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Anatomical and physiological adaptation of camel to desert environment

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Abstract

The dromedary (Camelus dromedaries), also called Arabian camel or one humped camel. It is able to survive in hot dry desert due to anatomical structure. Anatomical adaption any alteration in the structure or function of an organism the organis becomes better fitted to survive and multiply in its environment. Adaptation of animal to its environment in general is used often for the process of adjustment to the environmental changes. The camel, however is able to utilize these mechanisms more effectively when exposed to the direct rays of the sun and for extremely long periods without drinking water. The orbit is circular, equidistant, completely osseous and markedly projecting laterally. Camel has long double eyelashes and a nictitating eye membrane to protect the eyes from the sun and sand. It also has 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. The legs are long and thin with thick covers on knees. Hooves have a broad, flat leathery pad. Camel body temperature keeps fluctuating from 34°C to 41.7°C (93°F-107°F.). This helps the animal sweat less.

Key words: Adaptation, dromedary, nictitating.

A. Introduction

Camels have an important role in the lives of human beings, especially in arid regions, due to their multipurpose role and unique ability to adapt to harsh conditions. Dromedary camels adapted to desert areas can survive and reproduce despite extreme temperatures and limited water availability using a variety of physiological, anatomical mechanisms to either avoid or tolerate environmental conditions that can result in heat stress and dehydration. Camel production has several comparative advantages over other domestic animals within the camel's optimal environmental limits. Apart from different adaptation mechanisms for desert survival, camels are environmentally friendly animals. Here we will be focusing on various mechanisms which are useful for adaptation of camel to desert environment.

B. Physiological Adaptations

1. Water conservation

Desert adapted camels have evolved physiological adaptations that reduce the amount of water lost or can tolerate significant amounts of water loss. During the winter and cold seasons of

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the year, camels can go without water for months. They do not even drink when offered water. Under very hot conditions, it may drink only every eight to ten days and lose up to 30 percent of its body weight through dehydration.

The digestive and urinary tracts are well specialized in water conservation. Cattle lose 20 to 40 litres of fluid daily through feces, whereas camels lose only 1.3 litters. This is one of the primary methods for resisting water deprivation in the desert. Fluid is absorbed in the end part of the intestines, where the small fecal balls are produced.

The camel's kidneys play a major role in the process of conserving water through increasing the osmolarity of urine. The kidney is characterized by a long loop of Henle, and a well-developed medulla (the ratio medulla: cortex is about 4:1). During dehydration, the kidneys reduce water losses both by decreasing the glomerular filtration rate and by increasing the tubular reabsorption of water. Antidiuretic hormone (ADH) is important in regulating the volume of urine excreted and its concentration. ADH is produced in the hypothalamus and is released into the bloodstream in response to increased blood osmolarity. Larger release of ADH leads to a fast-renal response that causes increased reabsorption of water. This leads to a smaller volume of more concentrated urine being excreted.

The body of camels can tolerate loss of water over 30% of body weight whereas most mammals die if they lose half of this value.

2. Unique features of blood

The erythrocytes of the camel are oval-shaped and nonnucleated which resist osmotic variation without rupturing; these cells can swell to twice their initial volume following rehydration. The ellipsoid shape of camel erythrocytes is very stable and that the cytoskeleton differs from that of human red cells and they may expand with distilled water to 400% before they rupture.

Another unique feature of the erythrocytes is their long-life span when the camel is dehydrated. The life span of the erythrocytes of hydrated camels is 90 to 120 days. When camels are chronically dehydrated during summer (40°C mean during the day; 20°C mean at night) the life span of erythrocytes extends to 150 days. Erythrocyte turnover is water and energy expensive. Therefore, extending the life span of erythrocytes reduces energy and water expenditure.

3. Thermoregulation

Body temperature regulation

A fully hydrated camel has a daily body temperature range of 36 to 38°C. However, when dehydrated and exposed to high environmental heat load body temperature may fluctuate by 6 to 7°C, from approximately 34 to 41°C. Other animals also allow body temperature to increase but not to the same extent. For example, *Bos Taurus* cattle will have a 2 to 4°C variation in body temperature when exposed to hot conditions. The increase in body temperature of camels exposed to high heat

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load, especially following a 2°C reduction below the normal minimum, is advantageous because it allows a considerable amount of heat to be stored during the day and dissipated at night (by radiation) without the expenditure of water.

Selective brain cooling

Selective brain cooling has been assumed as a mechanism for animals to maintain brain temperature below thermal critical values when body temperature increases the camel can resist intensely high body temperatures without damaging its brain. Camels, like most other animals, need to maintain a constant brain temperature. However, this is very difficult considering they live in an extremely hot environment. moreover, camels have a "rete mirabile", it is a complex of arteries and veins lying very close to each other which utilizes counter-current blood flow to cool the blood flowing to the brain. This helps camels to maintain a stable brain temperature, essential for survival.

4. Digestion and metabolism

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 cellulose by camels is due to a specific and differentiated motility, a very active microflora and better microbial digestion and more significant food mixing in pre-stomachs. Water is absorbed very slowly from the stomach and intestines allowing time for equilibration without severe osmotic problems.

Lipid metabolism

The well-known 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 dehydrated dromedaries, liver lipids decrease from 13 to 2.5%, indicating a strong mobilization of hepatic lipids. On the contrary, concentrations of triglycerides and free fatty acids remain unchanged. However; severe water deprivation during 14 days would induce lipolysis revealed by the increase in concentrations of triglycerides, free fatty acids, phospholipids and cholesterol.

Glaycidic metabolism

The camel's energy metabolism differs in particular from that of ruminants. The dromedary presents a normal glycemia of about5 mmol/l, a value fully similar to that of monogastric species. After a 10 days water deprivation, the glycemia increases from 20 to 80% without glucosuria. The glucose urinary elimination is accompanied by enormous water losses like in diabetes cases. Thus, a dehydrated camel reduces moisture losses by maintaining a high glycemic and practically null glucosuria. The hypo-insulinemia would allow the camel to maintain a low basal metabolism by decreasing glucose use.

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Nitrogen metabolism

The nitrogen recycling in Camelids increases in the case of lower proteins in the diet and/or dehydration. This great aptitude of urea recycling is due to very powerful mechanisms whose effectiveness does not deteriorate in the case of dehydration.

B. Anatomical adaptation

1. Skin and hair coat

The skin of the camel is attached tightly to the underlying tissues and has short fine hairs (Weber) which help in thermoregulation. The camels' thick coats insulate them from the intense heat radiated from desert sand and during the summer the coat becomes lighter in color, reflecting light as well as helping to avoid sunburn. The coat of the camel is fairly sparse which allows sweat to evaporate at the surface of the skin. Dromedaries have a pad of thick tissue over the sternum called the pedestal. When the animal lies down, the pedestal and other small areas of padded contact points on with the ground their legs raise the body from the hot surface and allow cooling air to pass under the body.

2. Eye, Nostril, Ear, Pol Gland, Hump and Lips

The eyes are large and prominent enable the camel to see in different directions and for long distances and they have long eyelashes that help to protect the eyes from the sun and the blowing sand. They have also a third, clear eyelid that protects their eyes from blowing sand. The slit-like closable nostril protects against blowing sand and moistens air on its way to the lungs. When camel exhales, water vapor becomes trapped in their nostrils and is reabsorbed into the body to conserve water. Split upper lip assists feed selection and easy prehension during browsing and their mouths have a thick leathery lining, allowing them to chew thorny desert plants.

The ear contains small hairs to filter and warm the air entered the ears in a sandy environment. The poll gland is situated towards the top back of the neck behind the ears. It is more active under the condition of heat and fatigue than that at any other time except when the male is in a rut, so it acts as a modified sweat gland to help in the evaporation. Hump is rounded mass or protuberance, such as a fleshy structure on the back of the camel. The hump composed of the adipose tissue which contains white fat. It acts as food (fat) storage which will be converted to energy and water in case of starvation in the desert.

3. Large body size and height

The large size and height of the camel can be of some advantage in heat regulation. A large body mass heats up much more slowly than a smaller mass exposed to the sun. Body size is related to the metabolic rate. While their overall energy requirements are higher, large animals have lower mass-specific metabolic rates than do small animals; these low metabolic rates contribute comparatively less metabolic heat to the total thermal load.

The long legs and the large humps, containing adipose tissue, give camels a large skin surface to the body mass. The height above the ground is used to hold their body far from the hot sand and allows the desert winds free access to the body thus in some circumstances cooling it effectively. It also enables the camels to browse high above the ground reaching 3.5 meters into the canopies of trees and bushes. This characteristic together with their preference to browse on many kinds of bushes makes them an excellent complement for multi-species herds in different kinds of rangelands, increasing the productivity of the land without really competing with other livestock.

4. Large foot pad

Their large broad 'elastic' pads with two-finger nail-like toenails on the front are also important structures to easily walk on the desert sand which is not possible for other ungulates to walk on tips of hoof covered toes. The advantage of this broad leathery pad in camels is to disperse their weight in a wider surface area and their feet don't sink in the loose sandy soil.