Short communication

Seasonal variations of serum copper concentration in Raeini cashmere goats

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Abstract The aim of this study is to determine the serum copper (Cu) concentration found in Iranian Raeini cashmere goats in different seasonal and climatic conditions. Twenty four male (6 to 18 months old) and 48 female (6 to 18 and 18 to 30 months old) Raeini goats were selected from the station, rural, and nomadic flocks. The average Cu concentrations among the male and female goats were 0.5 ± 0.04 and 0.5 ± 0.02 mg L^{-1}, respectively. Serum Cu concentration was higher during autumn (0.7 ± 0.03 mg L^{-1}) than spring, summer, and winter. The mean serum Cu concentrations in the station, rural, and nomadic flocks were 0.4 ± 0.04, 0.6 ± 0.04, and 0.3 ± 0.04 mg L^{-1}, respectively. In conclusion, Raeini cashmere goats showed clear seasonality in serum Cu, with low levels from winter to late summer and maximum level in autumn.

Keywords: goat, rural, nomadic, feed, mineral

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Introduction

The trace minerals required to be supplemented in the diet of the animals include iron, manganese, cobalt, iodine, zinc, selenium, and copper (Cu) (Underwood and Suttle, 1999; Shamsaddini Bafti et al., 2012a; Aditia et al., 2014). Copper is an important element because of its role in farm animal health, productivity, and hair growth and also plays a key role in many biochemical functions such as metalloenzymes, Cu/zinc-superoxide dismutase, ceruloplasmin, and thyroid hormones (George and Haenlein, 1999; Hussein and Staufenbiel, 2012; Shamsaddini Bafti et al., 2012b; Yatoo et al., 2013). Copper deficiency is a major problem in ruminants in many parts of the world. The minimum required amount of Cu is 8-10 mg kg^{-1}, but higher levels may be toxic. Raeini goat is an Iranian cashmere goat which is raised in Kerman Province, Iran, where goat products significantly contribute to the agricultural economy. Raeini goats are typically kept by nomads that graze their herds in Kerman Province during spring and summer. They are also raised in rural areas. Some are also kept in research stations. In this study, we report the correlation between age, sex, diet, herd, season, and serum Cu content among Raeini cashmere goats in Kerman Province under different husbandry conditions.

Materials and methods

All the samples were taken with the permission of authorized officials and farm owners.

Flocks and animals

Raeini goats were randomly selected from three flocks and categorized on the basis of sex and age. The goats included 24 males (6 to 18 months old with the mean live weight of 24 ± 5 kg) and 48 females (6 to 18 and 18 to 30 months old with the mean live weight of 21 ± 5 and 26 ± 5 kg, respectively) without any apparent signs of disease. One of the flocks belonged to Baft Goat Breeding Station (29°17´N 56°36´E). The goats in the third flock were raised in Orzueeyeh throughout the year (Rural). The nomadic flock was in Orzueeyeh (28°45´N 56°36´E) and migrated to Baft for spring and summer.

Sampling and testing

Blood samples were obtained from the jugular vein on the second week of every second month during each of the four seasons (n = 288(72*4)). Blood was collected into venoject tubes (BD, USA) on ice and allowed to clot. The blood samples were centrifuged at 700 g for 15 min and the clear, nonhemolyzed supernatant sera were quickly removed and kept at -20°C. Twenty four soil samples were collected at the time of feeding on pasture in an area of about 100 m^2 from two locations, near and far from the plant (Edwards, 2010). At the same

same time, twenty four samples from the water used for goat consumption were collected from the surface and deep water. Thirty forage samples from both pasture forage and hand feeding diet were selected randomly, considering the plants commonly eaten by the goats in pasture feeding.

The concentration of Cu was measured by atomic absorption spectrometry (GBC902 Plus model). Separate standards and procedures were used for each sample. All the chemicals were of analytical grade.

Statistical analysis

Analysis of variance was performed using a mixed linear model (SAS, 2006). The significance of including herd as a random effect in the model was tested by comparing the difference in the residual log-likelihoods of the model with and without the random effect. The full statistical model used for all the traits was:

$$y_{ij} = \mu + \eta_i + \varepsilon_{ij} \quad (1)$$

where y_{ij} represents the dependent variable analyzed; μ is the overall mean; η_i is the effects of season, location, and diet; and ε_{ij} is the residual random errors assumed uncorrelated. Repeated measures ANOVA and Pearson's correlation test were used for the analysis. Probability level of 5% was considered.

Results and discussion

The mean serum Cu concentration was about 0.5 mg L^{-1}. While the gender and age did not affect serum Cu concentration, it was significantly affected by the husbandry system and season of the year (Table 1, $P \leq 0.001$). The Cu concentration in the feed samples ranged from 6.1 to 9.7 mg kg^{-1} (mean ± SE of 7.9 ± 1.8) and was not affected by sex, age, and husbandry system. The mean Cu concentration in the soil samples was significantly different ($P \leq 0.001$) by regions and was not different by season and sampling region. Figure 1 shows the concentration of Cu in drinking water by the husbandry system in two areas containing both surface and deep water wells.

The normal range of serum Cu concentration in small ruminant was reported between 0.43 and 1.39 mg L^{-1}. The Cu concentration value of less than 0.08 mg L^{-1} caused symptoms deficiency (Galbraith et al., 1997; George and Haenlein, 1999; Erdogan, 2002; NRC, 2006; Olmedo-Juáreza et al., 2012; Altug et al., 2013; Yatoo et al., 2013).

Khan et al. (2007) reported that the serum Cu concentration in summer fluctuated from 0.71 to 0.78 mg L^{-1}, whereas this amount varied from 1.14 to 1.46 mg L^{-1} in winter. In this study, the mean serum Cu concentration was 0.5 mg L^{-1}, which indicates low borderline levels. Copper level in plasma fluctuated only to a limited extent and was regulated by biliary and fecal excretion as well as level of liver Cu storage (Underwood and Suttle, 1999; NRC, 2006). Moreover, the secondary deficiencies of Cu could be due to the interference with other minerals provided in excess, such as iron, sulfur, or molybdenum in the diet. Underwood and Suttle (1999) estimated Cu requirement as 4.3-28 mg kg^{-1} dry matter (DM). Copper absorption was more important than its concentration in the food. There was no significant difference in serum Cu concentration between the samples taken from the hand feeding diet and those from the pasture. The Cu concentration in the feed samples was marginally lower than the Cu requirement; however, molybdenum levels were not estimated in this study. When the concentration of Cu blood was low due to the large internal body reserves, deficiency might not

Table 1. Effects of gender, age, husbandry system, and season on serum copper concentration (mg L^{-1}) in Raeini goats (least squares means ± SE and ranges)

Effects		Number	Mean ± SE	Minimum	Maximum	P value
Gender	Male	4*24	0.5 ± 0.04	0.46	0.54	NS
	Female	4*48	0.5 ± 0.02	0.48	0.52	
Age (month)	6-18	4*48	0.4 ± 0.02	0.38	0.42	NS
	18-30	4*24	0.4 ± 0.04	0.36	0.44	
Husbandry system	Breeding station	4*24	0.4 ± 0.04	0.36	0.44	0.001
	Rural	4*24	0.6 ± 0.04	0.56	0.64	
	Nomadic	4*24	0.3± 0.04	0.26	0.34	
Season	Spring	72	0.5 ± 0.03	0.44	0.53	0.001
	Summer	72	0.3 ± 0.03	0.27	0.33	
	Autumn	72	0.7 ± 0.03	0.67	0.73	
	Winter	72	0.4 ± 0.03	0.37	0.43	

NS= Non-significant

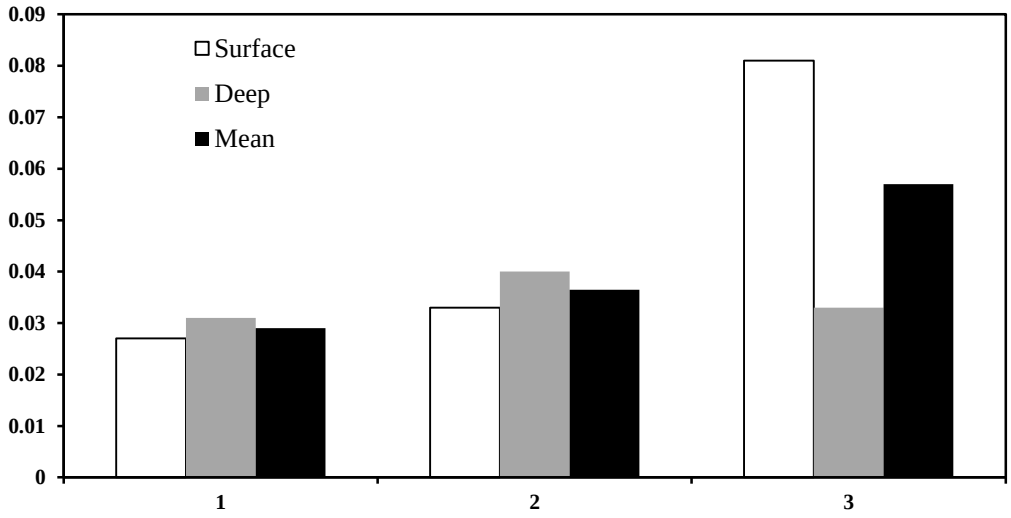

Figure 1. Effects of husbandry system (herd number: 1, breeding station; 2, nomadic; 3, rural flocks) and area of water (surface and deep) on water copper concentration (mg L^{-1})

be observed.

In addition, much higher supplement levels improves growth performance with no signs of toxicity in goats (Solaiman et al., 2006). Therefore, the supplementation of Cu up to 38 mg kg^{-1} could not produce any hepatic dystrophy and clinical symptom of toxicity during the 84 days of the feeding trial. In sheep, and perhaps other species or breeds, mineral mixture used as a supplement should be designed specifically for the ruminant species.

The concentration of Cu in forage was higher in autumn than summer. In autumn, the concentration of Cu was adequate for goats, but found to be borderline to deficient during summer. The concentration of Cu in plant species was less than the critical range needed by the animal; in other words, deficiency of Cu content in the feed was found in both dry and wet seasons. Warly et al. (2006) reported that the concentrations of microminerals as Cu in forage were significantly affected by species and season. Lundu (2012) reported that the Cu concentration in plasma, plant material, and soil was affected by season.

Since the Cu levels in different areas of pasture plants were almost equal, it was suggested that some bio-geophysical factors such as photoperiod, climate-herbage system, and soil-plant trace nutrient composition, as well as nutrition and husbandry are all important and effective environmental conditions (McGregor, 1998; Aditia et al., 2014).

Ontario Grain and Feed Association performed a survey of Cu analyses on forage and water samples (Menzies et al., 2003). The mean water Cu concentration was about 0.5 mg L^{-1} which was much lower than the upper acceptable limit for the livestock. The mean Cu concentration in forage was generally lower than 10 $g.g^{-1}$ DW although some sample concentrations were greater than 15 $g.g^{-1}$ DW.

The mean Cu concentration in the soil of station region was higher than that of the rural region. There was no difference in mean Cu concentration in the soil samples taken from different regions in different seasons; but, the amount of Cu was different for the samples from different regions (while ignoring seasons). The results indicated that all the Cu concentrations tended to increase in the summer season.

In conclusion, the mean Cu concentration in serum in different seasons was significantly different, which mainly indicated the relationship between the feed type and region of goats. The present study showed that the mean serum Cu concentration was very variable, which might indicate that subclinical Cu deficiency in Raeini goats may be prevalent in geographical regions covered in this study. Although Cu supply sources according to husbandry system, climate, and animal house location are usually varied, the required Cu value in blood must be within a normal range; of course, it can be easily adapted to various rearing environments, but further interventional studies may be needed to confirm our results. According to the findings of this study, the amount of Cu in the feed was not significantly different in various seasons and was at the level needed by goats; however, it was slightly more during the autumn season.

This study could prepare the baseline information to farmers and animal nutritionists on the seasonality of minerals in serum, feed material, and soil, which is required for formulating supplements to complete produc-

tivity among different types of goats in the husbandry system.

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بررسی تغییرات فصلی میزان مس سرم خون در بزهای کرکی رائینی

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چکیده هدف این برر سی تعیین غلظت سرمی مس (Cu) در بز های کرکی رائینی در فصول و شرایط مختلف آب و هوایی ا ست. از تعداد ۲۴ رأس بز کرکی رائینی نر (۶ تا ۱۸ ماهه) و تعداد ۴۸ رأس بز ماده (۶ تا ۱۸ و ۱۸ تا ۳۰ ماهه) از گله های ایستگاه، روستایی و عشایری خون گیری بعمل آمد. متوسط غلظت مس در بزهای نر و ماده به ترتیب ۰/۰۴ ± ۰/۵ و ۰/۰۲ ± ۰/۵ میلی گرم در لیتر تعیین شد. غلظت مس سرم در پاییز (۰/۰۳ ± ۰/۷ میلی گرم در لیتر) بیشتر از بهار، تابستان و زمستان بود. میانگین غلظت سرمی مس در گله های ایستگاه، روستایی و عشایری به ترتیب ۰/۰۴ ± ۰/۴، ۰/۰۴ ± ۰/۶ و ۰/۰۴ ± ۰/۳ میلی گرم در لیتر بود. در این مطالعه غلظت ســـرمی مس، در بز های کرکی رائینی از زمســـتان تا اواخر تابستان پایین ترین مقدار و در پاییز بالاترین مقدار مشاهده گردید.