OPEN ACCESS
Advances in Animal and Veterinary Sciences

Research Article

Relationships Between Age, Breed, Body Condition Score, Lipogram and Antioxidant Parameters in Female Dromedary Camels with Reproductive Abnormalities

Tariq I. Almundarij

Department of Veterinary Medicine, College of Agriculture and Veterinary Medicine, Qassim University, Buraydah, Saudi Arabia.

Abstract | This study aimed to document the effect of body condition score (BCS) on blood metabolites and hormones and their link with the occurrence of reproductive abnormalities in female dromedary camels. To determine their link with two different ages of the Majaheem (black) and Waddah (white) breeds, measurements of lipogram and antioxidant parameters were assessed. During the breeding season, 16 dromedary she-camels that appeared to be in good health included in this study as controls. Their average body weight ranged from 430 kg for camels under 8 years old to 480 kg for camels over 8 years old. Twenty-nine overweight female dromedary camels were examined, with a BCS over 4.5 and an infertile period lasting between 12 and 36 months. When comparing repeat breeder female camels to their respective controls, their estrogen levels were significantly different at $P<0.01$ at age ≥ 8. Malondialdehyde (MDA) levels in repeat breeder female Majaheem and Waddah camels with a BCS over 4.5 were compared to levels in healthy female camels and revealed that the MDA levels in the two breeds were considerably higher ($P<0.05$). When compared to the corresponding controls with a BCS of 4, the catalase (CAT) values in overweight female camels with a BCS over 4.5 were substantially lower at $P<0.01$ in both breeds under study. At age ≥ 8 for both breeds, the glutathione (GSH) and superoxide dismutase (SOD) values were lower in the overweight camels than in the healthy ones, with a statistically significant difference ($P<0.05$). Therefore, based on these results, reproductive abnormality in camels was associated with high BCS and abnormal blood metabolites. Knowledge of the camel's metabolic status and BCS may offer a more solid foundation for preventing metabolic problems and increasing output.

Keywords | Body condition score, Dromedary camels, Estrogen, Lipid profile, Malondialdehyde, Catalase, Blood metabolites, Biochemical serum indices, Antioxidants

Received | September 28, 2023; **Accepted** | November 24, 2023; **Published** | January 08, 2024
***Correspondence** | Tariq I. Almundarij, Department of Veterinary Medicine, College of Agriculture and Veterinary Medicine, Qassim University, Buraydah, Saudi Arabia; **Email:** Tmndrj@qu.edu.sa
Citation | Almundarij TI (2024). Relationships between age, breed, body condition score, lipogram and antioxidant parameters in female dromedary camels with reproductive abnormalities.
Adv. Anim. Vet. Sci., 12(1):99-106.
DOI | https://dx.doi.org/10.17582/journal.aavs/2024/12.1.99.106
ISSN (Online) | 2307-8316

INTRODUCTION

According to official FAO estimates, there are more than 35 million one-humped camels worldwide as of 2018 (Data, 2020). Over the past ten years, their population has increased by roughly 15%, and it is expected to continue to grow steadily in the future (Data, 2020). While it is difficult to predict the economic significance of camels presently and in the future (Faye and Bonnet, 2012) there are several reasons for their increasing popularity. Camels are versatile mammals that are utilized for meat, milk, wool, hides, and skins, as well as they also play an active role in the

agricultural, cultural, and recreational activities of many populations worldwide (Faye and Bonnet, 2012). Camels' reproductive efficiency can be adversely affected by diseases and infections of their reproductive system (Benaissa *et al*., 2015). Therefore, these factors are impacting productivity, indeed, the fertility rate can be also influenced by various management and environmental factors including BCS, age and breed (Benaissa *et al*., 2015). BCS is a crucial tool for herd management since it provides a qualitative evaluation of the amount of energy from an animal's fat storage that can be used for lactation and reproduction. Lower BCS in female south American camelids has been linked to decreased ovarian activity, which in turn leads to decreased reproductive effectiveness (Perez-Guerra *et al*., 2022). In contrast to what has been found in cattle, BCS can be controlled by breed, age, and body weight, a prior exploratory study indicated that BCS in camels is predominantly influenced by body weight (Kumar *et al*., 2014). The ability of camels to survive times of food shortages is the product of a lengthy evolutionary process that took place in environments where food availability varies seasonally. Different body scoring-systems, comprising visual and palpatory evaluation of various body areas have been reviewed for animals, including camels (Duncanson, 2012; Wagener and Ganter, 2020; Wagener *et al*., 2023). The nutritional status is often assessed on a scale of 1 to 5 (emaciated = 1, thin = 2, optimum = 3, overweight = 4, and obese = 5) (Gauly *et al*., 2018). A straight line connecting the upper spinous and the lumbar spine can be used to identify an ideal BCS (Gauly *et al*., 2018). According to Wagener and Ganter (2020), a negative correlation between concave line and BCS was exist. Poor management practices, such as a restricted animal to feeding space ratio, a lack of food availability, an endoparasite infestation, dental issues, or any other chronic condition, can all contribute to a dromedary's poor nutritional status. There are numerous methods for evaluating BCS in animals, and some data exists on the relationship between BCS and health in camelids, such as llamas and alpacas (Proost *et al*., 2020). However, there is currently no available data on the relationship between higher BCS and lipogram and antioxidant parameters in female camels with reproductive abnormalities. To determine the degree of correlation between BCS and laboratory parameters, we conducted this work.

MATERIALS AND METHODS

Animals

In the present study, 16 seemingly healthy dromedary she-camels were designated as the control group and were investigated at the University Veterinary Hospital, Burydah, Qassim University, Saudi Arabia during the breeding season. Two breeds, Majaheem (black) and Waddah (white), were chosen for the study, and the camels were raised outdoors in a yard. Their average body weight ranged from 430 kg for young camels under 8 years old to 480 kg for animals over 8 years old. The camels had access to drinking water throughout the day and were fed a diet consisting mainly of barley, concentrate cubes, and berseem, along with roughage material. To diagnose or exclude any genital organ disease or pathology, all camels underwent examination. A total of 29 female dromedary camels were examined due to their overweight body condition and infertility that lasted between 12-36 months.

Inclusion criteria

Only animals with known breed, age, and BCS were considered for inclusion in the analysis. For each animal, the absolute bodyweight in kilograms was not recorded. As a result, they were only examined in a small group of animals.

Information of the animal

The animal's clinic ID, breed (Majaheem and Waddah), gender (female), day of inspection, birthdate, age and, if available, the animal's bodyweight in kilograms were the basic pieces of information. Nutritional information for this study was acquired during veterinary diagnostic procedures with the owners' signed consent.

Clinical scores

BCS was evaluated during the initial clinical examination that followed the presentation of the animal to the clinic. The score was described on a scale of 1 (emaciated) to 5 (obese) with 0.5 increments. Skilled examiners palpated the lumbar spine to evaluate BCS using the previously described approach. The camel was graded at a distance of 2 to 3 meters based on visual criteria, with occasional touching to validate the visual assessment. A note was given to the flank, with consideration given to the aspect of the basin, vertebral column, rib, and shoulder. The back received a second note on the hump's aspect and the basin around the tail. The final score was the mean of the two notes, rounded up to the nearest half. The procedure could be replicated with the help of two skilled technicians, with the technicians agreeing in approximately 80% of cases. In fewer than 5% of cases, the two scorings could differ by more than a half point, but solid training is required. Based on the description provided by Faye *et al*. (2001), the animals' BCS was rated on a scale of 0 to 5, divided into two groups of the same age and breed: Control as ≤4 and high as ≥4.5 in repeat breeder animals, based on visual inspection and palpation of the camel's body fat cover.

Clinical exam

The clinical examinations included a general assessment of the animal's behavior and condition, measurements of the heart and respiratory rates, the getting of rectal temperatures,

swinging auscultation of the rumen, percussion auscultation of the abdomen on both sides, and rectal examination. According to Hassan *et al.* (2019), the examination was carried out.

Blood samples

Jugular venipuncture was used to obtain blood samples from all camels at the same time as the ultrasonography. Blood was sampled in three containers totaling 20 ml: 10 ml without an anti-coagulant and 10 ml with EDTA. Following centrifugation, serum and plasma were frozen at -20 °C and subjected to further hormonal and biochemical analysis using commercial test kits in accordance with the manufacturers' established protocols.

Determination of oxidative biomarkers and lipid profile

Levels of serum cholesterol (Quimica Clinica Aplicada, Spain), triglycerides (TG, Linear Chemicals, S.L., Spain), high density lipoproteins (HDL, Cintronic GmbH), and low-density lipoproteins (LDL, TRI-(TRI/5+HDL) were measured calorimetrically according to Jain *et al.* (2007) using kits. Activities of catalase (CAT, Elabscience, USA), Glutathione (GSH, Elabscience, USA), superoxide dismutase (SOD, Elabscience, USA) and malondialdehyde (MDA, Elabscience, USA) were measured in sera calorimetrically using kits (Wu *et al.*, 2004). Estrogen was measured in sera by ELISA test system using kits (monocent, USA).

Statistical analysis

GraphPad prisms 5 was used for statistical analysis. Descriptive statistics and simple one-way analysis of variance were performed. The descriptive values of data were expressed as mean ± standard error. Post hoc analysis using the Mann–Whitney test was performed to compare the two groups and, with $P < 0.05$, $P < 0.01$ and $P < 0.001$ reflecting a significant difference (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

A total of 29 female dromedary camels were referred for examination due to their overweight body conditions and infertility lasting between 12-36 months (Figure 1). In both breeds, Majaheem and Waddah, animals over and under 8 years old were diagnosed with various ovarian and uterine abnormalities such as ovarian hydrobursitis and pyometra due to pseudopregnancy or repeated breeding (Figure 1). The diagnoses included adhered bursa at left side (n=2), hydrobursitis (n=9), endometritis (n=9), vaginal adhesions (n=2), hydrosalpinx (n=1), luteal cyst (n=2), inactive ovaries (n=2), cervical stenosis (n=1), and pyometra plus vaginal adhesions (n=1). The values of estrogen and antioxidant biomarkers MDA (mmol/L), CAT (U/L), GSH (U/mL), and SOD (U/mL) are summarized. The estrogen (pg/mL) values in repeat breeder female Majaheem (Figure 2) and Waddah (Figure 4) camels with BCS over 4.5 were significantly lower ($P<0.01$ and $P<0.05$, respectively) compared to respective controls for animals under 8 years old. The MDA value in repeat breeder female Majaheem and Waddah camels with BCS over 4.5 was significantly higher ($P<0.05$) than the value of healthy female camels. The CAT values in overweight female camels with BCS over 4.5 were significantly lower ($P<0.01$) in both breeds studied compared to respective controls with a BCS of 4. The GSH values were lower in overweight camels than in healthy ones, with a statistically significant difference ($P<0.05$) for both breeds in animals over 8 years old. Similarly, the SOD values were lower in overweight female camels compared to the respective healthy ones, with a statistically significant difference ($P<0.05$) only for Majaheem breed over 8 years old (Figures 3, 5).

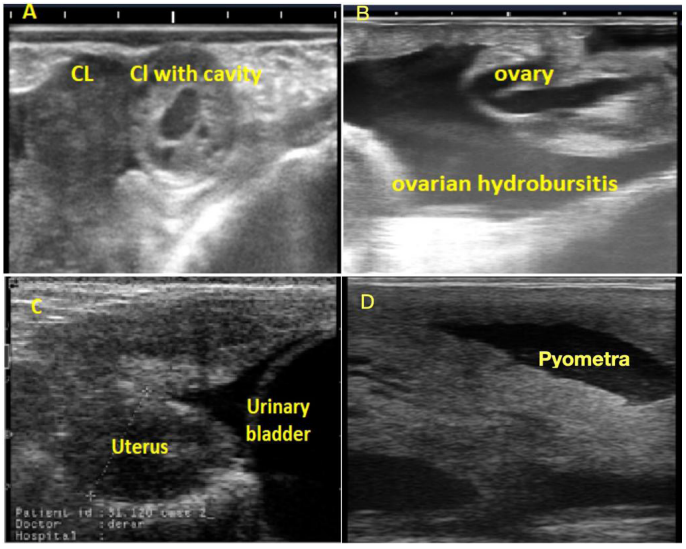

Figure 1: Ultrasonographic features of the normal(A) and abnormal ovary (B), normal(C) and abnormal uterus (D) of female camel.

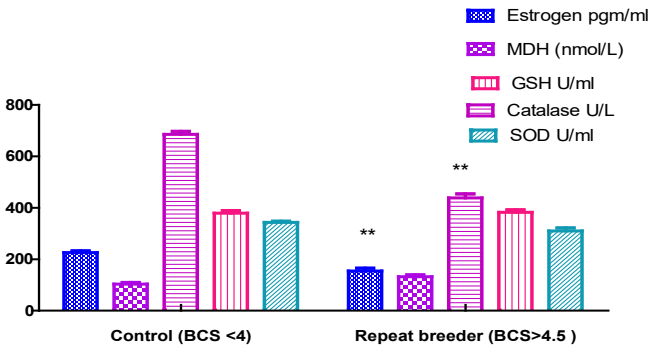

Figure 2: Means ± standard errors of the estrogen and antioxidant biomarkers in diseased female Majaheem camels aged ≤8 years with a complain of repeat breeding compared to controls. Column having ** in the same column have significant values at ($P<0.01$) compared to the respective control group.

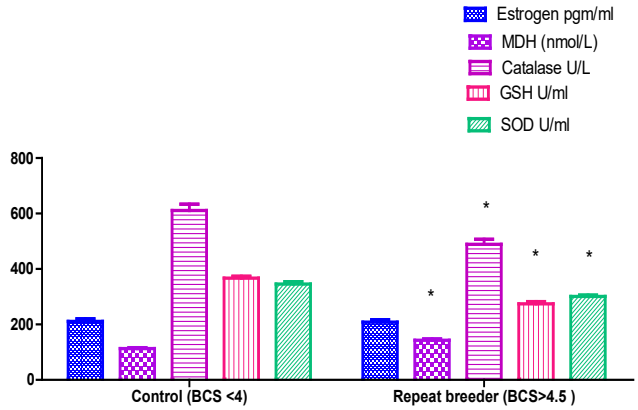

Figure 3: Means ± standard errors of the estrogen and antioxidant biomarkers in diseased female Majaheem camels aged >8 years with a complain of repeat breeding compared to controls. Column having mark * have significant values at (P<0.05) compared to the respective control group.

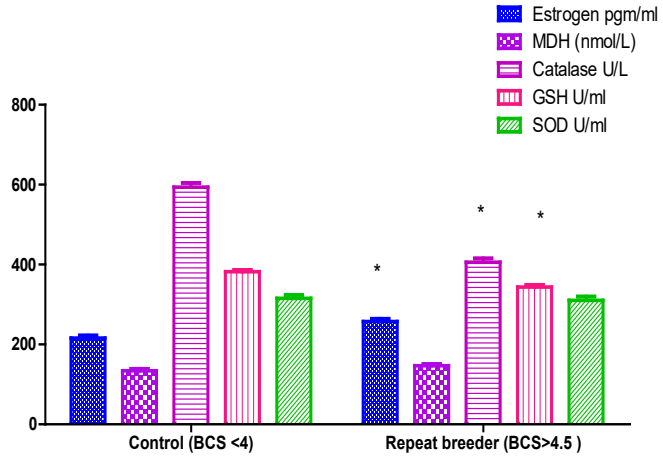

Figure 4: Means ± standard errors of the estrogen and antioxidant biomarkers in diseased female Waddah camels aged <8 years with a complain of repeat breeding compared to controls. Column having mark * have significant values at (P<0.05) compared to the respective control group.

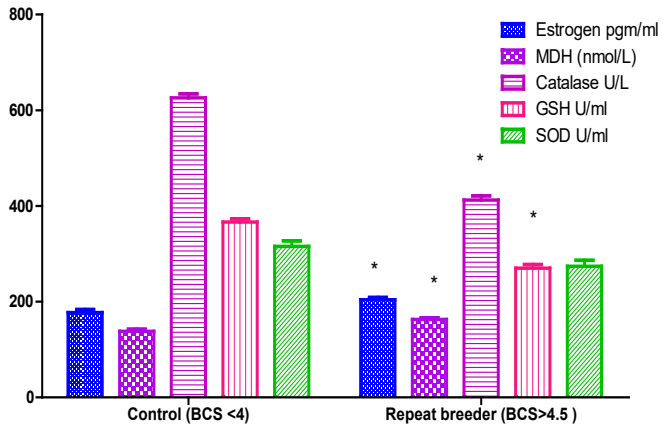

Figure 5: Means ± standard errors of the estrogen and antioxidant biomarkers in diseased female Waddah camels aged >8 years with a complain of repeat breeding compared to controls. Column having mark * have significant values at (P<0.05) compared to the respective control group.

The lipid profile is shown in Table 1. Cholesterol (mg/dL), triglycerides (mg/dL), and LDL (mg/dL) values were significantly higher in the Majaheem group with BCS over 4.5 at age over 8 years old compared to the healthy group (at P<0.05, respectively). In contrast, the HDL value was lower in both breeds' groups with BCS over 4.5 at both ages compared to healthy animals, with a statistically significant difference of P<0.05 and P<0.001, respectively. Triglycerides (mg/dL) was significantly higher in Waddah group with BCS lower than 4 at age less than 8 years old compared to the healthy group (P<0.01). Cholesterol (mg/dL) and LDL (mg/dL) values were significantly higher in Waddah group with BCS over 4.5 at age over 8 years old compared to the healthy group (at P<0.05 and P<0.01, respectively). However, triglyceride (mg/dL) and HDL (mg/dL) values were significantly lower in Waddah group with BCS over 4.5 at age over 8 years old compared to the healthy group (at P<0.01 and P<0.05, respectively).

Table 1: Lipid profiles in repeated and normal breeding camels.

Breed	Age	State	BCS	Cholesterol (mg/dL)	TG (mg/dL)	HDL (mg/dL)	LDL (mg/dL)
Majaheem	≤8	Control	≤4	141.739±6.55	145.756±4.82	19.56±3.09	49.123±5.65
		Repeat breeder	≥4.5	153.921±7.08	165.154±8.09	8.100±2.32*	72.178±4.66**
	≥8	Control	≤4	138.228±8.88	122.069±5.83	17.37±3.64	51.004±6.44
		Repeat breeder	≥4.5	186.416±9.34*	192.254±11.55*	8.56±2.21*	77.568±5.53*
Waddah	≤8	Control	≤4	191.859±3.52	116.182±4.87	5.95±1.62	51.026±6.54
		Repeat breeder	≥4.5	219.712±10.27	182.555±6.22**	6.53±2.08	66.820±4.08
	≥8	Control	≤4	216.201±3.50	131.248±6.32	23.78±1.09	35.677±3.88
		Repeat breeder	≥4.5	258.96±4.34*	224.959±7.59**	13.86±2.41*	68.571±5.81**

Means having mark * and ** in the same column have significant values at (P<0.05) and (P<0.01) compared to the respective control group within the same breed and age, respectively.

As camels age, their BCS tends to increase, which is typically attributed to changes in body composition that occur with aging (Ouchene-Khelifi and Ouchene, 2021). The use of serum biochemical assays has provided valuable information regarding the physiological state and overall health of animals. The MDA was significantly higher in the repeat breeding Majaheem and Waddah animals with BCS 4.5 than in the healthy female camel group (≥ 4 BCS). In both studied breeds, the values of CAT in obese female camels with a BCS over 4.5 were considerably lower than those in corresponding controls with a BCS of 4. For both breeds aged ≥8, GSH values were lower in overweight camels than in healthy ones, with a statistically significant difference. Similar to this finding, only Majaheem breed female camels older than 8 years showed a statistically significant variation in their SOD values compared to healthy ones. One significant effect of oxidative stress is the oxidative degradation of lipids, known as lipid peroxidation, which yields malondialdehyde (MDA) as a stable end-product instead of short-lived free radicals (Sharma *et al*., 2011). Free radical overproduction is regulated by antioxidant defense systems, such as the enzymes CAT, GSH, and SOD, which are utilized as defense mechanisms. A cellular or individual level imbalance between oxidants and antioxidants is known as oxidative stress. Therefore, Oxidative stress should be recorded as a disease marker because it has been linked to several illnesses across numerous species, including mastitis, enteritis, sepsis, respiratory and musculoskeletal diseases, as well as transport and pregnancy-related disorders (Piccione *et al*., 2013).

The reference ranges for serum MDA concentrations provided by El-Deeb and Elmoslemany (2015) and El-Bahr and El-Deeb (2016) were consistent with the MDA concentrations observed in overweight camels. According to El-Deeb and Elmoslemany (2015), this was likely due to physiological oxidative stress, which leads to excess production of free radicals as a result of lipid peroxidation. The difference in serum MDA levels between the two breeds was not significant, and they were also within the physiological reference ranges. Additionally, she-camels had serum MDA levels that exceeded the reference ranges. Moreover, Jarikre *et al*. (2017) noted that a significant increase in MDA levels could increase the risk of cellular damage and inflammation. Although the body is supported by various antioxidants to counteract the damaging effects of reactive oxygen species (ROS), several studies have focused on the role of superoxide dismutase (SOD) as an antioxidant biomarker (Alhidary *et al*., 2016). SOD facilitates the conversion of superoxide anions produced during metabolic activities to hydrogen peroxide (Shoieb *et al*., 2016). The most well-known low molecular weight natural antioxidant is GSH. CAT is one of the first-line defense antioxidant enzymes, and it can also have a pro-oxidant role, although to a lesser extent than its antioxidant activity (Abd El-Hamid, 2021). Long-term oxidative stress causes a continuous increase in malondialdehyde (MDA) levels and a decrease in the quantity of antioxidants and antioxidant enzymes, such as GSH and CAT, following an initial increase (Gaucher *et al*., 2018). This helps counteract and mitigate the damaging effects of oxidant chemicals. The current study suggests that a significant decrease in the serum concentrations of these antioxidant indicators in overweight camels may exacerbate oxidative stress and worsen related illnesses. Similarly, Kamr *et al*. (2020) observed significantly lower levels of CAT and higher amounts of MDA in overweight camels compared to healthy ones. The lower antioxidant levels observed in the current study may be attributed to the consumption of these enzymes for cell protection, which delays the onset of peroxidation and the creation of harmful end-products such as thiobarbituric acid reactive substances (Islam *et al*., 2019).

Hence, it was essential to concentrate on specific breeds and age ranges to examine variations in these parameters. The lipid profile results, which included TG, HDL, and LDL, showed that young camels had higher values for these parameters than old ones, but there was no significant difference between the age groups. This study also found that the Majaheem breed had higher values than the Waddah breed for certain lipid characteristics, and breed had a statistically significant effect. Specifically, the Waddah breed had slightly higher total cholesterol levels than the Majaheem breed, while the Majaheem breed had significantly higher HDL levels than the Waddah breed. These findings are consistent with previous reports by Sahraoui *et al*. (2016) on Algerian breeds.

It is well-established that an increase in TG storage is associated with a linear rise in cholesterol production, which, in turn, is related to an increase in cholesterol in bile and an elevated risk of illness (Zhang *et al*., 2020). However, the exact biochemical mechanisms underlying the association between overweight and the aforementioned lipid profiles have not been fully elucidated. Similarly, higher levels of circulating TG in overweight individuals are associated with lower levels of HDL, which may explain the higher risks for disease (Latha *et al*., 2015). A number of disorders, including obesity, have been strongly associated with abnormalities in the lipid profile, particularly hypertriglyceridemia and low levels of HDL (Shahid and Sarwar, 2020).

Nazifi *et al*. (2003) found that age had a significant impact on the serum concentration of cholesterol, TG, total lipid, HDL, and LDL in camels. Hugi and Blum (1997) reported that while TG levels did not consistently change with age, cholesterol concentration increased momentarily

as animals aged. Studies on the levels of cholesterol, TG, and lipoproteins in domestic animals have shown that there are differences between species and even within species. Mohamed (2008) evaluated the lipid status of Sudanese camels according to age, sex, and breed. Gender did not affect lipid status, but age had a significant impact, with adult camels having a higher lipid status than yearlings and newborns. There were also significant differences between breeds, with Arabi having a higher lipid status than Anafi.

According to Nazifi *et al.* (2009), age has a major impact on the serum lipids and lipoproteins of camels, with older animals having higher concentrations of HDL, TG, cholesterol, and LDL, while younger animals have lower concentrations of these lipids. Significant correlations between cholesterol and both HDL and LDL were found in 5- to 6-year-old camels. Khajeh *et al.* (2008) found a negative correlation between TG and HDL in camels, while LDL had a positive correlation with cholesterol. Although the percentage of LDL increased with age, serum cholesterol levels decreased.

In this study, serum cholesterol levels were comparable to those reported by Sazmand *et al.* (2011), but lower than those reported by Aichouni *et al.* (2013) and higher than those reported by Sazmand *et al.* (2011). The repeat breeder Majaheem had the highest serum TG concentrations ($P < 0.05$) at both examined ages, likely due to an enhanced rate of TG synthesis in the intestinal mucosa as a result of a greater availability of substrates. The imbalance between certain lipid fractions during under- and overnutrition may have contributed to this phenomenon. Maintaining dromedaries on a favorable nutritional plane is essential for healthy reproduction and reducing fluctuations in body condition score (BCS). Therefore, monitoring BCS can provide a more precise picture of the animal's state, enabling veterinarians to control the camel's nutritional management (Ahmed *et al.*, 2023).

CONCLUSIONS AND RECOMMENDATIONS

There was a correlation between breeding camels aberrant reproductive processes and age, breed, and BCS. However, knowledge of the camel's metabolic status that may be obtained through specific strategic metabolic markers and BCS may offer a more solid foundation for preventing metabolic problems and increasing output.

ACKNOWLEDGMENTS

The researcher would like to thank the Deanship of Scientific Research, Qassim University for funding the publication of this project.

NOVELTY STATEMENT

There is currently no available data on the relationship between higher body condition scores and lipogram and antioxidant parameters in female camels with reproductive abnormalities. To determine the degree of correlation between clinical findings and laboratory diagnostic parameters, we conducted an investigation into these circumstances based on the present results, reproductive abnormality in camels was associated with high body condition scores and abnormal blood metabolites.

Ethical approval

Animal Ethical Committee, Scientific Research Deanship in the University of Qassim, Saudi Arabia approved this study (Approval no. 20/21-17-3).

Abbreviations

BCS, Body condition score; CAT, Catalase; ELISA, Enzyme linked immunosorbent assay; GSH, Glutathione; HDL, High density lipoproteins; LDL, Low density lipoproteins; MDA, Malondialdehyde; ROS, Reactive oxygen species; SOD, Superoxide dismutase; TG, Triglycerides.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Abd El-Hamid I (2021). Blood constituents, antioxidant activities and hormonal profile in she-camels (Camelus dromedarius) during different physiological statuses in the Northwestern Coast of Egyption. Int. J. Vet. Sci., 10: 247-258. https://doi.org/10.47278/journal.ijvs/2021.055

Ahmed M, Ibrahim A, Mahamed S (2023). Study on prevalence of one humped camel mange and its associated risk factors in selected kebeles of Kebribeyah District of Fafan Zone, Somali Regional State, Ethiopia. https://doi.org/10.21203/rs.3.rs-2619682/v1

Aichouni A, Belhadia M, Kebir N, Aggad H (2013). Season influence on serum organic parameters of dromedarius (*Camelus dromaderius*) in Algeria. Biochem. Biotechnol. Res., 1(1): 8-12.

Alhidary IA, Abdelrahman MM, Khan UR, Harron RM (2016). Antioxidant status and immune responses of growing camels supplemented a long-acting multi-trace minerals rumen bolus. Ital. J. Anim. Sci., 15(2): 343-349. https://doi.org/10.1080/1828051X.2016.1186502

Benaissa MH, Faye B, Kaidi R (2015). Reproductive abnormalities in female camel (*Camelus dromedarius*) in Algeria: relationship with age, season, breed and body condition score. J. Camel Pract. Res., 22(1): 67-73. https://doi.org/10.5958/2277-8934.2015.00010.7

Data FFA (2020). Available online: http://www. fao. org/faostat/en/# data. QC (accessed on 26 March 2021).

Duncanson G (2012). Nutrition and metabolic diseases veterinary treatment of llamas and alpacas: CABI Wallingford UK. pp.

13-21. https://doi.org/10.1079/9781780640068.0013
El-Bahr S, El-Deeb W (2016). Trypanosoma evansi in naturally infected dromedary camels: lipid profile, oxidative stress parameters, acute phase proteins and proinflammatory cytokines. Parasitology, 143(4): 518-522. https://doi.org/10.1017/S0031182016000123
El-Deeb W, Elmoslemany A (2015). Cardiac and oxidative stress biomarkers in Trypanosoma evansi infected camels: diagnostic and prognostic prominence. Parasitology, 142(6): 767-772. https://doi.org/10.1017/S0031182014001899
Faye B, Bonnet P (2012). Camel sciences and economy in the world: current situation and perspectives. Paper presented at the Proc. 3rd ISOCARD conference. Keynote presentations. 29th January-1st February.
Faye B, Bengoumi M, Messad S, Chilliard Y (2001). Fat storage and adipocyte patterns in camel a tool for management of reproduction. Adv. Reprod., 5(3): 8-17.
Gaucher C, Boudier A, Bonetti J, Clarot I, Leroy P, Parent M (2018). Glutathione: antioxidant properties dedicated to nanotechnologies. Antioxidants, 7(5): 62. https://doi.org/10.3390/antiox7050062
Gauly M, Vaughan J, Cebra C (2018). Neuweltkameliden: Haltung, Zucht, Erkrankungen: Georg Thieme Verlag. https://doi.org/10.1055/b-005-145257
Hassan HY, Gadallah S, Kamr A, Abdelazeim A (2019). Serum iron, calcium, phosphorus and magnesium concentrations and their effects on hemato-immune dynamics in diseased camels (*Camelus dromedarius*). EC Vet. Sci., 4(10): 01-11.
Hugi D, Blum J (1997). Changes of blood metabolites and hormones in breeding calves associated with weaning. J. Vet. Med. Ser. A, 44(1-10): 99-108. https://doi.org/10.1111/j.1439-0442.1997.tb01091.x
Ibrahim MA, Abdelrahman H, Elmetwaly H (2017). Hormonal profile, antioxidant status and some biochemical parameters during pregnancy and periparturient period in dromedary she camel. Egypt. J. Vet. Sci., 48(2): 81-94. https://doi.org/10.21608/ejvs.2017.2040.1022
Islam S, Ferdous J, Rahman MK, Akter S, Hassan MM, Islam A (2019). Reference values for hematological and serum biochemical parameters of dromedary camel (*Camelus dromedarius*) in sub-tropical climate of Bangladesh. Adv. Anim. Vet. Sci., 7(4): 232-237. https://doi.org/10.17582/journal.aavs/2019/7.4.232.237
Jain KS, Kathiravan MK, Somani RS, Shishoo CJ (2007). The biology and chemistry of hyperlipidemia. Bioorg. Med. Chem., 15(14): 4674–4699. https://doi.org/10.1016/j.bmc.2007.01.017
Jarikre T, Ohore G, Oyagbemi A, Emikpe B (2017). Evaluation of oxidative stress in caprine bronchoalveolar lavage fluid of pneumonic and normal lungs. Int. J. Vet. Sci. Med., 5(2): 143-147. https://doi.org/10.1016/j.ijvsm.2017.09.001
Kamr A, Gadallah S, Arbaga A, Hassan HY (2020). Oxidant and antioxidant biomarkers and the risk factor of age on their concentrations in pneumonic Arabian camels (*Camelus dromedarius*). J. Camelid Sci., 13(1): 40-48.
Khajeh GH, Razi JM, Daneshgar E (2008). Electrophoretic pattern of blood serum lipoproteins in one humped camels (*Camelus dromedarius*).
Kumar SM, Johnson E, El-Badry D (2014). Relationship between age, breed, body weight, gestational status and parity on the body condition score of omani breeding camels Biotechnology and Conservation of Species from Arid Regions Nova Science Publishers, Inc, pp. 101-103.
Latha M, Vandana G, Deepa M (2015). A comparative study of serum lipid profile between pre and post menopausal women. IOSR J. Diagn. Med. Sci., 14: 51-53.
Mohamed H (2008). Factors affecting the plasma lipid status in camels (*Camelus dromedaries*). Res. J. Biol. Sci., 3(4): 444-445.
Nazifi S, Gheisari H, Poorkabir AM, Saadatfar S (2000). Serum lipids and lipoproteins in clinically healthy male camels (*Camelus dromedarius*). Vet. Res. Commun., 24: 527-531. https://doi.org/10.1023/A:1006487718002
Nazifi S, Saeb M, Abedi M (2003). Serum lipid profiles and their correlation with thyroid hormones in clinically healthy Turkoman horses. Comp. Clin. Pathol., 12: 49-52. https://doi.org/10.1007/s00580-002-0471-x
Nazifi S, Saeb M, Baghshani H, Saeb S (2009). Influence of road transportation during hot summer conditions on oxidative status biomarkers in Iranian dromedary camels (*Camelus dromedarius*). Afr. J. Biochem. Res., 3(7): 282-287.
Ouchene-Khelifi N, Ouchene N (2021). Relationships between age, body measurements, and testicular measurements in Arabia bucks in Algeria. Trop. Anim. Health Prod., 53: 1-9. https://doi.org/10.1007/s11250-020-02500-6
Perez-Guerra UH, Quispe YM, Gonzáles HI, Luque N, Ruelas DA, Carretero MI, García-Herreros M (2022). Ovarian follicular dynamics and its functional significance in relation with follicle deviation, vaginal cytology, and hormone profiles in llamas (*Lama glama*). Animals, 12(23): 3299. https://doi.org/10.3390/ani12233299
Piccione G, Casella S, Giannetto C, Bazzano M, Giudice E, Fazio F (2013). Oxidative stress associated with road transportation in ewes. Small Rumin. Res., 112(1-3): 235-238. https://doi.org/10.1016/j.smallrumres.2012.11.001
Proost K, Pardon B, Pollaris E, Flahou T, Vlaminck L (2020). Dental disease in alpacas. Part 2: Risk factors associated with diastemata, periodontitis, occlusal pulp exposure, wear abnormalities, and malpositioned teeth. J. Vet. Intern. Med., 34(2): 1039-1046. https://doi.org/10.1111/jvim.15740
Sahraoui N, Doudou A, Douadji O, Babelhadj B, Hornick JL (2016). Impact of natural vegetation on some biochemical parameters of the Arabian camel (*Camelus dromedarius*) in Algeria. J. Camelid Sci., 9: 62-71.
Sazmand A, Rasooli A, Nouri M, Hamidinejat H, Hekmatimoghaddam S (2011). Serobiochemical alterations in subclinically affected dromedary camels with Trypanosoma evansi in Iran. Pak. Vet. J., 31(3): 223-226.
Shahid SU, Sarwar S (2020). The abnormal lipid profile in obesity and coronary heart disease (CHD) in Pakistani subjects. Lipids Health Dis., 19(1): 1-7. https://doi.org/10.1186/s12944-020-01248-0
Sharma N, Singh N, Singh O, Pandey V, Verma P (2011). Oxidative stress and antioxidant status during transition period in dairy cows. Asian-Australas. J. Anim. Sci., 24(4): 479-484. https://doi.org/10.5713/ajas.2011.10220
Shoieb S, Ibrahim H, Sayed-Ahmed M, El-khodery S (2016). Antioxidant trace elements and oxidative stress levels associated with pasteurellosis in camel-calves (*Camelus dromedarius*). J. Vet. Sci. Technol., 7: 393. https://doi.org/10.4172/2157-7579.1000393
Steel R,Torrie J, Dickey D (1997). Principles and procedures of statistics: A biometrical approach. 3rd ed. McGraw-Hill , New York , NY.
Wagener MG, Schregel J, Ossowski N, Trojakowska A, Ganter M, Kiene F (2023). The influence of different examiners

on the body condition score (BCS) in South American camelids experiences from a mixed llama and alpaca herd. Front. Vet. Sci., 10: 1126399. https://doi.org/10.3389/fvets.2023.1126399

Wagener M, Ganter M (2020). Body condition scoring bei Neuweltkamelen. Der praktische Tierarzt, 101(7): 684-696.

Wu X, Beecher GR, Holden JM, Haytowitz DB, Gebhardt SE, Prior RL (2004). Lipophilic and Hydrophilic Antioxidant Capacities of Common Foods in the United States. J. Agric. Food Chem., 52(12): 4026–4037. https://doi.org/10.1021/jf049696w

Zhang Z, Yuan Y, Ma M, Hong Y, Sun Z, Xu Y, Qiu Z (2020). Lipid status and linear relationship between total cholesterol and triglycerides in glycogen storage disease type Ia. https://doi.org/10.21203/rs.3.rs-46912/v1