Thermophysiological Responses and Heat Tolerance of Saudi Camel Breeds

Al-Haidary[1] A. A., E.M. Samara, A.B. Okab and K.A. Abdoun,

Abstract—The present study was conducted to investigate the variation in thermophysiological responses of four Saudi camel breeds. Sixteen dromedary native breeds (Almajaheem, Almaghatir, Alsafrah, Alzargeh) of 4 animals each were used in this study. Exposure of camel to hot summer (40o C) compared to spring (21o C) conditions resulted in variable breed-dependent thermophysiological responses. Where, the observed percentage increase in rectal temperature (Tr) and respiratory rate (RR) due to summer heat exposure were highest in Almaghatir and Alsafrah breeds, respectively and lowest in Alzargeh breed. The percentage increase in packed cell volume (PCV) was highest in Almajaheem and Alzargeh and lowest in Alsafrah and Almaghatir. Further, the obtained results indicate that coat color do not influence heat tolerance in camels. Nevertheless, further studies are needed to explore the role of breed variation in the structure of insulating coat and optical properties of hair on thermoregulation and heat tolerance of camels.

Keywords—: Breed, Camel, Heat tolerance, Thermoregulation.

.

I. INTRODUCTION

The one-humped camel (*Camelus dromedarius*) is a domestic animal of economic importance in some of the hotter, drier regions of the world, where it represents an essential source of meat and milk. The world camel population is regularly increasing with a yearly growth of 3.4% [1]. Saudi Arabia belongs to the countries with regular growth of camel population. The coat color represents the main criteria to name the breed in Saudi Arabia [1]. Accordingly many breeds are identified in Saudi Arabia including *Almajaheem* (black), *Maghatir* and *Alawark* (white), *Alhomor* (brown), *Alsafrah* (dark brown), *Alshaele* (grey to brown red), *Alawadi* (red to white), *Alsaheli* (red), *Alhadhana* (yellowish to red), *Asail* (yellow to brown) and *Alzargeh* (blue grey).

Heat tolerance superiority of an animal having a glossy, light coloured, i.e., a highly reflecting coat, over an animal having a dull, dark coat, can only be evaluated in the presence of solar radiation [2]. It has been reported that susceptibility to heat stress in individual animal is determined by many factors including previous exposure to heat stress, temperature, species, sex and condition score [3]. Energy exchange has been reported to be affected by skin and coat properties such as heat absorption, density, depth, diameter and colour [4]. Breeds colour has been indicated as an important influential of body temperature and heat tolerance ([5];[6], [7]. In the tropics, the pigmentation of the skin is essential in protecting deep tissues against excess solar radiation [8], where, light coats are the most desirable under such conditions [9];[10], [6] compared to dark coats which is known to gain more heat load from solar radiation. Skin characteristics (thickness, colour, sweat glands) and coat characteristics (angle to the skin surface, texture, intensity, diameter and length) determine the protective properties through affecting the routes of heat exchange (conduction, convection, radiation, evaporation) between the animal and the environment [11]. Genetic role have also been reported in cattle, where genes responsible for the expression of short coats in *Crioula* breeds have shown to determine part of their heat tolerance [12]-[14].

Heat tolerance and adaptation capacity to hot environments have been evaluated using physiological parameters including respiration, heart rate, body and skin temperatures, sweating rate, packed cell volume, potassium content in erythrocytes, individual heat tolerance coefficient, hormonal secretion and decreased rate of production [8], [15], [16],[17].

Despite the reported differences in the phenotypic coat color of camel breeds existing in Saudi Arabia [1]; there is no single report on heat tolerance variation between these breeds. Therefore, this study has been designed and conducted with the aim of exploring thermophysiological responses and heat tolerance of four Saudi camel breeds.

II. MATERIALS AND METHODS

This study was conducted during spring (21^o C) and summer (40^o C) seasons at Al-Kharj region, Kingdom of Saudi Arabia. Sixteen dromedary bull camels of native breeds (*Almajaheem*, *Maghatir, Alsafrah, Alzargeh*), 4 animals each, with mean body weight of 250±10.5 kg and 18 months of age were used in this study. Animals were housed as a group in a partially shaded pen with open yard, fed twice a day at 07.00 and 16.00 hours, and had free access to clean tap water.

Ambient temperature (Ta), relative humidity (RH), solar radiation and wind velocity were measured at 3 hours intervals for 2 successive days. Ambient temperature and RH were recorded using 2 data loggers (HOBO Pro Series data logger, Model H08-032-08, ONSET Co., Southern MA, USA) placed inside the pens. Thereafter, temperature-humidity index (THI) was calculated according to [18]. Solar radiation and wind velocity were recorded using black globe temperature and anemometer (Wilh. Lambrecht GmbH, Gottingen, Germany), respectively.

[1] Department of Animal Production, College of Food and Agriculture Sciences, King Saud University, 11451 Riyadh, Saudi Arabia, (96614678475) email: ahaidary@ksu.edu.sa

Respiratory rate was counted at the space from 9th to 11th rib or from 3rd to 6th intercostal space using stethoscope (Littmann Stethoscope, USA) and expressed as breath/minute. While, a digital thermometer (ARTSANA, Grandate Co, Italy) measuring to the nearest 0.1 ºC was used for measurements of rectal temperature (T_r). Body surface temperature (T_s) was recorded using a forward-looking and automatically calibrating thermal infrared camera (VisIR-Ti200 infrared vision camera, Thermoteknix Systems ltd, Cambridge, UK) placed perpendicular and approximately 150 cm from camel's surfaces. This camera were equipped with 25° lens, 1.3 M pixel visible camera, and LCD touch screen, and have a 7.5–13 µm spectral range, and thermal accuracy of ± 2 °C in addition to thermo-electrically cooling systems. After capturing, thermo-grams were stored inside a 250 MB internal memory, readout and analyzed using a special thermo-grams analysis program (TherMonitor, Thermoteknix Systems ltd, Cambridge, UK). For all thermo-grams, a rainbow color scheme was chosen. Thermo-grams were analyzed by defining the body surface circumscribed by hand with the software polygon function. The software then gave back the average surface temperature (T_s). Heat tolerance coefficient (HTC) was calculated according to Iberia heat tolerance test developed by Rhoad (1944) using the following equation: HTC (%) = 100 – 10 (average T_r after exposure – normal control T_r).

Blood samples were collected by jugular venipuncture using 6 ml vacutainer tubes coated with sodium fluoride as anticoagulant. The samples were placed immediately on ice. Packed cell volume (PCV) was determined from whole blood shortly after collection.

The collected data were analyzed using Proc GLM; the general linear models (GLM) procedure for analysis of variance (ANOVA) of Statistical Analysis System [19]. Statistical means were compared using Duncan's multiple range test (DMRT). The overall level for statistical significance was set at $P<0.05$. All values were presented as least square means ± standard error of the means (LSM ± SE).

III. RESULTS AND DISCUSSION

Climatic data: The climatic data prevailed during this study is shown in table 1. Ambient temperature (T_a), black globe temperature and temperature humidity index (THI) were significantly (P<0.001) higher, while relative humidity (RH) was significantly (P<0.001) lower during the summer compared to spring season. Wind velocity did not vary significantly between the two seasons. Temperature humidity index (THI) values below 22.2 are normally considered as acceptable i.e. absence of heat stress, while those above 25.6 are considered as sever to extreme heat stress [20]. Therefore, the recorded climatic data during this study indicates that the studied camels were under comfortable environmental conditions during the spring season and were exposed to heat stress during the summer season.

TABLE I
Climatic data prevailed during the experiment

Climatic parameter	**Spring**	**Summer**	***P value***
Ambient temperature (ºC)	21.38±0.21	39.85±0.20	<0.001
Relative humidity (%)	33.93±1.33	9.20±0.16	<0.001
Black globe temperature (ºC)	23.01±0.57	50.05±1.17	<0.001
Wind velocity (m/s)	3.23±0.14	2.93±0.21	0.270
Temperature humidity index (THI)	19.22±0.14	31.97±0.14	<0.001

Thermophysiological responses: Table 2 shows the thermophysiological responses of the studied camel breeds during the exposure to the hot summer conditions. Exposure of camel breeds to the hot summer (40º C) compared to spring (21º C) natural environmental conditions resulted in variable breed-dependent thermophysiological responses. Where, the observed percentage increase in rectal temperature (T_r) and respiratory rate (RR) due to summer heat exposure were highest in *Almaghatir* and *Alsafrah* breeds, respectively and lowest in *Alzargeh* breed. It is well documented that exposure of animals to heat stress elevates T_r and RR [21] - [24]. On the other hand, the percentage increase in packed cell volume (PCV) was highest in *Almajaheem* and *Alzargeh* breeds and lowest in *Alsafrah* and *Almaghatir* breeds. The higher PCV values have been reported to be an adaptive mechanism of desert animals to provide the necessary water required for evaporative cooling process [22]. The body surface temperature (T_s) was increased significantly (P<0.001) in all studied breeds, with the lowest percentage increase (+32.07%) observed in *Almajaheem* breed. The observed increase in T_s in all breeds may be attributed to the increased blood flow to the skin surface [22],[25],[26]. Adaptation capacity to hot environments can be evaluated using body temperature and respiratory rate, where average relative deviations (ARD) from normal due to exposure to hot climates in thermal parameters of the animals, could be used in the estimation of adaptability to a hot climate [23]. Therefore, the observed thermophysiological responses indicate that *Alzargeh* and *Almajaheem* Suadi camel breeds have higher adaptation capacity to hot environments than *Alsafrah* and *Almaghatir* breeds.

Table II
Thermophysiological responses of Saudi camel breeds exposed to heat stress

Breed	Spring (21°C)	Summer (40°C)	% Change	*P value*
PCV				
Almajaheem	26.75±0.78	32.13±0.80	+20.11	0.003
Alzargeh	25.38±0.43	29.88±0.63	+17.73	0.001
Alsafrah	24.33±0.44	26.17±2.21	+7.56	0.461
Almaghatir	24.75±0.72	26.17±3.17	+5.74	0.632
T_r				
Almajaheem	37.88±0.05	38.30±0.09	+1.11	0.006
Alzargeh	37.98±0.06	38.15±0.34	+0.45	0.629
Alsafrah	38.03±0.08	38.73±0.39	+1.84	0.092
Almaghatir	37.85±0.09	38.87±0.38	+2.69	0.030
RR				
Almajaheem	14.74±1.47	17.86±0.66	+21.17	0.192
Alzargeh	15.17±1.45	17.63±1.85	+16.22	0.406
Alsafrah	12.62±0.23	19.66±1.23	+55.78	0.030
Almaghatir	14.52±0.77	19.10±0.22	+55.03	<0.001
T_s				
Almajaheem	30.25±1.45	39.95±0.12	+32.07	<0.001
Alzargeh	25.90±0.20	38.90±0.51	+50.19	<0.001
Alsafrah	26.25±0.95	40.85±1.15	+55.62	0.010
Almaghatir	25.35±0.65	39.30±0.97	+55.03	<0.001

Heat tolerance: All studied camel breeds showed heat tolerance coefficient of 90% or more (Table 3). *Alzargeh* breed proved to be the best heat tolerant Saudi camel breed followed by *Almajaheem*, then *Alsafrah* and finally *Almaghatir*. Despite the previous reports on the influential role of breed color on thermoregulation and heat tolerance [5]-[7], our results indicate that coat color do not influence heat tolerance in camels. Nevertheless, further studies are needed to explore the role of breed variation in the structure of insulating coat and optical properties of coat hair on thermoregulation and heat tolerance of camels**.**

Table III
Heat tolerance coefficient (%) of the studied Saudi camel breeds

	Almajaheem	Almaghatir	Alsafrah	Alzargeh	N
Heat tolerance	95.8	89.8	93.0	98.3	4

ACKNOWLEDGMENT

This study has been supported by the National Plan for Science and Technology (NPST) program by King Saud University under the project 09-BIO 885-02.

REFERENCES

[1] Faye, B, HR Abdallah, FS Almathen, I Harzallah and SE Al-Mutairi, 2011. Camel biodiversity and camel phenotypes in the Kingdom of Saudi Arabia. Camel Breeding, Protection and Improvement Center, UTF/SAU/021/SAU, FAO and Ministry of Agriculture, KSA.

[2] Bianca W, 1961. Heat tolerance in cattle – its concept, measurement and dependence on modifying factors. Inter J Biometeor, 5 (1): 5-30.

[3] Brown Brandl TM, 2009. Overview of the Progress in Reducing Environmental Effects on Cattle. In: Proc Am Dairy Sci Assoc, 18th Discover Conference, 2-5 Nov 2009, Nashville, IN, USA.

[4] Bertipaglia ECA, RG da Silva, V Cardoso and LA Fries, 2007. Hair coat characteristics and sweating rate of Braford cows in Brazil. Livest Sci, 112: 98–108.

[5] Silva RG, N La Scala Jr and H Tonhati, 2003. Radiative properties of the skin and hair coat of cattle and other animals. Trans ASAE, 46: 913-918.

[6] Otoikhian CSO, JA Orheruata, JA Imasuen and OP Akporhuarho, 2009. Physiological response of local (West African Dwarf) and adapted switndzerla (White Bornu) goat breed to varied climatic conditions in South- South Nigeria. Afr J Gen Agric, 5: 1-6.

[7] McManus C, H Louvandini, R Gugel, LCB Sasaki, E Bianchini, FEM Bernal, SR Paiva and TP Paim, 2011. Skin and coat traits in sheep in Brazil and their relation with heat tolerance. Trop Anim Health Prod, 43: 121-126.

[8] Castanheira M, SR Paiva, H Louvandini, A Landim, MCS Fiorvanti, BS Dallago, PS Correa and C McManus, 2010. Use of heat tolerance traits in discriminating between groups of sheep in central Brazil. Trop Anim Health Prod, 42: 1821-1828.

[9] Alamer M, 2006. Physiological responses of Saudi Arabia indigenous goats to water deprivation. Small Rum Res, 63: 100-109.

[10] McManus C, E Prescott, GR Paludo, E Bianchini, H Louvandini and AS Mariante, 2009a. Heat tolerance in naturalized Brazilian cattle breeds. Livest Sci, 120: 256-264.

[11] Silva RG, 2000. Introdução á Bioclimatologia Animal. S&O Paulo. Nobel. 286p.

[12] Olson TA, AC Hammond and JrCC Chase, 1997a. Evidence for the existence of a major gene influencing hair length and heat tolerance in Bos taurus Cattle. Archiv Latinoamericanos de Prod Anim, 5 (Supl. 1): 521–523

[13] Olson TA, AC Hammond and JrCC Chase, 1997b. Evidence for the existence of a major gene influencing hair length and heat tolerance in Senepol cattle. J Anim Sci, 75 (Suppl. 1): 147.

[14] Olson TA, C Lucena, JrCC Chase and AC Hammond, 2003. Evidence of a major gene influencing hair length and heat tolerance in Bos Taurus cattle. J Anim Sci, 81: 80-90.

[15] Baccari Junior F, 1989. Mecanismos adaptativos de ovinos lanados nos trópicos. In: Simpósio Paulista de Ovinocultura, Fundação Cargill, pp. 18–21.

[16] Charoensook R, K Gatphayak, AR Sharifi, C Chaisongkram, B Brenig and C Knorr, 2012. Polymorphisms in the bovine HSP90AB1 gene are associated with heat tolerance in Thai indigenous cattle. Trop Anim Health Prod, 44: 921-928.

[17] Li Q, J Han, F Du, Z Ju, J Huang, J Wang, R Li, C Wang and J Zhong, 2011. Novel SNPs in HSP70A1A gene and the association of polymorphisms with thermo tolerance traits and tissue specific expression in Chinese Holstein cattle. Mol Biol Report, 38: 2657-2663.

[18] LPHSI, 1990. Livestock and poultry heat stress indices, Agriculture Engineering Technology Guide. Clemson University, Clemson, SC.

[19] SAS, 2003. SAS User's Guide: Statistics. Version 8 edition, SAS Institute, Cary, NC.

[20] Marai IFM, MS Ayyat and UM Abd El-Monem, 2001. Growth performance and reproductive traits at first parity of New Zealand White female rabbits as affected by heat stress and its alleviation, under Egyptian conditions. Trop Anim Health Prod, 33: 457-462.

[21] Srikandakumar A, EH Johnson and O Mahgoub, 2003. Effect of heat stress on respiratory rate, rectal temperature and blood

chemistry in Omani and Australian Merino sheep. Small Rum Res, 49: 193-198.

[22] Al-Haidary, AA, 2004. Physiological Responses of Naimey Sheep to Heat Stress Challenge under Semi-Arid Environments. Inter J Agric Boil, 6: 307–309.

[23] Marai IFM, AA El-Darawany, A Fadiel and MAM Abdel-Hafez, 2007. Physiological traits as affected by heat stress in sheep - A review. Small Rumin Res, 71: 1-12.

[24] Al-Haidary AA, R S Aljumaah, M A.Alshaikh, K.A Abdoun, E.M Samara, A B Okab and M.M.Alfuraiji, 2012. Thermoregulatory and physiological responses of Najdi sheep exposed to environmental heat load prevailing in Saudi Arabia. Pak Vet J, ISSN: 0253-8318 (Print), 2074-7764 (Online), Accessible at: www.pvj.com.pk.

[25] Marai IFM, AA El-Darawany, EI Abou-Fandoud and MAM Abdel-Hafez, 2009. Reproductive and physiological traits of Egyptian Suffolk rams as affected by selenium dietary supplementation during the sub-tropical environment of Egypt. Livest Res Rural Dev, 21: 1-12.

[26] McManus C, GR Paludo, H Louvandini, R Gugel, LCB Sasaki and SR Paiva, 2009b. Heat tolerance in Brazilian sheep: Physiological and blood parameters. Trop Anim Health Prod, 41: 95-101.