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Physiological and Biochemical Characteristics of Majaheem and Waddah Camel Breeds under Extensive Management System

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ABSTRACT

Background: Physiological and biochemical characteristics have been shown to effect on body health and functions.

Methods: Camel farm in Riyadh area bred Majaheem and Waddah breeds under extensive management system were followed for physiological and biochemical characteristics. Number of insemination per pregnancy, rectal temperature, pulse rate and SPO2 were monitored. In addition, blood samples were collected for hematology and plasma biochemistry profiles.

Result: The results indicated that number of insemination per pregnancy were significantly lower in Waddah she-camels if compared to Majaheem ones. In addition, rectal temperature (°C) was increased (P<0.01) in Majaheem she-camel group. Furthermore, pulse rate was higher (P<0.05) of Majaheem she-camel group whereas SPO2 values were not differed between groups. The Majaheem group had significantly lower (P<0.0001) RBCs counts compared to Waddah group. Similarly, the Majaheem group had a lower PCV (24.0%) compared to Waddah group (29.80%). In addition, the Majaheem group also had lower hemoglobin levels (11.0 g/dl) compared to Waddah group (12.0 g/dl). The Majaheem group had lower (P<0.0001) WBCs count and their types compared to Waddah group. The Majaheem group had significantly lower values in all of plasma biochemical profiles if compared to Waddah group. It could be concluded that physiological, hematological and plasma profiles might be differed due to camel breeds and grazing system conditions.

Key words: Biochemistry, Blood, Majaheem, Physiological, Reproductive, Waddah.

INTRODUCTION

With the global population expected to reach 10.4 billion by 2100 driven by increased lifespans and lower death rates, food security has become a critical in 21st century challenge. Meeting this demand requires intensified and sustainable agricultural production, including both crops and livestock, a trend already underway (Gilbert *et al.,* 2021). Camel breeds are the most important domesticated animals in Saudi Arabia, uniquely adapted to harsh environments, playing a crucial role in this effort, providing essential meat, milk, urine, wool and fertilizer for both nomadic and settled dwellers (Banaja and Ghandour 1994; Mohammed and Alshaibani 2024, 2025; Mohammed *et al.,* 2025).

The global camel population, estimated at 35 million, is concentrated primarily in Africa including countries like Somalia, Ethiopia and Sudan with largest dairy camel herds (Sikkema *et al.,* 2019). It has been reported that 90% of camels are the one-humped *Camelus dromedarius*. The number of milk-producing *C. dromedarius* camels, along with annual camel milk production, is steadily increasing. Camels are considered a vital protein source, particularly for those in arid regions, such as nomadic communities with limited access to other protein. The growing demand for camel milk and its products reflects its increasing recognition as a nutritious and therapeutic food (El-Hanafy *et al.,* 2023). Several studies indicated beneficial effects of camel milk in decreasing blood glucose values, improving liver and kidney enzymes (Alharbi *et al.,* 2022; Hamouda *et al.,* 2024; Arain *et al.,* 2025).

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Majaheem camels are a prominent breed in the Arabian Peninsula, particularly Saudi Arabia. They are easily recognizable by their large size and striking black coat, which can range from dark brown to nearly black. Majaheem is a vital part of Saudi Arabia heritage and a testament to the country's long-standing tradition of camel husbandry. In addition, the Waddah camel, primarily found in Sudan, is a distinct breed known for its striking white coat, a stark contrast to the darker hues of many other camel breeds (Fig 1). In general, both breeds are excellent milk producers, but Majaheem camels are often cited as having a slight edge in terms of both quantity and quality of milk (El-Hanafy *et al.,* 2023).

Majaheem or black camels and Waddah (or Maghatir) or white camels are the most common camel breeds in

Saudi Arabia (Tharwat and Al-Hawas, 2024). Physiological and blood parameters are vital indicators of an animal's health and well-being (Senosy *et al.,* 2017, 2018). Normal ranges for physiological and blood parameters vary between breeds, age and animal's health. The average milk yield (kg/week) of Majaheem and Waddah camel breeds in Saudi Arabia is 38.0 and 33.3 kg, respectively (El-Hanafy *et al.,* 2023). The camel species raised in extensive management system in KSA suffer from harsh environmental condition including high temperature and radiation, shortage of nutrient availability and quality, which negatively effect on productive and reproductive performance (Mohammed *et al.*, 2025). In addition, there is a negative relationship between milk production and reproductive performance (Amma *et al.,* 2024). Therefore, the aims of the present study were to explore the changes in number of insemination per pregnancy, rectal temperature, pulse rate and SPO2 of Majaheem and Waddah breeds under extensive management system. Besides, the changes in haematological and plasma biochemistry profiles were investigated as reference values in the Majaheem and Waddah breeds for gaining insights into the overall health of Majaheem and Waddah breeds.

MATERIALS AND METHODS

The experimental procedure was approved by the ethical committee of King Faisal University [KFU-REC-2025-FEB-EA252670]. The procedures of experiment were carried out in the experimental animal lab of Agriculture and Food Sciences College, KFU University.

Site of study and animal management

The present study was executed from December 2024 to February 2025. Ten Majaheem and Ten Waddah she-camel breeds under extensive management system were selected for the study (Fig 2). The animals were multiparous, none pregnant and 8-10 years old during 2-4 months of lactation stage. Animals were fed on grazing system in addition to berseem hay only. The relative humidity (%) and temperature (°C) values during the study were controlled to 35±2.50°C and 40±9.0%, respectively. The duration of study was twelve weeks.

Monitoring numbers of insemination per pregnancy

After calving of she-camel, the numbers of insemination per pregnancy were counted per she-camel until confirmation of pregnancy.

Monitoring values of rectal temperature, pulse rate and partial pressure of oxygen

The she-camel Majaheem and Waddah breeds were sedated using xylazine for immediate recording of rectal temperature, pulse rate and SPO2. Rectal temperatures were monitored using clinical thermometer (Citizen). Pulse oximeter device was used for recording pulse rate and partial pressure of oxygen (CMS60D-VET) (Mohammed *et al.,* 2024).

Blood sample collection and analyses

Blood samples were collected from the jugular veins of she-camel Majaheem and Waddah breeds. The obtained blood samples were analyzed using automatic hematology

Fig 1: Camel breeds under extensive grazing system; (A) majaheem breeds (A), waddah breeds (B) and feeding berseem hay.

analyzer and biochemistry analyzer (Mythic 5Vet PRO and Skyla VB1 Analyzer). The resulting blood parameters include red and white blood cell profiles. The resulting biochemistry parameters include total proteins, urea, creatinine, liver and kidney enzymes and mineral values.

Statistical analysis

Number of insemination, rectal temperature, pulse rate, SPO2, blood and plasma profile values of Majaheem and Waddah breeds were statistically analyzed using T-test procedure to compare the means of two groups (SAS 2008) according to model:

$$Yij = \mu + Ti + eij$$

Where,
μ = Mean.
Ti = Effects of Majaheem and Waddah breeds.
Eij = Standard error.

Duncan's multiple range test (1955) was used to compare between means of Majaheem and Waddah groups.

RESULTS AND DISCUSSION

Number of insemination, rectal temperature, pulse rate, SPO2, blood and plasma profile values of Majaheem and Waddah breeds are presented in Table (1-3).

Number of insemination, rectal temperature, pulse rate and SPO2

Number of insemination per pregnancy, rectal temperature, pulse rate and SPO2 are presented in (Table 1). Number of insemination per pregnancy was significantly decreased in Waddah she-camel group compared to that of Majaheem she-camel group. In addition, hyperthermia of rectal temperature (°C) was recorded in Majaheem she-camel group. Furthermore, pulse rate was higher ($P<0.06$) of Majaheem she-camel group whereas SPO2 values were not differed between groups.

Blood and plasma profiles

Values of blood profiles of Majaheem and Waddah breeds are presented in (Table 2). The Majaheem group had significantly lower (<0.0001) RBCs counts (7.31×10^6/μl) compared to Waddah group (8.20×10^6/μl). Similarly, the Majaheem group had a lower PCV (24.0%) compared to Waddah group (29.80%). In addition, the Majaheem group also had lower hemoglobin levels (11.0 g/dl) compared to Waddah group (12.0 g/dl). The Majaheem group had lower ($P<0.0001$) WBCs count (17.36×10^3/μl) and their types compared to Waddah group.

The values of plasma biochemical profiles of Majaheem and Waddah breeds are presented in (Table 3). The

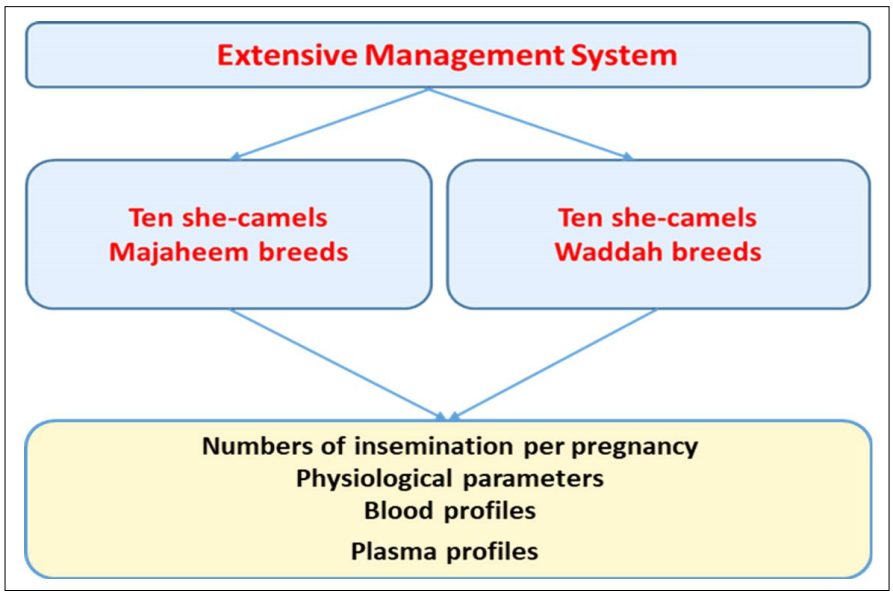

Fig 2: Experimental design of study for majaheem and waddah breeds.

Table 1: Number of insemination per pregnancy, rectal temperature, pulse rate and SPO2 of majaheem and waddah breeds.

Parameters	Majaheem	Waddah	SE	P value
No. insemination/pregnancy	5.40[a]	5.0[b]	0.41	0.01
Rectal temperature, °C	37.62[a]	37.48[b]	0.16	0.01
Pulse rate, min.	65.5	61.85	1.41	<0.06
SPO2, %	81.28	80.85	3.13	0.07

[a],[b], Values between groups with different superscripts significantly differ at $P<0.05$.
SE standard error.

Majaheem group had significantly lower values in all of plasma biochemical profiles if compared to Waddah group.

Results of the current study are showed in Table (1-3) indicating physiological, hematological and plasma biochemistry profiles of Majaheem and Waddah breeds.

Number of insemination, rectal temperature, pulse rate and SPO2

Number of insemination per pregnancy, rectal temperature, pulse rate and SPO2 are presented in (Table 1). Majaheem she-camel required slightly more inseminations per pregnancy (5.40) compared to Waddah she-camel group (5.0). This might be attributed to higher milk production of Majaheem compared to Waddah she-camels (El-Hanafy *et al.*, 2023). There is an inverse relationship between milk production and reproductive performance (Antanaitis *et al.,* 2024). Majaheem had a higher ($P<0.01$) rectal temperature (37.62°C) than Waddah she-camel group (37.48°C). Such result could be related to breed differences in colour (Fig 1), where Majaheem and Waddah she-camels are striking black and white coats, respectively. Furthermore, pulse rate was higher ($P<0.05$) of Majaheem she-camel group whereas SPO2 values were not differed between groups due to higher body temperature.

Blood and plasma profiles

Values of blood profiles of Majaheem and Waddah breeds are presented in (Table 2). Blood and plasma profiles are indispensable tools that provide valuable insights into an animal's health and consequently reflect the appropriateness of management system. Red blood cell counts, hemoglobin and hematocrit levels help diagnose different types of anemia.

In addition, white blood cells (WBC_s) are a crucial part of immune system, defending body against infections and

Table 2: Changes of blood profiles of majaheem and waddah breeds.

Parameters	Majaheem	Waddah	SE	P value
RBCs, 10^6/µl	7.31[b]	8.20[a]	0.06	0.001
PCV, %	24.0[b]	29.80[a]	0.29	<0.0001
Hb, g/dl	11.0[b]	12.0[a]	0.08	0.001
MCV, fl	32.9[b]	36.4[a]	0.35	0.01
MCH, pg	15.0	15.1	0.06	0.07
MCHC, g/dl	46.0	42.00	0.33	0.07
RDW, %	16.90	17.0	0.18	<0.06
WBCs, 10^3/µl	15.7[b]	17.36[a]	0.35	<0.0001
Lymphocytes, 10^3/µl	5.045[b]	5.563[a]	0.07	<0.0001
Monocytes, 10^3/µl	0.859[b]	1.251[a]	0.000	<0.0001
Neutrophils, 10^3/µl	9.11[b]	9.664[a]	0.14	<0.0001
Eosinophils, 10^3/µl	0.693[b]	0.876[a]	0.000	<0.0001
Basophils,	0.003[b]	0.006[a]	0.000	<0.0001
PLT, 10^3/µl	793[b]	823[a]	9.17	0.05

a, b, Values between groups with different superscripts significantly differ at $P<0.05$.

SE: Standard error; RBCs: Red blood cells; PCV: Packed cell volume; Hb: Hemoglobin; MCV: Mean corpuscular volume; MCH: Mean corpuscular hemoglobin; MCHC: Mean corpuscular hemoglobin concentration; RDW: Red cell distribution width; WBCs: White blood cells, PLT: Platelet.

Table 3: Changes of plasma biochemistry profiles of majaheem and waddah breeds.

Parameters	Majaheem	Waddah	SE	P value
Total protein, g/dl	6.20[b]	6.50[a]	0.09	<0.0001
Urea, mg/dl	18.0[b]	26.0[a]	0.25	<0.0001
Creatinine, mg/dl	1.50[b]	2.10[a]	0.01	<0.0001
Glucose, mg/dl	121.0[b]	129.0[a]	2.12	0.05
Aspartate aminotransferase, U/l	75.0[b]	127.0[a]	2.13	<0.0001
Alanine aminotransferase, U/l	16.0[b]	29.0[a]	0.31	<0.0001
γ-glutamyl transferase, U/l	43.0[b]	71.0[a]	1.12	<0.0001
Creatine kinase, U/l	76.0[b]	84.0[a]	1.89	0.05
Lactate dehydrogenase, U/l	639.0[b]	793.0[a]	15.63	<0.0001
Iron, µg/dl	81.0[b]	93.0[a]	2.73	<0.0001
Cupper, µg/dl	73.0[b]	75.0[a]	1.12	<0.07

[a,b], Values between groups with different superscripts significantly differ at $P<0.05$.

SE: Standard error.

other diseases. The Majaheem group had significantly lower RBCs counts, PCV, hemoglobin values compared to Waddah group. On the other hand, the Majaheem group had higher ($P<0.0001$) WBCs count (17.36×10^3/µl) and their types compared to Waddah group. Such differences might be related to breed and milk production differences. It seems that the hematological parameters were ranged within normal levels of values of *Camelus dromedaries* (Martín-Barrasa *et al.,* 2023). These differences likely reflect physiological adaptations to their respective harsh environments; extensive management system.

Plasma carries a vast array of substances that are crucial for the body's function. Analyzing plasma provides valuable insights into various physiological processes and is essential in diagnosing management system. Waddah group had higher total protein, urea, creatinine ($P<0.0001$) and glucose compared to Majaheem group. This suggests potential differences in protein metabolism or kidney function. Waddah group had substantially higher levels of liver enzymes (aspartate aminotransferase, alanine aminotransferase and γ-glutamyl transferase) compared to Majaheem group. This suggests potential differences in liver metabolism or possible liver stress in Waddah group. Moreover, Waddah she-camels have higher ($P<0.05$) creatine kinase levels (84.0 U/l) than Majaheem she-camels (76.0 U/l), potentially indicating differences in muscle metabolism. Simultaneously, Waddah she-camels have higher ($P<0.0001$) lactate dehydrogenase levels (793.0 U/l) than Majaheem she-camels (639.0 U/l), which might indicate differences in energy metabolism. Although the Waddah she-camels have higher ($P<0.0001$) iron levels (93.0 µg/dl) than Majaheem (81.0 µg/dl), cupper levels might be due to grazing system, the copper levels are similar between Waddah (75.0 µg/dl) and Majaheem (73.0 µg/dl) groups. It has been indicated that hematological and biochemical profiles might be differed due to productive and reproductive performances (Senosy *et al.,* 2018; Martín-Barrasa *et al.,* 2023; Mohammed *et al.,* 2025). The results of this study might give references values for the Majaheem and Waddah breeds and might contribute to the understanding of differences in hematological and biochemical profiles in dromedary camel with potential impacts in body health and welfare for those breeds.

CONCLUSION

It could be concluded that Waddah she-camels have notable differences in several hematological and biochemical parameters compared to Majaheem one. Waddah generally exhibit higher levels of RBCs, WBCs, urea, creatinine, liver enzymes, creatine kinase, lactate dehydrogenase and iron. These differences could be attributed to variations in metabolic processes, physiological adaptations, or potential health variations between the two camel breeds. Further investigation and analysis are still needed to determine the underlying causes and clinical significance of these differences.

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Disclaimers

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Informed consent

The Ethical Committee of Deanship of Scientific Research, King Faisal University, Saudi Arabia, approved all animal procedures, experimental animal care and handling techniques for experiments (KFU251474).

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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