PRODUCTION AND MANAGEMENT
OF
CAMELS

Bakht Baidar Khan
Arshad Iqbal
Muhammad Riaz

Department of Livestock Management
University of Agriculture
Faisalabad
2003
PREFACE

The camel, without exaggeration, is the most ignored among the domestic ruminants in Pakistan. This is as much true in terms of lack of efforts to improve its care and productivity as it is in terms of lack of any planned research on it. Had it been an unproductive and a useless animal, its population would have gradually diminished, but it is the other way round. Its population is steadily growing. On papers, its population is being shown as stagnating, but most probably it is not so. On the international scene, there seems now a growing awakening in respect of the camel. At places, it has been termed as a ‘food security animal’. In Pakistan too, some teaching institutions have taken an initiative and have incorporated “Camel Production” in their teaching courses. No doubt, it is a very timely step.

Scientists from Germany, England, India, Australia and UAE have published books on camel. These are, of course, good books but as usual their prices are prohibitive for our students, extension workers and even for teachers. Moreover, these books contain a little information about camels in Pakistan. Therefore, an easy-to-understand book on ‘Production and Management of Camels’ using a question-answer format, has been compiled. This should provide ready-made answers to so many questions simmering in the minds of students, teachers, researchers and extension specialists. It embodies about 400 questions along with their answers. The book discusses the distribution of camels in different continents/countries, breeds and types of camels with cross reference to other species, nutritional physiology and reproductive management, the way camels adapt to hot arid environment, milk and meat production and work performance, practical management and training of camels, marketing, health care and some diseases, including valuable information on several other aspects. Camel breeds and camel raising practices in Pakistan have been adequately discussed.

We feel great pleasure in acknowledging the hard work done by so many researchers/authors/editors, whose published information has been used, mostly as such, in compiling the book under reference. Their efforts have been amply acknowledged in the text/tables/figures etc. It was beyond our means to individually contact them in this regard.

We are highly thankful to Akhter Saeed MD for providing us useful literature from abroad. We are equally thankful to Dr. Ghulam Muhammad, Chairman CMS, UAF, for his cooperation in providing pertinent literature. Ch Sikander Hayat and Nawaz Ahmed Sipra also deserve our heart-felt appreciation for helping us out of many problems pertinent to the publication of this book.

No book has ever been claimed to be perfect in all respects and so is this one. The readers are requested to convey in writing their suggestions about omissions/shortcomings noticed in this book. Their suggestions would not go unnoticed.

Bakht Baidar Khan
Arshad Iqbal
Muhammad Riaz

August, 2003

FOREWORD

For a long time the camel has been the victim of disregard and deliberate neglect of scientists and development workers. However, the last about two decades have witnessed a resurgence of interest in this species. Most of the work to exploit the productive potential of the camel has been undertaken by those who come from such countries that do not even possess camels. I think this should be more than enough to make us realize our responsibility towards a multipurpose domestic animal species, of which this country has a sizeable population. We need to investigate its peculiarities and exploit its potential especially in terms of milk and meat production and to explore the possibility of increased export of live camels to several Middle East countries. Presently some of these countries are importing camels from Australia.

To strengthen the possibility of implementing such plans, we must be equipped with recent knowledge about various aspects of camels. In this connection and as an animal scientist myself, I feel pleasure to mention that a book with the title ‘Production and Management of Camels’ has been brought out by experienced teachers/researchers, which should suffice to meet the needs as mentioned above. The contents of this book make me believe that it should be as much helpful for students, teachers and research workers as for extension specialists.

Dr Zaheer Ahmad
Professor / Dean
FAH, Univ. of Agri.,
Faisalabad.
PART – I

Part – I includes:

- Introduction
- Breeds and Types
- Feeding and Nutrition
- Breeding and Reproductive Management
- Productivity and Performance
INTRODUCTION

Q. Is the camel a monogastric or a polygastric animal?
The camel is a polygastric animal, but not a true ruminant. True ruminants have four-compartment stomach, whereas there are three compartments in the camel stomach. Since after feeding, the camel also ruminates, therefore, it is called a special ruminant or sometimes as a pseudoruminant.

Q. Write down the synonyms for the one-humped camel.
The term Arabian camel and dromedary exactly mean the same as one-humped camel.

Q. What is the probable origin of the word camel?
The word camel is said to have been derived from the Greek word ‘Kremal’ or from the Sanskrit word ‘Kreluk’. The latter means ‘throw away legs’ and thus appears to make sense since a running camel seems as if it has thrown out its legs in the air with little control over them (Isani and Baloch, 2000).

Q. On what basis the two-humped camel is named as Bactrian?
Probably the name ‘Bactrian’ was derived from the word ‘Bactria’, the old name of the present day Turkmenistan in Central Asia.

Q. Write a note on old world and new world camels.
Old world camels belong to the genus Camelus. They are found in deserts/plains. They are bigger in body size and weight. They have either one or two humps. Those having two humps are mostly found in cold mountainous regions such as parts of Afghanistan, China and Mongolia. New world camels are placed in genus Lama. They are much smaller in size and body weight. They are found in areas located at much higher altitudes. They are humpless. Their habitat is by and large restricted to South America and are thus also called South American camels.

Q. Do the llamoids have hump like that of dromedaries?
Researchers believe that llamoids migrated to South America via North America and that probably they lost their humps during the course of evolution in South America. The modern one-humped camel is said to have evolved from the Bactrian camel. Some embryologists also support this idea on the basis that the dromedary has two humps in its embryonic stage, which are fused into one hump before birth.

Q. What, in general, is the socio-economic importance of the dromedary?
Precise data to assess the real socio-economic importance of the dromedary are not available. However, during the last about two decades, some academic and research institutions and international and national development agencies of a few countries have undertaken studies in this regard. Most of these studies have termed the camel as an animal of great socio-economic importance in large tracts of the third world. Two-thirds of the world’s camels are in Africa. Of these, over 5 million constitute a giant milking herd in Somalia and some bordering areas of neighbouring countries. Elsewhere many are still engaged in transport of salt, fuel wood, agricultural produce and household goods, and the rest are involved, sometimes with other animals, in the subsistence of both sedentary and nomadic human groups. Camels may still be seen being used in varying
types of agricultural operations and drawing wheeled vehicles for intracity transport of goods in several areas of Indo-Pakistan subcontinent, including the streets of cities like Karachi, Multan and Faisalabad. In addition to power and transport, camels provide milk and meat not only in very arid regions but also in several urban areas in many countries. It has the ability to withstand the adverse effects of severe drought. Compared to small and large true ruminants, mortality rate in adult camels is very low in the event of drought conditions.

It has been established that at least in the medium term, adoption of better camel husbandry practices can improve the life of African nomads who largely earn their living through camel raising. There are a lot of predictions in the air about increased global warming, the camel probably would be the most favoured animal in that scenario. In Australia, the Central Australian Camel Industry Association is currently studying the possibility of moderate to large scale meat production becoming a commercially viable enterprise. Production will be based initially on the large existing feral camel population. The market possibilities are for a local and export trade worth $A15 million by the year 2005 (Manefield and Tinson, 1997).

In the wealthy Arabian Gulf states, notably UAE and Qatar, a thriving camel industry exists which is based on racing. The amount of money being turned over and the number of people involved many of them expatriates, justifies the use of the term ‘camel racing industry’. At important annual race meetings, it is not uncommon for the value of trophies, usually vehicles ranging from top of the range Mercedes, through Range Rovers to GMC pick ups, to be around US$3M. The wealthy owners usually give these trophies to the trainers who are, in turn, expected to express gratitude to their staff with more than words.

It is not out of place but in a sense an unpalatable suggestion that to improve, in general, the present plight of the camel in terms of its reproductive performance and milk and meat production, if it is made mandatory that at least 10 to 15% of the total annual prize money to be paid to the winners is deposited, as a cess for Camel Improvement, with the state government where camel races are held. The state government then should allocate, under an approved plan, part of the money collected for the purpose, to two institutions, one in Africa (e.g. Sudan) and another in Asia (e.g. Pakistan), for the phased improvement of the one-humped camel. Such a development programme shall have to be persistently pursued for about 15 to 20 years. The outcome of these efforts, including the progress and problems, should be annually reviewed. The aims and objectives should be scientifically weighed and precisely defined. Such a project if successfully implemented, can ultimately benefit millions of people in Africa and Asia whose livelihood is linked with the camel. It is, however, really heartening that already research on some aspects of camel production is underway in the UAE U and the Scientific Centre for Racing Camels.

Camels may be bred by common folk, trained successfully for racing, can be purchased by members of the royal families and wealthy businessmen. Scouts may spot fast camels from places as far away as Sudan. It is said that the top price paid for a racing camel was 15 million dirhams (3.65 dhs = US$ 1), while the price for good race winners is 2 to 6
Q. Discuss the contribution of the camel to the agrarian economy of Pakistan.

The camel contributes to the agrarian economy of Pakistan in various ways, but precise data in this regard are not available. The contribution of the camel even in terms of milk and meat production does not seem to have been properly assessed.

The people residing in remote desert areas and nomads consume fresh raw or soured milk (a sort of yogurt). The nutrient contents of the camel milk are as good or even better than that of the cow milk. Of great relevance for human nutrition in desert arid areas is its high vitamin C content ranging between 29 and 36 mg/litre milk, which amounts to three times the level of cow’s milk and one and a half times as much as in human milk. Almost around all major cities in Pakistan mobile camel dairies are found. The nomad camel keeping families keep on moving from one suburb locality of the city to another and sell camel milk there. The reported milk yield ranges between 900 and 4000 litres in a lactation period of 250 to more than 500 days. The average daily yield under different management systems is reported to vary from 3 to 8 litres. The females are milked twice to four times a day in Pakistan. According to a very modest estimate, the camel milk annually produced in this country is 0.24 million tons valued at Rs. 2.4 billion.

The camel meat is largely consumed in remote rural and desert areas, but cities are no exception. In a city like Karachi, about 10 camels are slaughtered on each meat day. The carcass weight of a camel reared under low input varies from 180 to 300 kg. The dressing percentage ranges from 46 to 50. A very moderate estimate indicates that over 5000 tons of camel meat is being annually produced in Pakistan valued at Rs. 250 million. The meat of camel slaughtered at the age of 3 to 4 years tastes like beef, but most of the people here have not developed taste for it. However, at many meat shops it is sold mixed with buffalo and cattle meat mostly in minced form. The number of people who like camel for sacrificial slaughter on Eid-ul-Azha is gradually increasing every year. Mainly young animals are preferred for slaughter on the occasion of Eid.

Camels serve as a source of power for drawing water from wells, for working mini oil extraction (from oil seeds) mills, grinding of wheat, corn, gram and for sugarcane crushing. They provide energy for ploughing land, pulling cart for transportation of goods as well as people. In addition, baggage camels comfortably carry loads up to 300 kg to distant places at a rate of 30 km/day. Thus they are a comparatively cheaper source of power for various agricultural operations and to meet allied transportation needs of small farmers and nomads.

Camels raised and trained as riding/racing animals, or for dancing and wrestling or those trained to perform acrobatics, fetch two to four times higher prices than the normal prices of common camels. Similarly, camels raised to be sold for sacrificial slaughter on Eid-
Azha, fetch on average, no less than Rs. 20 to 30 thousand per animal. With a little more than usual input in feeding and care of such animals, profit margin can be substantially enhanced. These facts tend to suggest that the camel can be of immense help to improve the economy of those involved in raising it, provided they supplement their traditional management systems with modern husbandry practices and health care of their animals. Native camels also indirectly contribute to the economy by surviving under pastoralists/nomads or small farmer’s management systems with surprisingly low inputs mostly in the difficult and drought stricken arid areas and mountainous regions where long term survival of other livestock does not seem possible. Also, they do not compete with other livestock for their nutritive requirements since most of the time they browse top of trees and shrubs.

Q. **Discuss in detail economic potential of the camel.**

The camel (dromedary) is an important livestock species uniquely adapted to hot and arid environments. It produces milk, meat, hair, some wool, hides, serves as a beast of burden and used for riding and as a draft animal for agriculture and short-distance transport. The majority of camels in Pakistan are kept by migratory pastoralists in subsistence production systems except those kept in irrigated areas by farmers and a small number used for pulling camel carts in cities. Not all farmers keep a camel but most often maintaining one camel suffices for various agricultural operations of a farmer. Off-take of live animals for sale as slaughter stock is much less as compared to that of sheep, goat, cattle and buffaloes. However, apart from routine slaughter, on festive and religious occasions such as Eid-ul-Azha, hundreds of people would slaughter camels and consume their meat.

The importance of the camel as a long-distance transport animal has been gradually declining but this does not minimize its importance since various studies tend to show the camel as an emerging source of increased meat and milk production, more particularly milk. With increasing human population and simultaneous increase in gap between supply of meat and milk, there is urgent need to develop previously marginal resources such as the semi-arid and arid rangelands and optimize their utilization through appropriate livestock production systems, of which camel production is certainly complementary and the most suitable one.

| Table 1. Numbers of domestic ruminants and camels in the world and Pakistan (million head) |
|---|---|---|
| Species | World | Pakistan |
| Buffalo | 165 | 28.4 |
| Cattle | 1350 | 23.3 |
| Sheep | 1058 | 24.6 |
| Goat | 720 | 52.8 |
| Camel | 18.23 | 1.2 |


From a global perspective, the economic significance of camel production is minimal as the comparison of livestock numbers (Table 1) clearly shows. Even for Pakistan alone the
economic potential of the camel, judged by numbers only, remains limited in comparison to the other livestock species. Certainly the importance of camel production becomes more evident if one considers the arid areas of Balochistan, Sindh, Punjab and NWFP alone where camels make a considerable part of the local livestock. Unfortunately it is very difficult to evaluate the economic significance of camel production by conventional parameters such as cash flow analysis, gross margin calculation etc.

Q. Discuss in general, the present status of camel production.
A growing awareness that the camel can serve as a major food (milk and meat) producer in semi-arid and arid areas has helped change its image from ‘ship of the desert’ to ‘a food security animal’. The last three decades have also seen an increased scientific interest in all matters concerning utilization and management of arid lands and with it is a substantial number of scientific publications on the camel. According to Wilson (1989) most of these publications covered veterinary aspects, anatomy and general and reproductive physiology. Studies on feeding and nutrition, camel management, production systems, productivity and economics are very rare. Most of the published work is either based on small number of animals, short observation periods, one time surveys and interviews or estimates. Since camel production is usually a migratory system and it is practised mainly in remote areas with harsh living conditions, poor infrastructures and low economic potential, therefore such studies would be difficult, time consuming and expensive. As a consequence not a single long-term, methodical study of any aspect of camel productivity under such conditions has been published. Schwartz and Dioli (1992) stated that research on camels conducted during the past two decades has had very little, if any, impact on the promotion and development of camel production. Numerous symposia and learned conferences on various aspects of the camel have been held in recent years, three bibliographies on camel research have appeared, international and national institutions have established coordinating units, produced newsletters and commissioned consultancies. However, there is still not a single project or programme in the field focusing mainly on the improvement of practical camel production. Considerable effort is required to facilitate development and implementation of feasible and sustainable programmes to improve the present camel production. As suggested by Schwartz and Dioli (1992), interventions are conceivable on the biological and ecological system level, the managerial and economic level, the institutional and legal level and probably the most important is the political level.

Q. Write a note on percentage distribution of camels in Africa and Asia.
There are an estimated 18.58 million camels in the world. Of these, 16.2 million are one-humped camels. More than 80% of all Arabian camels are found in Africa. East Africa contains about 63% of all old world Camelidae. Somalia and Sudan account for 70% of camels in Africa; Ethiopia, Chad and Kenya contain a further 12%. In addition to these countries, Mauritania, Niger and Mali have sizeable populations as do Maghreb countries of Algeria, Morocco and Tunisia. In Asia about 70% of dromedaries are found in India and Pakistan.

Q. Give an estimate of world population of camels and their distribution in various continents.
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There are about 18.58 million camels in the world. Africa has the highest number (13.62 million) followed by Asia (4.76 million) and Australia (0.2 million). Elsewhere, the number of camels is highly negligible.

Q. **Give the total population of camels in Pakistan and its percentage distribution provinciwise.**

Pakistan possesses 1.2 million camels (FAO, 2000). Balochistan province has the largest population (36.43%) followed by Punjab (33.51%), Sindh (22.76%) and NWFP (7.30%) (Isani and Baloch, 2000).

Q. **Discuss the relationship between environmental influences and world distribution of camels.**

With few exceptions one-humped camels are found in areas where rainfall is low and occurs in a relatively short period followed by a long hot dry spell of several months. Thus their normal range is the African and Asian tropical and subtropical dry areas, including the deserts of northern Africa, parts of western Asia and the Indo-Pakistan subcontinent. The northern and western edges of dromedary’s in Africa are Mediterranean sea and the Atlantic ocean. In Africa, the limit extends from the Senegal coast through central Mali to the south of Niger. In Chad and Sudan, the southern limit in recent years has been gradually pushed southwards. However, the presence of tsetse and other biting flies has restricted the distribution of the camel further south. In eastern Africa, the arid conditions of the Red Sea coast, the Gulf of Aden and the hinterland of Indian ocean coast are favourable to the camel. In Asia, dromedaries extend northwards into Turkey, the southern parts of the former Soviet Union and Afghanistan where their range overlaps with that of the Bactrian camel. The main area of distribution of Bactrian camels is the deserts of Inner and Central Asia (from western Kazakhstan to Mongolia and northern China) with a continental climate comprising very long and very cold winters and short hot summers (Wilson, 1998).

Q. **Do social and cultural factors have any relevance to the distribution of camels in various regions?**

Camels are the domestic animals of nomads. The nomadic owners are obliged to take their camels with them to assure their basic needs of milk, meat and transport. The greatest cultural impact on the recent distribution of camels was the advent of Islam. As Arabs spread the message of God, they took their one-humped camels with them, extending its range northward and eastward in Asia and westward along the Mediterranean sea. Until the arrival of motorized transport and the monetarisation of desert economies, camels remained almost the only beast of burden and personal transport animal in the area to which they were adapted. The internal combustion engine and the wider distribution of money have considerably affected the transport role of the camel, but they have had much less effect on its cultural relevance. This and its continuing economic significance are evident from the several countries that issue currency with the camel as a motif (Wilson, 1998).

Q. **What is the recent view about the evolution of camelids?**

There are different views in this regard. The most recent, however, is that all the camelids evolved in North America. The Tylopoda were recognizable in the Middle Eocene of 50
million years ago and well differentiated some 10 million years later. Early camels were probably small but some subfamilies comprised genera in which animals were very big, as indicated by their genus names such as Megatylopus, Megacamelus, Gigantocamelus and Titanotylopus. Camels migrated across the land bridge (which is now the Bering Strait between Alaska and Russia) from North America to Asia. Some species subsequently reached Africa and Europe. Other species migrated into South America. These migrations probably occurred between three and four million years ago. When camels disappeared from North America is not exactly known.

Q. Discuss the domestication of camel.
The genus *Camelus* was probably among the last of the major domestic species to be put to regular use by man. There is a little direct evidence for an exact time of domestication, mainly because the camel has changed relatively little as a result of selection and, whereas it is possible at archaeological sites to observe the changes in other species, this is not the case for camels. Since the early camel owners were nomadic, they left few permanent mementoes of their presence. The most likely time of domestication, however, is about 4000 years BP (before present). Southern Arabia (which is now the north eastern part of Yemen and the west of Oman) is the most likely area. There is, indeed, little firm evidence of true domestication until about 2500 BP.

There is more direct evidence of domestication of the South American camelids than of the old world ones. The archaeological evidence suggests that llama and alpaca were domesticated at very high altitudes of 4000 to 5000 m in the Andes of southern Peru and western Bolivia. An approximate time of first domestication would be about 6000 years BP. This period has been based on changes in the type of molar teeth and the increasing numbers of bones of young as compared to old animals found at archaeological sites.

Q. Discuss the taxonomy of the camel.
Both of the old world and new world camels belong to the subfamily Camelinae of the family Camelidae in the suborder Tylopoda of the order Artiodactyla. Camels are even-toed ungulates but differ from most others of their order in having soft, padded feet. They are generally referred to as special ruminants or occasionally as pseudoruminants because of their ruminating habits. Camels do not belong to the same suborder as the other major meat and milk producing domestic herbivores. It is now customary to place old world camels in genus *Camelus* and new world or South American camels in genus *Lama*. Within *Camelus* two species are generally accepted: *C. dromedarius*, the one-humped or Arabian camel or dromedary; and *C. bactrianus*, the Bactrian camel or two-humped camel. Biologically, the species division is not correct, as the two freely interbreed in either direction and produce fertile offspring. There are four species of new world Camelidae of which two are domesticated and two wild. The llama, *L. glama*, is used mainly as a pack animal, while the alpaca, *L. pacos*, is primarily a producer of high quality fibre. The two wild species are the guanaco, *L. guanicoe* and the vicuna, *L. vicugna*. All the South American Camelids have a very similar karyotype with the same number of chromosomes (2n = 74), which is identical to that of the old world camels.

Q. Give a comprehensive list of the distinguishing features of the camel.

_Bakhat Baidar Khan, Arshad Iqbal and Muhammad Riaz_  
_University of Agriculture, Faisalabad._
Part – I  Production and Management of Camels

Bakhat Baidar Khan, Arshad Iqbal and Muhammad Riaz  University of Agriculture, Faisalabad.

i) It has exceptional tolerance to heat and deprivation of water. The physiological characteristics assist the camel in the conservation of water.

ii) Being a homeotherm, the camel can vary its normal body temperature over a considerable range.

iii) The camel can concentrate its urine and recirculate and reutilize urinary nitrogen when it is deprived of water. Moisture in faecal balls is also considerably reduced.

iv) Male camels exhibit little sexual activity outside a specific rutting season.

v) During rutting, the soft palate of the camel increases in length. It then hangs out of mouth on one side and is called ‘Dulaa’.

vi) Camel prefers most of the time to browse top of bushes and trees rather than graze because of its flexible long neck, long legs and cleft upper lip.

vii) In contrast to other ruminants, camel is hornless and has no gall bladder.

viii) It has almost no competition for feed with other animals.

ix) It has unique ability to walk through long stretches of desert and hence called ‘the ship of desert’.

x) Dentition differs from other ruminants in that there is a pair of well developed and pointed canine teeth in each jaw.

xi) There are long conical papillae on inside of the cheeks directed backwards, thus the camel can browse at the thorny plants without any harm. The canine teeth help the camel to take into grip the twigs and remove them from the trees.

xii) The camel is a hardy animal, comparatively eats less, goes into so called sleep for short intervals and possesses a long lasting memory. It is said that it remembers any extraordinary harsh treatment given to it such as heavy beating by its caretaker or the rider and is said to take revenge at an appropriate time.

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

Q. Write down the principal physical characteristics of one-humped riding and pack camels.

Physical Characteristics of Riding Camels: Slender animals with a long and level shoulder, head small with a fine muzzle, moderate lips, ears small and set close together, eyes alert, lower jaw deep below the eye; the neck is fine and supple and joined low down to the trunk; a smallish hump; the shoulder long and fine, the chest very deep, abdomen tucked in, ribs well sprung and terminating not far from the pelvic bone; the fore legs set close together, straight, no brushing at the knees, feet not turned out, the hind legs straight, with no cow hocks; the quarters well muscled and the tail set high; the feet medium sized, the pace easy and tireless; liveweight rarely exceeds 400 and 550 kg in females and males respectively; the animal needs not to be driven; the skin fine and supple.
Baggage Camels: They should not have faults inadmissible in riding camels. They are much ‘coarser’ animals, with heavier head and neck, with fore- and hind quarters having more balanced appearance, shorter legs, heavier bone and larger feet. Hump more pronounced in well fed animals. Their pace slower and shorter than that of the riding types but equally tireless. Liveweights of 600 kg in females and 750 kg in males are not uncommon. Apart from riding and pack animals, another way to classify one-humped camels relates to location, allowing camels to be classed as lowland or mountain types (Table 2).

Q. Describe the salient physical characteristics of one-humped lowland and mountain camels.

Table 2. Salient physical characteristics of one-humped lowland and mountain camels

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Lowland</th>
<th>Mountain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall size</td>
<td>Large</td>
<td>small</td>
</tr>
<tr>
<td>Withers height (m)</td>
<td>1.93-2.13</td>
<td>1.82 – 1.96</td>
</tr>
<tr>
<td>Conformation</td>
<td>Rangy</td>
<td>compact</td>
</tr>
<tr>
<td>Neck and legs</td>
<td>Long</td>
<td>short</td>
</tr>
<tr>
<td>Hindquarters</td>
<td>Light, sloping</td>
<td>well developed</td>
</tr>
<tr>
<td>Feet</td>
<td>Oval, usually soft</td>
<td>round, hard</td>
</tr>
<tr>
<td>Coat</td>
<td>Short, fine</td>
<td>long, coarse</td>
</tr>
</tbody>
</table>


Q. Write a note on camels as a source of recreation.

Many people have a desire to ride a camel. A few actually own pet riding camels. Some want to ride for a brief period only and others to caravan overnight into the desert and experience a little camel culture. The senior author himself enjoyed a few camel rides and the longest very comfortable ride was 60 km through a desert in two days. Camel riding can be witnessed in Central Australia and in the deserts of Cholistan, Tharparkar, Rajasthan and on the beach in Karachi where beautifully decorated camels make their riders believe that camel ride is no less comfortable. Visitors to the zoo enjoy the structure and stature of the one-humped and the two-humped camels kept there as show animals. Organised camel racing as in the UAE and Qatar, has become a very popular sport involving thousands of camels (about 15000 racing camels in UAE alone) (Chaudhary and Akbar, 2000) as well as thousands of camel owners, trainers and their staff and spectators. It is thus not only a popular recreation but a source of living for a very large number of people. Apart from organized racing, there are camel races throughout the camel range, which are of a more light hearted and spontaneous nature. There is also widespread involvement of the camel in local and international tourism. Apart from riding, camel troops in various places take part in festivals and exhibitions, where dancing camels attract large crowds. The camel troopers of the Rangers of Pakistan and of Border Security Force of India perform an elaborate musical ride and other entertaining evolutions. Also in Rajasthan, at the annual Pushker Festival, camel
wrestling is an important event among others. Trained bull camels take part in wrestling in a ring of spectators. No doubt, the camel is involved in many other recreational activities that differ in different regions (Manefield and Tinson, 1997).

Q. Discuss the temperament of one-humped camel.

Depending upon the individual variations (what may be called as inherited personality factors) and the conditioning influences of training, some camels become very docile and tractable, while others never seem to lose the habit of making defensive threats in response to routine handling. Opinions differ on the extent to which camels express curiosity. Generally they do investigate new objects by close sniffing and mouthing. They are often described as patient, docile and tolerably stupid. At times they can be quite obstinate. Some of them never learn to cough or rise willingly to a command or some other cue. Some force or threat is necessary and still they may continue to vocally complain during their whole working life. The more handling they receive, the more tractable they appear to become. Black camels are said to be untrustworthy and unpredictable. There are stories of human skulls being crushed and arms being severed. It should be the practice to wear hard safety type hat when handling strange camels. Strikes and kicks can be very swift and dangerous because of the two horny claws on each foot. Striking with the forelimbs is often performed as part of a rearing jumping action while on the move. With the hind leg the camel can kick to its own shoulder in swinging sideward and kick forcefully rearwards. They are able to deliver a strong sweeping kick while in sternal recumbency. The camel is also capable of delivering quite a forceful, backward kick with the front leg. Wild camels in open country will run away while they can, but may be very aggressive when confined. They may appear to take a dislike to a particular person and rush past a closer person to attack the targeted one. Generally, however, they settle down soon and accept new surroundings, confinement and the presence of humans.

It is wise to regard all strange camels as potentially dangerous, test them cautiously and trust them only when they are known to be trustworthy. Never forget that bulls in rut often show behaviour that is more aggressive than at other times. To become a good camel handler, one must behave tactfully and seek to acquire some knowledge of ’camelology’ (Manefield and Tinson, 1997).

Q. Write a detailed note on endurance capability of Arabian camels.

The chosen gait of the one-humped camel on free range is a leisurely but almost a continuous walk. When walking the camel covers about 4 km/hour. They have often been tracked to cover >50 km during a day’s feeding, but 30 km is very common. Very young camels exhibit vigorous, spontaneous play, including some running and jumping. By 2 to 3 weeks age they are involved in playgroups similar to those formed by lambs, kids and buffalo/cow calves. These groups remain almost together between feeds. Mature camels will hasten towards a feed supply, usually at a jog, but sometimes at a gleeful canter or gallop. Some running and chasing may be exhibited by males in rut. Females will sometimes chase and show male sexual behaviour. Other than when being forced to faster gaits, this is about the limits of a camel’s natural tendency to exercise. When forced, the camel’s feats of endurance and strength can be remarkable. Mixed
camel/horse races over distances of 30 km, have been held in the UAE. The horses have
won these races but generally have suffered greater post race distress than have the
camels, but some have stopped the race and refused to go on. Judged by its physical
equipment, the camel would be expected to be an endurance rather than a speed animal.
During the first kilometer or so of an 8 to 10 km camel race, it will reach a speed of about
45 km/hour. In the UAE, the best speeds recorded over these full distances are 34.7
km/hour for 8 km and 33.8 km/hour for 10 km. In outback Australia, a race between a
camel and a horse took place from Bourke to Wanaaring, a distance of 160 km. The
journey was completed in one day, between sunrise and sunset, with the horse winning by
a small margin. Overnight the horse died. Next morning the camel set out to return to
Bourke. In 1874, the explorer Giles marched 350 km across south Australian desert in
40°C temperature, with two horses and three camels. The horses were given water but did
not survive the trip. The camels completed the march in 8 days without water. Giles later
marched 480 km in 17 days across the Victoria desert. The camels completed the march
without difficulty. There are numerous accounts of men surviving in the desert by killing
a camel and drinking the liquid from its stomach.
The camel’s relatively low oxygen uptake has surprised the workers in the field of
exercise physiology. Maximum oxygen uptake has been measured at 55 to 65 ml/kg/min
for camels, about 120 to 175 for horses and dogs, and 30 to 80 for man. At speeds of
6m/sec, the camel’s cost of locomotion is 50% that of the horse and 40% that of man. It is
postulated that the camel’s athletic ability may result from its having relatively long legs
and efficiency of locomotion. The rolling pacing gait of the camel has a significantly
smaller vertical lift component than that of the galloping horse. The camel has been
described as an animal capable of accomplishing great feats of endurance in extreme
environmental conditions because of its ability to employ unique biochemical and
biomechanical mechanisms (Manefield and Tinson, 1997).

Q. **Briefly describe the morphology of the dromedary.**
The dromedary or one-humped camel is a large special ruminant characterised by a long,
fine, low set neck and a hump of a varying size over the center of the thoracolumbar
region. The mature weight and height at the withers respectively are 400 to 700 kg and
2.2 meters. Female and male racing camels aged 4 to 6 years in the UAE, on average
weigh 350 to 450 kg and 400 to 480 kg respectively. The head is carried high in an
‘aloof’ style with the anterior nasal plane almost horizontal. At eye level this plane is
dished and a nearly Roman nose is the norm lower down. Large supra-orbital process
produces a beetle browed (prominent brows) appearance. In baggage types the head is
plainer and it is more refined in riding animals. The upper lip is cleft and overhanging the
lower one. The external nares slit-like and capable of being closed. The ears are small
and roundish. The eyes are soft and calf-like in appearance. The eyelids are equipped
with relatively long lashes (Figures 1 and 2).
The coat colour varies from occasional almost white through reds, rusts, fawns to almost black. Two coloured pied camels are also found in certain areas. Long seasonally deciduous wool occurs on the back and upper body sides.

The body has a deep, narrow chest and a relatively small abdominal waist. The croup slopes at 45 degrees or more to the horizontal. The legs are long and fine. The thoracic limbs support about 65% of the standing weight and are slightly more robust than the pelvic limbs, which may be relatively straight. Below the fetlock, the skeletal structure is biped and the termination is a pair of horny claws on each foot. The integument is common and the ground surface is a single almost circular keratinised pad. Keratinised pads are also present on the knees, elbows, stifles, hocks and sternum. The pad underneath the sternum is called the pedestal. This may be 7 to 8 cm thick vertically and keeps the animal’s body clear of the ground when it adopts sternal recumbency. The footpads of newly born camels are quite soft and delicate. They should not be forced to travel over terrain with sharp objects until their pads have hardened.

The tail hardly reaches stifle and has about 8 cm long hairs that are restricted to the sides and the tip of the tail. The udder is four quartered and situated between the hindlegs. The scrotum is situated high against the perineum. The preputial opening is directed backwards when the penis is relaxed (Manefield and Tinson, 1997).

Q. **What is meant by camel pads? What is their significance and how do they form?**

The camel is equipped with some keratinised skin areas on its body generally referred to as pads. These are secreted from a vascular membrane that covers a foundation of fibrocartilage. These pads enable the camel to rest for prolonged periods in sternal recumbency even on fairly abrasive surface. There is one pad on each knee, one on each elbow, one on each stifle, one on each hock and a large one on the sternum, called the pedestal. All except the sternal pad are barely proud of the skin and the hock pads may be insignificant on some camels. The sternal pad is backed by fibrous tissue and usually protrudes 7 to 8 cm below the ventral line of the chest in the standing animal. In couched position, unless the abdomen is very full, the only parts in contact with the ground are the pads and the limbs distal to the carpus and the tarsus. The anterior, dependent part of the prepuce in the male may also touch the ground.

The pads are not fully developed in the neonate and are covered with hair, which wear off during the first few months of life as keratinisation occurs. This occurs first on the knees at 5 to 8 weeks and then soon after on the elbows. The pedestal may show some keratinisation at 8 weeks and is usually completely keratinised by 12 weeks. The development of stifle pads also starts between 9 to 12 weeks. All pads except those of hocks are well developed by 10 to 12 months age. It takes 3 to 4 years when hock pads develop and are usually smaller, even absent, in some camels. The knee pads, although first to keratinise, are often the smallest. Camels from places such as stony desert as in Australia, develop large, thicker pads earlier than camels from sandy deserts. This holds true for their footpads as well (Manefield and Tinson, 1997).

Q. **Write a descriptive note on the hump of an Arabian camel.**
Since the Arabian camel is an one-humped animal, the discussion on hump will be restricted to one hump. The hump is the major storage place for subcutaneous fat. There is no internal bony support and the hump is covered by relatively elastic skin and reinforced by fibrous tissue. The fibrous tissue is mostly in the anterior part and where the hump rests on the vertebrae. Here the fibrous tissue of the hump merges with the supraspinous ligament. The hump is thus anchored to the vertebrae by aponeurosis. The size of the hump is usually a good indicator of a camel’s condition. The hump is taller and extends down the sides of a fat camel. In contrast, the hump is highly reduced in size and so depleted as to tend to fall over to one side in a lean thin animal. Localising of subcutaneous fat in the hump indirectly assists the camel with cooling. Except in very fat animals, an appreciable amount of diffusely distributed subcutaneous fat is rarely seen in camels.

For too long it was though that the metabolism of fat from the hump was a major source of the camel survival for many days without water intake. This has since been shown to be a fallacy. It was experimentally shown that fully fed camels were dehydrated for over 10 days. They lost about 25% of their body weight but the height, length and circumference of the hump did not change. The fat in the hump is mainly a reserve of energy for times of primary shortage or secondary need such as illness. Camel fat is generally white and soft. When rendered down 96% of the hump weight is recovered as a very clear oil, which is said to be highly regarded for traditional Chinese cooking. The hump fat is about 61.7% saturated (palmitic 37.9% and stearic 14.5%) fatty acids and 38.3% unsaturated (oleic 30.9% and linoleic 3%). The cholesterol content is about 87 mg/100 g.

Ruptured aponeurosis should be suspected whenever a large lump is seen to be unstable and carried to one side. This may be due to rough treatment of very fat camels with a massively domed hump. Later, when the hump fat has been utilized in time of food shortage, the hump will be seen draped to one side and flopping about like a balloon half filled with water. The hump is considered by some a good site for subcutaneous injection.

Q. Describe general guidelines for selecting camels.

Camels sold in markets are mostly not the best animals, therefore, it is advisable to go out to the herd where it is grazing. Valuable milking animals are invariably not used to carry loads, thus there should be no signs that the animal has been used in this way. Only strong, healthy animals, having no obvious faults should be selected. Handle the animal twice or thrice to check its temperament.

**Head:** Check for blindness and defects in both eyes. Examine the teeth to determine the age of the animal. Press your hand on the animal’s cheeks to make sure that all the teeth are present. Also, see that the animal is no under- or overshot.

**Legs:** These should be straight. Watch for limping or other problems when the camel is walking, sitting down or getting up.

**Front Legs:** There should be ample space between the chest and the front legs. The legs should not rub against the chest pad and the knees should not rub against each other. The fetlocks should be straight. Examine the knees for sores or scars, which show that the
camel has been restrained with a rope around its front legs. This partially indicates that it was not considered useful during the rut and was used for work instead.

**Rear Legs:** The hock joints should not be too close to each other while the camel is standing, and should not touch when it walks. Also, see that the Achilles tendon is not swollen or painful. This may show that the camel has been used too early and too much as a pack animal.

**Feet:** Check the soles of the feet for wounds or bruises.

**Chest:** A narrow chest can show that the camel was malnourished as a young calf. There should be no sores or abnormal growths on the chest pad.

**Hump:** It should not be very big. A very big hump shows that a male is a poor breeder (probably no rut) and that a female is sterile.

**Brand marks:** These might be a good indication of the diseases for which the camel has been treated in the past. Brand marks on a joint may show the camel has had joint problems or lameness. As a rule only owner’s or tribal brand marks should be present.

**Scars:** Examine the animal well for scars and old wounds, especially on the short ribs and shoulders since these heal with difficulty and show that the camel has been used as a pack animal. A tuft of white hair on the hump or shoulder indicates a wound caused by use as a pack animal.

**Females:** If a breeding, pregnant or lactating female is being sold, it most probably has problems. Remember that a female may still be a heifer because it is sterile. All four quarters of the udder should be well developed, distinct and evenly spaced. The teat should be large. If the animal is lactating, milk it yourself or ask the owner to do it. Check whether she is pregnant (when approached by a bull or a man, if it lifts its tail, it is considered pregnant). Ask how many calves it has delivered, and check against the animal’s age.

**Males:** The scrotum should be well developed and penis very long. The penis and testicles should not be injured or swollen. Ask to see any offspring the bull has sired.

**Calves:** Try to see the mother and father of the calves, if possible.

Q. Discuss the normal conformation of male/female camel.

A clearcut sexual dimorphism can generally be observed in camels. The male camel is usually taller and of heavier built than the female. The whiskers tend to be longer, the tushes more pronounced and in general there is a better overall muscle development. In geldings castrated before 3 years of age, the sexual dimorphism is less distinct. They attain full height but are of light built, the voice is more high pitched, the preputial sheath is reduced in size and dulaa (soft palate) cannot be inflated. The earlier the castration is done, the more pronounced are its effects on male camel. Conformation usually varies according to production type or the geographical habitat. Draught animal, milch type, meat and racing or riding camels are the usually recognized types in *Camelus dromedarius*.

Certain important conformation characteristics of the dromedary are: well developed prominent forequarters, being higher than the weak appearing hindquarters. Joint angulation is wider in the forequarters compared to the hindquarters, therefore front legs appear straighter and more in line. The elbows are clear of the body. A prominently
arched back is followed by a 15 to 20 degree horizontally inclined short loin. The rump is also quite short with an excessive downward inclination of 45 to 50 degrees from the horizontal plane resulting in a so called goose rump. Setting of the longer and wider feet in the front is square and even. Rear feet are slightly camped under and turned outward.

Q. Give below a detailed account of conformation faults that are commonly observed in one-humped camel.

Angular deformities of the skeleton, especially of the limbs, are one of the most commonly observed conformation faults in the camel. These are frequently seen in very young calves. Hyperflexion of the fetlock (caused by extreme contraction of the flexor tendons), undershot knees and lateral deviations of the carpal joints in newborn calves are often of temporary nature. These conditions resolve without treatment within 3 to 4 months of birth. Schematic presentations of correct and faulty positions of the pectoral limb in lateral view have been shown in Figure 3.

The normal position is the straight or post leg. Angular deformities of the fetlock cause some discomfort to the animal and predispose to lameness. Camped front limbs, either forward or behind, might be symptoms of acute painful conditions of the abdomen or chest or may be an indication of wounds of the foot, particularly injured sole. Figure 4 shows a schematic presentation of normal and faulty position of pelvic limb of the camel in lateral view. The straight leg and the leg camped behind both are considered normal, if however, the hind leg is camped forward, it is often an indication of an acute, painful inflammation in the abdomen.

Pigeon toes, splayed fetlock and brushing knees (Figures 5 and 6) are conformational faults of limbs commonly seen in large sized and heavy camels living in hilly areas. Malformation can predispose to other joint problems and lameness. Affected animals rarely show a good working performance. Camel pastoralists often try to treat these conditions by branding the affected joints. Occasional success is achieved in young still growing animals. In mature animals the condition cannot be corrected. The formation of a narrow chest in camel can be related to nutritional deficiencies during the early postnatal growth stages. This condition can predispose to other problems such as brushing elbows or brushing pedestal. Constant friction can lead to painful skin lesions and excessive scar tissue growth of the irritated area. Working ability can be severely impaired.

Q. What may be considered as a desirable udder conformation in camel? Also pinpoint important faults.

Just like in dairy cows and buffaloes, a desirable conformation of the udder is of great importance in camels. The camel’s udder resembles closely to those of cow and buffalo. A desirable udder conformation in camels should include all characteristics, which are desirable in cows and buffaloes when milking by hand. The udder should be spongy, quarters well and evenly developed, the teats large, distinct and squarely placed. Spacing of teats is an important characteristic, since both milker and calf usually need access to the udder at the same time. Some of the common faults in udder conformation are: small udder, large but meaty udder, half of the udder deformed, teats small, teats fused at the
base with no clear distinction between two teat bodies and supernumerary teats. Insufficiently spaced teats become a predisposing source of infection from one quarter of the udder to the adjacent one. Small teats are difficult to milk.

Q. **Write an essay on life span of the camel and camel mortality, indicating the stages of life when they are more prone to it.**

Some authorities claim that the average life expectancy is 20 years. In Australia, a study of feral camels established a figure of 30 years. However, there are people who declare that camels live up to 50 years. This may be true in some individual cases, but the mean age is unlikely to be as much. The literature appears to support a range of 20 to 35 years, being representative of a large majority of the camel population. Depending upon the continuous work intensity, the camel’s working life can reasonably be expected to be 12 to 20 years. The best years of an animal’s life in heavy baggage and transport work appear to be from age 6 to 20 years. There are reports from the UAE of good camels winning races at 17 years age. Some authorities claim that breeding life of the camel concludes at age 20. This figure appears to hold good for most males, but the Australian feral camel study found females still breeding at age 30 years (Manefield and Tinson, 1997).

Apart from generally known causes of mortality such as starvation, malnutrition, fatal injuries and diseases, there is an age specific mortality in all species, which is high during post-natal and post-weaning stages. It falls to a minimum in the cohort of 4 to 12 year old, increasing again with higher age and reaching 100% at approximately 25 to 28 years. Whatever the causes of mortality, herd growth and productivity are adversely affected. The age specific mortality can be reduced by nutrient supply, better management practices and preventive measures against diseases. In particular, calf mortality is in most cases due to or related to malnutrition or starvation, even if actual mortality causes are diseases or parasitism. A whole range of interventions is conceivable which would have a good chance of significantly reducing early mortality. However, tolerating high male calf mortality in certain areas, can be a conscious management decision which is economically sound if the production target is milk and the demand for males for slaughter, work, breeding or racing is low.

Q. **Does there exist any dominance hierarchy in camels?**

Because of their tendency to be rather widely scattered and their habit of moving relatively quickly from one feeding point to another, camels are more demanding of their herdsmen than are other domestic animals. This situation is perhaps exacerbated as camels do not form kinship groups and there is no stable leadership, although there is a dominance hierarchy in the order of adult males > females and bachelor males > subadults > calves, so the variable subunits add further to the herdsmen’s work load. Many camel-owning groups have thus adopted a tactic of riding one of the camels in the herd in order to better control the group as a whole. In Cholistan desert (Pakistan), large herds of free-ranging camels are seen and mostly they are not tended by any body except at milking time. Each herd has its own brand mark. Since Cholistan is mostly a state
owned large desert tract, grazing of camels, cows, sheep and goats is allowed in exchange of very nominal charges per animal/year. However, where land is owned by various tribes and big landlords, tending of animals becomes necessary whether on foot or on camel back.

**Note:** Figures relevant to each chapter are given at its end.
Fig. 1. Body points of camel
Fig. 2. Skeleton of camel
Fig. 3. Schematic presentation of normal and faulty position of the pectoral limb of camels in lateral view: A = normal (straight or post leg); B = contracted flexor tendons of fetlock; C = calf knee; D = hyperextension of fetlock; E = camped behind; F = camped forward; I = scapula; II = humerus; III = radius/ulna; IV = metacarpal bone; V = digital bones

Fig. 4. Schematic presentation of normal and faulty position of the pelvic limb of camels in lateral view: A = normal (straight); B = camped behind; C = camped forward; I = pelvis; II = femur; III = tibia; IV = metatarsal bone; V = digital bones
Part – I  Production and Management of Camels

Fig. 5. Schematic presentation of normal and faulty position of the pectoral limbs of camels in frontal view: A = normal; B = carpal valgus (predisposition to C) C = angular deformity of the fetlock (splayed); I = scapula; II = humerus; III = radius/ulna; IV = metacarpal bone; V = digital bones

Fig. 6. Schematic presentation of normal and faulty position of the pectoral limbs of camels in frontal view: D = narrow chest (predisposition to brushing elbow and brushing pedestal; E = angular deformity of the fetlock (pigeon toes) I = scapula; II = humerus; III = radius/ulna; IV = metacarpal bone; V = digital bones
BREEDS AND TYPES

Q. Discuss new trends in classification of camel breeds.
According to conventional categorization, camels are placed in four classes such as beef, dairy, dual purpose and racing. There appears little justification for such classification at present, because except in experimental lots, no camels are reared primarily as meat producers; racing camels do not constitute separate breeds, rather are selected from within existing populations only after they have shown a particular aptitude for speed and so on.

It was once said that no true breeds could be recognized and camels were named after the tribes that breed them and that types could often be identified with their help. Modern classifications have advanced little beyond these concepts, because little attempt has been made to assign the quantitative production parameters that are now so important in other species for the breed description. One such quantitative approach uses six morphological and biological characteristics such as habitat, function and geographical distribution, physical size based on linear measurements, ease of milking and rapidity of weight gain as parameters in the breed description. In Saudi Arabia, the most commonly used classification is based on colour. The relative proportion of colour varies from region to region depending on the selection process but it is not yet clear whether there are production differences between or among the colour types. In the former Soviet Union, all one-humped camels are of the Arvana breed. Three main types of Bactrian camels are also recognized in the former Soviet Union: Kalmyk, Kazakh and Mongolian.

Q. Do there exist precisely different specialized types of one-humped 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 as a secondary or tertiary product. Capital accumulation and security functions are also of considerable importance for camel-owning groups. Largely as a result of the nomadic way of life there has been relatively little differentiation into specialized types in the camels. The lack of specialization can be attributed to the uniformly harsh conditions in which camels are bred and reared. Thus there owners require them to be multipurpose. However, a sort of specialization that has occurred is in the dichotomy of riding and pack types, both within the overall transport function.

Q. Do there exist pure breeds of camel? Discuss in detail.
Over the last so many centuries no organised efforts seem to have been made for planned breeding of camels to create pure breeds with specific purposes as do exist in buffaloes, cattle, goats, sheep and horses. No breed societies concerning camels exist. No doubt people interested in camels within their own regions, over long periods of time, selected for traits which make the camel most suited for work in that area. Some camel owning groups possessed extraordinary skill and they were able to fix the type. Such animals were then termed a ‘breed’, which in reality was not a breed. The development of a breed(s) is a slow and discouraging process, especially in camels, since the culling rate essentially required for rapid genetic progress is difficult to achieve in camel. The amount...
of nutrients required for full expression of genetic potential may not be available. Necessary economic stimulus has been lacking. The camel has a relatively long (on average 5 years) generation time. Its reproduction rate is low. Neonatal mortality in many areas and situations is between 30 and 50%. A further constraint has been the necessity to integrate camel management with that of cattle, goats and sheep on the same range. Selection for speed as is being practised by wealthy people with large herds in the UAE, Qatar and other camel racing countries is possibly the one contemporary exception to highly organized breeding. It has been demonstrated that, given sufficient financial support, it is possible to markedly reduce the constraints of low fertility and rearing difficulty in camels.

While it is arguably true that no pure breeds exist, camel types have evolved through time and expediency. In some areas the business of transportation has provided stimulus to select for superior performance in a certain terrain. Breeding has then proceeded within these groups on a ‘like begets like’ basis. Topography has a definite influence on type. Mountain and lowland types exist. Lowland types can be further divided into riverine and desert types. Riverine types are tall strong animals employed for draught and baggage work. Representatives can be seen in Punjab and Sindh areas of Pakistan and Nile delta. Baggage and riding types are represented among the desert camels. The real speedsters of the camel world are desert bred. The light coloured animals of the Sudan are especially valued for their speed. Whether the present breed situation will change in time remains to be seen. Undoubtedly enough variation exists in mature body weight, conformational characteristics, working ability and production potential to make genetic improvement possible. The use of such technology as multiple ovulation, embryo transfer (MOET), can speed up the expression of genetic superiority. Improved husbandry practices and health cover can reduce calf mortality. Breeds suitable for specific purposes and regions could now be developed if the necessary economic stimulus is available.

Recent DNA studies suggest that the basis of breeds may already exist. What selection has been done, has quite likely established heritable genetic patterns. On the basis of colour this seems reasonable, with the pied camels of Mauritania, the pale camels of Sudan and some black strains in Saudi Arabia being examples. The Mauritanian camels have blue eyes.

Q. **How many camel breeds are there in Pakistan? Give a provincewise list of such breeds.**

Precise information about the camel breeds in Pakistan is not available. In fact the camel has so far not attracted the attention of planners and policy makers in this country. Its importance and potential as a milk and meat producing animal has neither been realised nor its role in agrarian economy has been properly assessed. Moreover, export potential of this species has also not been visualized. The camel appears to be a victim of intentional neglect as if it is an unwanted animal. Probably, none of the teaching institutions in Pakistan offering degrees in animal science ever included in their curriculum a teaching course on camel. However, very recently, the University of
Agriculture, Faisalabad, has taken lead and has included the camel in the teaching courses for the degree of B.Sc. (Hons.) Animal Husbandry.

In spite of an all out neglect, the camel as a farm animal and as an economic entity has not only survived but has also exhibited a steady growth in its population. This fact itself speaks of the importance of camel. A large number of Asian and African countries and Australia have shown growing interest in improvement and development of the dromedary. Investigations to effect improvement in various aspects of reproduction and production of the camel are underway in so many countries. In UAE, Qatar and other neighbouring states, development of racing and riding camels has assumed the proportion of an industry. In India, an independent camel breeding farm is functioning. In addition, a National Institute of Camel Research is operating there since long. The literature on various aspects of health and husbandry of camel is flooded with the names of Indian workers, whereas in Pakistan only a few studies on milk production, blood picture, some diseases and reproductive behaviour of the camel have been undertaken during the last decade or so.

Countries like Saudi Arabia and may be some others, are importing camels from Australia. We wish that our policy makers and the L. & D.D. Departments in various provinces of the country could do some serious thinking about the matter. Of course, camels in small numbers are exported from Pakistan too.

The only well documented information available about the camel breeds in Pakistan is by Isani and Baloch (2000). They have listed twenty breeds of camel in addition to some information about the Bactrian camel. The characteristics of some of the breeds are so much overlapping that it may be safely stated that there are more names than real breeds of the camel. In other words, except some very distinct breeds, the same type of animals found in contiguous regions of the country are claimed as different breeds, which in many cases, at best, may be termed as varying strains and not breeds. Isani and Baloch (2000) have rightly suggested that there are so many gaps in our knowledge in this regard, therefore further detailed studies might bring more facts to surface.

On the basis of information as mentioned above, the province wise list of the camel breeds is as follows:

**Balochistan:** Brahvi, Kachhi, Kharani, Lassi, Makrani, Pishin and Rodbari

**NWFP:** Gaddi, Ghulmani, Khader and Maya

**Punjab:** Bagri (Booja), Brela (Thalocha), Campbelpuri, Kala-Chitta, and Marecha

**Sindh:** Dhatti, Kharai, Larri (Sindhi) and Sakrai

Q. Give salient characteristics and brief description of various camel breeds found in Pakistan.

<table>
<thead>
<tr>
<th>Breeds of Balochistan</th>
<th>Weight (kg)</th>
<th>Milk yield (litres)</th>
<th>Lactation length (days)</th>
<th>Hair yield (kg)</th>
<th>General description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brahvi</td>
<td>Birth: 48</td>
<td>Weaning: 98</td>
<td>Adult: 692</td>
<td>1620</td>
<td>587</td>
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Bakhat Baidar Khan, Arshad Iqbal and Muhammad Riaz  
University of Agriculture, Faisalabad.
### Breeds of Balochistan

<table>
<thead>
<tr>
<th>Name</th>
<th>Habitat</th>
<th>Colour</th>
<th>Weight (kg)</th>
<th>General description</th>
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<tbody>
<tr>
<td><strong>Lassi</strong></td>
<td>Lasbella and adjoining areas of Balochistan and Sindh</td>
<td>Fawn with reddish tinge, dark red hair cover hump, shoulder and part of the belly</td>
<td>Birth: 39, Wean: 65, Adult: 550</td>
<td>Medium sized, muzzle pointed with a longer face, dual purpose animal used for riding and carrying baggage, age at 1st breeding 3.7 years. Since hometract is Lasbella, hence the breed named as Lassi.</td>
</tr>
<tr>
<td><strong>Makrani</strong></td>
<td>Makran, Kharan, Lasbella, parts of Jhalawan and in some parts of Dadu &amp; Karachi</td>
<td>The strain found in coastal areas of Karachi and Makran is light brown being darker over neck and flanks: The Jabilu strain is brown to dark brown, fawn coloured animals also seen</td>
<td>Birth: 46, Wean: 80, Adult: 677</td>
<td>The animals found in coastal areas are comparatively slim and smaller. The Jabilu type (mountainous) have long hair and comparatively stout built up, short neck, medium hump mostly soft footed; Jabilu variety has hair with black tinge on neck, flank region and legs above knees and hocks, Makrani camels are baggage type, if properly fed females are fairly good milk producers, age at 1st breeding on average is about 4 years.</td>
</tr>
<tr>
<td><strong>Pishin</strong></td>
<td>Pishin, Quetta and adjoining areas</td>
<td>Light brown to dark brown</td>
<td>Birth: 49, Wean: 98, Adult: 702</td>
<td>Pishin camels are baggage type and carry heavy loads, comparatively short stunted, very sturdy, perform well both in hilly and sandy areas, cream coloured animals considered inferior, age at 1st breeding about 4 years.</td>
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</table>
### Production and Management of Camels

<table>
<thead>
<tr>
<th>Name</th>
<th>Habitat</th>
<th>Colour</th>
<th>Birth</th>
<th>Weaning</th>
<th>Adult</th>
<th>Milk yield (litres)</th>
<th>Lactation length (days)</th>
<th>Calving interval</th>
<th>General description</th>
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<tbody>
<tr>
<td>Rodbari</td>
<td>Makran coastal range, Pasni, Turbat, area around Gwader, extending to Panjgur and part of Khuzdar</td>
<td>Dirty grey to light red</td>
<td>49</td>
<td>118</td>
<td>707</td>
<td>1693</td>
<td>467</td>
<td>3.0</td>
<td>Baggage type, comparatively slim body, short neck, part of neck that joins head and body including hump are covered with dense growth of hair, used for lifting water from deep wells, age at 1st breeding about 3 years.</td>
</tr>
<tr>
<td>Lucky Marwat</td>
<td>part of Waziristan Agency and D.I. Khan</td>
<td>Creamy white</td>
<td>41</td>
<td>70</td>
<td>589</td>
<td>1310</td>
<td>315</td>
<td>2.0</td>
<td>Baggage type, also used for draught purposes, tall, well built, strong and massive legs with good stamina to work. It is considered by some a crossbred animal. Age at 1st breeding over 3 years, calving interval 736 days.</td>
</tr>
<tr>
<td>Dera Ismail Khan</td>
<td>also found in D.G. Khan and Zhobe area</td>
<td>Mostly white, white coloured</td>
<td>50</td>
<td>125</td>
<td>738</td>
<td>2041</td>
<td>538</td>
<td>803</td>
<td>Tall, sturdy, baggage type camel, broad forehead, shallow depression in the middle of bridge of nose, lips large, lower part of the head and the adjoining lower part of the neck covered with dense hair, good stamina to work, also well adapted to work in forest area, hair yield 1.7 kg.</td>
</tr>
<tr>
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</tr>
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</table>

### General description

- **Name**: Rodbari, Lucky Marwat, Dera Ismail Khan
- **Habitat**: Makran coastal range, Pasni, Turbat, area around Gwader, extending to Panjgur and part of Khuzdar; part of Waziristan Agency and D.I. Khan; Dera Ismail Khan, also found in D.G. Khan and Zhobe area
- **Colour**: Dirty grey to light red, Creamy white, Mostly white, white coloured
- **Birth**: 49, 41, 50
- **Weaning**: 118, 70, 125
- **Adult**: 707, 589, 738
- **Milk yield (litres)**: 1693, 1310, 2041
- **Lactation length (days)**: 467, 315, 538
- **Calving interval**: 3.0, 2.0, 803
- **Weight (kg)**: 671, 450, 1519
- **General description**

- **Rodbari**: A long legged slim breed, neck short, dorsal and ventral surfaces of the body run almost parallel and the body looks like a barrel, hump is small and placed right in the middle of nearly a straight back, primarily a baggage breed, hair yield 2 kg.
- **Lucky Marwat**: Dark brown to blackish
- **Dera Ismail Khan**: Its general look is that of a Bactrian camel, neck short, well built and sturdy, dark brown long hair form mane as well as present on lower side of neck, throat, flanks and hump; long eye lashes and long hair in the ears, primarily a baggage camel, but also used for riding in rugged mountainous areas, hair yield 4.4 kg, because of its good speed it is locally named as
<table>
<thead>
<tr>
<th>Variety</th>
<th>Habitat</th>
<th>Colour</th>
<th>Birth</th>
<th>Weaning</th>
<th>Adult</th>
<th>Milk yield (litres)</th>
<th>Lactation length (days)</th>
<th>Calving interval (days)</th>
<th>General description</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Maya’.</td>
<td>Pothowar plateau including Attock, Chakwal, Rawalpindi Jehlum and parts of Sargodha and Mianwali</td>
<td>Fawn</td>
<td>54</td>
<td>129</td>
<td>741</td>
<td>1660</td>
<td>553</td>
<td>812</td>
<td>Primarily a draught breed, occasionally used for riding, mostly heavy weight animals, large head, short neck, dense growth of brown hair on throat, upper half of neck and hump, muscular legs, ears small, age at 1st breeding 3 years, hair yield about 3 kg.</td>
</tr>
<tr>
<td></td>
<td>Pabbi, Kala-Chitta range, Sohawa and Salt Range</td>
<td>Mostly creamy, but animals with darker shades also seen</td>
<td>48</td>
<td>90</td>
<td>691</td>
<td>1496</td>
<td>310</td>
<td>820</td>
<td>A fine baggage type camel, adapted to work in rugged hilly areas, comparatively heavy breed, neck is massive with its three-quarter part covered with dark brown hair, ears a bit longer, hump well developed with a steep slope to the rump region, its home tract almost coincides with that of Dhanni cattle, age at 1st breeding about three and a half years, hair yield about 2 kg.</td>
</tr>
<tr>
<td></td>
<td>Cholistan desert and adjoining irrigated areas, some specimens also seen in D.I. Khan and surrounding areas</td>
<td>Chestnut to blackish shades, other shades also seen</td>
<td>43</td>
<td>75</td>
<td>637</td>
<td>4180</td>
<td>429</td>
<td>748</td>
<td>Marecha camel serves dual purpose, riding and baggage, females are good milkers, they have medium head with a pointed muzzle, body in general not massive, legs long, hump well developed, neck comparatively long, age at 1st breeding is more than three and a half years, hair yield 2 to 2.5 kg.</td>
</tr>
<tr>
<td></td>
<td>Cholistan and Thal deserts</td>
<td>Fawn is the favourite colour, brown and white shades also seen</td>
<td>44</td>
<td>75</td>
<td>656</td>
<td>2056</td>
<td>565</td>
<td>752</td>
<td>Good riding and racing animals, have lean body structure, mainly desert animals but when kept in irrigated areas they become heavy weight, their gait very smooth, without jerks, males trained for dancing and acrobatics fetch high prices, females good milkers, one strain of Bagries called Rojhan is found in Multan and D.G. Khan, age at first breeding is a little more</td>
</tr>
</tbody>
</table>
### Breeds of Sindh

<table>
<thead>
<tr>
<th>Name</th>
<th>Habitat</th>
<th>Colour</th>
<th>Weight (kg)</th>
<th>General description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dhatti (Thari)</td>
<td>Dhatt area in Tharparkar, also found in Mirpurkhas, Umerkot, Sanghar and Badin</td>
<td>Light to dark fawn</td>
<td>40 65 570</td>
<td>Excellent riding and racing camel, well adapted to travel fast on sandy soil, easily trained for dancing and to perform acrobatics; Dhatti a typical desert camel, has a slim body and long legs, head small and well carried, belly appears tucked up; belly, head and portion of the neck close to head covered with bushy hair; age at 1st breeding over 3 years, hair yield 2.5 kg, home tract Dhatt, hence breed named Dhatti.</td>
</tr>
<tr>
<td>Kharai</td>
<td>Kharo Chhan and Chohar Jamali, also found in coastal parts of Karachi, Thatta, Badin and parts of Kacch</td>
<td>Dark brown to black</td>
<td>43 70 602</td>
<td>Kharaies are medium sized, neck and legs comparatively thinner, hump well developed, long black hair in ears, body surface is covered with curly brown or black hair, used mainly for riding and traction of load, they provide riding entertainment to visitors at Karachi beaches, age at 1st breeding three and a half years, hair yield over 3 kg.</td>
</tr>
<tr>
<td>Sakrai</td>
<td>Mirpur Sakro to Sujawal Tallukas of Thatta district</td>
<td>Reddish brown, neck more darker</td>
<td>41 68 571</td>
<td>Sakrai serve as baggage animals as well as for riding. They are not as good for riding, medium sized animals, short hair coat, hump comparatively well developed. They also provide riding entertainment at Karachi beaches, age at 1st breeding about three and a half years, hair yield 2 kg.</td>
</tr>
<tr>
<td>Larri</td>
<td>In and around Hyderabad and Badin, found on both banks of river</td>
<td>Dark fawn to dark brown</td>
<td>58 14 5</td>
<td>Larries are riverine camels, good baggage and draught animals, heavy weight with massive body frame, head large with a prominent</td>
</tr>
</tbody>
</table>
Indus, found in most parts of Sindh

<table>
<thead>
<tr>
<th>Name</th>
<th>Habitat</th>
<th>General description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sindhi</td>
<td>Indus, parts of Jhang, Multan, Muzaffargarh, Mianwali including Thal area</td>
<td>Mainly found in riverine and irrigated tracts, big, tall and strong body with a massive head and neck, muscular legs, broad chest, well developed hump, somewhat hanging lips, good baggage animals, a section of people raises them as fighting animals and earn a lot of money, age at 1st breeding 3 years, hair yield about 2.5 kg.</td>
</tr>
</tbody>
</table>

**Q. Give a detailed account of baggage or pack camels.**

‘Baggage’ is the preferred term for camels since the word ‘pack’ is mostly used for horses and mules. The camels that carry goods on their back are called ‘baggage camels’. They are usually heavier in structure than the riding type. Heavier muscling, particularly in the hindquarters, signifies a better ability to stand up with the load (Figure 7). Good general conformation is desirable. Baggage camels, as implied by their main function, have slower speed than the riding camels. In many situations it may be advantageous if the baggage camel can also be ridden, usually as a part of the total load. Therefore, the more comfortable, better going camels are preferably selected for this dual role. Larger feet may be desirable to spread the base of support and reduce the foot/ground pressure per unit area. Castrated animals are the first choice for commercial caravans. Animals of about 650 kg liveweight are considered ideal. Lighter animals must be loaded more lightly.

For almost continuous work, a load equal to one-third and not more than one-half of the camel’s body weight is compatible with continuing good health and performance. With this load the camel comfortably can cover 30 km/day. The load is determined not only by the age, sex and stature of the animal, but also by the terrain to be traversed, the season, the availability of feed and water during the journey and its duration. Overloaded and/or overdriven camels lose body weight and become progressively weaker, despite being...
well fed. A general rule to prepare a work schedule is that the camel should be allowed one day of rest for each day worked, but the rest period may be allowed after a work period of several days. Preferably, the rest be allowed in a favourable area. The working day should be restricted to about 8 hours. The camel being a ruminant needs ample time to eat and ruminate. A caravan incharge who knows the route will preplan his stops accordingly at favourable campsites.

Loading the camels should commence early morning and have them moving as early as visibility permits. In real hot climates, the march should stop at mid morning, the loads removed and, if possible, the camels allowed to browse. During this break the saddles may not be removed, but at least once daily the saddles should be removed and the camels examined for any problems, which might lead to abrasion or pressure necrosis of the skin. Overloading, overdriving and ill-fitting saddles adversely affect the animals making them ulcerated, thin with bony points more prominent at the end of a long journey. The march is restarted after mid afternoon. Where terrain and visibility permit, night travel may be favoured because it avoids the heat of the day and keeps the camels warm during the cooler hours. One man can without much difficulty control at least five camels, the total transported per man may be equal to that of a small truck. This means that in a country where the roads are poor to non-existent, the baggage camel may be the transport of choice.

Loading of the camel is best accomplished with the animal in sternal recumbency and, unless it is a fully trusted animal, the front legs tied in flexion by a rope over the neck or the halter held by an assistant. Packsaddle design varies a great deal in different regions. The loader should always make sure that the saddle is adequately padded to prevent skin abrasion, that the load is evenly distributed on each side and that the load is kept clear of the hump. When the camel is standing after loading, girths may be tight enough to just permit passage of the hand. No part of the load should restrict freedom of limb movement. Over tightening of the flank girth, either per se or as a result of load slippage, can damage the penis and urethra of male camels.

Conditioning of working camels—baggage, draught and riding—is important. Ideally, this means gradually increasing the load and distance traveled from half to full over a period of 8 to 10 weeks. This will benefit musculoskeletal system as well as the skin which will become tough at the load bearing points and more resistant to saddle sores. Fully loaded, unconditioned camels and those overloaded, are likely to have difficulty lifting the load and are subject to tearing of the muscular attachments of the forelimb. Long camel trips or continuous daily work should be planned on the basis of a loaded camel travelling 15 km/day (30 km travel and one rest day). They can be pushed a lot harder, but their body condition will not hold up, their resistance to disease will be diminished and their working life would be shortened. Well managed camels involved in baggage and transport work are expected to have normal working life from age 6 to age 20 years.

Q. Write a note on draught camels.

There are many countries in Africa and a few in Asia where even today the camel provides power for wheeled transport, tilling of agricultural land, grain grinding machines, for oil extraction devices, cane crushers and for drawing water from wells.
Castrated males of a heavy build are preferred but all types and even females are used. The camel is roughly comparable to the light draught horse in power output but staminawise the camel far exceeds the horse. The camel can be harnessed to two or four wheeled vehicles. Large teams were once used to pull wagon loads of wool in outback Australia. One example is that of a transporter in Australia who regularly hauled 14 tons of wool with a 14 camel team. Daily stages of 30 km with the loaded wagon and 45 km with the empty wagon were common for Australian team. May be the camels were changed along the way on long journeys and/or suitably rested at the end of each trip. It is a general rule that one day of rest should be provided to the camel for each day of heavy work, but not necessarily day by day. Perhaps work a week and then some days spelled. Otherwise the animals lose body condition and general health and resistance declines.

The draught camel drawing a wheeled vehicle has the advantage that it is not constantly supporting a heavy load against a gravitational pull. Once the load is rolling over the firm ground, the tractive effort is minimal on level going and almost nothing on a downgrade. Big effort is only required to start or make the load moving and on upgrades. In fact many camels are renowned for dead pull ability. They have been used to extricate stuck up motor vehicles.

For ploughing the camel can be used singly, in pairs and even yoked together with a different species. The stature and morphology of the camel requires a relatively high point of draught and, unless the traces are relatively long, there is tendency for the plough to lift. Possibly a camel of heavy build but short in legs should be selected for tillage work. Otherwise the distance of the camel in front of the ploughman may require the camel being led by another person. Six to eight hours of work per day is reasonable. Since ploughing usually is a seasonal work, therefore rest for the camel is not a problem. Off season provides ample time for rest and recuperation. One really good camel can plough 1 hectare of medium resistance land in 20 hours working 7 to 8 hours/day. In any form of draught work, particularly when ploughing, it is important that the harness is properly designed to suit the animal’s morphology. Otherwise up to 50% of the animal’s effort may be lost.

Q. What do you understand by the term ‘downer camels’. Give the causes along with a suitable treatment.

Camels that are unable to rise to a standing position are called downer camels. There may be a variety of reasons for this problem such as damage to muscles, bones and nerves. Metabolic and some severe infectious diseases may also result into this type of inability. Severe pelvic fracture, hind leg long bone fracture, broken back, spinal injury and infections and abscesses, plant poisoning, snake bite, tick paralysis and epidural anaesthetic overdose all cause this inability. In addition, some camels conditioned by bad training learn that they can evade the handler’s intentions by merely getting down and refusing to rise to standing position. It is, however, necessary to be sure that there is no other reason for the continued recumbency before using force to induce the camel to rise. Pain and inflammation is often at least part of the reason for the camel’s involuntary recumbency. Therefore, early use of antiinflammatory drugs e.g. Finadyne, Dexatemonol and corticosteroids (Dexone-5) can be of benefit. As soon as the primary cause of
recumbency is determined, its treatment must be pursued with vigour. A debate exists as to the value of using slings to get the camel off the ground, as against allowing it to be recumbent until it either recovers or is deemed to be a hopeless case. However, over the time it is necessary that these animals are assisted to stand at least twice in 24 hours and given support for some time to watch whether they have gained stability. It is important that these animals be fed a sound nourishing diet so that their strength may be maintained.

Q. Give a full length description of conformation of riding camels.
Riding camels should have a well-balanced conformation so that both the rider and the camel are comfortable at the faster gaits. They are finer boned and more agile than the heavier baggage and draught camels. The feet should be of medium size, but large enough to support the weight of the camel and rider and small enough to be consistent with agility. The forefeet should face forward while the hind may toe out slightly. The sole pads should be tough, yet pliable and evenly worn. The forelimbs should be well muscled, long and straight and, while closer together than in the heavier types of camels, the elbows must not brush the pedestal. The hind legs should be long, nearly straight to quite straight and free from sickle hocks and bowing. The croup should slope anteriorly up at 45-55 degree. The thigh and gluteal muscles, although small in camels and more so in riding camels, yet be well formed.
The head should be smallish, fine and neat, with large prominent eyes. The head carriage should be such that the anterior facial plane is almost parallel to the ground. The neck should show good muscling without coarseness. It should have a low body attachment and extend forward horizontally for almost half of its length before sweeping vertically upward. The body should show good chest capacity. The flanks should be short and the abdomen small but well rounded.
The description given above should not be interpreted to mean that animals lacking all the above features cannot be ridden. Any camel can be trained to be a riding camel. However, animals with less desirable conformation are usually less comfortable and tiring to both the rider and themselves, especially over long journeys.
Military protocol and records provide the best insight into the capabilities of the riding camel. The load includes rider, saddle, arms, and personal gear for army camels, which together make about 160 kg. The standard daily patrol for Egyptian Army camels was 40 to 50 km, Australian Camel Corps 55 km for 5 days and Indian Army camels 50 to 60 km/day. In Sudan, 60 km/day for 5 days and the same is for Rangers Camel Corps in Pakistan. For long and/or stressful journeys the camels must be conditioned first, commencing with some half distance, half speed work and should be gradually built up to the required performance over a period of several weeks.
The center of gravity of the camel is said to be about 15 cm above and behind the elbow. Therefore, for long journeys it is preferable for the rider’s position to be in front of the hump. This position affords better control over the camel. For racing and the training of novice riders, a position behind the hump is preferred since it gives the rider a definite sense of security. In an emergency he can grasp the hair on the top or sides of the hump (Manefield and Tinson, 1997).
Q. Are riding and racing camels much different conformationwise? Give an outline of selection, training and management of racing camels.

Conformationwise racing camels are not much different from real riding type of camels. As a matter of fact racing camels emerge from fine and faster groups of riding camels. It is their training that helps them develop into racing camels. The fastest of them appear to have developed in Sudan, where racing as a sport also occurs since long. Camel racing has probably been going on since the animal was first employed for riding. As a highly organized sport on specially prepared tracks, with rules governing participation and conduct, it has only been going on for the last two and a half decades. Royal sheikhs and other wealthy people have set up breeding centers, some using sophisticated artificial breeding methods, to speed up the reproductive rate of their best camels and increase the likelihood of producing champions.

Although seemingly the camel does not appear to be a trainable animal, yet training must be undertaken to condition all the body systems to withstand the physical, physiological and psychological stresses involved. The intensity of competition dictates that every possible advantage must be exercised since races may be won or lost by a few centimetres. In the Arabian states, seasonal training commences in July/August with long training walk/jogs (gradually increasing to 20 km) in the early cooler hours of the morning. Practice conditioning races commencing at 2 and working up to 4 km are held regularly in September on country tracks. These tracks are generally straight raceways fenced with a top rail of water piping and a couple of plain wires. Gradually the camels are jogged and raced into fitness to race longer distances. In the UAE, racing on the main tracks commences sometime in October and runs through early April. In fact, there is some racing activity year round, while the already trained racing camels are resting from May to August, the new 2 year old crop is being trained and tested in the early hours of morning.

Segregation of competitor camels is made first on the basis of purebred local, crossbred Sudani and pure Sudani. They are further subdivided to run in age groups of 3 to 4 years, 4 to 5, 5 to 6 and over 6 years. The criterion for age is tooth eruption. Serious racing commences at the distance of 5 km. As the season progresses, most of the races are held over 8 km. Tracks are so constructed as to provide the distance with one circuit. Over an 8 to 10 km distance the camels may get quite a long way away from the spectators. To compensate for this the grandstands are equipped with television sets. Race times do vary from track to track. For 5 km a very good time is under 8 min 30 sec, for 6 km under 10 min. For 8 km the best time is between 13 and 14 min, but camels running under 14 min 20 sec may win some races. For 10 km the best times are under 18 min, but 18 min 20 sec can still win some races. For a detailed account of training racing camels, you are referred to Manefield and Tinson (1997).

To be able to select superior racing camels at an early stage of their career, three scientific criteria are suggested. It has been demonstrated that camels that have exhibited superior racing performance have had larger maximum oxygen uptake capacity ($VO_{2\text{max}}$) than individuals with poor performance. It is an inherited trait and no training method seems to modify it. Better camels have a $VO_{2\text{max}}$ close to 60 ml/kg/min, while poorer
performers may be in the 40 to 50 range. The same superior camels have also been shown to generate less plasma lactate when they are exercised at a given intensity (velocity and time) on a treadmill at a sub-maximal level. Tests for this trait would be best performed up to a 5% slope. Also, superior camels have a greater stride length, both pacing and galloping. This is also probably an inherited characteristic. A study showed that the fastest camels had the longest stride length and the lowest stride frequency. The fastest camel had a stride length of 5.6 m and a stride frequency of 1.64/sec at 32.5 km/hour. Such assessments can be made by using a treadmill. For VO$_2$max any workable system that can be used for the horse, should be adequate for the camel. The design and fitting of the mask is important, especially for the closed system where an airtight fit is required.

**Management:** For the purposes of management, racing camels are generally kept in camp groups of 25-50 animals almost throughout the year. Basic training of new young camels commences in special camps at about 12 months of age. After this they are tried as racing camels and only the swiftest find their way into a racing camp at about 2 years age. During the racing season, the camps are usually centralized near the race tracks, forming large communities of camps with thousands of racing camels. During the resting (hot) season, the camps generally disperse from the central location to some favoured area where the camels may be allowed free ranging during the day. These areas are also chosen for their relative freedom from worrying insects and disease occurrence. Each camp is self sufficient in having all necessary personnel, a water tank, a vehicle to transport fodder. Some groups may have access to a purpose built training swimming pool and a treadmill. Each camp is under the control of a head trainer whose assistants are responsible for timely feeding, exercise and continuous care of the animals.

Until a few years ago, all camels were tethered to a buried object within their camps, with front leg hobbled with a rope. This method is still used for many young camels. Now portable pens constructed from steel piping are becoming popular. They are so constructed as to pin together to form small pens or large yards. Some people do provide permanent stabling for their animals. They are usually runs of 4x4 meter pens under a gable roof. Height at the ridge is about 4 meters and at the eaves 3 meters. Most camps provide at least plywood or date frond (leaves) shade houses for the summer, often tethering the camels under them. This simple protection from radiant heat affords significant comfort. The desert nights and winds can be very chilly in winter. To protect the animals from wind chill, a common practice is to surround the camp with a permanent wall, a shade cloth fence, or bulldoze up a surrounding earth mound behind which the camel can couch and shelter. In addition the camels are rugged with a blanket. Nothing is worn for fast training runs (tafheems) on the track.

**Feeding:** Feeding and watering is performed daily. The camels eat and drink from flat troughs approximately 90 cm high, 2.5 meters long, 1 meter wide and 30 cm deep. Alfalfa and hay are often fed in similar troughs with fine mesh bottoms. Several camels may eat or drink from each trough simultaneously. Fresh water and feed are delivered daily by the camp’s vehicles. Little actual grooming is done but the camels are washed almost daily with a motorized pump mounted on the back of the water tanker. Camels are...
usually not watered within 48-72 hours prior to competing. This practice has not been found detrimental to their performance.

Fresh cut alfalfa is the main source of roughage in racing camel’s diet with occasional feeding of hay during times of shortage, while the main source of energy is barley. A typical daily ration contains 10 kg (fresh weight) of alfalfa tops, 3 to 4 kg of soaked whole barley, 1 kg of dates, 2 litres fresh milk, occasional hay and in some camps vitamin and mineral supplements. These quantities are divided between two feedings. The camels are reported to run well and look healthy on this diet, but there are reports of frequent digestive upsets. The quantity could be reduced if the grain was cracked. It would assist with maintenance of less acid rumen pH if more of the alfalfa stem and/or more hay is included in the ratio to increase the roughage and decrease the protein.

Successful feeding of the racing camel requires that its ration must not be too bulky and gut filling to allow the camel to produce optimum performance and it should not be too highly energy concentrated and low in fibre to permit healthy rumen function. The feeding of vitamin and mineral supplements is becoming more common to seek some sort of specific performance boost rather than maximizing performance by optimizing general health through better nutritional practices. Much of the supplements fed are washed and excessive quantities may in fact be harmful. If some trainers have some success, they tend to think that if the recommended amount is good then more must be better. Camels in the UAE have been shown to be deficient in vitamin A precursors, vitamin B₁ and vitamin E.

The racing camel trainer likes his camels to present the silhouette (a profile or shadow-outline portrait) of a fit greyhound i.e. underline of the abdomen arched upwards. He feels, probably correctly, that a large belly impedes the forward action of the hind legs and reduces the power to weight ratio. A rumen reasonably full of fibre may be a healthy one, but it appears to be an unnecessary weight on race day. Management and feeding practices given above pertaining to the racing camels reflect those being followed in the UAE, probably the world’s premier camel racing country at the present time (Manefield and Tinson, 1997).

All camps are visited at least twice each week by a vet and daily when required. Some Sheikhs owning large camel herds employ their own vets and technicians and have sophisticated private laboratories. Routine blood and faecal samples are examined every 4 to 6 weeks. Additional samples are collected from sick camels for diagnostic purposes and whenever the camel registers a poor performance. Blood is drawn 48 hours after the race or fast track run to allow homeostasis to tend to normalize the measured values. The blood is collected into plain and EDTA evacuated tubes for biochemical and haematological screening. The blood is obtained before the camels eat or leave for morning exercise.

The trainer and his staff are very close to the camels and observe the smallest and most subtle changes in their behaviour. Certain parameters have been found useful in evaluating a camel’s fitness to compete (not necessarily to win). Although PCV cannot be used as a parameter to indicate fitness, it has been noted that camels generally perform best at values between 27 and 33%. The wise trainer and the technician attempt to
maintain the camels within these limits. Low PCV may be associated with environmental stress such as going to a new race venue or onset of disease or digestive upset. It appears to be seasonal with the coming of warmer weather. Severe parasitism and trypanosome infection are potent causes. Even if the parasites are not seen in a blood film, but if PCV is <25%, trypanosomiasis can be suspected. Mild cases caused by stress or idiopathic factors will often improve dramatically following the administration of haematinics and vitamins as tonics. To treat low PCV, Hemo-15, 10 ml and Jurocyl, 10 ml, both together in the same syringe IV daily for up to 7 days is useful or Folic/12, 10 to 20 ml IV daily for up to 5 days has given good results. It is advisable to give some vitamin B1 as well.

High PCV may be due to temperament. Two year old camels, during their first year in camp, are particularly prone to it. The restraint must be gentle and the venipuncture and blood extraction done quickly and smoothly if a false high reading is not to be obtained. Some are even difficult to put the halter on and are upset and have a contracted spleen even before the technician approaches. Allowance for elevated PCV and erythrocyte count has to be made if the serum protein is within the normal range. The expected elevation is about 4%. True elevation of PCV seems to be associated with imbalance in water and electrolyte intake. The performance of most racers begins to deteriorate once the PCV reaches 35-36%. The serum protein may be at the upper normal to slightly increased level. For marked increases in serum protein occur in camel when it is severely dehydrated. Good response to treat for high PCV is usually obtained by the administration of electrolytes such as Lectade Plus or Hydrate Liquid twice daily for 3 days.

Serum iron levels fluctuate drastically in camel. Normal levels are between 50 to 150 µg/dl. Levels outside this range can indicate the onset of a serious disease and the camel needs to be carefully monitored. High iron level (>150µg/dl) with concurrent low PCV, has been reported in a group of camels with trypanosomiasis. Probably in these camels iron was being released from damaged red cells faster than it could be stored and/or excreted. Low iron level may be treated with injections such as Hemo-15 or Hippiron. High iron level can be due to underlying disease or overdosage. Excessive parenteral use of iron has caused kidney damage in equines. Serum copper levels are also regarded as important and optimum racing levels are between 50 and 100 µg/dl. Supplements used are Bomin, 20 ml, one dose or Copprite capsules 2 of 4 mg repeated after one month. Copper absorption or availability is complicated by the levels of molybdenum, sulphur and iron in the diet. Although camels are more tolerant of low and high levels of copper than sheep and goats, yet the intake needs to be monitored carefully because excessive intake is associated with poor performance.

Depressed appetite may be shown by camels after racing when overstrained, in illness, due to boredom with the diet or may be a chronic state of ruminal acidosis. It is important that the cause is identified. In conjunction with correction of the cause, Vigest can be used as an oral medication or Mega B, 20 ml, once daily can be injected as a tonic restorative. Camels that leave grain and only eat lucerne should be given some hay since they are probably acidotic. An oral dose of Rumininodigest and Bykagest antacid will help. When ruminal atony persists, Leocud powder, one, twice daily for three days will help.
Q. Write a note on milking camels.
The greatest collection of milking camels (over five million) is in Somalia and the adjoining areas of neighbouring countries. The milk of these camels is the main source of income and a key to the survival of the associated human population. Even here, where great use is made of the camel’s ability to produce milk in very arid area, no selection has been made on the basis of measured milk production. Good milking camels do exist in Pakistan and some border areas of India but their potential to produce more milk has not been properly exploited. In North Eastern Africa where about two-thirds of world dromedary population is found, so great is the requirement for milk production and so low is the camel’s reproductive rate that all females will be bred and milked. Culling of any animal with mammary gland seems impossible. Therefore it is not possible to apply the degree of selection pressure necessary to achieve increased production and type fixation.

No reliable work on results from selection seems to have been published. However, enough variation exists for selection to have significant benefit. Milk production for 305 days has been reported to vary from 1200 kg to 10,700 kg. It shows that given sufficient time for selection for milk yield, milk quality, less intense maternal instinct and development of management systems, camel dairying may be commercially feasible. It appears appropriate to suggest that if a milking type is to be developed, such activities will need to be carried out at appropriate institutions.

Q. Discuss the salient features of Bactrian camel.
The Bactrian camel (*Camelus bactrianus*) is two-humped. It is a sort of the closest cousin of the one-humped *Camelus dromedarius*. It is possible to interbreed the two species. The female progeny are normally fertile, long hump is a feature of the crossbred animals. Embryologically they are identical and may be subspecies of a single humped species. The breeding of F₁ hybrids probably commenced 2000 years ago and was a thriving business in Syria and Turkey seven to eight decades before present (BP). The favoured cross was a Bactrian male to a dromedary female, but the reciprocal cross is quite possible. F₁s were frequently backcrossed with a male of either parentage, but the Bactrian was preferred as the progeny resembled the male parent morphologically. Other crosses, especially the F₁ x F₁ were considered to produce weaker animal with an unpalatable temperament.

Bactrians from Bactria, an ancient name for the region of Western Asia between the Oxus river and the Hindu Kush mountains, is regarded as a part of the natural range of the Bactrian camel. It did not spread to the extent of the dromedary, and came to occupy a range running east-west adjacent to and sometimes overlapping the northern boundary of the dromedary range. This area includes mountains and the cooler deserts of China and Mongolia. The Bactrians prefer an habitat with an average ambient temperature <21°C, but the range of temperatures in these deserts can be very high between summer highs and winter lows. From ancient times the Bactrian has been raised to produce wool, meat and milk, and was first recognized as an important draught animal on the famous silk road. Today, they are primarily kept for wool production in China, Mongolia and southern parts of former Soviet Union. There are found different breeds/strains of
Bactrian camels in various parts of their range, reportedly developed for varying purposes such as superior wool or milk production or draught capability. Compared to the dromedary, the Bactrian is generally a poorer producer of milk (average two litres/day), but a better producer of wool. Its draught capability is about the same as that of a one-humped camel.

One of the most striking differences between the dromedary and the Bactrian is that of hump; the other pertains to the distribution and characteristics of coat. The Bactrian has a thicker, longer coat, a mane on the upper and under sides of the neck and an obvious tuft (like a forelock) on the forehead. The elbows and forearms are also covered with long hair. Their heads are relatively fine and their bodies are strong and robust. They are not as nimble (agile) as most of the dromedaries but the work rate at slower speeds is comparable. Their body colour varies from dark brown through fawns to grey with an occasional white, which is highly priced. They can endure hardship and within their own range can easily survive for 7 to 8 days without water.

For some time it was believed that the Bactrian camel no more exists in wild state. Recent investigations, however, have shown that wild Bactrians exist in a border area of China-Mongolia, in Lop Nur area, Aljin Mountain area and Taklamakan Desert. The number of such animals is very small (700-1000). Uncontrolled hunting and their capture for domestication adversely affected wild Bactrian population. Severe drought in 1980s further reduced their number. In contrast, the number of existing domesticated Bactrians is estimated as 2 million. To protect the remaining wild Bactrians, a joint project has been launched involving the Chinese Environment Protection Agency and the UNEA together with Mongolian and Russian input. The Lop Nur area having about 100 animals, has been proposed as the site for the International Protection Center for the wild camel and the Wild Camel Protection Society has been formed to prevent the extinction of the Bactrians as a wild species. The Bactrian camel was introduced to Ladakh area in the 19th century by traders from Tibet. With the closure of the trade route in 1950s, the animals were released in the grazing area of Nobra situated at an altitude of 3000 metres. They became a tourist attraction there. Because of their dwindling numbers a protection project is underway to preserve them.
Plate IV  Marecha camel

Plate V  Maya camel

42 b
Plate II  Larri camel

Plate III  Lassi camel

42 a
Fig. 7. Schematic presentation of the racing camel (above) and the heavy baggage camel (below)
FEEDING AND NUTRITION

Q. Describe some of the peculiar features of Camelidae in respect of their nutrition.

All Camelidae have a thin upper lip, split in the middle, and prehensile for selecting and grasping feed. The upper dental pad is hard. The small tongue is very active and helps in feed selection. All the salivary glands are very well developed and these allow digestion of the feed to start immediately when it enters the mouth. The oesophagus is very large. The size and long legs of the camel, its economy in the use and turnover of water, its ability to stand high levels of salts in its feed and water and the peculiarities in its digestive system and digestive processes are adaptations to the arid environments in which the camel is usually found. The Camelidae seem to be much more efficient in digesting dry matter, fibre and crude protein than other ruminants and domestic non-ruminants. The way in which the stomach contents are turned over rapidly and frequently (although kept in stomach for a long time) is probably the reason for this better efficiency.

Q. Is camelid stomach different from true ruminant stomach?

The camelid stomach has three distinct compartments, whereas there are four in true ruminants. Although Camelidae are ruminating animals they are not classified as Ruminantia. They differ from true ruminants in that they walk on the pads of the two last digits instead of on the sole of the foot, they have no horns. The same general characteristics of rumination and microbial digestion of fibrous feeds in a large and compartmented stomach system have developed independently in camelids and ruminants. The independent development resulted in marked differences in morphology, histology and motility of stomach system.

The forestomach in camelids consists of three distinct compartments. The largest one is compartment 1(C1) which is subdivided by a strong muscular ridge into a cranial and a caudal portion. The relatively small compartment 2(C2) is only incompletely separated from compartment 1. The ventral parts of the compartments 1 and 2 are made up by series of glandular sacs. Compartment 3(C3) is a long tubiform, intestine-like organ, situated at the right side of compartment 1. The HCl producing hind stomach (H) is a short terminal part of the tubiform compartment 3 with no clear separation from it. The dorsal parts of the stomach compartments 1 and 2 are lined with smooth stratified epithelium. The ventral parts and the entire compartment are lined with glandular mucosa, which is arranged in longitudinal folds in compartment 3 (Figure 8). The most striking feature differentiating it from the appearance of the true ruminant stomach are the glandular sacs. These sacs were once considered to be the famous water store of the camel. It is now thought that the sacs are secretion areas for enzymes where fermentation of feed takes place. They are also the areas where the absorption of the digested feed into camel’s system takes place (Schwartz and Dioli, 1992).
Q. Is intestinal system of camelids different from ruminants?
The intestines of camelids are similar to those of true ruminants. The colon is large in diameter and is a major site of water absorption. The liver is markedly lobulated. The camel has no gall bladder and thus does not produce bile to help in digestion.

Q. Write a note on rumination in dromedaries.
Initial reduction of the size of the feed eaten is achieved primarily by chewing, but this leaves fairly large pieces. Rumination or rechewing the cud is therefore essential for breaking down of particle size. The total time for chewing and ruminating is limited, restricting thus further breakdown of particles to very small sizes. Most rumination in camels that are herded by day takes place at night. Regurgitation of the feed from the stomach occurs at the time when the upper part of C1 is at its maximum contraction. Eructation (belching) of the gases that are the products of digestion and fermentation takes place at the same time as the contraction of the lower part of C1 and C2, while the upper is relaxed.

Q. Discuss recycling of urea in camels.
Camels are well adapted to diets that are low in protein due to their ability to recycle very effectively one of the end products of digestion i.e. urea. Recycled urea in reality is the same protein that is used more than once. The recycling rate of urea increases when camels are put under stress. Recycling efficiency of urea increases from 47 to 86% in camels in which dietary protein is reduced from 13.6 to 6.1%. The llama given diets containing the same level of energy but different levels of protein, those on low protein used 78% of nitrogen from recycled urea in metabolism, but animals fed a diet with high protein used only 10% of recycled urea nitrogen. Camels partially overcome the effects of diets that are low in protein by their ability to select high quality material. They can, however, only do this if they are given a wide choice of feed in grazing and browsing areas and allowed sufficient time to make their own selection. On the other hand, if they are provided with ordinary diets that are high in protein, they are simply competing with other ruminants and some of the advantages of keeping camels are thus lost.

Q. What do you know about stomach motility in one-humped camel? Discuss.
Stomach motility differs strongly between true ruminants and camels. In the former the total digesta in the reticulo-rumen are mixed and transported within the organ a few hours after feed intake rather homogeneously; in the latter particles and fluids are separated in a suction-pressure rhythm during the motility cycle, whereby fluids and solutes are pressed into glandular sacs for potential absorption, thus selectively retaining larger feed particles in the fore stomach for prolonged microbial degradation.
The contents of C1 and C2 pass to C3 when the strong contraction of C2 causes an expansion of the connecting canal. In llama, the flow rate is estimated at 850 ml/hour equivalent to about 17 ml at each contraction. The size of the digested feed particles varies from 0.1mm to 10.0mm in C1 and C2. The maximum size of particles which can pass from this area to the lower parts of the alimentary canal is 3 to 5mm in camels. The size of particles tends to increase as the amount of fibre in the diet increases. Digestion (to reduce the size of the particles) therefore takes longer if high roughage diets are fed.
Because the camel still feels ‘full’ it reduces the amount of feed eaten and therefore absorbs less nutrients for production purposes.

Q. **The longer the diets high in fibre are retained in fermentation chamber of C1 and C2, the better it is. Discuss.**

The time that feed particles remain in the fermentation chamber of C1 and C2 is important because it is responsible in large part for the amount of fibre digested. Longer retention times are required for efficient digestion of diets high in fibre. In the forestomach of the camel, small particles are retained for 41 hours, while larger particles are retained on an average for 57 hours. This is longer than in other camelids. For example, small particles are retained for 29 hours in the llama. Engelhardt (2003) reports that the bulk of fore-stomach contents is slowly turned around counter-clockwise within C1. Fluid is squeezed out of the bulk contents by the strong contractions. Due to the motility sequences, fluid and small particles are exchanged between the ventral region of the cranial and the caudal C1 and between the caudal C1 and C2. Fluid and small particles in C2 are finally sucked into the canal and are carried on into C3. Camels have longer retention times than true ruminants and therefore should be more efficient in digesting fibre although they perform better when allowed to select feed which is low in fibre such as green leaves of browse. Fluid is retained in the forestomach of the camel for 14 hours, this being shorter than that of the llama and true ruminants. High fluid turnover rates support rapid microbial fermentation through a higher buffering capacity and improve outflow of the soluble products of microbial metabolism. Major factors that seem to be responsible for large particles being retained in C1 and C2 longer than small particles (so that they can undergo further breakdown) are an unequal distribution of particles and camel motility. Large particles that do pass into C3 are held up to ten times longer than small particles and fluid in the omasum/abomasum area.

Q. **Discuss in detail feeding behaviour and feed preferences of camel.**

All livestock species (free ranging animals) ingest higher numbers of forage species during the growing season than during dry season. Goats (20 and over 25 forage species in growing and dry season respectively) followed by camels (18 and 22 forage species respectively) accept the highest number of forage species resulting in a more even utilization of available vegetation. Cattle and donkeys in comparison use a very limited range of forage species, which can lead to their overgrazing.

Cattle feed near ground level for over 80% of the feeding time, thus almost exclusively using the herblayer. Camels in contrast to cattle spend less than 5% of their feeding time near ground level and about 70% at heights of over 1.0m above ground. The preference of the camel for higher vegetation strata, gives the camel the advantage of continuous access to high quality plant material since all plants reaching this height are shrubs, bushes and trees, which are deep rooted, often tapping into the groundwater and remaining green long into the dry season or throughout the year, when the herblayer is dry and highly lignified. Plant species reaching the higher strata of the vegetation as a rule belong to the dicotyledon group. Since over 90% of their intake comes from dicotyledon plants, they can be referred to as browsers, whereas cattle, feeding almost exclusively in the herblayer and on grasses, are referred to as grazers. Sheep and goats, in
that order, rank as intermediate feeding types with a certain emphasis to one or the other extreme.

The one-humped camel when given the opportunity, selects a diet, which is higher in quality than the average of what is available, making the camel a ‘concentrate selector’. When allowed free choice, its preferred diet comprises mainly browse. A diet on browse consists on average of about 35% of leaves of leguminous and other trees and 65% of seeds, pods, flowers and twigs. Its ability to select high quality feed is helped by the long neck and legs and grasping upper lip and mobile tongue. Camel in this respect is rather like the giraffe.

Camels will not only eat tree fodder but also graze grasses if no or little other choice is available. In parts of Pakistan, India, in eastern Ethiopia, western Somalia, parts of Mauritania and in southern Arabian Peninsula, they are also grazers. In addition, the camels maintained by farmers in irrigated areas in Pakistan where crop agriculture is predominant, willingly eat green and dried guar and gram bhoosa.

Browsing is, however, of considerable advantage to the camel itself in reducing competition for feed resources with other species. The browsing habit is also advantageous for the camel owners in allowing them to keep a greater total biomass (more numbers) of domestic herbivores on a unit area, without contributing to increased environmental degradation and at the same time adding to the sustainability of the system.

When given a free choice, the feed preferences of the camel and its ability to select the most nutritious and digestible parts of plants ensure that it has a good quality diet that is high in protein throughout the year. It is able to maintain on a diet with a minimum crude protein content of 14% in the dry season, while cattle at this period are on a very low protein diet as reported from Kenya. In terms of cellulose content, camels select a diet with the lowest value of this feed component, while cattle have the diet with the highest proportion of cellulose (Table 3).

### Table 3. Crude protein and cellulose contents (% of dry matter) at three seasons for domestic herbivore species in a part of Kenya

<table>
<thead>
<tr>
<th>Livestock species</th>
<th>Season and feed component (% of diet)</th>
<th>Crude protein</th>
<th>Cellulose</th>
<th>Crude protein</th>
<th>Cellulose</th>
<th>Crude protein</th>
<th>Cellulose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry</td>
<td></td>
<td></td>
<td>Intermediate</td>
<td></td>
<td>Green</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crude protein</td>
<td>Cellulose</td>
<td>Crude protein</td>
<td>Cellulose</td>
<td>Crude protein</td>
<td>Cellulose</td>
</tr>
<tr>
<td>Cattle</td>
<td>4-5</td>
<td>37-40</td>
<td>6-8</td>
<td>33-39</td>
<td>10-12</td>
<td>32-36</td>
<td></td>
</tr>
<tr>
<td>Donkey</td>
<td>5-8</td>
<td>37-40</td>
<td>7-9</td>
<td>28-32</td>
<td>11-13</td>
<td>24-30</td>
<td></td>
</tr>
<tr>
<td>Sheep</td>
<td>9-11</td>
<td>20-29</td>
<td>10-13</td>
<td>17-20</td>
<td>15-20</td>
<td>21-25</td>
<td></td>
</tr>
<tr>
<td>Goat</td>
<td>11-14</td>
<td>15-22</td>
<td>11-14</td>
<td>16-18</td>
<td>17-22</td>
<td>16-22</td>
<td></td>
</tr>
<tr>
<td>Camel</td>
<td>14-17</td>
<td>14-22</td>
<td>14-17</td>
<td>13-16</td>
<td>18-22</td>
<td>14-17</td>
<td></td>
</tr>
</tbody>
</table>


**Q. Does bite size or bite rate make some difference to browsing camels?**
The selective habits of camels, while allowing feeding on very thorny species of browse, also make feeding a lengthy process. It is not only the rapidity with which bites are made which affect feed intake but also the bite size. A slow bite rate can be compensated for by large mouthfuls and if the dry matter content is high nutritional requirements might be fulfilled. On the other hand, a rapid rate will compensate for small bite size. In general, feeding habits vary widely, between different animals and even with the same animal. High rates of dry matter intake would allow a 300 kg camel to achieve a daily dry matter intake of 2.5 kg per 100kg liveweight (which is an average amount of intake for most ruminants) in a feeding period of about 6 hours. Slower rates of feeding could, however, mean long hours to feed (Table 4).

Table 4. Feed intake rates of camels in Mauritania

<table>
<thead>
<tr>
<th>Feed type</th>
<th>Bites (No./hour)</th>
<th>Bite weight (g)</th>
<th>Dry matter intake (g/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia tortilis (branch tips)</td>
<td>140</td>
<td>1.00</td>
<td>140</td>
</tr>
<tr>
<td>Balanites aegyptiaca</td>
<td>260</td>
<td>2.00</td>
<td>520</td>
</tr>
<tr>
<td>Salsola</td>
<td>124</td>
<td>0.76</td>
<td>94</td>
</tr>
<tr>
<td>Nucularia</td>
<td>550</td>
<td>1.76</td>
<td>998</td>
</tr>
<tr>
<td>Maerua</td>
<td>440</td>
<td>1.26</td>
<td>528</td>
</tr>
<tr>
<td>Capparis</td>
<td>360</td>
<td>1.35</td>
<td>486</td>
</tr>
<tr>
<td>Ziziphus</td>
<td>500</td>
<td>1.10</td>
<td>550</td>
</tr>
<tr>
<td>Aristida pungens (dry stems)</td>
<td>240</td>
<td>2.85</td>
<td>684</td>
</tr>
<tr>
<td>Panicum turgidum (fresh growth)</td>
<td>760</td>
<td>1.65</td>
<td>1254</td>
</tr>
</tbody>
</table>


Q. Give estimates of dietary overlap between camel, cattle, sheep, goats and donkey.

Studies conducted in eastern Africa showed that camels compete least with cattle (i.e. they have least dietary overlap) for the same feed. A maximum of 8.5% of the same plant species is eaten by cattle during the green period and only 3.3% in the dry season of the year. The greatest competition for feed resources is found between camels and goats with 47.5% dietary overlap in the dry season and 12.4% in green season. Sheep (30.5 and 14.2%) and donkeys (18.9 and 7.2%) are intermediate in dietary competition with camels. Camels feeding in a national park in Sudan (which is normally not permitted) competed for the same feed resources with giraffe but there was little to no dietary overlap with antelope.

Q. Indicate relatively how much time in a day is spent feeding, travelling and resting by Arabian camels?

Where camels are herded, feeding and travel activities are usually limited to 12 to 15 hours that is daylight. Because they can go for long periods without water, they can thus make more effective use of time for feeding. In some areas camels spend more time...
resting on watering days because of the long time they spend waiting at wells or other sources. In Kenya, camels spend up to 8 hours per day actively feeding and voluntarily travel 15-18 km in search of their nutritional needs. On watering days camels travel as much as 24 km. Relatively little time is spent resting by camels during the day while out at pasture. An indication of total time spent ruminating from Somalia is 6 to 7 hours, whereas a study in Pakistan showed average ruminating time as more than 7.5 hours. Nocturnal rumination time was about thrice as much as for diurnal rumination (Khan et al., 1996).

Q. Name the major plant groups used as feed by camels.
More than 70% and often as much as 95% of the feed selected by camels is composed of dicotyledons (broad-leaved plants including browse and legumes). Major plant groups eaten by camels include the Leguminoseae (Acacia species such as tortilis, nilotica and mellifera; Indigofera), burseraceae (Commiphora), Capparaceae (Boschia; Maerua; Cadaba), Rhamnaceae (Ziziphus), Simaroubaceae (Balanites) and Salvadoraceae (Salvadora; Dobera). Among the grasses, the Aristida species contribute to camel diets, as do Stipa and in very dry areas Panicum turgidum, is often a large proportion of total intake. As noted earlier, even when eating the same range as the other domestic herbivores, camels are rarely in direct competition with other browsers/grazers as they feed at different levels above the ground than do goats and sheep (Figure 9a).

Q. Write notes on intake and digestibility of feed in dromedaries.

Intake: There is still relatively little known about the amounts of feed eaten by camels, especially under free-ranging conditions. Published results are conflicting but it does appear that intakes of feed per unit of body weight are low compared to other domestic species. This may be because of the larger body size of camels and lower energy requirements but it again emphasizes the advantages of keeping camels, since they need less feed to produce the same amount of body weight as other species. Growing camels of one year age in Tunisia had a very low voluntary intake of 1.6 kg DM/100 kg liveweight with a gain of 326 to 525 g/day at a conversion ratio of 7.4 kg DM/kg of gain. Studies in Egypt have shown an intake of 4 kg DM/head/day (no liveweight figures provided) to give a gain of 214 to 238 g/day. Camels drinking salt water have lower dry matter, TDN and digestible crude protein intakes than camels consuming fresh water. Camels deprived of water can increase the proportion in the feed of TDN and digestible crude protein by selective feeding.

Digestibility: The proportion of the major nutritional components that are digested (the coefficient of digestibility) is often higher in camels than in other farm ruminants. This is because camels adapt to poor quality forage if they have no alternative sources of feed, in particular by increasing the retention time in the alimentary canal. The major strategy of camels in relation to diet quality, however, is to select green parts of plants with high protein and low cellulose. This strategy is aided by low energy use, high salivary flow and high levels of ammonium for microbial synthesis. It needs emphasis that camels should be allowed as wide a choice of feed sources as possible if best use is to be made of their ability to thrive in areas where other farm animals do not.
Q. Name the browsing and grazing plants found in Pakistan that are fed to camels.

In deserts of Pakistan, India, Iran, some of the Middle East countries and in parts of Africa, the plants, bushes, shrubs, weeds and trees are more or less identical. Before giving a list of browsing/grazing plants it seems appropriate to discuss that camel feeds can be divided into three groups. First group: green grasses, weeds, vines, twigs and leaves of trees, shrubs and bushes; second group: includes fodders that are dried and stored for feeding and almost all the feeds used in green state and straws of some of these left after threshing and third group: concentrates of all kinds i.e. grains, oil cakes, etc. A large number of plants included in first group grow in deserts, semi-deserts and plains of tropical and subtropical areas. Except a few poisonous plants, leaves of every weed, vine, shrub, bush and tree, whether salty or bitter-tasting, are eaten by camels. With the exception of a few vines, weeds and shrubs that grow in deserts, most of them have been classified botanically and their local names are known; the list of such plants is given below:


**Vines:** *Momordica dioica* (kakoda), *Tribulus terrestris* (gokhru, bhakra), *Citrullus colocynthis* (indrayan) and Sata.

Q. Do camels eat cultivated crops in green or straw form?

In addition to shrubs, bushes and green leaves of trees, camels in irrigated areas are fed on green crops such as moth, guar and jowar. Camels are also fed straws obtained from crops as bajra, jowar, makki, taramira etc. and bhoosa of gram, moth, mung, guar etc. Sometimes when a camel gets weak, green moth with grains or green guar with grains or if available lucerne and clover are also fed to help camel regain condition.

During drought years the leaves of the following trees may also be eaten by camels: *Ficus bengalensis* (banyan tree), *Ficus glomerata* (gular), *Ficus religiosa* (peepal), *Morus alba* (white mulberry), *Dalbergia sissoo* (shisham) and *Mangifera indica* (mango).

Q. How to feed dry roughages to camels?

Camels working in cities or those kept by rangers on desert area borders, under conditions of scarcity of grazing especially in summer, are fed dry roughages and some concentrates. Dry roughages consist of bhoosa (straw), tree leaves and pods collected in rainy season. When bhoosa of two leguminous crops as moth and gram or moth and mung is mixed, it is called missa bhoosa. Mixed bhoosa is commonly fed to rangers/army camels. Bhoosa (straw) is chaffed into small pieces. Chaffed grass mixed with straw of...
one of two different crops is also used for feeding camels. Various types of bhoosa fed to camels, in order of preference are, moth bhoosa, gram bhoosa, mung (greengram) bhoosa and clusterbeam (guar) bhoosa (Table 5). When bhoosa is mixed with dried leaves of trees such as khejri or jharberi, it makes very palatable and nutritive ration for camels. Protein, mineral and vitamin A contents of these leaves are high. In hilly areas maize straw is commonly used for feeding camels. According to an estimate 8.3% camels obtain their feed (green or dry forage, straws) from irrigated/cultivable areas, while the rest mainly depend on range vegetation plus an occasional feeding of some molasses, concentrates.

Q. Do camels need concentrate feeding?
Free ranging camels probably are never fed concentrates. Common camel keepers most often do not feed concentrates to their camels unless they become rundown. In that case they feed some millet flour or barley flour and gur (molasses) for a few days till the camel regains his condition. Those who use their camels to pull camel-carts for haulage of goods or as baggage animals, they feed them concentrates daily to maintain them in good condition. Such concentrate ration usually consists of 0.5 to 1.0 kg moth flour or bajra or barley flour and 300 to 400g gur (molasses). In winter, mustard or sesame oil is given for 15 to 20 days to camels that are in poor body condition.

Table 5. Nutritive contents of some straws, bhoosa and grasses commonly fed to camels (% of dry matter)

<table>
<thead>
<tr>
<th>Name</th>
<th>Moisture</th>
<th>Dry matter</th>
<th>Ash</th>
<th>Total organic matter</th>
<th>Protein</th>
<th>Ether extract</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bajra straw</td>
<td>5.07</td>
<td>94.93</td>
<td>8.00</td>
<td>92.00</td>
<td>6.00</td>
<td>1.00</td>
<td>85.00</td>
</tr>
<tr>
<td>Jowar straw</td>
<td>7.15</td>
<td>92.85</td>
<td>8.75</td>
<td>91.25</td>
<td>6.25</td>
<td>1.00</td>
<td>84.00</td>
</tr>
<tr>
<td>Moth bhoosa</td>
<td>5.15</td>
<td>95.00</td>
<td>15.0</td>
<td>85.00</td>
<td>4.25</td>
<td>2.00</td>
<td>78.75</td>
</tr>
<tr>
<td>Gram bhoosa</td>
<td>4.60</td>
<td>94.40</td>
<td>15.35</td>
<td>84.65</td>
<td>7.75</td>
<td>0.50</td>
<td>70.40</td>
</tr>
<tr>
<td>Guar bhoosa</td>
<td>-</td>
<td>-</td>
<td>16.5</td>
<td>-</td>
<td>12.90</td>
<td>0.87</td>
<td>57.40</td>
</tr>
<tr>
<td>Beri leaves</td>
<td>5.10</td>
<td>94.90</td>
<td>16.0</td>
<td>84.00</td>
<td>5.13</td>
<td>2.00</td>
<td>76.87</td>
</tr>
<tr>
<td>Khejri leaves</td>
<td>5.20</td>
<td>94.80</td>
<td>10.55</td>
<td>89.75</td>
<td>6.50</td>
<td>0.50</td>
<td>82.75</td>
</tr>
<tr>
<td>Acacia leaves</td>
<td>6.00</td>
<td>94.00</td>
<td>12.05</td>
<td>89.95</td>
<td>6.25</td>
<td>1.00</td>
<td>80.70</td>
</tr>
<tr>
<td>Phog twigs</td>
<td>4.50</td>
<td>95.50</td>
<td>20.75</td>
<td>79.25</td>
<td>4.50</td>
<td>1.50</td>
<td>73.25</td>
</tr>
<tr>
<td>Wheat</td>
<td>5.40</td>
<td>94.40</td>
<td>18.3</td>
<td>81.35</td>
<td>5.00</td>
<td>1.50</td>
<td>74.85</td>
</tr>
</tbody>
</table>
Cereal or leguminous grains should be crushed and preferably soaked for about 6 to 8 hours before feeding. Oil cakes can be fed 0.5 to 1.0 kg/daily in combination with small quantities of other concentrates and gur (molasses). Cottonseed, if economical, may be given 0.5 to 1.0 kg daily crushed and soaked in water along with 450 g crushed moth, guar or gram. It has been reported to be a convention in certain desert areas in Indo-Pakistan to feed their camels about 1 kg molasses along with 25 g pink alum during long journeys. Both these components are mixed together in 3 to 4 litres water and poured down the throat of the camel. Molasses, of course, is a source of energy and perhaps alum is administered to counteract the laxative effect of molasses (Table 6).

### Table 6. Nutritive contents of some concentrates commonly fed to camels (% of dry matter)

<table>
<thead>
<tr>
<th>Name</th>
<th>Moisture (%)</th>
<th>Dry matter</th>
<th>Ash</th>
<th>Total organic matter</th>
<th>Protein</th>
<th>Ether extract</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram</td>
<td>4.00</td>
<td>96.00</td>
<td>6.15</td>
<td>93.85</td>
<td>21.88</td>
<td>4.40</td>
<td>67.57</td>
</tr>
<tr>
<td>Moth</td>
<td>4.00</td>
<td>96.00</td>
<td>4.75</td>
<td>95.25</td>
<td>25.88</td>
<td>0.40</td>
<td>68.97</td>
</tr>
<tr>
<td>Guar</td>
<td>4.00</td>
<td>96.00</td>
<td>6.90</td>
<td>93.10</td>
<td>34.38</td>
<td>2.00</td>
<td>78.55</td>
</tr>
<tr>
<td>Moong</td>
<td>6.53</td>
<td>93.47</td>
<td>3.10</td>
<td>96.00</td>
<td>10.00</td>
<td>9.20</td>
<td>80.86</td>
</tr>
<tr>
<td>Bajra</td>
<td>5.67</td>
<td>94.13</td>
<td>4.00</td>
<td>96.00</td>
<td>10.00</td>
<td>9.20</td>
<td>80.86</td>
</tr>
<tr>
<td>Jowar</td>
<td>5.00</td>
<td>95.00</td>
<td>8.50</td>
<td>91.50</td>
<td>9.69</td>
<td>2.80</td>
<td>79.01</td>
</tr>
<tr>
<td>Wheat</td>
<td>4.00</td>
<td>96.00</td>
<td>4.75</td>
<td>95.25</td>
<td>11.88</td>
<td>1.00</td>
<td>83.37</td>
</tr>
<tr>
<td>Barley</td>
<td>5.00</td>
<td>95.90</td>
<td>7.75</td>
<td>92.25</td>
<td>10.35</td>
<td>4.20</td>
<td>77.02</td>
</tr>
<tr>
<td>Maize</td>
<td>4.10</td>
<td>95.90</td>
<td>7.50</td>
<td>92.50</td>
<td>10.68</td>
<td>5.80</td>
<td>76.02</td>
</tr>
<tr>
<td>Sesame cake</td>
<td>5.61</td>
<td>94.39</td>
<td>11.75</td>
<td>88.25</td>
<td>38.44</td>
<td>14.00</td>
<td>35.81</td>
</tr>
<tr>
<td>Mustard cake</td>
<td>5.77</td>
<td>94.23</td>
<td>6.15</td>
<td>93.85</td>
<td>28.75</td>
<td>11.00</td>
<td>54.10</td>
</tr>
</tbody>
</table>

Source: Rathore (1986).

Q. **Give some examples of rations that are practically suitable for feeding of camels of various ages.**

The army camel corps in India have prescribed rations for camels. These are regularly fed when the camels are stationed at headquarters. When they are on march or in camps, these rations are changed to suit the situation. When browsing/grazing is available the
roughage ration is reduced. With minor modifications, the rations given below can be applicable here as well.

When at headquarters, the suggested ration is:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram (crushed)</td>
<td>1.30 kg</td>
</tr>
<tr>
<td>Barley (crushed)</td>
<td>1.30 kg</td>
</tr>
<tr>
<td>Missa bhoosa</td>
<td>8 to 9 kg</td>
</tr>
<tr>
<td>Salt</td>
<td>0.14 kg</td>
</tr>
</tbody>
</table>

Camels are taken out for grazing, however, if grazing is inadequate, following ration is given:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram (crushed)</td>
<td>3 kg</td>
</tr>
<tr>
<td>Missa bhoosa</td>
<td>10 kg</td>
</tr>
<tr>
<td>Salt</td>
<td>0.14 kg</td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moth crushed</td>
<td>3 to 4 kg</td>
</tr>
<tr>
<td>Missa bhoosa</td>
<td>10 to 12 kg</td>
</tr>
<tr>
<td>Salt</td>
<td>0.14 kg</td>
</tr>
</tbody>
</table>

OR

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moth (crushed)</td>
<td>1.50 kg</td>
</tr>
<tr>
<td>Millet</td>
<td>1.50 kg</td>
</tr>
<tr>
<td>Missa bhoosa</td>
<td>10 to 12 kg</td>
</tr>
<tr>
<td>Salt</td>
<td>0.14 kg</td>
</tr>
</tbody>
</table>

Following rations have been prescribed for camels of various ages at the state camel breeding farm, Bikaner.

<table>
<thead>
<tr>
<th>Camels by age</th>
<th>Fodder or bhoosa (kg)</th>
<th>Concentrates (kg)</th>
<th>Salt (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Under one year age</td>
<td>1.8</td>
<td>0.45</td>
<td>28</td>
</tr>
<tr>
<td>b) 1 to 2 years old</td>
<td>3.6</td>
<td>0.90</td>
<td>56</td>
</tr>
<tr>
<td>c) 2 to 3 years old</td>
<td>5.4</td>
<td>1.5</td>
<td>85</td>
</tr>
<tr>
<td>d) Above 3 years</td>
<td>7.3</td>
<td>2.0</td>
<td>115</td>
</tr>
<tr>
<td>e) Stud camels</td>
<td>8.2</td>
<td>2.5</td>
<td>142</td>
</tr>
</tbody>
</table>

**Note:** Ration scales a to d will remain effective from 1st April till 31st July when there is comparatively less browsing/grazing material available. From 1st August to 31st October, only half the above ration scales will be allowed if there are adequate rains and there is plenty of browsing/grazing available. From 1st November to 31st March, half of the above ration scale will be allowed if adequate browsing/grazing is available. This variation will not affect scale e above. In addition, stallions will be given 1 kg of mustard or sesame oil twice a week during the mating season i.e. usually from 1st December to the end of March.

**Q. What is the daily salt requirement of an average sized camel?**
Camels entirely on browsing/grazing do not need additional provision of salt. When they are working and being maintained on bhoosa or straw and concentrates, they need about 50 to 100 g salt/head daily. It may be mixed with flour or crushed grains. Camels appear...
to have rather high mineral requirements. Occasionally they show preference for halophytic forage species, brackish water and salty soil. Standard mineral mixtures with an anthelmintic in proper concentration results in self-dosing against internal parasites.

**Q. What are the proper times for feeding camels?**

Free ranging camels are at liberty to browse or to take rest. Usually their feeding takes place during day time with one or two short intervals of rest and/or rumination. Large camel herds having owner’s brand mark on them are not even tended by any body. It is a common practice in Cholistan desert in Pakistan as well. Individually owned camels whether used for intracity transportation or for farm operations, are fed in the morning before being put to work. In the afternoon when at rest, they are again fed and then in the evening. Those working in the city to pull intracity camel carts, they are often fed some bhoosa or green fodder whenever there is a loading or unloading interval. The cart drivers carry with them the feed for their camels. Ranger’s/army camels are fed according to their prescribed schedules. They are fed early in the morning, usually about an hour before they are taken out for work or parade. In the afternoon they are fed again during the resting time; third time in the evening when camels are at rest. They are generally first fed concentrate ration and afterwards bhoosa is given to them for the night. When grazing is available, ranger’s camels are sent for browsing/grazing in the day time; on their return in the evening they are fed concentrate, and as usual bhoosa is left before them.

**Q. Give useful suggestions for proper feeding of one-humped camels.**

i) Do not suddenly feed the camel with grains if he is not used to them.

ii) Do not starve the camel for long; this causes stoppage of cud chewing and the atony of the stomach.

iii) Do not feed grain or bhoosa after a long exhausting journey, especially if performed without feed and water. This may cause colic or impaction, and the camel may die. After exhaustion or fatigue, give the camel a small quantity of flour mixed with molasses and 1 to 2 litres of water and not more than 8 to 10 litres at a time, then after half an hour give him the usual feed [it seems to be, more or less, an empirical observation, however, a part of it does have some rationale].

iv) If offered the fodder of their choice, especially green fodder such as lucerne, green moth or jowar, the camel may resort to overeating, resulting into tympanites and flatulent colic. Therefore such fodders be given in modest quantities.

v) A camel must not be taken for long fast riding after heavy feeding, for he may develop colic or tympanites.

vi) The camel thrives best in the place where he has been brought up in his early life, for he develops a liking for the local shrubs, bushes and leaves. If, however, taken away from his native area, he should be fed carefully at first till he gets used to eating new plants; otherwise he may develop digestive upsets.

vii) The camels that are not fed at home would need at least 8 to 10 hours of grazing/browsing every day.
Avoid sending camels for browsing/grazing in such area that has become slippery after rains.

Camels should not be allowed to graze/browse in developing reserve forests, for they will eat away tender tops of young trees.

Do not feed the camel whole grains and seeds, especially barley, oats, gram, cotton etc. These should be fed after crushing and soaking in water for at least 6 hours. This will enable the camel to take full advantage of the grains or seeds.

When the camel is not grazing, give him common salt every evening with concentrates.

Q. Write a note on supplementary feeding of camels.

Generally, camels are free-ranging animals and under many circumstances need little by way of supplementary feed. At certain stages of the life cycle, however, when camels are expected to perform extra work or produce more milk, additional feed may be required. With the exception of a few experiments, information on extra rations for camels is surprisingly scant. Suitable feeds for supplementary feeding are cereal straws, missa bhoosa, oilseed cakes, green or conserved fodders including grasses and legumes such as lucerne (Medicago sativa) or berseem (Trifolium alexandrinum), crushed barley, moth or guar and compound rations either home produced or ready manufactured. It needs to be stressed again that extra feeding should only be given for special purposes and to special groups of animals otherwise camel keeping will compete with that of other farm animals, which may benefit more from supplementary feeding.

Both energy and protein supplementation may be needed or just one or the other. For improved growth rates, for example, both are required. For work such as transport or ploughing, energy is the feed component most in demand, whereas more protein is needed for milk production.

Q. Does it seem possible to improve reproductive performance by supplementary feeding? Explain.

Better reproductive performance through improved nutrition can be achieved using two approaches: one to reduce age at first calving and the other to shorten the interval between successive births. Sexual maturity is often related to physical maturity, so if physical maturity is attained earlier, it would help attain puberty the earlier, whether female or male. For reproductive purposes, attaining earlier maturity in females than males is considered more important. Therefore provision of supplementary feeding to females may be beneficial. Feeding at any time will be helpful, but best results are obtained if animals are given supplementary feed from the time they are weaned.

In Tunisia, the camels receiving 500 g ready-mixed concentrate attained sexual maturity 6 months earlier than those given no concentrate. The youngest of the treated animals had its first calf at 3 years 2 months age and the average of all animals was 3 years 8 months compared with normal age of 4 to 5 years of animals receiving no supplementary feed. The supplementary feed group animals were also bigger and had better conformation. At the time of first conception these animals weighed about 64% of their final adult weight. Similarly, their height was more than 80% of the final adult height. It is desirable that
mating of camels for the first time should be at about these stages of growth. Camels with a high nutritional status return to heat more quickly than those in a poor condition. If it is intended to breed camels every 18 months, they should be provided with supplementary feed to bring them back into breeding condition quickly.

Q. Discuss feeding of camels for milk production.
Camels producing milk need large quantities of water (milk is about 90% water) and the main nutrient required is protein. A 400 kg camel producing 15 litres of milk daily requires 3 times the amount of protein of a 500 kg camel being used for transport but has only two-thirds of the energy requirement. Brassica crops, berseem and pods of several varieties of beans are said to yield good results. In general, any high protein type of feed given at about 250 g per litre of milk produced, should prove satisfactory for milk production.

Q. What type of feeds need to be given to working camels?
Large amounts of energy are used to perform work. Thus feeds high in carbohydrates or energy are needed for transport and draught camels. Energy is best supplied by cereals, their by-products, molasses etc. More expensive high protein feeds such as oil cakes should be avoided as they are better fed to other livestock for economic reasons (Table 7).

Q. Do the natural feed sources suffice to meet the mineral and vitamin needs of camels?
Camels on natural feed sources will normally take in enough minerals and vitamins for their needs. Where there are known deficiencies and no salt cure is possible, imbalances should be corrected by providing a mineral lick containing the necessary elements.

Table 7. Energy and protein feeds suitable for camels

<table>
<thead>
<tr>
<th>Feed</th>
<th>Type of nutrient supplied</th>
<th>Energy</th>
<th>Protein</th>
<th>Energy + Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard concentrate mixture</td>
<td></td>
<td>***</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>Cereal straw</td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young green grass/legumes</td>
<td></td>
<td>**</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>Grass hay</td>
<td></td>
<td>**</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>Legume hay</td>
<td></td>
<td>**</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>Oilseed cakes</td>
<td></td>
<td>*</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Wheat bran</td>
<td></td>
<td>**</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>Cereal grains</td>
<td></td>
<td>***</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>Pods of legume trees</td>
<td></td>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>Leaves of legume trees</td>
<td></td>
<td></td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>


Q. Write a note on voluntary feed intake of adult camels.
Based on observation of tethered animals, voluntary feed intake (VF1) of camels appears to be half to three quarters that of average sized buffalo/cattle, in terms of dry matter as a percentage of body weight. In practical terms it would be about 7.5 kg dry matter/day for a 450 kg camel. There are reports of adult camels having been maintained on 5kg of poor quality hay per day. VF1 in the camel is optimized when the roughage component of the diet is 70%.

**Q. Discuss the energy requirements of the camel for maintenance and work.**

A 450 kg camel’s daily requirement of energy for maintenance on average are 37MJ. A camel performing draught work at a speed of 3.6 km/hour can sustain a pull of 0.15 to 0.2% of its body weight. This represents an output of 450 watts for a 500 kg camel. Assuming an energy conversion efficiency rate of 20%, 8.2 MJ per hour of this work would seem to be a reasonable allowance. It sounds logical to consider that baggage work would require almost equal inputs when the load they carry is given consideration. The requirement for faster work may be calculated from data generated from oxygen uptake studies. A figure of 2.0MJ/km traveled appears to be realistic.

**Q. What advantage the camel has in respect of protein requirements over the true ruminants?**

Due to its pronounced urea recycling ability, the camel is better equipped to handle protein deficient diets.

On a 4% crude protein diet, nitrogen balance in camels has been shown to be far superior to that of sheep. When subjected to water deprivation, nitrogen retention increased by 34% in sheep and 150% in camels. Even in watered state, recycling of urea to the rumen is very efficient in camels. In general, sheep consume twice as much nitrogen per unit of body mass as do camels. Fermentation rates in the forestomachs of camels appear to be similar to those of the true ruminants, but better nitrogen economy may be the basis of more efficient biosynthesis. There is some evidence that dietary crude protein levels for any class of camels such as pregnant, lactating, need not to exceed 9.6%. Its high urea recycling rate enables the camel to be a superior utiliser of low quality high roughage diets typical of the natural range plant material. Pending further evidence, it may be wise to provide higher protein levels for rapidly growing young camels and lactating females. For adult working animals, 300g of DCP should suffice. The requirement of racing animals and those under stress is similar but the quality (biological value) of the protein should be high. Camels also respond well to protected protein. The provision of 100g per day has significantly improved weight gains in camels in poor condition.

The requirements of camels for fat are not known. Probably they obtain all that is necessary from the feeds traditionally eaten by them. Racing camels are known to tolerate a daily intake of about 200 g of protected fat.

**Q. Do camels have electrolyte requirements? Discuss briefly.**

Electrolytes are important in camel feeding since the alimentary fluid is rich in sodium and bicarbonate particularly. Natural range plants are rich in these electrolytes. Artificial diets may induce deficiencies if not adequately supplemented. It is appropriate to include 2% NaCl in formulated diets for the camel. When crystalline salt is fed ad lib, an adult camel may consume 120 to 150 g/day. Hard salt blocks generally do not allow full intake
and may induce behavioural problems. Inadequate salt intake manifests itself in the form of skin disease (lackluster coat and necrotic dermatitis) and/or arthritic lameness and lowered production. In parts of North East Africa camels having salt deficiency are deliberately grazed on salty areas, which are known to effect ‘salt cure’

**Q. Give a brief account of mineral and vitamin requirement of the camel.**

The camel is said to tolerate deficiencies of minerals and vitamins better than other ruminants. Normally supplementation may not be required unless maximum performance is desired from the animals. Since many of the mineral and vitamin needs of the camel have not so far been quantified, therefore NRC standards for cattle may be followed.

With regard to Zn and Cu, the camel shows less effect than do other species in soil deficient areas. Daily intake equivalent of 18 to 20 mg of ZnSO₄ and 15 to 20 mg of CuSO₄ appears to be sufficient for good health. When drinking water and/or diet is high in sulphur and/or molybdenum, copper availability may be limited and intake be adjusted accordingly. Vitamin E and selenium deficiency can be a serious problem in camels in intensive breeding systems. Supplementation with vitamin E benefits both athletic and breeding performance. Daily allowance of 100 mg vitamin E and selenium 0.1 to 0.5 mg/kg of the diet appears to be adequate. A thiamine responsive condition regarded as being polioencephalomalacia is seen in racing camels. It is associated with imbalance of grain to roughage in the diet. Supplementation with dietary thiamine has been shown to raise blood thiamine levels. However, injections of thiamine may be a more practical and effective means of administration.

**Q. Write a note on water requirements of one-humped camels.**

Camel’s requirements for a source of free water depend much on type of grazing and environmental temperatures. Up to 20 litres per day may be met by herbaceous intake. During the cooler months camels may draw water from plants and standing water pools alone and may not seek to drink at a fixed water point for up to a month. Annuals and salt bushes contain up to 80% water almost in all seasons. Salt-containing vegetation has about the same water content in dry years as in wet. Camels show a liking for high salt herbage. Such plants are usually drought resistant. Their preference for high salt herbage explains high concentrations of electrolytes in the alimentary tract. Dune plants have a more stable year round water content than those growing on rocky ground.

Consensus indicates that camels drink once per week in summer, every 7 to 10 days in spring and autumn and every 3 to 4 weeks in winter. In 30 to 35°C air temperatures, visits to water points by free ranging camels will be sporadic. With temperatures >40°C, visits are likely to be regular at intervals of 4 to 7 days. Water requirement increases with activity. Given the same feed, yarded camels require less water than grazing camels that may voluntarily travel 30 to 60 km per day during browsing. In the Sahara, camels have marched 1000 km in 20 to 30 days without drinking water. Dehydrated camels will usually choose to remain stationary during the day, but can be forced to walk great distances. Racing camels are almost regularly deprived of water 3 days prior to competition in an attempt to improve power to weight ratio.

The power of kidney to produce urine with sodium concentration above that of sea water makes it theoretically possible for camels to quench their thirst from the sea. Certainly
they will drink brackish water but usually reject sea water. Visiting camels may sometimes refuse to drink brackish water that is being drunk daily by local camels. Of course, there seems to be a taste acquisition factor. Consideration of all the variables indicates that daily water allowance for camels should be 30 to 40 litres. Because of its lower urinary excretion rate (20% lower), and its much lower rate of faecal water loss, with water available \textit{ad libitum}, the camel may consume only 10% of the water consumed by the bovine in the same environment (Manefield and Tinson, 1997).

Q. Do camels have a limited range of feedstuffs or is it otherwise? Discuss in detail.

Camels generally thrive in dry arid climates where feed quantity and quality vary widely, but most of the time quality is poor. However, the fattest camels, as indicated by their hump size, can be seen among those wandering the desert and not among the hand fed in domestic confinement. Nevertheless, there are times such as with a calf at foot, when the camel appears unable to satisfy its nutritional requirements by foraging alone. As with a good dairy buffalo, production of milk appears to have a higher priority than maintenance of body weight. The camel’s digestive ability has been shown to be at least as efficient in utilizing low quality roughage as that of buffaloes. It can eat and digest a wide range of plant material. The camel does possess a microflora that facilitates digestion of a large range of plant material including tannins. These microorganisms do not normally inhabit the rumen of buffalo, cattle and sheep. However, the rumen of cattle and sheep sharing a range with camels will become populated with them and exhibit some enhancement of digestion. The camel’s active forestomach contraction cycle and its active recycling of urea also enhance its digestive capabilities. The adaptability of the camel’s digestive system has been shown by grazing them on alfalfa (lucerne) and panicum grass. Camels utilize these feedstuffs as efficiently as the true ruminants. Camels have been seen eating from garbage containers of Arab villages. Waste from fruit and vegetable processing can easily be supplemented with nitrogen rich saltbushes. Fattening for meat production has been profitable on a diet of straw, beet pulp, silage, molasses and barley.

The nutritional needs of camels kept in corrals and stalls have not been well worked out. Good health and fertility have been maintained on 5 kg of poor quality hay plus 2 kg of grain per day. While large (600 kg) working camels in Indo-Pakistan subcontinent are traditionally fed about 2 kg of grain, 9 to 12 kg (fresh weight) of green feed, 7 kg of hay/straw and some salt. Although precise requirements for camels in lactation are not known yet the allowances for buffalo/cattle would probably be a reasonable assumption. It is a common observation that free ranging camels with calves at foot lost body weight. Under these circumstances it does not seem possible for them to take in total required nutrients within the limits imposed by their voluntary feed intake (Manefield and Tinson, 1997).

Q. Write a note on feeding of racing camels.

Racing camels need a more concentrated diet. In order to obtain a better power to weight ratio, bulky feeds are restricted. Racing camel trainer feels very happy when his camel is in thin condition with the body underline being similar to that of a well conditioned...
greyhound dog. Lack of roughage sometimes leads to the occurrence of thiamine deficiency. It is important that the protein fed to the racing camel should have high biological value. Since the bulk of the protein is rumen produced bacterial protein, the mineral status of the animal must be optimized. The imbalance due to excessive protein in the diet may result in inefficient utilization of energy and perhaps contributes to the indigestion syndrome so commonly reported.

Because of their high energy potential, fats could make a useful contribution to the racing camel diet. Fats probably only become an important energy substrate in endurance type races and seem to have little value in feeding for the usual 8 to 10 km events. The camel has been reported to tolerate dietary fat to the level of 3% of dry matter without compromising rumen function. About 200g protected fat has been fed to racing camels without any problem. The approximate daily feed intake of racing camels in the UAE, consists of up to 4 kg of soaked whole barley, 10 kg of fresh alfalfa tops, 1kg of dates, 2 litres fresh cow milk, occasional hay and in some camps mineral and vitamin supplements. The total quantity is divided equally and fed twice to the animal. Camels generally perform well and look healthy using this diet, but they do suffer from digestive upsets. These range from ruminal overload/indigestion to thiamine deficiency. These problems seem to be a legacy of the desire to feed energy dense diet with minimum rumen fill. The consequent imbalance between fibre and concentrates induces a chronic/acute ruminal acidosis, seriously affects healthy fermentation and bacterial synthesis of essential nutrients. One possible way to avoid this condition is to feed grain in a more digestible form such as cracked or flaked. Thus the required energy can be provided by less mass of grain. When whole grain is fed, undigested kernels have been shown to constitute up to 20% of faecal mass, that amount is totally wasted. This reduction in grain mass could then be substituted by good quality hay or the lower part of the alfalfa stalk. Usually the alfalfa is presented as sheaves and the lower half is cut off and discarded. Racing camels should be fully watered daily except immediately prior to fast work and racing. Some trainers have been reported to withhold water for up to 3 days prior to racing with no apparent harm.

Q. Does plant poisoning occur in camels? If it does occur, name a few such plants that may cause poisoning and indicate the usual symptoms.

Camels have been seen to eat known poisonous plants and suffer no ill effect. This is thought to be due to the very varied diet of the camel and its active ruminal contractions that thoroughly mix the contents. This tends to prevent the occurrence of strata within the rumen and building up of toxins to dangerous levels within these.

The handlers should be familiar with plants that are potentially poisonous. During long journeys they should not tether their camels at such points that are suspected of having poisonous plants. Camels moved into an area in tropical eastern Australia, consumed ironwood (Erythrophloeum chlorostachys) and exhibited staggering, star gazing, blindness and died. Hay contaminated with the bark of this tree was responsible for the death of five camels and illness in further 20. The toxins are alkaloid esters of diterpenoid acid. Ingestion of cape tulip (Homeria breyniana), oleander (Nerium oleander) in Indo-
Pakistan causes salivation, tremors, convulsions and death in camels. More investigations need to be done to determine what other plants have poisonous effects in camel in Pakistan.

Other plants known to be poisonous in Australia are: *Gastrolobium grandiflorum* (desert poison bush) with the toxin, a fluoracetate; *Gyrostemon ramulosus* (camel poison); *Dubosia hopwoodii* (emupoison bush) with the toxin, pyridine alkaloids; *Setaria* grass, toxin is oxalate content and *Trema tomentosa* (poison peach). In Africa, ingestion of the magico medicinal plant *Capparis tomentosa* has been reported to cause nervous signs including muscular tremors, stiffening of limbs, ‘S’ shaped distortion of the neck, dyspnoea and finally convulsions. Death often occurs in 24 hours. Post-mortem shows hydrothorax, hydropericardium and pulmonary oedema. Care and treatment of poisoned camels is almost the same as observed for large true ruminants.

Q. Name various other plants that can cause poisoning in camels. Give usual signs of plant poisoning along with appropriate treatment.

Some plants cause severe poisoning and death, while others cause mild disease such as stomach pain and/or diarrhoea. Poisoning due to different plants results in different symptoms. Camels usually recognize certain poisonous plants and avoid eating them. However, a camel may eat such plants when it is without feed for a long time or when it is moved into new grazing areas with no experience of the local vegetation.

Some of the following symptoms may result from poisoning due to different plants:
- Excitement, depression, weakness, loss of coordination
- Stumbling, jumping, running in circles
- Groaning, kicking of the belly, bloat, stomach pain
- Shivering, twitching of the face, head and neck, fits, convulsions, salivation or foaming at the mouth, difficulty in breathing, excessive sweating, uncontrolled urination, diarrhoea, vomiting, strange behaviour such as pressing the head against a post or a tree stump
- Stiffness, paralysis, coma and death

Prevention lies in avoiding grazing in areas known to have poisonous plants. Most of the treatments for poisoning are based on removing the poison from the body. These medicines are called purgatives, such as Epsom salt (magnesium sulphate, castor oil, mustard and linseed oils and liquid paraffin to make the animal excrete the poison in the faeces. Drenching with charcoal (½ kg ground charcoal) mixed with 3 to 4 litres of water helps prevent the absorption of more poison from stomach. Drench with 200 g kaolin (China clay) mixed with water. Repeat each day for 4 to 5 days (K. Rollefson *et al.*, 2001).

*Buxus semper virens* (Phappar): It is an abundant plant in Punjab (Pakistan) and Iran. It causes swelling of throat, cough, swollen belly, pain, vomiting and straining to defaecate, hard dry dung at first, then becoming soft, then evil-smelling diarrhoea, sometimes severe hiccough. The camel may die within 3 days.

The animal should be drenched with soup made from sheep fat. Mix 60 ml (about 12 teaspoons) of turpentine with 1 litre of linseed oil and drench. About an hour later, drench with warm ghee and milk. Inject 130 mg of arecoline subcut to make the animal
Part – I  Production and Management of Camels

Bakhat Baidar Khan, Arshad Iqbal and Muhammad Riaz  University of Agriculture, Faisalabad.

defaecate. Then give linseed tea or warm ghee and milk every 4 hours to soothe the inflamed gullet, stomach and intestines.

Calotropis procera (Aak): Camels do not usually eat this plant, but if they do they may vomit and have diarrhoea.

Capparis tomentosa: It is found in many African countries and in some parts of Australia.
The camel’s neck becomes twisted into an S-shape. The animal is weak in legs and staggers, convulses, death takes place in most cases within 24 hours after the symptoms appear. One of the treatments for poisoning listed above may be used. Better graze animals away from areas with many Capparis shrubs, especially along river banks.

Cassia occidentalis (Senna, Kesudo): It causes diarrhoea. The animal usually recovers unless a large amount of this plant has been eaten. Rice gruel given every 3 to 4 hours leads to recovery.

Daphne oleiodes (Spurge laurel, Laghunay): Treat in the same way.

Datura alba (Thorn apple, dhatura): A bush with large angular leaves, white funnel-shaped flowers and prickly fruit, usually found on banks of water courses. The affected camel becomes very quiet and goes to sleep.

Bloat also develops. Drench the camel with a purgative such as 0.5 to 1kg Epsom salt or one litre of castor oil/linseed oil/liquid paraffin and 2 to 4 kg ghee. Repeat the administration of ghee every 4 hours until the camel has recovered.

Euphorbia tirucalli (Milk-bush): It is a bush with small thorns but no leaves, growing in thickets beside water courses in some African countries. The milky sap is intensely irritating. The symptoms and treatment are the same as for Buxus semper virens.

Lantana indica (Lantana): This plant appears to be very poisonous to camels. Major symptoms are diarrhoea, sensitivity to light and rapid death. To eliminate the poisoning effects, drench three times with 250 g of ghee mixed with 250 g of jaggery.

Nerium oleander (Oleander, Nora, Kaneer): Normally camels do not eat it but those not familiar with this plant can eat and are affected. The camel stops feeding and starts vomiting 6 to 8 hours after eating the plant. There is dullness, shivering, yawning, staggering, diarrhoea, convulsions and the camel may die after about one day.

Immediately drench with 1 kg of Mag. sulphate. Also drench with 2 to 3 litres of linseed oil or a mixture of 4 litres of milk with 8 eggs. Inject 130 mg of arecoline subcut to make the animal defaecate. Only once a day, mix a little of tartaric acid in water and force the animal to drink it. About 5 minutes later, drench with 3 g of potassium permanganate dissolved in water. Inject 0.01 to 0.1g of atropine sulphate subcut. It relaxes the intestines.

Sacrotemma andongenese: Paralysis, twisting of the neck (as if it is broken) are the salient signs resulting from the ingestion of this plant. Preferred treatment is to drench the camel with baker’s yeast mixed with sugar and water. Inject vitamin B complex. Also, give a drench of melted sheep fat.

Sorghum bicolour (Sorghum, Jowar): Sorghum stunted under drought conditions contains cyanide, a poisonous substance. When used in this condition, it causes poisoning
in many livestock species including the camel. It causes bloat and severe pain in the belly followed by difficult breathing and death. Mix up to 25 g of ammonium carbonate with oil and water and drench. Drench with 500 to 1000 ml of Tympanyl or liquid paraffin. Inject 0.01 to 0.1g of atropine under the skin. As a last resort, puncture the rumen with a trocar and cannula or a sharp knife (Figure 9b).
Fig. 8. Schematic presentation of the stomach system of ruminants (above) and camelids (below); Oe = oesophagus, Ru = rumen, Re = reticulum, Om = omasum, Ab = abomasums, D = duodenum; C1 = compartment 1, C2 = compartment 2, C3 = compartment 3, Gs = glandular sacs, H = hindstomach
Fig. 9a. A comparison of times spent feeding at different heights by camels, goats and sheep in northern Kenya. Source: Wilson (1998).

Fig. 9b. Where to puncture the rumen with trocar and cannula in case of severe tympanites. Source: K. Rollefson et al. (2001).
BREEDING AND REPRODUCTIVE MANAGEMENT

Q. Is hybridization between *C. dromedarius* and *C. bactrianus* possible? Discuss briefly.

For centuries it was believed that hybridization between *C. dromedarius* and *C. bactrianus* was not possible. However, this fallacy was disproved about 2200 years BP, but it was then assumed that the offspring of the interspecific mating were infertile as the mule and the hinny resulting from the donkey/horse. This latter premise has also long been proved false. It seems therefore that there is no reason, other than established usage, to maintain the species distinction.

Most research on crosses between the dromedary and the Bactrian varieties has been done in the former Soviet Union, especially in Kazakhstan. Hybrids have for long been known in Turkey, in northern Iran and in Afghanistan. Organized hybridization was still very important in Turkey in the second decade of the last century, when up to 8000 dromedary females were imported from Syria and farther south to be served by Bactrian males, being the most usual pattern of hybridization. The *F*₁ hybrids are almost always fertile with normal spermatogenesis in the male. The first generation female hybrid when bred back to one or other of the species produces offspring that resemble either of the male parent (dromedary or Bactrian). The *F*₁ shows heterosis in body size, hardiness, endurance and longevity. Some Bactrian characters such as hairy beard and legs are retained and the single hump is longer and not as well developed as in the dromedary. This cross is a strong draught animal whose wool yield tends towards that of the Bactrian. The milk yield and milk fat content of the hybrid are intermediate between the two parents. Other crosses, particularly from inter se breeding of the *F*₁, apparently produce weaker animals of poor conformation, which are difficult to train. Recently Dr. Skidmore (2002) in Dubai successfully crossed the dromedary with llama. The offspring was named as ‘Camella’.

Q. Give an overview of the camel’s reproductive performance, problems, and suggestions to improve the prevailing situation.

Camels are slow breeders with rather low reproductive rates. This in part is due to their large size, long life and their adaptation over thousands of years to the harsh environments in which they live. Reproductive performance can be improved by better management throughout the life of the animal, whether it be male or female. Good feeding practices in early life to encourage rapid growth and early sexual maturity will help reduce the age at which a camel has its first young. Possibly, early weaning of calves and improved nutrition of the breeding female during the period when the calf is suckling will help to shorten the interval between two successive births. Better feeding and management may also help prolong the lifespan of a camel. Diseases also affect reproductive performance. Trypanosomiasis, for example, reduces fertility and heavily infected animals may abort. Brucellosis and other bacterial diseases may also cause
abortions. Attention to health matters should thus be a priority. All these measures will result in more calves being born to a female during her lifetime and will thus reduce the need to keep large numbers of females. Overall management problems are thus reduced and damage to vegetation and the general environment minimized.

Q. Describe the anatomy and physiology of genital organs of a male camel.

Anatomy: The sheath or prepuce is large, fleshy, triangular in shape and laterally compressed. A well developed lateral preputial muscle along with the normal caudal and cranial muscles, directs the penis towards rear when urinating but toward the front at erection for copulation. The shape of the glans in the camel is like a crochet-needle (Figure 10), but it is straight and pointed in the buffalo or cow bull. Moreover, the sigmoid flexure in the camel penis is prescrotal, whereas in buffalo or cow bull it is postscrotal. At sexual maturity the penis becomes free of the prepuce under the action of the male hormone, testosterone; this usually occurs at about 3 years of age. The scrotum is small. It is attached high up between the back legs and does not hang loose. It is not distinctly divided into two compartments. The testes have already descended into the scrotum at birth but are small up to 3 years age. At this time a spectacular increase in weight and volume occurs as the camel reaches puberty. It is not advisable to use camels for breeding until they are at least four years old. Some viable sperm is present in camels throughout the year but male camels are the most fertile when their testicles are heaviest and largest. Tables 8a and 8b show the effect of age and seasons on testicular development in camels.

**Table 8a. Testicular development in Israeli camels (age and testis position)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Age and testis position</th>
<th>&lt; 3 years</th>
<th>3-5 years</th>
<th>≥ 6 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Left</td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Weight (g)</td>
<td></td>
<td>2.3</td>
<td>2.4</td>
<td>38.7</td>
</tr>
<tr>
<td>Circumference (mm)</td>
<td></td>
<td>38.7</td>
<td>38.7</td>
<td>94.8</td>
</tr>
</tbody>
</table>


**Table 8b. Testicular development in Indian camels (season and testis position)**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Age and testis position</th>
<th>August-November (moderate summer)</th>
<th>December-March (winter)</th>
<th>April-July (extreme summer)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Left</td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>4-8</td>
<td></td>
<td>60.8</td>
<td>58.8</td>
<td>78.4</td>
</tr>
<tr>
<td>9-14</td>
<td></td>
<td>168.2</td>
<td>162.2</td>
<td>194.7</td>
</tr>
<tr>
<td>15-20</td>
<td></td>
<td>168.0</td>
<td>166.0</td>
<td>199.0</td>
</tr>
</tbody>
</table>

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The seminiferous tubules are the site of sperm production. The seasonal changes that occur in tubule diameter are also related to fertility, these being widest when the testicles are heaviest and the camel most fertile. The epididymis (tube) carries the sperm from the seminiferous tubules to the testicles to which it is attached to both ends. The sperm mature in the first and middle part of the epididymis and are stored for a time in its end part.

The erectile tissue of the penis comprises many venous spaces of various sizes, which contain elastic fibres but no muscular tissue. The end of the penis is curved in a sickle shape and there is no true glans penis. The penis is about 60 cm long. Its diameter varies from 2.2 cm at the root to 1.6 cm in the middle and to 0.4 cm at the extreme end.

**Physiology:** Under most conditions male camels attain puberty at 3 to 4 years. Spermatogenesis is continuous throughout the year, but in many areas activity varies with the season. Sperm production is at a low level at 3 to 4 years and rises to a peak at 6 to 7 years, varying on average from 70 to 370 m/ml. The possibilities of getting conceived of a female thus appear to be more with an older camel than with a younger one.

Male camels show a strong rut when they are ready for breeding. The intensity of the rut varies in different climatic areas. In Pakistan, the rut season usually is December to March. However, February, March and April are the usual months for breeding in the highlands. The physiological changes associated with the physical signs of rut are an increase in androgens in the blood. The poll glands in male camels increase in size during the rut and secrete a sticky dark reddish fluid which has androgen concentration similar to that of the blood. These secretions are often the first signs of the approaching mating season and an indication for the handler to prepare his herd for mating.

Q. **Write a note on the accessory sex glands in the camel.**

The prostate gland in the camel is a discoidal mass, dark yellow in colour and located on the superior edge of the first portion of the pelvic urethra, at the level of the neck of the bladder. It measures 3.7 X 5 cm. It has several ducts on either side, which perforate the urethra. The bulbo-urethral glands are formed by two lobules situated on either side of the terminal portion of the pelvic urethra. They are whitish in colour, almond shaped, and measure 2.5 X 1.2 cm. The seminal vesicle is not present in the camel.

Q. **Discuss the behavioural changes that are usually observed in a camel in rut.**

A rutting bull when approached by other males or humans, assumes a typical stance. The rear legs are widespread and the bull positions himself laterally so that he seems bigger and more threatening. He shows typical scent marking behaviour. The poll gland secretion is rubbed onto shrubs repeatedly, especially in the presence of other bulls. In bachelor herds mostly bulls appear to go through a quiescent rutting period, which develops into full rut when a male joins a female herd. During the rutting period, the camel becomes aggressive to other camels, to its handler and can be extremely dangerous. A rutting male grinds his teeth, lashes his tail, waves his head and neck, froths at the mouth and urinates frequently, splashing urine all around. During rutting the incidence of fights among males in mixed herds is very high. After having established dominance, only the dominant bull, which is usually the oldest and heaviest will display the characteristic behaviour, while other males only show a subdued version or lose libido and go out of rut. The dominant bull drastically loses condition due to loss of
appetite and reduction in feed intake; at times diarrhoea may accompany. His abdomen is markedly tucked up and hump gradually decreases in size. A characteristic feature of the rut is the protrusion of the soft palate or ‘dulaa’. The palate is filled with air from the lungs and it is possible that its protrusion and the accompanying gurgling sounds are attractive to the female. Rut is a period of strong sexual activity during a limited time presumably controlled by the level of testosterone. Rut can be induced with gonadotropin treatment and better nutrition.

Q. **What do you understand by the term ‘Dulaa’?**

Dulaa is the Arabic name for the mucous membrane covered expandable diverticulum on the ventral center of the Arabian camel’s soft palate, near its origin. It is present in both sexes, but much more developed in entire males who inflate it as a part of sexual display (Figure 11). The diverticulum is based on loose connective tissue and mucous glands are present. The exact method of inflation is not well understood. When inflated, most commonly during the breeding season, the dulaa projects from the side of the mouth as a rather dramatic, pink to red, balloon-like structure. Reports indicate that majority of male camels display the dulaa at the right side of the mouth. Young bulls and some females can produce the mature bulls gurgling dulaa rattle but neither can produce the full male display, complete with bubbly saliva. The Bactrian camel does not have a dulaa.

Surgical removal of the dulaa is undertaken when it is believed to be causing airway obstruction. The operation is carried out with the camel sedated with Xylazine and Ketamine.

Q. **Describe the salient features of courtship and mating behaviour in camel.**

During oestrus the female will seek the bull camel, may even sit in front of him. However, the intensity of heat varies both individually and seasonally. It has been reported that 14, 31 and 55% of females exhibit weak, moderate and intense signs of heat respectively. Those in heat are restless, bleat frequently and actively try to get close to the dominant male. The tail is lifted and waved about and small quantities of urine are passed frequently. A foul smelling slight discharge from the vulva may be present. The vulva is relaxed and slightly oedematous. The bull camel tends to herd its females and constantly investigates their perineal regions. He displays ‘flehmen’, a typical behavioural pattern seen in ungulates. Receptive females are pursued by him and then one of them is forced down (Figure 12). Once in sternal recumbency, the bull will mount the female from the rear (Figure 13). Copulation act is indeed unusual in that it takes place with the female on the ground. The male rotates his penis until the vulva is found. During copulation the bull gurgles, froths and may even extrude the dulaa (soft palate). The whole sex act lasts on average for about 8 to 12 minutes. It usually consists of several entries and the male may exhaust himself on one female if he is not removed by the handler. If the female has conceived she will refuse to lie down and curl up her tail when approached by the male.

The earliest time tail lifting (curling) can be observed is 20-25 days after copulation, however, at this time it does not appear to be a reliable indicator of early pregnancy. If it still persists 2 months later, it is reliable. Mid-term pregnant females always show tail curling when approached by bulls.
Q. Write down the characteristics of semen of a dromedary.
The semen colour is usually creamy white but varies from light grey to milky. The colour is related to the density of sperm (darker colours having more sperm) and is considered as an indication of potential fertility. The volume of a natural ejaculation can be as much as 15 ml but the volumes obtained using an artificial vagina or an electro-ejaculator are less. Motility varies from 60 to 80%. The proportion of females becoming pregnant from a single mating early in breeding season may be lower as fewer sperm are actively seeking the ovum. It is thus advisable to allow two or three matings at this time and reduce the number later on. Comparatively older males are always likely to get a higher proportion of females pregnant than younger males with lower sperm counts and smaller ejaculate volumes. The total length of camel spermatozoa is short and is usually less than 50 µm. The head is elliptical. Abnormal sperm are uncommon. Semen collection using an artificial vagina is not always successful but electro-ejaculation is a sure way of obtaining semen. A bull in his prime, 7-13 years old, can serve up to 50 females during one breeding season.

Q. Describe the anatomy and physiology of genitalia of a female camel.

Anatomy: The vulva is 3 to 5 cm deep with thick velvety lips, the clitoris being very small. The urethra is short and the opening in the bladder for the passage of urine is very narrow. The vagina is 30 to 40 cm in length and lined with mucosal folds. It is wide and as pregnancy advances, it extends and mucosal folds stretch with increasing weight of the uterus. The cervix consists of outgrowth ridges arranged in three or four rows. The oviducts, 17 to 28 cm long, follow a tortuous course to the horns but more so in the ovarian part of the fallopian tube and the ampulla than in the isthmus. Unlike other mammals, the oviducts are enlarged at the uterine end. This unique arrangement allows large numbers of spermatozoa to be stored for a long time. This arrangement increases the chance of conception and of reproductive success.

The camel has a bicornuate uterus, which is T-rather than the normal Y-shaped. The body is short, reddish in colour and smooth, the left horn being longer than the right. The uterus is usually attached low in the abdomen and it increases in weight during follicular activity. The ovaries are flattened, consist of a series of lobes and are reddish brown in colour. Each is enclosed in an ovarian bursa. The size of the ovary is 15 mm x 30mm. Non-functioning ovaries may weigh as little as 3.7 g, those with Graafian follicles 5.5 g and those containing a corpus luteum of pregnancy about 8 g (Figure 14). Graafian follicles occasionally persist into pregnancy but in non-pregnant females are distributed randomly over the ovarian surface. They are opaque and spherical and up to 18 mm in diameter. Ovarian activity is related to the development of the follicles rather than to that of a corpus luteum, which is usually present only when an animal is pregnant. The udder has four quarters, the front two being separated more distinctly from each other than they are from the two smaller rear quarters. The udder is covered by a thin black skin. The teats are small and each has two small openings.

Physiology

The Follicular Wave: The regular and recurring hormonally controlled sequence of events which ends in automatic release of an ovum (or ova) is in a way known as the
oestrous cycle. The term oestrous cycle thus correctly refers to animals which are spontaneous ovulators, this type of ovulation being the norm in the majority of animals. In a few mammals, including cats, the rabbit and the camel, the breaking open of the follicle to allow the release of the egg does not occur spontaneously and some kind of stimulus is required to induce release of the ova. This type of cycle involving reflex or induced ovulation is known as follicular wave.

In spontaneous ovulators, the oestrous cycle consists of four distinct phases known as pro-oestrus, oestrus, met-oestrus and di-oestrus. In induced ovulators, and specifically in the camel, there are also four distinct phases. The four phases of the follicular wave in camels are:

i) **The mature follicular stage** is equivalent to oestrus or heat in other farm animals. The camel may not be considered to be in continuous oestrus in spite of the fact that ovarian maturity is follicular. Female camels accept the male only during the mature follicular stage. Camels should therefore be watched for signs of heat and mated only at that time (in this respect it is an interesting fact that among some camel tribes in Eastern Africa, it is a common practice to forcefully mate female camels whenever a rutting bull is available. With this technique over 50% of the females are reported to get pregnant).

ii) **The atretic follicular stage.** The follicle regresses and becomes smaller in size. This stage starts if mating does not take place during the maturing follicular stage.

iii) **The non-follicular stage.**

iv) **The growing follicular stage.**

**Q. What, generally, is the age of puberty in camels?**

It is generally accepted that in camels the age of puberty, in both sexes, is 3 to 4 years. Pregnancy testing of 20 camels in Australia indicated that 6 herd mated animals 2 to 2.5 years old were in early stages of their pregnancy. The prepuberal gonads and genital tract have been reported to be responsive to the exogenous gonadotropic hormones. This property has been utilized in reducing the age of puberty and thus improving the reproductive performance of the dromedary camels.

**Q. Discuss the peculiarities of breeding behaviour of one-humped camel.**

Camels are seasonal breeders but male activity is more affected than that of the female. **Male:** The seasonal breeding behaviour of the male camel is referred to as ‘rut’. It is mainly exhibited from mid November to the end of March in various parts of Indo-Pakistan subcontinent. Since geographical and topographical factors are involved, therefore rut is exhibited in the Southern Hemisphere during the months of May to October. It is generally first exhibited at around the age of 3 years. Males in rut become more aggressive and testicular size increases. In the presence of a female or another male in view, they stand with their legs apart, flick urine onto their back with the tail, froth at the mouth while making gurgling noises and protrude their dulaa. The poll glands become active and exudates a dark, acrid smelling secretion, which appears to attract females. Variations of this behaviour are used in the wild to repulse challenges from other bulls and protect the established ‘harem’. Rutting bulls also tend to be more aggressive to handlers and unpredictable in their general behaviour. Urine of the rutting
bull has high testosterone levels and some pheromones. Androgens levels in poll gland secretion are the same as those in the blood.

Males as young as 6 months may attempt to mount their recumbent mothers. Adult males may attempt to mate recumbent females even when they are not in oestrus. Some males may be fussy and refuse to mate with thin young females because of discomfort. Inexperienced bulls may be seen to attempt to mount from any direction, even over the female’s head. This may induce the female to bite and occasionally inflict damage to the bull’s genital organs. It is usual for the male to smell the vulva and urine, and react by lifting its head and elevating the upper lip (flehmen). Particular stimulus appears to be from pheromones in oestral urine. The male may wrestle uncooperative females to the ground, pin and choke her into submission with his neck over hers and then proceed with mating, always in the couched position. A bull in rut can serve 50 to 60 females in a season under controlled mating conditions, which helps prevent too much time being spent with each female, and provided he continues to eat well and hold his condition. Reports from Australia indicate that it is common to observe bulls in very thin body condition at the end of the breeding season. Apart from the time spent in courtship and coitus, these animals have had to be constantly on guard against intrusion by rival males. Thus the time available for eating may be quite limited. The length of an individual bull’s rut varies from 2 to 4 months, which may depend upon the availability of feedstuff and various social factors. A bull that was dominant early in the season may be weakened and driven off by another bull later in the season.

The rut may be induced early or extended beyond its course by the use of hormones. Gonadotropin releasing hormone (GnRH e.g. Receptal 10 ml) given IM 2 to 3 times daily for three days then once daily for 4 to 5 days usually induces signs of rut. During rut libido may be improved by the same daily dose of GnRH, reduced to every second day for 2 to 3 weeks when the response is established. The use of GnRH is preferred to testosterone, which tends to accentuate aggressiveness.

**Female:** Females kept separate from males will make a gurgling call, almost like that of the male in rut, when she is ready to mate. She will get as close as possible to the male as allowed by the situation. For controlled mating the traditional procedure is to take the female to a sandy location and couch her with her head slightly downhill if possible. About 50% of females ready for mating will couch spontaneously as the male approaches. Others, especially young animals may have to be forcibly restrained in couched position with the front legs hobbled together across the animal’s neck. In a free mating situation, the male will dominate by wrestling the female to the ground. Coitus takes place with the female in the couched position. The male covers the female by placing a front leg each side of the female’s hump, his pedestal on her dorsal midline behind her hump and crouches back and down into the coital position. Depending upon the relative sizes of male and female, the front feet of the male may or may not reach the ground.

The process commences with the bull making forward probing, thrusting movements with hips. To save time and prevent contamination during hand mating, it is usual for an attendant to grasp the penis and direct it through the vulval labia. In the wild intromission
may take some time to establish. Coital activity then proceeds with short thrusting bursts punctuated by longer periods of inactivity. Some bulls are more vigorous than others. Some older bulls tend to just crouch and do very little. Coitus may last from 3 to 30 minutes, but averages 8 to 12 minutes. Over vigorous or rough, heavy bulls can cause dislocation or fracture of the female’s sacrum. Some physical stimulation of the female appears to be necessary for ovulation to occur. Artificial introduction of semen into the female genital tract does not stimulate ovulation.

Q. Discuss the normal increase or decrease in certain hormones in the rutting period in the camel.

The rutting period in male has many physiological and behavioural peculiarities. There are significant increases in FSH, LH, testosterone and cortisol during the rutting season. The male camel loses a considerable body weight (up to 25%) during this period because its sexual activity distracts him from normal feeding.

Gonadotrophin-releasing hormone (GnRH) is a decapptide hormone secreted from the hypothalamus in a pulsatile manner. Its synthesis and release is affected by season, photoperiod and endocrine status. It acts on the pituitary gland to stimulate release of LH and FSH, in a ratio influenced by the feedback effects of steroid hormones. Sexual activity in normal male camels outside the breeding season could be stimulated by GnRH treatment. It is also possible that the pheromonal ‘male effect’ may induce female camels to cycle earlier in the breeding season. There also appears to be an alteration in the semen consistency with GnRH administration.

In the non-breeding season hyperprolactinaemia accompanied by decreased serum levels of FSH, LH, testosterone and cortisol has been observed in Arabian camels. It seems that hyperprolactinaemia is a causative factor of low fertility and libido in the male camel during the non-breeding season. This is probably due to its action in reducing the synthesis and secretion of FSH and LH. There is also a possibility that prolactin has an anti-gonadotrophic action at the gonadal level. In the male camel, as also in other species, instances of lack of sexual desire and inability to copulate during the rutting season have been observed. Because of comparatively lengthy act of copulation, and the fact that several ejaculations may occur during mating, wide variations in ejaculate volume and in sperm concentration and motility have been reported. Thus poor semen quality could be a cause of herd infertility under range conditions (Chaudhary, 2000).

Protrusion of the soft palate in camel is observed in the rutting season, but it is not extruded in the female. Erection of the penis does not occur during courtship in the standing position, which indicates that foreplay and a set period of time for full arousal are not necessary for successful breeding in the camel.

Q. Give below the salient characteristics of semen of one-humped camel.

Indicate the sperm concentration for artificial insemination.

Considerable variation in the semen characteristics of Arabian camel have been reported. The semen is greyish-white in appearance and total volume ranges from 2 to 8 ml. Sperm concentration ranges from 256 to 440 X 10⁶ per ml. Sperm motility in raw semen examined 15 minutes after collection ranges from 30 to 50% and motility may be
preserved best at room temperature by diluting the semen 1:2 in skim milk/glucose diluent containing antibiotics.

Good quality semen to be used for artificial insemination in camels should have at least sperm concentration of 325 to 331 X 10^6/ml and sperm motility of 49.5 to 50.5%. The proportion of dead spermatozoa should not be more than 18 to 19%, sperm showing morphological abnormalities 27.7% and sperm showing acrosome abnormalities 8.5%. The sperm concentration is usually measured with haemocytometer. The sperm motility is evaluated using phase contrast microscope at a magnification of X 128, slide being put on a warmed stage (38°C), standard commercial stains such as Krass for examining morphology and Eosin colour test of Bartmann for recording percentage of dead spermatozoa.

**Q. What do you think is the optimum time and proper site for artificial insemination in the Arabian camel?**

Proper time for artificial insemination involves the time during an oestrus period best suited for the successful union of the ovum and the sperm cell as well as the optimum cyclic conditions of female reproductive tract. It is recommended that the optimum time for insemination with fresh semen is first day on which the camel shows signs of oestrus, ovulation usually occurs 24 to 36 hours later. When inseminating with frozen semen, it is good to inseminate twice 24 hours apart, so as to be sure of supplying ample ovulation inducing factor. Best results have been obtained when inseminated 24 hours after mating with a vasectomized male.

Artificial insemination in the camel is either vaginal or uterine. The uterus is bicornuate. The cervix is dilatable and two fingers can easily be inserted into it at the time of follicular activity. This indicates an easy by pass of cervix by AI gun for insemination or for embryo transfer. The incidence of ovulation after deep vaginal and uterine inseminations was reported as 87 and 100% respectively, showing the possibility of higher conception rate with uterine insemination in the camel. The camel is inseminated restrained preferably in sitting position. However, some authors inseminated camels in standing position using a mare inseminating catheter, guided through the cervix by manipulation per-rectum (Chaudhary, 2000).

**Q. Discuss infertility in one-humped camel.**

The fertility of she camels is maintained almost throughout their lives and breeding in alternate years is the usual practice. The fertility of female camels is apparently high and the herd owners claim that 80 to 90% of those mated in one season produce calves. A similar fertility rate has been reported in herds managed intensively. The abattoir studies confirmed that the structural defects of the genitalia, including cystic ovaries and ovariobursal adhesions are relatively rare. Endometritis associated with a partially involuted uterus and a regressing corpus luteum is sometimes seen. The fertility in the pastoral herds of camels is unlikely to be more than 50%, or up to 65% under improved management. It has also been seen in field studies involving a large number of Asian and African countries that delayed puberty (first pregnancy at 5 years of age), long interval between births (>24 months) and early culling of breeding females limit the average production of calves to less than three per female. Anoestrus, due to malnutrition or
debilitating diseases, is probably a major cause of infertility. Embryonic death is known to occur, especially in twin gestations. Poor nutrition and trypanosomiasis are probably responsible in part for the embryonic deaths. Reports of bacterial infertility in female camels are scant and most investigations have been done in slaughtered camels with no previous breeding histories. *Corynebacteria, Anthraxoids, Micrococci, Sarcina* and gram-negative bacilli were isolated from the normal genital tract of pregnant and non-pregnant slaughtered camels. Other bacterial species such as *Staphylococcus epidermidis* and *Escherichia coli* were also identified.

**Q. Discuss pregnancy in dromedary, giving details of implantation, foetal development, duration and diagnosis of pregnancy.**

Ovulation occurs about 30 hours after coitus. After fertilization in the fallopian tube, the embryo enters the uterus 5 to 5.5 days after ovulation. Unfertilised ova degenerate in the fallopian tube as in the mare. The conceptus is visible ultrasonically at 17 to 18 days and is elongating by day 20. Migration within the uterus is common and 7 to 9 day embryos placed into right horn will migrate to the left. Nearly 99% of pregnancies occupy the left uterine horn. Implantation occurs at about day 14. Placentation is diffuse and epitheliochorial, as in the mare. The camel, however, has three foetal membranes. In addition to the allantois and amnion, camelid foetuses are enveloped, except at certain points, by a closer epidermal membrane. This third membrane permits the lips, genitals, anus, teats and hooves to have access to the amniotic fluid.

**Foetal Development:** The camel embryo elongates quickly and soon protrudes from the left horn onto the right uterine horn. Videoscopic studies showed allantochorion to be in left horn at day 20 which extended into the right by day 25. Examination at day 44 showed the exposed surface of the allantochorion to have a roughened and hazy appearance, presumably due to the development of simple chorionic villi in the process of implantation and placentation. When examined by the transmission electron microscope, these villi are present on the trophoblast cells of embryos as young as 7 days. At 44 days the tail and four limb buds are visible on the foetus and the head, eye, umbilical cord and heart beat are discernible. At 55 days the allantochorion is thickened and spotty and presses on the internal os of the cervix. The foetus is clearly seen to have rudimentary bones and a more camel-like head and neck. Blood vessels are also more developed by now. When the FBL (foetus body length) is 1 to 10 cm, the allantoic fluid volume is 1.5 litres. When FBL is 90 cm, fluid volume is 5 to 6 litres and finally reaches about 8.5 litres when the FBL is 100 to 107 cm. The fluid resembles pale urine. When the FBL is 0 to 10 cm, the volume of amniotic fluid is 13 ml. It increases to a volume of about 1 litre at parturition. The fluid may be watery or cloudy due to the presence of meconial debris.

The extra close fitting of epidermal membrane becomes apparent when FBL reaches 41 cm. It closely envelopes the foetus but leaves the orifices open to the true amnion. It appears to be a major source for the relative ease of birth in the camel.

**Duration of Pregnancy:** It has a range of 370 to 405 days with an average of 388 days. The period of gestation for female calves averages at 390 days, while for males 385 days. Lower limit for survival of foetus is 350 days. Calves born at or just before this time may appear weak but otherwise normal for the first 24 hours post partum but then go into
irreversible decline surviving only for 2 to 3 days. Average pregnancy duration in the Bactrian is about 400 days.

**Signs of Pregnancy and Diagnosis:** An evident sign is that the pregnant female is no longer receptive to the male. She will try to repulse close male attention by biting. A pregnant dromedary exhibits the tail up reflex after about 15 days. The reflex can vary in intensity from a tail held just above horizontal to an almost vertical tail, exhibiting tremor. The reflex is elicited by the approach of a male. The inexperienced observer can confuse the reflex with a tail up response to fear. The tail up response due to fear usually has no tremor. The true tail up reflex appears to depend upon the presence of a corpus luteum. It is also present in a female treated with hCG (human origin chorionic gonadotropin) and in females treated with natural progesterone, 100 g once daily for more than 4 days. When hormonally induced, the reflex does not persist for more than 18 to 20 days.

Accurate diagnosis is based upon manual and/or ultrasonic examination per-rectum. Manual examination can be performed in the dromedary at 45 to 50 days and in the Bacterian at 30 days. Workers at the SCRC (Dubai) has recently established the ultrasonographic appearance of the gravid uterus and foetal structures from 17 to 320 days of pregnancy, using a 5MHz probe on an Aloka machine. Pregnancy can be diagnosed as early as 17 to 18 days when a non-echogenic space (fluid filled) 10 to 15 mm long and 4 to 6 mm wide will be seen. At 20 days, the embryo within its spherical, fluid filled yolk sac can be seen and the heart beat is discernible. At 26 days the conceptus occupies the entire left horn and the allantois is visible. The enlarging allantois forces the embryo dorsally within the vesicle until the 35th day, after which the yolk sac is sufficiently incorporated in the developing umbilical cord to allow the foetus to move towards the ventral uterine wall again. Blood progesterone assay has also been used for pregnancy testing in the dromedary. Persistence of a level >1ng/ml after day 12 (post mating) is considered a strong indication of pregnancy. Generally, however, progesterone assay has a limited application in reproductive management in the dromedary.

The birth of twins is rather rare in camels (Manefield and Tinson, 1997).

**Q.** What is the usual frequency of embryonic resorption in dromedary?

Almost 10 to 15% of camels diagnosed pregnant at 20 days are found to have lost the embryo by day 40. The reason for this resorption is not understood. Since the persistence of the corpus luteum appears to maintain the pregnancy throughout the gestation period in camel, therefore it is not likely to be due to change over to placental control. The resorption rate has been reported to be the same following both natural and embryo transfer pregnancies.

**Q.** What are the salient signs and various labour stages observed in the process of parturition in the camel?

Varying degrees of abdominal distension are exhibited by camels when they are close to parturition. Some breeds show considerable enlargement from about 6 months. Other more reliable signs are udder enlargement with the presence of colostrum and varying degrees of oedema, vulval oedema during preceding 5 to 7 days, sacrosciatic ligament
relaxation in the preceding 10 to 14 days. Signs of imminent parturition are restlessness, the tail carried in a horizontal position, voluntary isolation if permitted by situation. The first labour stage may have a duration of 5 to 24 hours and is characterised by restlessness, the tail being held almost continuously horizontal, frequent passage of small quantities of urine, frequent coughing, rising, rolling, straining commences during the later part of this stage. The second stage marks the appearance of the intact allantochorion at the vulva or a discharge of fluid from its prior rupture. Strong expulsive efforts made and may be some struggling type discomfort shown by primiparous animals. The foetal nose appears at the vulva with the head resting on or between the front legs. Posterior presentations are very rare. The foetal expulsion takes about 20 to 40 minutes. In the presence of the normal lubricating foetal fluid, the camel foetus presents less problems for expulsion. The additional epithelial membrane enveloping the camel foetus may have a significant role in this respect since it is highly slippery when lubricated with amniotic fluid. Primiparous females usually complete the second stage of labour in the standing position. They wander around as if they do not quite known what to do. The calf from these animals is literally dropped into the world and as a result the umbilicus breaks earlier than is usually the case. Total volume of foetal fluid is about 9 litres, of which 80 to 90% is allantoic fluid. It is fairly established that amniochorionic sac ruptures first in the Bactrian but some authors opine that the allantochorionic sac ruptures first in the dromedary, as is the case in the mare and the cow. The third labour stage covers the events from birth to expulsion of placenta (foetal membranes). This stage on average occupies about 30 minutes. Apart from the case of primiparous animals, rupture of the umbilicus occurs when the calf vigorously moves away or the mother stands. Camels do not eat the foetal membranes. The mother nuzzles and prods the newborn rather than to lick it in the fashion of other species. The calf takes on average 30 minutes to 1 hour to stand up and time to first suckle is between 1.5 and 2 hours. Within a few days it is able to follow its mother. Retention of placenta beyond 12 hours is unusual. When necessary manual removal may be resorted to after injecting 1M, 5 ml of oxytocin. Removal of placenta should be followed by insertion of antibiotic pessaries (e.g. Utozyme foaming pessaries). Q. What percentage of difficult births are encountered in camels? What precautions and procedures need to be adopted in dystocia cases in camels? Although the camel foetus has long legs and neck yet only in about 1% of births difficulty is encountered. Such cases are on record where live calves have been delivered after 12 hours of stage 2 labour. Of course, unnecessary delay is not advisable, yet it is suggested not to interfere until stage 2 has been in operation for at least 1 to 2 hours without any visible progress. The most dangerous dystocia case is that when the foetus is so retained that presence of its nose or limbs within the cervix does not reflexively stimulate voluntary expulsive efforts. In such cases the pregnant animal may become comfortable and resume feeding. Thus if preparturient females are not under adequate, quiet surveillance by experienced personnel, dystocia in these animals may be missed until they show up as very ill, toxic animals, retaining decomposing foetuses. As a precautionary measure, plenty of
unobtrusive observation is the key to this problem. Binoculars can be an invaluable aid. Once the placental sac is visible or ruptured, the camel should be examined, if there is no progress for foetal delivery within an hour, regardless of the expulsive effort or lack of it. When it is decided to manually examine the animal, she should preferably be restrained in stocks, since any malposition is rather easily corrected in the standing position. If stocks are not available, some sort of hobbles should be applied to ensure that all kicking is controlled. If it is impossible to examine the animal in standing position then she may be couched, but it makes the obstetrical procedures very difficult.

The perineum of the animal is thoroughly cleaned and washed with a mild disinfectant solution. The obstetrician should wash his hands and arms in a fresh bucket of similar mild disinfectant. Any loss of natural birth lubricants due to use of soap, can be counteracted by the use of K-Y jelly or obstetrical lubricant. Obstruction to foetal expulsion should be removed by correction of malpresentation or any parturient problem. When the foetus is dead, in cases such as extreme lateral neck allows limb traction to deliver first the foetal body and the severed head and neck later. When foetus is alive and correction and vaginal delivery do not seem possible then a caesarean section should be performed.

In an anterior presentation, delivery may be assisted by applying traction to both legs and head. Obstetrical soft ropes should first be applied above the fetlock and then a half hitch thrown around the pastern. Thus the traction load is shared between the metacarpus/metatarsus and the pastern. This helps avoid fracture of the metacarpus/metatarsus and damage to the fetlock joint. The head rope should noose with its loop placed just to the ears and the sliding portion within the mouth. Main traction should be applied first to one leg then the other, while moderate tension on the head rope prevents the neck from bulking within the canal.

Q. Give the procedure to perform caesarean section in the camel.

Instead of risking the life of a valuable calf through prolonged obstetrical manipulation, it is better to subject the camel to caesarean section and save the calf as well as the mother. The operation is preferably performed with the camel in sternal recumbency until the uterus is sutured. If, however wound tension indicates, the animal may be placed in lateral recumbency for abdominal closure. Xylazine and Ketamine are used for restraint and analgesia, whereas the incision line is infiltrated with a local anaesthetic. Some operators use epidural anaesthesia to immobilize the tail and to minimize voluntary straining due to cervical stimulation. Before the laparotomy incision is made in the left flank, the whole area should be shaved, washed with povidine iodine scrub and then liberally painted with pyodine. The use of drapes depends upon the choice of the surgeon (Manefield and Tinson, 1997).

The laparotomy incision should be 25 to 30 cm long. Some surgeons commence the incision 8 to 10 cm below the lumbar transverse processes and proceed vertically downwards about 10 cm caudal to the last rib. The muscle wound is best made as a straight cut in a vertical wound since it provides better access than developed splits. With the oblique incision the opening may allow a split in the external oblique muscle and the others are cut. Whatever the technique used, the surgeon must take pains to protect
spleen, which in the camel is attached to the caudolateral aspect of the rumen. The gravid uterus should be identified by palpating portions of the calf through the wall of the uterus. The preferred uterine incision site is around its greater curvature to avoid large blood vessels. The incision area should be brought as close to the wound as possible. If the incision site can be exteriorized, spillage of uterine fluid into the abdomen can be largely avoided. On many occasions, because of the mass involved, it is not possible to achieve the ideal exposure. If the use of a scalpel within the peritoneal cavity is deemed to be unsafe, the uterus may be penetrated and opened using straight Mayo scissors. Before taking up uterine closure, the placenta should be freed from the vicinity of the wound to avoid its being penetrated and caught by the sutures.

In case the placenta is relatively loose, it can be freed and removed but remember that surgical time should not be unduly prolonged. Also, any attempt at removal should cease if haemorrhage is induced. Initial closure of the uterine wound is achieved by a simple, continuous, right through suture of size metric 7 chromic gut. This prevents the mucous membrane retracting from the wound and gives good control of haemorrhage along the wound edge. Just before closing, an antibiotic foaming pessary may be inserted into the uterus. A second suture tier of continuous horizontal mattress, Lembert or Connell pattern is placed to strengthen and seal the wound. Heavy chromic catgut of size metric 7, is used to separately close the muscle layers of the abdominal wall. Some surgeons prefer a single tier of interrupted horizontal mattress sutures. Some tension may be experienced in closure of the wound with the camel in sternal recumbency. Some surgeons therefore advocate performing the entire operation in right lateral recumbency. Those who prefer the sternal position can reposition to the lateral to facilitate closure if they like.

Q. Discuss the possibility of the use of artificial insemination (AI) in camel breeding.

There are owners who may be reluctant to travel their good bulls to other places for breeding; some may have injuries that make natural mating difficult to impossible. AI can overcome these constraints. Also, the breeding worth of bulls may not be known until they are 7 to 8 years old, the freezing of semen and use of AI can insure against premature loss of the animal. With AI one bull is able to get more females pregnant within one breeding season. Genetic material can be transferred to places where it is not possible to transport the male animal(s). Semen for AI may be used fresh or frozen. The major constraint to successful AI is that the camel is suspected to be a coitally induced ovulator.

The visual signs of oestrus in the camel can be described as erratic. Therefore, it is advisable to inseminate when ovulation potential is optimum, as determined by rectal palpation and preferably by ultrasonic examination (Manefield and Tinson, 1997). The female is presented for insemination in suitable stocks or restrained in couched position. The perineal region is cleaned and dried. The semen containing 300 to 400 million motile spermatozoa is introduced into the uterus. Frozen straws should be evaluated after thawing and the number of straws required for insemination calculated. After deposition of the semen, a dose of human origin chorionic gonadotropin (hCG) e.g. Chorulon, 300 IU, IV, is administered and insemination may preferably be repeated in 24 hours. An
alternative more suitable for field conditions is to administer a dose of prostaglandin F$_{2a}$ (e.g. Estrumate, 2 ml) and equine origin chorionic gonadotropin (eCG) e.g. Pregnercol, 2000 IU, IM, and wait for 9 to 10 days then inseminate and give hCG, the luteinising hormone. By increasing the likely number of follicles of ovulatory size being present, the eCG increases the likelihood of a mature ovum being released when luteinising hormone is administered. If the site of the follicle with best ovulation potential is known, the semen should be deposited into the ipsilateral (on the same side) horn. If multiple follicles are present, may be as a result of eCG administration, it is just as well to deposit the semen into the body of the uterus. If the animal can be examined 48 to 72 hours after the hCG administration and no ovulation has occurred, then an increased dose of hCG (Chorulon, 5000 IU, IV) with GnRH (gonadotropin releasing hormone) e.g. Receptal, 5 ml, and a further insemination is required.

Q. Describe the procedure of embryo transfer in one-humped camel.

Genetic improvement by natural breeding in camel is very slow. Even the traditional camel societies are in search of ways and means that can enhance the reproductive performance of their camels. Multiple ovulation, embryo transfer (MOET) programme, though currently beyond the means of a common man and not cost effective, offers a technique that can help overcome the constraints to the improvement of desired traits. Manefield and Tinson (1997) have described the procedure as given below:

It is common to recover 10 to 15 embryos per collection from a good donor (29 were recovered in one case). In programmes where 40 donors are matched with 160 recipients, it is possible to achieve 10 pregnancies per donor within one season for 20 to 25% of the donors flushed. This is equivalent to 20 years natural breeding potential for each successful flushing. In case of very valuable camels that only provide two embryos, the normal breeding rate may be at least doubled, and therefore, the result is considered acceptable. Two breeders working on a cycle of one month, can match 40 donors to synchronise with 160 recipients and collect and transfer >200 embryos. It is possible to repeat this cycle 4 times per breeding season with the use of 40 to 50 additional recipients for each cycle. Pregnancies up to 145 per season can be expected.

**Superovulation (SO):** It is achieved by injecting FSH (e.g. Falltropin-V; Embryo-S) or eCG (e.g. Pregnercol; Folligon) following natural progesterone in oil (e.g. Bomagest-E; Progesterone; Progestin) 100 mg once a day for 14 days. Response to the various FSH preparations can vary from camel to camel. The usual dosage schedule for Falltropin-V at a dilution of 20 mg/ml is: day 1 and 2, 3 ml IM twice a day; day 3 and 4, 2 ml IM, twice a day; day 5, 1 ml IM, twice a day; day 6 and 7, 1 ml IM, once a day. The ovaries are examined ultrasonically on day 8 and the usual time of mating is day 9 to 10. Most camels produce embryos, but number and quality varies. No adverse long term effect of 50 has been noted. After repeated 50, camels have been allowed to undergo a natural pregnancy and successfully returned to the MOET programme later. Likewise donors can be used year after year depending upon their continued response to 50 and value to the programme.
**Time of Mating:** It is determined by ultrasonic examination and the female is served twice with a 12 hour interval when follicles of 12 to 18 mm diameter are detected. This ensures best ovum maturation and ovulation.

**Embryo Collection:** Embryo collection is first performed 7 days after mating and repeated 12 to 24 hours later. The donor female is restrained in a suitable set of stocks. After thoroughly cleaning the perineum with a Savlon solution and towelling off the surplus, a silicone rubber Foley catheter is introduced and inflated in the cervix. This operation is assisted by employment of a fine metal stilet within the catheter. The operator puts on a long rectal glove with fingers cut off and a sterile surgical glove over this. Care must be taken to determine that the cuff inflated with 40 ml of air, is situated within the anterior cervix. The body of the camel uterus is so short (2 to 4 cm) that placement therein may occlude one horn and so prevent a complete simultaneous, bicornuate flush.

Flushing is accomplished by connecting a ‘Y’ shaped Vigro Bovine Uterus Tube Flushing Set to the flushing fluid reservoir (plastic bag) and the Foley catheter in the manner shown in Figure 15. This allows fluid returning from the uterus to pass through a 75 micron embryo filter. Clip 1 (C1 in Figure) is opened and the flushing fluid bag is squeezed to fill the uterus, as judged by the operator’s finger against the cervix and catheter bulb per vagina. Clip 1 is closed and clip 2 (C2 in Figure) is opened to allow the uterus to empty. The process is repeated until the flushing fluid is exhausted. Once the flush is satisfactorily established, with no cervical leakage, the operator may insert an arm per rectum to determine that both horns are being well flushed, that the horns are not being subjected to excessive fluid pressure and he can massage the organ to assist fluid recovery. Overfilling the uterus can result in endometrial tearing and a blood contaminated flush, complicating the identification and washing of the embryos. The clip below the embryo filter (C3 in Figure) is opened periodically to prevent the filter from overflowing, but also so that at all times during collection, the cup fluid level is maintained at about one-third full. For protection and continued viability of embryos, it is important to keep them totally immersed in fluid. The following two flushing fluids have been found to be satisfactory. 1) Vigro Complete Flush Solution, 2) Dulbecco’s Phosphate Buffered Saline, which includes Kanamycin 25 mg/litre and 20 ml of Bovine Serum Albumin is added to each 1 litre bag.

After flushing has been completed, the fluid in the cup above the filter grid, containing the embryos, is transferred into a gridded (having horizontal and perpendicular lines) petri dish. This dish is scanned with a stereo dissecting microscope. As each embryo is found it is picked up by a pipette and transferred to a drop of filtered holding fluid, which is one of 5 separated drops in another petri dish. Within this drop the embryo is flushed up and down 2 to 3 times. This ‘washing’ process is repeated sequentially through the rest of the drops until after the 5th rinsing, there is no debris in the drop or attached to the embryo. As each embryo is washed, it is placed in a filtered holding solution ready for grading. This solution may be Vigro HEC-2 or may be prepared by adding 1 ml of foetal calf serum to 9 ml of flushing fluid. It is filtered through a 0.2 mm Naglene filter. The embryos are graded 1 (excellent) through 5 (dead) using the usual criteria of shape,
Part – I Production and Management of Camels

Bakhat Baidar Khan, Arshad Iqbal and Muhammad Riaz University of Agriculture, Faisalabad.

colour, dead cells, compactness and shape of blastomeres in the early morula, amount of perivitelline space, cracks in the zona, definition of trophoblast border and presence of tightly adherent debris. Grading can vary a little because of its inherent subjectivity. Camel embryos do vary between animals and between flushes, but a large majority rate between 1.5 and 2.

**Recipient Preparation:** Ideally, recipients should be selected from young camels, preferably from maidens, that have uteri free from all pathology. Parallel with the SO of the donors, the recipients are given 100 mg of natural progesterone in oil once a day (e.g. Bomagest E; Progesterone; Progestin) for 10 days followed by Pregnecol, 1500 to 2000 IU and 2 ml of Estrumate on day 11. This is done to ensure creation of follicles and hence a CL (the better the luteal material, the better are the chances of pregnancy). Ovulation and luteinisation is induced in the recipients by giving them Chorulon, 3000 IU IV, 24 hours after the donors receive the same. Thus an attempt is made to have CL’s in the recipients that are one day younger than those in the donor. Best results have been achieved when the matching of recipient to donor is minus 12 to 36 hours.

**Non Surgical Embryo Transfer:** For transfer, embryos are loaded into straws and these into an embryo transfer gun. The whole procedure and apparatus are similar to that used for AI in buffaloes and cattle. Place of the embryo should be at the tip of a uterine horn. Left or right horn, placement results in a similar pregnancy rate. Almost 99% of camel pregnancies occupy the left horn, but embryo migration from the right takes place regularly. Otherwise pregnancy rate will depend upon the grade of the embryo, the health of the recipient’s reproductive tract and the degree of synchronization that has been achieved. In small groups when grade 1 embryos are transferred fresh to grade 1 recipients, a pregnancy rate of 65% can be expected. Maiden camels aged 5 to 6 years have proved to be the best recipients. In larger groups this rate falls to 50%. With cryopreserved (maintaining viability by storing at very low temperature) embryos, only 15 to 20% of transfers result in pregnancy.

**Surgical Embryo Transfer:** The recipient camel is held in stocks and sedated with 0.15 mg/kg of Xylazine and Ketamine IV. An incision line is infiltrated with a local anaesthetic and surgical transfer of embryo is made through a 20 cm horizontal incision 5 to 10 cm cranial to the iliac crest, in the left flank. The muscular opening is by muscle split and the tip of the left uterine horn is exteriorised. A small punch (an instrument for perforating or excising a segment of a tissue) incision is made in the outer uterine wall. Through this a transfer gun with a 10 ml sterile glass pipette containing the embryo is ‘popped’ through the endometrium, slipped along the lumen and discharged. The laparotomy is routinely closed. There is some difficulty in exteriorising the uterine horn in maiden recipients. Therefore, animals that have already had one calf are better. One surgical transfer requires about 40 minutes and a non-surgical transfer requires about 15 minutes. The rate of pregnancy for both methods was 33%, at the time it was done. Since then non-surgical transfer pregnancy rate has risen to 50%. Since surgical transfer method has produced no better results, is slower and more labour intensive, therefore it has been abandoned.

**Q. Write a note on progesterone and estrogen levels in camels at oestrus.**

_Bakhat Baidar Khan, Arshad Iqbal and Muhammad Riaz University of Agriculture, Faisalabad._
Progesterone levels in camels at oestrus are about 0.5 ng/ml, while oestrogens are at peak of 75 pg/ml. The level of oestrogen rises to 3.5 ng/ml at days 3 to 6 and then to a peak of 4.5 ng/ml at day 9 in mated camels; it then falls rapidly again. Oestrogen levels drop to 15.1 pg/ml at the first stage and remain low. The concentration of luteinizing hormone rises rapidly to a maximum of 6.9 ng/ml from a basal level of 2.7 ng/ml, starting one hour after coital (or other) stimulation, reaches a peak at three hours and remains high for about 10 hours. Ovulation takes place 36 to 48 hours after mating. These variations in level can be used to determine the best time for mating to take place.

Q. Do you think that camels (one-humped) are polyoestrus? Discuss in detail.

It has long been accepted that camels undergo several cycles, which follow each other; they are in fact polyoestrus animals. It was long thought that oestrus occurred only at certain times of the year. However, it is now known that in most areas follicular wave activity does occur all the year round. In areas having marked weather changes among the season, follicular activity is at its greatest in winter and spring and the total cycle is longer at this period. During the summer, the phase lasts only for a very short time and the growing follicular stage is relatively long.

In Egypt, the mean duration of the follicular wave is 24.2 days with oestrus lasting 4.6 days within a range of 0 to 15 days. In Sudan, the length of the wave is 28 days with oestrus lasting 4 to 6 days within a range of 1 to 7 days and in India the wave is 23.4 days and oestrus averaged 5.0 days within a range of 3 to 6 days. In all areas the natural mating season is at that part of year when the follicular wave is the longest. Most conceptions occur at this time. Long cycles are certainly associated with environmental conditions, including lower temperature and better nutrition. Mating seasons can probably be prolonged or even made to be year round if feeding and other management factors are adjusted to ensure that conditions are appropriate for the longer cycles.

Q. What is frequency of occurrence of dystocia and vaginal prolapise in camel?

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

Q. What may be an appropriate age at first parturition in dromedaries? Give examples in this respect.

In traditionally managed herds in Kenya, camels first calved at an average age of 4 years and 10 months. In one of the studies in Niger, it was found that between 3 and 80% of females first gave birth at 4 to 5 years. About 95% had produced at least one young at 6 years, whereas one of these groups of camels did not produce their first young till 8 to 9 years age. A survey carried out among herders in Sudan indicated that 2% of females first had a calf at 3 to 4 years age, 10% at 5.5 years, 37% at 5 to 6 years and 51% at more than 6 years. At the National Camel Research Centre in India, age at first calving was reduced from 5 years 2 months in the period 1961-85 to 4 years and 1 month from 1986-90,
mainly due to the effects of better management. In the United Arab Emirates animals whose own birth dates were known were mated first at 3 years and 7 months and calved at 4 years and 7 months.

In summary, it seems that the management implications of this are clear: better feeding, improved health care and better overall management will enable camels to produce their first calf at a younger age and add to the total length of their breeding life. In traditional systems better feeding conditions may result from long-distance migration. In sedentary or modern systems, supplementary feeding in early life and keeping camel numbers down to the carrying capacity of the feed resource will help to lower the age at first calving. Further information on feeding to improve overall performance is given in chapter on Feeding and Nutrition.

Q. Write a note on traditional and improved parturition intervals in camels.

Most of the available information indicates that the interval between successive births in camels is about 2 years. However, under commercial ranch management in Kenya, the average of 460 intervals was 16.7 months. Most intervals averaged about 18 months but there were some at about 13 to 14 months and relatively few longer than 30 months. Parity did not have any real influence on the interval. An abortion or the death of the young before weaning led to a shorter interval to the next birth than if the young survived to weaning. This was probably because lactation stopped so the hormones controlling milk production which also suppress the reproductive hormones disappeared and allowed animals to start their sexual cycles again. Traditional systems in Kenya, however, do not aim for short intervals and breed their animals only once every two years and maintain a ratio of one breeding bull to 50 or more females.

In other studies, the interval between births has been established as 14.3 months in Najdi camels in Saudi Arabia and in commercial milk herds in the Al-Jouf region, a calving interval of 14-15 months has been obtained. In some areas of Saudi Arabia, females are run in two units, each of which is mated in alternate years; pregnancy rates are said to be 80 to 90% in each of the units (i.e. 40 to 45% annual calving rate).

The management implications thus are twofold: i) more calves can be obtained (i.e. intervals between births can be reduced) if the negative effects of the lactation hormones can be overcome. This can be done by removing the calf and causing its mother to dry off. The calf then has to be fed artificially of course, and ii) if the calf is not weaned, the effects of the lactation hormones are gradually suppressed by the reproductive hormones and the influence of these can be made stronger and earlier if nutrition is better. Supplementary feeding of the adult female camel will therefore also lead to better overall reproductive performance.

Q. Write a note on annual reproductive rate (ARR) and total lifetime production in one-humped camel.

In northern Kenya calving percentages of 21.1 and 47.4 have been reported for non-treatment and treatment herds. The ARR on commercial ranches in Kenya was 64%. In northern Niger, the ARR was calculated as 0.46 young per breeding female.

In Nigeria a total of 215 camels gave birth to 573 young or an average of 2.7 per breeding female in their lifetime. In Kenya the average lifetime production of young was 3.5 per
female on commercial ranches. At the India national camel farm, females gave birth to 2 to 8 young during their breeding life with an average of 4.49.

Q. Is breeding in all Asian and African camels confined to the same season as in Pakistan.

Data obtained from different areas show a marked seasonality, with most activity in winter. In Somalia there appear to be two main breeding seasons, related to two rainy seasons. In the United Arab Emirates most births are in October to January but a few in April and May, indicating the possibility of extending the breeding season if feed and management are adequate. In Kenyan traditional herds there is some breeding all the year round but greater activity in December/January and may possibly be associated with better nutritional status at conception (Table 9).

Table 9. Breeding seasons of the one-humped camel in various countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Breeding season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pakistan</td>
<td>December-March</td>
</tr>
<tr>
<td>India</td>
<td>November-February</td>
</tr>
<tr>
<td>Somalia</td>
<td>April-May/June; September-November</td>
</tr>
<tr>
<td>Egypt</td>
<td>December-April; May-August</td>
</tr>
<tr>
<td>Sudan</td>
<td>March-August</td>
</tr>
<tr>
<td>UAE</td>
<td>October-January; limited April-May</td>
</tr>
<tr>
<td>Mali</td>
<td>February-March; August-September</td>
</tr>
<tr>
<td>Morocco</td>
<td>May-June</td>
</tr>
</tbody>
</table>


Q. Discuss very briefly camel genetics.

Camelids have a diploid chromosome number of 74. The karyotype consists of 33 pairs of acrocentric and 3 pairs of submetacentric autosomes, a large submetacentric ‘X’ and a very small acrocentric ‘Y’. The identical patterns in chromosome linear differentiation for the Camelidae suggests that their karyotype has been highly stable for millions of years. It probably represents the most extreme case of chromosome conservatism among mammals. Their identical karyotype, despite their longstanding geographical separation, would suggest that their early genetic make up was very adaptive and that any divergence from this was non adaptive and deleterious to survival. This is certainly interesting given the difference in the environmental influences on the Old World and the New World Camelids over the last a few million years, since their common ancestry in North America.

The close relationship of the Camelids is reflected in their ability to interbreed. All four species of the New World Camelids (llama, guanaco, alpaca and vicuna) can interbreed and produce fertile offspring. Crosses between the one-humped dromedary and the two-humped Bactrian are possible, the progeny having one long hump, but some F1 males are reported as sterile. The chromosome similarities are there, but physical incompatibilities and gestational differences need to be overcome (Old World 385 days; New World 345
days). Despite gestational and physical differences, successful cross between a dromedary and llama has given birth to ‘Camella’ in Dubai under the supervision of Dr. Skidmore (2002). *Camelus dromedarius* appears to have a high degree of genetic polymorphism and that genetic probes and PCR (polymerase chain reaction) technology will be useful in determination of parentage and selecting for traits. Parentage of South American camelids can be determined with 95% accuracy on inheritance of blood groups, since they display types A, B, C, D, E and F.

The dromedaries only seem to share B with their South American cousins. At the Scientific Centre for Racing Camels (SCRC) in Dubai, blood groups and various enzymes were studied using electrophoresis to detect genetic variation. Unlike the New World camelids, the Old World camels showed no significant differences. DNA study was therefore undertaken. Initially RAPD (random amplified polymorphic DNA) was used to analyse the genome variation. This technique is based on the use of polymerase chain reaction (PCR) using short, single and random primers to detect variation, without prior knowledge of DNA sequences. A number of different markers have been studied and genetic variation in the camel has been demonstrated. This technique is also being used to look at the variation in subspecies or strains (e.g. Sudani camels compared with Emirati camels) to determine whether crossbreds can be identified accurately.

Some DNA fingerprinting on parentage in camels, using human minisatellite probes, 33.6 and 33.15 hybridised with DNA, has been tried elsewhere and has proved to be accurate. The technique can be very time consuming. Determination of parentage has been attempted at the SCRC using STR (short tandem repeat) polymorphic markers also known as microsatellites. The early results are encouraging. This technique could ultimately prove to be faster, more accurate and requires less DNA.

**Q. Discuss in genetic terms that P=G+E, where P=phenotypic measurement of a trait, G=combined effect of all genes concerned, E= environmental factors influencing the trait.**

Many traits of economic value in the camel are influenced by a number of genes, each of which has a relatively small effect. In other words, the traits are not influenced primarily by genes at a single locus. Such traits are called quantitative or multifactorial traits, many of which can be measured quantitatively e.g. the speed of a racing camel over a certain distance and conformation and production characteristics. The measurement can be expressed as a product of both genetic value of the camel and influence of environmental factors, thus P=G+E.

In other words, camels have different phenotypes because of the two factors; valuable genotypes and exposure to different environments during development. Some of the differences in environment to which camels are exposed can be: different nutrition regimens, climate, training and housing systems and disease control measures. Some differences cannot be specified such as errors of observation. It is possible by means of suitable statistical methods to obtain quantitative estimates of these several sources of variance. Estimates can also be obtained by using records on relatives. Estimates of the proportion of the phenotypic differences, that are genetic, are important to the camel breeder (Shereif and Tinson, 2000).
Q. Write notes on the following selection parameters:

a) Genetic variation: Selection can be effective only when the population contains genetically variable individuals. Some traits have little genetic variation and others express considerable genetic variation. The information concerning variation in different traits of camels is greatly lacking. However, based on information from other domesticated animal species, it is likely that there is little genetic variation in fitness traits e.g. fertility.

b) Standard Deviation: This measure is important to identify a superior camel for a quantitative trait. The standard deviation is the square root of the phenotypic variation and describes the phenotypic variation of a trait about the average for this trait. In a normal population, 68% of all the values should fall in the range of the average ± 1 standard deviation. About 95% of all individuals are included in the range of the average ± 2 standard deviation. A camel would be superior to 95% of the general population if its value for the trait was greater than the value of average ± standard deviation. If a smaller value of a trait is desired, the camel’s value would be less than the average ± 2 standard deviation. In a breeding programme for a certain trait, the intensity of selection (i) can be calculated for the desired selection differential (s) from the knowledge of standard deviation (σp) using the following formula:

\[ i = \frac{S}{\sigma_p} \]

The selection differential refers to the superiority or inferiority of those individuals selected for parents (P_s) as compared to the average of the population (P) from which the breeding animals were selected. Selection differential may be noted by the following: S = (P_s - P).

Intensity of selection can have an important effect on genetic progress, particularly in the selection of male camels since fewer males than females are needed under conventional breeding programme.

c) Heritability: Each camel has a genetic limit for each trait and this limit is set at conception. Rarely does an individual reach its genetic potential since environmental factors influence the trait. To eliminate these environmental factors, heritability estimates have been calculated for many quantitative traits in various species. Heritability estimates refer to the portion of the phenotypic variance in a population that is due to heredity and expressed in percentages.

To estimate the heritability, different methods are used such as intrasire regression of offspring on dam, offspring-parent regression and sib analysis, including full-sib and half-sib. Probably, except a few no heritability estimates are available for traits of economic importance in camels. The heritability for height at withers is high (84%), showing that only 16% of the variability is caused by environmental influences. Therefore, a high heritability estimate is an indication to the breeder that considerable genetic progress can be made in improving the trait when selection is based on the individual’s own phenotype. High heritability also indicates that additive gene action is more important for that trait and the mating of the best to the best should produce more desirable offspring. A low heritability estimate indicates that there is low correlation...
between genotype and phenotype. Therefore more attention should be paid to environmental influences since a breeding programme aimed at improving the trait may not yield the required results.

d) **Response to Selection:** A thorough knowledge of the selection parameters enables you to predict the genetic progress in one generation for any desired trait in the camel. In nature camels have undergone the process of selection whereby survival and reproductive success are the main components. It also implies that if a particular characteristic in the camel is favoured in a given environment, the genes giving rise to it survive the selection process and are passed onto the next generation. In this way favoured alleles increase in frequency at the expense of less desirable alleles and the genetic constitution of the population changes and evolves (Shereif and Tinson, 2000).

**Q. Discuss the selection of camels with superior genotypes.**

Organized selection is being practised more in racing camels than any other type of camels. In racing camels selection practices have been based on identifying and mating the best to the best. Better results are obtained when both the parents have excellent racing records and that racing ability has a high heritability. Since selection in such matings is largely based on environmental influences rather than the true breeding value of the camel, therefore in many cases the outcome is disappointing. In order to identify camels with superior genotypes, it is important to minimize environmental influences by examining accurate performance records. These records include the record of the concerned animal, performance record of the progeny, and closely related relatives. The order of importance of these records varies according to the heritability of the trait. To adjust performance records to a common base, information is also needed regarding environmental factors that may affect the chance of winning such as age, nutrition, skill of the trainer, sex, health, starting position, level of competition and the condition of the racing track. Unlike race horses, adjustments for these factors have not been made in racing camels. Therefore, biases are expected from the use of unadjusted records, resulting into slow rate of progress.

The essential trait for racing camels is speed over a certain distance. Conformation and temperament are important to the extent that they influence racing ability, but racing ability is a composite measure of all such factors. There are fast camels of varying conformation and temperament, which implies that no hard and fast standard for conformation and temperament has been framed. It may be said that camels can have good conformation and temperament without good performance, but cannot have good performance without good conformation.

**Q. What may be the implications of inbreeding in racing camels?**

Most breeding programmes in racing camels involve the use of a limited number of champion parents to produce the progeny. The obvious outcome of such matings is the increase in homozygosity through inbreeding. When inbreeding is accompanied by selection, individuals that are homozygous for desired traits are selected and used as breeding animals. Subsequently they pass their desirable genes to the next generation. Inbreeding has the disadvantage that it uncovers undesirable recessive genes that are expressed phenotypically in many forms such as genetic defects, small sized animals,
reduction in fertility and vigour. It is therefore suggested that in using the present system of inbreeding in racing camels, a large proportion of the less desirable individuals in the population needs to be regularly culled. This certainly requires that a large number of camels be produced which may prove to be very expensive.

Q. Name and discuss new breeding and genetic developments in camels.

**Identification System:** Microchip identification is widely used in several countries in cattle, horses, domestic pets, etc. The chips are implanted in the nuchal ligament in the neck when the calves are 4 to 6 weeks old. This system provides permanent identification. A computer programme can be developed to retrieve information specific to every camel including parents, farm location, trainer, racing history, treatment, vaccination etc. Accurate identification is particularly important in the camel embryo transfer (ET) technology. Firstly, it is occasionally possible for an ET camel calf to have up to three mothers (genetic, surrogate and foster). Secondly, it can take up to 3 years before assessment of good racing ability can be made with camels often moving locations between trainers. When superior offspring are identified, it is then possible to reuse their respective parents as donors in future ET programmes.

**Multiple Ovulation Embryo Transfer:** This technology is a method of rapid genetic improvement by increasing the selection intensity of both parents. The same has been applied to dairy cattle, sheep and goats. In camels the technique is being used since 1989 in the ET unit at Al-Ain, United Arab Emirates (Shereif and Tinson, 2000). Ultrasonography is necessary to follow the complex follicular waves in order to optimize the embryo production and collection. It is not only applied for racing ability but also can be used for any trait of economic interest in camels.

**Important Advantages of Embryo Transfer:** Under normal breeding management because of long gestation period (about 13 months), one female produces a calf every two years. It often takes 3 to 4 years before the performance of the offspring is assessed. Some of the best females can continue to race up to the age of 15 to 16 years before their genes are passed to the next generation. Female camels are generally faster than males, thus are more sought after for the production of offspring. ET facilitates rapid selection for the top females. On the other hand, AI is normally used to increase the selection intensity of male parents. Moreover, there is evidence from other domesticated animals that the response to selection is greater using ET as compared to AI. For example by using ET in dairy cattle, a genetic improvement in milk production was found to be 30% above that obtained by AI. ET facilitates progeny test of many bulls using the same female for each bull concomitantly and thereby minimizes the environmental influence and increases the speed and efficiency of estimating the true breeding value of each bull. The top racing camels purchased by wealthy Sheikhs of Middle East can fetch prices as high as one million US dollars or even more.

**Frozen Embryo Storage and In Vitro Fertilization (IVF):** The first pregnancy from frozen embryo transfer was achieved in 1991, whereas the first birth from a camel embryo previously stored at -96°C in liquid nitrogen did not occur till February 1995 (Shereif and Tinson, 2000). The technique, however, still needs more improvement.
Collecting mature ovum directly from the follicles before they are released and then fertilization with the sperm is done under controlled laboratory conditions. IVF offers the possibilities of breeding camels with reproductive pathological conditions such as ovarian/bursal fluid syndrome where neither normal breeding nor embryo collection is possible. It is also anticipated that the collection of oocytes directly from the follicle would facilitate possible mixing with sexed sperm using flow cytometry sperm selection and intra-cytoplasmic sperm injection to increase the percentage of females produced. IVF technology is also necessary for any future gene transfer project in camels. Molecularly cloned DNA can be introduced into freshly fertilized egg, whether the cloned DNA is for increased quality/quantity of milk production, disease resistance, or for a factor yet to be identified associated with speed (Shereif and Tinson, 2000).

**Recombinant DNA Technology:** Recent advances in molecular techniques opened a new era with a wide range of application in animal and plant breeding, medicine, forensic science, evolution etc. The recombinant DNA technology has been applied to numerous organisms for different purposes. In camels, parentage was accurately resolved using human minisatellite probes 33.60 and 33.15 hybridized with camel DNA. Random Amplified Polymorphic DNA (RAPD) finger printing technique has been used to detect genetic variation in racing camels and to differentiate between strains of *Trypanosoma* including detection of mixed infection. Electrophoretic karyotyping and arbitrary primer-polymerase chain reaction (AP-PCR) has been used to study genotype and drug resistance phenotype *Trypanosoma evansi* in a population of camels. Recombinant DNA technology can also provide a useful tool for camel archeological studies. Parentage and kinship identification are particularly important in the pedigree analysis and pedigree programmes. Work in this field on racing camels using short tandem repeat (STR) polymorphic markers is already in progress. Such work requires development of a range of highly heterozygous STR loci in camels facilitating parentage identification with a very high accuracy (>99%). STR alternatively known as microsatellite loci, are regions of DNA composed of short (1-6 bp) sequences repeated in tandem. Now minisatellites have been replaced by microsatellites as a method of choice in parentage identification of Eukaryotic organisms. Microsatellite analysis relies on PCR rather than on Southern blotting and hybridization procedures employed in minisatellite analysis. It is faster and requires much less DNA. It has been suggested that camelids, in general, represent the most extreme case of chromosomal conservatism among mammals. Studies of polymorphism in the old world camels also showed little or no genetic variation of blood proteins. Based on several studies, a general agreement emerged that DNA techniques should be exploited more often in future on camel breeding, parentage verification, population differences, disease control and archeological studies.

Transgenic methods are best demonstrated in the mouse, but these can also be used in camels to produce better animals. The nutritional value of milk can be enhanced by increasing the ability of the camel’s mammary gland cell to secrete casein. Another possibility is to develop transgenic camels that can resist viral disease by modifying their genes to produce viral glycoprotein. Camels can also be bred to increase their production of the antiviral substance interferon.
Researching mitochondrial DNA (mtDNA) in camels can also provide valuable information. Animal mtDNA is maternally inherited, and therefore, it facilitates a unique way of identification by comparing sample results with those of even distant relatives. During fertilization only about 1% of the mitochondria are contributed by the sperm. Thus an individual’s mother, sibling and all maternal relatives contain almost identical copies of mtDNA. Although mtDNA represents less than 1% of total cellular DNA, however, it exists in a high copy number. Mammalian cells typically have several hundred mitochondria, each containing several copies of mtDNA for a total of approximately 1000 to 10000 copies per cell. The special characteristics of mtDNA makes it a valuable tool for species identification, population studies and evolution.

A DNA project needs to be designed to map the camel genome. This project would generate databank of genetic information that could be used to improve camels for disease resistance, milk production, racing ability, and any other desirable trait in much less time with a greater efficiency. Researching the camel genome should be a major project requiring substantial amount of funds, qualified work force and collaboration with relevant scientific institutions. The availability of data from human, mouse and other mammalian genomes will greatly facilitate the identification of the counterparts in the camel (Shereif and Tinson, 2000).

Q. What possible effects are expected due to reversal of the process of natural selection?

In this regard two models have been proposed. First, the homeostatic model, in which heterozygous individuals at the loci affecting the trait are assumed to have higher fitness. For this model, individuals around the population mean are likely to be more heterozygous. Fitness of individuals would be at the maximum at the mean phenotypic value of the trait and would decline as it departs from that value. The second model is the optimum mode, which relates fitness directly to the phenotype of the trait, irrespective of the underlying genotype. Both models imply that individuals with intermediate values for a particular quantitative trait have the highest fitness. Thus any shift in the mean of the trait would be expected to result in a reduction in fitness components such as reproductive efficiency, differential mortality at immature stage, viability, competitive ability, sterility etc. Thus basic principle of natural selection should be duly considered whenever directional selection is attempted for a quantitative trait.

It is noteworthy that while natural selection allowed the camel to evolve incredible physiological adaptations to desert, there may have been in the process a negative selection for reproductive efficiency. The high incidence of embryonic death and abortion, coupled with long gestation length and high intercalving interval would appear to support this theory. In range bred camels the yearly calving rates were as low as 40% and neonatal to yearling death rates on an average 30%. The breeding seasonality of the male and his ‘difficulty’ in mating unaided also contribute to inefficient breeding. It could be stated that it was a necessary ‘negative selection’ to ensure the population survival in an environment where feed and water resources are scarce. Modern artificial breeding techniques and application of genetic principles can reverse this inefficiency and optimize the available individual’s potential. With ET technology calving rates per
individual can be enhanced to 300% and calf mortality rates in properly managed herds can be reduced to less than 10%.

Q. Write a brief note on congenital defects in camel.
Because of slow reproductive rate and slow herd growth, many aspects of the camel are yet to be studied in detail. A few examples of congenital defects are ectopia cordis (a closure defect of the ventral body wall during foetus development), parrot mouth (in this condition the mandible is shorter than the maxilla; affected animal may have grazing problem), short digit (in this condition the animal has shortened digital bone(s) leading to impaired walking and idiopathic alopecia (almost complete baldness). These conditions occur rarely and thus considered of little economic importance. Camel pastoralists do not use such animals for breeding if they survive to maturity.

Q. Is ultrasonography of the genital tract of camels a useful technique?
As a technique of choice for examination of genital tract, ultrasonography has gained a wide acceptance in several countries. Its application in female theriogenology ranges from the determination of physiological status, ovarian activity and pregnancy diagnosis to the detection and diagnosis of the genital tract diseases. Ultrasonography of the male helps in the evaluation of the testicular tissue, testicular envelopes and epididymus as well as the pelvic organs. Determination of ultrasonographic characteristics of the ovarian structure and uterus and their relationship to each other, at different stages of the cycle, has led to more efficient management of reproduction in several species. Similarly, in camelidae, the technique has proved to be a valuable tool for research on follicular dynamics and is becoming popular for early pregnancy diagnosis and management of breeding both in the dromedar y and Bactrian. Even in some developing countries, the field use of this technique has become possible.

Q. Discuss briefly the principle involved in the technique of ultrasonography.
It is an imaging technique reflecting the degree of propagation or reflection of a beam of ultrasound applied to layers of animal tissue. The transducer or probe of the ultrasound has both the emitting and receiving properties for ultrasound waves. The beam of ultrasound is sent directly over the area being investigated. These sound waves propagate at different rates depending on the density of the tissue being examined. When the tissue has a minimum density, a proportion of the ultrasound wave is reflected back and is received by the transducers. It is then converted to electrical impulse signal that is displayed as a grey-scale image on the screen. The intensity of grey in the image increases as the amount of echo received increases and the image becomes totally white on the grey-scale when a large proportion of ultrasound waves emitted are reflected back. The general description of an ultrasonogram starts by describing the echotexture of the image (homogeneous or heterogeneous echotexture) and then the intensity of the echo (anechoic, hypoechoic or hyperechoic). In the case of heterogeneous echotexture, all areas should be described in relation to their anatomical position such as the main organ investigated and the degree of their echogenicity (Tibary and Anouassi, 2000).

Equipment: The equipment used is different from one application to another. However, high end equipment is usually suitable for many applications if fitted with an appropriate transducer. A multipurpose ultrasound machine should allow use of both M (motion) and
B (brightness) real mode ultrasonography as well as a choice of linear and array probes. The frequency of the ultrasound waves produced is an important criterion of choice for the transducer. The most common frequencies used in animal practice are 3.5, 5 and 7.5 MHz (Megahertz). The difference between these sound wave frequencies resides in the penetration, distance and the detail of the image obtained. Low (3.5) frequency sound waves travel farther than high frequency waves (7.5 MHz), but produce a low resolution image. Another difference in transducers is the arrangement of the elements or piezoelectric crystals responsible for the conversion of electrical energy into ultrasound and vice-versa.

Two types of arrangement are available: linear or sector. In the linear array transducers, the elements are arranged side by side along the length of the transducer. These send and receive the ultrasound in a linear fashion allowing visualization of the structure in a rectangular plan with a width corresponding to the size of the probe and a length corresponding to the penetration rate of the waves. The sector scanners have a narrow arrangement of the elements and send a focal beam that spreads over an angle and produce a pie shaped field of examination. This type of transducer is used if the area to be examined lies just under hyperechoic structure. These probes (transducers) are generally used to investigate organs within the rib cage so that the ultrasound beam is sent through the intercostal space avoiding the ribs. For gynecological use, the ultrasound machine should operate on a B-mode with at least a 5 MHz linear probe and preferably a second 3.5 MHz. The 5 MHz allow visualization of follicles as small as 2 mm in diameter and enable the operator to distinguish between very subtle degrees of echogenicity. The 3.5 MHz transducers are used for the examination of deep structure (foetus in advanced pregnancy). M-mode ultrasonography is used in some instances to evaluate the heart function of the foetus. The most recent technical development in the gynecological ultrasonography is the introduction of special vaginal transducers for aspiration of follicles and should be considered in research laboratories dealing with *in vitro* fertilization.

**Q. What type of ultrasound scanner should be purchased for large animal practice?**

There are several types of ultrasound scanners available in the market. The following is a summarized list of the most important questions that should be addressed when deciding ‘which is the best machine’? i) What would be the main use of the machine? ii) What is the volume of work for its use? iii) What is the degree of familiarity with the machine? iv) Is there a technical support available nearby? v) What is the reliability of the equipment and the manufacturer? vi) What is the comparative price of the equipment? One critical factor to consider when purchasing any such equipment is the availability of technical help and the ability to service the machine within a reasonable time frame (Figure 16). Acquire an ultrasound machine from a reputable, internationally known firm and directly from an exclusive agent. The price of the machine should be weighed adequately against the reputation of the equipment and availability of technical support.

**Q. Discuss the examination technique and preparation of the camel for ultrasonography of the genital organs per-rectum.**
Ultrasonography of the genital tract is done per-rectum or per-vagina in the female. External abdominal ultrasonography is not done in camels because of the lack of penetration. In practice, examination per-rectum is the most widely used technique. Vaginal ultrasonography is used in research for echoguided follicular aspiration or aspiration of uterine cysts and embryos or injection of embryos and intrafollicular injection. In the male, ultrasonography is used externally for the examination of the scrotum and its contents. It is used per-rectum for the evaluation of the pelvic organs.

**Preparation of the Animal:** The preparation is identical to that required for routine rectal palpation. Most of the camels can be palpated in a standing position if stocks are available (Figure 17). Reluctant or agitated animals should be tranquillized by intravenous injection of 0.2 to 0.3 mg/kg of 2% Xylazine. This causes immobilization of the animal and relaxation of the anal sphincter, making manipulation very easy. Sedation and examination of the animal should be done as soon as possible because agitated camels quickly develop a profuse diarrhoea (due to hypermotility of the intestines), which makes palpation and ultrasonography difficult. Clean the rectum of faecal material by scooping out faecal balls with a lubricated hand. Usually, the dilation of the anal sphincter causes a reflex defaecation that should be allowed to progress naturally by removing the hand. After emptying of the rectum, the genital tract is palpated completely, starting with the cervix. The cervix is identified by placing the hand flat on the floor of the pelvis in continuation with the uterine body. It is not easily grasped in the hand as in buffalo or cattle. The uterus and its horns are identified just cranial to the cervix and can be within the pelvic cavity (young females) or slightly in front of pelvic brim (old or pregnant females). The uterine horns are easy to identify in animals with a mature follicle because the uterus is contracted and the horns are straight. The uterine tube is usually felt as a tortuous band. The ovaries are palpated laterally and caudally to the ipsilateral horn. They are usually elliptical and very irregular especially in older animals due to the presence of many old corpora albicantia. They measure 3x2x1.5 cm. Corpora lutea are easily identified as well protruding structures measuring 16 to 25 mm with a liver like consistency.

It is mandatory to evaluate the animal first by palpation per-rectum before ultrasound examination. It allows the practitioner to determine the general position of the genital organs so that the ultrasound probe can be positioned properly. The probe is introduced in the rectum taking care to provide ample lubrication. The probe is always maintained within the hand of the operator with crystals facing ventrally. Different parts of the genital tract are examined in the following order: the cervix, body of the uterus, then each uterine horn followed by the ipsilateral uterine tube and ovarian bursa. Thorough examination requires that the probe be in very close contact with the mucosa so that the image is very clean. The probe should be moved very slowly along different parts of the genital tract. In order to have a good contact with rectal mucosa, the probe should be dipped in a coupling gel or in a lubricant before insertion in the rectum.

**Ultrasonography Per-Vagina:** It is used mainly for retrieval of oocytes from growing follicles and a special 30 to 40 cm long probe fitted with a sector transducer is used. The animal should be sedated because most female camels are reluctant to vaginal
Part – I  Production and Management of Camels

manipulation. The probe is inserted into the vagina and advanced gently until it comes in close contact with the fornix. The genital tract is manipulated per-rectum so that the ovary is presented to ultrasonographic field and the follicles are identified. Each follicle can then be aspirated by inserting a single or double bore long needle from the base of the probe and guiding it in the special canal of the probe until it becomes visible on ultrasonogram when it comes out at the transducer end. The follicle is stabbed and aspirated using a suction pump hooked to the needle and set at a predetermined negative pressure. If a double bore needle is used, the second needle can be used simultaneously for suction and flushing the content of the follicle.

**Ovulation:** In camels, ovulation takes place between 24 and 48 hours after mating. Detection of ovulation by ultrasonography is very difficult unless the female is monitored very closely. Ovulation is usually suspected when the dominant follicle disappears following breeding or treatment with hCG or GnRH.

**Evaluation of Superovulation Treatment:** In recent years, one of the major uses of ultrasonography in camels is the evaluation of superovulation treatment and management of breeding in donors and the planning for recipients preparation. In well equipped laboratories, ultrasonography is used to examine the ovaries of superovulated females on alternate days. The first appearance of a follicular wave induced by treatment with PMSG (eCG, 2500 to 3000IU) or FSH (35 to 45 mg given in decreasing doses over 4 days) takes place 3 to 5 days after initiation of treatment. Most of the superovulated females show mature follicles between 6 and 8 days following the beginning of the treatment. The stimulatory response of these treatments is variable from zero to a multitude of follicles. In some cases the number of follicles is so high that it becomes impossible to have an accurate count. This situation is of great importance because it is usually linked to a failure of ovulation or results in many corpora lutea but no embryo at collection. Ultrasonographic monitoring of superovulated animals is a good tool to study the causes of ovulation or failure of fertilization (Tibary and Anouassi, 2000).

Q. **Discuss the use of ultrasonography in early pregnancy diagnosis and evaluation of the growth and viability of foetus.**

Early pregnancy diagnosis and evaluation of the foetus are the most common uses of ultrasonography in the female camelids. This technique has been used successfully in dromedary and bacterian camels. Pregnancy diagnosis in llamas and alpacas can be done using abdominal ultrasonography, however, this technique can be applied in animals pregnant for more than 3 months. Pregnancy diagnosis is possible in camelids as early as 15 days postmating. This diagnosis is based on two main criteria: i) visualization of an embryonic vesicle, and ii) visualization and maintenance of a corpus luteum of pregnancy. For early diagnosis of pregnancy by ultrasonography requires that the uterus should be investigated all along its length and finding should be compared to the ovarian situation. Visualization of a functional corpus luteum in one of the ovaries is a must in order to confirm pregnancy status.

**Visualization of the Early Embryo:** The embryonic vesicle in camelids is relatively difficult to visualize in early pregnancy because it is very elongated, the embryonic fluid
is dispersed and the uterus is relaxed. In the early stage (14 to 16 days postmating), the embryonic vesicle appears as a cross-section of the uterine horn like a star shaped anechoic area. Diagnosis is best made by visualizing the vesicle at the tip of the horn where it is likely to have most of the accumulated embryonic fluid. The vesicle is almost always present in the left uterine horn. The best results are obtained at this stage with 5 MHz transducer. As pregnancy advances, the embryonic vesicle increases in size and is better visualized. It is round in cross-section and oblong in longitudinal view of the uterus. At 18 days of pregnancy, diagnosis of embryonic vesicle should not pose any problem for an experienced examiner.

The embryo becomes visible within the embryonic vesicle around day 20 postmating. The embryonic mass continues to grow and the foetal heart beats are evident between day 22 to 25 of pregnancy. The foetus becomes separated from the uterine wall by day 35 and the amnion becomes visible as a thin echogenic film above the foetus. The amniotic fluid is slightly more echic than the allantoic fluid. All parts of the foetus and its envolopes are easily identifiable by day 50 postmating. At 3 months postmating and beyond, visualization of the foetus becomes rather difficult because of the increased size of the pregnant horn especially if a 5 MHz transducer is used. The development of the foetus beyond this stage is appreciated better with a 3.5 MHz sector transducer.

**Visualization of Pregnancy Corpus Luteum:** The corpus luteum is the major source of progesterone during pregnancy in camelids and its presence is required throughout the gestation period. Thus visualization of the corpus luteum adds to the accuracy of the early pregnancy diagnosis. All pregnant animals should have at least one functional corpus luteum. In the dromedary, the minimum size found of a single corpus luteum of pregnancy is 18 mm. The presence of 2 and up to 4 corpora lutea during pregnancy has been reported in camelids. Multiple corpora lutea can be smaller in size. It is almost impossible (or difficult) to visualize the corpus luteum beyond 3 months of pregnancy because the ovary then is beyond reach.

Q. **What usually is the degree of accuracy of early pregnancy diagnosis using ultrasonography?**

The accuracy of early pregnancy diagnosis using ultrasonography is very high. However, from a management view point, it is important to differentiate between a pregnancy diagnosis results and delivery and accuracy. It is important to remember that accurate early pregnancy diagnosis does not guarantee a birth about 13 months later. Pregnancy diagnosis should be confirmed at later stages because of the high level of embryonic loss in first 2 months of pregnancy.

Q. **Write short notes on determination of gestation stage, diagnosis of foetal viability and determination of foetal sex by ultrasonography.**

**Determination of Gestation:** It is important in management in order to have a predetermined parturition date. You may be asked to determine approximately the stage of gestation especially in case of misbreeding or group breeding. Age of the foetus can be determined by measuring some of its body parts. In many species this is done by measurement of the head or trunk diameter. In the camel, visualization of the foetus is possible only in first 4 months of pregnancy and measurements are difficult to make.
Determining Foetal Viability: Compared to other farm animals, camelids have very high incidence of embryonic loss. It is, therefore, important to determine the viability of the foetus at each pregnancy diagnosis attempt. The criteria used to determine the status of pregnancy include shape and growth of the embryonic vesicle, ethogenicity of embryonic fluids, cardiac activity of the foetus, growth of the foetus and finally its movement. In the early stages of pregnancy, the most used criteria are the shape of the embryonic vesicle and the echogenicity of its contents. The normal embryonic fluid is anechoic. It becomes slightly echoic or contains echogenic debris in case of embryonic death. Foetal heart beats are a good indicator of embryo viability at all these stages of pregnancy where the rib cage can be visualized without problem. Embryo mortality is suspected when there is no foetal heart beat, the embryonic fluid is echogenic and contains debris and there is evidence of a separation of the placenta from the uterine wall.

Determining the Foetal Sex: Ultrasonography has been used in determining foetal sex in equines and bovines between 60 and 100 days pregnancy. This diagnosis is based on the visualization of the scrotum, testis or udder and the relative position of the genital tubercle. Accuracy of this diagnosis depends greatly on the position of the foetus. In the camel, sexual differentiation is already completed by 50 days of pregnancy. However, there are some reports of unsuccessful attempts in determining sex of the foetus between 50 and 70 days of pregnancy (Tibary and Anouassi, 2000).

Q. Can ultrasonography be carried out of the reproductive tract of the male camel?

Ultrasonography is a valuable technique for the examination of the scrotum and its contents as well as the pelvic organs in the male. Examination of the pelvic organs in the dromedary is done with the animal restrained in the same manner as for palpation per-rectum in the female. Aggressive males should be sedated with Xylazine in order to reduce risk both to the animal and operator. After thorough evacuation of faecal material, the operator starts identifying parts of the internal genitalia per-rectum, such as the pelvic portion of the penis, the bulbourethral gland and the prostate and sometimes the ampullae of the efferent duct. Ultrasonography of these organs is best accomplished with a 5 MHz transducer (Figure 18).

For examination of the scrotum and testes, the scrotal area is cleaned of dirt and dry faeces to avoid interference in ultrasound. The testes are immobilized by gentle downward traction. The transducer is placed directly on the scrotal skin oriented according to the axis to be examined. Each testicle is examined following a transverse view by placing the tranuducer perpendicularly to its long axis by moving it slowly from the dorsal to the ventral part. A round image corresponding to a slice of tissue is produced. Then the transducer is placed vertically parallel to the long axis of the testis to obtain a longitudinal view of the testicular parenchyma. Finally, the testicular cord is examined by placing the transducer in such a way that the image obtained corresponds to a transverse view of the tissue. Ultrasonography also provides a good means for precise measurement of testicular size.

The normal testicular tissue has two zones with different echogenicity. The periphery corresponding to the testicular parenchyma is homogeneous with medium density that...
tends to increase with age. The central area is more echogenic and corresponds to the rete testis. Particular attention should be given to the presence of pockets of fluids or more echogenic area that can represent cystic dilation or presence of fibrosis, respectively. Presence of large quantity of fluid between the testis and its envelops has been observed in some males suffering from hydrocele.

For more detailed account of ultrasonography of the reproductive tract of the dromedary, you are referred to Tibary and Anouassi (2000) In: Selected Topics on Camelids (Gahlot: Editor). Answers to questions pertaining to this aspect have mainly been derived from the same source.

Q. Discuss pregnancy diagnosis from a different angle than discussed using ultrasonography.

For using any indirect method of pregnancy diagnosis, the camel will almost certainly have to be restrained in a sitting position to obtain a blood or urine sample and to make a rectal exploration for pregnancy diagnosis. Clinical method of rectal palpation is recommended for pregnancy diagnosis in the camel. The technique of palpation of the genital organs is the same as for the buffalo or cow, but the following features need to be kept in view in case of the camel: a) large corpora lutea are only present during pregnancy, b) 99% pregnancies are in the left uterine horn, c) the empty right horn is congenitally shorter than the left, and d) the amount of foetal fluid at all stages is less than in the cow. The presence of a CL in one or both ovaries is a very strong indication of pregnancy.

The palpable swelling of the pregnant (left) uterine horn in the dromedary cannot be detected before week 8, when the whole of the left horn is enlarged. At this time, both ovaries (one or both with CL) together with the uterus, are within the pelvis. At the end of third month, the pregnant left horn is clearly larger. It is at the pelvic brim and its corresponding ovary is in the abdomen. At the fourth month, the uterus is just in front of the pelvic brim, but most of it can be felt. During the sixth month, the foetus can be felt. From the seventh month individual parts of the foetus such as its head and legs can be identified. External observation of the animal’s right flank shows spontaneous foetal movements from the ninth month and the foetus can be ballotted externally from the tenth month. In the following months there is obvious abdominal enlargement and the camel is lethargic. There is greater enlargement of the udder, sacro-sciatic ligaments relax, vulva becomes swollen. Rectal palpation reveals the uterus projecting backwards, occupying the anterior two-thirds of the pelvis. The foetus can be ballotted from both the flanks. The presence of follicle stimulating activity has been identified in the blood of camels pregnant with foetuses measuring 11 to 85 cm. It has been found that the cuboni test for the demonstration of estrogens in urine can be successfully applied in the camel, as in the mare. Well developed corpora lutea are known to be present only during pregnancy and because progesterone level of >1.0 ng/ml is reached only after fertile mating, therefore, blood or milk progesterone assays can be a valuable tool for diagnosis of pregnancy in the camel.

There is no record of freemartinism in the small number of twins born. The incidence of twin gestation is 14% and the twins are born in only 0.4% of all births.
Early pregnancy diagnosis is very important for the successful application of modern breeding technologies such as artificial insemination and embryo transfer. Significant structural changes in the reproductive tract of female animals even during pregnancy can be visualized by ultrasonic image detection and videoendoscopic monitoring. Videoendoscopic hysteroscopy during early pregnancy in the camel is an exciting tool for descriptive and investigative research purposes. It is a new method for observing the interior of the vagina, cervix and uterus in non pregnant large animal species and for monitoring foetal development and obtaining samples of foetal fluids and tissues for research investigations during pregnancy. The flexible videoendoscope utilizes a powerful xenon light source. It gives greatly improved brightness, depth of focus and colour reproduction compared to the conventional fibre-optic endoscope. The process of endoscopy is not recommended for routine pregnancy diagnosis since it involves some risk. Ultrasonography, on the other hand is a safe and accurate method for the diagnosis of important reproductive events including pregnancy diagnosis (Chaudhary, 2000).
Fig. 10. Anatomy of the male genitalia

1. ureter, 2. ductus deferens, 3. urinary bladder,
4. prostate, 5. ischio-cavernosus muscle,
6. retractor penis muscles, 7. retractor penis,
8. sigmoid flexure, 9. tuberculum spongiosum,
10. urethral process, 11. mucus membrane fold,
12. terminal process, 13. free portion of the penis.

Source: Chaudhary (2000).
Fig. 11. Extrusion of the dulaa (soft palate) by a mature bull camel

Fig. 12. Secreting occipital glands in a mature bull camel

100 a
Fig. 13. Male camel forcing a female camel down (a above) and then copulating in the typical position for this species (b below). Source: Wilson (1998).
Fig. 14. Anatomy of the female camel genital tract

1. rectum, 2. rectogenital fold,
3. retroperitoneal space, 4. cervix,
5. uterus, 6. bladder, 7. left ovary

Source: Chaudhary (2000).
Embryo flushing in the camel
1: flushing fluid; C1, C2, C3: tube blocking clips; 2: flushing tube set; 3: cuffed catheter; 4: vagina; 5: cervix with catheter inflated; 6: uterus; 7: embryo retaining filter
Fig. 17. Female dromedary placed in stocks for examination per-rectum

Fig. 18. Male dromedary restrained in a palpation chute for ultrasonography of testes
PRODUCTIVITY AND PERFORMANCE

Q. What does productivity denote?
Productivity of an animal can be defined as product output per animal unit per time unit i.e. litres of milk per buffalo and year or hectares ploughed per ox team per day. Productivity can also be defined as product output per unit input i.e. kg wool per man-hour of herding or kg liveweight gain per kg concentrate fed. Also productivity is defined as value of product output per unit input in monetary terms. Productive potential of an animal or a livestock species defines the biological limits, which may be of genetic, nutritional or physiological nature, within which productivity can be realized. Livestock management is the art to exploit the productive potential of an animal or a species to maximum productivity, which in term is not to be confused with maximum performance. In its usual habitat, the hot and arid rangelands of Africa and Asia, the camel is a multipurpose animal. It produces milk, meat, leather, hair and wool and serves as riding, pack or draught animal. Productivity of a multipurpose animal is a composite value with many facets contributing. Exploitation of the productive potential for the various possible outputs will be a matter of producer preference, which in turn is influenced by natural, social and economic factors. If a racing came l can be sold for Rs. 60,000 and for much beyond that, there is probably no need to worry about milking its dam. However, if camel’s milk is a subsistence staple, then it does not matter that a good milker is a slow runner.

Milk
Q. Give below a detailed account of milk production and composition and lactation length in Camelus dromedarius.
Camel milk is a valuable human food source in the semi-arid and arid environments of Africa and Asia. Total dry matter ranges from 12 to 15%, protein from 2.7 to 4.5%, fat from 2.9 to 5.2% and lactose up to 5.5%. Of special importance is the high content of vitamin C in areas where food of plant origin is rare, which may reach 2.9 to 3.6 mg/100 g. Estimates of milk yields differ widely. Reported daily yields range from 3.5 to over 20 litres, corresponding lactation yields range from 800 to over 4000 litres (Table 10). Likewise lactation lengths show a large variation of 8 months to almost 2 years. However, many of the higher yields quoted do not appear to be representative particular under pastoral production systems, where the largest proportion of camel’s milk is produced.
Table 10. Summary of some reported milk yields (litres)

<table>
<thead>
<tr>
<th>Source</th>
<th>Daily yields</th>
<th>Total yields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bremaud (1969)</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>Dahl and Hjort (1976)</td>
<td>3.5-4.5</td>
<td>1890-2160</td>
</tr>
<tr>
<td>Ensminger (1973)</td>
<td>7.5</td>
<td>3300</td>
</tr>
<tr>
<td>Field (1979)</td>
<td>21</td>
<td>1887</td>
</tr>
<tr>
<td>Hartley (1979)</td>
<td>9</td>
<td>1800</td>
</tr>
<tr>
<td>Khan and Iqbal (2001)</td>
<td>11.66</td>
<td>4260/year</td>
</tr>
<tr>
<td>Knoess (1976)</td>
<td>10.4</td>
<td>2847</td>
</tr>
<tr>
<td>Lakosa and Shokin (1964)</td>
<td>8.1-19.0</td>
<td>4388</td>
</tr>
<tr>
<td>Leese (1927)</td>
<td>4.8</td>
<td>-</td>
</tr>
<tr>
<td>Leupold (1968)</td>
<td>6.7-10.0</td>
<td>2700-3600</td>
</tr>
<tr>
<td>Rossetti and Congiu (1955)</td>
<td>5</td>
<td>3105</td>
</tr>
<tr>
<td>Williamson and Payne (1979)</td>
<td>9</td>
<td>2722</td>
</tr>
<tr>
<td>Yasin and Wahid (1957)</td>
<td>9.1-14.1</td>
<td>1068-4118</td>
</tr>
</tbody>
</table>


Daily yields between 3 and 6 litres, with total yields between 1500 to 2500 litres produced within lactation periods of 15 to 18 months are most likely the common range of performance. Such yields do not sound very impressive when compared to milk yields obtained from buffaloes and cattle kept in intensive conditions. Considering the local feed base in semi-arid and arid areas, which is frequently inadequate to secure the mere survival of cattle, such yields are impressive. Beside the absolute quantity of milk produced it is the persistency of production, which is important for the subsistence of pastoral populations since it provides staple food throughout dry seasons and short drought periods, when milk production from cattle and goats has already ceased. It is in this context that production of camel milk assumes more importance.

There is now a continuous drift of nomads to urban centers. Because of this, mobile informal camel dairies consisting of 5 to 10 camels are often seen in the periurban areas of many medium sized and large towns of Pakistan. A large number of milch camels is always there around Karachi who daily provide milk for the milk shops. Women of camel herders each carrying about 15 litres of milk sell it to the city dwellers who use it for making milk products such as Yogurt and Khir. Camel milk mixed into buffalo and cow milk is daily sold at large consumption centers in Pakistan. Camel milk is now being marketed through a commercial dairy in Mauritania both as pasteurized milk and as cheese and some of these gourmet products are being exported to France. Full-scale commercial dairying has also developed in parts of Saudi Arabia and Libya. Camel milk accounts for more than half of the pastoralists nutrient intake during the growing seasons. The composition of camel milk is similar to that of the goat but it contains more lactose and ash than cow milk and more ash than buffalo milk. Casein is lower in camel milk than that of the cow but whey protein is higher. Camel milk is usually bluish white in colour and may have a slightly salty taste and a very slightly acid or ‘sharp’ taste since...
the pH is about 6.5. An odd thing about camel milk is its reduced content of total solids when produced by dehydrated animals or those under water stress. Total solids are usually in the region of 11 to 14% and fat 3 to 5%. Protein in camel milk varies from 2.7 to 5.4% while lactose is up to 5.5%. Mineral contents vary according to the type of feed eaten but usually there is a low calcium level while phosphorus levels are similar to that of other farm animals such as cow, goat etc. The amino acid make-up of camel milk is similar to that of other domestic species. Camel milk is a good source of vitamin C but contains little of carotene that can lead to the formation of vitamin A. The content of vitamins of the B complex is comparable to that of other milch farm animals. The camel milk is said to have medicinal uses as well because the vegetation used as feed by camels includes several herbs having potential medicinal value.

Q. Write a brief note on composition of colostrum of one-humped camel.

Early colostrum of camel is very low in fat (only 0.23%), but it becomes normal at about 10 days. There are also changes in other constituents over the same period. Protein, for example, is reduced from 13.0 to 4.0%, lactose rises from 2.7 to 5.1% and total solids fall from 20.5 to 14.7%. By tenth day fat content rises to about 2.7%.

Q. Generally what factors may affect milk yield in camels?

The factors affecting milk yields are those common to all dairy animals such as nutrient supply, health status, genetic potential for milk production, number of previous lactations or age of the animal and adequate water supply. The first three are readily exploitable for increasing milk production provided the respective inputs and services are available and their application is profitable.

Q. Is it possible to improve the genetic potential for enhanced milk yields in East African camels?

It is possible but only in very long term. Because of the low reproductive rate of camels, selection will be inefficient since virtually all fertile females will have to be bred and selection can be carried out in male breeding stock only. Crossbreeding with recognized high yielding dairy breeds of Asian origin is possible but has two main drawbacks. Firstly it would take 7 to 8 years before the first cross could be tested, secondly it is by no means ascertained that the improved genetic potential could be exploited in the pastoral systems in Eastern Africa. Feeding concentrates coupled with mineral supplementation and health care might help attain the goal. It is probable that good quality feed would be better used for dairy animals (buffaloes and cows) already bred for milk production. It, however, needs to be kept in view that many reported milk yields even for research stations, fail to take into account the milk taken by the camel calf.

Reports indicate that in Pakistan camels outyield Friesian x Sahiwal and Sahiwal cattle as well as buffalo under some conditions and that these higher yields compensate for lower fat content in camel milk. Yields as high as 5330 litres in 13 months have been obtained under station management at Al-Jouf in Saudi Arabia and 3900 litres in 305 days at Matar in Tunisia. However, it is likely that traditional owners will continue to breed camels that can produce milk for up to 18 or more months and may not want to lose this trait in exchange for high daily yields. These apparently low yields should be seen in relation to the needs of the owners, climate and feed conditions. As already mentioned,
sufficient milk is taken by the calf and is not recorded. Milking frequency also influences the apparent and probably the real yield since it varies from as little as once every 2 to 3 days to as often as six times a day.

**Q. Give a detailed account of quality of the camel milk.**

For as long as records concerning camel milk have been kept, the special properties of camel milk have been mentioned. It was because of these properties that caused man to take a milking camel with him to cross vast deserts. Apart from this, milk was available even under harsh conditions. The most special property of the camel milk is its water content. This, at first, does not seem to be a physiological reaction, because the quantity of milk produced by goats and cows, which face lack of drinking water, declines and the milk becomes concentrated i.e. saving of body water. However, if lactating mammals in the cold provide their young with large amounts of fat in their milk to provide energy, it thus seems logical that a desert mammal in the heat should provide its young with more water to prevent dehydration. When the lactating she-camel is deprived of drinking water, her milk becomes diluted to over 90% water. This logical reaction has been confirmed by endocrinological studies showing that all hormones involved in water homeostasis and milk production act to dilute milk in the same way as they act to dilute sweat. A similar diluting mechanism was also found in partially dehydrated cows and women. A 600 kg camel has about 200 litres of fluid in the alimentary canal and this is available for milk production, giving 20 litres per day for 10 days.

As fat is present in fixed amounts in milk, its percentage changes according to the water content. Hence a fall in water content will increase the fat percentage while an increase in water will decrease it. In the desert a high water content of milk with low fat percentage is a definite advantage. The fat does not form a layer on the camel milk when kept undisturbed, unlike cow milk, but is spread throughout the milk in small micelles. This makes the fat easier to digest as normally the bile and pancreatic enzymes must act to bring the fat to this state. Camel fat in general contains much higher concentrations of long-chained fatty acids (C-14 to C-18) rather than the short-chained fatty acids, which are most prevalent in buffalo and cow milk. Protein is present in sufficient nutritional quantities for human purposes.

Both salt and urea are essential requirements for the calf’s and child’s well being. The most important factor in the milk and human nutrition (besides the higher water content) is the high concentration of vitamin C. The vitamin C (ascorbic acid) has a powerful antioxidant action. The low pH brought about by the ascorbic acid stabilizes the milk and keeps it potable for relatively long periods. Refrigerated milk remains tasty for weeks. Camel milk is often virtually the only source of vitamin C for humans and shortages can result in serious complications in growth and brain function. Vitamin C also gives to the camel milk its sweet taste, often masking other tastes given to the milk by type of fodder eaten (bitter, salty etc.). The vitamin C content in camel milk is as high as 36 mg/kg, compared to cow’s milk having an average of 10 mg/kg (Yagil, 2000).

**Q. Write a note on lactation in camel.**

A better understanding of its reproductive cycle and lactation can lead the camel to become an important producer of milk in hot arid regions. The camel has an advantage
over buffalo and cattle in hot climates of being able to continue eating. Some experiments with sucklings have shown that in the presence of adequate feed, fully watering camels only once every 10 days had no effect on milk production, whereas other workers strongly suggest that production is improved by daily watering.

The camel does not conserve water by restricting milk yield during periods of dehydration. It produces an increased amount of milk which is more dilute than normal and having a water content of >90%. This is thought to be a physiological adaptation to keep the calf hydrated. Production figures reported by various workers and from different countries are highly variable; up to 50 litres milk yield per day has been reported. If standardized to 305 days, lactation yields worked out to be 1200 litres to 10,700 litres. Camels grazing pasture were reported to produce 1,123 litres in a lactation of 13 months, with a production peak of 4.4 litres on day 56. As with yield of milk, the length of lactation also shows great variation. Depending on the reproductive status, management and frequency of milking, 9 to 18 months would appear to be reasonable. It is reported that camels tend to dry off when 4 months pregnant. With better feeding and delayed calf weaning; lactation length is usually prolonged.

The information available does suggest that sufficient variation exists for selection for milk yield to lead to significant improvement. However, in areas having a demand for milk, the shortage is so acute as to discourage the culling of any animal with udder and the inherent difficulty in producing a calf more than once every two years. A further constraint to milk production is the necessity of the presence of the calf to initiate milk flow and prolong lactation. High calf mortality then also adversely affects milk production. Whether this factor could be modified by selection, is not known. The camel does suffer from mastitis, but the incidence is much less than that seen in buffalo or cattle.

**Q. Write an essay on endocrine control of lactation in the camel.**

As in all body functions, hormones control all aspects of lactation. The combination of hormones which elicit udder and teat development as well as milk production and let-down are already well documented. However, specific hormones regulate milk production of the one-humped camel lying in arid areas. The four most prominent interrelated hormones are prolactin, oxytocin, aldosterone and vasopressin. Since the most important constituent of camel milk under the desert is water, especially in the dehydrated camel, it therefore, becomes clear why the aldosterone and vasopressin play such an important role in camel milk secretion. Prolactin and oxytocin prepare the udder tissue for milk production and after partus stimulate and maintain milk production. For most mammals it is accepted that prolactin is active only in the initial period of lactation, whereas further maintenance of milk production is dependent on oxytocin, which is secreted during evacuation of milk from the udder, either by suckling or milking. Since prolactin is important in combating the scarcity of body water, its secretion in the dehydrated camel will guarantee alimentary water absorption. However, it is the oxytocin secretion, brought about by milking, which *de facto* retains milk secretion. Thus extraction of milk determines milk secretion. This point is stressed because if the camel is not milked properly and milk is allowed to remain in the udder, hormonal control will
lower milk production. Camel herders are not aware of the importance of keeping a camel at its maximal milking capability and tend to skip milkings or leave milk in the udder. The practice of ‘strengthening the calf’ by not milking its mother for 4 to 5 days after birth will certainly depress milk production per day and per lactation period. Herders should be taught ‘the more you take the more you get’ or ‘use it or lose it’.

In the dehydrated camel all the hormones, which act on the secretion of milk also act on the kidneys and alimentary canal to retain body water, making it available for the milk. Vasopressin and aldosterone have the same effect as in maintaining homeostasis i.e. retaining salt and water (Figure 19). In addition, the intermediate hypophysis changes anatomically and functionally to resemble neurohypophysis and therefore, more vasopressin and possibly oxytocin, are secreted. Another important factor is that vasopressin in large amounts acts as oxytocin and vice versa. In practice, therefore, large amounts of milk cause the secretion of large concentrations of oxytocin (and vice versa), which then acts to provide the necessary water by exerting an antidiuretic effect. Prolactin is an active initiator of salt and water metabolism, even in male animals. Its action on alimentary canal is similar to that of aldosterone, in a manner similar to vasopressin-oxytocin; when there is a need for salt and water, these hormones act similarly (Yagil, 2000).

Q. Discuss milking and the frequency of milking in camels.

Camels have four teats like those of buffaloes and cows. They are milked traditionally by men. Because of the height of the udder milking is done standing with one knee raised to support the milking bowl. Under most circumstances one-half of the udder is milked and the other one simultaneously suckled by the calf. Occasionally both udder halves are milked at the same time by two herdsmen. Not all camels accept this, particularly during the early stages of lactation, and in most cases the calf has to suckle first to stimulate milk let-down. In later stages of lactation, it is normally sufficient that the calf is present but does not need to suckle. Sometimes, when the calf is stillborn or dies early after birth, its skin is used to build a calf dummy that is shown to the mother to induce the release of milk. This is successful when the mother has had calves before, mostly it does not work with first calvers. In many such cases the mother will simply dry up within a week. These animals are quite often immediately bred again with good success.

The frequency of milking camels is variable and depends on supply of and demand for milk. Several factors affect milking frequency such as season, the quantity of milk produced per animal, the number of milking camels present, availability of other food for the herders household and sex, age and health of calves. Higher frequencies commonly produce a higher total yield, which is noticeable up to four milkings a day. It is not unusual to milk camel up to six times a day.

Q. Possibly what milk products can be made from camel milk?

For many years it was thought that because of its composition, it is difficult to convert camel milk into butter. There were apparently similar problems with making cheese. Recent research on the chemistry and biochemistry of camel milk and advances in processing technology have made it possible to make both butter and cheese without too much difficulty. Processing time may, however, be longer than for other milks and
techniques have to be adapted to the peculiarities of camel milk. Other traditional products such as fermented milks are not difficult to make and are highly appreciated by the owners.

Camel butter is pale in colour and sometimes has a slightly greasy texture. Milk takes a long time to cream, partly because of the size and distribution of the fat globules but also because camel milk fat contains a high proportion of fats with high melting points and a lower proportion that melt at about 15°C. Coagulation of cheese takes 2 to 4 times longer than for milk of other species but can be greatly reduced by adding 15g/100 litres milk of calcium sulphate (CaSO₄) or calcium chloride (CaCl₂). The usual bacteria can be used to form surface moulds (P. caseicolum) and blue cheeses (P. roquefortii). The taste of all types of camel cheese is generally acceptable to most people. Other products of lesser overall importance but which are made in various areas to suit local tastes are a variety of yogurts, soured milks, ice cream, Khir etc.

Meat

Q. Discuss in detail the production of camel meat.

Milk and work, in a wider sense, are the principal products of the camel. Meat is usually a by-product of a camel system and comes mainly from old males and females that have served usefully in other functions in earlier life. Only a limited number of castrated males are raised especially for slaughter. Of course, there are sizeable exceptions to the camel meat as to its being a by-product of a camel system. For example about 0.17 million camels are slaughtered in various countries by well-to-do adult Muslims on their annual religious festival called Eid-ul-Azha. At least 50% of this number are young male camels aged around 4 years. Many people keep and very fondly raise the camels simply for the sacrificial slaughter on this annual festival. The number of sheep, goats and cattle slaughtered by the Muslims with the same objective on this religious occasion around the world far exceeds 12 million.

Camel meat is a good source of protein but a lesser source of energy. The meat of one average sized camel will provide a person with 35 days supply of protein but only 5 days of energy. While camel meat is usually from old animals, it often has a specialized market. Camel meat markets, except in Sudan, are not well developed, but lucrative export opportunities to Egypt, Libya, Saudi Arabia and Gulf States do exist. It has been scored as high as or better than beef by taste panels in the Arab states. Even outside Arab States, meat from young camels has been graded as having the taste of a good beef. Camel meat is usually only a small proportion of the meat consumed in a country. In Pakistan, approximately 70 to 75 camels are slaughtered daily in various slaughterhouses except on meatless days. In several African and Asian countries, the consumption of camel meat is equivalent to 5 to 50% of nationally produced red meat. The meat is usually eaten fresh, cooked as such or in minced form, but is sometimes air-dried. Meat from camel is also used for sausages, in which form it has cooking and taste qualities similar to those made from beef.

Dressing percentages of camels are in the range of 45 to 55%, exceptionally up to 60% (Table 11). Using standard cattle butchery procedures, forequarters comprise about 34% of the total carcass, while the hindquarters constitute 25%. The rest of the carcass
Part – I  Production and Management of Camels

includes about 5.0% liver, heart and lungs, with the head being 3.6% and the feet about 4.3%. The wet hide is equivalent to about 10.0% of liveweight and the blood to about 3%. A detailed study of 52 fattened male camels in Sudan, whose average body weight was 456 kg (range (395 to 512 kg), produced the following information. Dressing percentage was 55.8 when animals were slaughtered full and 63.6% after a fast of 48 hours. Individual body components were weighed and expressed as a percentage of fasted body weight, given in parentheses here: head 14 kg (3.5%), hide 35.8 kg (8.6%), gut full 54 kg (13.9%), stomach empty 10.3 kg (2.6%), intestines empty 15.4 kg (3.8%), mesenteric fat 6.6 kg (1.4%), kidneys 1.7 kg (0.4%), lung, trachea and diaphragm 5.9 kg (1.5%), heart 2.7 kg (0.71%), four feet 14.4 kg (3.6%), spleen 0.5 kg (0.1%), testicles 0.6 kg (0.2%) and tail 1.4 kg (0.4%).

Reports of weight gains in camels vary greatly. Some are randomly quoted here. Under open range conditions liveweight increase of 1 kg/day has been reported. In Egypt, animals fed on a high energy diet compounded from cottonseed, rice, molasses and mineral mix gained 150 kg body weight in 6 months (almost 0.82 kg/day). Well fed young camels under intensive conditions have gained 0.58 kg/day. In tribal situations, 222 g/day have been recorded in poor years to the age of 6 months, and 655 g/day in wet years when the calves were allowed to take all the mother’s milk.

Table 11. Live and carcass weights and dressing percentage of Sudanese camels from Darfur

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sex</th>
<th>Male (n=21)</th>
<th>Female (n=39)</th>
<th>Total (n=60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liveweight (kg)</td>
<td></td>
<td>Mean 447.9</td>
<td>414.4</td>
<td>426</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range 305.5-581.0</td>
<td>307.5-522.5</td>
<td>305.5-581.0</td>
</tr>
<tr>
<td>Carcass weight (kg)</td>
<td></td>
<td>Mean 231.3</td>
<td>196.3</td>
<td>208.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range 144.0-310.0</td>
<td>141.0-248.0</td>
<td>141.0-310.0</td>
</tr>
<tr>
<td>Dressing percentage</td>
<td></td>
<td>Mean 51.4</td>
<td>47.4</td>
<td>43.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range 46.2-55.6</td>
<td>41.3-53.5</td>
<td>41.3-55.6</td>
</tr>
</tbody>
</table>


Camels can utilise urea, molasses, dried sugar tar and poor quality feedstuffs treated with ammonia. These reports suggest that feedlotting may be cost effective. It may be possible to combine a system of low cost open range breeding with an intensive finishing period. Reported liveweight variation in camels suggests an ample scope for genetic manipulation and development of a meat type (Manefield and Tinson, 1997).

Q. Write a brief note on composition of total carcass of camel.

Total carcass composition is about 66% muscle, 19% bone and 14% fat, the latter being mainly in the hump. Lean meat has more moisture and less fat than beef, with the pH
being about 5.75. Muscle has 75.5% water, 21.4% protein and 1.4% fat. As a percentage of cold carcass, proportion of muscle was 56% bone 19% and carcass fat 13.7%. The latter figure would vary according to the degree of fatness of the animal, its conformational type and environmental factors. Bactrian camels have been reported with 25% carcass fat.

Q. Give average and range of birth weights of various breeds of Arabian camels and the factors that affect these weights.

It is probable that birth weights differ significantly among breeds in the same area as shown by averages of some breeds in Pakistan and India. Weights at birth are

**Table 12. Birth and mature weights and weight gains of various camel breeds**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pakistan breeds</th>
<th>Indian breeds*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kachhi</td>
<td>Gaddi</td>
</tr>
<tr>
<td>Birth weight (kg)</td>
<td>44</td>
<td>41</td>
</tr>
<tr>
<td>Mature weight (kg)</td>
<td>662</td>
<td>589</td>
</tr>
<tr>
<td>Average gain (g/d) 0-3 months</td>
<td>642</td>
<td>786</td>
</tr>
<tr>
<td>3-6 months</td>
<td></td>
<td>540</td>
</tr>
<tr>
<td>6-12 months</td>
<td>134</td>
<td>290</td>
</tr>
<tr>
<td>1-2 years</td>
<td>189</td>
<td>186</td>
</tr>
</tbody>
</table>

* Source: Adapted from Anonymous. 1990. Annual report, National Research Center on Camel, Bikaner, India.

also influenced by dam nutrition, health status and health care. Gestation length seems to have some effect on birth weight. Season of year and parity also influence this parameter. In contrast to many other species, female calves are usually as heavy as or heavier at birth than males. Birth weights range from 25 to 45 kg (Table 12). Heritability of birth weight is probably higher in camels than in other species. This suggests that it could respond rapidly to selection. Improved nutrition and better management are probably appropriate improvement paths to achieve heavier birth weights (Table 13). Heavier birth weights should result in better calf survival and consequent overall improvement in herd performance.

**Table 13. Average birth weight of camels from various countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Birth weight (kg) (mean ± s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pakistan</td>
<td>43.5</td>
</tr>
<tr>
<td>India</td>
<td>41.9 ± 1.35</td>
</tr>
<tr>
<td>Tunisia</td>
<td>27.2 ± 0.65</td>
</tr>
</tbody>
</table>
Q. **Give a brief account of mature weights of one-humped camels and the factors that may influence these.**

Mature weights range from 400 to 800 kg. These weights are mainly related to breed or type of the camel. An animal’s genetic make-up is usually the most important factor in its final mature weight. The effects of management, nutrition and health care can, however, influence the time at which the mature weight is reached. This has been amply shown in Kenya where Rendille-Gabbra camels in a traditional pastoral system do not reach 400 to 500 kg mature weight before about nine years yet achieve this range at four years under ranch conditions. Benadir type camels on another ranch reach 600 to 700 kg by five years, whereas traditionally managed herds have animals of this weight only at older ages. Male Ogaden camels in south-east Ethiopia weigh about 685 kg at maturity in the traditional system, while females weigh 525 kg. Better management and health care such as deworming and removal of ticks coupled with mineral supplements and feeding from lower grazing pressure areas and higher rainfall can thus pay handsome dividends in camel production. These dividends are reduced age at sexual maturity when the animals can be bred or can be sold for meat or as transport animals. Mature weight of camels in Pakistan on average varies from 550 to 740 kg.

Q. **Discuss the daily gain in body weight of dromedaries in some of the African and Asian countries.**

Daily weight gains of camels vary from 300 g to more than 1000 g for animals from birth to one year old. In Saudi Arabia, males and female calves grow almost at the same rate, with daily gains from 780 g/day in the first month after birth to 1040 g/day in the fifth month and then decline to 400 g/day in month twelve. There is found an inflection in growth curve (i.e. slow growth) at 4 to 5 years age, this being a normal occurrence in all livestock as they approach mature size (although it occurs at different ages in different species). Allometric (unequal) growth results in relatively more rapid increases in linear body size than in weight. For example, in Tunisia, camels at first conception were only 64% of final weight but averaged almost 90% of final size in six linear measurements. Weight changes can be influenced by management interventions and by improved nutrition. The cost in weight gain of restricted access to water was that 12 to 14 month old camels of about 200 kg liveweight gained 430 g/day over six months on daily watering while only gaining 380 g/d when watered weekly. Breeds with lighter birth and mature weights may gain weight more rapidly than breeds of heavier weights and thus may become physically mature at an early age.

Rates of feed intake in relation to liveweight gain are generally in the ratio of 4 to 8 kg for each kilogram of gain. In other words, 22 to 29 MJ ME are needed for every kilogram of weight gain for young animals. Of course, more energy is needed for older animals.
whose efficiency of growth is reduced as they approach mature weights. Nutrition and management interventions are more effective in increasing weight when used early in life. Calves in Israel gained 870 g/day in very early life at a metabolisable energy intake of 19.45 MJ/day with an average daily gain of 680 g up to 180 days age. Animals one year old in Tunisia fed 175 days on oat hay *ad libitum* and a concentrate of wheat bran and olive pulp gained 326 to 565 g/day (with a linear relationship of \( y = 284 + 5.4 \, x \), where \( y \) is weight in kg and \( x \) daily dry matter intake in g/kg\(^{0.75}\)) eating 1.6 kg DM/100 kg liveweight or 61 g DM/kg\(^{0.75}\) per day at a conversion ratio of 7.4: 1.0. Heavier camels (665 kg in Ethiopia gained only 100 g/day over 90 days at lower intake levels of about 1.25 kg DM per 100 kg or 50 g DM/kg\(^{0.75}\).

**Q. How would you determine the weight of a camel at a particular age?**

Weight at a particular age may be determined from regression equation provided some prior data are available. For Bikaneri camels a linear relation of \( y = 90.53 + 0.29 \, x \) (where \( y \) is weight in kg and \( x \) age in months) accounted for 94% of total variation. Heritabilities of weight at 6, 12, 18, 24 and 30 months age have been estimated as 0.52, 0.40, 0.29, 0.12 and 0.31 in India.

Weight at a particular age is mainly a reflection of gain in body weight. It is influenced to some extent by birth weight as well as by the same genetic and environmental factors that affected weight gain in camels. The month and the year in which an animal is born are the most important factors affecting weight as these two periods effectively control the amount of feed available to an animal. The influence of these two periods is, however, progressively reduced with age. The number of calves already born by their dam affect weight at young ages only. Compensatory growth occurs from about 24 to 30 months of age and it is this phenomenon that causes most other effects to disappear after this stage.

**Q. Discuss various means of determining the body weight of camels. Also indicate the purpose of carrying out this exercise.**

Determining the liveweight of camels is necessary in deciding on breeding, culling, slaughtering and in rare cases in feeding them. Body weight is rather important for proper dosing with drugs. Because of their height camels cannot be weighed in regular buffalo and cattle weighing crates, which usually have small weighing platform. A specially designed weigh bridge with a large platform and a dial should be used for weighing camels. Hydraulic or electronic platforms are also available. The former is a cheap alternative.

Body weight of camels can be calculated from body measurements as is done for other farm animals. Boue (1949) as cited by Schwartz and Dioli (1992) had developed a formula for estimating liveweight of the camel based on three measurements of its body. If these measurements {i.e. shoulder height (H), thoracic girth (T) and abdominal or hump girth (A)} are taken in metres, weight in kg can be estimated from the following formula: Liveweight = 53 x (TAH). This formula was applied by Schwartz *et al.* (1983) together with weighing on a hydraulic weighing platform and used a slightly modified formula (Figure 20) (all measurements in metres). Liveweight (kg) = SH x TG x HG x 50 (Table 14).
Table 14. Correlations between body measurements, estimated and exact liveweights of small East African camels on a ranch, Laikipia District, Kenya (n = 328)

<table>
<thead>
<tr>
<th></th>
<th>SH</th>
<th>TG</th>
<th>HG</th>
<th>Exact weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated weight (EW)</td>
<td>.93</td>
<td>.95</td>
<td>.95</td>
<td>.98</td>
</tr>
<tr>
<td>Height (SH)</td>
<td></td>
<td>.95</td>
<td>.92</td>
<td>.95</td>
</tr>
<tr>
<td>Thoracic girth (TG)</td>
<td></td>
<td></td>
<td>.94</td>
<td>.97</td>
</tr>
<tr>
<td>Hump girth (HG)</td>
<td></td>
<td></td>
<td></td>
<td>.94</td>
</tr>
</tbody>
</table>


The three body measurements were highly and positively correlated to each other. It is therefore possible to use only one of them to estimate liveweight with a little error margin. The thoracic girth appears to be the most reliable parameter in this context. Liveweight of tall and slender camels, like the racing type or young calves of all types will be overestimated if the same numerical factor is used, whereas the liveweight of short and compact animals tends to be underestimated by this formula. Accordingly, the numerical factor in the formula has to be adjusted to age/type of animal.

Q. What normally is the rate of growth of world population of one-humped camel and what factors may affect this rate?

Estimates of numerical increase in world population of one-humped camel have averaged about 1.16% per year over a period of 15 years from the late 1970s to the mid 1990s. The proportional increase in numbers has been slightly less in Africa (1.14% per annum) than in Asia (1.18% per annum). However, in Africa, numbers have increased more rapidly in countries that already had large camel populations and where they are an important part of the agricultural and national economies. Some 70% of the one-humped camels in the world are kept in pastoral systems in eastern and north-eastern Africa. Here it is the need for milk that drives the system and the potential for meat is largely ignored by the owners. In East Africa, dairy herds mostly consist of breeding females while in other herds where transport is still important, there is greater percentage of males but females usually still predominate.

The age and sex composition of the herd influence in part the rate at which a population increases. Other parameters that affect population growth are reproductive performance and mortality rates (Table 15). Camels are large, slow maturing and long-lived animals. Population growth rates thus tend to be slower than for the other farm animal species. Off-take of males for slaughter at three years and upwards also needs to be accounted for.

Table 15. Production parameters affecting herd structure and population growth in certain farm animals under dry land conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Animal species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Goats</td>
</tr>
<tr>
<td>Age at first parturition (months)</td>
<td>15</td>
</tr>
<tr>
<td>Number of young per parturition</td>
<td>1.4</td>
</tr>
</tbody>
</table>
### Table 1

<table>
<thead>
<tr>
<th>Interval between parturitions (months)</th>
<th>9</th>
<th>10</th>
<th>20</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of young per female per year</td>
<td>1.8</td>
<td>1.4</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Mortality rate to 12 months (%)</td>
<td>35</td>
<td>35</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>Mortality rate after 12 months (%)</td>
<td>10</td>
<td>10</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>


### Q. Discuss the prospects for improving the production of camel meat.

Meat production efficiency of a livestock species is affected mainly by two factors. One is the reproductive efficiency influencing off-takes, the other is the individual growth potential. As already pointed out, camels, due to the intrinsically low reproductive rate, cannot be efficient meat producers. Off-take rates of 3 to 5% might already constitute a stress on the population. The fact, that all camel populations in many African countries and some of the Asian countries according to some estimates, with a few exceptions, are either declining or are stagnating in numbers, proves that a pronounced consumer preference for camel meat combined with strong purchasing power can be detrimental to population growth. The individual growth is determined by sex and genetic potential. Genetic improvement is faced with the same constraints as were pointed out for milk production.

The most powerful interventions to improve meat production in camels are improving nutrition especially of the calves, early weaning of calves and reducing mortality through hygiene and health care.

Since production in the traditional subsistence system is mainly geared to milk production, male calves are thus considered of little future value and face a much stiffer competition with the herders for their dam’s milk than female calves. They are often allowed to suckle only one teat, or are given access to the dam’s udder after all teats have been milked, whereas female calves usually have regular access to two teats. Consequently the pre-weaning survival rate of male calves is less than half of that of females and weaning weights are lower. Total productivity on the other hand is higher in dams with male calves due to the high milk off-take for human consumption, with milk accounting for approximately 80%. In females with female calves, milk off-take for human consumption contributes only 30% of the total. This trend to deprive the male calves of their due share of milk is evidently detrimental to their growth which in turn adversely affects their potential to produce meat.

### Q. Are slaughtering and skinning of camels done in a different manner than for other large animals? If so, discuss briefly.

In contrast to other livestock species, camels are slaughtered when they are in sternal recumbency. The reason being that camel would require a scaffold at least 4 to 5 m high to facilitate butchering a hanging carcass. Butchering camels lying on the back is also not practicable because the distinctly arched spine and the hump make balancing the carcass virtually impossible. Instead camels are seated in a normal posture, front and hind legs are tied, the head is bent sideways and backward, and with a quick incision all major
cervical vessels at the base of the neck severed. Immediately after the nuchal ligament is cut just in front of the shoulder, so that the neck and the head rest on the ground. Death is immediate. The carcass is kept in sitting position. For better balance of the carcass the hind legs are pulled backward and outward. Skinning begins with a long incision along the spine and the crest of the hump. The skin is removed down the sides and cut off the legs before the elbow and knee callosities. Butchering begins with splitting and removal of the hump. Removal of the various cuts is always done symmetrically to maintain the balance of the carcass. The spine and the long muscles of the back are left intact until all internal organs are taken out. Then the spine is cut out between the withers and the pelvis and the remainder of the carcass collapses and is cut into smaller pieces. At last the skin is cleaned out and cut in two symmetrical pieces. If there is no immediate disposal of skin, it should be salted and spread over a wooden frame.

Work

Q. Give a list of various types of work performed by the camel.
Camels are used as riding and pack animals, to pull carts and to provide draught for various agricultural operations such as ploughing and seed-bed preparation, operating chaf cutters and cane crushers and drawing irrigation water from deep wells. They are a power source for small scale oil mills and grain grinders. Loading camels are regularly used to carry firewood and trade goods. In farflung desert areas camels perform transport functions during migrations and most importantly carry water for household consumption.

Q. Give an overview of work performance of the camel.
Probably no other domestic animal performs as wide a range of power functions in support of man as the camel. They still make a major contribution to the energy needs of urban and rural communities in most areas of their distribution. Under traditional pastoral livestock production system, migration might range from once/twice in Pakistan and India to six times per year in several countries in Africa. Of crucial importance to these migratory systems is availability of adequate numbers of loading camels for haulage of households, water etc. Migration distances might be short or extend over a few hundred kilometres. The performance of camels as draught animals compares favourably with oxen and equals that of horses (Table 16).

Besides household needs such as water, camels commercially carry building material, grains, salt and many other goods in Niger, Mali and Ethiopia. In Pakistan and India, camels drawing pneumatic-wheel carts deliver many urban goods to individual service points more economically than motor transport. This is because the capital cost of a camel and cart is lower and it is not expensive in spare parts. Other considerations in this context are that it does not pollute the environment with carbon monoxide fumes and with noise.

Camels seem to be equally as efficient in producing draught as most other species. However, harness and yoke system used should be comfortable and such that cause no injury to the camel. The camel is also used for individual transport as a riding animal. It is still very common in rural areas in many countries. Camels still serve as mounts for
army, rangers/border police in some of the Asian and African countries, but their importance is declining. On the other hand, their monetary value as racing animals has increased tremendously in recent years. Camel racing and other sports and leisure activities such as pleasure riding, trekking and camel safaris have recently become a tourist attraction in many parts and developed into a minor industry.

Q. Give below the normal walking and trotting speed of an average camel and the weight it can carry easily.

Camels walk on average at the speed of about 4 km/hour and trot at 10-12 km/hour, while they can run over short distances at about 32 km/hour. Camels can carry load’s up to one third to one half of their body weight over a distance of 60 km per day.

Table 16. Sustainable draught power of various animal species for ploughing

<table>
<thead>
<tr>
<th>Species</th>
<th>Liveweight (kg)</th>
<th>Sustainable draught power</th>
<th>Working speed</th>
<th>Daily working time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Relative (% liveweight)</td>
<td>Absolute (kp)</td>
<td>(km/hr) (hr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Donkey</td>
<td>125</td>
<td>20</td>
<td>25</td>
<td>2.0 3-3.5</td>
</tr>
<tr>
<td>Horse</td>
<td>300</td>
<td>12</td>
<td>35</td>
<td>2.7 5-6</td>
</tr>
<tr>
<td>Oxen</td>
<td>350</td>
<td>14</td>
<td>50</td>
<td>2.4 4-6</td>
</tr>
<tr>
<td>Camel¹</td>
<td>450</td>
<td>8</td>
<td>35</td>
<td>2.5 5-6</td>
</tr>
<tr>
<td>Camel²</td>
<td>450</td>
<td>12</td>
<td>54</td>
<td>2.5 5-6</td>
</tr>
</tbody>
</table>

1 = If absolute draught power is assumed to equal that of a horse.
2 = If relative draught power is assumed to equal that of a horse.


They can carry as much as 200 kg with relative ease but are often asked to do much more, for which there is a price to pay in slower speeds and extended periods of rest. On camel carts having pneumatic wheels, a single camel can pull a load of over one ton. About two and a half decades back, a team of 16 camels in Australia used to pull on rough roads loads of 8 tons at speeds of 2.5 km/hour.

Q. What pattern of settlement around water points is followed by camel raising desert dwellers?

Camels are vital for nomads/desert dwellers for their personal transport and for moving the camp, carrying firewood and water and for earning cash through transport for third parties. They usually follow a natural pattern for locating their camping units around watering points. Those having 1 to 2 camels will settle within less than 3 km from the watering point, whereas those with 3 to 4 camels would camp within 5 to 6 km and such nomads as having 8 or more camels would locate their camping units beyond 10 to 12 km from the water source. Browsing/grazing areas close to a water source are usually in poor condition, due to high grazing pressure and present a higher contamination risk with respect to intestinal and ectoparasites. Pastoralists who are forced to maintain their herds here have a limited choice of pasture resulting in limited milk and meat supply to the household and can thus adversely affect the quality of herd management.
**Leather, Hair and Wool and Manure and Blood**

**Q. Discuss the production of leather from camel hides.**

Reliable data in respect of these by-products from various countries of Africa and Asia are not available. About 22500 camel hides including those of animals slaughtered annually by Muslims on the religious festival of Eid-ul-Azha are obtained in Pakistan. Of these 15 to 20% hides are damaged. These are used to manufacture saddlery, sandals and beautiful decorative articles some of these items are exported as well.

Some time back the people had poor opinion about the leather made from the camel hide, but the better processing of the hide in Sudan and the use of better technology in Australia have shown encouraging results. By splitting the hide, thus allowing the hump section to flatten, tanning has been performed in commercially available machines. Vegetable tanning produces a soft leather suitable for craft work and the tourist industry. Chromate tanning produces a harder leather suitable for commercial applications, but still useful for selected craft work.

It has been found that camel hides do not lack strength and possess 5 times the pulling strength of bovine hides. Work in Sudan indicates that camel hides are superior to cattle hides in many ways such as these flay and flesh more easily, are 60% heavier than cattle hides, the large neck area in camels makes good leather and the crust leather yield from camels is 50% more than that from cattle. Camel hides absorb salt better, cure better and dry faster than cattle hides. Dehairing of camel hides is faster and deliming and tanning better and therefore split easier. The tensile strength is 20% greater than cattle leather. The finished chrome tanned camel leather is denser yet softer than the cattle product. When made into ladies handbags, spectacle jackets, wallets and shoes, acceptance wise these products were graded higher than the same products made from cattle leather.

**Q. Are camels in Pakistan a substantial source of obtaining hair, wool, manure and blood?**

The production of camel hair makes a negligible part of the about twenty thousand tons of hair produced in Pakistan. However, as in other camel producing countries, these are used locally for manufacturing blankets, floor mats, tent cloth and ropes. Manufacturing of these products provides living to hundreds of people. Wool yield from camels is much lower than the hair produced by them. Calves are born with a soft woolly fleece, which usually can be shorn once. The yield approximately varies from 0.5 to 1.0 kg of raw wool. This wool is mixed with hair in manufacturing blankets.

Camel raisers leading a nomadic life are most of the time not involved in agriculture. However, many farmers having cultivable land keep one or at the most two camels. The excreta of these animals obviously becomes a part of the farm yard manure produced by other farm animals such as buffaloes, cows, sheep/goats maintained by the farmers and as such is used for fertilizing their lands.

Blood of camels slaughtered in regular slaughterhouses in Pakistan is collected along with the blood of other animals slaughtered there, but no separate precise figures are available for camel blood. The blood thus collected is dried/sterilized and used as blood meal in animal feed especially poultry feed. Such data concerning most of the countries possessing camels are lacking.
The Turkman one-humped camel from southern central Asia produces about 2.5 to 2.7 kg fibre per year with a diameter of 12-27 µm and a length of 4 to 12 cm. Compared to most of the African and Asian one-humped camels, the Bactrian and South American camelids yield fibre which is much better quantity- and qualitywise.

Q. Are South American camelids and Bactrians a good source of wool and hair production?

Both types of fibres, wool and hair, are found in the coats of camelids. The worlds most highly regarded wool is obtained from the South American camelids, especially the Vicuna. Among the old world camelids, the Bactrian is superior to the dromedary as a wool producer.

The entire camel is covered in wool and hair that vary in length according to the season and location on the animal. The longest hairs are seen on the hump, shoulders and under the throat. Coat colour ranges from almost white through brown and fawn to almost black. Two coloured camels are common in some regions. Fibres are grouped in clusters except on the lip margins, external nares and lower eyelids. This arrangement may assist the camel to evaporate sweat at the skin surface rather than on the hair tip. Coat over the back may reach a length of 40 cm in the Bactrian and alpacas. The long coat sheds and tends to be rubbed off during the summer season. Even then it protects from radiant heat, and camels, which are mistakenly shorn for comfort may suffer from increased heat stress. Camels permanently domiciled in equatorial regions tend to have a sleek, glossy coat the whole year round. Reflection from such a coat helps to reduce radiant heat absorption.

The wool of the camel has had times of demand for textile production and reports indicate that currently there is a strong resurgence. The coarser fibre is used for the manufacture of tents, carpets and blankets. Large Bedouin tents are still used. The fine fibres are used for the manufacture of coats. Shearing takes place once a year in spring. The finest camel wool is obtained from the coat of the Bactrian yearlings. The fibre diameter is 16 to 18 µm (fine Merino wool is 18 to 19 µm) with 85% of fibres non-medullated. In Mongolia, adult Bactrian males may produce up to 15 kg. The average herd yield is 5 kg. About 25% is long coarse fibre shorn from the knees, elbows and chest. The remainder, with a fibre diameter of 21 to 29 µm comes from the body and sides of the neck. Wool production is the primary goal of camel keeping in parts of China, Mongolia and eastern parts of the old Soviet Union. In cold climates the dromedary may produce up to 5 kg of hair annually but 2 to 3 kg is more usual. Australian camels give heavier yields than those in the Middle East. Temperature in winter nights in Australian deserts often falls to minus 9 to 10°C. The wool from the adult male dromedary has a fibre diameter of 31 to 35 µm. Finer wool is produced by yearlings with yields of 1 to 4 kg. There is a camel wool farm on Blackspur in Victoria, Australia. Prices realised for the product are reported as 250 to 300/kg Australian dollars when carded and spun.

Q. Discuss the comparative productivity of camel. Give your reasons in favour or against.
The camel’s supposedly low productivity must be seen in the context of low inputs and the harsh conditions to which it is adapted. The camel’s comparative advantage lies in its ability to produce and to thrive in areas where feed and water are limited, where climatic and other environmental stresses are severe and where other domestic species are incapable of similar performance. In addition to work, the camel produces large amounts of protein relative to food energy for human use.

The value of the camel in harsh environments is, perhaps paradoxically, best shown by its limited increase in productivity in response to improved conditions. In comparison with other main farm animals, improvements in output are only half those of goats, about one-sixth of that of sheep and only one-eighth those of cattle. Instead of criticizing the camel as a domestic animal, this response failure is a powerful argument in favour of its husbandry in difficult areas. Improved management, feed and water supplies coupled with proper health care do result in increased output from camels. Such interventions should always be used, however, in the context of the economic and biological environments.

Nomadism and transhumance are the main elements in traditional system of camel raising. Camels have rarely been kept as the only species in a production system, either at local or at larger scale and their has almost always been herding of a mix of species yielding a range of products including milk, transport, power, meat, wool and hair. The keeping of a mix of domestic animal species is a common strategy to reduce risk. Pastoralist strategies are in fact designed to minimize the risk of destitution and not to maximize production. Production (total output) and especially productivity (output in relation to inputs) is therefore difficult to quantify, however, both are often considered to be low or poor.
Fig. 19. Endocrine control of lactation in the dehydrated camel
Fig. 20. Body measurements for the calculation of liveweight in camels using the formula: Liveweight (kg) = SH(m) x TG(m) x HG(m) x 50 [SH = shoulder height; TG = thoracic girth; HG = hump girth]