that regulates the management of the species, the commercialization and the transformation of vicuña fibre), is executing through the CONACS.
- Several actions to accomplish the sustainable manage of the specie have been started.
- In the national South American Census, that will take place in 2005, we hope to count a population above 145 000 units.
- In economical terms, the vicuña manage is more profitable than the alpaca raising.

Camel production systems in Asia

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Summary

Due to uneven distributing of global population (i.e. 18.58) million heads, >80% camels are found in Africa. Asia is the second largest host of camelids where 70% population is found in India and Pakistan. Both dromedary and bactrian camels are found in Asia, however, former is in eventual majority. All camel habitats are unique ecological niches i.e. extremely marginalized and highly inaccessible temperate as well as tropical deserts. The physical / physiological uniqueness of camel enabled humans to inhabit these deserts. hence pastoralism involving exclusively camels or mixed livestock remains the dominant use of natural resources in arid and semi-arid ecosystems of Asia. Within these ecological specificities camel production is the mainstay of livelihood. Being extremely low input animal, the camel has been supporting the main subsistence needs of pastoralists across large-scale biological and geo-political diversities, Camel has been the key resilience animal species of pastoralists to absorb various external shocks particularly climatic and geo-political vulnerabilities. The adventitious vulnerabilities of camel pastoralists had led to various camel production systems.

The Camel Applied Research and Development Network (CARDN), Pakistan has documented the camel production systems in Indo-Pak subcontinent based on socio-cultural terms. Hence, three categories of camel pastoralists have been recognized which are migratory or nomadic pastoralists, transhumant or semi-migratory pastoralists and sedentary or household pastoralists. The International Livestock Research Institute (ILRI) has reported 10 global livestock production systems. The agro-ecologically based production systems are also directly applicable to camel production systems in Asia. The livestock production systems have been redefined in commercial context. These include a) traditional rural livestock production; b) commercial milk production; and c) desert / rangeland production. These are equally good to be used for camel production. The camel production systems have very recently been reported as following a) traditional system; b) peri-urban system; and c) ranching of camels. Although very complex issue, we need to define camel production systems based on universally agreed parameters.

As a consequence of vulnerability to external forces, socio-economic transformation of camel as well as other pastoralists is emerging as gradual phenomenon, hence, the treasures of biological as well as cultural diversity are at stake. This changing scenario is calling for appropriate collaborative research and development initiatives to optimize the general understanding of key external shocks like macro economic framework, demography and access to land & other natural resources, drought and other climate related events.

Key words: camel population, distribution, statistics, species and breeds, habitats, production systems.

Introduction

The camel was domesticated around 2500 – 3000 B.C. (Graham, 1996). It was believed that the dromedary camel was domesticated in southern Arabia, the north eastern part of Yemen and the west of Oman (Khan *et al*., 2003) Camels were the domestic animals of particularly nomads for the milk, meat and transport needs. However, the greatest cultural impact on the recent distribution of camel was the advent of Islam. The Arabs took their one-humped camels with them towards north east Asia and Mediterranean sea. Gradually dromedary emerged as food security animal in extremely harsh and arid sandy as well as mountainous deserts. The Muslims developed especial religious association with camel since it was quoted in the '*Quran*' as a gift for man from God.

The camel production was also strongly recommended in the pre-Islamic sacred religious books in Iran. Maqddam and Namaz-Zadeh (1998) reported the use of camel during ancient Iran era, hence contradicting the notion of the Muslims driven distribution of dromedary out of Arabian Peninsula.

It was believed that the bactrian camel was domesticated on the border of Iran and Turkmenistan and spread towards Mongolia and China (FAO, 1982). The bactraian camels were domesticated before 2500 B.C (Graham, 1996). Isani and Baloch (2000) found little or no knowledge about the domestication of two humped camel.

Camel population and distribution

The statistics of world camel population differs from source to source. The National Research Centre on Camel (NRCC), Bikaner, India reported in its website total 19.31 million camel, worldwide. It was further reported that there were 15.13 million camel in Africa, and 4.17 million in Asia. Based on camel population, various countries were ranked as following. Ist Somalia (6.2 million), 2nd Sudan (3.2 million), 3rd Mauritania (1.2 million), 4th Ethiopia (1.07 million and 5th India (1.03 million). Isani and Baloch (2000) cited 18.84 million camels throughout the world distributed over Africa (13.82 million), Asia (4.76 million) and 0.01 million in former Russian states. Khan *et al*. (2003) reported 18.58 million camels in the world i.e. Africa 13.62 million, Asia 4.76 million and Australia 0.2 million. They further mentioned that there were 1.2 million camels in Pakistan.

FAO (1978) estimated that there were 2.9 million camels in Asia and the regional camels population is summarized in Table 1.

Another website indicated camel population for various Asian countries as reported in table 2.

The camel population in Iran has decreased from 0.3 million in 1975 down to 0.14 million in 1998 (Moqaddam and Namaz-Zadeh, 1998)

More than 80 % of all dromedary population is found in Africa. East Africa contains about 63% of all old world camelidae. In Asia, about 70% of dromedaries are found in India and Pakistan.

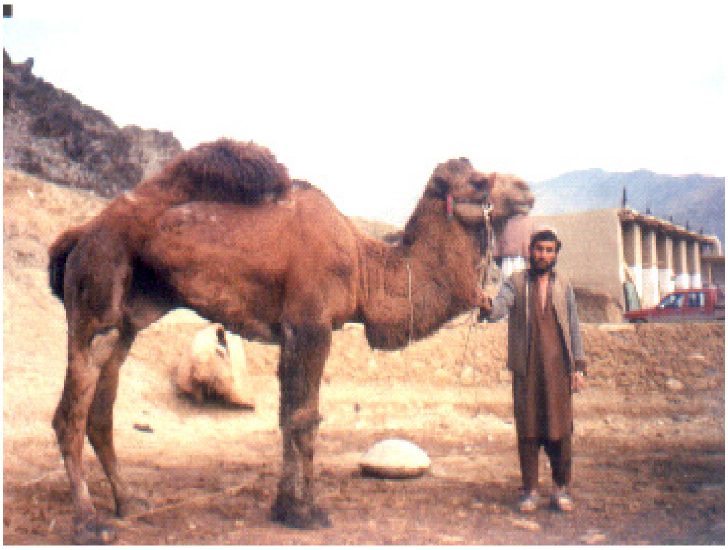
The statistic cited in above paragraphs is concerning single humped (i.e. dromedary) camel. Estimates for bactrian camels are scant. However, the bactrians are mainly found in central Asian states of former USSR and in China. More than 90% of the habitat of the bactrian camel lies in Inner Mongolia (China), outer Mongolia (Gobi desert) and the desert steppes of Kazakhstan. Bactrian is also found in northern Afghanistan and a few animals in Northern Areas of Pakistan (Isani and Baloch, 2000). This species has also been reported to a lesser extent in Iran and Turkey (Moqaddam and Namaz-Zadeh, 1998)

Table 1. Regional camel population in Asia (FAO 1978).

Country / Region	Million camel
India	1.2
Pakistan	0.8
Afghanistan	0.3
Iraq	0.2
Saudi Arabia	0.1
Iran	0.03
S. Arabian & Gulf states	0.02
E. Med. Countries	0.05

Table 2. A possible alternative composition of the Asian camel population.

Country	Million camels
India	1.52
Saudia Arabia	0.422
Yemen	0.18
UAE	0.16
Oman	0.094
Jordan	0.018
Kuwait	0.0086



Species and breeds

There are two species of camel, dromedary (*Camelus dromedaries*) or single humped camel and bactrian (*Camelus bactrianus*) or double humped camel Dromedary, commonly called Arabian camel has generally been categorized into three work classes i.e. racing camels, baggage or draft camels and milch camels. Modern breed description has rarely been applied for camel till the Camel Applied Research and Development Network (CARDN) initiated the spade work in this region. Under the auspices of CARDN, Isani and Baloch (2000) documented twenty breeds of camel in Pakistan based on morphological characteristics, habitats and geographical distribution. However, Khan *et al.* (2003) concluded that in depth research work was needed to verify the breed documentation of Pakistani camel due to gaps in knowledge and overlapping of characteristics of some local breeds, NRCC, Bikaner has reported three camel breed in India (Kachchi, Jaisalmeri and Bikaneri). Moqaddam and Namaz-zadeh (1998) cited four breeds of Arabian camel i.e. Torkammam, Baloochi, Bandari (Port) and Kalkooi in Iran. In Saudia Arabia the most commonly used classification for camel breeds is based on colours. In the former Soviet Union, all one humped camels are categorized as Arvana breed (Khan *et al.*, 2003). Lot of work on documentation of camel breeds in member countries of CARDN is in progress.

Three breeds of bactrian camel are recognized in the former Soviet Union i.e. Kalmyk, Kazakh and Mongolian. Khan *et al.* (2003). Moqaddam and Namaz-Zadeh (1998) reported long legged bactrian and short legged bactrian camels in Iran.

Habitats

Since its domestication, the camel has been a food security animal of subsistence oriented pastoralists in exclusively very harsh arid and semi-arid ecosystems. Due to its uniqueness, the camel emerged as key animal species of both cold and hot deserts. Because of specific adaptations, the Bactrian camels inhabited the cold arid deserts where as the dromedary camels encroached into warm as well as hot arid deserts.

The dromedary habitats

The dromedary accounts for 95% of total world camel population (Wardeh, 1996), hence this single humped camel is distributed over vast arid and semi-arid mountainous as well as plain areas in Asia.

Mountainous highlands

his habitat stretches over Afghanistan, north eastern Iran and Balochistan province and Sulaiman Rodkohi mountains of Pakistan. The climate is hyper arid to semi-arid where annual precipitation varies from 50 mm to ≥250 mm. Mountainous terrain is a dominant topographic feature of this habitat, hence animal grazing is an ultimate land use, however, along with minimal crop and orchard farming. Temperature regimes vary widely from cool temperate to sub tropical. Shrubby vegetation is classical characteristic of this habitat.

Sandy deserts

Rajestan in India, Cholistan, Thal and Thar deserts of Pakistan and sandy deserts of Saudi Arabia, Gulf States, and other middle eastern Arab countries are classical examples of this type of habitat. Sandy deserts are characterized by great daily variations in temperature, maximum being in summer rising to ≥ 41°C and sometimes as high as 50°C; minimum in January ranging from 3 to 8°C, with few frost days and relatively low humidity. These extreme temperatures are accompanied by hot and high wind velocity. Droughts and famines are frequent in these hyper arid to arid deserts. Mean annual rainfall ranges between 100 to 250 mm. The vegetation is essentially dictated by sand dunes formation.

The bactrian habitats

The two humped camel inhabits mainly the mountains of central Asia at altitudes of upto 2 000 m. It may be found at even higher altitudes under snow cover. Wild forms of bactrian are found in Gobi desert. The annual precipitation in the desert steppes of central Asia is 80 to 120 mm, hence extremely arid climate where winters are very cold. The bactrian camel is generally not found in temperature over 21°C.

Production systems

Camel production systems to be discussed here would be relating to the dromedary only. Historically, the production systems have been very extensive and migratory in nature. However, over the period, the traditional subsistence role of camel has been subject to visible changes throughout Asia. Thus, emergence of various production systems is a gradual phenomenon. The CARDN, Pakistan documented the most traditionally prevailing camel production systems in at least four countries i.e. Afghanistan, Iran, India and Pakistan. Socio-economic importance of camel is closely associated with existing production systems. These system are generally determined by climatic conditions, topography, plant phonology, water resources, socio-cultural norms etc.

Migratory production system

The migratory production is characterized by extensive animal husbandry in both mountainous and sandy desert habitats with following three basic features:

- Camel heads are diversified with other species of livestock like sheep, goat and donkeys. This strategy involves socio-economic considerations of a pastoralist family.
- Herds mobility is an obvious fundamental strategy for survival.

- It enables the pastoralist to share camel with other fellows of different areas incase of a natural disaster or less forage availability.

Based on differing migratory natures, the migratory production system is further divided into following two: a) Nomadic production; and b) Transhumant production.

Nomadic production system

True nomads are generally found in mountainous habitat of camels i.e. Afghanistan, Iran and Balochistan province of Pakistan. These nomadic pastoralists are infact international and migrate between at least two countries i.e. Afghanistan and Pakistan or Afghanistan and Iran. They follow seasonal patterns of forage production. They would spend summers in highlands of Afghanistan and winters in warmer and relatively low lands of Pakistan in Balochistan province and / or adjoining Iranian provinces. Nomads travel on historically / traditionally approved routes across open grazing lands with herds camping for a few days at a location. The camping duration would be linked with availability of range vegetation to animals.

These nomads are called '*Kuchies*'. The *Kuchies* have been facing great problems since the advent of Afghanistan crises. The present Afghanistan government is trying to address their problems at national as well as international levels. Due to security concerns, some of these pastoralists had opted to contain their movements within one country i.e. Pakistan or Iran, however, schedule and routes remain unchanged. In low lands, they enter into contracts with local farmers for buying stubbles, grazing rights, straw and other forage for their animals to mitigate feed shortage in winter. Meanwhile, they would work as labourer to support their family income through seasonal employment. These low lands also offer them an opportunity to market their surplus animals / products etc. Their backward migration coincides with the seasonal regeneration of vegetation in uplands. Usually they depart from winter places in early spring and reach their summer grazing areas in early summer.

There are three types of nomad camel herders.

1. *Nomadic camel herders*. They own pure herds of camels. Herd size may vary from 50 to few hundreds.
2. *Mix camel herders*. This type of nomad family would own on average 24 camels, 95 sheep and 32 goats. Three or four families usually keep their livestock together hence, making up herd / flock size of about 380 animals. Jasra and Isani (2000) estimated that these pastoralists generated 48% of their gross income by sale of live animals, camel services, 30% by marketing small ruminants and 8% by off-farm employment.
3. *Nomad pastoralists*. The livelihood of these partoralists is largely based on small ruminants (sheep and goat) production, however a normal family may keep more then one camel for travel and transportation of goods, household items etc.

Transhumant production

Transhumance is semi-nomadism and is also basically a migratory livestock production system. Some researchers have linked transhumance with shifting of tillage operations among rainfed area during certain seasons of a year. However, this definition does not necessarily apply on camel producers in all habitat as most camels are owned by small farmers, peasants or landless pastoralists.

The transhumant producers would always move between specific locations hence, their migrations follow fixed annual routes. In mountainous habitat, the local farmers in highlands would cultivate their rainfed crops mainly winter wheat and as soon as sowing is over, they would move alongwith their camels and other livestock down toward low lands, where they behave like true nomads.

The other category of herders is almost completely dependent on their camel herds as well as small ruminants. They are co-owners of common tribal rangelands and in most cases their migrations take place within the limits of their tribal lands. They may move from commonly owned rangelands to open rangelands as forage availability fluctuates and would usually return to their permanent dwellings during summer months.

Migration of camel herders from one place to another is a regular phenomenon in most sandy deserts. Seasonal migrations are primary feature of camel herders. The camel production practices vary among tribes, however, two practices are generally recognize.

1. *Wandering camel herds.* The pre-monsoon period i.e. April to June in sandy deserts of Indo-Pak is very hot and harsh. Just to avoid high labour input in hot summer, few tribes would execute jointly the wandering camel grazing scheme till the onset of monsoon in July. They would let their camel herds un-attended to graze freely in desert however, would appoint duty persons at watering wells distributed

over the desert. These duty persons would wait for thirsty camels to offer them water. With the onset of monsoon rains, all watering ponds are filled in hence the duty persons on wells are no more needed and camel herds keep grazing the lush green desert as free roaming animals. Sometimes in October, the post monsoon period, all tribes put up a search for their camel herds and drive them back to their settlement. During winter, their grazing movements are watched since it is the breeding season.

2. *Watched camel herds*. Some tribes never leave their camel herds un-attended in desert. They would migrate to riverine banks and / or adjoining irrigated plains during the pre-monsoon period to avoid harsh hot weather and to feed their animals from unconventional feed resources. The migration period may vary from three to six months, however these pastoralists would return to desert as soon as monsoon is commenced.

Sedentary production system

This kind of pastarolists are permanently settled. They own mostly cultivable land and keep other animal species like sheep, goats, cattle etc alongwith camels. Herds are rarely moved far away from their base area. These camel producers are generally subsistence oriented small farmers, peasants, landless tenants and camel is their main traction / draft power source to undertake tillage and other agricultural operations. They would one or few camels / family.

Sedentary camel producers are found throughout mountainous region, sandy deserts and irrigated plains of India and Pakistan. However with the influx of tractors, the role of camel as a source of traction power is considerably declining. The classical example in this regard is the Thal sandy desert in Punjab, Pakistan, where camel used to be prime draft animal. However, since 1980's camel has gradually been knocked out by tractors and allied machinery.

In Indo-Pak subcontinent, the dietary preference of local people for camel milk and meat has been very low as compared to other animal species. Hence, the value of camel as milch and meat animal never got a boost for exploiting its commercial aspects. Although camel milk and meat are consumed at domestic level, but marketing of both is not customary. Camel meat is sold by mixing with other beef and similarly camel milk is mixed with cow / buffalo milk for selling. Thus, such environment discourages commercial camel production for camel products. However in Afghanistan and Western mountain ranges of Pakistan, the preference for camel meat is relatively higher than in sandy desert and irrigated plains. Thus, there is absolute need to promote camel milk and meat as delicacy, for example for diabetic persons, however, based on sound research findings. Unless the commercialization of camel milk and meat is targeted, the camel production in south East Asia would remain at subsistence. The camel producer would continue to stay below poverty line and most probably the camel population would drastically decline in coming few decades.

ILRI defined 10 livestock production systems for the developing world. The description of each system is primarily based on agro-ecological classification (Thorton *et al*., 2002). In Pakistan, three livestock production systems have been reported which are a) Rural livestock production b) Desert/Rangeland livestock production and c) Commercial milk production. The former two are infact sedentary and migratory production systems as defined by Jasra and Isani (2000), however, the latter one is recent development applicable to commercial cattle/buffalo dairy farmers (*www.pakissan.com*). These are equally good to be used for camel production. Khan *et al* (2003) have reported the camel production systems as following:

1. Traditional system.
2. Peri-urban system.
3. Ranching and
4. Research system.

Most of these systems do not describe properly the camel production systems in Asia. Hence, there are so many ways to define camel production systems and there is need to define universally agreed parameters in this regard.

Conclusions

As a matter of fact, the CARDN work in Pakistan has been taken as case study for the dromedary production systems in Asia. Jasra and Isani (2000) identified following major constraints for camel development;

1. **Issues of production systems.** Majority of camel herders (90%) inherit this profession from their ancestors of subsistence economy. Though they are well versed with camel raising yet their indigenous camel production system need up-gradation based on modern animal husbandry practices keeping in view a shift from subsistence level to commercial camel production.

2. **Management specific constraints.** The primitive approach of camel management in all three production systems (i.e. nomadic, sedentary and transhumant) manifested in general poor feeding of animals, hence slow growth rate, delayed maturity, long calving interval, low calving rate and high disease incidence are common constraints on camel productivity. Mean pubertal age of females was reported as five years. Average calving rate ranged between 70.6% to 82%.
3. **Socio-economic implications.** 88 to 94% camel herders are illiterate. For usual farm operations in mountains > 50% respondents preferred camel over bullocks. Majority camel producers are below poverty line and their livelihood focus is subsistence.
4. **Marketing concerns.** In sandy deserts, 21 to 100% camel herders reported problems with marketing of camel milk and meat during survey. Upto 60% reported middlemen exploitation. More than 80% of respondents in coastal areas reported low marketing prices for their animals and no government control on market operations.
5. **Disease problem.** High incidence of parasitic as well as infectious diseases in camel herds was reported as serious concern. Trypanosomiasis was reported in 30 to 45% of sample camels population of coastal zone. Similarly, 28 to 50% respondents of irrigated Punjab reported Surra. Mange and Ticks were reported by upto 98% respondent camel herders. Among infectious diseases Pneumonia was widely reported.
6. **Veterinary extension service.** In sandy deserts, 45 to 100% respondent herders were using traditional medicine for sick camels. More than 65% of respondents were un-satisfied with a general treatment of diseases. None of the respondents drenched his animals against parasites or treated again Trypanosomiasis.
7. **Policy implication.** At both policy level (i.e. federal as well as provincials), the livestock sub-sector has traditionally been given low priority within agricultural sector. And under livestock sub sector, the camel had been victims of neglect by both research and development functionaries.
8. **Technological deficiencies.** There is severe deficiency of camel specific and appropriate technological packages for camel herders to construct a track for camel development.
9. **Gender issues.** Women were rarely involved in marketing of camel and their products and were mostly not consulted for decision making. Majority of women were unaware of the concept of development and an increase in number of animals was development for them.

9\. **Machinery threats.** Camel is quickly loosing its traditional draft value. Mainly against machinery and tractors over the past thirty years. It was estimated that machinery and tractors had taken over almost 50% of camel draft power responsibility in terms of transportation and agricultural operations in sandy deserts. Under this scenario, the traditional camel production systems may not sustain too long.

11. **Drifting of production systems.** The second phase survey revealed that all three traditional classes of pastoralists (i.e. nomad, sedentary and transhumant) were subject to transformation in one or other way in Balochistan Province, the largest camel habitat. Expanding cultivation under government policies is gradually restricting movements of free roaming flocks / herds. Nomads were found highly vulnerable to external forces. It was further concluded that the drift in traditional pastrolists' production systems was conclusively occurring because of changes in overall household as well as community economic structures and part of survival strategy under given socio-political and biological constraints.

This scenario is calling for commercial camel production, however, a rough task due to a little market demand for camel milk and meat.

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Camel genetic resources in North Africa

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Introduction

The dromedary (*Camelus dromedaries*) has demonstrated its high adaptability to the most rigorous environments in North Africa. Its ability to grow on feed that is not regarded as sustenance for most other domestic animals made the dromedary a special component for marginal, arid and semi-arid ecosystems. The dromedary, or Arabian Camel, is one of the six species in the camelidae family, along with the bactrian camel (*Camelus Bactrianus*), Llama, Alpaca, Guanaco and Vicuna. The dromedary populates the semi-arid and arid tropical and subtropical regions of Africa and Asia and other regions like Australia. The Bactrian is found in regions of Asia with a colder climate and is well suited to high mountainous regions. Both types of animals have provided man with animal protein and energy and given nomads immense mobility (Knoess, 1979). The Arabian Camel has one hump and it is adapted to the desert conditions. The term 'dromedary' is derived from the word *dromos* (Greek for "road"). Even though considerable research work has been done on health, nutrition, anatomy, physiology and reproduction, dromedary productivity is still low and new innovative management practices are mostly needed. The association of camels, in general, with harsh environments and the lack of appropriate genetic management strategies did not help camels reach a better economic status when compared with their counterparts, such as cows, sheep and goats. The objectives of this article were: 1) to describe the dromedary population in North Africa, and 2) to propose a plan of action for dromedary improvement in the region.

North Africa population trends

North Africa has a population of about 78 million inhabitants which represents 28% of that of the Arab countries and 15% of all the Mediterranean basin. This population has been multiplied by 2.4 times since 1965 with an average annual growth varying from 2.26 in Tunisia to 3.76 in Libya (Table 1). The urban population growth rate has been increasing during the period 1965-2000 by 3.76, 2.96, 2.82, 2.56, and 2.26 per year in Libya, Algeria, Morocco, Mauritania and Tunisia respectively. The ratio (Agricultural Gross Domestic Product : Gross Domestic Product (AGDP/GDP)) was between 12-13% in Algeria,

Table 1. North Africa total population.

Country	1965	1995	2000	2000 (%)	Increase 1965-2000
Algeria	11 923	27 655	30 291	0.39	2.96
Mauritania	1 096	2 275	2 665	0.03	2.82
Morocco	13 323	27 213	29 878	0.39	2.56
Libya	1 623	4 755	5 290	0.07	3.76
Tunisia	4 630	8 943	9 459	0.12	2.26
Total	32 595	70 841	77 583	1	

Morocco and Tunisia. The GDP per inhabitant was $5 349, $2 238, $1 580, and $1 193 in Libya, Tunisia, Algeria and Morocco respectively (MED AGRI, 2002).

Improvement of standards of living in the region, combined with a high population growth rate and a high rate of urbanization has caused a massive increase in demand of livestock products that native breeds could not satisfy. This situation resulted in the importation of exotic specialized breeds and intensification of livestock production systems, especially in dairy cattle and poultry. Little is invested in camel production development.

North Africa farm animal resources

North Africa is home of a very rich animal resources biodiversity of small ruminants, cattle, equines and camels that have been adapted for centuries to a variety of environments encountered in the region (Table 2). Approximately 2 millions of camels are raised in the region. It is quite difficult to have exact camel numbers within each country because of the movement of camels among countries. This is why it may be more interesting to see the total camel population size within the region and not within a given country per se.

Farm animal resources play many agricultural roles in the region (food production, social, employment, traction, fuel, fertilizer, bank, culture, tourism). The livestock sector contributes around 30-35% to the GDP.

Livestock food production

Total camel milk and meat production in the region are reported in table 3. Mauritania has the highest camel population size and it is the highest producer of milk and meat (FAOSTAT, 2003).

Total production of meat and milk by country and by species in the region are mainly coming from other species (Figures 1 and 2). Poultry, sheep and cattle contribute approximately by 45%. 30% and 24% respectively to the total meat produced. Milk production is mainly coming from dairy

Table 2. Livestock numbers in North Africa (in 1 000 heads) and percentages.

Country	Sheep	Goats	Camels	Cattle	Horses	Asses
Algeria	0.34	0.20	13	0.25	0.17	0.13
Mauritania	0.12	0.25	70	0.21	0.06	0.10
Morocco	0.30	0.34	2	0.40	0.46	0.61
Libya	0.12	0.13	2.5	0.02	0.14	0.02
Tunisia	0.12	0.08	12.5	0.12	0.17	0.14
Total	53 750	16 783	1 851	6 718	327	1 595

Source: FAOSTAT, 2003.

Table 3. Camel milk, meat and leather production (Mt).

Country	Number (1 000 heads)	Milk	Meat
Algeria	245	8 000	3 400
Mauritania	1 292	22 000	20 000
Morocco	36	3 800	2 000
Libya	47	2 000	3 500
Tunisia	231	1 000	1 400

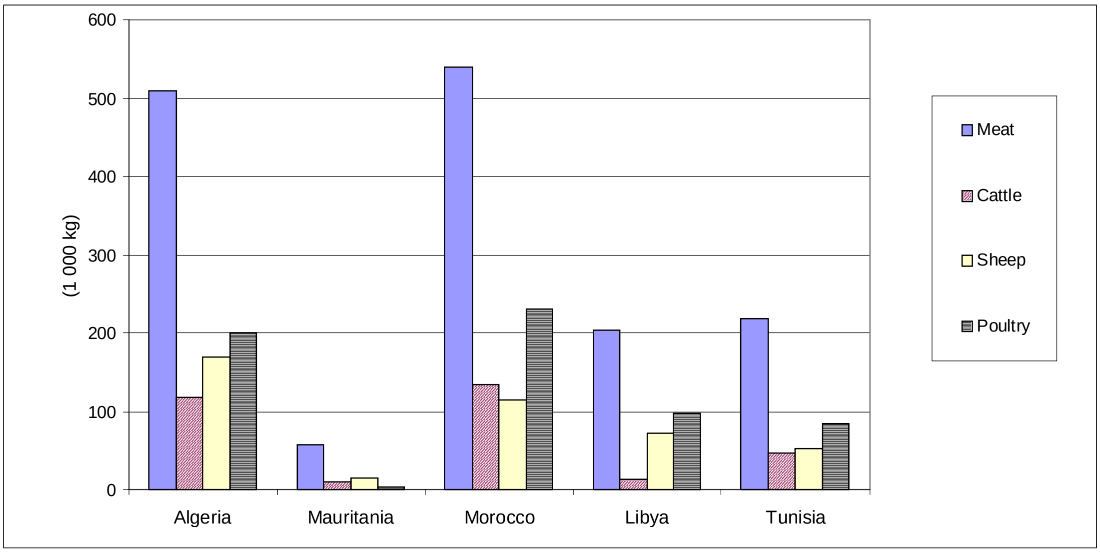

Figure 1. Meat production in North Africa by species.

cattle in all North African countries, exception made for Mauritania, where the three species (cattle, sheep and goats) contribute almost equally to the total milk produced.

In the case of camels, it should be understood that the lack of a complete evaluation of its potential led to an underestimation of its real capacity to produce meat and milk. As reported by Kamoun in 1995, the daily

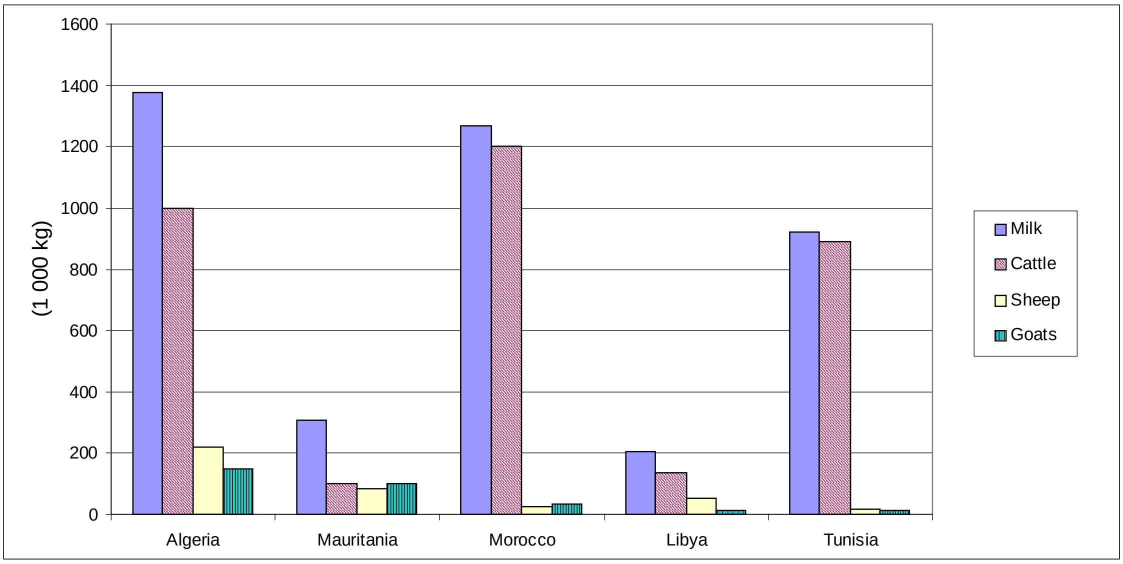

Figure 2. Milk production in North Africa by species.

milk increase can reach 28.5% when the number of milking changes from 2 to 3 per day. The part taken by the young camel should also be measured accurately in order to assess the total milk produced on average by lactation. There is no doubt that variability in production potential does exist among and within camel breeds (Ismail and Al Mutairi, 1998). This variability can be very useful for screening productive animals under harsh conditions. In Tunisia, Kamoun *et al*. (1990) reported milk yield averages varying from 1 000 to 2 700 kg.

Importance of camels in the region

Data on the actual amount of milk produced from camels in the region by lactation are not known very accurately for judging their milk-producing capacities. However, they are valuable animal genetic resources and constitute an indispensable natural resource that must be properly managed due to their unique characteristics especially under the most stressful conditions. As awareness of the importance of animal resources and food safety has increased in the region as well as worldwide, agricultural development and food security are becoming the main components in most countries' agricultural policies. It is becoming clear that the food security argument is putting additional value on local agricultural products, irrespective of their opportunity costs. The strategic idea is to minimize the country's dependence on external food supply sources and produce a product that can be traced back regarding its origin. This choice should allow camels in the future to regain economic importance. If a sharply rising population in the developing countries is to achieve higher real incomes and a better quality of life, agricultural output must rise more rapidly than population growth. In order for the rise in agricultural output to be maintained over time, natural resources, including camels, which provide the basis for such output must be preserved and new technologies offering higher productivity must be developed.

Genetic considerations

The adult Arabian camel weighs between 450 to 650 kg and its height varies from 190 to 230 cm. Various types are encountered. In Tunisia, the most common name of the breed is “Maghrebi”. The adult live weight of males is 450 kg on average while for females it is 400 kg. Algeria has 9 camel varieties in total (Chaambi, Chameau de l’Aftout, Chameau de la Steppe, L’ait Khebbach, L’ajjer, Ouled Sidi Cheikh, Reguibi, Sahraoui and Targui). Their adult live weights vary from 600 to 700 kg on average. Their milk yield is 1100 kg on average and days in milk are 345 days on average (DAD-IS, 2004). In Mauritania, there are 2 varieties: Chameau de l’Aftout and Chameau du Sahel. In Morocco, four varieties are encountered: Jebli (central atlas and anti atlas) Khaouri, Marmouri and Sahraoui. Milk yield of these types varies from 500 kg in 180 days to 2 500 kg in 720 days (DAD-IS, 2004)

Almost no research has been done on a multidisciplinary way including genetic improvement aspects as to the capacity of the camel to produce milk and meat under drought conditions or under conditions where human nutrition is so precarious. No thought is given concerning the genetic ability improvement of this animal to produce food in severe drought periods.

Looking at camels from a genetic point of view will soon clarify why camels did not progress the way cattle, sheep and goats did in developed countries. While developing countries are trying to follow the steps of developed countries in breeding strategies for cattle, sheep and goats, the situation is completely different for the camel case because the camel is mainly encountered in developing countries. This situation did not stimulate developing countries to investigate more the breeding component in camels. The latter (Genetic improvement component) with all its organizational aspects (Breed Associations, legislature, etc) is still not considered as a priority for animal improvement when compared to health, nutrition and feed resources. The common view is expressed that there is no need to worry about genetics until management is sufficiently improved to allow full expression of the existing available genetic potential. This view, however, fails to recognize that an animal population is dynamic in nature (culling and replacements) and that genetic variability does exist in any given environment. Therefore, the notion that there is a genetic potential for each level of management is conceptually and practically more accurate (Falconer, 1996). The absence of national recording systems and the lack of reliable breeding strategies have been for long time major limitations to improvement. This explains the absence of specialized breeds in camels. The main traditional typology classifies camels into riding and pack types. A further typology allows camels to be classified as lowland or mountain types (Lease, 1927). These classifications assign little importance to the main products (milk and meat). Recent attempts have categorized camels into types comparable to those applied to cattle (beef, dairy, dual purpose and racing) (Wardeh, 1991). This could build a new way of orienting research work in camels and allows the development of breeds based on main products rather than tribe names.

A plan of action

Breeding programs have been successful in developed countries because they serve real needs and they were designed on solid bases, i.e. identification of economic objectives, recording, genetic evaluation, dissemination of favorable genes and breed or farmers' associations backed up by reliable research institutions. Well-trained people and caring breeders, working together in harmony, have made breeding programs successful and essential for their breed improvement in a sustainable way. These considerations should be taken into account for camels in the future. In order to improve their productivity, a complete strategy, including technical and organizational components, should be implemented according to the prevailing production systems or society use as follows:

Technical component

1. Identify types of breeds (meat, milk or dual purpose, racing) based on:
   - Number.
   - Production system.
   - Community preference.
2. Develop a breeding strategy for each important breed that includes:
   - Breeding goals.
   - A simplified reliable recording system.
   - Reliable genetic evaluation methods.
   - A plan for dissemination of results and wanted genes.
   - An evaluation of management progress and genetic trends in the recorded herds on a yearly basis.
3. Implement a sound management program (nutrition, health, etc) specific to each proposed breeding strategy.

Organizational components

In order for the technical components of the strategy to be maintained on a continuous basis, the following organizational steps should be followed:

1. Create a national/regional association for the chosen breed with the recorded herds taken as the breed nucleus.
2. Educate and design training programs for nationals who will have the responsibility of implementing the breeding strategy and advising the breed or farmers' association.

3. Increase the awareness of administrators in Ministries of Agriculture about the importance and potential of the genetic management of the breed and the role of the associations in promoting the breed. This could be achieved through special short courses (Cunnigham, 1987)
4. Build working links between the association and specialized national research institutions.
5. Use the association as a framework for extension programs to enhance the multidisciplinary involvement (nutrition, genetics, socio-economics, environment and marketing) and to develop services and technology transfer to farmers. National legislatures could help enhance this type of organization. International organizations like ILRI, ICARDA, ACSAD and the FAO have a lot to offer in the field of education and training in animal breeding, management and breed associations organization. They can play a facilitating role in bringing key people and national institutions together to implement and manage the proposed strategy. It is important to stress again that the proposed plan of action considers the breeding component as a leading issue due to its dynamic nature in a sustainable way and the amount of information that it generates. The breed / farmer association is taken as a framework through which any program (nutrition, health, range improvement...) aimed at improving the breed can be implemented. It is also essential to note that all the mentioned actions should be taken into account together in order for the strategy to be successful (Djemali & Wrigley, 2002). Resource requirements for the implementation of the strategy could be partially fulfilled by farmers' participation.

Organizational aspects

During the past three decades, most developing countries have established an institutional infrastructure for livestock development research: extension, veterinary laboratories, disease control services and educational institutions at various levels. The technical performance of this infrastructure varies from country to country and from institution to institution. The development concern these days is not so much about the capacities, in terms of physical infrastructures or size of trained manpower, but about the usefulness of this capacity in improving farm output. One of the alternatives to enhance this capacity resides in the establishment of coordinating mechanisms among different active forces working in agriculture within countries as well as at regional and international level. The future of local livestock breeds in general and camels in particular depends on the steps taken today toward their improvement. Van Vleck (1987) reported that the true model in studying livestock traits should be defined as y = f (genotype, environment, people). It is the organization of people for the benefit of their animal resources (breed or scientific associations) that generates progress at the productivity level and ensures its sustainability. Successful examples are seen in the developed world (European Association for Animal Production, American Dairy Science Association). This is why it is very important that national livestock scientists in countries with arid and semiarid climatic characteristics should join their efforts in order to create mechanisms that allow them to meet regularly to present, discuss and exchange information on topics relevant to the conservation and improvement local breeds.

Conclusions

The potential of camels as a food producer in the region should be studied, utilized and improved. The absence of reliable genetic strategies is a real handicap for camel development. A plan of action is proposed considering the breeding component as a leading issue and a generator of useful information with the breed / farmer association taken as a framework for extension programs and a larger multidisciplinary involvement. In order for the camel industry to benefit from science, dynamic mechanisms should be established to bring together livestock scientists working in arid and semi arid areas to facilitate exchanges of findings, avoid redundancy and set up research priorities relevant to local animal breeds in general and camels in particular.

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Camel genetic resources in Morocco

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Introduction

In the kingdom of Morocco, the camel (*Camelius dromedarius*) is considered as an important national resource that deserves to be protected and not neglected. The reason is that camel husbandry contributes largely to the socio-economic life of herders in large part of the country, especially in the desert areas. In addition, camel husbandry has a considerable role in providing subsistence and transport for the Saharan population, in spite of the observed reduction of the number of camels during the last two decades.

In Morocco, the number of camels is estimated at 150 000 heads (survey of 1998) with 106 200 females at the age of reproduction. 58% of camels are found in the southern Saharan regions and 26% in the east-west band from Ouarzazate to Figuig passing by Rachidia. In these regions of Morocco, camel livestock plays a considerable role among the population activities, being the main factor of production, consumption and source of income for the herders. The number of herders is estimated at 19 000. Meat production averaged 5 000 tons in 2000, which is maintained constantly during the last decade.

Key words: identification, characterisation, Guerzni type, Marmouri type, Khouari type, genetic markers, milk production,

Research background

Since 1985, several camel development programs have been developed by the Ministry of Agriculture in order to improve the productivity of this species in the regions of high concentration. The aim of these development programs was to improve meat production efficiency while milk production efficiency was also considered in some urban regions where the demand for milk is very high (Lahyoune, Boujdour and Dakhla). The camel production development programs were supported by research studies in laboratories and fields conducted by specialized institutions, particularly the Institut Agronomique et Vétérinaire Hassan II with a financial contribution of the Ministry of Agriculture. The research program focuses mainly on topics dealing with nutrition, reproduction, diseases and production parameters of different varieties of camels found in Morocco. The laboratory Research studies are conducted at the specialized labs of the Institut Agronomique et Vétérinaire Hassan II and the field research studies are performed at the

Camel Research and Development center created by the Ministry of Agriculture at Lahyoune (south of Morocco) to do research studies in the field under the Saharan environment.

Identification and characterization of Moroccan camels

Methodology

The present work was carried out in all Moroccan regions where the camel herding was practiced. It included data on surveys made with camel herders and determination of morphologic and genetic criteria.

1. Surveys. The aim of the surveys with herders was to bring out the different criteria (color, size, productivity and endurance) used to identify the camel varieties and to figure out the possibility of a better utilization of these criteria.
2. Morphometric measurements. These measurements, made on the body of the animal, included:
   - Shoulder height.
   - Body length.
   - Body girth (abdominal, thoracic and at the hump).
   - Coxal width.
   - Head length.

   The data collected were compared to the survey data and then processed in order to come up with a formula that allows identification of the different camel breeds.
3. Genetic markers. This technique is based on the determination of protein markers in the blood cells and plasma. It was used to make genetic separation or grouping of the different camel varieties identified through the morphometric studies.

Description of the phenotic characteristics

The skin was mainly dominated by the brown colour (from light to dark). However, there was a minority with a white skin, while some individuals were albinos. Different colours of the ear were found on the same skin. The main skin colours which were used to differentiate between the types of camels are showed in the photos.

Morphologic measurements

The majority of camels measured have a shoulder height of less than 180 cm, indicating that this group of camels belong to the draught and transportation type, since the ride camel has a shoulder height of more than 180cm, especially in males. Body length of measured camels averaged 134 cm and coxal width averaged 41 cm. These measurements did not allow distinguishing between the groups of camels. Body girths (abdominal, thoracic and at hump) were well correlated with body weight and the best correlation was obtained with the hump girth:

$$BW(kg) = 2.96 \times HG\ (cm) - 282.76;\ r^2 = 0.86.$$

The morphologic measurements were helpful in estimating body weight and in distinguishing the 2 types of the camel population: the Marmouri type (20%) and the Guerzni type (60%). The crossing between the two types has given a third type named Khouari (20%).

- *Guerzni Type*. This is the heavy type, which makes up the majority of camels maintained by nomads. It is a pack camel with small size, teak skin, abundant ear and well-developed hump. A mature animal weighs about 400 – 500 kg. Females have small mammary glands but are more adapted to harsh environments.
- *Marmouri Type.* This is the type that is used for riding. It is lighter in body weight, with long legs, a well-developed neck, and a small hump. It has a thin skin with less abundant ear. Females have well-developed mammary glands but they are very sensitive to harsh environments.
- *Khouari Type.* This is the product of crossing between Guerzni males and Marmouri females. The Khouari type has morphological and physiological characteristics similar to the Marmoury type.

Genetic markers

A limited number of studies were performed by looking at some genetic markers in the blood that can separate between dromedary types. Some genetic markers were tested and the information collected was not convincing. The blood groups were not identified in dromedaries; it seems that most camelids of Africa and Asia belong to the same group (B) while small camelids of South America showed six blood groups: A, B, C, D, E and F.

Studies on biochemical polymorphism, especially protein polymorphism, showed a very small genetic variation between dromedary types. No differences were observed on some blood enzymes such as: D-esterase, isomerase gluco-phosphatase, dehydrogenase phosphoglutanate and some blood proteins such as: Albumin, Transferin, and protein transporting Vit D. Some variations in hemoglobin and beta-lactoglobin were detected in dromedaries of different types of Somalia and other variations in albumin and haptoglobin were reported in the Sudanese dromedaries. Concerning catalase, opposed opinions are reported in the literature. In India, no polymorphism of milk protein was detected but differences between breeds were observed in phosphatase and amylase of milk. These results may indicate that dromedaries have very few genetic variations of blood markers of protein origin, which makes this animal very special when compared to other domestic species. The use of DNA typing, based on molecular biology, remains the best technique to detect genetic differences between dromedary types or breeds.

Performances of milk production in the two main types of dromedaries found in Morocco

Camel production was known as an extensive production based on grazing large areas with poor vegetation. However, with urbanization and high demand for camel products, herders developed new intensive systems for fattening and milk production. These systems require daily feed supplies. Therefore, and with the absence of specific feeding standards for lactating camels, cattle nutrients requirements were used instead. Studies dealing with nutrient requirements of camels at maintenance and fattening (Guerouali *et al.* 1992) showed estimates of feed conversion coefficient different from those reported for cattle. The aim of this work was to estimate the coefficient of transformation of nutrients into milk of the two type of camels and to compare growth rates of calves belonging to the Marmouri and Guerzni dromedaries.

Materiel and methods

Eight lactating camels (4 Marmouri and 4 Guerzni) with an average weight of 450 kg and an average age of 8 years were used. Camels were housed individually and fed a ration composed of 65% forages and 35% concentrate distributed in two equal meals per day (Table 1). The ration was analysed and estimated to correspond to 2.5 maintenance energy requirements (Guerouali *et al.* 1993) with 17% of crude proteins. All animals had free access to drinking water. The camels were adapted to the respiratory gas collection chamber and to the milk production estimation technique prior to the experimental period. The experimental design was based on the continuous measurement of the oxygen consumption for 24 h at the peak of lactation. Oxygen consumption was determined by flush through indirect calorimetry and energy expenditures were estimated by the equation developed by Mclean (1972):

$$HP = O_2 \text{ consumption x } 4.89$$

Milk production was estimated by weighing the offspring before and after suckling (for 15 min) three times per day for three successive days. Milk energy was estimated from daily milk production and the energy concentration of camel milk (3.46 MJ/kg) as it was estimated by Guada *et al* (1985). Metabolizable energy intake was estimated from the amounts

Table 1. Dry matter, metabolizable energy and crude proteins of the feeding ration fed to lactating camels.

Ration composition	Fresh matter (kg)	Dry matter intake (kg)	Metabolisable energy intake (Mj)	Crude proteins (g)
Ground barley	3	2.64	34.40	363
Sun-flower meal	1	0.90	6.11	380
Wheat straw	2	1.80	15.23	70
Alfalfa fodder	30	4.10	33.51	999
Total	46	10.44	89.25	1 812

of feed consumed and their digestibility and metabolizability was taken from the literature (INRA, 1988). The amount of MEI of all lactating camels was comparable during the peak of lactation and was estimated to average 89.25 Mj/d. Energy Balance (EB) of camels was calculated by subtracting Total Heat Production (THP) and milk energy (LE) from metabolizable energy intake (MEI):

$$EB = MEI - (THP + LE).$$

Results and discussion

All feeds offered to lactating camels were consumed except some perturbations in alfalfa intake and metabolizable energy intake averaged 88.25Mj/d in the Guerzni type and 90.25 in the Marmouri type (Table 2). Total heat production of camels, averaging 59.17Mj/day, did not change significantly with the camel type. This amount of heat production was about twice the amount reported in camels at maintenance (Guerouali *et al*. 1993) indicating that the physiological stage of lactation is at least twice demanding in energy expenditures compared to the maintenance stage.

Milk production in Marmouri was significantly higher than in Guerzni camels and averaged 5.95 ± 0.48 kg /camel/day (Table 3). Higher camel milk production was reported in the Malhah (9.3 kg/d) and Wadhah (8.94kg/d) breeds in Saudi Arabia (Basmail *et al*, 1994) and lower milk production (3.6kg /d) was reported in Niger (Saley *et al*. 1994). Energy contents of camel milk, estimated from its composition, averaged

Table 2. Metabolizable energy intake (Mj/d) and total heat production (Mj/d) in camels at the peak of lactation.

Camel identification	Metabolizable energy intake	Total heat production
Guerzni type		
A	85.6	50.68
B	87.4	59.34
C	88.7	53.95
D	91.3	63.17
Mean	88.25	56.785
SD	2.40	5.56
Marmouri type		
E	93.6	63.29
F	89.2	64.9
G	90.5	59.49
H	87.7	58.52
Mean	90.25	61.55
SE	2.5	3.04

Table 3. Milk production and its energy concentration in lactating camels.

Camels identification	Milk production (kg/d)	Milk energy (Mj/d)
Guerzni		
A	5.83	20.19
B	5.62	19.48
C	5.2	18.11
D	5.58	19.36
Mean	5.5575	19.29
SE	0.23	0.75
Marmouri		
E	6.2	21.4
F	5.94	20.54
G	6.53	22.48
H	6.76	23.24
Mean	6.3575	21.915
SE	0.313	1.028

3.46 Mj/kg and had more energy than cow milk (3.02 Mj/kg) and goat milk (3.16 Mj/kg) but less energy than ewe milk (4.52 Mj/kg). Lactating camels received an amount of MEI corresponding to 2.5 times that for maintenance energy requirement and showed a positive energy balance at the peak of lactation with about 9.5 Mj of daily tissue energy deposition (Table 4). This energy partition of lactating camels was different from that commonly observed in dairy cattle which usually have a negative energy balance at the peak of lactation. In fact, at the peak of lactation, high producing dairy cows can mobilize daily up to 1.5 kg of lipids and 200g of proteins from their body reserves to satisfy their needs for milk production (INRA, 1988). Lactating camels, however, showed body reserve conservation and even development at the time when the animal was in high demand of energy for milk production

This conservation process might be one of the adaptation strategies of the camel for surviving under difficult conditions in the desert. With the development of an intense camel production system (modern camel farms) and a genetic selection, it is possible to have an improvement in milk production in the lactating camels through body reserves mobilization as it was experienced in dairy cattle (Chupin *et al.* 1993). With lower milk production and total heat production, the Guerzni type showed more body tissue energy retention when compared to the Marmouri type. The energy balance was more positive in the Guerzni type with 12.18Mj/d than in the Marmouri type with 7.79 Mj/d. The efficiency coefficient of utilisation of MEI for milk production was estimated based on the following considerations:

Table. 4. Energy balance in lactating camels at the peak of lactation.

Camel identification	Metabolisable Energy intake (Mj/d)	Total heat production (Mj/d)	Milk energy (Mj/d)	Energy balance (Mj/d)
Guerzni				
A	85.60	50.68	20.19	14.73
B	87.40	59.34	19.48	8.58
C	88.70	53.95	18.11	16.64
D	91.30	63.17	19.36	8.77
Mean	88.25	56.79	19.29	12.18
SD	2.40	5.56	0.86	4.12
Marmouri				
E	93.60	63.29	21.40	8.91
F	89.20	64.90	20.54	3.76
G	90.50	59.49	22.48	8.53
H	87.70	58.52	23.24	5.94
Mean	90.25	61.55	21.92	6.79
SD	2.51	3.04	1.19	2.41

- Metabolizable energy intake can be partitioned into metabolizable energy for maintenance (MEm) estimated to average 32.40 Mj/d in 450 kg lactating camel (Guerouali *et al*, 1993) and metabolizable energy for production (MEP).
- MEP = MEI – MEm = 89. 25 – 32.40 = 56.85 Mj/d.
- Since the lactating camels were producing milk and at the same time gaining weight, metabolizable energy for production can also be partitioned into ME for milk production (MEL) and ME for body tissue deposition or growth (MEg). MEg was estimated from the amount of energy deposited in maternal tissue (estimated from the energy balance) and the efficiency coefficient of utilisation of ME for gain calculated in other studies (Guerouali *et al*, 1993) to average 61%. Metabolizable energy used for body tissue deposition

  MEg = 9.48 /0 .61 = 15.54 MJ/d.
- ME for milk production was determined as the difference between the ME used for production and the ME used for body tissue deposition.
- MEL = MEp – MEg = 56.85 – 15.54 = 41.31 Mj/d

The daily amount of milk energy in lactating camels was calculated at an average of 20.60 Mj/d and the ME used for milk production was estimated at 41.31 Mj/d on average. The efficiency coefficient of utilisation of ME for milk production (Kl) is defined as the ratio between the energy deposited in the milk and the ME used for milk production.

Kl (%) = 20.60 / 41.31 * 100 = 50 %.

Efficiency lactation of 50% is reported for the first time in camels and was lower than the efficiency reported in dairy cattle, varied around a mean value of 62% (Moe *et al.* 1972). Precise estimates of Kl for different species could not be averaged because of the significant effect of the diet composition and digestibility. Kl averaged 61% in cows fed low quality forages and 72% in cows fed high quality forages (VanEs, 1975). Kl varied from 51% to 66% in the same cows receiving diets of different composition (Hoffman *et al.* 1972).
Kl estimated in lactating camels was generally lower than most values of Kl reported for dairy cattle indicating that camels were less efficient in transforming MEI in milk energy. The determination of the efficiency coefficient of utilization of MEI for milk production allowed the estimation of energy requirements of lactating camels producing 5 kg of milk at 4% fat (Table 5).
Lactating camels averaging 500 kg required 65.3Mj ME for producing 5 kg of milk in comparison with 74.0 Mj of ME for lactating dairy cattle of the same weight and level of production. When partitions ME, camel and cattle required 33.9 and 44.2 Mj of ME for maintenance and 33.9 and 29.8 Mj ME for milk production respectively. Hence camels required 35% less ME for maintenance and 12% more ME for lactation than dairy cattle. The same trend was observed in camels weighing 600 kg and producing 5 kg of milk (70.0 Mj ME) compared to that (82.8 Mj ME) of dairy cattle of the same weight and level of production (Hoden *et al.*, 1988).

Comparison of growth rate between Guerzni and Marmouri calf camels

In another trial, four ten-months-old calf camels of the Guerzni type were compared to other four of the Marmouri type receiving the same amount of feed. The young camels were weighed every week during a period of eight weeks and growth rate was determined (Table 6). The growth rate in the Guerzni type was significantly higher than the growth rate obtained in the Marmouri type indicating the potential of meat production in the Guerzni type.

Table 5. Daily energy requirements (expressed in mega joules and forage units) in lactating camels producing 5 kg of milk at 4% fat.

Body weight		Energy requirements*	
Kg	$Kg^{0.75}$	Mj / d	UF / d
300	72.1	55.0	4.8
350	80.9	57.7	5.0
400	89.4	60.3	5.2
450	97.7	62.8	5.5
500	105.7	65.3	5.7
550	113.6	67.7	5.9
600	121.2	70.0	6.1

*Energy requirements for maintenance and production of 5 kg of milk at 4% fat.

Table 6. Comparison of growth rate between calf camels from Guerzni and Marmouri types receiving the same feeding ration for period of two months.

Calf camels	Weight at 1st day(kg)	Weight at 56days (kg)	Weight gain (kg)	Growth rate (kg / d)
Guerzni				
A	180	195	15	
B	144	170	26	
C	150	177	27	
D	132	156	24	
Means	-	-	23	0.41 kg / d
SD				0.98
Marmouri				
A	133	152	19	
B	128	170	15	
C	155	177	22	
D	148	164	16	
Means	-	-	18	0.32 kg / d
SD				0.056

Conclusions

The Marmouri type showed higher milk production and a more negative energy balance when compared to the Guerzni type. But Guerzni showed more potential for meat production.
The efficiency coefficient of utilization of ME for milk yield (Kl) averaged 50% in the lactating camel and was lower than Kl reported in cattle. However, camels with lower MEm compared to cattle, required 12% less Metabolizable energy to produce 5 kg of milk at 4% of fat under harsh environmental conditions for dairy cattle.

Acknowledgements

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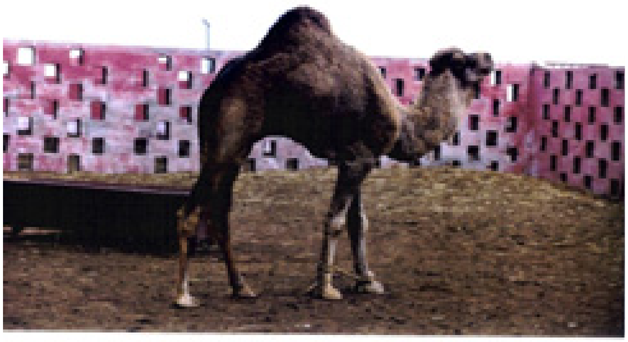

Figure 1. Guerzni type camel.

Figure 2. Marmouri type camel.

Figure 3. Khouari type camel.

Figure 4. Lasfar type camel.

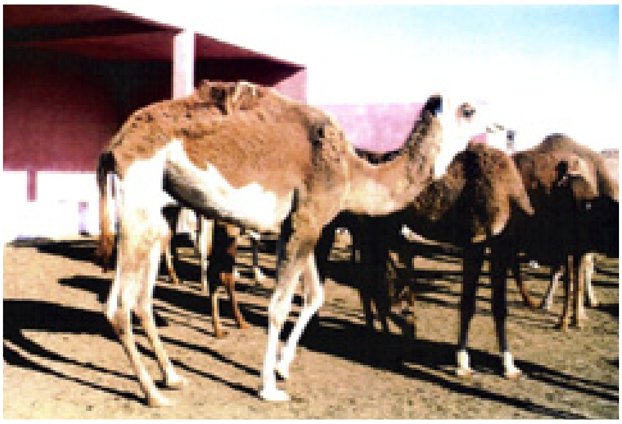

Figure 7. Lazrag type camel.

Figure 5. Lakhdar type camel.

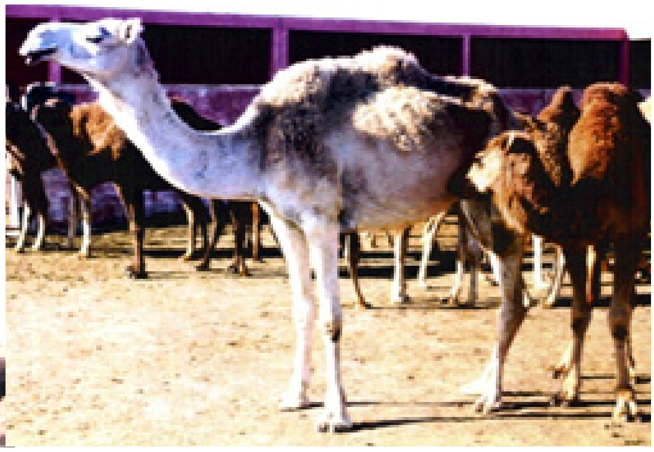

Figure 8. Labied type camel.

Figure 6. Lahmami type camel.

Figure 9. Dkhan type camel.

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Mongolian camels

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Summary

In the world there are about 19.1 million head of camels, including 0.8 million of bacterian; about 30% of this last one bred are in Mongolia. In 1954, there were 895.3 thousand head of bacterian in the country but last years the number of camels decreased by 3 times, as result of increased production for camel meat and losses of them after livestock privatization. Nowadays, Mongolian two humped camels are endangered species.

Key words: characteristics, Mongolia breeds, Galbiin Goviin ulaan, Khaniiin khetsiin khuren, Tokhom-tungalag, behaviour, semen collection, semen evaluation, parturition.

Biological characteristics

The two native humped camels have excellent potential as they are used for draught power, transport, wool production, and meat. The high resistance of the camel to the hot desert climate in summer is due to the economic use of reservoir water. Camel reduces the frequency of respiration and they are not subjected to sweating through the nose cavity; paunch of camel also favour the economic use of water. Camel can survive without food and water for 3 to 4 days.

The Mongolian camels have the following morphologic characteristics: elongated roundish muzzle, large forehead, hare lip, short ears, well developed muscles, mobile body, long ribs, short tail and strait legs.

Body weight is in progress up to 7 years old. Most intensive development of the younger animals happens during the first 3.5-4 years and depends on the natural and climatic factors.

The Mongolian bacterian puts on weight from May to October and the average daily gain ranges from 338 to 475 g. Adult castrated male weighs 424-600 kg. Killing-out percentage is 54.6-60.3, including 30-60 kg fat. Mongolian camels are well adapted to severe continental climate of Gobi area and they have a high ecologic and physiological plasticity to resist to the extreme conditions: hot summer and cold winter during which they loose 20-25% of their body weight.

Colour of Mongolian breed of camel is mainly brown, light-brown. About 80% of camels have brown coat. Camels with white and light-bay coat are found rare. Wool yield in adult she-camel and castrated male is 5.2

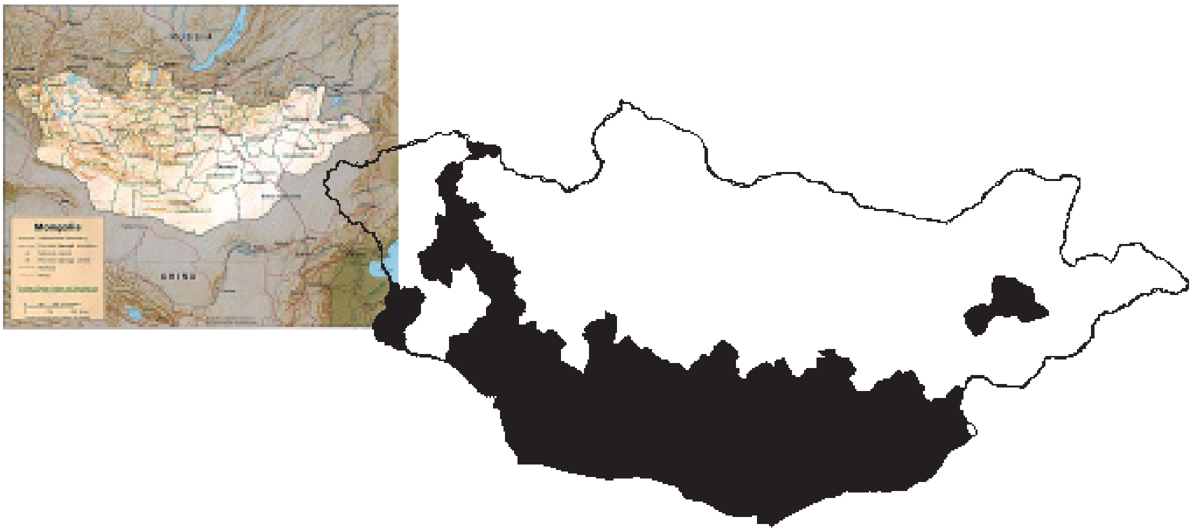

Figure 1. Distribution of camels in Mongolia.

kg/year, while wool production in bull-camel averages 8.1 kg, bat can reach 16-18 kg. The fibre diameter and lengths for under coat from she-camel are reported to be 20.8 micron and 81.2-98.4 mm respectively, for outer coat-22.69 micron and 73.4-140.4 mm. The diameter of wool in camels becomes coarser according to their age. Clean yield of wool varies up to 84.3-94.2%.

The Mongolians have tradition that use camel milk as curative. In the Gobi desert, lactation period of she-camel is 528 days /17.6 month/. She-camels are dried up after 5 months from conception. Average milk yield during lactation period is reported to be more than 300 litres (174-576 litres) The camel milk contains 14.56% dry matter, 5.65% fat, 3.17% lactose, 3.81% protein 0.67% ash. The milk of she-camel is rich in amino-acids, P, Ca and vitamin C. Killing-out percentage of adult camel is 54.5-60.3%. Weight at slaughter ranges from 209 to 301 kg. Fat weight in the humps is reported to be around 13.4-43.4 kg. On average, camel meat of castrated male contains 60.2% moisture, 21.1% fat, 17.8% protein and 0.9% ashes. Weight of a warm hide is 27.2 kg. Castrated camels are able to transport 200-240 kg of load and travel at 30-40 km per day.

Reproduction biology of Mongolian camel is particular interest. Mating season begins at the beginning of the winter season. Behaviour of the male camel is getting aggressive. Female pregnancy period is 387-415 days long.

Optimal structure of camel's herd is considered to be as follows: she-camels - 35-38 %, the males - 2 %, the young animals - 30-38 % and castrated - 25-27%.

Breeds of Mongolian camels

There are a number of outstanding local breeds of camel such as Galbiin Goviin ulaan, Khaniiin khetsiin khuren and double maned Tokhom-tungalag. These breeds are widely used for the genetic improvement of native Mongolian camels.

Figure 2. Galbiin goviin ulaan.

Galbiin goviin ulaan

The tables 1 and 2 report the main physical characteristics of the Galbiin Goviin ulaan, while figure 2 shows an adult Galbiin goviin ulaan .

Table 1. Body measurement of Galbiin goviin ulaan.

Sex	Height, cm	Length, cm	Girth, cm
Adult castrated male	174.5	150.9	233.1
Adult she-camel	167.3	139.8	213.0

Table 2. Live weight and wool characteristics of Galbiin goviin ulaan.

Sex	Live weight, kg		Wool yield, kg
	Spring	Autumn	
Adult castrated male	569.4	667.5	6.4
Adult she-camel	413.2	523.1	5.3

Khaniin khetsiin khuren

This breed is characterised by a lighter weight compared to the other camel breeds. It is found in Khanbogd and Bayan-ovoo soums of Omnogobi province. About 60% of breed have red brown color. Tables 3 and 4 summarise the physical characteristics of the Khaniin khetsiin khuren. Figure 3 shows an adult Khaniin khetsiin khuren.

Table 3. Body measurement of Khaniin khetsiin khuren.

Sex	Height, cm	Length, cm	Girth, cm
Adult castrated male	171.9	151.0	230.3
Adult she-camel	164.7	138.1	208.2

Table 4. Live weight and wool characteristics of Khaniin khetsiin khuren.

Sex	Live weight, kg		Wool yield, kg
	Spring	Autumn	
Adult castrated male	549.7	622.6	7.2
Adult she-camel	378.1	465.4	6.0

Figure 3. Khaniin khetsiin khuren.

Double maned Tokhom-Tungalag

It is found in Togrog soum of Gobi-Altai province. Main pecularity of the breed is the double mane. There are three types in the breed: A (woolly); B (heavuer in live weight); and C (standard).
Tables 5 and 6 summarise the physical characteristics of the double maned Tokhom-Tungalag. Figure 4 shows an adult double maned Tokhom-Tungalag.

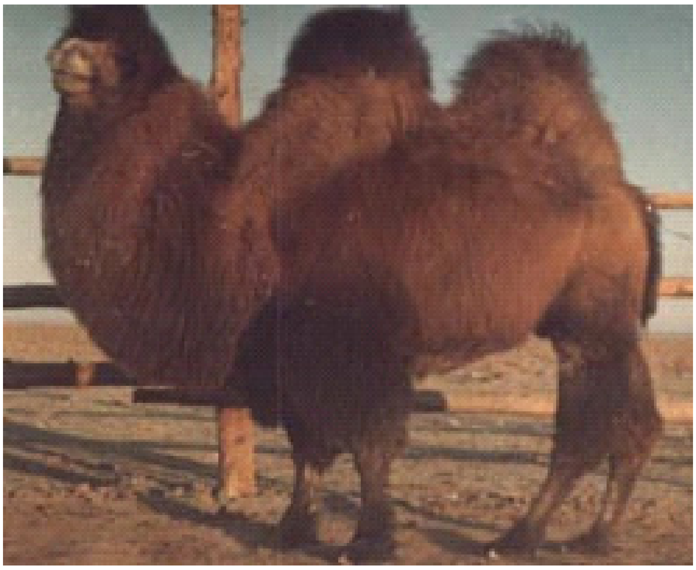

Figure 4. Double maned Tokhom-Tungalag.

Table 6. Body measurement of double maned Tokhom-Tungalag.

Sex	Height, cm	Length, cm	Girth, cm
Adult castrated male	173.8	147.5	239.0
Adult she-camel	167.1	139.5	226.3

Table 7. Live weight and wool characteristics of double maned Tokhom-Tungalag.

Sex	Live weight, kg		Wool yield, kg
	Spring	Autumn	
Adult castrated male	540.0	600.0	7.6
Adult she-camel	372.1	440.5	5.9

The sexual behaviour of Mongolian wild and Indian bull camelids

A humped bull camel was tame and calm in non-breeding season. The reproductive behaviour of a one/two-humped bull camelids (*Camelus bactrainus*, *Camelus ferus* and *Camelus dromedarus*) becomes more aggressive during the rutting season. The mating behaviour of bull camelids is preparative to sexual activity during the rutting season. The preparative (*zengerleh*) stage before sexual activity (occurring between non-breeding and breeding season) is different from that of other ruminant male animals.

Approaching the time of the sexual activity, the behaviour of humped bull camelids modifies: saliva forms a foam at the mouth blowing, teethes produce acute sounds, emitting a gurgling or blubbering vocalisation, flipp urine up over the back, accumulation of dirt in the urine soaked hair fibres a crush on the back of hump, snuff secreting of poll glands of the typical symptom. The intensity symptom of mating behaviour of wild bull is more evident than that of both domestic Mongolian and dromedary bulls.

The dulaa protrudes and two parts of secreting of poll glands of the dromedary bull has to contrast symptom with domestic and wild bactrian bulls. The poll gland of the bull camels is more developed than in castrated male camel.

Semen collection, evaluation of Mongolian bull camel in breeding season

Attempts for semen collection in Mongolian and dromedary bull camels produces a refusal to ejaculate or an incomplete ejaculation in the artificial vagina. Sometimes at the collection of semen it is possible to recover aspermic bulbourethral, dead spermatozoa and dust contamination.

Typical camel semen is sparkling white, milk colour with partially released from liquefacting coagulum. The semen volume of wild bull camel is higher that that of both Mongolian and dromedary bulls. The spermatozoa concentration of domestic Mongolian bull is higher than that of both dromedary and wild camels.

Some characteristics of the semen are the following: mean volume 5.78±1.96 ml, sperm mobility 0.6, medium density, pH=7.5, sperm concentration is 706.34 h 10^6/bl. The total and the head length of the spermatozoa is 42^36±1^09µ and 6^62±1^32µ. Dilution with an extender (sacrose/lactose+egg yolk+glycerol) is feasible and diluted semen shows a reasonable mobility allowing a deep freezing.

The sperm mobility in raw semen is similar in both Mongolian and dromedary bull camels.

The morphology of the spermatozoa of Mongolian bull camel is determined to be 89.86% normal and the remain 10.14% are abnormalities in rutting season. The most preminent abnormalities are non-headed or non-tailed spermatozoa , a sharp demarcation of head, bending or curling of tail.

A study carried out to determine the acrosomial status of spermatozoa in fresh condition revealed that acrosome integrity was 69.2-74.0% in intact healthy spermatozoa. The remaining 26.0-30.8% of all intact acrosomes were loosen or detached, swollen and lost acrosome with spermatozoa.

Histological studies of the skin of the gland

The three layers of the skin of gland are epidermis, dermis and hypodermis. The structure of the skin glands were similar to that of other portion's of body. The simple coiled tubular sweat glands are associated and deeply embedded in the dermis with primary hair follicles. The secondary hair follicles are not associated with sweat glands. The sweat glands of the bull camel are more developed than those of the females and of the castrated male camels. During the breeding season the sweat gland of the bull camel excretes a coffee-colored and acrid smelling fluid.

Parturiton of Mongolian female camel

The behavior of female camel before parturition changes from calmness and quietness to unstable. The female camel begin to reduce the grazing time, look into distance and emitting a specific sound and secluding just before parturition The vulva swells up, the udder and teats increases in size. The female camel is unease and tends to seek solitude by wandering out from the herd. She laid down and get up quickly sometimes, she urinates many times small amount of urine, she whinnies many times.

Camelid genetic resources. A report on three Arabian Gulf Countries

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Key words: taxonomy, origin, classification, camel breeds, camel types, riding camel, camel traditional breeds, meat production camels, milk production camels.

Introduction

Camel breeds in the Gulf region resulted from a community of breeder's efforts for generations. This community dwells in the same area, keeps and breeds camels for specific purposes and exchanges camels among themselves. In some traditional societies, camels are associated with specific group such as a tribe or family. In the Gulf region, camels are used for meat, milk, transportation and racing. Arabian societies believe that camels are regarded as assets of the community as a whole that must be maintained for future generations; therefore, camels traditionally change ownership only when they are given as marriage dowry to the bride's family. Social aspects therefore, are important for keeping certain camel breeds that have become economically unviable.

The local breeders select their camels for their physical attributes, unique qualities, behavior and performance, therefore, they restricted the use of male camels until they have known what the offspring is like. Therefore most of the Arabian breeders avoided in breeding, certain types of color and performance or combinations produced for many generations. Generally, the breeders kept oral records of genealogies, tracing the ancestry of their herds in female lines. Every camel has a name and a female is usually named after its mother. Selection of male camels is done with utmost care, although, due to economic constraints, not all breeders can afford to use the highest standards. Features such as the looks, size, color, temperament and milk yield of the mother and other female relatives are taken into account. Male animals that produce calves that look similar to their father are regarded as "strong" genetically, and therefore, preferred as breeders. If a good quality male camel is available, it is obliged to be accessible for female camels to be mated.

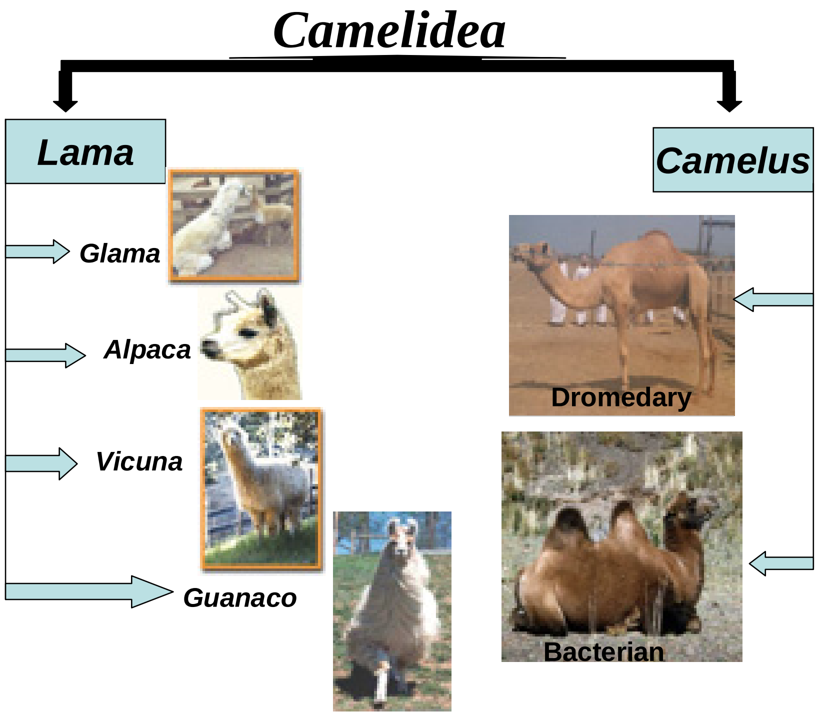

Figure 1. Taxonomy of the camelids

This paper will be overviews the classification of the Arabian camel in general then discuss the types and breeds in the Sultanate of Oman, United Arab Emirate and Saudi Arabia. The racing camel industry is getting well established in the region and recently it substantially developed in the whole region, therefore, the features of the Arabian racing camel breeds will be emphasized in this paper.

Taxonomy, origin and classification

Camelids belong to the order *Artiodactyla* (even toed ungulates), sub order *Tylopoda* (pad-footed), and Family *Camelidae*. They are pseudo-ruminants and have several unique features: they walk on pads rather than hoofs, do not have horns or antlers, and their red blood cells are oval in shape (Larson and Ho, 2003).
The Old World camels fall basically into two species, the Arabian (*Camelus dromedarious*) and the Bactrian (*Camelus bacterianus*). The Arabian camels have one hump and the Bactrian have two humps (Wilson, 1998). The Arabian camels (dromedary) prefer desert conditions characterized by a long dry and a short rainy season. There are still Bactrian camels in the Gobi desert as wild animals, but their numbers are dwindling due to human encroachment. The dromedary camels no longer have wild relatives. It has been suggested that they are actually derived from the Bactrian camels and lost one of their humps in the process of domestication. Introduction of dromedary camels into other climates has proven unsuccessful as they are sensitive to cold and humidity (Nowak,

1991). The Arabian camels are used as pack animals for human transport and as a source of hair, hides, meat and milk (Al-Ani, 2003). Today, there are several local camel breeds in the Gulf region, which have been mainly used in camel racing.

Scientists believe that ancestors of the modern camel lived in North America at least 40 million years ago, moving across the Alaskan ‘land bridge’ to Asia and eventually Africa. These migration probably occurred during the Pliocene or early Pleistocene between four and three million years ago (Wilson, 1998). In Asia, two groups separated to become the two chief types of camel known today: the one-humped longer-legged dromedary camel and the two-humped, shorter-legged Bacterian camel. There is little evidence for an exact time of dromedary camel domestication due to relatively little changes in camel morphology as a result of selection and also for the lack of archaeological evidence (Wilson, 1998). The earliest evidence for the dromedary domestication dates to about 4 000 years ago on a small island off the Abu Dhabi coast (on the Arabian Gulf). Northern Arabian tribes began to use dromedary camels as riding animals around 3 100 years ago (Kohler-Rollefson, 1991). The Arabian camel then spreaded into many parts of Europe and Asia by the Roman Empire. Similarly, the speard of the Islamic Empire led to wider use of these animals (Gauthier-Pilters and Dagg, 1981). With few exceptions, camels are found in areas where rainfall is low and occurs in a relatively short period followed by a long hot dry season of eight or more months. In Asia dromedaries extend from Gulf of Aden northwards into Turkey, the southern parts of Russia then Afghanistan where their overlaps with Bacterian camel. Dromedary camels occupy arid regions of the Middle East through northern India and arid regions in Africa, most notably, the Sahara Desert. They have also been introduced to arid regions of central Australia where some of the only feral populations now persist. The original range of their wild ancestors was probably south Asia and the Arabian peninsula.

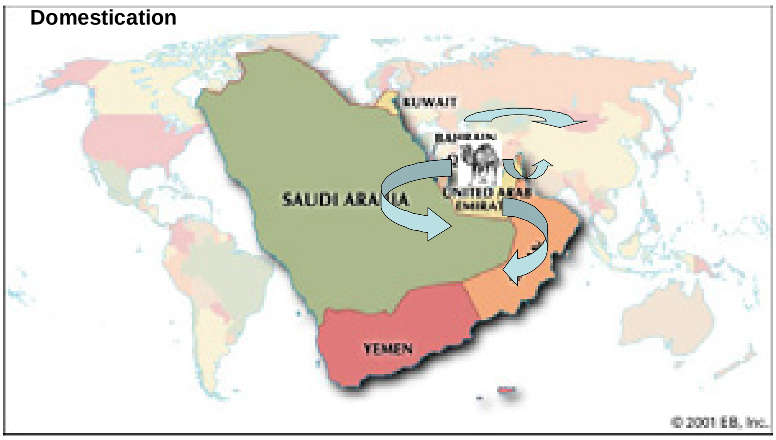

Figure 2. Domestication of the camels in the Arabian peninsula.

Breeds and types of dromedary camels in the Gulf Region

Although there has been relatively little differentiation into specialized types in the camels over years, there are many classifications of the dromedary camel throughout the regions of its traditional global habitat. In general, traditional breed classification divided the dromedary into three types: riding, transport and multipurpose camels. In most areas, camels are multipurpose animals with the females used primarily as milk producers, the males for transport or draught and both sexes providing meat. The lack of specialization can be attributed to the uniforml harsh conditions, in which camels are bred and reared and therefore their owners' requirements for them to be multipurpose. If, indeed, specialization has occurred it is in the dichotomy of riding and pack types, both within the overall transport function. There is evidence that some camels have a finer confirmation and are considered to be the equivalent of the thoroughbred horse breed. They are much sought after by the camel racing fraternity in the Gulf region.

Riding Camel

The dromedary camel bears a remarkable similarity to that of the thoroughbred racehorse. The head is small with fine muzzle, small lips, small ears, set close together, alert eyes and lower jaw deep below the eye. Therefore, they have been used for military purpose to protect the desert border. The neck is fine and supple and joined down to the trunk. The shoulder is long and fine, the chest very deep, ribs well sprung and terminating not far from the pelvic bone. The fore legs should be set close together, be straight, not brush at the knees and the feet not turned out. The quarters are well muscled and the tail set high, the feet medium sized, the skin fine and supple. According to Al-Ani (2003) the highest point from the tip of the hump to the ground is estimated between 1.8 to 2.2 meters with 450 to 600kg weight of the male. This type of camel can carry a rider and walk for 10-12 hrs continual without water or feed. They can also walk at speed 15-20 km/h for three days without rest.

Baggage camel

Baggage camels are much tougher than riding camel, with heaver head and neck, shorter legs, heavier bone and larger feet. Their pace is slower and shorter than that of the riding types but equally tireless. This type of camel measures 1.4 to 1.9 meters from the tip of the hump to the ground and average weight between 550-700 kg. They can carry 160 to 290 kg and walk between 4-6 km/h (Al-Ani, 2003).

Traditional breeds in the Gulf Region

Little appears to be known about types and breeds in this part of the world. Although, there is little justification for the present classification, camels were named after the tribes that breed them or due to their colour. However, recently, attempt has been made in some countries to categorize camels into conventional types such as meat producer, milk producer, dual purpose and racing.

Modern advances in the technology for studying genetic variation provide a powerful tool in the study of evolution of camel breeds. There are little quantitative production parameters that are now so important in other species to the breed description, such as riding, transport, milk, meat and double purposes camels. Selection programme can be used to clarify the ancestry of domestic camel breeds in the region and provide a valuable aid to animal breeders to genetically improving production of the local breeds.
Generally, the camels in the Gulf region can be classified according to their productivity into four classes according to their foundation:
1. meat producers;
2. milk producers;
3. dual purpose; and
4. racing camels.

Meat production camel

Large size camels characterised by a long neck, bulky muscles, large single hump and rapid growth rate. The best camel meat comes from young male camels. It is regarded as a delicacy in the Arabian diet, and is gaining popularity in arid lands where it is difficult to herd sheep, cattle and goats. Camel meat is started to have its own way through the meat industry in the gulf region.

Milk production camel

Al-Dowasir breeds, which, reared in Saudia Arabia, are medium sized camels with good size udder and uniform body with moderate to high milk production according to the nutrition status of the animals. Al-Dowser has the highest milk yield of all breeds in the Gulf region. Camel milk is much more nutritious than that from a cow. It is lower in fat and lactose, and higher in potassium, iron and Vitamin C. It is normally drunk fresh, and the warm frothy liquid, heavy and sweet, is usually an acquired taste for the Western palate. Most the Arab Gulf Countries camels are females reared for their milk in dairy herds.

Dual purposes camel

Al-Kawar breeds are medium to large size camels. They can produce a moderate amount of milk. Al-Kawr camels are found in United Arab Emirate.

Racing camel

Camel racing in the Arab Gulf Countries is a traditional sport comparable to horse racing in the Western World. Selective breeding of racing camel has taken place by individual camel owners in these traditional areas of the world. However, over many years of natural breeding in the arid areas of the Arab Gulf countries, the camel has evolved to produce a typical racing animal. This is still basically slim, lightweight with high-speed type of camel and is unique only in that it is derived from the dromedary camels.

According to FAO (2003), the number of camels in the Arab Gulf Countries is about 665 620 in 2002, distributed over six countries. The traditional classification of camel's breeds in this region, according to the coat's colors, is Al-Majahem, Al-Wathah, Al-Hamrah, Al-Safrah, Al-Zarkah, Al-Shakha, Al-Shalah, Al-Kimta and Al-Malhah camels. Variety of local camel breeds are available in different Gulf countries, therefore, the camel breeds will be classified according to each individual country in the region.

Sultanate of Oman

Omani camels are characterised by relatively small head, long body, narrow neck and deep chest, straight rear legs, with distant hocks and raised tail. They have smooth skin and light colors, fine bones and light weight (Wardah, 1989). Although there is no defined breed, certain types and sub types of this group have been recognized and developed by various families and tribes. A list of types of racing camels identified in Oman is summarised in Table 1. Omani tribes cross the boarders and get their female camel mated by superior United Arab Emirate male camels. However, generally the government encourages camel owners to keep local breeds as pure as possible.

United Arab Emirate

Number of camels significantly increased in United Arab Emirate for the last two decades due to selection programme for racing camels. The government and private sectors is strongly supporting camel racing industry. The camels in the United Arab Emirate are mainly grouped into three breeds:

1. Al-Arabiat. One of the earliest breeds in the region that contribute to well recognized subtypes including:
   a. Al-Esseker
   b. Wahbar
   c. Al-Komry
   d. Sokan
   e. Om Sbeehan
   f. Teban
2. Al-Kazmiat. It is a multipurpose heavily built breed, the camels of this breed are well known for meat and milk production. Al-Kowar is one of the most famous breeds belong to this group.
3. Racing camels. Racing camel has shown a market development during the last two decades. The government imported well-known racing camels from different countries and they were used for crossing with endogenous breeds. Therefore, new racing breeds have been established such as:
   1. Sokan
   2. Hamlol
   3. Msehan
   4. Al-Thenian

Table 1. Types and Sub-types of Omani racing camels.

Name	Origin	Color	Characteristics
Samha	Interior region	Brownish-Red	Walking long distances and known as good racing camel
Farha	Al-Sharkia Region	Red, blond or yellowish	Divided into 6 subtypes. It is beautiful with fine skeleton. Good for racing
Buwadah	Al-Sharkia Region	Whitish	Famous for long distance traveling and tolerate hunger for long period, easy to handle
Arjaa	Interior Region	Yellowish & blondish	Originated from Samha a good long distance racing camels and has good milk yield.
Musaiha	Batinah Region	Golden	Known for good breeding males and long distance racing
Shahbar	Batinah Region	Reddish to blondish	Famous for being intelligent, good milk producer and her body's is higher at the front than the rear
Al-Azkiyah	Al-Sharkia Region	Light yellowish	Famous for racing and milk production. It has a medium hump size.
Al-Bahree	Batinah Region	Reddish to yellowish	Famous for short distance racing
Al-Kawara	Batinah Region	Reddish to yellowish	It has long and big body size and used for long distance traveling. The front and rear ends have the same height.
Gazaella	Al-Sharkia Region	Reddish to white	It has a high and heavy body with long neck.
Al-Azbah	Al-Sharkia Region	Blondish	Easy to handle with fine skeleton and straight head. It has a big size body with fine legs. Goodracing camel.
Kudsha	Al-Sharkia Region	Reddish-Blondish	Fast racing camel used for long distance. Have a medium body size with centrally located hump

(To be continued in the next page...).

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Name	Origin	Color	Characteristics
Dhibian	Al-Dhahira Region	Reddish	Al-Dhibian tribe breeds this camel. It has a short neck with large skeleton. Famous in long distance racing
Sadoorah	Interior region	Light red	Famous for short distance racing. It has a strong body.
Zabeia	Al-Sharkia Region	Blondish	Famous for long distance traveling. It has a long back and her body's is higher at the front than the rear
Al-Derehiah	Al-Zahra Region	Yellowish-Blondish	Subtypes descendedfrom it such as Al-Esefer, Habar and Hamza's daughters and Al-Draae. It has a medium size body with lightweight with tolerate fatigue.

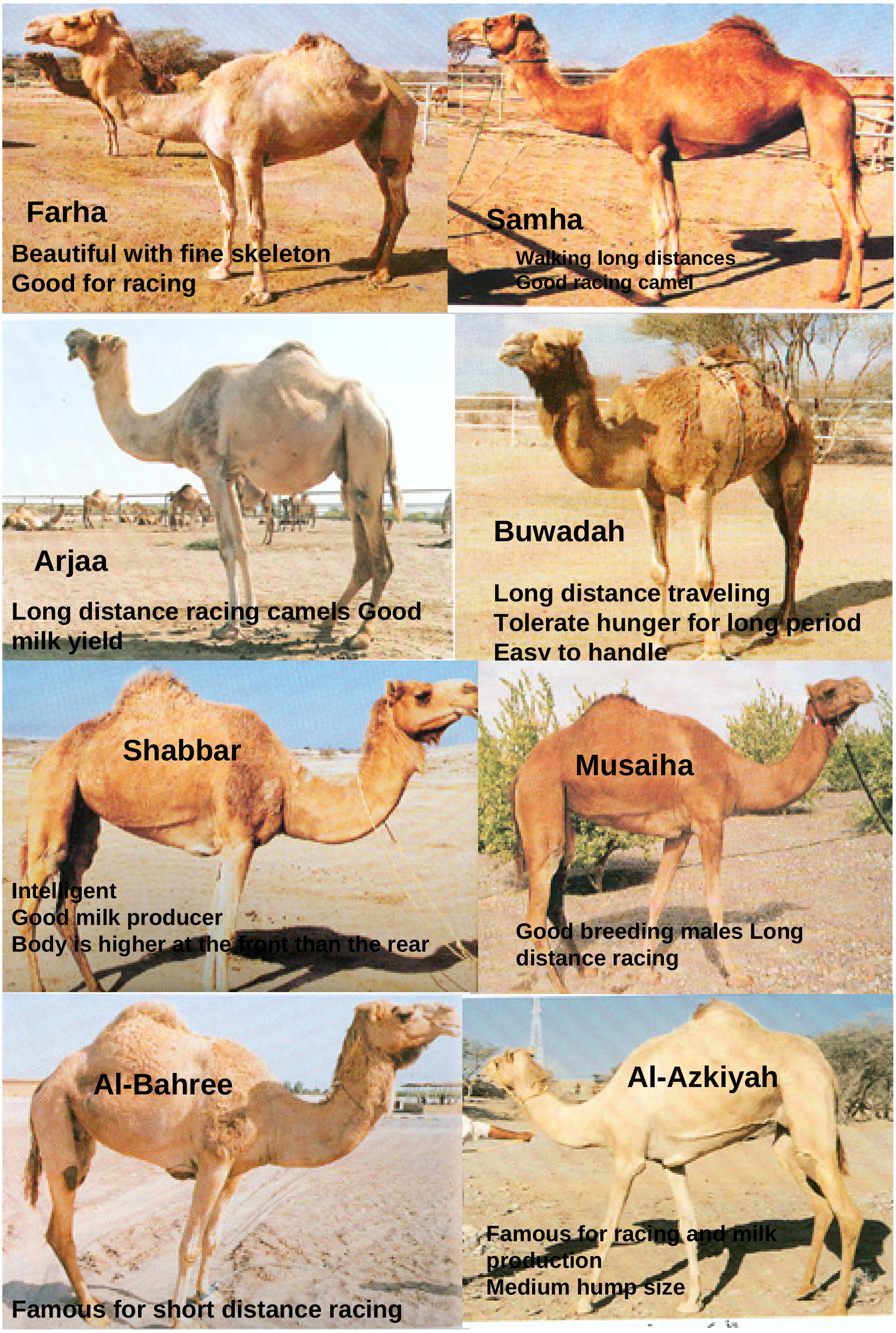
Source: The original of Omani Camels, Royal Diwan Court, Sultanate of Oman (1998).

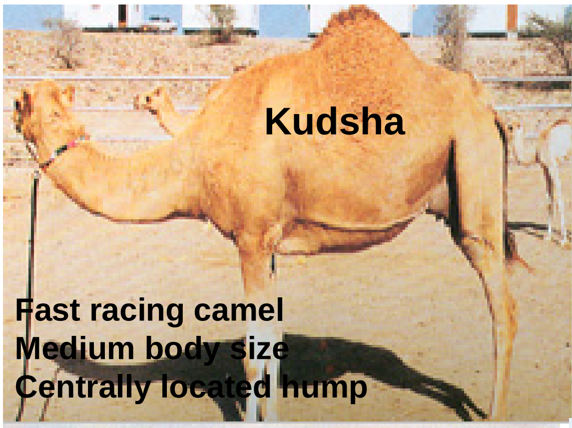
Saudia Arabia

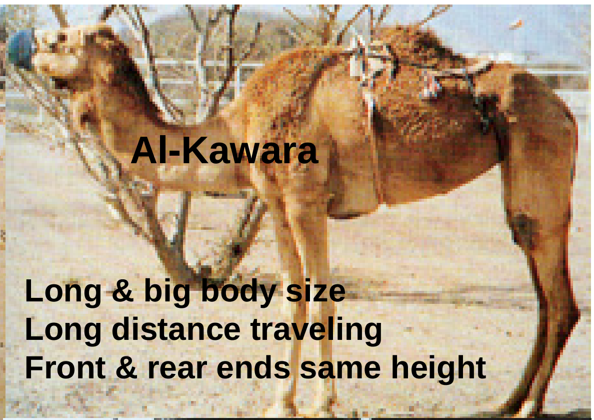
Camels are one of the main strength of animal production in Saudia Arabia. These are relatively larger with high milk production and located in the desert area used for riding and light baggage as well as being major source of meat and milk for owners.

The main camel breeds are:

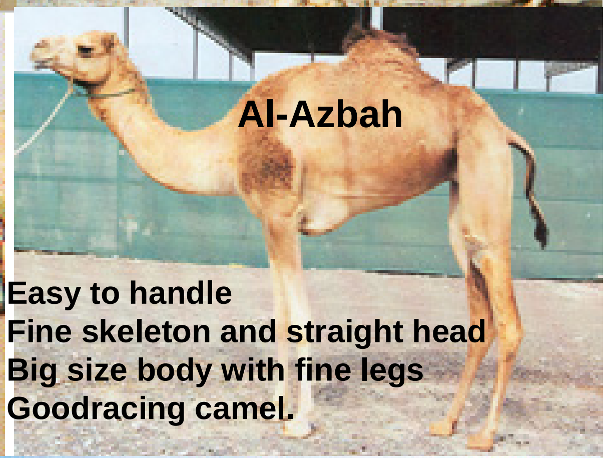
1. Al-Majahem. The coat colour of this breed varies from dark yellowish to black with high milk production. This breed is located in the eastern south of the country. This group includes the following sub-types:
   a. Al-Dawser. Large size black camel with high milk production.
   b. Al-Sohib.
   c. Shomer Al Enza.
2. Al-Makater. The coat colour of this breed is white and located in the northern part of the country. This group includes:
   1. Horat Al Madenia
   2. Al-Shiabeen and Okban
   3. Al-Shorarat
   4. Al-Shahab
3. Lorak. The coat colour of this breed varies from white to reddish brown and located in the Tohama and Aseer regions.
4. Racing camels, groupping the following:
   1. Al-Omaniat: Known as Jaish for its speed
   2. Al-Hurah (Al-Hararyer): The camels of this breed are of good height, strong in build with their nose tilt upwards and have smooth fur.
   3. Al-Sodaniat: Known as Sudanese Jaish for its speed

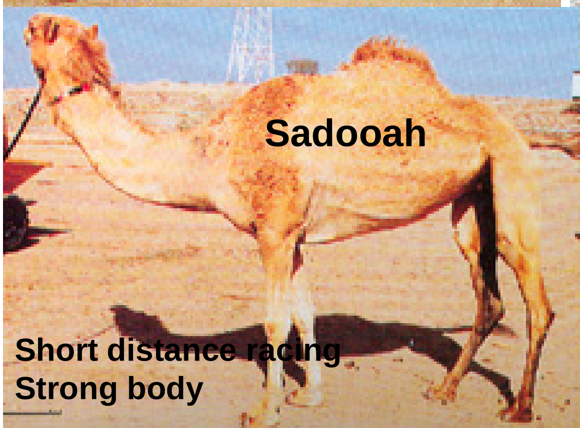

Farha
Beautiful with fine skeleton
Good for racing
Samha
Walking long distances
Good racing camel
Arjaa
Long distance racing camels Good milk yield
Buwadah
Long distance traveling
Tolerate hunger for long period
Easy to handle
Shabbar
Intelligent
Good milk producer
Body is higher at the front than the rear
Musaiha
Good breeding males Long distance racing
Al-Bahree
Famous for short distance racing
Al-Azkiyah
Famous for racing and milk production
Medium hump size

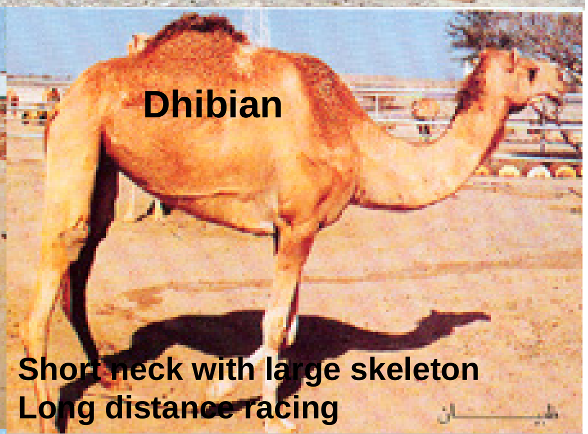

Kudsha
Fast racing camel
Medium body size
Centrally located hump

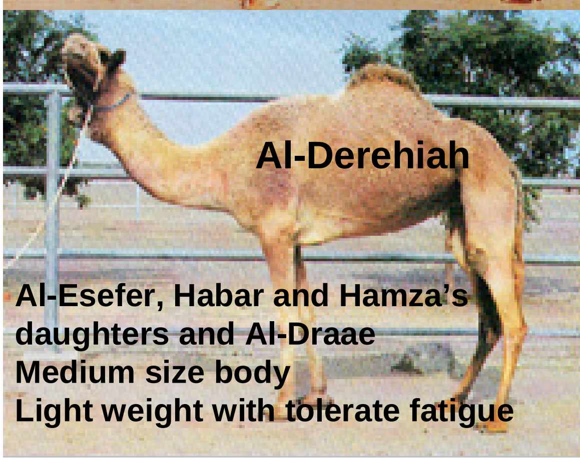

Al-Kawara
Long & big body size
Long distance traveling
Front & rear ends same height

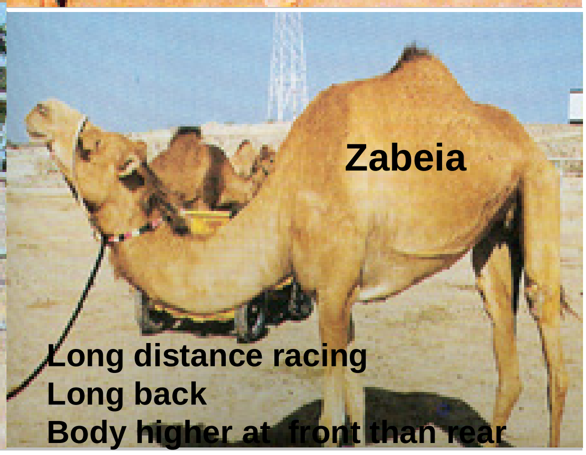

Gazaella
High & heavy body with long
neck.

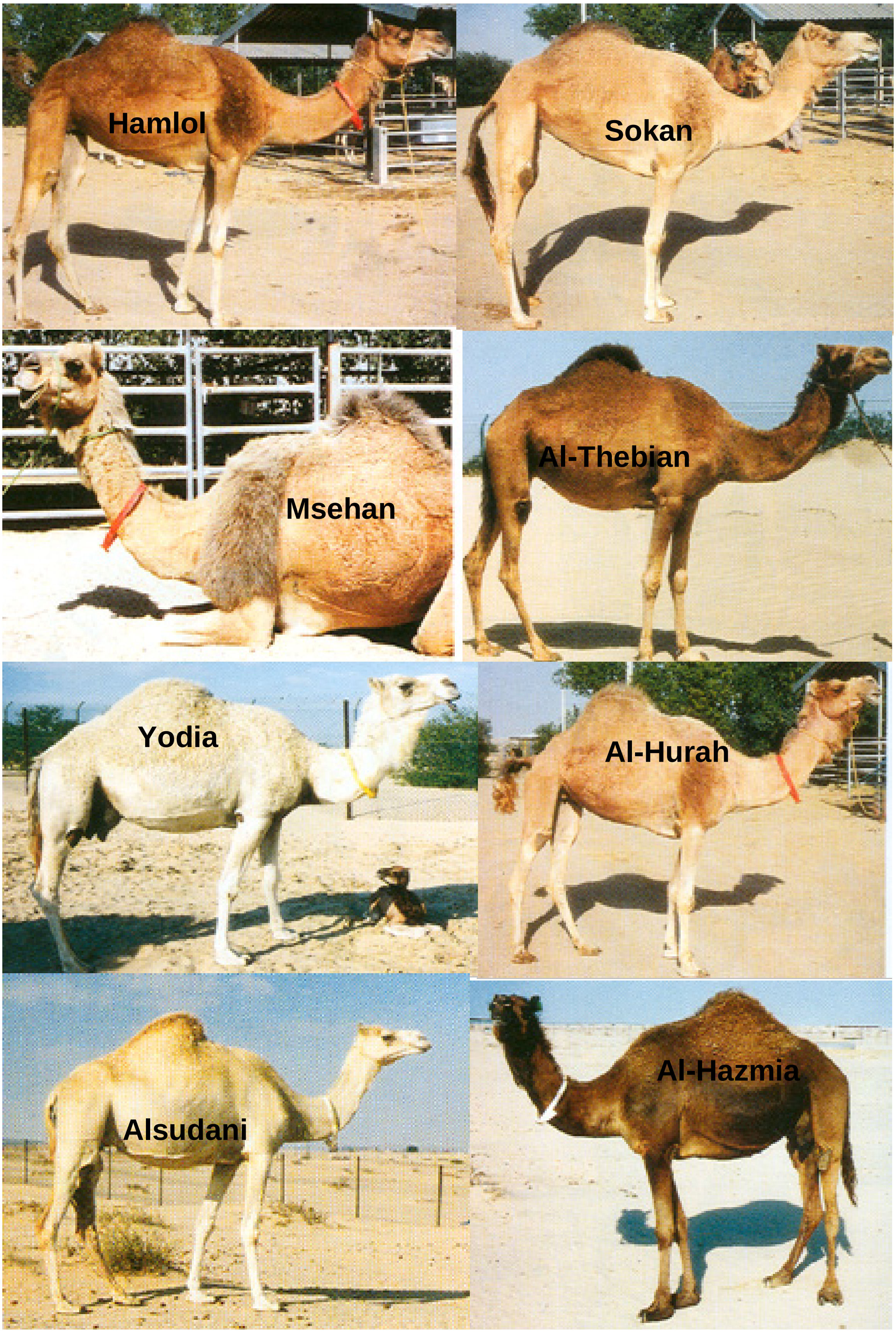

Al-Azbah
Easy to handle
Fine skeleton and straight head
Big size body with fine legs
Goodracing camel.


Sadooah
Short distance racing
Strong body


Dhibian
Short neck with large skeleton
Long distance racing


Al-Derehiah
Al-Esefer, Habar and Hamza's
daughters and Al-Draae
Medium size body
Light weight with tolerate fatigue


Zabeia
Long distance racing
Long back
Body higher at front than rear


Hamlol
Sokan
Msehan
Al-Thebian
Yodia
Al-Hurah
Alsudani
Al-Hazmia

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Dairy productivity potential of camels

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Summary

While it is recognized that the camel has the ability to produce more milk than the cow in similar conditions, camel milk productivity is not well known. Data from the literature are scarce, mainly issued from observations in research stations, and more rarely from pastoral areas where performance monitoring is not common. Elsewhere, the data are not homogeneous among the authors: mean daily yield, total yield per lactation, herd average... Therefore comparisons are not easy. Furthermore, there is a high variability of reported productions which leads to suppose a potential for selection on that criterion. This selection is possible but rarely achieved except in the Soviet Union period for dromedary and Bactrian camels.

The world production of camel milk was officially estimated at 1.3 million tons in 2002. However, according to the high level of self-consumption and the individual potential, this production could probably be higher (i.e. 5.4 million tons). The individual production varies between 1 000 and 12 000 litres per lactation according to some sources. The lactation curve is similar to bovine with a better persistence. The lactation length is very variable (from 8 to 18 months in general), i.e. longer than that for dairy cattle in similar conditions. Obviously, the feeding and seasonal conditions have an impact on those performances. Some intensified systems found in many places showed good prospects in camel milk production to supply populations from arid lands.

Key words: camel milk production, genetic variability and lactation characteristics, climatic and feeding factors, parity, health.

Introduction

For the general public, for funding agencies and policy makers, the camel is poorly associated to high productivity, except for packing and racing activities. The potential for meat and milk production is not known for this species. This misunderstanding could be attributed to two factors:

1. in the past, camel dairy production was mainly destined for self consumption or, in case of extra production, for giving to the poorest or to guests;

2. on literature basis, a few references are available in the international scientific community, even if recent data are more reliable than in the past.

The published results on camel dairy production come mainly from observations achieved in experimental stations, and more rarely from pastoral zones. In fact, it is quite difficult to perform dairy production monitoring in traditional farming systems where animals are usually submitted to high mobility. Elsewhere, the measurement procedures are rarely mentioned or set up in a standard manner and can change among authors. Moreover, the available publications give some results as daily average quantities, total lactation yield or year yield, herd average, after camel calf suckling or not. Therefore the comparisons between authors are not easy. Finally, even if camel scientists and producers are able to attribute a high dairy potential to the camel, further investigations are necessary to propose an objective outcome of this potential. The oldest reference on camel dairy production is dated 1854 (Gouhaux, 1854). Since then, the number of references on this subject has not exceeded one hundred papers and most of them came from the soviet literature in the fifties and sixties, poorly available for international scientific community (Saint-Martin, 1990).

The world camel milk production

Cow milk represents approximately 85% of the entire milk produced and consumed in the world. The she-camel production has a marginal position (less than 2%), far behind buffalos or sheep and goats. With a world camel population 70 times less important than the cattle population, this difference should not be surprising. According to FAO statistics, camel milk production in the world, both for dromedaries and Bactrian camels, was 1 283 672 tons in 2002 (Table 1).

It should be noted that, first, these data were not complete because data from Central Asia and from some countries in Near- and Middle-East are missing. Second, a gap can be observed between the estimated population and the stated production, as for example in Sudan, where the camel population is half of the Somalian population, milk production is 10 times lower.

A different assessment could be proposed by the extrapolation of the expected production for a she-camel. The world camel population is around 20 million heads (this number is probably under-estimated), the proportion of lactating camels is around 18% (Hjort af Ornäs, 1988) and the mean production could be estimated at 1 500 litres per year. So, the world production could be estimated at 5.4 million tons from which 55% is taken by young camels. In fact, there is strong uncertainty concerning the world camel milk production, all the more as an important part of this milk is removed from the market sector.

Table 1. Camel milk production in the world, comprehensive of dromedaries and Bactrian camels, in varius countries in 2002.

Country	Production (MT)
Afghanistan	8 100
Algeria	8 000
Saudi Arabia	89 000
China	14 400
Djibouti	5 900
Arab Emirates	33 400
Eritrea	5 100
Ethiopia	22 450
Iraq	672
Kenya	25 200
Libya	2 000
Mali	54 900
Morocco	3 900
Mauritania	21 500
Mongolia	1 000
Niger	10 800
Qatar	13 300
Somalia	850 000
Sudan	82 250
Chad	21 800
Tunisia	1 000
Yemen	9 500
Total	1 283 672

(Source: FAO, 2002).

The milk potential of camels

The estimations of camel milk yield available in the literature mention the quantities produced per lactation or year. In most of the cases, the authors do not specify if these yields include or not the part taken by the young camel which represents about 40% of the entire production, sometimes even 75% under certain conditions. Lastly, the number of milkings may change depending on the circumstances and the producer's practices, and could have an effect on the whole production (Knoess, 1977). When the number of milkings changes from 2 to 3 per day, the daily increase of milk production could be 28.5% (Kamoun, 1995). So, a high variability is described in the literature and comparisons are not easy.

Africa

Northern-Africa

In Africa, references can change between 1 000 and 2 700 litres depending on the studies, the considered breeds and the farming system. For example, in Tunisia (Kamoun *et al.*, 1990), the extreme values reported in experimental conditions vary between 942 and 3 300 litres for a lactation length between 190 and 404 days. In Libya, Hermas (unpublished data) reported milk yields between 320 and 2139 kg at the Al-Assa station with a mean standard production (305 days of lactation) corresponding to 1 016 kg. Araba *et al.* (1998) conducted a study on Maghrebi camels from Morocco and reported a milk yield of 935 litres in 305 days. In Egypt, Yagil (1982) reported different results from several observations with a dairy yield between 1 500 and 4 000 litres. In Egypt, dams maintained on irrigated pasture could yield 15 to 35 litres milk / head per day, while yield was 3 to 5 litres on desert range (El-Badawi, 1996).

Horn of Africa

In Ethiopia, milk yield of five Dankali camels kept on natural pastures was recorded over a period of 12 months. Mean yield per head was 1 123 litres. The peak yield of 404 litres was obtained at day 56 (Richard and Gérard, 1989). This quantity is comparable to that reported by Dessalegne (1985) in South Ethiopia with the Somali breed, i.e. 1 045 litres for 430 days. Former studies performed in Ethiopia by Knoess (1977) reported a mean daily yield of seven camels milked twice daily: 6.6 litres, i.e. approximately 2 000 litres for a standard lactation. Field (1979) estimated daily milk yield of camels in North Kenya at 21 litres in the second week of lactation, falling between 4.8 and 2.2 by the sixteenth week of lactation. In this country, the observations on the Somali breed reported by Karue (1998) were between 1 614 and 2 151 litres, with an average of 1 876 kg for the herd. Gebre-Mariam (1987) stated that average daily milk yield of Somali camels ranged between 5 and 6 litres. Hashi (1993) found that Somali camels produce on average 800 to 3 600 litres during lactation from 9 to 18 months. Kaufman (1998) analyzed the three camel husbandry systems of the Rendile, Gabra and Somali pastoralists in Northern Kenya. Considering different proportions of poor, average and good yielding camels in the herds, average milk off take per lactation was 1 096, 1 400 and 1 581 litres for the Rendile, Gabra, and Somali respectively. In two traditional camel calf management systems in Kenya involving 42 multiparous lactating Somali camels, the total milk yield was 2 956 litres in the group with camels separated from calves, and 2 441 litres in the control group (Simpkin *et al.*, 1997). An average of 6 litres milk yield per camel per day under the feedlot system was reported by Ibrahim (1990). For Schwartz (1992), yield of Somali and Kenyan dromedaries ranges from 1 300 to 2 500 litres, but with good grazing their yield may even exceed 3 000 litres.

West Africa

In Nigeria, from data monitored in a pastoral area, Saley and Steinmetz (1998) estimated the annual milk yield at 1 760 litres with two milkings and at 2 400 litres with three, the young camel taking 50% of the whole quantity. The milking quantity of the Azbin camel in Nigeria was estimated at 1 187 kg for 366-day lactation length and 1 417 kg when the young camel sampling was included (Chaibou and Faye, 2003). In Chad, observations in a pastoral area (Ganda and Buron, 1992) put forward a mean dairy yield of 2 280 litres for 12 months. In Mauritania, Martinez (1989) reported mean values from 3.1 to 4.3 litres per day in peri-urban camel farms with a mean yield of 684 litres in 6 months between the 3rd and 8th lactation month, the first three months being totally let to the young camel.

Asia

In Asia, extreme values between 650 and more than 12 000 litres are reported, the dromedary camels having a better milk potential than the Bactrian ones, but there is a lack of available references for this last breed. In Central Asia, crossbreeding strategies between *Camelus dromedarius* and *Camelus bactrianus* aim at improving milk production.

India and Pakistan

In India, at the Bikaner station, Khanna *et al*. (1998) reported a mean yield of 1 655 litres (5.5 litres per day) in dromedary camels, but observations between 2 000 and 6 000 litres were reported in a review paper (Khanna, 1986). According to Ranjhan (1997), a dromedary may produce 8 to 10 litres of milk daily. In Pakistan, Yasin and Wahid (1957) found that well-fed and well-managed dromedaries produced 9 to 14 litres of milk daily and 2 722 to 3 629 litres in a lactation period of 16-18 months, while under desert conditions the average lactation yield varied from 1 134 to 1 588 litres of milk in 9 months. Knoess *et al*. (1986) collected data on lactation yields of seven dromedaries in Punjab and reported a mean daily yield of 18.7 litres, i.e. 5 695 litres for a standard lactation. Yagil (1982) reported that production in Pakistan was between 1 350 and 3 600 litres per lactation according to diverse publications. Schwartz (1992) reported that heavy camels of Pakistan and India may produce up to 12 000 litres of milk per lactation. In a camel survey conducted in Balochistan (Pakistan), total lactation yield ranging from 1 250 to 3 650 litres was found, with an average of 1 800 litres (Jasra and Aujla, 1997). According to Iqbal (1999), mean milk yield of the Punjabi camel was found to be 4 260 litres.

Near and Middle-East

In the Arabian Emirates, the average milk yield is set around 2 000 litres per lactation (Quandil and Oudar, 1984). Sohail (1983) reported that, on average, Arabian camels can produce up to 2 275 litres of milk per year. Shareha (1985) reported in Syria 7.3 to 12.2 litres daily when the udder was completely milked. According to Qureshi (1986), a camel my produce on average 8 to 20 litres of milk daily, but under intensive management conditions it may produce from 15 to 40 litres daily. In Kuwait, a good, a medium and a poor milker can produce 9 030, 3 185 and 805 litres respectively in 350 days (Ibnoaf, 1987). In Saudi Arabia, the average milk yield ranges from 2.4 to 7.6 litres daily (Basmaeil and Bakkar, 1987). El-Naggar (1998) reported that the camel can yield about 2 700 to 3 666 litres per lactation.

Central Asia and China

In Turkmenistan (Saparov, unpublished results), precise measurements showed that the Arvana camel, recognized for its milk potential, may produce 5 000 to 6 000 litres per lactation. Yagil (1998) asserted that a yield up to 8 200 litres, even 12 000 litres, may be possible under intensive conditions. Bactrian camels seem to have a lower milk potential. The average milk yield is only 800 to 1 200 litres. In China, the total lactation yield varies between 500 and 1 254 litres (Xhao, 1994).

Finally, available data on camel milk production potential at world level are partial and the proposed estimations are often approximate, especially concerning Africa. However, the productivity potential of camels seems higher than that of cows in similar climatic and feeding conditions. In Ethiopia for example, *Afar* pastoralists who breed cattle and camels simultaneously, got an average daily milk yield of 1-1.5 litres from the *afar* cow and 4-5 litres from the *Dankali* camel. According to Schwartz and Dioli (1992), in the Horn of Africa milk productivity related to live animal weight was higher in camels (250 kg/Tropical Livestock Unit/year) than in small ruminants (220 kg) and zebu cattle (100 kg).

Genetic variability and lactation characteristics

Genetic variability seems very important and allows to suppose high possibilities for selection. In Somalia for example, the *Hoor* breed may produce 8 litres per day for 8-16 months lactation i.e. around 2 000 litres per lactation. The *Sifdaar* breed may produce 6 litres on average for 12 months (1 550 litres per lactation), while the *Eydimmo* breed is able to produce 4 litres only for 6-12 months, i.e. a production of 1 000 litres per lactation (Herren, 1993). In India, comparisons were conducted in the Bikaner station between the *Bikaneri*, *Kachchi* and *Jaisalmeri* breeds with mean yields of 4.19, 3.94 and 3.72 litres respectively (Sahani *et al.*, 1998). Potential of milk production was reported on 4 phenotypes of Arabian camels for three consecutive lactations and the milk yield was compared. The *Malhah* breed produced the most milk (9.33 kg per head), followed by the *Wadhah* breed (8.94), the *Safah* breed (8.13) and the *Hamrah* breed (6.83). A maximum of 18.3 and 14 kg per head was observed in the *Malhah* and *Wadhah* breed respectively (Ismaïl *et al*-Mutaïri, 1998).

In general, Asian breeds are considered to have a higher milk potential than African breeds. In that field, However, information is partial. Some breeds may be considered as milk breeds, but selection pressure was low in camel species. Variability within the same breed is probably very high, which allows to suppose a possible improvement of milk potential in some breeds.

The shape of the lactation curve in dairy camels is comparable to that of cows (Richard and Gérard, 1985). The peak occurs at 2-3 months and may reach 5 to 6 litres for a total lactation yield between 1 800 and 2 000 litres, 8-10 litres when the total lactation yield is 3 000 to 3 500 litres. The persistence coefficient which expresses the ratio between the milk yield at month +1 on the previous month is high, generally up to 80%, according to available data.

Lactation length may vary between 8 and 18 months. It seems to depend on certain practices such as the milking or suckling frequency. Milking frequency could be two to six times daily (Dioli *et al*., 1992). The milk down induction necessitates the presence of the young camel at the teat. This presence contributes to the maintenance of milk production of the dam. As for the cow, the biggest part of expulsed milk during milking or suckling has a cistern origin rather than alveoli cells origin. So, the milk way down may be obtained by the beginning of suckling by the young or by ocytocin injection (Balasse, 2003). Other subterfuges could be proposed by the farmers in case of stillbirth or calf mortality, such as the introduction of a puppet covered with the camel calf skin or the adoption or vaginal blowing (Bernus, 1992).

Feeding plays an important role on lactation length and yield. Under good feeding conditions, the lactation length may increase from 8-12 months up to 16-18 months. Anyway, the differences between breeds could sometimes be attributed to differences in feeding conditions rather than to strictly genetic factors. The duration of lactation depends also on the dam's gestation status. First, lactation could inhibit ovarian activity and then delay reproduction time. Second, the end of gestation may lead to a milking refusal for the dam. Generally, the lactation length increases with the calving interval. However, lactation and gestation are not incompatible.

Some variation factors

Variation factors in camels are similar to those reported in other species. Some data are available in the scientific literature (genetic, quality and quantity of available feed, milking frequency, parity, health status).

Effect of climatic and feeding factors

Camels depend on natural resources most of the times. The feeding availability is generally linked to the climatic conditions (heat, humidity) which have obviously an effect on milk production. The difference in milk yield according to the calving season could be up to 50%: milk performances are lower at the end of the dry season than in the rainy season (Khanna, *et al*. 1998). Milk yield does not seem to be affected by water shortage. In Israel, Yagil and Etzion (1980) observed a continuing production in camels after 10 days of dehydration followed by an *ad libitum* drinking and then another 10-day period of dehydration. In a previous observation, 6 camels continued to produce 6 litres per day during the hot season with once a week watering (Yagil *et al*., 1979).

Effect of parity

As for other dairy animals, milk yield in camels tends to increase with parity. However, alhough the lactation length could be important, data are scarce and limited to very small consecutive lactation. According to Ismail and Al Mutairi (1998), the maximum may be reached at the second or third lactation.

Effect of health status

Most of the parasites (trypanosoma, internal parasites, ticks and mange) may have a cross reaction with milk yield. In pastoral zones, the use of classical veterinary inputs for parasitic disease prevention contributes to an increase of 65% in milk production (Simpkin *et al*., 1997).

Conclusion

The contribution of the camel to the world milk supply is marginal but essential for human populations in arid and semi-arid areas; on the one hand, for satisfying the human needs in communities culturally attached to camel products and contributing to food safety, on other hand, for stimulating the local economy by the maintenance of an agricultural activity in marginal desert areas. However, available data on the camel's production potential are not sufficient. The great variation in camel milk production may be attributed to the methods employed to determine yield (Khan and Iqbal, 2001). Further investigations and probably standardisation of the methods are necessary to point out the importance of camel milk production for the food security of desert areas in the world. The international scientific community has to turn its attention to a good performance control of dairy production in camels. Specific tools for dairy yield monitoring are necessary. The LASER software set up by CIRAD-EMVT could be a possible tool for performance monitoring in camel herds as it has been tested in some arid countries (Juanes and Faye, 2001).

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Meat recording systems in camelids

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Summary

There are very few data on meat recording systems in camelids, particularly on the relationships among production systems (conditions), growth, fattening, body size, and qualitative aspects. These aspects regarding camelids will be discussed. Furthermore, work on Tunisian dromedary will be presented for illustration and comparison. These researches were mainly conducted for several years at the Ecole Supérieure d'Agriculture Mateur . This works concerned growth, fattening and carcass and meat quality on camel reared from birth until on-station slaughtering. Data were collected each four weeks on conformation traits and animals were weighed each two weeks. Studies on growth of dromedaries revealed a significant relationship between daily gain (y = 282+5.4 x) (y in g) and daily intake of concentrate (x, in g per kg $lw^{0.75}$). The growth of youngest dromedary has been modeled and data on linear growth permitted to determine a prediction formula for live weight. After slaughtering 15 males aged from 15 to 50 months and weighing between 280-560 kg were used to examine the following aspects: slaughtering and jointing yield, carcass tissue composition, and meat quality. Results concerning growth, quality and yield of carcass are discussed in order to draw some practical conclusion regarding potential recording systems for camelids on production traits and eventually to identify future axes for research.

Key words: camel, carcass, meat, quality, weight and growth of camel, compensatory growth, meat characteristics.

Introduction

The camel can survive, reproduce and produce meat in a very harsh environmental conditions that are difficult for all other domestic livestock constituting an important source of meat and income in these arid regions. The potential of the camel as a meat producer has received little attention. The camel has a slow growth rate and has not been selected for meat production, so that it is very unlikely better than cattle breeds under intensive or semi-intensive conditions.

There are very few data on meat production potential of this species. The growth patterns, the efficiency of growth, fattening and carcass and meat quality, were not looked into in different breeds and under different ecological conditions. So and for want of specific data on meat recording systems in camelids, these aspects will be inferred by analogy with study carried out, for several years, with camel herd of the experimental farm at Higher Agriculture School in Tunisia.

Factors affecting weight and growth of camel

Weight of dromedary camels at birth are in the range 27-45 kg and are affected by sex, parity of dam, period (month, season, year) and whether or not dams have been subjected to nutritional and health interventions or not (Wilson, 1992). Breed probably affects weight at birth but no studies have been performed on this variable.

Studies carried out at breeding farm in India with reference to Bikaneri camel breed has reported the following results: average birth weight was 37.2 kg (Bargava *et al.*, 1965), 41.6 kg with hertability 0.6 (Berhat and Choudhary, 1980) significant sire effect was observed. The average birth weight for males was 41.9 and for females 39.9 kg (Tandon *et al.*, 1988). In the last study, which involved 532 records, effect of birth parity of dam and sex was highly significant.

Studies carried out in Tunisia with reference to Maghrabi camel breed reported these, in experimental farm conducted by Kamoun (1993, 1995a) reported, the smallest calf weighed 24 kg that is the half the weight of the heaviest calf, which was 48 kg, the average birth weight was 33.1 kg. Burgemeister (1975) recorded the birth weight of camel reared on pasture as 25.8 kg, lower than the average weights of 33.1 kg given by Kamoun for the same breed.

Such differences reveal the variations in camel calf performances attributable to breed, strain, environment and management. The exact role of these factors in the camel has not been investigated.

Average daily weight gains as high as 870 g from birth to 30 days and 570 g from birth to 180 days can be achieved when nutrition is adequate (Wilson, 1992). Weight at specific ages and growth rate are important parameters, detailed knowledge of which is required if rapid improvement in camel productivity is to be achieved. Then Kamoun (1995a) studied postnatal growth performance of young dromedaries reared from birth on-station. The results of his observations are given in table 1. They showed that male calves tend to grow fasters than female ones. These calves achieved high average daily weight gains from birth to wean 760 g for male and 620 g for female. Suckling young are weaned between 8 and 10 month. Weaning weight varied from 200 to 260 kg.

Field (1979) observed the growth patterns of camel calves in north of Kenya. Two groups of animals were studied, one under pastoral conditions and the other one under special conditions where the young received a greater proportion of mothers milk. The first group showed daily average gain of 222 g and 255 g during the dry and wet seasons respectively, while gains ranged from 378 g to 655 g for second group. The Measurement of the growth rate of the young camels under different forms of management indicates that the amount of milk permitted for the calf is of fundamental importance in controlling the rate of growth.

Table 1. Live weight and daily weight growth in young camels reared in the experimental farm of the ESA Mateur (Source: Kamoun, 1995a).

	Live weight kg		Daily weight gains g	
	Males	Females	Males	Females
Age (month)	Number = 13	Number = 16	Number = 13	Number = 16
0	35 ± 6	32 ± 5	-	-
6	179 ± 9	156 ± 12	798	687
12	286 ± 22	244 ± 21	596	492
18	349 ± 10	295 ± 16	352	285
24	403 ± 26	348 ± 9	301	292
36	496 ± 15	421 ± 47	258	202

With dam producing least 1 550 liters of milk per year, camel calf can survive on daily suckling of at least 25% of milk if there is provision of water, good pasture and veterinary care and that beyond suckling 75% of dam milk, the milk suckled did not influence growth rate (Ouda, 1995). Calf milk levels intake need to be established in order to maximum on both the calf growth and amounts of milk taken by the owner.

At weaning, young camels were individually hobbled in a common barn. They were fed a standard concentrate ration (500-1 200 g/10 kg l.w.per day) and wheat straw *ad libitum*. Animals were weighed every 14 days. Under this experimental conditions the weight achieved by weaned male camel were 286, 349 and 403 kg respectively at 12, 18 and 24 month old. The calve multiply their birth weight three times during the first 90 days and achieved at 12, 24 and 36 month old respectively 47.6%, 63.0% and 82.7% of mature weight for male and 48.8%, 70.0% and 84.2% of mature weight for female. Male and female reached 88% and 95% of mature weight respectively at 4 years (Table 1).

Compensatory growth

In a study carried out at the experimental facility of the ESA Mateur in Tunisia Kamoun (1993), Kamoun and Wilson (1994) reported the growth patterns of camel calves. Two groups of animals were studied, one bought as wean in the market and another reared from birth on-station. At weaning animals born on-station were always heavier, and had greater linear measurements in relation to average mature size than those bought. These differences were maintained at 12 and 24 month of age. Compared to the station-born the market animals were about 6 month later in reaching a given weight (Table 2). Early restricted feeding in the market group had lasting effects on development. Compensatory growth was evident as market camels on station, at given age, had better conformation and weighed than their contemporaries in the traditional system (Kamoun, 1993). Also Field (1979) showed a better performance by calves born during wet season than by calves born in the dry season in spite of compensatory growth. The early environment of camels, with full access to milk before weaning, is a determining factor in physical development.

Growth

Weight at specific ages and growth rate are important parameters, detailed knowledge of which is required if rapid improvement in camel productivity is to be achieved. Little work, however, appears to have been done on the growth rate of camel under different climatic conditions. But only few empirical and experimental data are available probably because there are considerable difficulties involved in weighing camels in both experimental and traditionally managed herds. Less than 1.3% of all camel literature references provide information on growth and weight underline these problems (Wilson, 1992). Previous investigations on growth in the camels have been inconclusive and difficult to compare because of differences in experimental conditions.
So some work conducted for several years in Tunisia on growth in dromedaries under determined growth conditions. This work aims to contribute to the knowledge has already been acquire on the growth, and to the determination of equations for weight prediction, based on measurements carried out on the growing dromedary.
Data are collected from the camel herd of the experimental farm of the Ecole Supérieure d'Agriculture of Mateur on 39 growing animals of the Maghrabi race (10 bought as wean in the market and 29 reared from birth on the station) fed concentrate and straw ration. Animal weighed every 14 days using adapted livestock scale. Linear measurements were carried out monthly using three instruments graduated in centimeters and manufactured in craftsman technique (a tape-measure three meters long, a large height-gage and a small height-gage). 973 series of 20 types

Table 2. Comparative age of camels born on Station and bought from the market as wean at 200 kg and at 350 kg Live Weight (Source: Kamoun, 1993)

	Age (day) at given live weight (kg)	
Live weight (kg)	200	350
Age of camels bought from the market as wean (day)	430±48	876±180
Age of camels born on ESA Mateur Station (day)	230±28	687±150
Age late to reaching givens live weight	200 days	189 days

Table 3. Morphometric measurements recorded.

Animal no……(Date:……)		
Age (months)	Breadth (cm)	Neck girth (cm)
Weight (kg)	Chest	at the 1st CV
Height (cm)	Shoulder	at the 4th CV
Shoulder	Hip	at the 7th CV
Hump	Trochanter	Metacarpal length (cm)
Sacrum	Length (cm)	Metatarsal length (cm)
Girth (cm)	Scapulo-ischial	
Chest	Neck length	
Hump	Head length (chignon-nostril)	
Spiral girth	Head wide (between eyes)	

measurements were thus available for calculations (Table 3). From the 20 types of measurement done, only 7 were finally chosen because of their precision and their strong correlation to the live weight. Morphometrics measurements, from birth to 3 years and above, of those camels were given in table 4.

From this data a growth function has been adjusted to sequential body weights. The compertz growth equation is the same as that used by Laird (1966):

$$P=P0Exp[A / a(1-Exp(-at))]$$

in which P is the weight at time t, P0 is the birth weight, and A and a are constants. The model gives the evolution of weight in relation to time with co-ordinate at inflexion point Pi, t_i. Pi, t_i were weight and age at maximum growth rate. In table 5 is summarised the growth constants for both camel sexes.

The growth constants indicate a general tendency for the camel female to pass through her growth period faster and to mature earlier than the male. There was strong evidence of allometric growth. Large ranges were observed among linear measurement for developing rate, the classification from earlier to later Shoulder height, Chest girth and Hump girth respectively. In the other hand, linear measurements were developed much more rapidly than live weight in terms of final mature values.

An indication of weight may be required for improvement of camel breeding. Several formulas to predict weight, at different ages and for different categories, combining different linear measurements, were established. These prediction formulas are shown in table 6. Most of the barymetric formulas are based on the idea that an animal weight is proportional to its volume and that the best expression of the latter is a

Table 4. Physical characteristics of Tunisian Maghrabi camels born and reared on station in northern Tunisia.

	Males					Females				
Age (months)	0	12	24	36	60 or more	0	12	24	36	60 or more
Weight (kg)	34.5	285.7	403.0	496.4	640–730	31.9	244.1	350.4	421.0	500-580
Height (cm)										
Shoulder	97.8	145.2	155.4	163.3	172-176	98.5	141.1	152.0	158.0	160-170
Hump	98.6	161.0	169.0	182.5	198-202	99.9	158.7	169.8	180.8	185-200
Sacrum	95.9	143.0	153.6	161.8	163-165	95.1	140.0	150.23	155.5	155-160
Girth (cm)										
Chest	76.9	165.5	181.4	212.8	220-247	74.9	156.4	180.8	207.3	210-220
Hump	79.0	209.4	241.0	264.8	290-328	76.6	195.0	236.4	250.0	260-270
Scapulo-ischial length (cm)	64.3	129.3	146.4	155.0	173-175	61.8	123.2	145.2	155.8	158-165

Table 5. Growth model constants of camels.

Growth constants	Camel male	Camel female
A	0.0099	0.0081
(a)	0.0048	0.0044
ti (day)	151	138
Pi (kg)	116	92.5
Maximum rate (g / day)	556	408

Table 6. Formulas for estimating camels live weight.

Live weight formulas	Animal number	Country or area	Source
P (kg) = 53*T*A*H	38	South Algeria	Boue, 1949
P (kg) = 52*T*A*H	-	Chad	Graber, 1966
P (kg) = 507*T-457	28	Sudan	Wilson, 1978
P (kg) = 3.06*A-290.6	81	Egypt	Bucci *et al.*, 1984
P (kg) = 6.46*10-7*S3.17	9	Kenya	Field, 1979

T: Chest girth (in m); A: Hump girth (in m); H: Shoulder height (in m) and S = T + A + H in cm.

product of order 3 of linear magnitudes. However, for constructing simple chart we must use only 2 linear measurements. Then, the data collected from the camel herd on station, have been used and permitted to determine some prediction formulas for live weight based on tow measurements:

1. For young calves: Live weight (kg) = $52.17 \cdot HB^{1.6374} \cdot CT^{1.7171} + 1.35$ which HB hump height, CT Chest girth in meters ($R^2_{(5\%)} = 0.96$),

2. For growing male: Live weight (kg) $=9*10^{-6}*HG^{1.8953}*CA^{1.4637}$ which HG Shoulder height, CA hump girth in centimeters ($R^2_{(5\%)} = 0.98$) and
3. For growing female: Live weight (kg) $=1.9*10^{-6}*HG^{2.7082}*CA^{0.9957}$ which HG Shoulder height, CA hump girth in centimeters ($R^2_{(5\%)} = 0.96$).

These formulas were used for building abacus.

Nutrition and growth

There have been relatively few investigations on feeding standards for growing camel and assessment of these standards remains very empirical and often extrapolated from cattle data.

Dry matter intake values for growing camels grazing natural pastures have been estimated to be 0.97-1.21 kg/d/100 kg l.w. (Kamoun and Steinmetz, 1995). These camels were, often subjected to poor grazing conditions and the feeding level is often at or below maintenance, with considerable weight losses during dry seasons. Feed supply is the top constraint to increased camel meat production.

In view of searching the best growth and diet ration for camel, some trials were conducted in the experimental facility of the ESA Mateur in Tunisia (Hashi *et al.*, 1995; Kamoun, 1993; Kamoun 1995b; Kamoun *et al.*, 1989a, b). 16 young dromedaries, distributed in several groups, were fed medium quality forage (wheat straw or oats hay) *ad libitum* and concentrates in different quantities (0.4-3.2 kg) and for different qualities (16, 22 and 28% CP on a DM basis). The animals were kept under hobbled stalling. Feed consumption (feed offered minus refusals) was measured and recorded every day. Their intake during the tethered period ranged from 1.4 to 1.8 kg DM per 100 kg live weight. Forage intake was higher for the hay (0.94-0.97 kg DM per 100 kg lw), but it may have been affected by the quantity and quality of concentrate. However, total DMI of this species remained, in any case, limited even with high concentrate level (over 50% of total diet on DM basis). In the other hand, these results indicate the opportunities for low-cost seasonal supplementation of camel to optimize growth. The average daily weight gain variation ranges from 285 g up to 525 g. An overall average daily gain of 285 g was achieved with low energy consumption (8.5 MJ ME per kg DM).

A significant relationship (y=284+5.4x) between daily gains (y, in g) and daily intake of concentrate (x, in g per kg $w^{0.75}$) is shown. An amazing growth rate (280 g per day) has been observed using a medium quality ration. There is a need to further investigation in order to find out the responses to different supplements across a wide range of feeding conditions.

It has been claimed that camels fatten rapidly when fed 15 to 20 kg of mixture of straw, beet pulp silage, molasses and 10 to 15 per cent barley grains and that camels feeding on growing sugar beet tops gain as mush as 1.5 kg per day and can be made ready for slaughter in 60 days (Wilson, 1989). The compensatory growth explained this high average daily weight gains. In an attempt to provide at least some realistic data on the potential of camels for meat production. Some fattening trials were conducted at the experimental facility of the ESA Mateur in Tunisia between 1987 and 1995. A summary of the results is given in table 7, in which 15 young male camels and 20 young bulls were fed during 120 days oats hay *ad libitum* and received the same quantity of concentrate (1.2 kg per 100 kg/lw). The animals were kept under hobbled stalling. The average feed consumption (DM per 100 kg lw) and the average daily weight gains were ranged respectively between 1.72-1.90 kg DM and 797-806 g for camels and 2.83-3.21 kg DM and 1 151-1 172 g for Steers. These trials confirmed that camel voluntary intake is very low. There is some evidence that camel daily weight gain can be increased by better quality feed rather than an increase in quantity. The average daily gain can reach 1 000 g/day under the most favorable fattening conditions.

The carcass and camel meat characteristics

Camel meat is produced in around 537.7 thousand tons of meat, most of which is produced in Somalia, Sudan and Mauritania (Wardeh, 1992). A considerable number of camels are managed and bred specially for slaughter in the Near East, and North Africa. A large number of these camels are exported. Both Somalia and Sudan export large numbers of camels to Saudi Arabia, Egypt and the Gulf States, while Libya imports camels from Sudan, Mali, Algeria, and Mauritania every year for slaughter. The camel meat is relished as beef in Middle East and African countries, is highly appreciated in many parts of Arabia, Libya, Algeria and Tunisia. There is often some resistance to the consumption of camel meat in non-camel herding societies. However, in pastoral societies, camels are rarely slaughtered except during ritual ceremonies.

The potential of the camel as a meat producer has received little attention. The most problem relating to meat production concerns the lack of coordinated data. Slaughter enabled us to gather information on the way the animal is transformed into meat and in particular on the

Table 7. Comparison of dry matter intake and daily weight growth in young camels and steers receiving the same feeding ration (Source: Kamoun, 1995b).

Animals type	Camel		Steer	
Number	6	9	10	10
Duration (days)	120	120	120	155
Mean Live Weight (kg)	180±31	300±36	215±36	305±58
Average Daily Gains (g)	806±211	797±164	1151±155	1172±129
Dry Matter Intake (kg per 100 kg lw)				
Oats hay	0.64±0.22	0.72±0.18	1.52±0.29	1.96±0.10
Concentrate	1.26±0.14	1.00±0.08	1.31±0.31	1.25±0.06
Total intake	1.90±0.24	1.72±0.21	2.83±0.25	3.21±0.16
Kg DM per kg weight growth	4.56±1.57	6.7±1.35	5.34±1.14	7.60±1.19

importance of what is often called the 5th quarter, which represents more than 20% of the live weight. An indication of these parameters may be required to compare the meat production potential of these species, with different breed and under different management conditions.

Slaughtering and jointing yield

Actual slaughter weight, carcass weight and dressing percentage data are almost completely lacking.

There is a considerable phenotypic variation in the live weight of mature dromedaries, whose age at full growth ranges from 6 to 7 years for males and slightly earlier in females. For the same breed, animal weight varies with age, sex and depends mainly on husbandry practices and condition of the vegetation. Live weight is heavier and age at full growth is earlier when these animals were well managed from weaning to maturity. All recent figures are consistent with the average dromedary weights 450-600 kg, while the average bactrian camel is slightly heavier. Dong Wei (1979) stated that the economic importance of the Chinese bactrian camel is primarily in work output and wool production. However it was found that body weight ranged from 400 to 600 kg.

Average carcass weight of the Iranian dromedary was reported as 300-400 kg for males, with that females being 250-350 kg (Khatami, 1970). These Iranian camels must have been well fattened. The same author further gave a figure of 650 kg as a possible carcass weight for the Bactrian camel. In the other hand, Bremaud (1969) noted that the average carcass of Somali camels be estimated to weight 286 kg. A carcass weight of 231 kg was given for males and 196 kg for females in Sudanese camels (Wilson, 1978).

The dressing percentage varied from 55 to 70 per cent (Kamoun, 1989; Shalash, 1979). Camel males have a higher dressing percentage than females. In general the dromedary have a higher dressing percentage (in the range of 54-57%) than other domestic animals Wilson (1984). The dressing percent seems to be rather high and it is not clear the average dressing percentage on live weight or on empty body weight. Indeed, in the Sudan southern Darfur camels were found to have dressing percentage on live weight of 51.4 in males and 47.4 in females (Wilson, 1978).

Only few sources provide data relating to slaughter and carcass weight, dressing percentage on live weight and on empty live weight, carcass characteristics and age (Bahamou and Baylik, 1999; Biala *et al.*, 1990; El-Gasim and El-Hag, 1992; Kamoun, 1995a, b; Wilson, 1978; Youssif and Babiker, 1989). Main results are summarised in table 8.

In a Tunisian study involving 15 camels, well managed from weaning to slaughtering in ESA Mateur experimental station, Kamoun (1995a, b) derived some very useful results, which are shown in tables 9, 10, 11 and 12 for illustration and comparison. After slaughtering the fattened males, the following aspects were studied: slaughtering and jointing yield, and carcass tissue composition.

Table 8. Live weights, carcass and body components weight, and dressing percentage in camel males.

Source	Kamoun 1995	Biala *et al.*, 1990	El-Gasim and El-Hag 1992	Youssif and Babiker 1989	Wilson 1978	Bahamou and Baylik 1999
Country	Tunisia	Libya	Saudi Arabia	Sudan	Sudan	Algeria
Place	Experimental station	Experimental station	Experimental station	Slaughter house	Slaughter house	Slaughter house
Number	15	6	12	22	21	47
Age (years)	3	2	2	Mature	Mature	Mature–castrato
Type	Well-fattened	Fattened	Non-fattened	Well-fattened	Non-fattened	Non–fattened
Live weight kg	413.8	288	226.8-271.0	456.1	447.9	459.7
Empty weight kg	351.5	241.3	194-235	404.8	367	-
Carcass weight kg	231.1	146.8	119.5-132.5	239.9	231.3	244.2
Carcass % Live weight	55.8	51.0	52.1-56.1	56.6	51.4	53.3
Carcass % Empty weight	65.4	60.7	60.0-65.5	63.8	63	-
Hump weight kg	20.1	9.1	2.3-4.2	30.8	4.0	8.8
Digestive tact content % lw	15.1	16.1	13.2-14.4	11.2	23.2	-
Body components kg						
Head	12.5	7.7	6.7-8.6	14.1	12.1	12.9
Four feet	13.0	8.4	-	14.4	14.6	15.3
Stomach+Intestines(empty)	18.5	12.6	11.5-12.4	25.7	-	21.9
Liver	5.4	4.2	3.8-4.6	8.0	7.5	7.3
Lung and trachea	3.9	2.2	2.0-2.3	5.9	-	2.8
Heart	1.8	1.4	1.4-1.6	2.7	-	3.4
Kidneys	1.3	0.91	1.9-2.0	1.7	-	1.8
Spleen	0.4	0.3	0.3	0.5	-	0.3
Hide	35.2	19.8	-	35.8	34.8	25.3

The slaughter weight and carcass weight of mature Sudanese desert camels were in no –fattened male 306 - 581 kg and 144-310 kg, yielding dressing percentage on body weight and on empty body weight of 46.2-55.6% and 55.7-65.1% and in well fattened male 395-512 kg and 208-295 kg, yielding dressing percentage on body weight and on empty body weight of 47.2-62.8% and 53.1-74.7 respectively. Wile the mature castrato Algerian camels for the same slaughter weight give heavier carcass. For average camels carcass weight of 231-244 kg there are a great variation in the weight of humps, 4-31 kg (Table 8). The discrepancy on the live weight of this Sudanese desert camels breed may be explained by the weight of the digestive tract content, it self influenced by the duration of fasting between last weighing and slaughtering.

The slaughtering males, aged from 15 to 50 months and weighing 280-560 kg provide between 150 and 343 kg of carcass. The 5th quarter, blood and digestive tract content represent 22.6±1.7; 6.8±3.5 and 15.1±5.1 of the live weight, respectively. Slaughtering yield, expressed as the carcass weight on body weight and on empty body weight were 55.67±2.77% (52.3-61.4%) and 65.40±3.74% (60.30–72.12%), respectively. The hump, fat included, accounts for 8.4% (5-13%) of carcass weight. The rate of live growth did cause a change in the camel carcass yield and characteristics. Carcass weight and yield and hump increased as right increased. The fact that dressing percentage varies with live weight, carcass weight, age, sex, breed and the digestive tract content (Table 9). Camel body components are also summurised in Table 8 and 9. The camel head and four feet had an average weight of 12.5±2.8 kg and 13.0±2.7 kg, they represent about 3.5% of the empty body weight. Camel hide had a weight of 35.2±9.5 which represent 10% of the empty body weight. Liver, Lung with trachea, heart and kidneys weight were 5.4±0.8 kg, 3.9±0.9 kg, 1.8±0.4 kg and 1.3±0.2 kg and represent 1.5%, 1.1%, 0.5% and 0.4% of the empty body weight respectively. As for the empty digestive tract (stomach + intestines) it weighed 18.5±3.2 kg and represent 5.3% of the empty body weight. The relative proportion of body weight components indicated that the heaviest body component was the hide followed by digestive tract. The relative proportion of body component agreed with values reported by Bahamou and Baylik (1999), Wilson (1978) and Youssif and Babiker (1989). Compared with body components for bulls reared under the same conditions and weighing the same empty body weight, the camel had a lighter head and digestive tract but heavier hid.

Camel wholesale cuts are shown in table 10. The cut, into wholesale cuts are not set up in standard manner and change from one author to another. So the comparisons between authors are not easy. But, generally, the leg and shoulder weights as proportion of the hot carcass weight were the heaviest joints in the carcass followed by thoracic region (dorsal+flank) and neck. Carcass joints having lighter weights in the lumbar region and abdominal flank.

According to traditional cutting (Figure 1), the wholesale yield cuts have been studied on fifteen fattened males camels slaughtered at different body shape (Kamoun, 1995a, b). The neck, the fore limb, the thoracic-back region, the ribs, the lumbar region, the hind limb, the flank, the hump and others (kidney fat + tail + diaphragm muscle) represented respectively, 9.4%; 22.6%; 8.1%; 10.8%; 7.5%; 24.5%; 5.7%; 8.4% and 3.0% of carcass weight. In all cases, forequarters were heavier (51 and 49% of carcass weight), than the hindquarters.

Carcass tissue composition

The camel carcass and camel meat characteristics are important parameters, detailed knowledge of which is required if rapid improvement in camel meat production is to be achieved. Some work, however, appears to have been done on camel meat but only few experimental data are available. This can be attributed to the lack of the same reference methods for the assessment of carcass and meat characteristics which to be used at the end of camel production experiments.

Table 9. Comparison of carcass weight and dressing percentage of camels and steers.

	Kamoun 1995b Experimental Station in Tunisia						
	No. = 15 fattened Magharabi camels			No = 6 Steers (FFPN)			
	Mean	± SD	Range	Mean	± SD	Mean	± SD
Age (month)	30	12	15–50	9	1	13	1
Live weight kg	413.8	104.4	280–560	283.5	1.5	405.6	5.4
Empty weight kg	351.5	85.1	240–476	218.8	0.4	345.3	8.6
Carcass hot weight kg	231.1	63.1	149.5–343.3	134.0	0.1	219.0	9.2
Carcass % Live weight	55.67	2.77	52.33–61.41	47.3	0.2	54.0	2.2
Carcass % Empty weight	65.40	3.74	60.30–72.12	61.2	0.1	63.4	1.7
Hump weight kg	20.1	9.4	8.5–44.0	-	-	-	-
Hump % carcass	8.4	2.2	5.1–12.8	-	-	-	-
Digestive tact content % lw	15.1	5.1	11.2–18.5	22.8	-	14.9	-
Body components kg							
Head	12.5	2.8	8–18	14.7	1.1	21.0	0.5
Four feet	13.0	2.7	9.5–18.5	8.7	0.3	11.7	0.5
Stomach + intestines (empty)	18.5	3.2	13.5–23.7	17.7	0.3	29.3	2.5
Liver	5.4	0.8	4.3–7.1	3.3	0.1	5.7	0.2
Lung and trachea	3.9	0.9	2.2–5.5	2.2	0.1	5.1	0.1
Heart	1.8	0.4	1.2–2.6	1.3	0.1	1.6	0.1
Kidneys	1.3	0.2	1.0–1.6	0.8	0.1	0.9	0.1
Spleen	0.4	0.1	0.3-0.5	0.5	0.1	0.8	0.1
Hide	35.2	9.5	21.5–50.0	16.8	0.4	29.0	0.8

Youssif and Babiker (1989) reported that the mean composition of 9 carcass was 56% (43.6-67.6%) meat; 19% (13.4-25.3%) bone and 13.7% (7-18.4%) fat. In these 9 carcasses muscle: bone ratio ranged from 2.7 to 3.0. On the other hand Kamoun (1995a, b) determined the tissue composition by dissection of twelve camel male carcasses. He reported that these carcasses which weighed 256.6 kg (181-343 kg) contain, in average of 60.9% (57.3-64.9%) meat, 20.9% (16.2-23.7%) bone and 18.2% (12.5-24.0%) fat. However, the meat: bone ratio decreased while body shape increased. The muscle: bone ratio was ranged from 2.48 to 3.76 with mean of 2.95±0.39 (Table 11).

Wholesale yield cuts and joint composition are shown in table 12. The tissues were unevenly distributed in the carcass. Meat, bone and fat composition were respectively 66.9±1.3; 26.8±3.7% and 6.3±3.6% for the fore half and 54.5±3.2%; 14.8%±1.7% and 30.7±3.9% for the hind half.

Table 10. Yield of wholesale cuts from camel carcass (% of carcasses).

Source	Kamoun 1995	Biala *et al.*, 1990	Bahamou and Baylik 1999	Wilson 1978	El-Gasim and El-Hag 1992	
Country	Tunisia	Libya	Algeria	Sudan	Saudi Arabia	
Place	Experimental station	Experimental station	Slaughter house	Slaughter house	Experimental station	
Number	15	6	47	21	12	
Age (years)	3	2	Mature–castrato	Mature	2	
Type	Well-fattened	Fattened	No-fattened	No-fattened	No-fattened	
Forequarter	50.9	63.2	58.5	57.5	-	
Neck	9.4	10.4	10.2	-	Neck	7.5
Shoulder	22.6	22.8	23.6	-	Shoulder	31.6
Thoracic region	18.9	30.0	24.7	-	Rib	14.6
Hindquarter	49.1	36.8	41.5	40.5	Loin	6.0
Lumbar region	7.5	16.3	9.3	-	-	
Leg	24.5	20.5	28.7	-	Leg	28.8
Abdominal flank	5.7	-	-	-	-	
Hump	8.4	-	3.5	2.0	Hump	5.2
Tail-int.fat - m.Onglet	3.0	-	-	-	Others	6.3
Total carcasses	100.0	100.0	100.0	100.0	Carcass%	100.0
Carcasses kg	231.1	147.0	244.2	231.3	Carcass kg	126.0

The hump fat included, accounted for 60.0±4.7% of the hind half fat. The meat: bone ratio were respectively 3.73-2.55-4.30-3.59-2.67-2.49-1.53 in the hind half, fore half, fore limb, hind limb, neck, lumbar region, thoracic back region and ribs.

Joint composition indicated that the shoulder and leg had a muscle proportion around 75%. The joints, neck and lumbar region had a muscle proportion of 71% and 60% respectively. The proportion of bone in wholesale cuts was highest in the thoracic, dorsal and flank regions and a minimum in the flank joint. The proportion of fat was higher in the abdominal flanks which ranged between 25 and 45% while a minimum fat contents was found in the neck, shoulder and leg joints.

Quality of camel meat

The quality of meat has received little attention. Earlier camel meat was described as palatable, but coarser than beef, varying in color from raspberry red to brown red and having white fat (Leupold 1968). Khatami (1970) indicated that in appearance and color, texture and palatability, camel meat is very similar to beef.

Table 11. Live weight and carcass characteristics in males camel.

Sources	Kamoun 1995	Biala *et al*., 1990	Youssif and Babiker 1989
Country	Tunisia	Libya	Sudan
Place	Experimental station	Experimental station	Slaughter house
Number	12	6	9
Age (years)	3	2	Mature
Type	Well-fattened	Fattened	Well - fattened
Live weight kg	455.0	288	456.1
Carcass weight kg	256.6	146.8	239.9
Hump weight kg	20.1	9.1	30.8
Meat % carcass	60.9	60.5	57.8
Bone % carcass	20.9	28.1	18.8
Fat % carcass	18.2	9.2	13.7
Trimming % carcass	-	2.2	9.7
Muscle : Bone ratio	3.31	2.20	2.95

The quality of meat produced by younger animals was comparable to beef in taste and texture. With increased age, however, there is an increase in meat toughness; the meat also becomes less testy and of inferior quality. There is a great reluctance on the part of camel owners to sell their young stock. Since animals are usually slaughtered at the end of their productive life. Most trade therefore consist of meat from much older animals the low quality of which has a direct bearing on the extent of demand for camel meat outside the camel herding societies. Camel meat is often labeled inferior in urban societies, and its consumption is considered fit only for poor.

Unfortunately, in spite of all the indication of the superior quality of meat from young animal, objectives data on change of camel meat quality with age are almost completely lacking. In recent years the potential of the camel as a meat source has received creased recognition but only few investigation on the chemical composition and eaten quality of this meat have been published.

Meat differs in composition according to type and condition and the fat content of tissues varies. The chemical composition of camel meat has been studied. Nasr *et al*., (1965) indicated that the meat of young camels (below 5 years) has a higher moisture content (78.3%) than that of older animals (76.2%) and estimated the crude protein, fat and ash contents of the two age groups as 20 and 22%, 0.92 and 1.01%, and 0.76 and 0.86% respectively, with no significant difference between the sex.

Kamoun (1995b) found that quality of camel meat varies with age. The mean chemical composition was presented in table 13.

Table 12. Traditional wholesale cuts and joint composition in camel carcasses.

Source	Kamoun 1995a, b				Biala *et al.*, 1990			
Country	Tunisian cut				Libyan cut			
Number	12				6			
Age (years)	3				2			
	Weight kg	Tissue composition			Weight kg	Tissue composition		
Cut pieces		% Muscle	% Bone	% Fat		% Muscle	% Bone	% Fat
Forequarter	131.3±26.6	66.9±1.3	26.8±3.7	6.3±3.6	73.4-113.1	61.3-62.3	27.7-31.0	7.7-10.0
Neck	24.4±6.4	71.3±3.8	27.5±4.0	1.2±0.5	11.0-19.7	69.0-72.3	25.3-31.0	0.0-2.4
Shoulder	57.1±12.1	76.7±3.6	18.2±2.6	5.1±2.4	27.0-38.6	67.8-71.3	27.2-30.7	1.5
Thoracic dorsal region	22.7±4.2	56.0±3.2	36.4±7.9	7.6±5.5	35.4-54.8	51.1-53.1	29.7-31.1	15.8-19.2
Thoracic flank (Rib)	27.1±5.0	51.6±4.3	36.7±8.6	11.7±6.4				
Hindquarter	125.3±27.3	54.5±3.2	14.8±1.7	30.7±3.9	42.7-64.2	61.8-66.4	24.6-30.3	7.9-9.1
Lumbar region	16.9±2.8	60.4±7.6	25.6±4.8	14.0±3.6	18.8-28.6	51.8-55.6	24.7-29.3	18.9-19.7
Abdominal flank	16.2±3.8	66.1±6.8	0.0±0.0	33.9±6.8				
Leg	61.8±12.6	74.5±2.7	21.0±2.3	4.5±1.5	23.9-35.6	69.2-74.9	24.5-30.8	0.0-0.6
Hump	23.6±8.4	0.0±0.0	0.0±0.0	100±0	-	-	-	-
Tail + Kidneys fat + m. onglet	6.8±1.7	-	-	-	-	-	-	-
Total carcasses	256.6±53.3	60.9±2.1	20.9±2.5	18.2±3.5	116.1-177.3	61.6-63.5	26.5-30.1	8.3-10.0

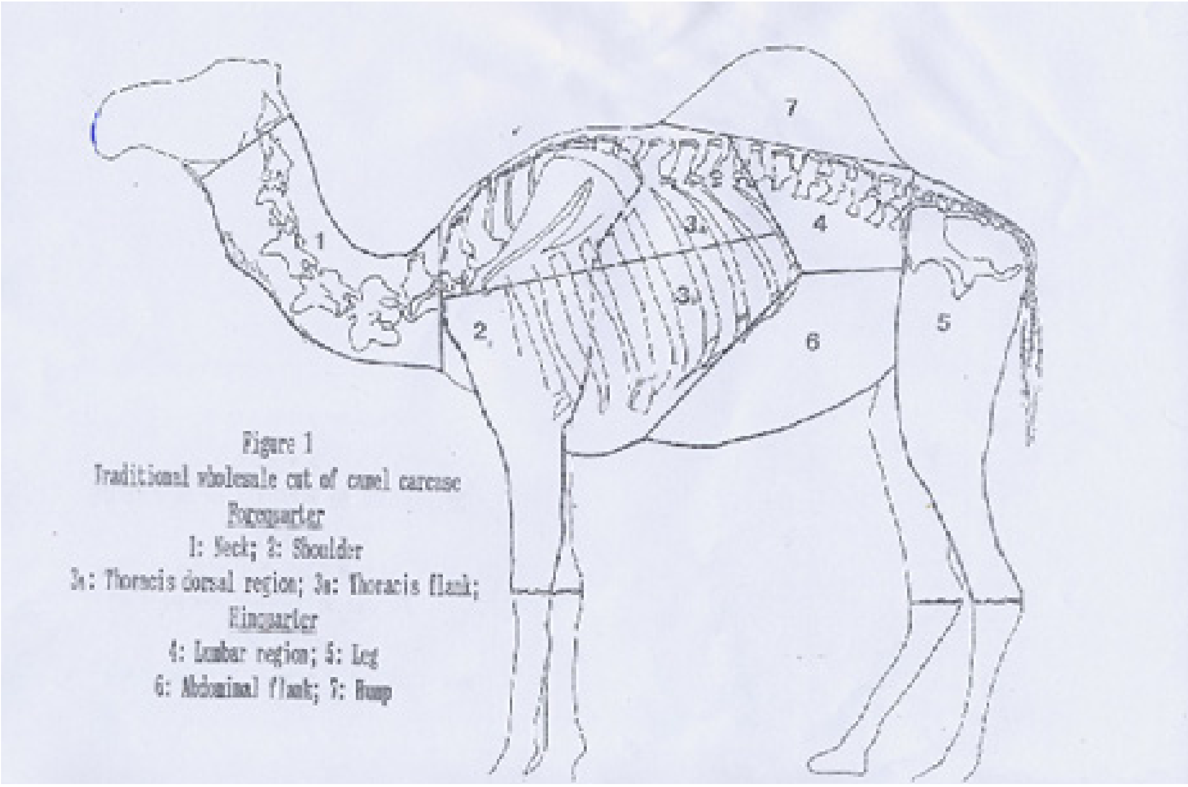

Figure 1. Traditional cuttings of camel meat.

Table 13. Chemical composition of camel and steers meat.

Type	Steer meat	Camel meat	Camel meat	Camel meat	Camel meat means
Age (month)	15	20±4	34±2	49±1	30±12
Moisture %	73.0±0.9	77.5±0.8	78.1±1.4	76.9±1.7	77.6±1.7
Dry matter %	27.0±1.30	22.5±1.3	21.9±2.0	23.1±2.2	22.4±1.7
As dry matter %					
Protein	77.0±2.9	91.4±3.3	91.2±4.0	89.6±9.0	91.0±5.1
Fat	18.5±3.3	3.55±3.25	4.25±3.69	5.89±8.77	4.2±4.9
Ahs	4.5±0.1	5.1±1.1	4.5±1.1	4.5±0.9	4.8±1.1
Collagen	2.69±0.95	2.35±0.9	2.54±0.76	2.47±0.79	2.4±0.8
Myoglobin	2.20±0.43	1.65±0.41	2.10±0.61	2.64±0.54	1.97±0.63
% collagen soluble	18.3±2.9	39.6±15.3	31.4±11.6	22.7±10.9	34.1±13.0

It was observed that the moisture content of fresh camel meat was 77.6% and camel meat contain 20.4% protein but only about 1% fat. The chemical composition varies with age: percent fat, increased as body shape increased while moisture decreased. Chemically, camel meat was compared with meat of steer 15 month old. The result indicated that camel meat contains more moisture, more protein, less intra muscular fat, the same level of collagen (Tenderness) and the same percentage of ash. However, few differences between meat were observed for protein excluding fat. It was also found that myoglobin (color), increased in camel meat as body shape increased. At four years old camel meat, reached the same color than that from steer below 2 years old.

Hamman *et al.*, (1962) found that the LD muscles obtained from 5 year old camels had an average 19.4% protein, 76.2% moisture, 2.6% fat and 1.1% ash, the round muscles (ST) had 19.8% protein, 78.3% moisture and 3.8% fat while shoulder muscles (TB) had 22.3% protein, 76.1% moisture, 0.95% fat and 0.79% ash.

It was of interest to test the meat quality in different cuts. Then chemical and sensory properties of the following six muscle from fifteen young fattened males camel were evaluated by Kamoun (1995b): Psoas major (PM), Longissimus dorsi (LD), Semimembranosus (SM), Semitendinosus (ST), Vastus lateralis (VL) and Triceps brachii caput longum (TB). These camel muscles weight and characteristics are given in table 14 and mean chemical composition in table 15. In the other hand, Babiker and Youssif (1990) compared the chemical composition and the eating quality attributes to LD, ST and TB muscles obtained from nine mature well finished camels, while El Kady and Fahmy (1985) studied the effect of aging by cold storage on some physical and chemical properties of buffalo and camel meat. A summary of these results is given in table 16.

Table 14. Weight and characteristics of six camel muscles.

Muscle removed from	Muscle	Weight kg	As percentage of Total carcasses	As percentage of Total carcass meat
Shoulder				
	Triceps brachii (TB)	3.60±0.93	1.39±0.11	2.22±0.22
Lumbar region (loin)				
	Longissimus dorsi (LD)	3.05±0.60	1.20±0.17	1.98±0.28
	Psoas major (PM)	1.70±0.22	0.68±0.10	1.11±0.16
Leg				
	Semitendinosus (ST)	1.07±0.37	0.41±0.08	0.68±0.14
	Semimembranosus (SM)	2.17±0.50	0.85±0.07	1.39±0.13
	Vastus lateralis	2.22±0.34	0.88±0.10	1.44±0.14

Table 15 Chemical composition and eaten quality attributes of the six major camel muscles (Source: Kamoun 1995b).

	PM	LD	SM	ST	VL	TB	Muscle means
Moisture %	77.7	75.1	78.1	78.4	78.3	77.8	77.6±1.7
Dray matter %	22.3	24.9	21.9	21.6	21.7	22.2	22.4±1.7
As dry matter %							
Protein	91.8	82.9	92.4	93.4	93.2	92.1	91.0±5.1
Fat	3.5	12.2	2.8	1.9	2.2	2.8	4.2±4.9
Ashes	4.9	4.8	4.8	4.7	4.7	5.0	4.8±1.1
Collagen	1.5	1.7	2.3	3.5	3.1	2.5	2.4±0.8
Myoglobin	1.75	1.64	2.63	1.59	1.89	2.29	1.97±0.63
Eaten quality							
Color :Myoglobin mg/g FM	3.9	4.1	5.8	3.4	4.1	5.1	4.4±1.4
Tenderness							
Collagen mg/g fm	3.3	4.1	5.0	7.5	6.6	5.6	5.5±1.8
Sensory tenderness	7.2	6.6	3.7	3.6	1.9	3.9	4.5±1.8
Percent collagen soluble	29.4	29.1	29.7	33.9	42.0	40.5	34.1±13.0
Sensory juiciness	6.2	6.8	5.2	3.8	4.1	5.8	5.3±1.1
Cooking weight loss %	44.6	45.0	49.3	48.2	51.1	50.8	48.2±2.5
Cooking volume loss %	41.1	42.0	45.6	44.3	47.8	44.7	44.2±2.2

Kamoun (1995b) observed few differences between muscles for dry matter excluding fat. However, a large range in percent fat (determined on lean tissue trimmed of all external fat) was observed: the LD the highest fat content (12.24±8.07 as % dry weight) and ST the lowest (1.94±0.78 as dry weight %). The six muscle PM, LD, SM, ST, VL and TB were ranked by percent fat, total myoglobin (color) and total collagen (Tenderness). Large ranges were observed among muscles for percent fat, total myoglobin and total collagen, the classification were: leaner to fatty (ST-VL-SM-TB-PM-LD), pale pink to bright red (ST-PM-LD-VL-TB-SM) and most tender to least tender (PM-LD-SM-TB-VL-ST), These muscle enclosed (0.42±0.17; 0.47±0.20; 0.61±0.26; 0.63±0.29; 0.73±0.39; 3.16±2.45) percent fat and (3.47±1.07; 3.89±0.79; 4.10±1.24; 4.12±0.97; 5.09±1.43; 5.77±1.72) mg of myoglobin and (3.34±0.64; 4.10±1.10; 5.01±1.00; 5.60±1.18; 6.62±1.36; 7.66±1.80) mg of collagen per gram of fresh meat respectively.

In all case, crud fat and total myoglobin increased while moisture and collagen solubility decreased as body shape increased. Chemical composition of LD is the one that varies the most with age, fat content increased as body shape increased while moisture decreased. After 3 years, intra-muscular fat deposited, coming from the hump, makes meat richer in fat, producing, as a result, marbled meat.

Table 16. Chemical composition and eaten quality in camel, steers and buffalos muscle.

Source	Kamoun (synthesis)			Kamoun (1995a, b)						Youssif and Babiker (1989)			El-Kadi and Fahmi (1985)	
Animal Types	Steer			Camel									Buffalo	Camel
Ages	Under 2 years			From 1 to 2 years			From 3 to 4 years			5 years or more			3 years	
Muscle	LD	ST	TB	LD	ST	TB	LD	ST	TB	LD	ST	TB	LD	LD
Chemical composition														
Moisture %	71.5	73.4	74.4	75.8	78.1	77.7	73.1	77.4	77.2	75.9	75.81	75.2	76.1	79.6
Dray matter %	28.5	26.6	25.6	24.2	21.9	22.3	26.9	22.6	22.8	24.1	24.2	24.8	23.9	20.4
Protein (% dm)	74.4	80.8	78.9	85.8	93.2	91.8	74.3	92.7	92.2	89.7	88.5	89.2	87.3	85.5
Fat (% dm)	21.4	15.0	16.8	9.2	2.0	2.9	21.1	2.5	3.1	5.9	5.8	5.7	9.32	11.1
Ahs (% dm)	4.2	4.1	4.3	4.9	4.9	5.3	4.6	4.8	4.7	4.4	5.7	4.9	3.38	3.44
Collagen (% dm)	1.8	3.2	4.1	1.5	3.4	2.5	1.8	3.8	2.5	3.8	2.0	2.6	1.25	2.04
Elastin (% dm)	-	-	-	-	-	-	-	-	-	-	-	-	0.94	1.26
Myoglobin (% dm)	1.7	1.0	2.0	1.4	1.3	1.8	2.3	2.3	3.1	-	-	-	-	-
Eaten quality														
Color														
Myoglobin (mg/g wm)	4.8	2.7	5.1	3.3	2.8	4.1	6.2	5.2	7.0	-	-	-	-	-
Degree of redness	-	-	-	-	-	-	-	-	-	17.2	13.8	15.9	-	-
Absorbance at 542 nm	-	-	-	-	-	-	-	-	-	-	-	-	0.640	0.252
Tenderness														
Shear force kg	3.5	3.7	3.9	-	-	-	-	-	-	4.8	5.7	5.8	2.5	2.3
Collagen mg/ g wm	5.0	8.3	10.5	3.5	7.4	5.6	4.8	8.5	5.7	9.2	4.9	6.4	3.0	4.2
Sensory tenderness	6.2	5.5	5.6	6.8	3.1	3.3	6.5	2.1	2.3	-	-	-	-	-
% Collagen soluble	24	17	19	33	41	49	21	17	36	25	34	10	-	-
Sensory juiciness	6.1	4.7	5.9	6.8	3.1	5.9	7.2	2.8	5.3	-	-	-	-	-
Cooking loss %	34	37	41	42	47	49	46	49	51	38	33	37	-	-

Comparing the chemical composition and the eating quality attributes to LD, ST and TB camel muscles, Babiker and Youssif (1990) found that those muscles had similar moisture (75.2-75.9%) protein (21.4-22.4%) and fat (1.40-1.43) content (Table 16). The concentrations of sarcomplasmic and myofibrillar proteins were not significantly different among the three muscles studied. The LD muscle appeared brighter red than the other two muscles and total collagen content was greater in LD than in ST or TB muscles. In this case LD and ST collagen data will be rather in inverse order, seeing that shear force and connective tissue strength were lower in LD than values for ST and TB muscles. Indeed Kamoun (1995b) found that total collagen content is lowest in the LD than ST as well as in camel meat and in Steer meat.
Otherwise El Kady and Fahmy (1985) have been studied the effect of aging by cold storage on some physical and chemical properties of buffalo and camel meat. They indicated that fresh camels meat has higher moisture content (79.6%) than that of buffalo (76.1%) and estimated the crude protein, collagen, elastin and ash contents (as % dry weight) of buffalo and camel as 87.3 and 85.5%, 1.25 and 2.04%, 0.94 and 1.26% and 3.38 and 3.44% respectively. For color it was noticed that buffalo meat was darker due to more myoglobin content than that of camel meat. They noted too, that after storage at 4°C for 7 days the tenderness increased and reached 112% -113% of the original value indicating that the increase of tenderness was continued through aging while water holding capacity (WHC) decreased. They mentioned, that the WHC and tenderness of buffalo meat where better than for camel meat during cold storage. In the other hand, crude protein, collagen and elastin value decreased slightly during aging while ash increased (Table 16).

Eating quality

The LD muscle was found to have more soluble collagen than the ST and TB muscle. TB had the highest shear force values, maximum connective tissue strength and least collagen solubility indicating that it will be the toughest muscle in this group (Babiker and Youssif, 1990).
Meat eating quality was assessed, the meat having been cooked in traditional way (40 minutes in boiling water. Theses six muscles (PM, LD, SM, ST, LV, TB) were ranked by eating quality, sensory tenderness, sensory juiciness, thermal solubility of collagen and cooking loss (Kamoun, 1995b). The ranking was given in table 15. A large range in percent cooking losses was observed, the VL had the highest weight and volume losses (51.1% and 47.8%, respectively) and PM the lowest (44.6% and 41.1% respectively).
The TB and LV muscle were found to have more soluble collagen than ST, PM, LD and SM muscles, possibly indicating less thermal stable bond between collagen molecule and weaker connective tissue structure of those muscles. Muscles of the lumbar region (loin) were more tenders and had less detectable connective tissue than muscle from shoulder and leg. The PM and LD were the most tender muscle and had less detectable connective tissue than all other muscles. However, few tenderness

differences were observed between SM, ST and TB muscles and they were also ranked acceptable for this trait. The VL was the least tender muscle. The LD had the highest juiciness score and the ST and LV were less juicy than PM, SM and TB muscles. The eaten quality of meat from young camels did not change between 1 and 4 years age wile the location of the cut determines to a great extent the tenderness of the meat.
As compared to Steers muscle (LD, ST and TB), camel muscles losses more weight when they were cooked (48±2% versus 37±2%). The camel boiled meat was less juicy than boiled beef meat, however no tenderness differences were observed between meat of the camel and beef. Wile Babiker and Tibin (1986) have reported that camel meat samples have less cooking losses and higher water holding capacity when compared with the beef samples.
With increased age there is an increase in meat toughness; the meat also becomes less testy and of inferior quality. However, Kamoun (1995a, b), noted that age is not a predominant factor in yield variation and meat quality, in the case of dromedaries fed on the same diet and slaughtered between 15 and 51 month of age. Results concerning growth, quality and yield of carcass are discussed in order to draw some practical conclusions regarding, for instance, the best age for slaughtering. This author suggested that the young males must be complemented and slaughtered at 2 years, although it is traditionally done when the animals are 3 years old, a figure consistent with the 3 years given by Dina and Klintegerg (1977). At this age the animals were not yet fully grown, they averaged about 60-70% of full live weight. Their meat is young and tender.

Camel fat

The hump fat and abdominal fat were also used for culinary purposes. The edible fats of the camel are obtained from hump, the mesentery and kidney area. The fat derived from the camel is of very great nutritional importance in meeting the need for fat in the human diet.
Fatty acids composition of the meat and the hump of the camel were studied by Rawdah *et al.*, (1994) and the results indicate that the saturated fatty acids in the meat account for 51.5% of total fatty acids, which is higher than the levels found in cattle meat (40.0%), wile the monounsaturated and polyunsaturated chains constitute 29.9 and 18.6%, respectively. The ratio of the polyunsaturated chains to the saturated ones is 0.36 as compared with 0.22, 0.26, and 0.36 in beef, mutton and goat respectively. The major fatty acids in camel meat are palmitic (26.0%), oleic (18.9%) and linoleic (12.1%). The main fatty acid of the hump fat is palmitic (34.4%) followed by oleic (28.2%), myristic (10.3%) and stearic (10.3%). In the other hand Babiker and Tibin (1989) reported that in the pad fat, hump fat and abdominal fat the cholesterol content is 0.16 g/100 g, 28 g/100g and 2.7g/100 g, respectively. So camel meat seems to have low fat and cholesterol content and high level of polyunsaturated fatty acids.

Camel meat product

When camels are slaughtered at the end of their productive live, these old animals often give toughest meat. The conversion of this toughest camel meat to minced meat or to sausages eliminated toughness and reduced the required cooking time.
Camel meat provides an excellent basis for various manufactured and cured forms of meat. It has highly desirable features as a sausage constituent and because of its superior performance, pigmentation and water holding, kebab and kefta makers often incorporate it with other meats.
The camel meat has greater total protein than beef and superior water holding capacity as well as low fat content which make it an ideal lean source for comminuted meat processing (Babiker and Tibin, 1986). Camel meat sausages can form a highly acceptable cooked meal. Then the physical, chemical and palatability aspects of camel sausage and beef were compared by Tibin an Babiker (1989) and they stated that emulsion type sausage camel with 10% and 15% fat were acceptable to the panelists and not significantly different from the beef sausage. Therefore camel and beef meat can successfully replace each other in sausage manufacture.

Conclusion

Despite the paucity of available data, the dromedary appears to be the most advantageous animal for the protein supply of population in arid zone. There is an urgent need to investigate the meat production potential of this species under different management conditions. Further standardization of the methods is necessary to point out the growth patterns, the efficiency of growth, dressing percentages and quality of camel meat.
An indication of weight may be required to determine the exact role of these factors. But, even under conditions where normal facilities are available camel are difficult animals to weight, and on open rangeland the problems are often insuperable.
In the other hand, with this complete chemical analysis, it has been shown that dromedaries have lean meat with high moisture level. In appearance and color, texture and palatability, camel meat is very similar to beef. Total collagen content and percent soluble collagen my be an important factors relating to cooked meat tenderness, although a trend was observed for muscles with higher percent fat to be more tender and more juicy. These data indicate that some muscles could have a potentially greater value if they were separated and used independently.
Camel meat is relatively rich in polyunsaturated fatty acids (18.6%) and its fat content (0.42-3.16%) is significantly low compared with beef (4.0-8.0%). Furthermore the meat is a good source of protein and is rich in mineral constituent. Hence the camel as a meat source seems to present a viable alternative to cattle.
The habit of eating fatty meat may predispose to health risks. The reduction of saturated fat level in the diet is a primary step in avoiding artery-sclerosis. Consequently, now, the general trend in the word is to

have biological meat and labeled lean meat as it is synonymous with good health. Thus the camel meat with its low fat and cholesterol content and high level of polyunsaturated fatty acids is an ideal health food. The camel meat is consumed locally either fresh or preserved. The eaten proprieties of camel and cattle meat are comparable. Nevertheless, evidence is accumulating which indicates that when quality standards are set and adhered to, camel meat can be successfully marked alongside that of cattle, sheep and goat.

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Fibre recording systems in camelids

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Keey words: fibre production, fibre characteristics, selection for fibre, suri, recording methodologies.

Introduction

Llama (*Lama glama* L.) and alpaca (*Lama pacos* L.) are domestic mammals classed in the Tilopods suborder together with guanaco (*Lama guanicoe* L.) and vicuña (*Vicugna vicugna* M.). Domesticated by the pre-conquest Andean cultures, they are currently used by South America Andean populations for fiber (both, llama and alpaca), meat and packing (llama) (Flores Ochoa and Mac Quarry, 1995 a, b; Bonavia, 1996).

In order to improve fiber production in both the South American domestic Camelids (SAC), llama and alpaca, three different project have been funded by the European Union during the last 15th years:

- PELOS FINOS, "Supported program to improve Argentinean South American Camelids fine fiber production" (EU DG 1, 1992-1995); involving Argentine, Italy and Spain;
- SUPREME, "Sustainable Production of natural Resources and Management of Ecosystems: the Potential of South American Camelid Breeding in the Andean Region", (EU DG XII, ERBIC18CT960067, 1996-2000) involving 5 South American Countries (Argentine, Bolivia, Chile, Ecuador, Peru) and 4 European Countries (Italy, Germany, France, U.K.);
- DECAMA "Sustainable development of Camelid products and services marketed oriented in Andean region" (E.U. INCO ICA4-CT-2002-10014; in progress), involving Argentina, Bolivia, Peru, Germany and Italy.

Two experiences of selection of fiber production have been carried out during the time of the projects: the selection of llama population on Jujuy Region, Argentina and the selection of the alpaca population in an open nucleus breeding scheme in the Caylloma Region, Perù, involving 18 000 animals and 500 breeders.

Fibre production in alpaca and llama

South American Camelids (SAC) fibre productions are generally divides in Llama and Alpaca fibres. Llama produce less quantity of fibre and present a greater size than Alpaca which is smaller with more ability to produce fibre. Also the commercial classification distinguishes between Llama and Alpaca. In table 1 the quality characteristics in fiber tops of alpaca and llama are presented (Vinella, 1994).

The SAC population presents a great variability and the type of fleece is one of the principal characters utilised to distinguish the different type of animals.

In the Alpaca it is possible to distinguish two different type according fleece structure: Huacaya and Suri. Alpaca "Huacaya" is the more common and is characterized by compact, soft and highly crimped fibres, with blunt-tipped locks which closely resemble those of Merinos sheep. By contrast, the "Suri" has straight, less-crimped fibres and locks with a "cork-screw" shape, very similar to those of Angora goat but not as bright.

The situation in llama is more complicated and different methods of classification according to the different breeding cultural Andean areas exist. A "Suri" type of fleece seems to segregate inside the population, but a "Suri" standardized flocks are never discovered. The dis-homogeneity and the variability of llama flocks derived from the lack of interest on fibre selection by breeders.

Until few years ago llama fleece was mixed with the Alpaca fiber in order to increase the quantity of product, compromising the Alpaca fleece quality of lots. At present, a commercialization of fleece from some "woolly" Llama exists in some Andean highland areas and fiber is directly classified as Llama lots.

Table 1. Quality characteristics in fibre tops of alpaca and llama.

Characterists	Woven goods	Knitwear
Fiber diameter	***	**
Variability of diameter	***	**
Fiber colour	***	***
Colour homogeneity	***	***
Fiber length	**	**
Variability of length	*	*
Dark hair (presence)	***	*
Kemps (presence)	****	*
Presence of impurities	**	**
Regularity tops	**	**
Lustre	***	**
Handle	***	**

Scale: * = Low importance; **** = High importance

The main difference in fleece between alpaca and llama is on the structure: Alpaca has a homotricous fleece in both Huacaya and Suri, while Llama generally presents a double coat structure expressed in different relationship between under coat and outer coat. Llamas is classified in two different types:

1. "*kara*" (or "*cargera*"), typical double coated animal, with many guard hair (outer coat) and markedly less woolly fibres (undercoat) ranging from short to very short, and
2. "*chacos*" (or woolly), single-coated animal with soft, crimped secondary fibres but with a low quality fleece with respect to Alpaca, because many primary fibres are mixed with the secondary ones.

The variation of llama and alpaca fleece is complicated by inter fertility among both and with the wild animals (vicuna and guanaco).

Alpaca and llama should be shorn annually, and expected fleece length and weight would be respectively between 90-160 mm and 3–5 kg (Australian Alpaca Association 1997).

At presents, an homogeneous and official methods to classify the different category of SAC fibres lacks. Generally, industrial classification prefers to grade the fineness according micron rank.

For example the official Peruvian classification is: Baby 20-22 µm; Superfine 25.5 µm; Suri 27 µm; Adult 27.5 µm; Huarizo 32 µm, Llama 34 µm; and Coarse 34-36 µm. Peruvian INCA Tops industry classify the fleece of 2 micron category (<20, 20 – 21, 21 – 22, etc). The Australian classification foresee 5 categories: Superfine (SF) < 22 µm; Fine (F) 22-24.9 µm; Medium (M) 25-29.9 µm; Strong (S) 30-36.9 µm, Coarse (C) > 37 µm.

Selection for fibre production in alpaca and llama

The objectives of selection for fiber production in alpaca and "woolly" llama are:

1. Mendelian characters: type of fleece ("Suri" *vs* "Huacaya") and coat colour;
2. Quantitative characters: fleece weight, fineness and variation of fineness, percentage of medullated fibers, fiber crimp, fiber length, morphological evaluation (linear methodology).

Mendelian characters

Suri

Two different type of fleece exist in SAC: Huacaya and Suri. Huacaya is predominant type and represents the 90% alpaca fleece processed in Peru (Hoffman *et al*., 1995).

The Suri is characterised by lustrous, silky fibre, with an absence of crimp and the fleece is similar to mohair with particular lustre characteristic. The Suri fleece seems to be dominant with respect to the no–Suri type (Huacaya) (Ponzoni, 1990). However intermediate animals that have no suri and no huacaya fleece structure can be observed when Suri and Huacaya are crossed.

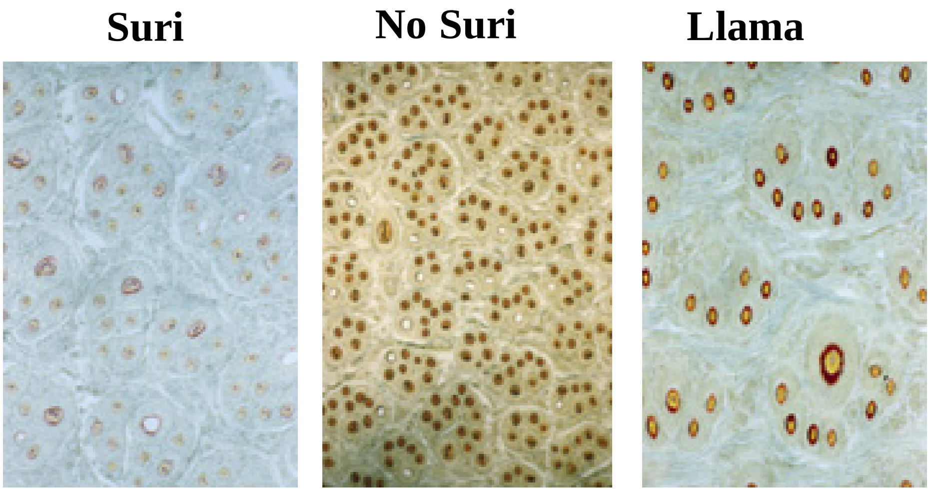

Figure 1. Follicle structure (Antonini et al.*, 2004).*

Among the parameter used to characterise and analyse fibre structure, cell scale frequency could be considered as differential parameter. The range vary from 3 to 18 (Antonini *et al*., 2001).

As described in table 2, 7 Scale / 100 ìm could be the distinctive parameter for Suri fibre. The independence of Suri cell scale frequency from fibre diameter variation under 35 ìm, suggests that this result can be use in selection to achieve single coated structures. The results can be used by textile laboratories in quantitative analysis of blend to differ fibre (Antonini *et al*., 2001).

Fibre Cuticle Cell High presents too low variability to be used as textile distinction tools and a differentiation between the three fleeces types is impossible (Table 3). For this reason Suri lustre and silky characteristic, in comparison with other lustre fibre as mohair, seems depend more by a reduced cuticle cell scale frequency, which gives rise to the typical fibre silky handle, than by the cell scale height. In fact, the cell high value is more similar to Llama and Huacaya with a lower brightness respect to other lustre fibre.

The follicular structure analysis produced some useful information on Suri and Huacaya differentiation. Density of skin follicles, percentage of medullated secondary fibres, and percentage of active secondary follicles reached their maximum values at 2 months in all the three types of SAC (see Table 4) (Antonini *et al*., 2004). The secondary / primary follicles ratio

Table 2. Means scale frequency in fibre cuticle cell.

	All Fibres	Fibres < 35µm	Fibres > 35µm
Suri	7.54	7.50	8.22
No Suri	9.10	9.06	9.28
Llama Woolly	9.72	9.40	10.65

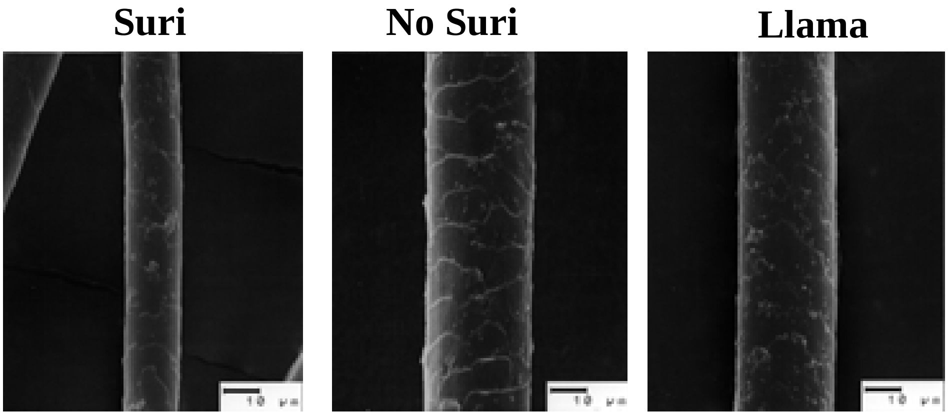

Figure 2. Cuticle structure.

Table 3. Fibre cuticle cell high..

	Means	Max	Min
Suri	0.232	0.05	0.75
No Suri	0.261	0.10	0.55
Llama woolly	0.201	0.10	0.60

(S/P) reaching the maximum value two months later, alpaca Suri and Huacaya and llama gained a complete and mature skin follicle apparatus at an early age.

With reference to the magnitude values of these four parameters, the huacaya and suri alpaca showed similar peak values for follicular skin density and S/P ratio; generally Huacaya presents higher values for both follicular density and S/P respect to Suri. The woolly llama is clearly different from alpaca, exhibiting the lowest values for all parameters (Antonini *et al.*, 2004).

The data presented may be exploited for a rational management of the "crias category". As kid fleece is the most requested by the market, and fibre production potential is present in llama and alpaca from an early age, producers can practise an anticipated first shearing, increasing revenues for animal (one shearing more for productive life).

Table 4. Skin follicular structure.

	Density (n/mm^2)	S/P ratio
Suri	19.90	6.89
No Suri	22.30	8.08
Llama woolly	17.98	4.66

Coat colour

The quality and quantity of melanins that are synthesised in follicular melanocytes determine the colour of hair and wool in mammals. There are two chemically distinct types of melanin pigments: the black to brown eumelanins and the yellow to reddish pheomelanins which are further divided into polymeric pheomelanins and dimeric trichochromes (pheomelanogenesis by-product). It is generally accepted that natural eumelanin is derived from copolymerization of 5,6-dihydroxyindole (DHI) and 5,6-dihydroxyindole-2-carboxylic acid (DHICA) while pheomelanins are characterized by the presence of 1,4-benzothiaziynilalanine structural units which arise biochemically from 3,4-dihydroxy-phenylalanine (DOPA) and cysteine even if pheomelanin-like pigments without sulfur also occur and arise probably by peroxidative cleavage of DHI units of the eumelanin polymer. Eumelanins and pheomelanins are syntethized within melanocytes on the specialized organelle, the melanosome, where the specific enzyme tyrosinase catalyzes conversion of the amino acid tyrosine to dopaquinone. Chemical proprieties of melanins have been described in alpca and llama. The morphology of melanosomes have been described in both llama and alpaca (Renieri *et al.*, 1991; 1995; Cecchi *et al.*, 2001; Cozzali *et al.*, 1998, 2001; Cecchi *et al.*, 2004).

Coat colour variation in llama and alpaca flocks is generally very large and no colour selection has been carried out, except for full white in some peruvian alpaca and argentine llama flocks (Lauvergne, 1994; Mc Quarry, 1995; Renieri, 1995; Lauvergne *et al.*, 2001). The great colour fleece variability is one of the main SAC characteristics. In the industrial cards colour it is possible distinguish 22 different types from white to all brown variable and black.

The variation has been established according to the four phenotypic dimensions; pigment pattern, type of eumelanins, alteration of pigment, type of white designs (Lauvergne *et al.*, 2001). The various phenotypic

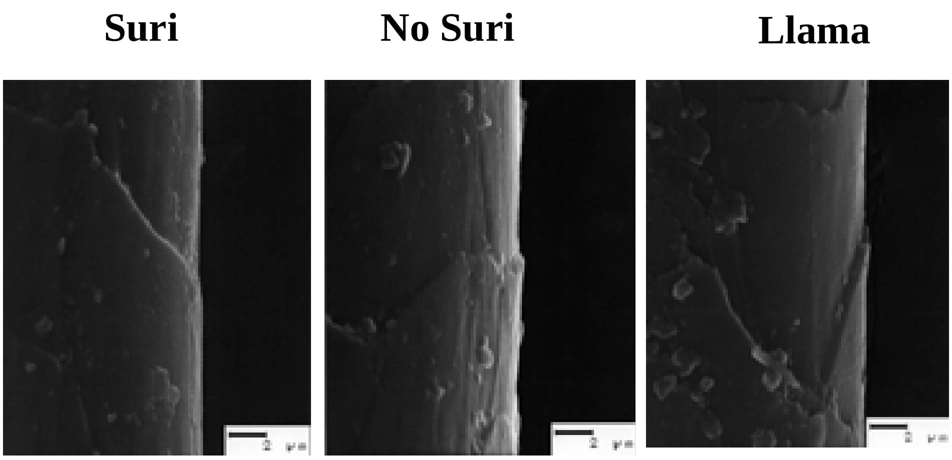

Figure 3. Scale height (Antonini et al., 2000).

variants already identified in llama and alpaca and the inheritance of each variants are given in table 5 (Lauvergne *et al*., 2001; Renieri *et al*., 2002; Frank *et al*., 2002)

According the results of biology and segregations analysis, specific reproductive plans can be carried out for coat colour selection in two alternative ways in llama and alpaca:

1. selection for full dominant white;
2. selection for pigment patterns; in this case, the objectives are:
   a. selection for the uniform patterns: eumelanic black, eumelanic brown and pheomelanic;
   b. selection against no uniform patterns;
   c. selection for grey and greying;
   d. selection against white designs.

Quantitative characters

The following characters can be taken into account as a selection objectives in both llama and alpaca:

- fleece weight at 1st shearing;
- fibre fineness and the variation of fineness at 1st shearing;
- percent of medullated fibres;
- fibre length;
- fibre crimp.

Table 5. Coat colour variations in llama and alpaca.

Dimension		Variants	Inheritance
Pigment pattern	Uniform	Eumelanic	Full recessive *vs* other patterns
		Red (Pheomelanic)	Unknown
	Composed by eumelanic and pheomelanic parts	Eumelanic and tan	Unknown
		Pheomelanic with eumelanic extremities	Dominant *vs* eumelanic and wild patterns
		Mule stripe	Unknown
		Mule stripe with black extremities	Unknown
		Badger face	Unknown
		Wild vicuna	Unknown
		Wild guanaco	Unknown
Type of eumelanins in the eumelanic part		Black	Dominant
		Brown	Recessive
Alteration of pigmentation		Grey	Dominant
		Greying	Dominant
		Dilution	Unknown
		Full White	Dominant and epistatic
White Design		Irregular spotting	Recessive
		Painted	Unknown
		Pack saddle	Unknown

Figure 4. Alpaca.

Figure 5. Llamas.

The very few estimations of genetic parameters for fibre production on alpaca and llama in the original countries are presented in table 6 and 7. The methodology of selection used in both the selection plans (Jujuy and Caylloma) has been the performance test. In both cases an open nucleus breeding scheme has been carried out.

Recording methodologies

Llama and alpaca fiber is tested for fineness by international recognized tests. A test is typically administrated by a recognized laboratory with an expertise in testing fibre. The American Society for Testing and Materials (ASTM) publishes a specification for testing Alpaca fibre.

Table 6. Estimated heritability of fleece characters in alpaca.

Characters	Shearing	Estimated heritability	References
Fleece weight	1st	0.35 ± 0.02	Velasco (1980)
		0.22	Bravo and Velasco (1983)
		0.21 ± 0.07	Roque *et al*., (1985)
		0.38 ± 0.34	Mamani (1991)
		0.31 ± 0.17	Ruiz de Castilla *et al*., (1992)
	All	0.79 ± 0.36	Ponzoni *et al*., (1999)
Fiber diameter		0.18	Leon-Velarde and Guerrero (2001)
		0.67 ± 0.30	Ponzoni *et al*., (1999)
Staple lenght	1st	0.43 ± 0.39	Mamani (1991)
		0.21 ± 0.07	Roque *et al*., (1985)
		0.31	Leon-Velarde and Guerrero (2001)
	All	0.63 ± 0.48	Ponzoni *et al*. (1999)

Table 7. Estimated heritability of fleece characters in llama.

Characters	Estimated heritability	References
Fleece weight	0.48 ± 0.02	Choque and Rodriguez (1988)
	0.27	Choque and Rodriguez (1988)
Fiber diameter	0.18	Frank (unpublished)
Staple lenght	0.34 ± 0.08	Choque and Rodriguez (1988)
	0.28 ± 0.37	Choque and Rodriguez (1988)

Fibres fineness, expressed as means fibre diameter, is the most important parameter to define fibre quality in relation to the comfort and lightness of textile product. At the same time the Coefficient of Variation (CV) of the diameter defines the homogeneity of the product, very important for the processing efficiency. ASTM Standards D 2130–90; D 6466–99 and D 6500–00 describe the official method for fineness and CV fibre analysis using respectively Microprojection, Sirolan-Laserscan Fiber Diameter Analyser and Optical Fiber Diameter Analyser.

The presence of medullated fibres and kemp is important dye resistance and light reflectance qualities. Medullated fibre have an abnormally large diameter; an high degree of medulla is probably responsible of low comfort of products (low resistance and "piercing" effect). ASTM Standards D 2968 – 95 defines the official method for medullated and kemp fibres analysis.
The length of fiber affects the quality. A peculiar fibre length is needed by each textile product. However fibre length has less importance in llama and alpaca with respect to other fine fibre producing animals. ASTM Standards D 1575–90 and D 519-04 describe the official method for Fibres length measurement respectively fibre Length of Wool in Scoured Wool and length of fibre in the top.
Fibre crimp is expressed as number waves or crimps per unit length. Crimps affect the carding and subsequent processing of the fibre into either a yarn or a non woven fabric. Staple crimp will also affect the bulk or openness of a yarn and therefore the hand and visual appearance of the finished textile product. In llama and alpaca fibre crimp is one of the more important distinctive parameter. ASTM Standards D 3937-90 describes the official method for Crimp Frequency of staple fibres. Unpublished data provided by the INCA Tops Peruvian Factory, show a significant difference between the Suri crimp (20.60) and other different non Suri fibre (Royal Alpaca – 39.00; Baby Alpaca - 34.40 and Superfine Alpaca - 32.57)

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Camelids in South America. Lama (*Lama pacos*) production systems in Bolivia

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Summary

In this paper, a review about the historical and actual context of the lama production systems, with special focus in the Bolivian Altiplano Lama Production Systems (BALPS) is presented. The BALPS are possible to include in two general systems manned *Pastoral (lama, or/and alpaca and sheep) System* and *Agropastoral System*, and gather near 54 thousands productive units. During the last five centuries, the life of many people in these systems was very hard, and the poverty and social exclusion are the principal results. Lama is the principal livestock component and has historically been used for their high protein meat, transporting merchandise along the Incan, colonial and republican roads, and in religious rituals; it provides the family with economic security, manure, traction and transport and has and specific cultural significance; moreover, in those Agropastoral Systems, the quantity of manure determined the extension of agricultural activities. In Bolivia as in other countries, the llamas' productive systems are, still, traditional and based on the extensive used of the native pastures. The productivity of the grasslands, not only is scare but too it has low quality as a result of the extreme climatic fluctuations, characterized for periods prolonged of frosts and droughts, and depended of a ecosystem fragile, marginal and inaccessible. However, the Altiplano, also presents opportunities as its biological diversity and the extreme conditions have generated traditional practices and knowledge that joint with modern technologies should be used to improve the actual low productive systems. The planners of *Ministery of Rural Affairs and Agricultural of Bolivia* consider that the successful developed of the camelid chain with fiber, meat, and leather productions require to develop of special markets as organic or ecological markets, and consider that this can be a one of a few opportunities that have the Altiplano people in order to resolved the secular poverty cycle.

Keywords: Lama (lama pacos), production systems, Bolivian highland.

Introduction

The camelids production systems in South America are located in the Andean Central Region, which include the highlands or Altiplano of Argentina, Bolivia, Chile, Ecuador and Peru. This mountainous area (with around 1.4 million square kilometres and more than 113 millions habitants) is inhabited by some of the poorest people in Latin America, most of them depend on agriculture for their livelihood. The majority of the farming systems are mixed systems based on crop-livestock. Livestock component plays an important role in the sustainability, because is less susceptible to widespread climatic risks than crops.

In 1580 with the initial Colonial Epoch, sheep and cattle were introduced to the Altiplano in order to replace the native livestock. This colonial behaviour was based more on religious consideration than on zootechnical criteria, because the catholic missionaries known the use of llamas in religious rituals. Moreover, llama meat was prohibited in the marketplace, as a way to reduce the availability of llamas for religious rituals.

Since immemorial times, in these systems, lamas have been used for their high protein meat, transporting merchandise along the Incan roads and in religious rituals. Five centuries later, with the construction of modern roads for transport, the demand for llamas for transporting drammatically decreasing, but, in the last decade the interest for lama's fiber increased and many rural developers agree that is possible to built an important textile industry based on lama fiber similarly to the alpaca sector that have been historically used for its fine fiber.

Actually, camelid take important roles such as: food supply, feed bank, work, and source of energy in the system, source of fertilizer, and link to local markets.

Livestock Andean problems

Before to the Spanish Conquest, Incan Empire developed agropastoral production systems that were able to produce significant goods based on the use of simple and low inputs external technologies. But, following the collapse, massive new genetic resources, socio-economic and administrative changes were introduced (Caro, 1992).

During the colonial times there were introduced new genetic resources, composted principally by sheep and cattle, that occupied the best lands and lamas and alpacas were confined to an obscure existence and used lands with increased agronomics difficulties. In addition, the mines demanded not only an important quantity of meat, vegetables and nature energy but also needed large llamas caravans, in order to transport the mines products from the highlands to the side cost. The irrational llamas' management and low prices for their products conduced to a development of the poverty cycle for livestock keepers.

Between these general context, in Bolivia 54 000 keepers depend on camelids productions. In the last five centuries, many people in these systems lived a very hard life, and the poverty and social exclusion are the principal results. They have only tree issues: poverty, soils of low quality and camelids. And with these last, they reproduce the first issue (MACA, 2002).

Agropastoral and pastoral systems with lama in marginal lands of Bolivia

Under a simplistic view, in the Altiplano of Bolivia is possible to find out, two general production systems associated to South American camelids. It is possible to identificate apastoral (lama or lama and sheep) system and an agropastoral system. In the last systems, the use of various types of crop enables farmers to minimise climatic risks. Animal husbandry has many functions besides the pure productive ones. It provides the family with economic security, manure, traction and transport and has and specific cultural significance.

Inputs of Bolivian lama production system

In spite of diverse efforts carried out in the last 40 years by the Bolivian Governments, these productive systems have, practically, no provided a system of commercialization jousts that assure to producers a minimum benefit of its products market, nor an opportune and efficient sanitary control, infrastructure of support or credit and technical support. Probably, the combination of the previous constraints explains by itself the present low production indexes of the flocks (MACA, 2002).

Human resources

In the management of the Altiplano by agropastoral production system, the size of the family, the age of these members, the ability to management the system, the level of specific knowledge, the size of production units and the size of flock are very important (Quiroz *et al.*, 1995). On the other hand, in the last years, the explosive growth of the population and the collapse of mines activity has resulted in massive pressure on the highland natural resource and originated the greatest series of migrations in Andean Bolivian history. As a result we find out:

1. Extreme poverty: low incomes; low education levels; limited access health services, Overgrazing of natural pasture; scarcity of water resources.
2. Process of migration with lost of the youngest and most able population.
3. Environmental impacts in both original areas (highlands) and receiving areas (lowlands)
4. Severe socio-economic and political problems partially generated by the necessity to find out best condition of life.
5. A minor or a lack attention to crop-livestock management, that results in a low productivity.

This socio-economic framework describes a rather alarming situation which can adversely affect the future of the economy for the communities of the Altiplano. The migratory process towards the cities or the lowlands will continue, and eventually, the cocaine production can increase. Unless the national governments implement special programs to resolve the poverty, some areas of the Altiplano will be the principal centres of social problems.

Habitat component

The Bolivian Altiplano is a large high plateaus above 3 500 m and has the same characteristics of the Central Andes Region. The variables temperature, precipitation, air pressure, solar radiation, and wind speed define the ecosystem's Altiplano. The southwest part is relatively arid with Regosols, Lithosols, Alluvial Soils, and the Calcimagnesian Sodic. The northern ranges are relatively more humid than the southern ones and have mixed brown forest soils, lithosols, and heavy-textured alluvial soils (MACA, 2002).

Elevation and the Humboldt Mass are important determinants of Andean cool climate, in this equation the latitude is only a minor factor in the expression of Andean climatic conditions. Moreover, local variations in topography influence temperature and humidity, particularly with respect to diurnal ranges.

Temperature has a range from 4°C to 6.5°C, but with much local variation. Under cloudy skies, the diurnal temperature range will decrease markedly. Within the tropical zone of Bolivia and Peruvian Altiplano, temperature gradients are very steep, at 10.5°C per 1 000 m during the cooler season and 12.5°C per 1 000 m during the warmer season (Alzérreca, 1992).

Since 1900, the pressure on natural resources has increased, according to high annual rate of human (2.9%) and livestock (2%) expansion. Today, the Altiplano ecosystem presents an important rate of degradation; only the soil lost is estimated in 14 000 kg per hectare / year (Le Baron *et al*., 1979). This process was parallel to the mines development in the highlands. This erosive process results in an important lost of biodiversity and the most important in the reproduction of the poverty.

Biomass component

The Altiplano native vegetation is a result of a short rainy season and low temperatures. It is further influenced by the specific effects of solar radiation, wide variations in temperature, low humidity, and low oxygen pressure. Currently, the Altiplano vegetation is typical, but changes in humidity from north to south create three different types: the humid Altiplano with vegetation characterized by typical grass vegetation, named Chilliguar grassland; the dry Altiplano, where the bunch grasses, called *ichu (Festuca* spp.) and tola shrubs, are dominant; and, the desert region, as the Puna of Atacama and Argentina has typical xerophytic plants (Beck, 1992).

In the Altiplano region, the native grasslands constitute the main feed resources for both camelids and ruminant species. And those are composed by different associations of plant species. Table 1 summarises the main grass associations, dry matter yields (DM) and lama stock rate.

Table 1. Biomass production.

Main grass association	DM Yield (tn / year)	Stock rate (Lama units)
Chilliguar grassland	1.7 - 2.2	2.0
Pajonal	0.8 – 1.2	1.0
Tolar – Parestrepia, Bracharis	0.3 – 0.4	0.2
Paramo rangelands	0.2 – 0.3	0.1
Bofedals	4.0	4.0

Source: Campero, 2004 (modifided from Quiroz, 1995).

Other important type of forage is the aquatic vegetation that is composed of plankton and macrophytic. Within the macrophytic, there are about 15 species. The most important ones are the llachu (*Elodea potamogenon*, *Myriophyllum elatinoides*) and the totora (*Schoenoplectus totora*) (Alzérreca, 1992).

Livestock (lama) component

The actual population of lama located in Bolivia, Peru and Northern Argentina is aroubd 4.5 million heads. Their special adaptation to high altitudes is associated to a specialised haemoglobin, that can absorb more oxygen than that of other mammals. Their red blood cells also have a longer life span than other mammals, an average of 235 days versus 100 days for humans.

Archaeologic evidence indicates that the lama have been domesticated approximately 5 000 years ago. On the base of corporal conformation, is high probably that the llamas were selected as pack animal. In fact, lamas are larger and stronger than the guanaco, their more closed wild parent. On the other hand, the alpaca has probably been selected and breed for fiber. The vicuña is their more closed wild parent.

Flock composition

According to National Census (1998), the typical structure of Bolivian llamas' flock shows a higher proportion of females than males. The females constitute 64.6% of the total; while, the male contribute with 35.4% of the total. The ratio between reproductive females and males is colose to 11:1 (Table 2). This flock structure is the result of the strategies of the sale and familiar consumption, which prioritize sale or consumption of male within a small flock with no more than 50 lamas in average.

Table 2 Average composition to llama flock (in thousand).

	Females		Males		Total	
	Number	%	Number	%	Number	%
1. Temporally teeth	455.7	15.19	341.7	11.39	797.4	26.58
2. Permanents: Two teeth	417.6	13.92	417.6	13.92	835.5	27.85
3. Permanents: Four teeth	227.7	7.59	75.9	2.53	303.9	10.13
4. Permanents: Full mouth	987.3	32.91	75.9	2.53	1 063.2	35.44
Total	2 088.6	69.62	911.4	30.38	3 000.0	100.00

Source: MACA, 2002.

Reproductive efficiency

The reproductive efficiency in Bolivian llama flock is still low and cloose to 55%. This value is the results of tropical highland environment, low levels of management, poor sanitary controls and over-grazing of native pastures. According to actually investigations, the reproductive efficiency may be improved, whiting certain limits, as direct function of energy intake (Campero, 2004).

The female lama reaches sexual maturity at one year of age, but in Bolivia it is common not to mate he animals until the female is two or three years old; the lenght of the gestation is about 348 days. Males get sexual maturity at about three years of age.

Traditionally, the breeding season begins in February and it has 60 days of duration. The partition occurs during the day mainly between 6.00 a.m to 12.00 p.m in the months of January and February. The live born lama does not receive any attention; the abortion is frequent and it is estimated to around 9%.

The weaning is carried out naturally in the months from August to October with a rank from 240 to 300 days of lactation. Generally, the mass weaning is near the 2/3 of mass adult. No separation of animals by sex or age exists and all of them constituted a single flock.

Traditionally, the males are selected under phenotypic criteria, being the mass corporal (weight greater than flock average) and fleece colour (brown or black) the principal criteria for the selection.

Weight corporal variations

Five characteristics are frequently associates with the corporal weight variation of lama, i.e.: age, sex, breed, colour of fleece and management. Obviously, the age and the sex have the major effects. In Bolivia, on the base of a population of 9 680 animals, Loayza and Iñiguez (1995) developed the following equations of prediction of the corporal weight as a function of age.

Male: $Y = 59.5 + 4.3X - 0.14\ X^2$ $(R^2 = 0.97)$

Females: $Y = 60.7 + 3.9X - 0.42\ X^2$ $(R^2 = 0.92)$

These equations were corrected to effects due to localities, sex and age.

In male, the weigh corrected by effects of localities increases lineally until to the 7 years of age, when the curve has a descendent tendency. In the females, the weight corporal tendency has a parabolic course. The corporal weight constantly increased until 4 years of age.
Figure 1, shows these variations according to four categories of age and shows that the growth, in practical terms, finalize after the fourth year. The average for to corporal weight predicted with the equations 1 and 2, corrected only by age (correction to 4 years) and omitting localities, shows a weight of 90.6 ± 8.7 kg and 86.5 ± 8.4 kg for male and females, respectively.

Fleece characteristic

Lama fiber is a medulated natural protein with no lanolin, which is classified as a specialty fiber. Positive characteristics are: fine, strong, comfortable and warm, available in 16 natural colours; its little elasticity is considered as the principal limiting factor.
In the national flock of lama, the distribution of fleece colours is black and brown (69.6%), spotted colour (22.8%), and white (7.6%) (Figure 2). The spotted pattern includes those diverse colour or tones that on a white colour fleece fund are presented. Figure 3 presents this model of colours fleece (Campero *et al.*, 2004).
These patterns of colour distribution, may be possibly explained on the regional preferences of the people for the black and brown colours. The selection of male is guided, among others criteria, by favouring the lama with brown colour fleece. Preliminary observations consistently suggested that the taller and heavier animals are those that have dark colours.
Empirical observations show that lama with brown and white spots fleece produce longer fleece, following by animals which fleece are dark or white colours. In order to maintain the corporal temperature in the highlands Andean condition, animals with white fleece colour probably require more energy than animals with dark colour. If this is true, the dark colour animals are more efficient in produceing fiber in the Altiplano region.

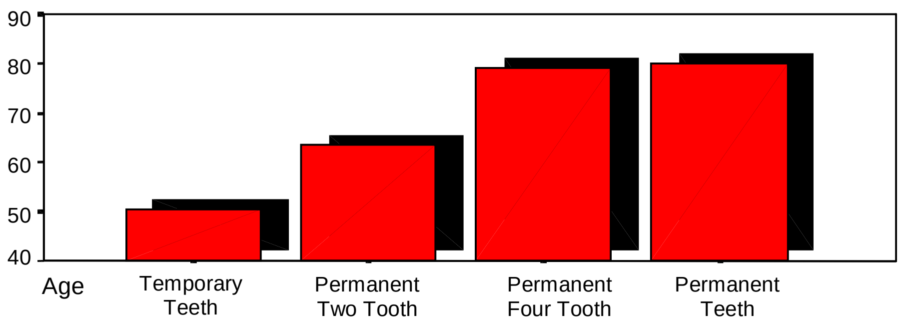

Figure 1. Weight corporal variations in lama (kg).

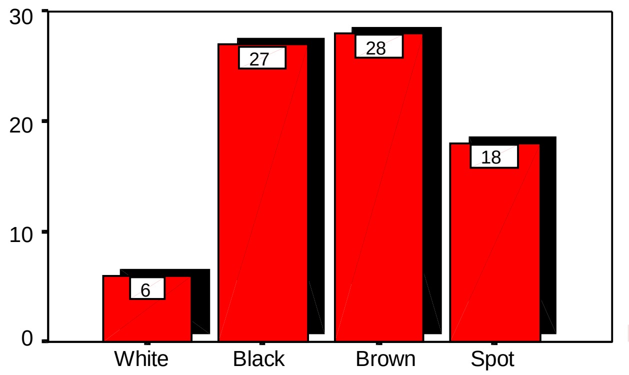

Figure 2. Fleece colour distribution in lama.

The below figure 3 shows only 12 colours of 30 tones of colours that are possible to find out in the fleece of lamas. A program, in order to improve the quality of fiber production in llamas, based on the selection by colour does not seem to be easy and quickly of development because is possible that at least four pairs of genes control and modify the colour of the fleece in llama.

Crop component

In pre-Colombian times, most Altiplano communities had land rights and cultivated land at lower elevations in the areas with temperate and tropical climates on the eastern slopes of the Andes. Today, the access to low lands has for them is not common, and each family has small parcels of land on the hill sides and these are often located in different ecological zones.

In order to minimize the climatic risks and protect their self-supplying production system, the farmers use various types of native crop like: potato, corn, ulluco, oca, mashua and tarwi. These species are sow together with barley, wheat and oats introduced by the Spanish 500 years ago. The extreme upper limit of potato cultivation is 4 200 m.

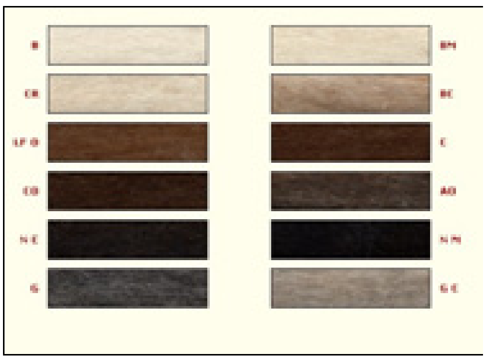

Figure 3. The image shows only 12 colours of 30 tones of colours that are possible to find out in the fleece of lamas.

Livestock has many functions besides the pure productive ones. It provides the family with economic security, manure, plough power and has a specific cultural significance. In these systems, the quantity of manure determined the extension of agricultural activities.
In the present days, most of the Andean producers are grouped in communities, with access to both private and communal lands. Usually, the community has rules for the management of the crops and animals. The crop cycle begins with potato, quinoa, followed by grain and barley and ends with a fallow cycle that has a range front of 5 to 8 year (Table 3). During the fallow, the secondary native grass is grazed, allowing a nutrient recycling through animal excreta. The Andean agriculture is frequently definite as an activity with high risk, and it principal constrains are frost and drought. In this regard, livestock minimizes the climatic and economic risks.

Outputs of lama production systems

In general, in these production systems, the animal production contributes to around 73% of the in-comes and the crops to 27%. However, 20% of animal production and 80% of vegetal production is for family consumption.

Meat production

The lama meat production is estimated ranging between 20 000 to 25 000 Tons per year, being Bolivia the principal producer, and its western region as the principal market. In these production systems, the annual crop of llamas was estimated in 11 per cent. It is certainly a low efficiency, but it can be explained by both low fertility and high rate of mortality of baby lama.
The carcase yield is not grater than 52%, and the ratio meat : bone is 4 : 1. Probably, under Altiplano conditions, the lama is the best option for meat and fiber production. Its products are more competitive than that of other more specialized species.
In Bolivia, the demand of lama meat increased of 76% during the period 1985 - 2004 and it is consumed as fresh or sun-drayed. In the same period, population of lamas increased more than 1 million of units. This facts may be explained by: a) the promotion of llamas' meat consume b) the nutritional value, which is high in protein and low in fats; c) the commercialization programs endorsement with norms of quality established by the Bolivian Institute for Norms and Quality (IBNORCA); and d) the lower price for special courts.

Table 3. Area and yields of principal crops in the Bolivian Altiplano.

	Potato	Quinoa	Barley	Pasture
Crop area (ha)	1.0	0.4	1.5	1.5
Yield (tn / ha)	5.5	0.6	1.2	3.5

Source: Campero *et al.*, 2004.

In order to resolve the extremely poverty of the people in Bolivian's highlands, the Ministery of Rural Affair and Agricultural (MACA) of Bolivia has been constructed the National Strategy of Rural Development (ENDAR) and its policymakers hope to increase the actual lamas meat demand. For this scope, it is necessary to resolve:

1. The presence of moderated infestation of *Sarcosystis aucheniae* and *S. lamacanis*. These parasite are not danger to human consumers and meat with high degree of infestation is confiscated; the parasitism incidence, which is transmitted by dog, is near to 46% in animals older than two years.
2. Other factor that limit llama husbandry are the degradation of the native pastures, external parasites, the high grade of inbreeding in many llamas populations, the high rates of mortality, and the use communal of natural pastures.
3. The breeding systems are placed, almost exclusively, in areas of extreme soil poverty and high climatic risk.

Despite to these limitations, llama is one of the species of highest potentialities in the Altiplano of Bolivia, which explains why families have continued in lama breeding activity. On the order hand, the Altiplano extended areas of natural pastures, paticularly adequate to camelids. These species are best adapted to this environment, being highly resistant to the effects of the altitude and climate and, differently from sheep or cattle, they do not disturb the fragile ecosystem of the Andean mountain during grazing activity.

Furthermore, as log as *Sarcosystiosis* can be controlled, the demand of lama meat will increas in both national and international markets, because its taste is similar to beef, the protein content is high, the fat content is low, and it does not promote the cholesterol formation in the humans. The amount of cholesterol for each 10 ml of serum blood of lama ranges fom 5 to 50 mg while in beef is 200 mg and in sheep is 300 mg. Table 4 describes the chemical composition of meat for four species including lama meat.

It is possible to reduce the mortality rate of the llamas by controlling external parasites, improving animal management and nutrition of the flocks. The actual llama meat production is near to 17 thousands tons, but it could be feasible to increase it to 34 tons as a result of the control of actual limiting factors.

Table 4. Chemical composition (%) of four species.

Species	Humidity	Protein	Fat	Ash
Llama	69.17	24.82	3.69	1.41
Alpaca	70.80	21.88	5.13	1.30
Cattle	72.72	21.01	4.84	0.91
Sheep	72.74	18.91	6.53	2.16

Source: MACA, 2002.

Fiber production

The shearing of lama is completely random and it occurs on same animal each two to three years. Technically, the annual shears is bette because the environmental factors cause less fleece damage, allows a better external parasites control and facilitates the selection for productive ability. Lamas fiber production is hardly influenced by genetic variation, as a result of the improvement and technician selection by this criteria. The present fiber production is probably the result of the natural selection for a better protection against adverse climatic conditions. Figure 4 illustrates the actual importance of fiber handcrafts for the altiplanic people.

Figure 4. Fiber handcrafts elaboration by the altiplanic people.

Today, the national fiber production is in rapid development, with a potential production of 714 tons. This production includes fiber and hair. The participation of the last one in the fleece, on the base of weight, is around 20%.

The de-haired lama fleece is possible through a manual or mechanical process. The fiber results without coarser hairs giving a soft, shiny and long hair. At the present, it is highly appreciated by the textile industry. The average general weight production of dirty fleece of llama in Bolivia is 1.14 ± 0.25 kg per animal (MACA, 2002), although, this information does not discriminate age of the fleece or shearing frequency. For Peruvian alpacas, Fernández reported averages of 2 600 g of fiber; while; average of 0.98 kg and of 2.6 kg of wool for Creole and Corriedale sheep, respectively were reported by Cardoso in Patacamaya (Bolivian Altiplano).

It is probable, that the length of camelids fiber has an average of 6.8 ± 1.5 cm; while the hair had a long average of 7.9 ± 2.0 cm. These values are smaller than 8.3 ± 0.7 cm reported for llamas originating in the Experimental Station of Patacamaya by Rodriguez (1982).

Nevertheless, this length is adequate to the characteristics requested by the industrial processes, and it is similar to many sheep breeds, higly productive in wool as the merino, that has a length of 8.1±0.1 cm.

Leather

The llama has a peculiar skin. Its collagen is very compact and provides a high elasticity to skin . For this particular structure, the camelids skin has a high versatility for manufacture production. This skin, appropriately processed, is used to produce jackets, boots, travel bags, suitcases.
The annual average production of skins by llama and alpaca is 434 000 units in Bolivia. Only the 20% of this production is used by national toners, being 25% exported legal and illegally to the Republics of Chile and Peru, and the remainder is badly utilized by rural people or simply is wasted.
In the last years, the demand for camelids skin or manufactured articles higly increased. This occurred not only in local markets but also in the international markets. It is a demonstration that the offer of manufactures with camelids leather, in case it posses a good quality, can contribute to increase the familiar in-comes.

Economic importance of South American Camelids

In Bolivia, the economic activity of the camelids chain is very dynamic. In the 2002, it represented 0.7% of to Gross National Product (GNP), generating 48 million dollars. This was possible with the participation of 54 thousandth of productive units and an indefinite number of small handcrafters. However, its distribution is not equal and primary sector is the least favourable and recieved back an income of only 160 dollars per year. A productive unit works with an average of 49 lama and 41 sheep.
During the last decade, with a investment of 11.3 millions dollars financed by the Bolivian Government, the camelid activity had, in average, an increase of near 6.2% per year. Its annual rhythm of growth was twice than the national economy and was bigger than agricultural production. In the context of this economy, the meat and dry meat of lama production grew at an average of 9%(MAA, 2002).
The dynamism of the camelids activity is reflected, also, by the positive growth of its export. In the period 1997-2002, the value of the export of camelids' fiber was increased by 5.2%; while, the exports of leather and leather manufactures was increased by 2.6%.
Moreover, in the chapter of the export, the most dynamic component was the exportations of manufactured products, as tops, textiles, clothes, processed leathers and leather manufactures. The export of these products represented between 23 and 27% of total camelids exports.

1. In the Altiplano ecosystem, besides to its fragility, other restriction or disadvantages are the marginality and inaccessibility. However, it also presents opportunities or advantages that should be use to improve

Conclusions

the actual agropastoral production systems. These advantages are its biological diversity and the extreme conditions that have generated traditional practices of Altiplano management.
2. In Bolivia as in other countries, the llamas' productive systems are, still, traditional and based on the extensive used of the native pastures. The productivity of the grasslands, not only is scare but it has low quality, too. Moreover, it is the result of the extreme climatic fluctuations, characterized by prolonged periods of frost and dry seasons. Probably, the fiber, meat and leather productions are the best opportunity that the region has to solve the secular poverty.
3. From the ecological point of view, the Altiplano ecosystems are susceptible to fast changes and loss of its ability to keep a sustainable crop-livestock production. Soils in most of the areas are acid, little fertile and of limited depth; however there are areas with better physical and chemical condition, particularly those of volcano origin. Consequently, an important problem in the Andean region is the soil erosion. Lands dedicated to agricultural and livestock systems need special attention. The action of the natural losses, plus the intervention of the man with inadequate agricultural and livestock practices contributes to the disappearance of native forage species.
4. Lamas have historically been used for their high protein meat, transporting goods along the Incan mountain roads, and in religious rituals. Alpaca fur is a finer fiber, and therefore alpacas have been historically been used for their fiber.
5. The resulting degradation of topsoil in the Altiplano region is a problem that has been more visible and publicized in the past few years, but its roots extend back to 400 years ago. In addition to other factors, this condition may be the root of traditional poverty cycle.
6. The impact of research on the feed resources has been limited and localized. The main constrains to adoption of research results are the heterogeneity of the region determined by factors such as altitude, climate, soils, quantity and quality of feed resources, and ethnic background.

Recommendations

In order to increase lama productiity, the following points need to be addressed:
1. To develop new national and international markets for the fiber, leather, meat.
2. To execute an integral plan of development focussed in the productive chain. This plan should consider that this activity represents the principal economic source for thousands of small livestock keepers, artisans and merchandises, whose optimized incomes will permit them to fight the poverty.
3. To establish a sanitary program associated to control or eradicate *Sarcosystiosis* and external parasites.
4. To promote recovery and management programs for native pasture.

5. To promote the continuity of the investigation and transfer of technology in the genetic aspects, improvement of pastures, credit programs for small producers.

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Production and handling systems of alpaca and vicuñas

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The alpaca: general characteristics

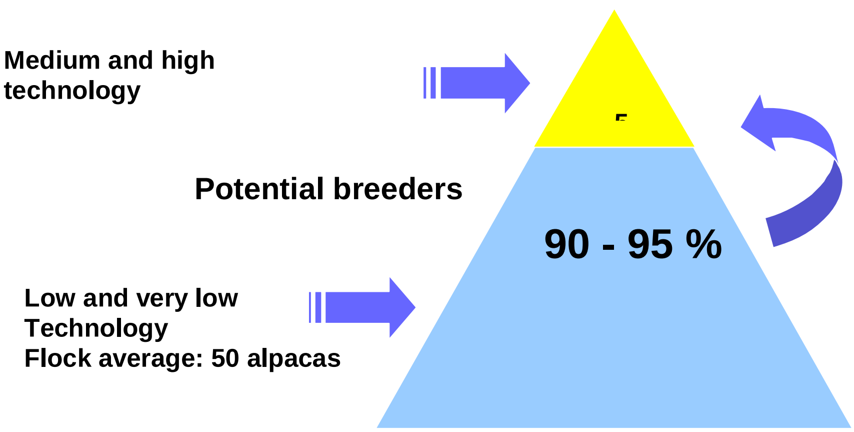
As a domestic breed, alpaca is raised in farms and its principal use is the fibre that presents many colors, mainly white. The animals are sheared once in a year and produce from 1.5 to 3 kilos of fleece (*vellón*).

The meat production is complementary and it is mainly used in the local market. However it can be submitted to a transformation process in dry-salty meat, commonly known as "*charqui*" (meat / dry-salty). As well, its skin can also be used to produce leather and coats.

The alpaca begins its reproduction between the 2 and 3 years of age, it has a gestation period of 11.5 months and gives one baby alpaca per year.

Breeders distribution

Figures 1 describes the distribution of the breeds and recalls the production system used for alpaca



Figures 1. Distribution of the breeders and the production system used for alpaca.

Family income distributions

Activities	Percentage
Alpaca breeding	36.9
Sheep breeding	17.5
Salary for work	15.0
Commercial activities	8.0
Llamas breeding	7.8
Craft	6.7
Bull breeding	4.8
Others activities	3.1
Poultry breeding	0.3
Total	100.0

Productive indicators

Indices	Unit	Low technology	Low technology	Mean technology	Ideal technology
Reproducers percentage	%	8.0	6.0	5.0	5.0
Natality	%	55.0	55.0	60.0	70.0
Litter mortality	%	15.0	12.0	10.0	8.0
Shering percentage	%	35.0	45.0	60.0	65.0
Fiber production per alpaca	Kg	1.50	2.00	2.50	3.00
Meat production	Kg	20.0	25.0	28.0	30.0
Reproducer price	US $		100.0	200-300	300-500
Fiber price	US $	1.00	1.20	2.00	2.50
Meat price	US $	1.00	1.00	1.10	1.20

Source: Bustinza 2001, Gutierrez 1993, Corpuno 1982, CONACS 2003.

Commercial productive structure of the worth chains in the domestic camelids sector

Rural sector Raising / Cattle		Rural sector / commercialization and transformation	Urban sector / commercialization and transformation
Alpacas and llamas	Fiber	Categorization / sorting / top / spinning / Preparation / clothes	
	Meat	Fresh and meat / dry-salty / jam, inlays / other	
	Skins	Skins / tannery	
	Animals	Reproducers / pets	
	Other	Tourism, semen, embryos	
Production area		Regional market National market	International market

Vicuña: conservation and management

The countries involved in the agreement (Peru, Bolivia, Argentina, Chile and Ecuador), have developed some mechanisms to control the production systems of the specie, that allow the increase of population and maintain its sustainable use. A resolution is emitted by the agreement, to the requesting country, to endorse the CITES Agreement and to modify the appendices.

Convention CITES

The CITES Convention is the entity that supervises the vicuña fiber's commerce, allowing the commerce only to countries that reach a certain credit of population as described in the Appendices II (threaten), and not in the Appendices I (extinction danger). Peru and Bolivia are the only countries that have the total of their species that respect the criteria contained in Appendices II.

Vicuña's management systems

The following are the countries who signed the agreement for vicuñas conservation and care that also established a management system:

1. Under Captivity: Argentina[1] and Chile[2].
2. Under Semi captivity: Peru, Argentina, Chile[3] and Bolivia[4].
3. Wild: All countries.

[1]Reports 20 deposits in the Jujuy province and 1 in the Salta province.
[2]Reports 3 captivity installations in the Tarapacá region.
[3]Reports 2 wild handling modules in the Tarapacá region.
[4]Reports 94 Vicuña's Conservation and handling units.
Source: Reports 2002-2003 of the countries members of the Agreement for the Vicuña Conservation and Handling.

Captivity production system

This production system consists of a complete system for the vicuña species, that includes infrastructures, shears, fiber handling, food handling, productive and health handling aspects.

Semi-captivity production system

This production system is defined as management system within the vicuña ecosystem or habitat, in extensive confinement conditions. (Define in the Resolution Nº 259-03, Agreement for the Vicuña Conservation and Handling).

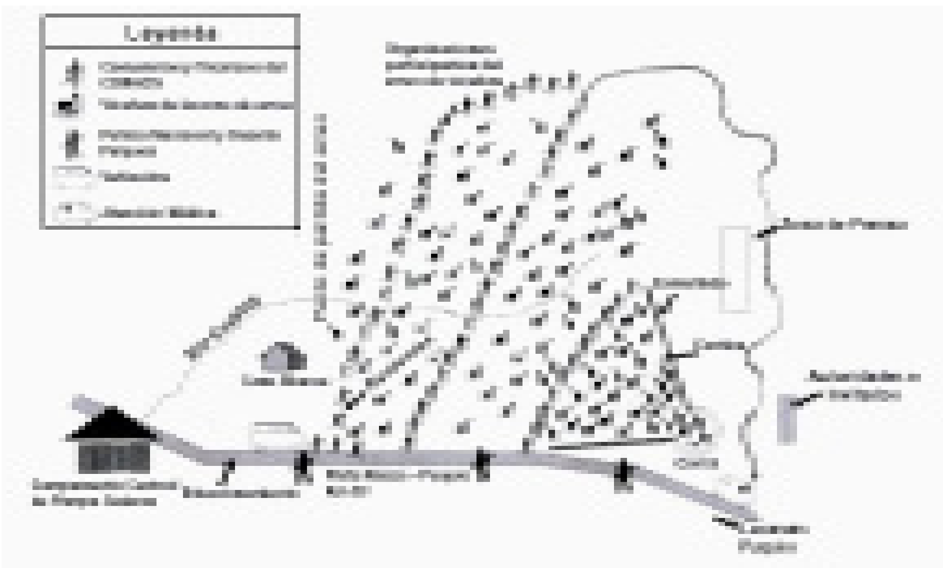
This management system has adequate conditions of territorial extension, of natural grass, similar to their wild habitat with a good health plan, without supplementary food and taking into account the species sociobiology, in other words, with an adequate relation between males and female vicuñas.

Module of Sustainable Use (MUS)

The Module of Sustainable Use (MUS) involves a progressive program of new technologies acquisition in the altoandinas communities, until the country could reach a complete capacity in executing and keeping the protection activities of the Vicuña, such as their conservation, handling and use.

The MUS involves three aspects in the management of the species:

1. The production of vicuña fibre obtained from the alive animal.
2. Guarantee the vicuña's protection against furtive hunters.
3. Provide an add value to the obtained fiber through the sorting and cleaning activity, generally performed by women.



Vicuñas' capture and shears operative in Pampas Galeras - Ayacucho

A Peruvian case

In Peru some activities have already started trough the MUS activities, that allow:

- Conservation and handling of the Vicuñas species performed by the farmers communities.
- Pre-treatment, preparation and processing of the fibre, before its transportation to the collecting centers.
- Correct management of sheared and not sheared Vicuñas in Chaccu of Pampa Galeras - Ayacuho.

Main conclusions of the seminar

The variety and broad scope of the topics covered, the different and rather unique species which are autochthonous to many different parts of the world, reflected also by the wide range of countries of origin of the authors and other participants of the workshop, make the consolidation of the conclusions of the workshop a difficult task. The listing of the main conclusions follows.

- The general impression persisted that the level of research in camelids lags behind the needs and that it is less than what these species deserve, given their importance for food security and sustainable livelihoods of communities living mainly in harsh and difficult environments.
- More needs to be known about the physiology of lactation, the relation of milk production to dry matter intake, lactation curves and the causes of the large variations observed in milk composition.
- Meat production is largely not a market oriented activity and more information is needed on precision and accuracy of weighing, factors affecting live animal and carcass weights, growth curves, performance measurements and carcass and meat evaluation.
- Unusually large variations in performance are observed among individuals of the same ecotype especially under harsh conditions. The degree to which emphasis should be put on genetic changes by selection and on improvement of the environmental conditions is still not known, since parameters like heritability and genetic correlations in general have not been estimated, and cost analyses of inputs relative to outputs have not been done.
- From the point of view of camelid genetic resources, breed definitions and the corresponding characterizations should be started as a first step in defining guidelines for genetic improvement.
- Although conscious that it will be hard for camelids to compete with other species for attention in a global organization such as ICAR, it was recommended that in the near or at least mid-term future camelids are considered of interest by ICAR.
- Also FAO is encouraged to enhance efforts in camelid development, recognizing though, that important publications have been produced by FAO in particular in camel reproduction and dairy products and that some important field projects have been conducted;
- Individual identification is not common and not at all standardized, and the evaluation and development of suitable identification systems for camelids should be the first step to consider by ICAR.
- Dairy recording in camelids is still very rudimentary. In order to develop reasonable recording systems, even the most simple ones, much more basic information than is available today has to be produced.

- Meat recording systems depend on the knowledge of growth curves and factors affecting growth, genetic variability, and the development of practical methods to estimate carcass quality and meat quality, and research in these topics should be encouraged.
- Fiber recording systems are more developed in South American camelids but their use is limited, among other factors, by the need to have laboratories to measure fiber quality.
- The need to raise awareness of issues affecting camelid production at academic, research and policy levels was widely recognized and it was felt that this workshop has contributed towards that goal.
- Finally, supporting networking among researchers, teachers, extensionists, veterinarians, agronomists and other professionals, producers, administrators, market people and the whole range of stakeholders should enhance attention towards these camelid species and improve the chances of directing research more efficiently.

The seminar, organised during the 34th ICAR Session, held in Sousse, Tunisia, offered the possibility:

- to get acquainted with camelid production systems in Africa, Asia and South America, including environmental, management, health, breeding, reproductive and market aspects
- to gain insignt on the status of camelid genetic resources in several countries of Africa, Asia and South America
- to discuss actual - if existing - and potentiel recording systems for camelids with emphasis on milk, meat and fiber production
- to evaluate the need for reasearch and development in camelids at regional and global level
- to exchange experiences among participants coming from different world areas