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RESEARCH ARTICLE

PAPER REVIEWED ARTICLE ON THE PHYSIOLOGY AND ADAPTIVE MECHANISM OF CAMEL /DROMEDARY/ IN SEMI-DESERT AND ARID ENVIRONMENT

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ABSTRACT

The camel is an important animal component of the fragile desert eco-system. With its unique bio-physiological characteristics, the camel has become an icon of adaptation to challenging ways of living in arid and semi-arid regions. The camelidus inhabit the most extreme climates on the globe and their process of multiplication is determined by the availability of food and protection for the newborn, consequently their reproduction is governed by these factors. The physiological mechanisms, which allow the camel to survive periods of over two weeks without drinking water and to eat the most unpalatable plants, all have to do with the conservation of water and Up to 30 per cent of its body weight can be lost by loss of water - amounts that would be fatal in the case of other farm animals or even man. All the functions of the dromedary organism are conceived to be physiologically adapted to "water and food restrictions" and to a very hot climate. More specifically as with all mammals, camel reproduction is adapted to its specific behavioural, anatomical, physiological and endocrinological peculiarities and in addition to this review will deal with the reproductive performance of the dromedary/ the one-humped, hot-desert camel. The camel is one of the most important desert animal and the following points discussing how the camel copes with the desert environment. Knowing the peculiar characteristics of camel physiology is essential for researcher and breeders for Better selection, disease control, improved husbandry could not only improves production but also could improve productivity and quality of camel herds general, Whereas Improving reproductive capacity of the female and males camels through proper selection and best husbandry practice could improves the economic benefits from camel.

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INTRODUCTION

A camel is an even-toed ungulate within the genus *Camelus*, bearing distinctive fatty deposits known as "humps" on its back. The two surviving species of camel are the bactrian, or two-humped camel (C. bactrianus), which inhabits Central Asia dromedary; and the one-humped camel (C. dromedarius), which inhabits the Middle East and the Horn of Africa (Al-Dahash and Sassi, 2009). As with all mammals, camel reproduction is adapted to its specific behavioural, anatomical, physiological and endocrinological peculiarities. The camelidus inhabit the most extreme climates on the globe and their process of multiplication is determined by the availability of food and protection for the newborn, consequently their reproduction is governed by these factors.

Camelidus are found high in the Andes mountains of South America (New World camelids), in the frozen Gobi desert in Asia (Bactrian camels), and in the hot deserts of Africa and Middle East (Dromedaries) Yagil, (1985). According to FAO statistics (2013) there are about more than 20million camels in the world, of which 16 million are found in Africa and 5 million in Asia. Of this estimated world population, about 18 million are believed to be one-humped dromedary camels (Camelus dromedarius) and 3 million two-humped (Camelus bactrianus). Approximately 11 million dromedaries, representing two thirds of the world's camel population, are in the arid areas of Africa, particularly in North East Africa, i.e. Somalia, Sudan, Ethiopia and Kenya. The camel is an important animal component of the fragile desert eco-system. With its unique bio-physiological characteristics, the camel has become an icon of adaptation to challenging ways of living in arid and semi-arid regions. The camels have been bred owing to the extraordinary power to withstand thirst and hunger for long duration in the most inhospitable ecological conditions

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(Al-Dahash and Sassi, 2009). The proverbial Ship of Desert earned its epithet on account of its indispensability as a mode of transportation and draught power in desert but the utilities are many and are subject to continuous social and economic changes (NRC, 2011). They provide milk, meat, and hair for textiles or goods such as felted pouches, and are working animals with tasks ranging from human transport to bearing loads (Simenew *et al*., 2013). The physiological mechanisms, which allow the camel to survive periods of over two weeks without drinking water and to eat the most unpalatable plants, all have to do with the conservation of water and Up to 30 percent of its body weight can be lost by loss of water - amounts that would be fatal in the case of other farm animals or even man FAO (1982). Much of camel region is dry and rocky, unsuitable for cultivation. Most areas characterized by an arid and semi-arid climate with low and erratic rainfall of extreme desert area. Numerous adaptations have allowed the camel to survive the incredibly harsh environment of the desert. The appropriate physiological mechanisms will be discussed further. What is of interest now is that severe desiccation is tolerated. Therefore it is important to consider and review heat storage within the body of the camel, selective brain cooling, fur, and concentrated urine from unique kidneys, respiration mechanisms, and digestive mechanism of camels. So that it is very important to review different research results depicted with camel physiology for developing well organised information of camel to enhance the attentions of researchers and concerned bodies in the effort of increasing camel's production and productivity under stressed environments of arid and semi-arid areas of the world in general, in Ethiopia in particular. In the present article, the available information on the reproductive activities of male and female dromedary camel and the physiological background, during the breeding and non-breeding seasons, are also reviewed.

Some important physiological adaptations ability of camels in the harsh environment

According Amsel, Sheri (2014) explanation Adaptation in a population of living things happens as a result of an adaptive trait. This is any inheritable trait that increases it's survival rate so that it can live longer, reproduce longer, and have more offspring (that also have that trait). Adaptive traits can improve an animal's ability to find food, make a safer home, escape predators, and survive cold or heat or lack of water. Thus are physiological adaptation mechanism of camels are discussed as follows.

- Heat storage capacity
- Selective brain cooling
- Fur cover
- Unique kidneys
- Respiration mechanisms
- hormones
- Digestive mechanisms

Heat storage capacity

During the hot desert day, camels are able to significantly increase their body temperature and store heat during the hot desert day (Schmidt-Nielsen *et al*., 1957).

The purpose of storing heat is to conserve water that would otherwise be lost to evaporation. The conservation of water in the desert is essential for the camel in times when water is scarce. At night when the temperature drops noticeably, the stored heat in the camel dissipates so that the body temperature of the camel returns to a normal level (Schmidt-Nielsen *et al*., 1957). The advantage of the storing heat on a hot desert day is that the camel does not waste any water on regulating its temperature. When the heat dissipates at night, the camel has not wasted any water during the day in regulating its temperature. When a dehydrated camel increases its body temperature by 7 degrees Celsius in the day, it gains approximately 2900 kcal of heat which corresponds with about 5 liters of water being saved (Schmidt-Nielson, 1997). Another advantage of storing heat in the day is that the heat gain from the surrounding environment no longer plays as a large role since the temperature gradient between the body temperature of the camel and the environment is reduced. This means that the total heat gain from the environment will eventually be reduced (Arabnet, 1996).

Selective brain cooling

The brain is one of the most heat sensitive parts of the body. Consequently the camel uses selective brain cooling so that it can keep the brain at a lower temperature during times of heat stress than the rest of the body according (Elkhawad, 1992). The same author explained that if the brain were subjected to the extraordinarily high temperatures that the rest of the body faces then those temperatures would be fatal for the camel. In camels, arterial blood to the tissues of the brain passes over the carotid rete before entering the brain (Elkhawad, 1992). In the long nasal cavity, evaporative heat loss occurs which then cools the venous blood that goes by the nasal cavity.

This cooled venous blood travels from where the nasal vein connects with the angular vein to the ophthalmic veins which connect to the cavernous sinus. The cavernous sinus incorporates the carotid rete; however the arterial blood of the carotid rete does not mix with the cool venous blood of the cavernous sinus. The two are separated by a thin arterial vessel wall which allows for heat exchange. The cool venous blood in the cavernous sinus cools off the arterial blood within the carotid rete. In this way the blood is cooled off before entering the brain and it is due to this process that the temperature of the brain can remain several degrees lower than the rest of the body temperature.

Elkhawad (1992) observed that the camel has some special adaptations with brain cooling when there is an increased temperature. Under normal conditions, the cool venous blood, after having passed over the nasal cavity, travels via a general circulation. However, when temperatures increase in the body the nasal and the angular veins, becomes wider while the facial vein is constricted.

This process maximizes the amount of cooling that is possible for the brain when the camel experiences heat stress. The camel would not be able to live in the type of environment that it does if it were not for this system of brain cooling.

Table 1. Some important physiological and behavioural characteristic of dromedaries

Characteristics	Results observed	List of referred
puberty	4-6 and 6 years male and female respectively	Novea, 1970
Breeding season	Seasonal both sex Varying with different country	Novea, 1970, Souilem Ouajd & Barhoumi Kamel (2009) Bannikove, 1945
Oestrus cycle	2 week length in female it last3-4 days No spontaneous ovulation Peak of progesterone 2 days LH appears 24-48 hours after matting Oestrus re-occurred after a day of calving Post-motrum develops within one month	Leord., 1894 Chen yan.,1979 Wassa and abusinea., 1978 Borcicov., 1939
Sexual cycle	Be behavioural and hormonal changes during rutting season Aggressive during rutting season and roaring with gurgling sound for male Attack each other and lips cover with saliva secretes bad smell from the ear gland Androgen increase and mat at 4-5 year age and can mat 50-80 females per season at good condition Females palatal floppy and neck gland and 6 year of age and breed 7-8 time of lifetime	Yagil and exsion., 1980 Hortley., 1979 Leese., 1977
Breeding habit	calving interval 24 month and 8 calve in live time Culled for some reason: •Slow breeding, poor milk, bad mothering, weak offspring •Copulation induce ovulation •Mating in down position ling periods to ejaculate / 10-15 minutes/	Yasinandwuhid., 1957 Hortley., 1979 Nouilem Ouajd and Barhoumi Kamel (2009)
copulation	Male serves many female per season Lasts15 minute and gives 7ml of semen and 15 million sperm per 1 mm	Yasin., 1957
Pregnancy diagnosis	Known by rectal palpation, biological assay and radio-immune assay	
gestation	365-395 days 373-393days	Yasin 1957 Chenand yuang.,1979
Fertilization rate and fertility	Very low, less than 50% have been recorded Repeated mating is often Injection of pregnant serum gonadotropin /psmg/ possible 100% calving. Infertility possible due to anatomic defect of follicles, foetal death and infertility as well as slow breeding habits associated with poor feed and managements	Novea 1970 Bermintves, 1951 Yuzlikoev 1965 Shalsh and Nawidin 1953

Sources: from FAO, 1982

Not only can it survive in the desert because of this adaptation, but the camel also has an increased tolerance to higher temperatures (Schmidt-Nielson, 1997).

Fur cover

The layer of fur on the camel serves as layer of insulation against the heat. As an effective barrier against the heat, the fur prevents excessive heat gain and consequently helps to conserve water. Camels that lack this important layer of fur due to human desire for wool for instance, can have much higher body temperatures and are more susceptible to dehydration (Schmidt-Nielsen, K., 1964).The camel actually possesses a double coat for the various seasons. In the spring, the camel will shed the top layer of it fur as it is merely a winter coat. A thick, dense layer of fur remains on the camel for the spring and summer months (Guirgis, *et al.,* 1992). One can infer that the coat of fur serves dual purposes. In the hot months, the single layer of fur is thick enough to prevent an excessive amount of external heat transfer. However, in the cooler months the camel uses its winter coat to prevent heat loss to the environment which means that the fur of a camel may seem rather insignificant at first, but in reality it plays a major role in the thermoregulation and water control in the camel (Guirgis, *et al*., 1992).

Other author agreed that the covering of the camel changes from a wool in the winter to a sleek shiny reflecting hair in the summer. Equatorial camels do not shed their hair, but maintain a smooth reflecting coat throughout the year. The hump does not serve as a water reservoir, nor solely as an energy reserve, but its greatest use is that being a concentration of body fat it leaves the subcutaneous tissues virtually fat-free, thus allowing for an efficient cooling to a relatively cooler environment (Cloudley-Thompson, 1969) in cited FAO (1982).

Unique kidneys of the camel

According to Nouilem Ouajd and Barhoumi Kamel (2009) the camel's kidney plays a major role in the process of conserving water through increasing the osmolarity of urine. The kidney is characterized by a long loop, and a well-developed medulla. The glomerular filtration rate is lower than other ruminants. The kidney has a strong capacity of water reabsorption and a faculty to eliminate very concentrated urine, which helps to explain the great tolerance of the dromedary to salt (Siebert & Macfarlane, 1974). Similarly the role of the kidney in the camel becomes essential to the camel in terms of urine concentration. The kidney can produce very concentrated urine when there is a need for water (Abdalla, 1979).

The same author explained that the ability to concentrate urine can be determined by the loop of Henle and the structure of the renal medulla. The longer the loop of Henle usually indicates the ability to produce more concentrated urine.

Respiration mechanisms

Water loss can increase quickly in a camel with high temperatures and respiratory frequencies (Schmidt-Nielsen *et al*. 1981). For this reason, the camel has special respiratory mechanisms. Water loss can be reduced by cooling off the exhaled air in the nasal passages which allows for the recovery of water (Schmidt-Nielsen *et al*., 1981). Together with the examples of physiological adaptation mentioned above, there are also behavioural adaptations. These consist mainly of presenting the smallest possible surface area to the rays of the sun (Ingram and Mount, 1975) and by being less active in the heat of the day. Even the covering of the camel changes from a wool in the winter to a sleek shiny reflecting hair in the summer.

Equatorial camels do not shed their hair, but maintain a smooth reflecting coat throughout the year. The hump does not serve as a water reservoir, nor solely as an energy reserve, but its greatest use is that being a concentration of body fat it leaves the subcutaneous tissues virtually fat-free, thus allowing for an efficient cooling to a relatively cooler environment (Cloudley-Thompson, 1969). Water economy mechanismof camel according to Souilem Ouajd & Barhoumi Kamel (2009) explained that the dromedary has a lower turnover in comparison to others species and is able to reduce the water losses in different ways: Cutaneous (sweating limited), Respiratory (camels do notpant), Digestive: reduction of all digestive secretions, Particular the salivary secretion, which can decrease from 80 to 16 litres/ day in a dehydrated camel, Urinary (reduced urine production and increased urine concentration).

Hormones

Globally, the dehydrated camel presents an increase in albuminemia, uremia, glycemia and cholesterolemia and in opposite a decrease of creatinin clearance. Indeed, albumin has an osmotic capacity and represents the principal factor of plasma hydration maintenance. It also prevents any extracellular dehydration Souilem Ouajd & Barhoumi Kamel (2009). It is noted by the same author that also a decrease in plasma volume countered by an increase in plasma sodium concentration, which represents a signal for the secretion of hormones responsible for maintaining water levels. Indeed, plasma arginin-vasopressin and plasma renin activity are significantly increased.

Arginin-vasopressin is quite effective in increasing the urine concentration and seems to play a greater role than aldosterone in camelids. Hypoinsulinemia and hypothroidism observed in dehydrated camel limit the basic metabolism and inhibit lipolysis (Bengoumi, 1993). This is also supported by (Ben-Goumi-M, 1993). Hormones play an important role in the conservation of water during times of high heat and dehydration. The concentration of urine that occurs in the kidneys is also partially the result of hormones.

Feeding habit and Digestive mechanisms

The camel selects only a few leaves from each plant and ingests the foliage parts. It prefers halophytes plants. It can take in a very large amount of water atone occasion for compensating previous fluid lossand is able to drink 200 liters in 3 minutes. It move sat long distances in the desert to seek water Souilem Ouajd & Barhoumi Kamel (2009). The camel has many adaptive traits for their life in the desert. They have wide feet for walking in sand. They have long eyelashes and thin, slit nostrils that they can close to protect them from blowing sand. They are adapted to survive a long time without water and food. They have an extremely long large intestine that absorbs every last drop of water from the foods they eat. On a long trip, the fat in their hump(s) will break down to supply their body with the energy it needs. By the end of a difficult trip, their humps may lay over on their side, emptied of the fat that filled them. When the camel finally reaches water, it can drink a huge amount very quickly to replenish itself, but it will take a little while to eat enough to rebuild its humps. These adaptive traits are all physical adaptations (Ben-Goumi, 1993).

Camels are in the taxonomic order artiodactyl /even-toed angulates, sub order typoloda /pad-footed/and family camilidea (Wellson, 1978). Camels are pseudo-ruminants that possess three chambered stomach lack Omasum that is found in the order of ruminants as part four anatomically (Wellson, 1978). Tylopoda and ruminant independently developed for stomach during evolution (Bello *et al.*, 2012). Species of sub order of artiodactyl ruminate have large fore stomach with extensive, microbial digestion to achieves superior digestibility of diet rich in cell wall constituents, however gross anatomy and microscopic structure of fore stomach mucosa are very different in camelids compared to ruminants (Mail, 1987)'

A behavioural adaptation for which the camel is famous is their reaction to the approach of a threat - they spit! The camel is a ruminant. This means that they have several stomach compartments where their tough, dry, grassy food needs to ferment and be broken down by special bacteria. Then they regurgitate it and chew it again - this is called “chewing their cud.” This may sound gross, but it allows them to live in habitats where other animals, like horses, would starve. Their cud is what they spit when stressed and because it is partially digested, it smells bad. This discourages predators from getting too close - and people too (Amsel, Sheri, 2014).

Although they chew cud, camels differ from true ruminants in a few anatomical features. Adult camels have two incisor teeth in their upper jaws; they lack an omasum, the third stomach division of the ruminants, which is considered the water reabsorbing portion of the stomach; they have no gallbladder; and the hooves have been reduced to claw-like toes, projecting beyond the pads (FAO, 1982). The same source revealed that within the arid regions the camel-breeding tribes have maintained a dominant position over other societies by virtue of their ability to exploit the often poor grazing ranges. The various proportions of VFA are similar to those found in the rumen of cattle (FAO, 1982). This suggests a great similarity in metabolism in the fore stomachs of camels as compared with other ruminants.

Gastric digestion:- The pre-stomachs of the camel are characterized by the presence of only three compartments in comparison with true ruminants. The great digestive capacity of cellulosis is due to a specific and differentiated motility, a very active micro flora and better microbial digestion and more significant food mixing in pre-stomachs Souilem Ouajd & Barhoumi Kamel (2009). Water is absorbed very slowly from stomach and intestines allowing time for equilibration without severe osmotic problems. Lipidic metabolism the proverbial capacity of the dromedary to resist thirst and lack of food is related to remarkable adaptive mechanisms, including the mobilization of the body reserves of lipids (fatty tissue) during malnutrition and the storage of fat during favourable periods. In ruminants, taking food and especially the fast result in a significant ketogenesis with blood accumulation of ketonic bodies, in particular 3-hydroxybutyrate in which could lead, in the case of prolonged food deprivation or insufficient ingestion, to serious medical disorders (ketosis) (Chilliard *et al*., 1995). In the dromedary, ketogenesis is weak in any circumstance and plasma concentrations of 3-hydroxy-butyrate and acetoacetate were 33 and 4 fold respectively, lower in comparison to sheep (Chilliard *et al*., 2000) in cited Souilem Ouajd & Barhoumi Kamel (2009).

Biological fitness of camel

The average life expectancy of a camel is 40 to 50 years Arabian (Dromedary) Camel 2012. A full-grown adult camel stands 1.85 m (6 ft 1 in) at the shoulder and 2.15 m (7 ft 1 in) at the hump. (Abu-Zidana., 2011) Camels can run at speeds up to 65 km/h (40 mph) in short bursts and sustain speeds of up to 40 km/h (25 mph)."How Fast Can Camels Run and How Long Can They Run For 2012. Bactrian camels weigh 300 to 1,000 kg (660 to 2,200 lb) and dromedaries 300 to 600 kg (660 to 1,320 lb). The male dromedary camel has in its throat an organ called a dulla, a large, inflatable sac he extrudes from his mouth when in rut to assert dominance and attract females. It resembles a long, swollen, pink tongue hanging out of the side of its mouth (Abu-Zidana., 2011). Camels mate by having both male and female sit on the ground, with the male mounting from behind. The male usually ejaculates three or four times within a single mating session and Camelids are the only ungulates to mate in a sitting position (Factsheets, 2012).

Camels do not directly store water in their humps as was once commonly believed. The humps are actually reservoirs of fatty tissue; concentrating body fat in their humps minimizes the insulating effect fat would have if distributed over the rest of their bodies, helping camels survive in hot climates. Roberts Michael and Bliss Vaughan (1986) when this tissue is metabolized, it yields more than one gram of water for every gram of fat processed. This fat metabolization, while releasing energy, causes water to evaporate from the lungs during respiration (as oxygen is required for the metabolic process); overall, there is a net decrease in water Rastogi (1971). Camels have a series of physiological adaptations that allow them to withstand long periods of time without any external source of water Roberts Michael and Bliss Vaughan (1986) unlike other mammals; their red blood cells are oval rather than circular in shape. This facilitates the flow of red blood cells during dehydration and makes them better at withstanding high osmotic variation without rupturing when drinking large amounts of water: a 600 kg (1,300 lb) camel can drink 200 L (53 US gal) of water in three minutes (Eitan et al., 1976). Camels are able to withstand changes in body temperature and water consumption that would kill most other animals. Their temperature ranges from 34 °C (93 °F) at dawn and steadily increases to 40 °C (104 °F) by sunset, before they cool off at night again. Roberts Michael and Bliss Vaughan (1986) Maintaining the brain temperature which utilizes counter current blood flow to cool blood flowing to the brain Anders Lundquist (2012) Camels rarely sweat, even when ambient temperatures reach 49 °C (120 °F). Any sweat that does occur evaporates at the skin level rather than at the surface of their coat; the heat of vaporization therefore comes from body heat rather than ambient heat. Camels can withstand losing 25% of their body weight to sweating, whereas most other mammals can withstand only about 12–14% dehydration before cardiac failure results from circulatory disturbance Yagil, (1982).

Reproductive physiology of camels

The reproductive characteristics of both male and female camels have been reviewed since the importance of camel milk and meat for human nutrition as well as source of lobar power. Purpose used in drought areas. The male camel is described as a seasonal breeder with a marked peak in sexual activity (the rut) during the breeding season and it is generally thought that the male is sexually quiescent for the remainder of the year, but it is capable of mating and fertilizing an estrous female at any time of the year. Similarly, the she-camel, although it shows strong tendency to be regarded as a seasonal breeder, pregnancy can occur at any season of the year as a polyestrus animal (Marai, 2009). Elevation of the ambient temperature during summer which is closely correlated and may be a result of the increase in daylight length seems to play the main role in affecting the camel reproductive activities through disturbance of the physiological activities (I.F.M. Marai, 2009). In the female an estradiol cycle is found only if there is no ovulation and after copulation there can be a short-lived rise in progesterone. When the females are pregnant the progesterone levels rise to above 2ng/ml (Yagil, 2006). In males there are elevated testosterone levels in the rut period .It is very important to review about puberty, breeding season, oestrus cycle and ovulation, fertilization and fertility of camel be reviewed from different research results. Other factors which that anatomy will be affected by age, season, size and weight (Yagil, 1985).

Puberty:-The change in body weight of the camel has major implications on reproductive function beginning by onset of puberty. Attainment of puberty is influenced by the overall growth and weight of the animal that are affected by nutrition. Therefore, encouragement of rapid growth during the pubertal period by the good nutritional and environmental conditions can assist early sexual development and breeding maturity in dromedary camels. Particularly, Abdel-Same and Marai (1997) indicated that the camels' body weight gain declined significantly in the non-breeding season (summer) than in the breeding season (milder weather) as a function of heat stress, similar to that recorded in most animals such as rabbits, sheep, goats, cattle and buffaloes (Marai *et al*., 2008).

In males: Young males may show sexual interest (show sexual desire) in females at 1 year of age, but they are incapable to mate due to adhesion of the penis to the prepuce. Shedding of the penopreputial adhesions (that adhesions make normal copulation impossible) does not occur until puberty is reached. Such anatomical change is accompanied with hormonal shift and is essentially androgen-induced phenomenon influenced by plane of nutrition (Maraietal, 2007). Increasing amounts of testosterone produced from the testes as the animal matures facilitates development of secondary sexual characteristics; in addition it allows the animal to grow. At 3 years, all males are without penile adhesions and puberty occurs at 3-4 years (Beil, 1999).

Sexual maturity is attained before full physical maturity. However, it is greatly influenced by breed and seminiferous tubule diameter increases up to about 9 years of age and the number of spermatozoa increases during the following years, then declines gradually. Meanwhile, there is little variation in total germinal cells-spermatogonia, primary spermatocytes and spermatids between 6 and 18 years of age (Zeidan *et al*., 2001). In nomadic herds the male become sexually mature at about 5 years old (1), but this age declines when herds are better controlled. Testicular weight and dimensions increase with age and reach their maximum values at 10 to 15 years of age, and then they decrease slightly after 15 years and Weight of the testes and the number of spermatozoa in the epididymis (Maraietal, 2007) show a seasonal peak. Corresponding with these changes, there were also changes in the circulating testosterone level. Full reproductive potential of the male camel is reached at 5-6 years; however, different literature reported that the first ejaculum that contains higher concentrations of spermatozoa is produced at 6 years old in dromedary camel. The full overt sexual activity may be delayed until 8 years. Physiological capacity may increase up to 10 years, then remains at a more or less constant of fairly high level until 18-20 years of age. In addition Yagil (2006) reported that the anatomical measurements and behaviour change of males and female camels.

Testes: They are found lying horizontally in the perineal region. In young males they are barely visible in the non-breeding season. In older males they are small and located almost completely between the legs. A faint median raphe divides the two testes. Between the ages of 6-10 years, its length averages 9cm, breadth 5cm, thickness 4.3cm and weight is 92grams. The right testicle is slightly smaller. In the rut season the testes become enlarged and protrude (Yagil, 2006).

Penis: according Yagil (2006) a cylindrical organ directed posteriorally. It is possible that this position prevents contact between the organ and the hot desert sand when the male squats, keeping the penal area above the sand. There are three groups of penal muscles: anterior, posterior and lateral. The contractions and relaxation of these muscles pull the penis forward during the breeding processes. The glans penis is curved along its ventral plane, giving it a hooked appearance. It is noteworthy that the diameter of the penis decreases from its root towards the thin tapered glans penis. During erection the differences in diameter give the impression of opening of an old-fashioned telescope.

Behaviour: The Dulaa is a palatal flap that is extruded on the side of the mouth during the mating season (Yagil, 2006). It is incorrectly assumed that this protrusion is the tongue. The flap is formed under the influence of testosterone, so the more virile the male, the longer is its dulaa which protrudes further in a ball-like structure. The male normally takes a deep breath and when the air is expelled it pushes the dulaa out of the mouth, the nostrils quiver and there is a typical sound of “bloo, bloo, bloo” and a large secretion of saliva. After a few seconds the dulaa collapses and the sac is withdrawn into the mouth. The importance of the dulaa is that its formation is correlated to the amounts of testosterone in the blood; the size is an indication for the females of the male's virility. Towards the end of the season the typical sound is made but no dulaa appears.

The poll glands are situated on the back of neck between ears and they secrete a copious, acrid-smelling secretion, which flows down the back of neck, marking the skin with a dark color. The males rub their necks on any solid object, thus marking their territory Souilem Ouajd & Barhoumi Kamel (2009). Laboratory examination of the poll gland secretions revealed similar concentrations of androgens as in the blood. Histological examination confirms that the poll glands are of endocrinological origin (Yagil, 2006).

Urination: Another peculiarity of the male in rut is spreading its legs, placing its tail between them, urinating on it and then swishes it over its back. (4, 8, 9), It is likely that pheromones in the urine attract the females.

Aggressiveness: When the males exhibit all the above signs they become very aggressive towards other males and can attack humans, even their owners BarhoumiKamel (2009). It is noteworthy that male elephants in the musth exhibit similar behavioral signs to those of the camel.

Infemale: In the dromedary female foetus, large polygonal FSH cells appear at 24-28 weeks of age. Prolactin and LH cells appear at 32-36 weeks of age. Primary ovarian follicles are seen at 8-12 weeks and secondary follicle sat 20-24 weeks of age. Uterine glands appear at 16-20 weeks of age and puberty of she-camel is reached at 3-4 year of age (Maria *et al*., 2009).Females become mature at 4 years and remain fertile for over 20 years. This age is reduced as the husbandry practices improve and if the animals are kept in feed lots (Yagil 2006).The length of pregnancy averages 1 year (308-440 days) but will be affected by the herders who determine the date that it conceives (Yagil, 2006).

Full reproductive capacity of the female camel is reached at 6 years, but it can be bred at 3-5 years of age (Khetami, 1970) in cited by age (Maria *et al*., 2009) reported that the female camel would breed until 30 years of age. The estrous cycle in the she-camel is incomplete when compared to that of the ungulates. It consists of proestrus (growing follicles), estrus (mature follicles) and diestrus (follicular atresia if mating has not occurred). Correspondingly, the follicular cycle was divided into a growth phase (10.5 + 0.5 days), a mature phase (7.6 + 0.8 days) and a regression phase (11.9 + 0.8 days). However, four distinct uterine activity phases were recorded:

the high phase, declining phase, low phase and increasing phase, during the estrous cycle (Al-Eknah *et al*., 1993). Estrous cycle duration of 4-6 days (Nawito *et al*., 1967) and 16-30 and 11-27 days (Bakkar and Basmaeil, 1988; Al-Eknah *et al*., 1993), have been observed. Such varitiaon in estrous cycle duration may be due to that the cyclic ovarian activity and estrous behaviour are largely dependent on the presence or the absence of coital stimulas. The phases of the cycle usually described for species with spontaneous ovulation (estrus and diestrus) do not exist in Camelidae unless the female is bred and has ovulated. In general the female genital tract is more similar to that of a mare than of a cow. The sizes are determined by the age of the animal. Externally the two uterine horns are joined but there is a definite median septum (Yagil, 2006). The left horn is well developed while the right one is rudimentary. There is a short cervical canal and the mucosal folds are arranged in 3-4 rows. The cervix tends to protrude into the vagina, creating a dorsal and ventrical blind sac. The vagina is about 31 cm long. The vulva is about 8cm long, and a sub urethral diverticulum with the urethral orifice above is in its ventral floor. The sizes of the ovaries are determined by the age, size, health and stage of female cycle. Follicles on the left ovary are generally larger than those of the right one. When palpated rectally the ovaries can be found close to the cervix.

Behavior: In the breeding season the female is receptive to the male for 3-4 days at a time, followed by about 10 days of quiet. This corresponds with the fluctuations in sex hormones in blood. When in rut the female approaches the male, presents her hind parts and urinates constantly and flaps her tail up and down in quick, short movements. The following Table showed as summary that some important reproductive and behavioural characteristic reviewed from different source. Knowing the peculiar characteristics of camel physiology is essential for researcher and breeders for Better selection, disease control, improved husbandry could not only improves production but also could improve productivity and quality of camel herds in general (FAO, 1982).

Anatomical and behavioural adaptations

Anatomical adaptations

Head and neck

- The head of the camel is small in comparison to that of other domestic animals. It bears no horns and has small bluntly erected ears to hear the minimal sound vibration and hear for long distance in the desert. Also, the ear contains small hairs to filter and warm the air entered the ears in sandy environment.
- The eyes are large and prominent enable the camel to see in different directions and for long distances. The massive supraorbital fossa or processes give some protection with the long lashes against the sandy environment of the desert in windy day.
- Also, the nostrils of the camel are long slit- like appearance having wing, so the camel is the only animal that can close its nostril as protection against sand and winds.
- The upper lip is split and hairy, extensible and slightly prehensile, it is very sensitive. This modification helps the camel to select its food
- (Selective feeding) and avoid the thorny plants.
- The camel has a long arched neck helping him to manipulate the high tree plants and to explore the enemy from long distances which all are being summarised by (Fayed, 2008)'

Trunk and tail

- Most of the fatty tissues of camel is stored in the hump than being diffused throughout the body. The hump acts as food (fat) storage which will be converted to energy and water in case of starvation in the desert.
- Skin of camel is attached rather tightly to the underlying tissues and has short fine hairs (weber) which helps in thermoregulation.
- Prepuce of camel is normally directed posterior ally; it is possible that this elevated position keeps the organ from touching the hot sand when the camel squats on the ground and avoiding its contamination with sand.
- Placenta of she camel is simple diffuse smooth type as in mare with no cotyledons so the retention of placenta is rare.

Limbs

The legs are relatively long and slender , an adaptation , perhaps to a long easy gait in sandy environment , and to adaptive cooling , and terminate in large disk -like feet .More than 65% of the camel's total weight is supported by the front limbs . The chest is deep and narrow which allows the balance to be shifted easily, so that it is directly over the weight bearing foreleg during locomotion. The foot of the camel is well designed to cops with the loose sandy soils of the desert. The bearing surface of the foot is like a large plate, this plate is able to maintain flat contact with the ground throughout the duration of the stride due to exception rotation at the first digital joint. The foot stays out on taking the weight of the camel and thus act as a firm base for levering the weight forward to the next stride. The camel foot is excellent for movements on sand. It is less suitable for traversing stony desert although some hardening occurs in animals habituated to this kind of country .The presence of the peculiar horny pads on the elbows; stifle and chest prevent more injuries to camel from the stony desert.

Behavioural adaptation

Under conditions of dehydration and intense heat the camel adopts behavioural mechanisms to conserve energy (Fayed R.H., 2008).

- The camel sits down in the early morning before the ground has warmed up . It tucks its legs underneath its body so that it absorbs little heat from the ground by conduction
- The camel orientates itself towards the sun presenting the least possible body area for the absorption of

radiant heat. Any heat absorbed from the ground or the sun would have to be dissipated later in the day

- A group of animals may lie down together, thus presenting an even smaller target area for heat accumulation
- The camel's metabolic rate increases in the normal way as the temperature rises

Digestive behaviour:- Camels are selective feeder not only with regard to plants but also in respect of the parts of the plants they eat .The natural selective feeding habits of the camel are considered the morpho-physiological adaptation of the camel's digestive tract. The digestive anatomy and physiology of the camel are peculiar in the adaptation to a wide range of food types and in particular, coarse forage, without the necessity of a specialized cellulose fermenting rumen. The camel does, however possess adaptive mechanisms to compensate for long periods of poor quality food and water deprivation , for example, there is a slow decrease in weight through fluid loss during exposure to high temperature (41c) allowing adjustments of fluid spaces and a stable metabolism (Yousri, 1976).

Camels are browsing animals; they feed on thorny plants of the desert. Anatomical adaptation as the mobile and prehensile split upper lip enable them to avoid the injuries of the desert plants, the camel jaw and dental pad enable it to seize and tear branches off trees if required and with slow lateral movements of the jaw, and the thorns of these plants are destructed. Also a small but mobile tongue with numerous hard, dentigerous papillae protruding from the lining of the cheeks and lateral aspect of the tongue assist in the mastication and ingestion of food. Although camels can resist thorns to some extent they are not completely immune to them and on very thorny species feeding is a slow business (Higgins, 1986). The oesophagus has a large potential diameter with much mucus–secreting glands. The areopharyngeal and oesophageal anatomy assist in the movement of hard materials without causing irritation to mucosa.

Conclusion

The capacity of the camels' /dromedary/ to live under desert conditions and to survive in incredibly harsh environment is due to its biological and physiological fitness. Indeed, all the functions of the dromedary organism are conceived to be physiologically adapted to water and food restrictions and to an excessively hot climate. With these circumstances they continue its production and reproductive performance in the stable manner relatively than other species of animal unable to do so. Therefore these animals are the hope of future generation of mankind in this and uncertain and susceptible world to climate change drastically. It has comparative advantages over other domestic animals in which capability of water economy, capacity of makeup water loss as water avails, tolerate water loss as much as 30% of its body weight those resulting go without water for more than10 days and does not loss its appetite for food as well as can fluctuate its body temperature and saving energy to be made that fit friendly with the environment due to plate like structure of feet. Knowing the peculiar characteristics of camel physiology is essential for researcher and breeders for Better selection, disease control, improved husbandry could not only improves production but also could improve productivity and quality of camel herds general, Whereas Improving reproductive capacity of the female and males camels through proper selection and best husbandry practice could improves the economic benefits from camel. Further investigation must be focused on dromedary welfare in experimental studies and to determine endpoints in some protocols like dehydration, food restriction and model disease reproduction level and compatibility with existed environmental condition in relation with climatic change.

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