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Physiological relationship between thyroid hormones and serum biochemical profile in clinically healthy bactrian camel (*Camelus bactrianus*)

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Abstract

To evaluate both thyroid hormones status in different ages and sexes of Bactrian camel (*Camelus bactrianus*) and the correlations between these hormones and some biochemical parameters, such as electrolytes, lipids, glucose, BUN, and creatinine, these parameters were measured in twenty-six adult camels. The camels in two sexes (male= 18 and female= 8), aged between 2 and 11 years old (2-4 years old= 8, 5-8 years old= 9, and 9-11 years old= 9) were chosen for this study. Significant differences were detected for the thyroid hormones between the two sexes and among the different age groups of camels. Also, there were significant correlations between these hormones and phosphorus, Fe, Na, K, Mg, cholesterol, triglyceride, LDL, HDL, urea, creatinine, and glucose. The cause of these findings and some contradictory findings regarding the relation between serum thyroid hormones, triglyceride and cholesterol are not clear and could be due to the effect of some factors such as breed, geography and diet on serum profiles of sampled groups. More research is needed to evaluate these parameters in *Camelus bactrianus*.

Key words: Thyroid hormones, Biochemical parameters, Bactrian camel (*Camelus bactrianus*)

Introduction

A wide variety of metabolic activity is regulated by thyroid hormones (Aziz Khan et al. 2014). Normal thyroid function has a significant influence on cellular activity, basal metabolic rate, and general body metabolism. Accordingly, dyslipidemia and disturbed mineral metabolism can be the result of thyroid dysfunction (Abdelgayoum 2014). A decrease in glomerular filtration rate was observed in experimental animals for which hypothyroidism was induced by drug administration (Bansalet al. 2014). Besides, several studies have confirmed the involvement of thyroid hormone in protein metabolism (Huszenicza et al. 2002). Increment of some enzyme activities following of thyroid hormone effect, can lead to elevating lipolysis in adipose tissue and lipogenesis (Eshratkhah et al. 2009). Commonly the amount of serum cholesterol changes inversely with thyroid activity (Bruss 2008, Gueorguieva and Gueorguiev

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1997), however, there are a few inconsistent findings regarding the relationship between serum thyroid hormones, on one hand, and cholesterol and triglycerides, on the other hand, in camels. Some studies demonstrate that the serum concentration of thyroid hormones is not dependent on cholesterol levels in male camels (Wasfi et al. 1987). However, Nazifi et al. (2009) found a positive correlation between serum thyroid hormones and cholesterol in male dromedary camels (Nazifi et al. 2009). *Camelus bactrianus*, also known as the Bactrian camel, inhibits parts of central Asia and western China. The distinguishing characteristic that sets Bactrian camel apart from dromedary camels is that they have two humps on their backs. There is little known concerning the serum lipids, protein, electrolytes, blood urea nitrogen, creatinine, glucose, and the relationship between these parameters and thyroid hormones in this species. Based on our findings, there has been no previous study examining the consequence of age and sex on serum biochemical profiles in Bactrian camels. Therefore, this study was undertaken to investigate the effects of age and sex on the serum thyroid hormones and biochemical profiles and the relationship between these parameters in Bactrian camels.

Materials and Methods

Animals and blood sampling

This study was conducted on female and male Iranian two-humped camels (*Camelus bactrianus*). The camels were reared at the research center devoted to Bactrian camels, in Ardabil province, Northwest Iran. Twenty-six adult camels in two sexes (male= 18 and female= 8), aged between 2 and 11 years old (2-4 years old= 8, 5-8 years old= 9, and 9-11 years old= 9) were chosen for this study. The age of the animals was assessed using dental features. Internal and external parasites were not detected in the animal examination and they were clinically healthy. Examination of the internal and external parasites were done using routine parasitological tests (fecal examination, blood smears and skin ectoparasites). The blood sample was collected into a 10-ml vacuum tube, chilled immediately after sampling, and transported to the laboratory within 1 h after the collection. Serum was harvested after centrifugation at 750 *g* for 15 minutes, and stored at -21°C until analysis.

Animal ethics

All animal experiments were approved by the State Committee on Animal Ethics, Shiraz University, Shiraz, Iran (IACUC no: 4687/63). The recommendations of the European Council Directive (86/609/EC) of November 24, 1986, regarding the standards in the protection of animals used for experimental purposes, were also followed.

Measurement of the parameters

Serum levels of triiodothyronine (T3), thyroxine (T4), free triiodothyronine (fT3) and free thyroxine (fT4) were measured by a quantitative sandwich enzyme immunoassay using commercial camel-specific kits (Shanghai Crystal Day Biotech, Shanghai, China). Serum biochemical parameters including blood urea nitrogen (BUN), creatinine, glucose, cholesterol, triglyceride, HDL-cholesterol, LDL-cholesterol, total protein, albumin, AST and ALT were measured using standard methods and commercial kits (Pars Azmoon Co., Tehran, Iran), and a biochemical auto analyzer (Alpha Classic AT^{++}, Sanjesh, Iran). The globulin values were calculated by subtracting albumin values from the total protein. To evaluate the serum concentration of elements, the digestion of serum was performed by a mixture of perchloric acid and nitric acid (3:7 ratio respectively). Then, Ca, P , Mg and Fe were measured using an atomic absorption spectrophotometer (Shimadzu AA-670, Kyoto, Japan).Serum concentration of sodium and potassium were measured using an flame photometer

apparatus (Fater Electron Company, Tehran, Iran).

Statistical analysis

Statistical analysis was accomplished using SPSS (Version 12.0; SPSS, Chicago, USA). Two sample t-test was used to detect differences in the parameters between the two sexes. Correlations were analyzed by Pearson's correlation tests and analysis of variance (ANOVA) tests were used to compare the serum concentrations of the measured factors among different age groups. Differences were considered significant at $P<0.05$.

Results

The concentration of serum thyroid hormones (T3, T4, fT3, and fT4) in two sexes of clinically healthy Bactrian camel (*Camelus bactrianus*) is shown in Table 1. There was a significant difference in the concentration of T3, T4 and fT3 in two sexes of clinically healthy Bactrian camel (*Camelus bactrianus*).

The concentration of serum thyroid hormones (T3, T4, fT3, and fT4) in different age groups of clinically healthy Bactrian camel (*Camelus bactrianus*) is shown in Table 2. There was a significant difference in the concentration of fT4 among different age groups of clinically healthy Bactrian camel (*Camelus bactrianus*).

The concentration of serum biochemical parameters in two sexes of clinically healthy Bactrian camel (*Camelus bactrianus*) is shown in Table 3. There was a significant difference in the concentration of urea, LDL-cholesterol, phosphorus and magnesium in two sexes of clinically healthy Bactrian camel (*Camelus bactrianus*).

The concentration of serum biochemical parameters in different age groups of clinically healthy Bactrian camel (*Camelus bactrianus*) is shown in Table 4. There was a significant difference in the concentration of urea, albumin, and magnesium in different age groups of clinically healthy Bactrian camel (*Camelus bactrianus*).

Moreover, we found a statistically significant positive correlation between T3 and phosphorus ($r=0.934$; $P<0.01$), Fe ($r=0.789$; $P<0.05$), cholesterol ($r=0.908$; $P<0.01$), urea ($r=0.890$; $P<0.01$), creatinine ($r=0.765$; $P<0.05$); T4 and phosphorus ($r=0.539$; $P<0.05$), glucose ($r=0.826$; $P<0.05$), Fe ($r=0.793$; $P<0.05$), cholesterol ($r=0.970$; $P<0.01$), LDL ($r=0.796$; $P<0.01$), triglyceride ($r=.730$; $P<.05$), creatinine ($r=0.858$; $P<0.01$), HDL ($r=0.809$; $P<0.01$); fT3 and creatinine ($r=0.427$; $P<0.05$), Na ($r=0.549$; $P<0.05$), K ($r=.458$; $P<.05$), triglyceride ($r=0.740$; $P<0.05$); and fT4 and urea ($r=0.798$; $P<0.01$), Fe ($r=0.518$; $P<0.01$), Mg ($r=0.668$; $P<0.01$), cholesterol ($r=0.476$; $P<0.05$), HDL ($r=0.836$; $P<0.01$), creatinine ($r=0.790$; $P<0.05$).

Table 1: Mean±SE of the concentration of serum thyroid hormones (T3, T4, fT3, and fT4) in two sexes of clinically healthy Bactrian camel (*Camelus bactrianus*)

Factor / Sex	T3 (ng/dl)	T4 (µg/dl)	fT3 (pg/ml)	fT4 (ng/dl)
Male (n=18)	2.53 ± 0.19^{a}	13.04 ± 0.65^{a}	5.38 ± 0.58^{a}	2.78 ± 0.27^{a}
Female (n=8)	2.21 ± 0.54^{b}	9.59 ± 1.21^{b}	3.28 ± 0.45^{b}	2.12 ± 0.22^{a}

Different letters in each column demonstrate significant differences ($P<0.05$).

Table 2: Mean±SE of concentration of serum thyroid hormones (T3, T4, fT3, and fT4) in different age groups of clinically healthy Bactrian camel (*Camelus bactrianus*)

Factor / Age (year)	T3 (ng/dl)	T4 (µg/dl)	fT3 (pg/ml)	fT4 (ng/dl)
2-4 (n= 8)	2.63 ± 0.28[a]	11.87 ± 0.57[a]	4.53 ± 0.79[a]	1.80 ± 0.21[a]
5-8 (n= 9)	2.49 ± 0.29[a]	14.31 ± 1.07[ab]	5.74 ± 0.83[a]	3.45 ± 0.36[b]
9-11 (n= 9)	2.20 ± 0.48[a]	9.75 ± 1.08[ac]	3.91 ± 0.75[a]	2.19 ± 0.21[ac]

Different letters in each column demonstrate significant differences (P<0.05).

Table 3: Mean±SE of serum biochemical parameters in two sexes of clinically healthy Bactrian camel (*Camelus bactrianus*)

Factor / Sex	Glucose (mg/dl)	Urea (mg/dl)	Creatinine (mg/dl)	TG (mg/dl)	Cholesterol (mg/dl)	HDL (mg/dl)
Male (n=18)	70.80±4.29[a]	63.66±4.54[a]	1.28±0.043[a]	26.41±2.13[a]	44.11±2.47[a]	9.47±0.44[a]
Female (n=8)	65.25±5.34[a]	42.63±5.23[b]	1.76±0.39[a]	29.87±4.58[a]	38.75±3.36[a]	10.86±0.46[a]

Different letters in each column demonstrate significant differences (P<0.05).

Continued Table 3:

Factor / Sex	LDL (mg/dl)	TP (g/dl)	ALB (g/dl)	GLB (g/dl)	AST (U/L)	ALT (U/L
Male (n=18)	32.69±1.98[a]	6.16±0.19[a]	4.76±0.14[a]	1.39±0.13[a]	40.33±0.42[a]	39.43±0.52[a]
Female (n=8)	24.77±1.95[b]	5.89±0.41[a]	4.62±0.27[a]	1.27±0.19[a]	39.51±0.57[a]	38.79±0.80[a]

Different letters in each column demonstrate significant differences (P<0.05).

Continued Table 3:

Factor / Sex	Na (mmol/l)	K (mmol/l)	Ca (mg/dl)	P (mg/dl)	Mg (mg/dl)	Fe (µg/dl)
Male (n=18)	128.67±3.15[a]	6.73±0.34[a]	11.49±0.27[a]	8.27±0.43[a]	2.86±0.07[a]	70.6±4.40[a]
Female (n=8)	134.50±8.64[a]	7.60±0.52[a]	12.01±0.57[a]	6.47±0.52[b]	2.54±0.12[b]	58.68±7.93[a]

Different letters in each column demonstrate significant differences (P<0.05).

Table 4: Mean±SE of serum biochemical parameters in different age groups of clinically healthy Bactrian camel (*Camelus bactrianus*)

Factor / Age (year)	Glucose (mg/dl)	Urea (mg/dl)	Creatinine (mg/dl)	TG (mg/dl)	Cholesterol (mg/dl)	HDL (mg/dl)
2-4 (n= 8)	66.68±3.95[a]	80.68±3.77[a]	1.36±0.06[a]	30.50±3.25[a]	39.93±3.99[a]	9.48±0.93[a]
5-8 (n= 9)	74.66±7.89[a]	49.66±4.30[b]	1.24±0.05[a]	23.10±2.79[a]	48.83±2.78[a]	9.51±0.40[a]
9-11 (n= 9)	65.66±4.73[a]	43.84±4.76[b]	1.69±0.35[a]	29.16±4.1[a]	38.33±2.99[a]	10.65±0.46[a]

Different letters in each column demonstrate significant differences (P<0.05).

Continued Table 4:

Factor / Age (year)	LDL (mg/dl)	TP (g/dl)	ALB (g/dl)	GLB (g/dl)	AST (U/L)	ALT (U/L)
2-4 (n= 8)	31.12±3.57[a]	6.58±0.26[a]	5.23±0.19[a]	1.34±0.12[a]	40.23±0.68[a]	39.07±0.92[a]
5-8 (n= 9)	35.38±1.94[ab]	5.92±0.23[a]	4.46±0.12[b]	1.46±0.25[a]	40.40±0.63[a]	39.60±0.67[a]
9-11 (n= 9)	24.35±1.77[ac]	5.79±0.37[a]	4.52±0.26[b]	1.26±0.17[a]	39.63±0.51[a]	39.02±0.74[a]

Different letters in each column demonstrate significant differences (P<0.05).

Continued Table 4:

Factor / Age (year)	Na (mmol/l)	K (mmol/l)	Ca (mg/dl)	P (mg/dl)	Mg (mg/dl)	Fe (µg/dl)
2-4 (n= 8)	125.88±3.39[a]	6.12±0.52[a]	11.58±0.31[a]	8.22±0.68[a]	3.13±0.05[a]	68.62±2.49[a]
5-8 (n= 9)	132.33±5.41[a]	7.32±0.45[a]	11.57±0.45[a]	8.62±0.57[ab]	2.66±0.06[b]	74.77±8.33[a]
9-11 (n= 9)	132.67±7.83[a]	7.46±0.48[a]	11.78±0.55[a]	6.36±0.47[ac]	2.54±0.11[ac]	57.77±7.06[a]

Different letters in each column demonstrate significant differences (P<0.05).

Discussion

In our study, age had a considerable consequence on the serum level of fT4. This finding is consistent with other studies conducted with different animals. Nazifi et al. (2002) showed that there were significant differences between age and T3 and T4 in Iranian goats. In another study, serum T4 and T3 levels raised in buffalo heifers in the first months of life (Kumar and Rattan, 1992). But, Tajik et al. (2013) detected no significant differences between the different age groups in serum levels of thyroid hormones in dromedary camels.

There was a significant difference in the concentration of T3, T4 and fT3 in two sexes of clinically healthy Bactrian camels. In contrast, in their study, Tajik et al. (Tajik et al. 2013) showed that there were no significant differences for serum thyroid hormones between the sexes. Moreover, in Turkoman horses, sheep, and water buffaloes sex does not affect the thyroid hormones (Nazifi et al. 2003, Eshratkhah et al. 2009, Tajik et al. 2011).

Aurthor and Beckett (1999) claimed that dietary intakes of electrolytes could affect thyroid hormone metabolism. In our study, some correlations between thyroid hormones and electrolytes were observed. This finding can be explained with the regulation effect of thyroid hormones on some electrolytes. For instance, fT3 promotes renal phosphate reabsorption and serum phosphate levels in rats (Alcalde et al.1999). Some previous studies have mentioned that hypothyroidism can cause hyponatremia (Adrogue and Madias 2000, Funk et al. 2010, Greenberg et al. 2010, Gross et al. 2011). Yousif et al. (2017) reported that Na+ and K+ significantly higher in grazing camels compared with the penned camels while Ca+ significantly lower in grazing camels compared with the penned ones. The higher values for serum Na+ and K+ in free grazing camels compared with penned ones could be due to the free grazing camels graze on plants rich in this mineral and or/ and may be contaminated with the soil. The results showed that Mg+, Na+ and K+ did not vary with the physiological status, while Ca++ significantly higher in non-pregnant camels compared with pregnant ones. The reduction of Ca++ in pregnant camels is attributing to the formation of the fetus bones.

In the current study, we observed some significant correlations between thyroid hormones and BUN and creatinine. Thyroid hormones stimulate the synthesis as well as the degradation of proteins (Müller and Seitz 1984). Also, in pilot animals, there are some reports about the effect of amiodarone-induced hypothyroidism on renal diseases, which is reversible upon amiodarone-withdrawal (Luciani et al. 2009). It was also stated that hypothyroidism can boost the impaired kidney function, and thyroxine therapy can correct it (Makino et al. 2000). These data can justify the positive correlation between thyroid hormones and BUN and creatinine in this study.

Beitz (2004) stated that the effect of adrenal corticoids on mobilization of amino acids from body proteins during pregnancy is associated with an increased rate of hepatic deamination. With insufficient water supplies, there is an evidence of an increase in blood total protein, albumin, and urea concentration along with the pregnancy progress (El-Sherif and Assad 2001, Poljicak 2009). Rodriguez et al. (1996) found that glomerular filtration and urea clearance were significantly reduced during late pregnancy.

The positive correlation between thyroid hormones and glucose was confirmed in our study.

Some investigations have shown that thyroid disorders are related to insulin resistance, which has been resulted in impaired glucose metabolism in type 2 diabetes mellitus (Abdelgayoum 2014). The most probable mechanism of diabetes in thyroid dysfunction was claimed to be the disturbing genetic expression with

decreased glucose consumption in muscles, high hepatic glucose production and increased visceral glucose absorption (Wang 2013).

The serum cholesterol level normally varies inversely with thyroid activity (Bartley 1989). In this study, we surprisingly observed a positive correlation between lipid factors and thyroid hormones. Our finding was similar to that of a study carried out by Nazifi et al. (2009), who showed that there was a significant positive correlation between some parameters of lipid profiles and thyroid hormone concentrations in clinically healthy camels (Nazifi et al. 2009). In general, thyroid hormones can have an influence on lipid peroxidation and decrease serum lipid concentration. Some studies have confirmed this point. Serum T4 had a negative correlation with triglyceride; in male camels, it had a low significant relationship with cholesterol in *Camelus dromedaries* (Tajik et al. 2013). Gueorguieva and Gueorguieva (1997) reported that in dairy cow's serum cholesterol was steadily and negatively correlated with serum T4 and T3 levels. However, species variations exist, and even within species, considerable differences could occur (Nazifi et al. 2005). For instance, Nazifi et al. (2002) and Wasfi et al. (1987) claimed that the concentrations of thyroid hormones and cholesterol were not significantly correlated in camels and clinically healthy Iranian male goats. These discrepancies can be attributed to the animals' hydration status (Nazifi et al. 2009). In a study, Khanna et al. (1996) showed that the T4 concentrations decreased in summer while dehydration status and the T4 concentrations increased after rehydration. However, the accurate reason for such findings has not been explained yet.

This study was the first investigation examining the effects of age and sex on the serum thyroid hormones and biochemical profiles and the relationships between these parameters in Bactrian camels (*Camelus bactrianus*). In conclusion, significant differences were observed for the thyroid hormones between the two sexes and among the different age groups of *Camelus bactrianus*. Furthermore, there were significant correlations between these hormones and phosphorus, Fe, Na, K, Mg, cholesterol, triglyceride, LDL, HDL, urea, creatinine and glucose. Some of these observations are in line with the findings of other studies. The cause of these findings and some contradictory findings regarding the relation between serum thyroid hormones, triglyceride and cholesterol are not clear and may be due to the effect of some factors such as breed, geography and diet on serum profiles of sampled groups. More research is needed to evaluate these parameters in *Camelus bactrianus*.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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References

Aziz Khan, F.; Patil, S.K.B. and Thakur, A.S. (2014). Lipid profile in thyroid dysfunction: A study on patients of Bastar. Journal of Clinical and Analytical Medicine, 5: 12-14.

Abdelgayoum, A.A.G. (2014). Dyslipidemia and serum mineral profiles in patients with thyroid disorders. Saudi Medical Journal, 35 (12):1469-1476.

Alcalde, A.I.; Sarasa, M.; Raldua, D.; Aramayona, J.; Morales, R. and Biber, J. (1999). Role of thyroid hormone in regulation of renal phosphate transport in young and aged rats. Endocrinology, 140(4):1544-1551.

Adrogue, H.J. and Madias, N.E. (2000). Hypernatremia. The New England Journal of Medicine,342(20):1493-1499.

Aurthor, J.R. and Beckett, G.J. (1999). Thyroid function. British Medical Bulletin, 55: 658-668.

Bansal, A.; Kaushik, A. and Sarathe, H. (2014). Effect of thyroid on lipid profile and renal function: An observational study from Tertiary Care Centre of Tribal Region of Bastar. The Annals of Medical and Health Science Research, 4 (Suppl 2): S140-S143.

Bartley, J.C. (1989). Lipid metabolism and its diseases. In: Clinical Biochemistry of Domestic Animals. 4th ed, Kaneko JJ, Academic Press Inc., New York. USA, 106-141.

Beitz, D.C. (2004). Protein and amino acid metabolism. In: Duke's Physiology of Domestic Animals. Reece W.O. (ed.). Cornell University Press, Ithaca, USA. P: 535-553.

Bruss, M.L. (2008). Lipids and Ketones. In: Clinical Biochemistry of Domestic Animals, 6th edn., Kaneko JJ, Harvey JW, Bruss ML (Eds.). Academic Press Inc., New York, USA., ISBN: 13-978-0-12-370791-7, Pp: 81-116.

El-Sherif, M.M.A. and Assad, F. (2001). Changes in some blood constituents of Barki ewes duringpregnancy and lactation under semi-arid conditions. Small Ruminant Research, 40: 269-277.

Eshratkhah, B.; Sadaghian, M. and Eshratkhah, S. (2009). Relationship between the blood thyroid hormones and lipid profile in Moghani sheep: Influence of age and sex. Comparative Clinical Pathology, 19(1): 15-20.

Funk, G.C.; Lindner, G.; Druml, W.; Metnitz, B.; Schwarz, C. and Bauer, P. (2010). Incidence and prognosis of dysnatremias present on ICU admission. Intensive Care Medicine, 36 (2):304-311.

Greenberg, A.; Adrogue, H.J.; Aggarwal, N.; Allon, M.; Anderson, S. and Andreoli, S.P. (2010). A primer on kidney diseases. ElSevier Health Science, 5th Edition.

Gross, P.; Benzing, T.; Hensen, J. and Monig, H. (2011). Practical approach to hyponatremia. The Deutsche MedizinischeWochenschrift, 136(34-35):1728-1732.

Gueorguieva, T.M. and Gueorguiev, I.P. (1997). Serum cholesterol concentration around parturition and in early lactation in dairy cows. Révue de Médecine Vétérinaire, 148: 241-244.

Huszenicza, G.Y.; Kulcsar, M. and Rudas, P. (2002). Clinical endocrinology of thyroid gland function in ruminant. Veterinary Medicine Czech, 47:199-210.

Kumar, R. and Rattan, P.J.S. (1992). Plasma thyroidal and adrenocortical hormones during different developmental stages in buffalo heifers. Indian Journal of Animal Sciences, 62: 747- 748.

Khanna, D.; Agarwal, S.P.; Gupta, M.L.; Rai, A.K. and Khanna, N.D. (1996). Effect of water deprivation during summer and winter on thyroid hormones concentration in the Indian camel. Indian Journal of Animal Sciences, 66: 253-255.

Luciani, R.; Falcone, C.; Principe, F.; Punzo, G. and Mene, P. (2009) Acute renal failure due to amiodarone-induced hypothyroidism. Clinical Nephrology, 72: 79-80.

Nazifi, S.; Gheisari, H.R. and Shaker, F. (2002). Serum lipids and lipoproteins and their correlations with thyroid hormones in clinically healthy goats. Veterinarski Arhiv, 72(5): 249-257.

Nazifi, S.; Saeb, M. and Abedi, M. (2003). Serum lipid profiles and their correlation with thyroid hormones in clinically healthy Turkoman horses. Comparative Clinical Pathology, 12(1): 49-52.

Nazifi, S.; Saeb, M.; Rategh, S. and Khojandi, A. (2005). Serum lipids and lipoproteins in clinically healthy Caspian miniature horses. Veterinarski arhiv, 75(2): 175-182.

Nazifi, S.; Nikahval, B.; Mansourian, M.; Razavi, S.M.; Farshneshani, F.; Rahseoar, M. et al. (2009). Relationships between thyroid hormones, serum lipid profile and erythrocyte antioxidant enzymes in clinically healthy camel (*Camelus dromedarius*). Révue de Médecine Vétérinaire, 160: 3-9.

Makino, Y.; Fujii, T.; Kuroda, S.; Inenaga, T.; Kawano, Y. aad Takishita, S. (2000). Exacerbation of renal failure due to hypothyroidism in a patient with ischemic nephropathy. Nephron, 4: 267-269.

Müller, M.J. and Seitz, H.J. (1984). Thyroid hormone action on intermediary metabolism. Part

III. Protein metabolism in hyper- and hypothyroidism. Klinische Wochenschrift, 62: 97-102.

Poljicak, M.; Terezija, S. and Marenja, K. (2009). Comparative hematological and biochemical values in pregnant and non-pregnant red, Cervuselaphus, and fallow deer, Damadama, females. Folia Zoology, 58:36-44.

Rodriguez, M.N.; Tebot, I. and Le Bas, A. (1996). Renal functions and urea handling in pregnant and lactating Corriedale ewes. Canadian Journal of Animal Science, 76: 469-472.

Tajik, J.; Nazifi, S. and Badiei, K. (2011). Correlations of serum leptin with lipids, lipoproteins, and thyroid hormones in Water Buffalo *(Bubalus bubalis*). Comparative Clinical Pathology, 21(5): 1013-1017.

Tajik, J.; Sazmand, A.; Hekmati Moghaddam, S.H. and Rasooli, A. (2013). Serum concentrations of thyroid hormones, cholesterol and triglyceride, and their correlations together in clinically healthy camels *(Camelus dromedarius):* Effects of season, sex and age. Veterinary Research Forum, 4 (4): 239-243.

Yousif, H.S.; Omer, S.A.and Ahmed, S.H. (2017). The effect of seasonal variations, pregnancy and management system on the blood minerals and thyroid hormones of camels. International Journal of Scientific Engineering and Science, 1(11): 99-103.

Wang, C. (2013). The relationship between type 2 diabetes mellitus and related thyroid diseases. Journal of Diabetes Research, 2013: 390534.

Wasfi, I.A.; Hafez, A.M.; Tayeb, F.M.A.; Taher, A.Y.; Eltayeb, F.M.A. and El-Taher, A.Y. (1987). Thyroidhormones, cholesterol and triglyceride levels in the camel. Research in Veterinary Science, 42: 418.