DOI : 10.5958/2277-8934.2018.00024.3 *Vol 25 No 2, p 171-179*

EFFECT OF ROAD TRANSPORTATION ON BLOOD AND SERUM PARAMETERS AND THYROID ACTIVITY IN SYMPTOMATICALLY HYPERGLYCAEMIC FEMALE DROMEDARY CAMELS

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ABSTRACT

Ten animals were divided into two equal groups according to short (150–200 km) or long (250–400 km) transportation distance. Compared to 10 clinically healthy control animals, the glucose level, globulin concentration, neutrophil count, catalase and total antioxidant capacity activity were significantly higher in the camels after both the short- and long-distance lorry transportation, while the eosinophil count and super oxide dismutase activity were significantly lower. Long-distance transportation resulted in elevated creatinine, but lowered albumin in the camels. The long-distance group also exhibited a significant increase in total T3 and total T4 levels; however, their TSH levels were significantly lower than in the control camels. The short-distance lorry transportation of camels led to an elevation of the white blood cell count and haemoglobin concentration, but lower haematocrit % and lymphocyte count. Thus, the altered thyroid hormone levels and changes in the physiological metabolic profiles taken together may be effective biomarkers of transportation stress in this species. Finally, it was cleared that the obtained pathophysiological changes may be resulted from the transportation-induced stress in hyperglycaemic animals.

Key words: Blood, dromedary camel, hyperglycaemic lorry transportation, thyroid

In the Kingdom of Saudi Arabia (KSA), camels are commonly transported for a variety of purposes including clinical examination, slaughter and sale. Animal transportation has been linked to health disorders and economic loss (Padalino *et al,* 2015). Previous studies have reported that the long duration (Chacon *et al,* 2005) and density of animals in the lorry during transportation (Waas *et al,* 1997) lead to a stressful condition in the animals.

Ideally, blood glucose levels in camels range between 70 and 90 mg/dL (Poonia *et al,* 2016). Under stress conditions, the body shifts physiologically into fight-or-flight mode, hence elevating the blood glucose. It is well known that transportation involves many stressful factors for large animals, including manipulation, foreign environments, noise and fasting. These responses can change depending on the duration of the transportation (Padalino *et al,* 2015).

As an endocrine response to stress, thyroid hormones in particular are known as important modulators of energy metabolism (Kaneko *et al,* 2008; Eshratkhah *et al,* 2010). The alteration in thyroid hormone concentrations following different stresses has been reported in some domestic animals (Saeb *et al,* 2010). In addition, these hormones may have the capability to regulate the activities and metabolic pathways of the anti-oxidant enzymes superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPX). In the serum of camels, these enzymes are changed during environmental stress (Kataria *et al,* 2010).

To the best of our knowledge, no study has been conducted to date describing the possible relationship between thyroid hormone status, antioxidant enzymes and serum and blood chemical profiles of symptomatically hyperglycaemic dromedary camels after short and long-distance lorry transportation. This study was therefore, undertaken to investigate the influence of lorry transportation on thyroid hormones, blood and serum biochemistry and antioxidant enzymes in the symptomatically hyperglycaemic camels admitted to Qassim University Veterinary Teaching Hospital.

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Materials and Methods

This study was carried out at the Qassim University Veterinary Teaching Hospital and the Qassim University Farm in the Qassim region, KSA, during the November and December 2017. The experimental protocol was approved by the Animal Ethical Committee of Qassim University Deanship for Scientific Research.

Animals

Ten non-pregnant, non-lactating, clinically healthy female camels (*Camelus dromedarius*) aged 3–6 years were used as non-lorry-transported control camels in the present study. These camels were selected from the Qassim University farm based on the absence of any disease. Their body condition scores were considered normal, ranging between 3 and 3.5. Another ten female animals were admitted to the clinic after lorry transportation suffering from long- standing decrease in body weight and progressive weakness and had high glucose levels as measured by glucometer. These camels were divided into two equal groups according to the distance of transportation: short (150–200 km.) and long (250–400 km.).The body condition scores of these animals ranged between 2 and 3.5.

Blood samples

Five-mL blood samples were collected by sterile jugular venepuncture into a tube containing EDTA and used for the haematological parameters. Another 5-mL were collected and serum was separated by centrifugation at 3000 × g for 20 min and kept in a deep freezer at -20ºC till assayed.

Haematological, biochemical and hormonal analyses

Haemogram and leukogram evaluations were carried out using an automated analyser (Vet Scan HM5, Abaxis, California, USA). The haemogram included red blood cell (RBC counts, × 10^6/µL), haemoglobin (HGB) concentration, g/dL), haematocrit (HCT, %), mean corpuscular volume (MCV, fl), mean corpuscular haemoglobin (MCH, pg) and mean corpuscular haemoglobin concentration (MCHC, g/dL). The leukogram included total leukocyte (WBC) count (× 10^3/µl), lymphocyte (LYM) count (× 10^3/µl), monocyte (MON) count (× 10^3/µl), neutrophil (NEU) count (× 10^3/µl) and eosinophil (EOS) count (× 10^3/µl). The serum samples were tested using an automated biochemical analyser (Vet Scan VS2, Abaxis, California, USA.) to determine the protein profile of total protein (TP, g/dL), albumin (ALB, g/dL), globulin (GLOB, g/dL), creatinine (CREA, g/dL), amylase (AMY, U/L), blood urea nitrogen (BUN, g/dL) and alkaline phosphatase (ALP, U/L). The electrolyte profiles included calcium (Ca, g/dL), phosphorus (P, g/dL), sodium (Na, mmol/L) and potassium (K, mmol/L).

Serum concentrations of total T_3, T_4 and thyroid stimulating hormone (TSH) were assayed by ELISA procedures using purchased kits (Immunotech Corporation, 90 Windom St., Boston, MA 02134, USA). For the antioxidant enzyme activity, Calorimetric measurement was performed using kits (Biodiagnostic) to determine total antioxidant capacity (TAC), super oxide dismutase (SOD) and catalase (CAT).

Statistical analyses

All values were expressed as mean and standard error (SE) with $P<0.05$ and $P<0.01$ seen as statistically significant. For comparison between the groups, the data were analysed by the Mann-Whitney U test and two-way analysis of variance (ANOVA).

Results and Discussion

Glucose level

The effects of short- and long-distance lorry transportation on the glucose level of the dromedary camels are shown in Table 1. Compared to the control group, the glucose levels were significantly higher in the camels after both short ($P<0.05$) and long ($P<0.01$) distance lorry transportation.

Protein profile

The effects of short- and long-haul lorry transportation on the protein profile of the symptomatically hyperglycaemic dromedary camels are shown in table 1. The ALB concentrations of the camels after long lorry transportation were significantly lower ($P<0.05$) than central group; however, non- significant difference was seen in the short-distance transportation group. In addition, there was no significant difference between the total protein in either the short- or long-distance transportation group compared to the control group of camels. Moreover, GLOB concentrations were significantly higher in both the short ($P<0.05$) and long ($P<0.01$) distance transport groups than in the control group.

ALP, CREA, BUN and Amylase

The effects of short- and long-haul lorry transportation on ALP, CREA, BUN and amylase

in the symptomatically hyperglycaemic dromedary camels were shown in table 1. The data revealed no significant difference in ALP and BUN levels of the camels in either group subjected to lorry transportation compared to the control group. Likewise, no significant difference in BUN was seen in either transported group compared to the control group. The CREA level of the short-haul transport group did not show any significant difference; however, the CREA levels of the camels in the long-haul transport group were significantly higher (P<0.05) than in the control group. Finally, the data showed that amylase activity in the camels under both short- and long-distance lorry transportation conditions were significantly lower (P<0.05) compared to that of the control group.

Leukogram

Table 2 shows the effects of short- and long-distance lorry transportation on the leukograms of the symptomatically hyperglycaemic dromedary camels. The WBC count of the camels after short-distance lorry transportation was significantly higher (P<0.05) compared to the control group, while after long lorry transportation, there was no significant difference in the WBC. There was a significantly greater decline (P<0.05) in the lymphocyte count of the camels after short lorry transportation than in the control group. On the other hand, compared to the control camels, there was no significant difference in the count after long-haul lorry transportation than lymphocyte group. In addition, no significant differences were observed in the monocytes count in any of the three camel groups. However, the netvoyage count was significantly higher in the camels in both the short (P<0.01) and long (P<0.05) distance transportation groups compared with the control group, while the eosinophil count was significantly lower in both the short (P<0.01) and long (P<0.05) distance transportation groups.

Haemogram

The effects of short- and long-distance lorry transportation on the haemograms of the symptomatically hyperglycaemic dromedary camels are shown in table 2. The data revealed no significant differences in the RBC count of camels in either the short-or long-distance lorry transportation groups compared to the control group. The hemoglobin concentration of camels after short-distance transportation was significantly higher (P<0.05) than that of the control group; similarly, their hematocrit % was also significantly higher (P<0.05). However, there was no significant difference in HGB concentration or the HCT %between the camels after long-distance transport and the control group. No significant differences were found in the MCV, MCH, or MCHC among all 3 groups.

Electrolyte profile

The data revealed no significant differences in calcium concentration in either the short- or long-distance lorry transport groups compared to the control camels. Similarly, neither lorry transport group showed any significant differences in the P levels, nor in Na and K, compared to the control group (Table 3).

Thyroid hormones

There was a significant increase (P<0.01) in the total T3 levels of the camels after long-distance lorry transportation compared to the control group. Similarly, total T4 was significantly higher (P<0.05) in camels after long-distance lorry transportation;

Table 1. Effect of short and long lorry transportation distance on biochemical profile of symptomatically hyperglycaemic dromedary camels.

Groups	Control		Short-distance lorry transportation		Long-distance lorry transportation	
Parameters	**Mean**	**SE (±)**	**Mean**	**SE (±)**	**Mean**	**SE (±)**
GLU (g/dL)	114.40	4.51	170.53[a]	15.81	224.82[b]	35.10
ALB (g/dL)	4.68	0.16	3.75	0.26	3.55[a]	0.51
GLOB (g/dL)	1.64	0.12	2.82[a]	0.41	3.03[b]	0.38
TP (g/dL)	6.18	0.16	6.57	0.29	6.58	0.35
ALP (U/L)	106.90	6.57	116.0	18.5	120.73	13.96
CREA (g/dL)	0.94	0.06	1.27	0.11	1.48[a]	0.29
BUN (g/dL)	26.31	0.84	20.23	2.74	26.97	2.73
AMY (U/L)	616.7	41.7	418[a]	69.0	412.2[a]	25.6

[a, b] Mean values of the short and long lorry transportation distance groups differed significantly from the value of the control group in the same row at P <0.05 and P <0.01, respectively.

however, their TSH levels were significantly lower (P<0.05) than those of the control camels (Table 4).

Antioxidant enzymes

A significant decrease was observed (P<0.05) and (P<0.01) in the SOD activity after short- and long-distance lorry transportation, respectively, compared to the control camels. Meanwhile, the CAT activity was significantly increased in the camels after short (P<0.05) and long (P<0.01) distance lorry transportation. However, the TAC activity in both transported camel groups was significantly higher (P<0.05) than in the control group (Table 5).

Animals exposed to unfavourable environments due to transportation experience very stressful conditions with a variety of physiological changes. These changes may have unfavourable effects on the camel's productivity and well-being.

Camels have developed resistance to harsh environments and found sustenance from sources unutilised by other species (Kadim *et al,* 2009). The complex physiological changes caused by lorry transportation stress can differ according to species and breeds within the same species (Ingram and Matthews, 2000). Different parameters, including metabolic, hormonal and behavioural changes, have been used to measure the physiological changes occurring during stress (Saeb *et al,* 2010; Nazifi *et al,* 2009).

Compared to the control group, glucose levels were significantly higher in the camels after short- and long-distance lorry transportation. This is in agreement with previous works conducted by Tadich *et al* (2005) and El Khasmi *et al* (2013) and with studies done on goats (Kannan *et al,* 2007; Minka and Ayo, 2010) and Holstein calves (Bernardini *et al,* 2012). However, results of other investigators did not support these findings, particularly those on cattle and goats (Earley *et al,* 2012). The elevated glucose level during lorry transportation may result from glycogenolysis in the muscle and liver due to an increased catecholamines from the sympathetic nervous system (Sanders and Straub, 2002; Almundarij *et al,* 2017) and glucocorticoids from the adrenal cortex (Tadich *et al,* 2005); however, these factors were not assessed in this study. In

Table 2. Effect of short and long lorry transportation distance on haematological profile of symptomatically hyperglycaemic dromedary camels.

Groups	Control		Short-distance lorry transportation		Long-distance lorry transportation	
Parameters	**Mean**	**SE (±)**	**Mean**	**SE (±)**	**Mean**	**SE (±)**
WBC ($\times10^3/\mu L$)	15.04	1.41	21.06[a]	3.79	16.37	4.22
LYM ($\times10^3/\mu L$)	3.21	0.54	1.53[a]	0.22	1.82	0.27
MON ($\times10^3/\mu L$)	0.100	0.01	0.14	0.02	0.13	0.04
NEU ($\times10^3/\mu L$)	8.81	1.04	18.80[b]	3.40	14.68[a]	3.73
EOS ($\times10^3/\mu L$)	2.92	0.53	0.58[b]	0.16	0.61[a]	0.33
RBC ($\times10^6/\mu L$)	8.69	0.32	10.53	0.76	8.77	0.92
HGB (g/dL)	13.60	0.49	17.00[a]	1.44	13.27	1.17
HCT (%)	24.14	0.66	28.81[a]	2.85	23.83	1.72
MCV (fl)	27.70	0.65	27.25	1.44	28.00	1.83
MCH (pg)	15.67	0.18	16.15	0.42	15.36	0.71
MCHC (g/dL)	56.31	1.18	59.45	2.04	55.42	1.09

[a, b] Mean values of the short- and long-distance lorry transportation groups differed significantly from the value of the control group in the same row at P<0.05 and P<0.01, respectively.

Table 3. Effect of short and long lorry transportation distance on electrolyte profile of symptomatically hyperglycaemic dromedary camels.

Groups	Control		Short-distance lorry transportation		Long-distance lorry transportation	
Parameters	**Mean**	**SE(±)**	**Mean**	**SE (±)**	**Mean**	**SE(±)**
CA (g/dL)	9.72	0.15	9.57	0.19	9.60	0.21
P (g/dL)	4.90	0.66	4.97	0.69	5.32	0.77
NA (mmol/L)	154.31	1.46	143.75	2.90	144.33	1.50
K (mmol/L)	5.57	0.09	4.92	0.22	4.56	0.30

contrast, a similar study in goats demonstrated that the elevation of blood glucose was due to the activation of the sympathetic nervous system rather than the plasma cortisol (Aoyama *et al,* 2008). In the present study, the elevated glucose levels resulting from the short-haul distance requiring a 2-3 h drive to the clinic could have been caused by a sympathetic outflow and increase in plasma cortisol either directly (O'Malley, 1971), or through ACTH (Maejima *et al,* 2006) mediated stress. On the other hand, both catecholamine administration and transportation have been shown to increase plasma glucose levels within 10-15 min in sheep (Parrott *et al,* 1994; Bassett, 1970). Additionally, a link was found between transportation stress, expression of the *c-fos* protein in the adrenal medulla and the increase in plasma glucose levels (Maejima *et al,* 2006). However, the blood glucose showed no significant change due to the length/duration of the transportation. Even when it increased from 170.5 g/dL to 224.8 g/dL, this might have been due to the variations of age among the animals, as previously mentioned by Eskandarzadeh *et al* (2014).

The increase in ALB levels during transportation may indicate the degree of stress in response to stressors (Križanović *et al,* 2008). The effects of short- and long-distance lorry transportation on the protein profiles of the symptomatically hyperglycaemic camels were recorded. Compared with the control group, the ALB concentration of the camels after long-haul lorry transportation was found to be significantly lower; however, no significant difference was seen in the short-haul transportation group. In addition, there was no significant difference between total proteins after either short- or long-distance lorry transportation compared to the control camels, whereas the GLOB concentrations were significantly higher in both groups of transported camels. As a result of lorry transportation, there was an elevation of GLOB and lowering of ALB without changes in the total protein. On the other hand, short lorry transportation had no effect on the ALB and total protein in the current study, suggesting that no dehydration occurred during the 2-3 h lorry transportation stress in the dromedary camels. The long-haul lorry transport of over 5-6 h had no significant effect on total protein concentration in the dromedary camels, as has been previously reported (Kataria and Kataria, 2004). It was concluded that no signs of dehydration had occurred in the dromedary camels during transportation, which may be a reflection of their ability to adapt to dehydration (Parker *et al,* 2003).

The data revealed that there was no significant difference in the ALP activity in either group of transported camels compared to the control group. The CREA and BUN levels of the camels after short-haul transportation were not significantly different; however, the CREA levels of the camels in the long-haul transportation group were significantly higher than those of the control group. This result is consistent with a previous study on different species (Hartung, 2003). Therefore, the elevated levels of CREA may have been due to the catabolism of protein by cortisol after food deprivation (Wensvoort *et al,* 2004). On the other hand, a different study showed no significant effect on CREA levels during drought stress (Kataria and Kataria, 2004). The present data indicated that neither short-nor long-haul transportation had extensive adverse effects on the protein catabolism of the transported camels.

The haemogram is one of the physiological stress indicators for transportation in camels (El Khasmi *et al,* 2013). The values of the control group were consistent with haematological values obtained in camels in Saudi Arabia (Al-Sultan, 2008). Camels have small, elliptical RBCs and a lower HCT % compared with other mammalian RBCs (Farooq *et al,* 2011). The data showed that the HCT % was significantly higher in the camels transported short-distance than in the control group. Moreover, the HCT % of the camels in the long-distance transport group was not significantly different from that of the control group. A previous study reported that the elevation of HCT % in animals might be attributed to haemoconcentration associated with splenic contraction induced by catecholamines (Tadich *et al,* 2005). It has been observed that HCT % may be increased during the handling and manipulation of animals (Tadich *et al,* 2005). The camel blood HGB concentration recorded in this study is in accordance with the values previously reported in Saudi Arabia byAl-Busadah (2007), in Iraq by Alsaad (2009) and in Iran by Ahmad *et al* (2004).

The blood index values (MCV, MCH and MCHC) and RBC count of the camels were similar to the reference values of Farooq *et al* (2011). Neither short-nor long-distance lorry transportation showed any significant difference from the control group. The HGB concentration of the camels after short-distance lorry transportation was significantly higher than that of the control group. However, there was no significant difference in HGB concentration between the camels after long transportation and the control

Table 4. Effect of short and long lorry transportation distance on total T3, T4 and TSH of symptomatically hyperglycaemic dromedary camels.

Groups	Control		Short-distance lorry transportation		Long-distance lorry transportation	
Parameters	**Mean**	**SE(±)**	**Mean**	**SE (±)**	**Mean**	**SE(±)**
Total T3 (ng/dL)	144.60	10.40	107.21[a]	33.91	214.2[b]	59.51
Total T4 (ug/dL)	10.46	0.76	9.98	2.46	18.52[a]	4.32
TSH (uIU/mL)	0.05	0.04	0.05	0.04	0.04[a]	0.02

[a, b] Mean values of the short and long lorry transportation distance groups differed significantly from the value of the control group in the same row at P <0.05 and P <0.01, respectively.

Table 5. Effect of short and long lorry transportation distance on serum antioxidant enzymes of symptomatically hyperglycaemic dromedary camels.

Groups	Control		Short-distance lorry transportation		Long-distance lorry transportation	
Parameters	**Mean**	**SE(±)**	**Mean**	**SE (±)**	**Mean**	**SE(±)**
SOD (U/mL)	305.51	5.89	232.72[a]	17.65	175.70[b]	31.50
CAT (u/L)	288.0	23.11	380.12[a]	36.11	602.32[b]	66.86
TAC (mM/L)	1.767	0.260	3.118[a]	0.528	2.701[a]	0.426

[a, b] Mean values of the short and long lorry transportation distance groups differed significantly from the value of the control group in the same row at P <0.05 and P <0.01, respectively.

group. The blood index values are in agreement with the previous works of Al-Sultan (2008) and Alsaad (2009) on camels. The variation in blood index values might be attributed to variable RBC size, age and physiological state.

The mean WBC count values recorded for the control animals in the present study were comparable to those reported by Ahmad *et al* (2004) and Alsaad (2009) and lower than those reported by Al-Busadah (2007) and Al-Sultan (2008). The WBC count of camels after short-distance lorry transportation was significantly higher than in the control group, which may be attributed to transportation stress, as reported in early studies (Tadich *et al,* 2005). However, there was no significant difference in WBC count after long-haul lorry transportation and in the control camels. Similar findings were presented by Minka and Ayo (2010). El Khasmi *et al* (2013) found no significant changes in WBC counts in camels transported under heat stress. Al-Wabel (2010) reported that the total WBC count in camels was not affected by the stressful conditions of transportation.

Differential leukocyte counts in the present study indicated that in the control group, lymphocyte were the most predominant leukocytes, followed by neutrophil, as has been previously reported (Al-Busadah, 2007) and contradictory to AL-Sultan (2008) and Al-Busadah and Osman (2000). Variation in the white cell values could be attributed to the differences in breeds or the stress of sample collection (Higgins and Kock, 1984). There was a significant decline in the lymphocyte count of the camels after short-haul lorry transportation when compared to the control group. On the other hand, no significant difference was seen between lymphocyte counts in the camels after long-haul lorry transportation and in the control camels. In addition, the monocyte count did not significantly differ among all three camel groups. However, the neutrophil count was significantly higher in the camels after both short- and long-distance lorry transportation compared with the control group. In contrast, the EOS count was significantly lower in both short- and long-distance lorry transported animals than in the control group. The observation of neutrophilia and lymphocytopeniain camels transported by lorry in the present study is supported by a previous study (Minka and Ayo, 2007). Al-Wabel (2010) found that transportation stress had no effect on the neutrophil counting camels, whereas it caused a slight reduction in the lymphocyte counts.

Endocrine responses constitute late response to stressors after nervous reflexes. Stress can affect the endocrine balancing of the essential parameters of production, metabolism, immunity and even growth. Hormonal signals play a pivotal role in homeostasis. Appropriate thyroid function and hormonal activity perform an essential task in the mechanisms that allow domestic animals to live and breed effectively (Todini, 2007). Many external factors are capable of

altering thyroid hormone concentrations by acting on the hypothalamus, pituitary and/or thyroid gland itself (Todini, 2007). A change in the thyroid blood concentrations has been used as an indicator of the stress response (Saeb *et al,* 2010). The serum concentrations of T4 and T3 in the control group parallel values reported earlier (Nazifi *et al,* 2009). The data obtained showed a significant increase of T3 and T4 levels in the serum of the symptomatically hyperglycaemic dromedary camels after long-distance lorry transportation compared to the control group. However, TSH levels in the camels after long-distance lorry transportation were significantly lower than in the control camels. Physiologically, as blood concentrations of T3 and T4 increase, both T3 and T4 inhibit TSH and as a result, the TSH level decreased during the long-distance transportation. These results are consistent with other studies which have shown that after long-distance lorry transport, T4 levels were elevated in Limousin calves (Fazio *et al,* 2001) and cattle (Fazio *et al,* 2005). In addition, Hartung (2003) stated that transportation stress might reduce animal fitness by inducing dysfunction of the pituitary and thyroid glands. The T3 and T4 variation during transportation may suggest the possible effect of stress on thyroid hormones (Saeb *et al,* 2010). Saeb *et al* (2010) found no significant change in serum T3 in camels; however, T4 increased after 1h of transportation, while T3 and T4 showed a significant increase after 5h of transport.

Antioxidant enzyme activities are major markers of oxidative stress. Results showed the effects of short- and long-haul lorry transportation on the activity of SOD, CAT and TAC in the symptomatically hyperglycaemic dromedary camels. A significant decrease was seen in SOD activity in camels after short- and long-distance lorry transportation compared to the control group. Meanwhile, CAT and TAC activity were significantly higher in the camels after short- and long-haul lorry transportation than in the control group. It has been suggested that the increase in both CAS and TAC acted as a compensation factor to balance the production of free radicals during the stress of transportation (Padalino *et al,* 2017). Both elevated and lowered antioxidant enzyme activities have been reported under different conditions as a result of enhanced reactive oxygen species (ROS) production, either by up-regulation of enzyme activity or depletion due to fighting the ROS during stress (El Khasmi *et al,* 2015). Pronounced deviations in the levels of ROS scavengers and free radical generation following or during stress have been noted in the serum of camels (Kataria *et al,* 2010). Transportation stress in camels leads to an increase in catalase activity (Nazifi *et al,* 2009). However, further studies should be focused on understanding the character of particular antioxidant enzymes in the tissues and under different stressful conditions.

In conclusion, this study has confirmed that the stress of long-distance lorry transport can be considered somewhat similar to severe stress. The altered thyroid hormone levels and changes in the physiological metabolic profiles taken together may be effective biomarkers of transportation stress in this species. Present study conclude that pathophysiological changes may result from the transportation-induced stress in hyperglycaemic animals.

Acknowledgements

The author would like to thank staff members of the Veterinary Teaching Hospital at Qassim University, KSA, for providing the animals and facilities.

References

Ahmad S, Butt AA, Muhammad G, Athar M and Khan MZ (2004). Haematobiochemical studies on the haemoparasitised camels. International Journal of Agricultural and Biological Engineering 6:331-334.

Aichouni A, Belhadia M, Kebir N and Aggad H (2013). Season influence on serum organic parameters of dromedarius (*Camelus dromedarius*) in Algeria. Biochemistry and Biotechnology Research 1:8-12.

Al-Busadah KA (2007). Some biochemical and haematological indices in different breeds of camels in Saudi Arabia. Scientific Journal of King Faisal University (Basic and Applied Sciences) 8:1428H.

Al-Busadah KA and Osman TEA (2000). Haematological parameters of adult dry, lactating and camel calves in Saudi Arabia. Pakistan Journal of Biological Sciences 3:1749-1751.

Almundarij TI, Gavini CK and Novak CM (2017). Suppressed sympathetic outflow to skeletal muscle, muscle thermogenesis and activity energy expenditure with calorie restriction. Physiological Reports 5.

Alsaad KM (2009). Clinical, hematological and biochemical studies of anaplasmosis in Arabian one humped camels (*Camelus dromedarius*). Journal of Animal and Veterinary Advances 8:2106-2109.

Al-Sultan SI (2008). Studies on Haematological and Certain Serum Biochemeical Values in Young Magaheim Dromedary Camels at Al-Ahsa Province.Veterinary Research 2:34-37.

Al-Wabel NA (2010). Transportation stress in camels and goats. Journal of Agricultural and Veterinary Sciences Qassim University 3(1)43-48.

Aoyama M, Negishi A, Abe A, Yokoyama R, Ichimaru T and Sugita S (2008). Physiological and behavioural effects

of an intracerebro-ventricular injection of corticotropin releasing hormone in goats. Veterinary Journal 177: 116-123.

Bassett JM (1970). Metabolic effects of catecholamines in sheep. Australian Journal of Biological Sciences 23:903-914.

Bernardini D, Gerardi G, Peli A, Nanni Costa L, Amadori M and Segato S (2012). The effects of different environmental conditions on thermoregulation and clinical and haematological variables in long-distance road-transported calves. Journal of Animal Science 90: 1183-1191.

Chacon G, Garcia-Belenguer S, Villarroel M and Maria GA (2005). Effect of transport stress on physiological responses of male bovines. Deutsche Tierarztliche Wochenschrift 112:465-469.

Earley B, Murray M, Prendiville DJ, Pintado B, Borque C and Canali E (2012). The effect of transport by road and sea on physiology, immunity and behaviour of beef cattle. Research in Veterinary Science 92:531-541.

El Khasmi M, Chakir Y, Riad F, Safwate A, Tahri E-H, Farh M, El Abbadi N, Abouhafs R and Faye B (2013). Effects of transportation stress during the hot-dry season on some haematological and physiological parameters in Moroccan dromedary camels (*Camelus dromedarius*). Journal of Life Sciences 7:13.

El Khasmi M, Chakir Y, Bargaâ R, Barka K, Lektib I, El Abbadi N, Belhuari A and Faye B (2015). Impact of transport distance on stress biomarkers levels in dromedary camel (*Camelus dromedarius*). Emirates Journal of Food and Agriculture 27:507.

Eshratkhah B, Sadaghian M, Eshratkhah S, Pourrabbi S and Najafian K (2010). Relationship between the blood thyroid hormones and lipid profile in Moghani sheep: Influence of age and sex. Comparative Clinical Pathology 19:15-20.

Eskandarzadeh N, Saeb M, Nazifi S, Saeb S and Ansari-Lari M (2014). The effect of short term starvation on galanin, leptin, thyroid hormones, insulin, prolactin, growth hormone, ghrelin and factors involved in energy metabolism in adult goats. Research Opinions in Animal and Veterinary Sciences 4:258-263.

Farooq U, Samad HA, Khurshid A and Sajjad S (2011). Normal reference haematological values of one-humped camels (*Camelus dromedarius*) kept in Cholistan desert. Journal of Animal and Plant Sciences 21:157-160.

Faye B (2015). Role, distribution and perspective of camel breeding in the 3rd millenium economies. Emirates Journal of Food and Agriculture 27:318.

Fazio E, Alberghina D, Medica P, Cavalieri S and Ferlazzo A (2001). Total and free iodothyronine levels before and after short and long distance road transport in Limousin calves. Biotechnology, Agronomy Society and Environment 5:76-77.

Fazio E, Medica P, Alberghina D, Cavaleri S and Ferlazzo A (2005). Effect of long-distance road transport on thyroid and adrenal function and haematocrit values in Limousin cattle: influence of body weight decrease. Veterinary Research Communications 29:713-719.

Hartung J(2003). Effects of transport on health of farm animals. Veterinary Research Communications 27:525-527.

Higgins AJ and Kock RA (1984). I. A guide to the clinical examination, chemical restraint and medication of the camel. British Veterinary Journal 140:485-504.

Ingram JR and Matthews LR (2000). Hands-on and hands-off measurement of stress.The biology of animal stress: Basic principles and implications for animal welfare. CABI Publishing, Wallingford, UK. pp 123-146.

Kadim IT, Mahgoub O, Al-Marzooqi W, Khalaf SK, Mansour MH, Al-Sinani SSH and Al-Amri IS (2009). Effects of electrical stimulation on histochemical muscle fiber staining, quality and composition of camel and cattle *Longissimus thoracis* muscles. Journal of Food Science 74.

Kaneko JJ, Harvey JW and Bruss ML(2008). Clinical Biochemistry of Domestic Animals. Academic Press.

Kannan G, Terrill TH, Kouakou B and Galipalli S (2007). Blood metabolite changes and live weight loss following brown seaweed extract supplementation in goats subjected to stress. Small Ruminant Research 73:228-234.

Kataria N and Kataria AK (2004). Use of blood analytes in assessment of stress due to drought in camel. Journal of Camel Practice and Research 11:129-133.

Kataria N, Kataria AK, Pandey N and Gupta P (2010). Serum biomarkers of physiological defense against reactive oxygen species during environmental stress in Indian dromedaries. Human and Veterinary Medicine 2.

Križanović D, Sušić V, Božić P, Štoković I and Ekert-Kabalin A (2008). Changes of bovine blood lipid peroxides and some antioxidants in the course of growth. Veterinarski arhiv 78:269-278.

Maejima Y, Aoyama M, Kobayashi N and Sugita S (2006). Adrenocorticotropic hormone-induced secretion of cortisol in goats is inhibited by androgen. Animal Science Journal 77:87-94.

Minka NS and Ayo JO (2010). Physiological responses of erythrocytes of goats to transportation and the mondulatory role of ascorbic acid. Journal of Veterinary Medical Science 72:875-881.

Minka NS and Ayo JO (2007). Effects of loading behaviour and road transport stress on traumatic injuries in cattle transported by road during the hot-dry season. Livestock Science 107:91-95.

Nazifi S, Saeb M, Baghshani H and Saeb S(2009). Influence of road transportation during hot summer conditions on oxidative status biomarkers in Iranian dromedary camels (*Camelus dromedarius*). African Journal of Biochemistry Research 3:282-287.

O'Malley BW (1971). Mechanisms of action of steroid hormones. New England Journal of Medicine 284: 370-377.

Padalino B, Hall E, Raidal S, Celi P, Knight P, Jeffcott L and Muscatello G (2015). Health problems and risk factors associated with long haul transport of horses in Australia. Animals 5:1296-1310.

Padalino B, Raidal SL, Carter N, Celi P, Muscatello G, Jeffcott L and de Silva K (2017). Immunological, clinical,

haematological and oxidative responses to long distance transportation in horses. Research in Veterinary Science 115:78-87.

Parker AJ, Hamlin GP, Coleman CL and Fitzpatrick LA (2003). Quantitative analysis of acid-base balance in *Bos indicus* steers subjected to transportation of long duration. Journal of Animal Science 81:1434-1439.

Parrott RF, Misson BH and De la Riva CF (1994). Differential stressor effects on the concentrations of cortisol, prolactin and catecholamines in the blood of sheep. Research in Veterinary Science 56:234-239.

Poonia R, Srivastava A, Sena S and Srivastava M (2016). Study on certain blood and serum parameters of camel (*Camelus dromedarius*) maintained on different diets. UK Journal of Pharmaceutical and Biosciences 4:12-18.

Saeb M, Baghshani H, Nazifi S and Saeb S (2010). Physiological response of dromedary camels to road transportation in relation to circulating levels of cortisol, thyroid hormones and some serum biochemical parameters. Tropical Animal Health and Production 42:55.

Sanders VM and Straub RH (2002). Norepinephrine, the β-adrenergic receptor and immunity. Brain, Behaviour and Immunity 16:290-332.

Tadich N, Gallo C, Bustamante H, Schwerter M and Van Schaik G (2005). Effects of transport and lairage time on some blood constituents of Friesian-cross steers in Chile. Livestock Production Science 93:223-233.

Todini L (2007). Thyroid hormones in small ruminants: effects of endogenous, environmental and nutritional factors. Animal 1:997-1008.

Waas JR, Ingram JR and Matthews LR (1997). Physiological responses of red deer (*Cervus elaphus*) to conditions experienced during road transport. Physiology and Behaviour 61:931-938.

Wensvoort J, Kyle DJ, Orskov ER and Bourke DA (2004). Biochemical adaptation of camelids during fasting. Journal of Camel Science 1:63.