Functional Anatomical Adaptations of Dromedary (Camelus Dromedaries) and Ecological Evolutionary Impacts in KSA

Mostafa Kandil Soliman

Abstract---The dromedary (Camelus dromedaries), also called Arabian camel or one humped camel, was domesticated in the Arabian Peninsula. About one million camels live in KSA with significant economic, social and ecological importance. It is able to survive in hot dry desert due to anatomical structure and its ecological adaptations. 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 .In KSA four subtypes of dromedary are known by different skin colors. Its hump is for storage of fat which is metabolized to provide energy and water. 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. 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 to prevent them from rupturing due to osmosis. Its kidneys are capable of concentrating urine markedly to reduce water loss. There is normal blood glucose which after ten days of water deprivation increases from 20 to 80% without glucosuria. An extremely long large intestine absorbs every last drop of water from the digested foods. Scientists believe that ancestors of the modern camel lived in North America at least 40 million years ago and migrated to Asia. All camels have 74 chromosomes with a very similar morphology. Three Pleistocene camel fossil localities were discovered in the south-western part of the An Nafud sand sea (northern Saudi Arabia). The Arabian camel genome is the first mammalian genome to be sequenced in the Middle East. The findings suggested the possibility of camel-specific evolution to adapt to desert environments

Key words---Adaptations, Dromedary, Ecology, Evolution Functional Anatomy

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I. Introduction

THE performance of the camel is the crucial link between its anatomical structure and its ecological adaptations. Most parts of the Arabian Peninsula are characterized by extreme aridity, which is manifested by adverse environmental conditions, leading to fragile ecosystems The family Camelidae includes the Bactrian (Camelus bactrianus; two humps), dromedary camel (Camelus dromedarius; one hump), as well as llamas, alpacas, guanacos and vicunas. Gestation period is about 13 months; gives birth to 8 - 10 calves in its breeding life of around 25 - 30 years. Grazing on most plants and trees as high as 3 m above ground. Camels have a higher salt requirement they eat halophytes (salt tolerant plants), thorny, bitter and toxic plants that are avoided by other herbivores. The camelid family is well adapted to their respective environments in the harsh and hot deserts of KSA. They have developed remarkable features which guarantee their survival in such inhospitable habitats. Under very hot conditions, the dromedary camel (Camelus dromedarius) may drink only every8 to 10 days and lose up to 30 % of its body weight through dehydration. [1],[2]

This remarkable attribute results from a very low basal metabolism and exceptional functional anatomical adaptations to defend environmental hazards .The camels are exposed permanently to the heat of the desert sun without shelter. In hot dry areas such as the Empty Quarter of Arabia, the Sahara in Africa or the Death Valley in America, the water loss through sweating (evaporation) is enormous .For camel, the question is how to secure water, It does not store water in its body, either in the stomach or in the hump.[3],[4], .[5]

II. Functional Anatomical Adaptations

Through evolution the 'ship of the desert' has developed several mechanisms for making life in a very harsh climate possible. The combination of these mechanisms is without comparative anatomical homology of any other domesticated animal

A. Head and neck region

Eye: Camels have long eyelashes that help protect the eyes from the sun and the blowing sand. While some say there are

http://dx.doi.org/10.15242/IICBE.C0115058

two rows of eyelashes, others believe that one row is eyebrows while the other a row of eyelashes evolutionary third eye lid nictitating membrane [6]

Mouth: Camel has 34sharp teeth ,the lips are thick to help the camel eat the prickly shrubs growing in the deserts without getting cut

Nose: Camels can close their nostrils completely so that no sand particles enter the nose.

Ear: covered by long hairs even inside with high acoustics power

Brain: is highly protected from heat by venous and nasal cooling systems; to be discussed in temperature regulation. (Fig1)[7],[8],[9]

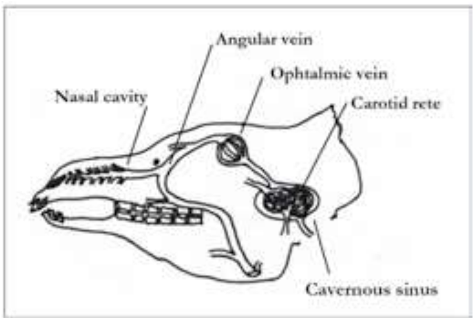

Fig1. The cooling system for the head and brain of camels (Elkhawad, 1992)

Neck: Has only 7 vertebrae in long neck- the same as humans. Special valves in the neck arteries help control the blood flow maintaining constant amount of blood to the brain.

B. Thoracic region

Heart: There is a bony structure; os cordis and cartilage; cartilagocordis in the heart of the mature dromedary camel.The heart of the camel contained only one bone. This bone is large, elongated and embedding insidethe heart wall where the cardiac muscles are inserted and fixed. . Moreover, the increasing of the calcified cartilage amounts and the development of bony structures in the camel heart skeleton are age dependent, which seems to be a sign of the over load of the mechanical forces and high pressure in the atrioventricular plane and the aortic ring of the heart during systole. Among all mammals the atrioventricular node of the camel is the largest one (28-32 mm).[10],[11]

Sternum: Covered With furry pads to protect against hot sand during laying down

Lungs: The camel breathes slowly, with no panting

Musculoskeletal: Both four limbs are strong tall and thin to raise the body away from hot sand

Feet: The hooves have a broad, flat leathery pad so that when the camel walks, the pads spread out and prevent the feet from burying into the hot sand.

Knee is covered by pad of leathery fur to support carrying heavy weights

Back (Hump): It is a large store of fat within a mesh of connective tissue but with no water. In the presence of oxygen fat is metabolized to produce energy and water.

Abdomen: Furry colored skin is present in the abdomen with seasonal molting for temperature adaptation.

Absence of gall bladder and cystic duct; this is to excrete converted toxins Metabolized by the liver directly to the lumen of the duodenum without storage in a cyst.

Stomach: Large and divided into three partitions as a ruminant animal

Kidney: is also of major importance in water conservation. The long loops of Henle, which are four to six times longer than in cattle, have the function of both, concentrating urine and reducing its flow. A dehydrated camel urinates only drops of concentrated urine which is not only serves to conserve water, but also allows camels to drink salty water which is more concentrated than sea water (above 3% NaCl), and to eat salty toxic plants (halophytes) .[10],[11],[12],[13]

Large intestine: Camels have an extremely long large intestines that absorbs every last drop of water from the foods they eat, where small, hard very dry fecal balls are produced.[14]

Temperature fluctuation: Dehydrated camels save water by increasing their body temperature to over 42 ºC, .The body temperature is adapted to the outside temperature. Which would damage the most heat sensitive cells, of the brain and retina ‘inbuilt air-conditioning system’. The large camel nasal surface absorbs the vapor and cools a net work of small blood vessels, named the ‘carotid rate’. This carotid vessel network surrounds the jugular vein and cools its blood. On the way to the heart the cooled venous blood meets the warm arterial blood going to the brain and eyes, cooling it by more than 4 ºC. This is called a ‘counter current’ effect. This is resemble marine mammals, evolutional adaptations of countercurrent heat exchange systems, help them cope thermal environmental hazards [10],[14].[15]

III. Comparative Embryology

A study of the comparative embryology of a group of animals such as the vertebrates when followed to its logical conclusion leads to a consideration of the comparative anatomy of the group. All camelids are induced ovulators, usually ovulating only after mating, and if the camel does not conceive the corpus luteum has a very short lifespan of only 8 – 10 days The umbilical cord of Camelidae is long; lengths up to 110 cm. There is no uterine invasions of trophoblast .The camelid placenta is adeciduate. There is neither a subplacenta nor are there metrial glands. Threre are successful hybridations between camel species with fertile living of springs (Fig. 2). [16],[17],[18],[19],[20],[21]

Fig. 2 Male hybrid between dromedary and guanaco

IV. Comparative Physiology

The red blood cells of camels are oval in shape not like other mammals that have circular red blood cells. They resemble human sickle cells. This is an adaptation to let the flow of blood continue even in a dehydrated state. As camels drink large amounts of water up to 2000 liters in 3 minutes, these are also more stable to prevent them from rupturing due to osmosis.

Plasma volume is maintained at the expense of tissue fluid, so that circulation is not impaired

The dromedary, presents a normal blood glucose After a 10 days water deprivation, the glycemia increases from 20 to 80% without glucosuria. . The hypo-insulinemia would allow the camel to maintain a low basal metabolism by decreasing glucose use [9]

They hardly ever urinate or sweat. Behavioral adaptation for which the camel is famous is their reaction to the approach of a threat - they spit. The camel is a ruminant. . Their cud is what they spit when stressed and because it is partially digested, it smells bad. This discourages predators from getting too close. [9]

V. Comparative Anatomy Of Fossils With Biogeography

Biogeography Used with fossil record to reconstruct evolutionary history Scientists believe that ancestors of the modern camel lived in North America at least 40 million years ago. Although the ancestors of the lamas and camels appear to have diverged sometime in the Eocene epoch, they weren't completely separated from each other until the Pleistocene, when the ancestors of the camels migrated across the Bering Strait (temporary) land bridge to Asia. Lamas migrated to South American, and all camel died out in North America. Once in Asia, camels migrated through eastern Europe, the Middle East and North Africa.[22]

Three Pleistocene vertebrate localities in lacustrine deposits which accumulated in interdune depressions were discovered in the south-western part of the An Nafud sand sea (northern Saudi Arabia). Although the fossil vertebrate fauna is restricted in diversity, its composition and stage of evolution suggest an Early Pleistocene age in contrast with the recent Pleistocene or Holocene lake beds occurring in several other interdune depressions in central and southern An Nafud. The Nafud fauna has clear African affinities whereas faunas from the Levant, dating from the Middle Pleistocene onwards, contain typically European elements. (Fig.3) [22],[23].[24]

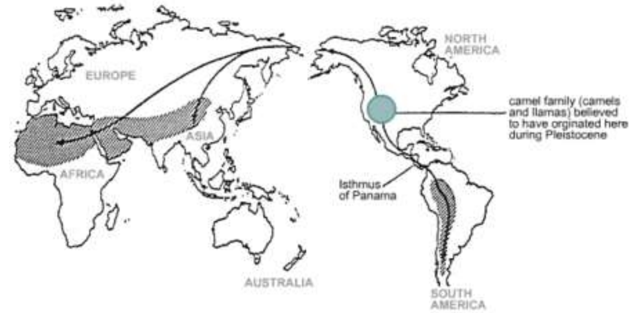

Fig. 3 Camel Biography

VI. Genetic Evolution

Cytogenetic chromosome maps offer molecular tools for genome analysis and clinical cytogenetics and are of particular importance for species with difficult karyotypes, such as camelids (2n = 74). Building on the available human–camel zoo-fluorescence in situ hybridization (FISH) data, we developed the first cytogenetic map for the alpaca (Lama pacos, LPA) genome by isolating and identifying 151 alpaca bacterial artificial chromosome (BAC) clones corresponding to 44 specific genes.. This collection of cytogenetically mapped markers represents a new tool for camelid clinical cytogenetics

An analysis of camel genomes, by Saudi and Chinese researchers, may help shed light on adaptation to climate change and the mechanisms behind diseases like asthma and diabetes.The researchers sequenced the genomes of the two-humped Asian camel, the single-humped Arabian camel, and one of their nearest relatives, the alpaca. The Arabian camel genome is the first mammalian genome to be sequenced in the Middle East.The researchers conducted a comparative analysis of the camelid genomes and all three camelids showed rapid evolution in genes related to the cellular response to insulin and in those related to energy, glucose, and fat metabolism. The identification of key genes involved in adaptation to desert environments may facilitate selective breeding to increase the proportion of camels with favorable genetic traits related, for example, to speed and milk yield Understanding the molecular mechanisms involved in the very high blood sugar levels of camels could pave the way for the development of therapies for diabetes.[24],[25],[26]

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