Sudan University of Science and Technology

College of Veterinary Medicine

Studies on the Normal Clinical Parameters of Selected Herds of the One-humped Camel (*Camelus dromedarius*) in Khartoum State

دراسات في القياسات الإكلينيكية الطبيعية في قطعان مختارة من الإبل وحيدة السنام في ولاية الخرطوم

Graduation Research Project

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بسم الله الرحمن الرحيم

﴿ أَفَلَا يَنظُرُونَ إِلَى الْإِبِلِ كَيْفَ خُلِقَتْ ﴾

الغاشية (17).

In The Name of Allah, the Most Gracious, the Most Merciful,

﴿Do they not look at the camels, how they are created﴾

Al-Ghashiyah (17).

<u>Dedication</u>

We dedicate this work to our Mothers, Fathers, Brothers, Sisters and Friends with deep love and sincerity.

Acknowledgements

We thank our Allah who gave us the aptitude and patience to conduct and finish this work.

We are grateful to Professor/ Mukhtar Taha Abu-Samra for his continuous support, supervision of this work and fatherly compassion.

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Finally we are indebted and very grateful to our parents for their love and support over the years.

Abstract

Studies on the normal clinical parameters of selected herds of the one-humped camel (*Camelus dromedarius*) in Khartoum State (Camel Research Unit-University ofKhartoum, Abu-Sha'ar Camel Farmand Al-Ameera Camel farm) were conducted in healthy camels showing no clinically detectable abnormality. The study was carried out with the objective of establishing base data on the normal physiological parameters of one-humped camel (*Camelus dromedarius*).

The study was conducted in 35 healthy she-camels of 4-8 years old. The data collected were recorded and statistically analyzed. The means of data recorded were as follow: The means of temperature were 36.5±2.16°C in the morning and 37.9±0.7 °C in the evening. The means of the respiratory rates were 11±1.7/min in the morning and 12±1.9 /min in the evening. The means of the heart rates were 41.6±5.5 in the morning and 44±4.8/minute in the evening.

These base data are intended to provide veterinarians working in the field and research workers with authentic normal physiological parameters that will enable them to differentiate between healthy and diseased camels raised under the Sudan climatic, nutritional, environmental, and management conditions.

Key words: Normal Clinical parameters, Temperature, Heart rate, Respiratory rate, Camel.

ملخص البحث

لقد أُجريت دراسات في القياسات الإكلينيكية الطبيعية في قطعان مختارة من الإبل وحيدة السنام في ولاية الخرطوم في ثلاث مواقع: (وحدة أبحاث الابل- جامعة الخرطوم، مزرعة أبو شعر للإبل -المويلح و مزرعة الأميرة للإبل - الخرطوم). لقد تم إجراء هذه الدراسة في حيوانات سليمة وخالية من أي علامات إكلينيكيةغير طبيعية. والهدف المنشود من هذه الدراسة هو توفير بيانات مرجعية في القياسات الفسيولوجية الطبيعية في الإبل وحيدة السنام.

أُجريت هذه الدراسة في عدد 35 من إناث الإبل السليمة بعمر 4-8 سنوات، وقد تم تسجيل البيانات بدقة تامة. كانت متوسطات القيم المسجلة على النحو التالي: متوسطات درجة الحرارة كانت 36.81 ± 0.8 درجة مئوية في الصباح و37.9± 0.7 درجة مئوية في المساء. ومتوسطات معدلات التنفس كانت 11±1.7/دقيقة في الصباح و 12±1.9/دقيقة في المساء، ومتوسطات معدلات نبضات القلب كانت 41±5.5/دقيقة في الصباح و44±4.8/دقيقة في المساء.

هذه البيانات نأمل أن توفر للأطباء البيطريين والباحثين قيماً حقيقية، تمكنهم من التفريق بين الإبل السليمة والمريضة التي تُربى تحت ظروف السودان المناخية، والغذائية، والبيئية والإدارية.

الكلمات المفتاحية: القياسات الإكلينيكية الطبيعية، درجة الحرارة، معدل النبض، معدل التنفس ، الإبل.

Abbreviations:

Abbreviation	Meaning
$	US dollar
°C:	Degree Celsius
°F:	Degree Fahrenheit
AM	Ante meridiem (Morning)
ASAL	Arid and Semi-Arid Land
BC	Before Christ
CRU	Camel Research Unit
DC	Anno Domini (Dopo Cristo – After Christ)
EDTA	Ethylenediaminetetra-acetic acid
FAO	Food and Agriculture Organization
Kg	Kilogram
Km	Kilometer
Max	Maximum
Min	Minute
Min.	Minimum
NGO	Non-Governmental Organization
PM	Post Meridiem (Afternoon)
SPSS	Statistical Package for Social Science
St.	Standard
Temp.	Temperature
UNDP	United Nation Development Program
WMO	World Meteorological Organization

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Introduction

The one-humped camel (*Camelus dromedarius*) or Arabian camel, commonly called the dromedary, is an important species uniquely adapted to hot and arid environments. It produces milk, meat, wool, hair, hides and short distance transport. The majority of camels are kept by pastoralists in subsistence production systems (Ishag and Ahmed, 2011).

Camels belong to the family *Camelidae* in the ruminant suborder *Tylopoda* of the order *Artiodactyla* (even-toed ungulates). The *Camelidae* differ from other true ruminants by not having horns or antlers. Their forestomach's are different morphologically and physiologically. A special feature of the *Camelidae* is the oval shape of their red blood-cells being unique among mammals (Bornstein, 1990).

The camel is able to survive in hot dry desert due to anatomical structure and its ecological adaptations. The dromedary camel has long double eyelashes and a nictitating membrane to protect the eyes from the sun and sand, and slit-like openings of closable nostrils. It breathes slowly with no panting. The lips are thick to help the camel eat the prickly shrubs. There is a thick coat of hair even inside the camel's ear. Its hump is for storage of fat which is metabolized to provide energy at times of drought. The legs are long and thin with thick callus on knees, stifles and pedestal pad. The hooves have a broad, flat leathery foot pad. The body temperature of the camel fluctuates from 34°C to 41.7°C (93°F-107°F.). Unlike other species of domestic animals; camels only sweat when the ambient temperature exceeds 42 °C, and only little sweat enough to decrease its body temperature is excreted. The red blood cells of camels are small and oval in shape to let the

flow of blood continue even in a dehydrated state, and are capable to resist and swell in isotonic solutions (water) without rupturing due to osmosis. The kidneys of camels are capable of concentrating urine markedly to reduce water loss. The normal blood glucose level in hydrated camels is in the range of 100-150 mg/liter, while in dehydrated camels; the blood glucose level reaches ten times the normal level without causing any physiological disturbance to the animal. Camels have a long large intestine, which absorbs every last drop of water from the digested food (Soliman, 2015).

Sudan ranks the second highest world population of camels after Somalia. According to recent census of livestock, there are 4,787,000 heads of camels (FAO stat, 2013). The common indigenous breeds of camels in the Sudan are Kenani, Rashaidi, Lahawee, Anafi, Bushari, Kabbashi, Maalia, Maganeen, Shanabli and Butani camel breeds spread all over the Sudan, but the majority are reared within the camel belt. Camels are used as pack (heavy) and riding (light) according to the function they perform and the selection applied by various came-keeping tribes; they provide milk, meat, hair for textile or goods such as felted pouches, and are working animals with tasks ranging from human transport to bearing loads (Ishag and Ahmed, 2011).

The body temperature, respiration, heart and pulse status is crucial in differentiating between health and disease in any mammal including man. However, in the available literature base data related to these clinical parameters in camels are not homogenous, meager under Sudan conditions; or measured in only a limited number of animals of different sex, age and season.

Objectives of the Study

General Objective:

To provide an accurate and homogenous base data on the normal physiological parameters of selected herds of the one-humped camel in Khartoum state.

Specific Objective:

To determine temperature, heart and respiratory rates in these animals at specified times of the day.

CHAPTER ONE

LITERATURE REVIEW

1.1. Scientific Classification

Kingdom : Animalia
Subkingdom : Metazoa
Phylum : Chordata
Sub-phylum : Vertebrata
Super-class : Tetrapoda
Class : Mammalia
Sub-class : Theria
Infra-class : Eutheria
Cohort : Ferungulata
Super-order : Paraxonia
Order : Artiodactyla
Sub-order : Tylopoda - Camelids
Family : Camelidae
Sub-family : Camelinae

Genus : *Camelus* (Old World Camels)
Species : *dromedarius* (Arabian camels)
Species : *bactrianus* (Asiatic camels)

Genus : *Lama* (New World Camels)
Species : *glama* (Ilamas)
Species : *pacos* (Alpaca)
Species : *guanicoe* (guanaco)
Species : *vicugna* (Argentine)
(Al-Ani, 2004).

1.2. Camel Domestication

The Genus *Camelus* was probably among the last of the major domestic species to be put to regular use by man. References of the one-humped camel as a domestic animal is mentioned in the Holy Koran and the Old Testament of the Christian Bible but there is little direct evidence for an exact time of domestication. This is because principally 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 in camels, (Abu-Samra, 2008).

The fossil history of camels in the later parts of the Pleistocene and Early Holocene is extremely meagre (Uerpmann, 1987: Cited by Bornstein, 1990). Domestication of the dromedary seems to have taken place in the Arabian Peninsula prior to 3000 B.C. The term "dromedary" is derived from *dromos* (Greek for road) and thus is only directly applicable to the riding or racing dromedary camel. Dromedaries were reintroduced into North Africa in the third century B.C. More were brought into Egypt during the Roman period, after the third century A.D., but became important domestic animals only with the Moslem conquests of Egypt in the seventh to eleventh centuries A.D. (Fowler, 2010).

The precise time and location of domestication of the Bacterian camel is unknown, but it is thought to have occurred sometime perior 2500 B.C. on the border of Turkmenistan and Iran on the east side of the Caspian Sea. The name Bacterian is derived from a place name, Baktria, on the Oxus River in Northen Afghanistan (Fowler, 2010).

1.3. Camel Population and Distribution

It is difficult to determine the exact number of camels in the world. This is because it is mainly an animal of nomadic people and pastoralists who are moving frequently, and because camels are not usually subjected to obligatory vaccination. So an exhaustive census for the camels is quite difficult. Officially, the total number of camels in the world was estimated to be around 25 million heads (FAOstat., 2009).This number is probably underestimated. Thus, by considering both the wild Australian camel population and the different national estimations, the camel world population is probably around 30 million heads.

More than 80 % of the world camel population lives in Africa, with 60 % in the horn of Africa. The most important countries for the camel economy with a camel population of more than 1 million are, in order: Somalia, Sudan, Ethiopia, Niger, Mauritania, Chad, Kenya, Mali and Pakistan. The world camel population is increasing regularly with a yearly growth of 3.4%. Since 1961 (First FAO statistics), the world camel population has more than doubled (Faye, 2013).

1.4. Camel Breeds

Many camel breeds distinguished by color, size, general conformation or other characteristics have been described. Breeds of camels are not as much differentiated as breeds in other livestock species. Systematic selection for productive traits has never been done in camels, accepting may be racing camels. This is due to the nomadic life where camels are raised. In most areas they are multi-purpose animals with the females used primarily as milk producers. The males for transport or draught and both sexes provide

meat as tertiary product. Capital accumulation and security functions are also of considerable importance for most camel-owning groups.

Two extreme types can be defined as far as weight and building. These are: (1) the riding or racing camel and (2) heavy pack or baggage type.

1.4.1. The riding or racing type:

This type is a slender animal with a long and level shoulder, a smallish hump, a markedly tucked-in abdomen and long legs with small foot pads. The hair in these animals is often short and fine, the skin is thin and supple, heights may differ greatly, but live weights rarely exceed 400 kg in females and 550 kg in males.

1.4.2. The pack or baggage type:

These are much heavier build with a more balanced appearance of fore and hind quarters. The hump is pronounced in well fed animals, shoulder and rump are relatively short and sloping steeply. The hair is often long and coarse. The legs appear short and sturdy and feet are large. Live weights of 650 kg in females and over 800 kg in males are not uncommon. All described breeds either resemble one of these types or fall in between (Abu-Samra, 2016).

1.5. Camels in the Sudan

It is believed that dromedary camels entered the Sudan from Egypt based on a specimen of camel hair rope of an old kingdom found at Fayum in Upper Egypt 2980-2475 B.C. In Sudan, the oldest evidence is a bronze figure of a camel with saddle found at Meroe 25-15 B.C., indicating that the animal moved south by that period (Hashim *et al*, 2015). Large numbers of camels were introduced into the Sudan through Egypt and across the Red Sea when Moslem Arabs invaded Egypt and Sudan in the seventh century. With the

greatest invasions, which occurred in the eleventh century, the camel attained its present numbers and importance (Shommein and Osman, 1987; El Amin, 1979).

1.5.1. Camel Types of the Sudan:

Sudanese camels are classified according to function (pack and riding) or to conformation and tribal ownership (Shommein and Osman, 1987, Ahmed, 2015).

1.5.1.1. Pack camels:

Constitute more than 60% of the camels in the Sudan. They are mainly owned by nomadic tribes of the Kordofan and Darfur regions. There is a heavy type which weighs about 400 kg in adulthood and the large massive type which has a body weight of about 500 kg. (Shommein and Osman, 1987).

1.5.1.2. Riding camels:

Are lighter and faster, and they are bred mainly in the eastern parts of the country. They are the camel equivalent of the Arab horse. The Anafi breed seems to be the best, followed by the Bishari breed and various crosses between these two types and other subtypes (Shommein and Osman, 1987).

1.6. Camel Nutrition

As a pseudo-ruminant, the camel has evolved as a browsing herbivore with the ability to utilize forages that are rich in fiber but contain a range of anti-nutritional factors.

1.6.1. Nutritional Requirements:

Little information is available on the appropriate nutritional requirements of camels for different purposes. Nutrient requirements for camels have not been determined and only few recommendations are

available, but unfortunately these estimates were mainly derived from cattle requirements.

Our knowledge of the anatomical, physiological and feeding differences between camels and cattle make the reliability of such estimates far from being realistic or accurate. There is an urgent need to start a structured program that involves different research groups from different countries to measure the requirements for energy, protein and other nutrients for breeding, growing and racing camels (Al-Jassim and Hogan, 2013).

1.6.2. Camel Grazing and Feeding Habits:

The average composition of the diet of camels in northern Kenya has been found to be dwarf shrubs 50, trees 25, herbs 14 and grasses 11 per cent, respectively. Camels feed over a considerable height-range, from ground level to 3.5 m, which gives them an advantage over other livestock. Perennial woody-plants comprise three quarters of the diet, the remainder being herbs and annual grasses, which are eaten in dry seasons as standing hay. Perennial grasses, eaten by cattle, have a high fiber content and low digestibility and nutritive value, and are avoided by camels.

Camels require minerals for their physiological needs, so they prefer salt loving (halophytic) shrubs such as *Sueda monoica* and *Salvadora persica*.

In semi-arid areas where cattle can survive, pastoralists such as the samburu and Rendell keep a combination of both cattle and camels to utilize the available spectrum of vegetation more fully. During the rains and shortly afterwards, when nutrition's is good, a camel may have surplus metabolizable energy in its diet which is converted to fat in the hump.

Young males are sometimes castrated so that they will accumulate more fat (Field *et al.*, 2005).

1.6.3. Drinking Water:

Like all animals, camelids require adequate amounts of good quality water to sustain life, reproduce, work, and produce fiber and milk. Water requirements can be met by free water consumption, moisture in feed, and water energy metabolism (Fowler, 2010). Camels consume about 60-80 liters of water a day. This depends upon the outside temperature, the type of food, and season of the year. When fresh, juicy green grasses are available, they will not touch water for as long as 30 days. When camels are exposed to 40 °C for 12 hours per day, water intake increases by an average of 200 %, and the ratio between water intake and dry matter intake reaches three times the ratio observed at 20 °C (Al-Ani, 2004). Water is lost through urine, milk, perspiration, and evaporation from the respiratory tract. Situations resulting in an increase water needs (Fowler, 2010).

1.7. Camel Management

Animal husbandry covers a variety of subjects which have direct or indirect impact on the final product. Breeding, feeding, housing, disease control and care - all affect the growth and production of animals. Husbandry has been based on superstition and practices handed down by father to son over the ages (Yagil, 1982).

The following three alternatives for housing and feeding camels can be considered:

1.7.1. Trdaitional pastoral system:

This system is based on wandering over great distances looking for food. However, the camels' way of feeding is entirely different from that of sheep and goats, which graze intensively, and cattle, which move slowly and demand large amounts of fluid. Camels are constantly on the move and take only small portions from each plant. In contrast, sheep and goats graze down to the roots, and goats often climb trees to obtain food. Even in extremely poor vegetation areas the camels doesn't not consume all the feed. Mixed ranching or breeding in the traditional camel areas is virtually impossible because the vegetation is not only dispersed and irregular, but is often unpalatable to other animals. These areas are not suitable for agriculture. Wandering with camels can be made more profitable by introducing plants into the grazing areas. They eat 8–12 kg of dry matter/day, about 30–40 kg of fresh pasture with 80 percent water content. However, the normal daily feed intake averages 10–20 kg fresh feed, i.e. 5–10 kg dry matter/day. The amount most frequently eaten is 6–7 kg of dry matter/day. This is a most important observation when discussing other methods of housing and feeding. In addition, the feed intake observation applies to an animal understanding (Yagil, 1982).

1.7.2. Semi-open method (Mixed animal practice):

A balanced family herd, containing ten or more females of varying ages can provide a relatively secure economic position with enough milk produced to cater for its household members. In this case, they feed camels on leaves, tree brush pile, wheat straws, and a little bit of concentrate. They try to raise camels to get benefit from camel's milk and at the same time are

feeding their camels with low-priced feed. The availability of agricultural by-products in these areas will help to minimize the cost of feeding, especially when they are raising only a few camels (Al-Ani, 2004).

1.7.3. Feedlot system:

This system requires an adequate supply of feed which must be guaranteed. It is not enough to supply feed for maintenance, but production must also be taken into account. Very detailed tables are available for cattle, swine and sheep holders which supply the energy value of each feed and the amounts necessary for each age and each stage of production. If little feed is available, it may be necessary to maintain fewer animals to guarantee maximum production per animal. This fact is often overlooked by the pastoral tribes and over-grazing often leads to severe damage at vegetation and to smaller and weaker animals.

Housing the animals will not necessarily cost a great deal. A shaded area is all that is necessary in the enclosed space. This method of holding camels will enable the population to enjoy the benefits of sedentary life such as education and health services, but especially it will allow for greater improvement of the growth and production of camels. Better production of animal protein can be attained by better use of grasslands, improved pasture and fodder production, and also the improved production capacity of the animals themselves (Abu-Samra, 2016).

1.8. Camel Breeding and Reproduction:

Breeding management consists of selection and/or culling of breeding female and male animals, and controlled breeding (Farah *et al.*, 2004). A

good female camel has small ears pointed like spear blades, eyes shining like red coals, a neck arched like the stalk of the date bunch, shoulders that are muscular, both breastbone and hoofs that are small, the shoulder blades bulging, the lower rib borders and a broad chest, the thighs finely shaped; she could be narrow in the lions, with a hump exactly above the abdomen. A hard and therefore erect neck, broad breast, arched ribs, and a bulging hip covered with flesh are likewise signs of the good qualities which a she-camel should have (Al-Ani, 2004). Females are six years old when they first give birth, then only calf once every two years. Building up a herd is thus not only expensive, but is a long-term undertaking. This can be remedied by improved breeding techniques (Yagil, 1982).

In selecting breeding stock, herders pay great attention to two main factors in a camel—its appearance and behavior, and the pedigree of young males. These young males are given special treatment, care and unrestricted suckling of their dams. By the time they reach the age of 5–6 years, as young potential sires, they are allowed limited breeding; only after their offspring have been proven will they be used intensively.

An outstanding male camel with a breeding lifetime of 15–20 years, can serve 150–200 female camels during a successful breeding season. Such males, besides ordinary grazing, receive supplements such as ghee, sesame oil and bran. During non-rutting seasons, they are usually kept separate from the females and given special treatment and exercise. Such breeding sires are not used for transport, unless other means of transport is not available (Farah *et al.,* 2004).

Rutting males sniff at the female's genitalia or excretions and subsequently display flehmen. Occasionally, they bite the female on the hump or vulva, utter low noises, and protrude the dulaa, or rub the poll

glands on their shoulders. Receptive females often spread their hind legs and present their genital regions while also urinating. On approach of a male, they rapidly move their tails up and down. During copulation, the female lies down in sternal recumbence (Kölher-Rollefson, 1991).

Camel herders can detect pregnancy in camels as early as 7–10 days after successful mating. Specific symptoms of camels' pregnancy recognized by herders are lifting and coiling upwards of the tail and curving of the neck when approached by a male camel, nervousness, lifting upwards of the head and pointing of the ears. A number of other more scientific methods for the determination of camel pregnancy have been developed (Farah *et al.,* 2004).

The gestation period of camels is about 13 months. Under normal conditions, a female camel that gives birth every other year will have between 8 and 10 calves in her breeding life of around 25–30 years (Farah *et al.,* 2004).

Performance records of both males and females are essential. Records must be kept of body type, growth rate, udder conformation, milk production and fertility the biggest problem in implementing improved breeding is the long time-gap involved on progeny testing. To meet today's standards a female will need to mature at 5 years of age, be pregnant almost a year, then have a further year of lactation before she can be judged. This is a minimum of seven years for a female. Judging a male for breeding will take about the same time.

It is therefore of vital importance to obtain:

a) Earlier sexual maturity. This can probably be attained with improved feeding and management.

b) Use artificial insemination and semen banks at central stations.

c) Decrease inter-calving intervals.

This can only be achieved if technical advisors and extension workers are able to move among the mostly nomadic tribes (Yagil, 1982).

1.9. Uses of Camel

1.9.1. Milk Production:

The most important camel product is milk, which is often the staple diet for nomads. Camel milk-yields may be six times those of local cattle under the same conditions, but vary, due to many factors which affect production. Wet-season daily yields are often double those of the dry-season. Climate affects forage condition and water availability. Camels watered more frequently produce more milk. Somali camels produce more milk than Turkana camels, under identical conditions. Increasing milking frequency may increase milk output by 30 per cent. In Kenya, pure-breed camels from Pakistan had higher milk yield than indigenous breeds, provided there is adequate forage. Milking regimes vary from twice daily in many parts of Kenya, to six times a day among the Afar of Ethiopia. Daily milk yield in Kenya vary from 2.4 liters under traditional management to 4 liters under improved ranch-management. Adequate veterinary inputs improve milk yield by just under a half a liter per camel per day. The treatment of helminthiasis alone can increase milk yields by more than 11 liters spread over five weeks, which cost effective, because the increased milk is more valuable than the cost of the drug.

Peaks in lactation occur in 6-10 weeks after parturition, when some camels can yield more than 12 liters per day. The duration of lactation in a camel varies considerably. While 12 months is average, it may be prolonged

to 30 months during drought. Once conception occurs, a camel normally dries-off within the following three months. Prolonged lactation is considered advantageous to subsistence-oriented camel owners. However, if one wishes to improve one's herd' and alleviate poverty, one should breed from the good milkers. Possibly, the tradition of prolonging lactation prevents the best genes from increasing, which may be a constraint to improving livelihoods.

The quality of camel milk is similar to cow milk, but the butterfat does not separate easily. However, vitamin C in camel milk may be as much as six times higher than cow milk. This is important in arid and semi-arid land (ASAL) regions as fruit and vegetables are not available as a source of vitamin C. Camels' milk is invariably found to be better than any relief food (Field *et al.*, 2005).

1.9.2. Meat production:

Camel meat is consumed infrequently by nomads, because it is a large animal which yields more meat than can be handled comfortably by a family. Camels are reserved for ceremonial occasions, such as weddings and funerals, or during drought when other animals are emaciated and unfit for slaughter. Increasingly, however, camel meat is popular in butcheries, because it is cheaper than beef and therefore more affordable. It is estimated that 7.5 per cent of a camel population could be slaughtered, or exported, annually without causing a decline in the population, but the actual off-take is lower. In Kenya, it was estimated that an annual off-take of about 6,000 camels would be possible. With an average live weight of 500 kg, and a 55 per cent carcass, they would yield 1.65 million kg of carcass valued at US$1.76 million, thereby helping to alleviate poverty.

Young camels grow slowly as they may be affected by climate, forage, disease, breed, sex, whether castrated or not, and maternal milk supply. Birth weights vary from 25 to 50 kg (Pakistan x Somali hybrid calves are heaviest). Male calves are normally heavier than females. Weaning occurs naturally at 8-15 months, soon after the mother's next conception, which may cause a growth check. In countries where camels are produced primarily for meat; calves are weaned at a later age. Mature body weight is reached at 6-7 years and is most affected by the breed.

Disease and management may delay a camel reaching mature body weight. In Kenya the Somali breed is almost twice the weight of other breeds, with maximum weight of 970 kg. The carcass average is about 55 per cent of the live weight, depending on the sex and the nutritional status of the camel. Despite their long legs camels have a higher dressing percentage and meat: bone ration than range- cattle, possibly because the stomach of a camel is relatively small as it is not a roughage feeder.

The meat of a camel up to 5 years of age is similar to beef, after which it may become tough. It has 22 per cent protein and only 1 per cent of fat, as this is stored in the hump, and is low in cholesterol. Camel fat has a high melting point, possibly because of the high ambient temperatures reached and the use of fat for insulation. It can be stored for at least a year without becoming rancid, which is convenient for nomads (Field *et al*, 2005).

1.9.3. <u>Hair and wool</u>:

Hair production of adult animals ranges annually between 1 to 3 Kg (Ahmad *et al*, 2010). The wool of the Vicuna is especially highly prized. This wild species, living in the high Andes, has very short wool, 2 to 3 cm long with an average yield of only 150 gm per animal. The fine internal

fibers are brown-yellow, and the coarser external fibers are brick red giving an overall red appearance. The Vicuna also has a large hank of fibers growing on the chest which are longer and stronger than the fibers on the rest of the body. These chest fibers are light-yellow to white in color. Ponchos and shawls made from Vicuna wool are highly prized and very costly (Yagil, 1982).

1.9.4. Hides:

Camel hides are very strong with a tensile strength, five times greater than cattle hides. Camel leather is being crafted for fashion garments such as leather wallets, handbags, purses and shoes (Breulmann *et al*, 2007, Abu-Samra, *et al*, 1999). The hide of the dromedary is not good quality, and is mainly used for making whips and saddles (El-Amin, 1979).

The Guanaco has a skin of good quality and, among other things, is used for making bed covers, coats and mantels. Ilama hide is used for making shoes, sandals and bags. The meat, skins and furs of the New-world camels are thus far more important for man than the milk and haulage ability of the Old-world camels. Nevertheless, the food producing characteristics of the desert-living camel, in respect of both milk and meat, are complemented by accompanying yields of wool, hides, skins and bones, which all help to provide man with clothing, shelter and other useful products.

When breeding for the ideal milk producer, the meat, as provided by the calves, and the wool can supplement local industry (Yagil, 1982).

1.9.5. Bones:

Camel bones have been used for carving ornaments, being not unlike ivory in appearance. They may also be burnt, ground in a mill and mixed with other minerals as a feed supplement (Field *et al*., 2005).

1.9.6. Urine and dung:

Camel urine is used as an ethno-medicine. It is highly concentrated and induces diarrhea and vomiting. In some countries especially in desert areas where there is little vegetation, camel dung is used for fuel. Nearer to cultivation, the dung may be harvested from camel enclosures and sold a fertilizer (Field *et al*., 2005).

1.9.7. The Camel as a Draught Animal:

Camels are large, strong animals, which move slowly and deliberately, making them suitable for traction. With the advent of the motor vehicle, camels have lost much of their importance as draught animals since vehicles are faster and can carry bigger loads. However, Rajasthan camels regularly pull carts in the face of competition from tracks. Camel owners cite the economic advantage of the camel, which does not require expensive fossil fuel but can be powered by cheap range-forage and grain, which it transports along with merchandise. It thus helps resource-poor people, with little capital, to set up in business. In many areas where there is difficult terrain, camels are used as baggage animals.

Camels have a useful working life of about fifteen years, undergoing their first training at three year of age. The traditional saddle is a complex system of ropes and poles, which hold protective layers of sacks and hides firmly to the back of the camel and create a frame for the attachment of loads. They are most frequently used for carrying water containers and portable houses.

Agricultural produce is carried from the market to the homestead, usually in the form of sacks of grain such as maize meal, or sugar, while

milk is back-loaded from the camp to market. Average loads are 100 kg which may be carried over distance of 25 km at speed of 4 km/hour. Camel saddles may be used as the frame for the transport of the sick, elderly or young children and to carry books for mobile libraries.

In regions surrounding the Sahara, camels take the place of motorcycles, being more efficient in negotiating soft sand. They have also been used for military and security purposes, being cost-effective when compared with modern alternatives, and are still being used in some areas of the Indian sub-continent.

Recently camels have been trained for recreational purposes, principally eco-tourism and racing. The former may involve safaris of several weeks, where riding camels are combined with baggage camels and the tourists alternately ride and walk. Apart from the Sudan where camel riding is traditional, racing has not taken off in the rest of Horn of Africa, as it has in the Arabian Peninsula.

Camels have been used for ploughing, milling, pulling carts, and in parts of Kenya, Ethiopia and Somalia, for de-silting dams by pulling a ripper followed by a scoop. However none of these activities has taken-off on large scale, although they have been promoted extensively by NGOs (Field *et al*, 2005).

1.9.8. Tourism

A Camel Farm could also be used as a tourist attraction. Tourists could enjoy day trips to the desert or the coast by riding camels (Camel safaris), enjoying the desert and possibly a sunset barbeque or spending a night in the desert before returning. This is an ecofriendly method to provide a link to nature. Tourists could purchase handmade camel leather products

such as fashion accessories and souvenirs directly from the farm (Breulmann *et al*, 2007).

1.10. Normal Clinical Parameters of the One-Humped Camel

Temperature, Heart rate, Pulse rate and Respiration:

The body temperature, respiration, heart and pulse of an animal; are important aspects of its physiological state and are, in fact, an index of its health and disease. These parameters undergo variations in the normal animal during the day (diurnal variations) which have been studied by many workers in the various domestic animals. In general the body temperature is lowest in the early morning, rises during the day to reach its maximum in the afternoon and falls again at night. The rates of heart, pulse and respiration are intimately related to the body temperature (Bornstein, 1990).

1.10.1 Body Temperature:

Farm animals maintain a relatively constant body core temperature, homeothermy during extreme ranges of thermal environments. This homeothermic state is achieved by physiological and behavioral mechanisms that modify either rates of heat loss from the body or the rate at which heat is produced by metabolism of feed or body energy reserves. For the body temperature to remain constant in changing thermal environments, the rate of heat loss must equal the rate of heat gain. The body temperature is a reflection of the balance between heat gain from the environment (radiation, conduction, convection) or due to metabolic activity (maintenance, exercise, growth, lactation, gestation, feeding) and heat loss to the environment (radiation, conduction, convection, evaporation) or due to metabolic activity (milk removal, fecal elimination, urinary elimination) . Absorption of heat

from the environment occurs when the external temperature rises above that of the body (Radostits *et al*., 2007). Heat production within the body results from intra-cellular oxidative and other processes, but it is added to from the exterior by radiation, conduction and convention (Kelly, 1984).

The camel is a large animal whose surface area per unit volume is relatively small. This gives it a substantial advantage in reducing heat gain. In a well-watered camel, the body temperature varies only by 2 ºC, whereas in a dehydrated camel the variation could be as high as 7 ºC, from 34 ºC in morning, to 41ºC in the afternoon. This contributes to a storage of heat without the use of water. The Camel uses only 1.1 liters of water/100kg body weight for evaporative cooling, whereas the donkey and man use 4.7 and 7.0 liters of water/100kg, respectively (Schmidt-Neilson, 1957). The height above the ground (long legged) allows the desert winds free access to the body thus in some circumstances cooling it effectively (Bornstein, 1990). The resting body temperature of adult camelids varies depending on the environment. Normal body temperatures of neonate camelids fluctuate in a wider range because thermoregulatory mechanisms are not yet sophisticated as those of adults. The dromedary is able to endure diurnal fluctuations of body temperature from 36.5 ºC to 42 ºC (97.7 ºF to 107.6 ºF). The body acts as a heat sink during the heat of the day, thus conserving vital water that would otherwise be lost through evaporation cooling. During the cool night, body heat is dissipated by conduction and radiation. It should be obvious that evaluation of a fevered state in the dromedary is difficult.

Species of South American Camelids evolved in harsh, cool climates and are well able to adapt to cold. Externally hot and humid climates are less well tolerated, and special cooling systems should be incorporated into

management programs to help them cope with heat stress. During hot summer seasons, some Lamas are able to allow to body temperature to elevate and remain 40 ºC (104 ºF). It is disconcerting to see how a heavily fleeced Ilama lying peacefully in full sunshine on a hot summer day. However, it should be remembered that fleece insulates from heat as well as from cold. The Ilama that is forced to remain recumbent because of trauma or disease is more subject to heat stress, even in neutral environments, because the underside is a fleece-free area of the body and the site for heat dissipation. If the Ilama is continually recumbent, neither normal nor fever-induced body heat can be dissipated (Fowler, 2010).

The diurnal rhythm of body temperature exhibited by the camel is similar to that in other species of domestic animals, but the range of variations is much more than in other species. Leese (1927) reported that the temperature is lowest at dawn and gradually increases until sunset before dropping during night and it might vary from day to day. Leese (1927) reported that the average normal temperature of the resting adult camel at sunrise is 97 ºF and at sunset is 100.3 ºF, with a mean range of 95.0 – 99.0 ºF in early morning and 99.0 – 101.6 ºF in evening during hot weather. Schmit-Nielson *et al.* (1957) recorded that the morning rectal temperature of the normal healthy camel varied from 34.0 ºC (93.2 ºF) to 40.0 ºC (104.0 ºF). Bhatt *et al.* (1960) reported an average temperature of the resting adult camel is 97.9 ºF with a range of 95.2 – 99.7 ºF. However, the temperature of the majority of the camels they examined ranged from 97.2 – 98.7 ºF and the average evening temperature is 100 ± 0.54 ºF.

1.10.2. Pulse:

Examination of the pulse in conjunction with the heart and the superficial veins enables the clinician to formulate an opinion as to the state of the whole cardiovascular system. Determining pulse rate requires a watch with a second hand and the waves are counted for a minimum period of one minute. The ball of the index finger is placed on the skin over the selected artery at a point where it overlies the bone, and applying gentle pressure until the pulse wave can be detected. In case the pulse wave cannot be felt or detected following the previously mentioned techniques as in case of restless animals, generalized muscle tremors or obesity; the heart beats can be an alternative and are counted using a stethoscope. However, this is an unsatisfactory substitute for more than one reason, and it is important to realize that the heart rate may not always accurately reflect the pulse rate; in conditions such as extrasystolic arrhythmias when the heart beats do not produce a pulse wave. In addition, determining the pulse quality enables the assessment of cardiac function and peripheral circulation (Kelly, 1984).

In adult camels the pulse is satisfactorily examined in camels in the sitting position.

There are many arteries that can be palpated in camels such as:

1) The posterior tibial artery in the area which is about 20 cm above the hock joint.

2) Middle sacral artery- in calm and young animals.

3) Femoral artery on the medial aspect of the hind leg in calm and young animals.

4) Middle coccygeal artery found in the mid-line of the median aspect of the tail about 5 cm below the level of the anus between the first and third coccygeal vertebrae.

Fowler (2010) reported that pulse evaluation is not used in camelids, because there are no readily accessible arteries. The heart is accessible for auscultation as in other mammals; by reaching under the fleece at the elbow, the stethoscope is placed on a fleece-free area caudal to the triceps, which allows for both cardiac and thoracic auscultation.

When determining the pulse in any species of animal the following properties should always be considered (Kelly, 1984): Rate, rhythm and quality.

1) **Rate:**

This is the number of pulse waves/min.

2) **Rhythm:**

The pulse rhythm is assessed by appreciating the time intervals between the peaks of a series of successive waves being regular or irregular. When the sequence is regular, the pulse waves succeed each other after an equal interval of time.

3) **Quality:**

The quality of the pulse depend mainly upon the amplitude of the pressure waves which may vary because changes in the rate of systolic filling or amplitude of the pulse is assessed by noting the degree of digital pressure required to obliterate the pulse wave in the artery.

The normal pulse wave is regular in sequence, amplitude and strength, and artery is well filled, the wall being distended and exhibiting a degree of tone which is readily appreciated by digital palpation (Kelly, 1984).

Physiological Factors Affecting the Pulse Rate in Normal Animals:

Species, size, age, physical condition, sex, pregnancy, parturition, lactation, excitement, exercise, posture, ingestion of food, rumination, and environmental temperature (Kelly, 1984).

1.10.3. Heart:

The only record of the camel's heart rate was by Bhatt *et al.* (1960) who reported that the heart rate of the normal resting camel is 34/min, with a range of from 24 – 48/min. However, the majority of camels they examined had heart rates ranging from 28 -39/min.

1.10.4. Respiration:

The principal function of the respiratory system is gas exchange in which oxygen is transferred from the environment to the blood and carbon dioxide is moved in the opposite direction (Radostits *et al*., 2007).

The resting respiratory rate of Old world camelids is 5-8, in cool weather, and 10-12, in summer. Normal lung sounds are muted in camelids and may be difficult to hear. With excitement and more rapid breathing, the sounds are vesicular rather than bronchiolar. The respiratory rate is best established by placing the stethoscope over the thoracic inlet (Fowler, 2010). At high ambient temperatures in the Sahara the respiratory rate increases slightly in the camel from 6-11 to 8-18 breaths per minute (Schmidt-Nielsen, 1964)

In quiet animals, determining the frequency and rhythm of the respirations is facilitated by placing one hand on the lower part of the costal arch region. The rate of respiration may also be determined by observing

nostril movements, or more efficiently by auscultation over the thorax or trachea.

When determining respiration in any species of animal the following properties should always be considered (Kelly, 1984): Rate, rhythm, type and quality.

1) **Rate:**

   Is the frequency (number/min.).

2) **Rhythm:**

   Regularity of respiratory cycles.

3) **Type:**

   Costal, costo-abdominal or abdominal

4) **Quality:**

   Amplitude or depth of the respiratory movements.

Counting the frequency of respiration is performed on the same basis as for the pulse. Physiological or abnormal variation may occur in any one of the four stated features (Kelly, 1984).

CHAPTER TWO
MATERIALS AND METHODS

2.1. Study Area:

The study was conducted in three camel breeding areas in Khartoum state, which are Khartoum (Soba Elhela), Khartoum north (Shambaat) and Omdurman (Almu'aleh). Khartoum State is located between 15° 15´ – 16° 45´ N and 31° 45´ – 34° 15´ E constituting an area of 22,122 km^2. Khartoum State climate is characterized by desert and semi desert zone, which are known for its hot to very hot summer, short rainy season and warm to cold and dry winter (UNDP, 2011). The hot summer extends from March to June, where the mean daily maximum and minimum temperature are 40 °C and 24.8 °C, respectively. May is the warmest month with a mean monthly maximum and minimum temperature of 41.9 °C and 27.3 °C, respectively. November to February, the winter months, are relatively cold, where the mean monthly maximum and minimum temperature are 32.6 °C and 17.6 °C, respectively. January is the month with the minimum mean maximum and minimum temperature, with 30.7 °C and 15.6 °C, respectively (WMO, 2016). Sandstorms (Haboob) are common in the region during the months May to August (UNDP, 2011).

2.2. Animals:

All camels examined were females - 4-8 years old. A questionnaire was prepared to record data obtain related to general household characteristics, herd management, breeding programs, disease history, uses of camels, and feed composition from the camel owners. All camels chosen for this study were normal and healthy without any clinically detectable abnormality as verified by critical general examination of the body for

discharges from natural orifices, examination of the skin texture and elasticity and freedom from external parasites with smooth and shiny hair coat. Normal appetite, absence of external parasites. The visible mucous membranes were also examined to ensure that they were of normal color. Blood smears stained with Giemsa and fecal examinations were conducted to ensure freedom of the selected camels from blood and internal parasites.

Figure 1: Normal healthy dromedary camels.
Al-ameera Camel Farm – Soba Elhella – Khartoum.

Normal physiological parameters were obtained from 35 she-camels distributed as follows: 8 camels from Khartoum north (Shambaat), 14 camels from Khartoum (Soba Elhela) and 13 camels from Omdurman (Almu'aleh).

Figure 2: University of Khartoum- CRU.
Shambaat- Khartoum North.

The instruments used to perform this study were: Stethoscope, digital thermometers, plexor and pleximeter, slides, gloves, disinfectants, sterile disposable syringes, vacutainers containing EDTA, and plastic containers for collecting fecal samples.

Figure 3: Taking blood Sample from she-camel - Al-ameera Camel Farm- Soba Elhella - Khartoum

The procedure adopted for the assessment of respiration is by watching the abdominal respiratory movements (flank region), and the respiratory cycles/minute were counted and recorded. The heart beats and sounds were assessed using the stethoscope placed on the cardiac area (the left side after pulling the left forelimb outside between the 3^{rd} and 6^{th} rib), and the heart beats/ minute were then counted using a stop watch and recorded. The rectal temperature was measured using a digital thermometer, which was inserted in the rectum at 45 degrees inclination on the rectal mucosa and the temperature of all animals was also recorded. The measurement of all parameters were taken in the morning (8:00 am) and afternoon (3:00 pm).

Figure 4: Measuring rectal temperature using a digital thermometer- Abu-Sha'ar – Omdurman.

2.3. Statistical Analysis:

The data collected from this study (35 she-camels) were analyzed by the Statistical Package for Social Science (SPSS version 16). The data were analyzed by simple and descriptive statistics to detect the normal range of these parameters and calculate the maximum/minimum means, standard deviation and standard error for all parameters measured in camels in the different locations in Khartoum State.

CHAPTER THREE
RESULTS

The minimum and maximum values, means and standard error of means of normal morning and afternoon Physiological parameters (Rectal temperature, Heart and Respiratory rates) for 35 non-pregnant dromedary she-camels are summarized in tables (1-4), these dromedaries were studied in Khartoum state representing its three governorates: Bahri, Khartoum and Omdurman.

The results obtained from these three governorates are summarized in tables (1-3), and descriptive analysis of all data collected are summarized in table (4), showing the normal values ranging between the minimum and maximum; in addition to the mean, standard deviation and standard error, in which the minimum and maximum values are obtained from adding and subtracting the mean from the standard deviation for each parameter.

The recorded respiratory rates were 11±1.7 and 12±1.9/min (deep and regular), the heart rates were 41.6± 5.5 and 44± 4.8 /min (rhythmic and regular) and the temperatures were 36.81±0.8 and 37.9±0.7 °C in the morning and evening, respectively for all parameters.

Table 1: Descriptive Statistics of normal morning and afternoon physiological parameters of the one-humped camel in Abu- Sha'ar Farm (Almu'aleh).

Parameter	No.	Minimum	Maximum	Mean	Std. Deviation
AM Rectal Temp.	**13**	**37.0**	**37.8**	**37.3000**	**0.28868**
PM Rectal Temp.	**13**	**36.1**	**39.7**	**37.8385**	**0.80471**
AM Respiratory Rate	**13**	**8.0**	**12.0**	**10.4615**	**1.45002**
PM Respiratory Rate	**13**	**10.0**	**14.0**	**12.1538**	**1.28103**
AM Heart Rate	**13**	**40.0**	**58.0**	**45.5385**	**4.84106**
PM Heart Rte	**13**	**42.0**	**50.0**	**46.1538**	**2.51151**
Valid N (Like Wise)	**13**				

Table 2: Descriptive Statistics of normal morning and afternoon physiological parameters of the one-humped camel Al-Ameera farm (Soba Al-hella).

Parameter	No.	Minimum	Maximum	Mean	Std. Deviation
AM Rectal Temp.	**14**	**36.30**	**37.70**	**37.1643**	**0.37336**
PM Rectal Temp.	**14**	**37.50**	**39.00**	**37.9643**	**0.37336**
AM Respiratory Rate	**14**	**8.00**	**14.00**	**11.1429**	**1.70326**
PM Respiratory Rate	**14**	**10.00**	**14.00**	**12.0000**	**1.56893**
AM Heart Rate	**14**	**36.00**	**50.00**	**41.5714**	**3.85735**
PM Heart Rate	**14**	**38.00**	**60.00**	**44.1429**	**5.78934**
Valid N (List Wise)	**14**				

Table 3: Descriptive Statistics of normal morning and afternoon physiological parameters of the one-humped camel in Khartoum University farm (Shambat).

Parameter	No.	Minimum	Maximum	Mean	Std. Deviation
AM Rectal Temp.	**8**	**34.90**	**35.90**	**35.4250**	**0.43012**
PM Rectal Temp.	**8**	**37.00**	**39.50**	**38.1625**	**0.80345**
AM Respiratory Rate	**8**	**8.00**	**14.00**	**11.5000**	**2.07020**
PM Respiratory Rate	**8**	**10.00**	**20.00**	**13.2500**	**3.01188**
AM Heart Rate	**8**	**30.00**	**38.00**	**35.2500**	**2.60494**
PM Heart Rate	**8**	**36.00**	**48.00**	**40.5000**	**4.10575**
Valid N (Like Wise)	**8**				

Table 4: Total Descriptive Statistics of normal morning and afternoon physiological parameters of the one-humped camel in Al-Ameera farm (Soba Al-hella), Abu- Sha'ar farm (Almu'aleh) and CRU- Khartoum University farm (Shambat).

Parameter	Camel No.	Range	Min.	Max.	Mean		Std. Deviation
					Statistics	Std. Error	
AM Rectal Temp.	35	2.90	34.90	37.80	36.8171	0.14299	0.84592
PM Rectal Temp.	35	3.60	36.10	39.70	37.9629	0.11085	0.65578
AM Respiratory Rate	35	6.00	8.00	14.00	10.9714	0.28839	1.70614
PM Respiratory Rate	35	10.00	10.00	20.00	12.3429	0.32265	1.90885
AM Heart Rate	35	28.00	30.00	58.00	41.6000	0.93772	5.54765
PM Heart Rate	35	24.00	36.00	60.00	44.0571	0.81369	4.81385
Valid N (Like Wise)	**35**						

CHAPTER FOUR
DISCUSSION

The 35 dromedary she-camels used for this study were examined and ensured that they were normal and free from any clinically detectable abnormality. This Resulted in homogenous data which gave accurate and authentic assessment of the normal physiological parameters.

The techniques used for studying these normal parameters were adopted to ensure valid comparison of the results obtained in the current study with those of previous workers.

Leese (1927) reported that the average temperature at sunrise was 36.1 °C and at sunset was 37.9 °C, ranging from 35-37.3 °C in early morning and 37.3-39.7 °C in the evening during hot weather; these findings were mostly affected by climatic, housing and management conditions. In support to this our studies showed that the normal temperature was 36.81±0.8 and 37.9±0.7 °C in the morning and evening respectively, ranging from 34.9-37.8 °C and 36.1-39.8 °C. This finding was also in agreement with Schmidt-Nielsen *et al.* (1957) who recorded that the morning rectal temperature of the normal healthy camel varies from 34.0-40 °C, and Bhatt *et al.* (1960) who reported that the average temperature of the resting adult camel was 36.6 (35.1-37.6 °C).

The normal heart rate in the resting camel recorded by Bhatt *et al.* (1960) was 34/min. ranging from 24-48/min. Fowler (2010) reported that the normal heart rate was 40-50 beat/min depending on the environmental and physiological conditions. In the current study the heart rate was found to be 41.6±5.5 and 44±4.8, ranging from 30-58 in the morning and 36-60 in the evening. The higher values recorded in our study

was probably due to environmental, nutritional or heat stress factors – our study was conducted during the hot months of summer season.

In this study the normal daily respiratory rate were 11±1.7/min and 12±1.9/min in the morning and evening, respectively - with a range of 8-14 in the morning and 10-20 /minute in the evening. This is comparatively higher than the values of Higgins and Kock (1984) who reported that the normal respiratory rate ranged between 5-10/min and around 12/min in the morning and evening, respectively. Our findings are in agreement with Schmidt-Nielsen (1964) who recorded that the normal respiratory rate was 6-11 and 8-18 breath per minute. All previous studies including the current study confirmed that the respiratory rate was slightly increased due to the high ambient temperature. In spite of this the normal respiratory rate is affected by age, sex, nutritional and environmental conditions (high humidity or high temperature). Our findings are also in agreement with Fowler (2010) who reported that the normal respiratory rate of resting camel was 5-8/min in cool weather and 10-12/min in summer.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion:

Our studies came in the range recorded by previous investigators. This was in our expectation because camel husbandry is practiced by countries in the arid and semi-arid zone which is quite similar to our conditions in the Sudan.

Recommendation:

When measuring the physiological parameters veterinarians and research workers are advised to put in consideration the status of the ambient temperature and humidity of the weather at the time these measurements are taken.

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