Determining mineral imbalances in Sistani cattle diet based on local pasture

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Abstract

This research conducted to determine which minerals might be deficient or excess in Iranian Sistani cattle diet based on mostly-grazed plant species. In late spring season of Sistan basin (located in southwestern Iran), four sites including Saberi, Lorg-Bagh, Kuh-Khaje and Zahak were selected and six major forage species consumed by Sistani cows including *Phragmites australis, Bolboschoenus glaucus, Aeluropus lagopoides, Tamarix spp, Cyperus longus and Setaria sp* were sampled and analyzed for minerals. Average macro-mineral concentrations of calcium, phosphorus, magnesium, sodium, potassium, chorine, sulfur and micro-minerals of iron, copper, manganese, molybdenum, cobalt and selenium were 17.37, 0.78, 6.85, 15.40, 3.13, 14.22, 9.49 g/kg and 820.2, 20.0, 72.8, 93.2, 0.43, 0.21 and 0.18 mg/kg for sampling sites and 12.14, 0.77, 6.35, 17.85, 3.59, 14.40, 5.01 g/kg and 1106.0, 18.5, 64.8, 122.4, 0.32, 0.19, and 0.16 mg/kg for forage species, respectively. Comparison of the plant minerals with Sistani cattle mineral requirements showed that Sistani cattle grazing natural indigenous forages was exposed to phosphorus deficiency and iron excess.

Introduction

Sistani cattle is a *Bos indicus* (humped) breed in Lake Hamoun region of southeastern Iran with high meat production ability and well-adapted characters to harsh ecosystem of this area such as hot dry climate and strong winds as well as being resistant to parasites (Faraji-Arough et al., 2019). Its feed is mostly dependent to grazing natural plants grown on reed-beds and grasslands, but recent decade drought conditions and certain water mismanagements caused low water availability and high soil salinity that resulted in poor quality and sparse vegetation and natural feed resource shortage (Van Beek and Meijer, 2006). Moreover, access to nutritionally balanced hand feeds is not sufficient to rectify the nutrient deficiencies. These conditions restrict nutrient supply for the cattle leading to a decreased longevity and population that can be exposed it as an endangered breed (Ebrahimzadeh, 2009). Therefore, the Sistani cattle needs balanced supplementary feeds to meet its nutritional requirements and save its population.

Minerals are nutrients required in a few levels as much as 2–3% of diet dry matter, however feeding livestock with minerals less than the required amounts can leave lot of negative effects on normal body structures and functions. Minerals as enzyme cofactors exert key roles in many biochemical processes including carbohydrate and protein metabolisms. In practical conditions, signs of dietary mineral deficiencies in livestock are mostly as chronic production and reproduction problems (McDowell and Arthington, 2005). The Sistani cattle also show weak biological performances under poor mineral nutrition. It seems mineral supplements can be helpful tools for improving health and production status of these animals. In this way, determining mineral concentrations of plants typically utilized by grazing livestock and their differences from the animal mineral needs can bring out a general recognition about mineral status of the animal and facilitate to formulate a balanced mineral supplement appropriate for the animal circumstances (Judson and McFarlane, 1998). There is little information about mineral status of this breed and its dietary forage species. The object of this study was to evaluate what mineral imbalances might be existed in plant species commonly used in Sistani cows diet regarding to the cattle mineral requirements and tolerances.

Materials And Methods

Study area

The study region was located in Sistan basin geographically positioned between latitude 30°33'44"-31°26'13" N and longitude 61°1'35"-61°43'56" E and consisted of seasonal wetlands distributed into four provinces Hamoun, Zabol, Hirmand, Zahak and Nimrouz with averagely altitude of 478 m, precipitation of 59 mm and temperature of 21.8°C. The region is climatically hot and dry with 120-days wind blows continued from mid-May to mid-September. The vegetation of the area is mainly thermophile divided into two categories of hydrophytes grown in beds and edges of lakes, mesophytes in shallow lakes and xerophyte as well as halophyte in lands surrounding lakes. The soil of the area is mostly saline and alkaline with a loamy texture. The Sistani cattle in past centuries due to its mentioned prominent potencies specially in meat production and accessing to more extensive lakes had been superior livestock of this area with a large population but during recent years fallen to 30000 head due to drought conditions.

Sample collections

Consideration of Sites for sampling was according to major Sistani farm locations cooperating with governmental centers and choosing palatable plant species for sampling based on personal field observations. The sampling sites were four locates named as Saberi, Lurgbagh, Zahak and Mount-Khajeh situated in northern, central, eastern and western parts of Sistan basin, respectively. Plant samples were from forage species of reedy lands and grasslands, which mostly grazed by Sistani cows or harvested and utilized handily in Sistani cow diets. These species were *Phragmites australis*, *Cyperus rotundus, Aeluropus lagopoides*, *Tamarix spp*, *Cyperus longus* and *Setaria sp.* In every site, three replicate samples of the species with pooling five stands each was randomly collected at complete growth stage from aerial parts around last June. The samples dried in open air under shade and chopped into 2–3 cm size. Replicate samples with the same species and sites mixed to each other, and totally prepared 12 samples as representative species of each site (Table 1).

Table 1
Final samples number of each forage species in different forage sites

	Forage species						
Forage sites	*Phragmites australis*	*Cyperus rotundus*	*Aeluropus lagopoides*	*Tamarix spp*	*Cyperus longus*	*Setaria sp.*	*Sum*
Saberi	1	1	1	1	1	0	5
Lorgbagh	1	1	1	1	0	1	5
Zahak	1	0	0	0	0	0	1
Mount-Khajeh	0	0	0	1	0	0	1
Sum	3	2	2	3	1	1	12

Laboratory analysis

Forage mineral assays carried out according to methods described in AOAC (2002). At first, the samples were ground through a 2 mm screen and oven-dried at 65°C for 72 h. Then, each sample digested in nitric acid and perchloric acid and wetly ashed. Concentrations of calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn) determined by method of flame atomic absorption spectrometry, cobalt (Co) and molybdenum (Mo) by graphite furnace atomic absorption spectrometry, and selenium (Se) by hydride generation atomic absorption spectrometry using the spectroscope of model GBC 932 Plus. Concentrations of phosphorus (P) and sulfur (S) measured by the photometer of model BEL and chlorine (Cl) using Volhard titration.

Statistical analysis

Mineral data were entered and arranged in Excel sheet and their averages based on sampling sites and forage species separately compared with mineral requirements of Sistani cattle in gestation and lactation stages (NRC, 2000) and maximum mineral tolerances (NRC, 2005) using single-sample TTEST procedure of SAS (2008) for detecting mineral deficiencies or excesses, respectively. Moreover, effects of sampling sites and forage species were separately analyzed using GLM procedure of SAS (2008) in a completely randomized design and Duncan’s test used for mean comparisons at $p < 0.05$.

Results And Discussion

Mineral deficiency of Sistani cattle diet

Macro- and micro-mineral concentrations of different forage sites compared with gestation and lactation mineral requirements of Sistani cows showed 100% P deficiency ($p < 0.01$) (0.78 g/kg) and 75% Mo deficiency (0.43 mg/kg). Macro- and micro-mineral concentrations of different forage species regardless of sites compared with gestation and lactation mineral requirements of Sistani cows also showed 100%

P deficiency ($p < 0.01$) (0.77 g/kg) and 83% Mo deficiency (122.4 mg/kg) (Tables 2, 3, 4 and 5). Similarly, studying on nutritional values of halophyte plants in Sistan showed a P level lower than livestock needs (Golzarnia, 2014; Najafi et al., 2014; Yousef-Elahi et al., 2019). Phosphorus deficiencies of grazing ruminants have been also observed in other arid and semi-arid conditions of Iran (Shadnoush, 2007) and most of world tropical regions (McDowell and Arthington, 2005). Regarding to important roles of P in carbohydrate and protein metabolism, its deficiency causes to disturb ruminal fermentation and then forage nutrient utilization for microbial protein synthesis (Breves and Schroder, 1991). Molybdenum in areas with alkaline soils has a low absorption, hence the low levels of forage Mo in this study can be related to soil Mo deficiency and as a result, decreased Cu tolerance is expectable (Gould and Kendall, 2011). However, as shown in Table 4, *Phragmites australis* as the main forage in Sistani cow diet shows no Mo deficiency, so Cu bioavailability can also depend to grazed plant species. There were S deficiency in Zahak site (1.01 g/kg) and Mn deficiency in Mount-Khajeh site (22.4 mg/kg), due to *Phragmites australis* and *Tamarix spp*, respectively (Table 2). This response indicates where a large portion of diet is of a limited number of plant species, possibility of mineral deficiencies increases; Study with beef cattle grazing upon weedy and forage plants of temperate pasture in Japan showed that increasing the plant diversity in the pasture reduced the risk of mineral deficiencies or toxicities (Yoshihara, 2013). High amounts of dietary reed (around 75%) increases risk of S deficiency in Sistani cows that this condition necessitates using a supplementary mineral because S deficiency in ruminants can lead to decreased ruminal digestion of plant fiber and so lost cow performance (Kandylis, 1984). Sulfur and Mn deficiencies of *Setaria sp.* indicates that feeding this forage in condition of water shortage of lagoons and reed reduction should be limited and mineral imbalances of consumed forage resolved with suitable supplements.

Table 2
Comparison of forage macro-minerals of different forage sites with Sistani cows requirements (R) and maximum tolerable levels (MRL)

R or MRL (g/kg DM)[1]	**Ca**	**P**	**Mg**	**K**	**Na**	**Cl**	**S**
GR[2]	3.93	2.48	1.20	6.00	0.70	1.00	1.50
LR[3]	4.92	3.28	2.00	7.00	1.00	1.40	1.50
MRL	15	7	6	20	18	27	5
Sites							
Saberi	13.05	1.02	6.47	15.37	3.49	17.55	5.64
Lorgbagh	11.96	0.71	6.37	17.48	3.40	11.70	4.15
Zahak	5.22	1.29	2.45	11.58	3.55	11.7	1.01
Mount-Khajeh	39.24	0.11	12.10	17.20	2.09	15.95	27.15
Mean of sites	17.37	0.78	6.85	15.4	3.13	14.22	9.49
GR *P*-value	0.171	0.007	0.066	0.006	0.006	0.003	0.273
LR *P*-value	0.20	0.00	0.09	0.01	0.01	0.01	0.271
Deficiency %	0	100	0	0	0	0	25
MRL *P*-value	0.77	0.00	0.70	0.04	0.00	0.00	0.51
Excess %	25	0	75	0	0	0	50

[1]R and MRL are based on NRC (2000) and NRC (2005), respectively; [2]GR, gestation requirements; [3]LR, lactation requirements.

Table 3
Comparison of forage micro-minerals of different forage sites with Sistani cows requirements (R) and maximum tolerable levels (MRL)

R or MRL (g/kg DM)[1]	**Fe**	**Cu**	**Zn**	**Mn**	**Mo**	**Co**	**Se**
GR[2]	50	10	30	40	0.50	0.10	0.10
LR[3]	50	10	30	40	0.50	0.10	0.10
MRL	500	40	500	2000	5	25	5
Sites							
Saberi	1112.4	21.1	68.7	148.4	0.33	0.15	0.16
Lorgbagh	1254.6	17.5	62.1	127.2	0.34	0.27	0.15
Zahak	331.0	25.5	105.1	74.6	0.68	0.33	0.25
Mount-Khajeh	583.0	18.5	55.4	22.4	0.36	0.11	0.15
Mean of sites	820.2	20.0	72.8	93.2	0.43	0.21	0.18
GR = LR *P*-value	0.0**4**	0.0**2**	0.03	0.1**6**	0.45	0.11	0.05
Deficiency %	0	0	0	25	75	0	0
MRL *P*-value	0.24	0.00	0.00	0.00	0..00	0.00	0.00
Excess %	75	0	0	0	0	0	0

[1]R and MRL are based on NRC (2000) and NRC (2005), respectively; [2]GR, gestation requirements; [3]LR, lactation requirements.

Table 4
Comparison of forage macro-minerals of different plant species with Sistani cows requirements (R) and maximum tolerable levels (MRL)

R or MRL (g/kg DM)[1]	**Ca**	**P**	**Mg**	**K**	**Na**	**Cl**	**S**
GR[2]	3.93	2.48	1.20	6.00	0.70	1.00	1.50
LR[3]	4.92	3.28	2.00	7.00	1.00	1.40	1.50
MRL	15	7	6	20	18	27	5
Species							
Phragmites australis	5.38	0.99	2.71	14.05	3.05	13.83	1.38
Cyperus rotundus	6.97	0.55	3.29	16.67	3.41	14.89	1.53
Aeluropus lagopoides	8.59	0.87	5.02	10.27	3.84	15.16	2.45
Tamarix spp	34.36	1.03	13.47	15.43	2.60	14.89	20.16
Cyperus longus	13.43	0.90	7.00	18.62	4.36	15.95	3.57
Setaria sp.	5.72	0.29	6.61	32.07	4.28	11.70	0.97
Mean of species	12.41	0.77	6.35	17.85	3.59	14.40	5.01
GR *P*-value	0.121	0.000	0.023	0.012	0.000	0.000	0.302
LR *P*-value	0.161	0.000	0.041	0.017	0.000	0.000	0.302
Deficiency %	0	100	0	0	0	0	33
MRL *P*-value	0.60	0.00	0.83	0.51	0.00	0.00	0.99
Excess %	17	0	50	17	0	0	17

[1]R and MRL are based on NRC (2000) and NRC (2005), respectively; [2]GR, gestation requirements; [3]LR, lactation requirements.

Table 5
Comparison of forage micro-minerals of different sites with Sistani cows requirements (R) and maximum tolerable levels (MRL)

R or MRL (g/kg DM)[1]	Fe	Cu	Zn	Mn	Mo	Co	Se
GR[2]	50	10	30	40	0.50	0.10	0.10
LR[3]	50	10	30	40	0.50	0.10	0.10
MRL	500	40	500	2000	5	25	5
Species							
Phragmites australis	551.7	29.5	90.2	171.1	0.69	0.26	0.16
Cyperus rotundus	987.5	17.9	80.3	265.1	0.29	0.23	0.19
Aeluropus lagopoides	1853.0	18.1	60.9	64.9	0.22	0.21	0.17
Tamarix spp	1084.3	14.1	52.1	34.3	0.29	0.20	0.16
Cyperus longus	1714.6	19.8	45.4	173.8	0.22	0.12	0.17
Setaria sp.	446.6	11.4	60.0	25.1	0.23	0.13	0.11
Mean of species	1106.0	18.5	64.8	122.4	0.32	0.19	0.16
GR = LR *P*-value	0.007	0.021	0.004	0.089	0.060	0.010	0.004
Deficiency %	0	0	0	33	83	0	0
MRL *P*-value	0.05	0.00	0.00	0.00	0.00	0.00	0.00
Excess %	83	0	0	0	0	0	0

[1]R and MRL are based on NRC (2000) and NRC (2005), respectively; [2]GR, gestation requirements; [3]LR, lactation requirements.

Mineral excess of Sistani cattle diet

Macro- and micro-mineral concentrations of different forage sites compared with maximum tolerable levels of Sistani cows showed 75% Mg and Fe excesses (6.85 g/kg and 820.2 mg/kg) and 50% S excess (9.49 g/kg). Likewise, macro- and micro-mineral concentrations of different forage species regardless of sites compared with maximum tolerable levels of Sistani cows showed 83% Fe excess ($p < 0.05$) (1106.0 mg/kg) in all of studied species except *Setaria sp.*, and 50% Mg excess in three species of *Tamarix spp*, *Cyperus longus* and *Setaria sp.* (13.47, 7.00 and 6.61 g/kg) (Tables 2, 3, 4 and 5). Although There is a few reports on mineral contents of halophyte plants consumed by livestock in Sistan region, however in agreement with present study Fe and Mg excesses in these plants was observed in some studies (Shadnoush, 2007, Golzarnia, 2014). Considering Fe interaction with bivalent metals such as Cu, Zn, Mn and Co via lumen absorption channels (O'Dell and Sunde, 1997) and also some reports about negative effect of Fe on P and Se metabolism (McDowell and Arthington, 2005), deficiencies of Cu, Zn, P and Se are expectable with the present Fe excess. X-ray study of this halophyte plant showed a crystal aggregation of Ca and Mg sulfates in salt glands of leaves (Storey and Thomson, 1994). In fact, Ca, Mg, S and Fe excesses of Mount-Khajeh region attributed to *Tamarix spp* (Table 1) and so use of this plant as a single feed for Sistani cow is likely to cause consequences such as P deficiency due to Ca and Mg excesses, Cu and Se deficiencies and polioencephalomalacia disorder due to sulfur excess, and Cu, Zn and Co deficiencies due to Fe excess (Van Ryssen et al. 1998). Therefore, it is necessary to restrict use of *Tamarix spp* in hand feeding of cows when forage for grazing reduces.

Conclusion

The results indicates that there is a P deficiency in forage consumed by Sistani cows and so it necessitates using a P supplement in diet of cows. There is also a Fe excess of major forage available in feeding Sistani cows, which causes a negative impact on micro-minerals such as Cu, Zn, Mn and Co and so it needs these mineral supplementation. In addition, there is S deficiency in *Phragmites australis* and *Setaria sp*., which can be compensated by other plants particularly *Tamarix spp* and so it needs no S supplement. Since the *Tamarix spp* usage in diet of Sistani cows may increases in condition of reed forage shortage, there is a risk of Ca, Mg, S and Fe deficiencies and it needs to control secondary deficiencies of P, Se, Cu, Zn and Co by using higher levels of these elements in mineral supplements.

Declarations

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AM and DB conceived and designed research.

Author contributions: AMT and MKS conceived and designed research. AMT and MKS conducted experiments. AMT and MKS contributed new reagents or analytical tools. AMT analyzed data. AMT wrote the manuscript. All authors read and approved the manuscript.

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Data availability The authors affirm that all data necessary for confirming the conclusions of the article are present within the article and tables.

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References

1. Faraji-Arough, H., Rokouei, M., Maghsoudi, A., Mehri, M., Ansari Mahyari, S., Christian Sorensen, A., 2019. Effect of using reproductive Technologies on genetic progress in Sistani native cattle of Iran: A Simulation Study. Iranian Journal of Applied Animal Science, 9, 59-71.
2. Van Beek, E., Meijer, K., 2006. Integrated water resources management for the Sistan closed inland delta; Water Resource Institute, Netherlands, pp. 7-47.
3. Ebrahimzadeh, I., 2009. Analysis of recent droughts and lack of water in Hamoon Lake on Sistan economic functions. Iran-Water Resources Research, 5, 71-76.
4. McDowell, L.R., Arthington, J.D., 2005. Minerals for Grazing Ruminants in Tropical Regions, Forth Ed. University of Florida, IFAS, pp. 10-42.
5. Judson, J.G., McFarlane, J.D., 1998. Mineral disorders in grazing livestock and the usefulness of soil and plant analysis in the assessment of these disorders. Australian Journal of Experimental Agriculture, 38, 707-723.
6. AOAC, 2002. Official methods of analysis, 16th Ed. Association of Official Analytical Chemists, Arlington, VA, 56-65.
7. NRC, 2000. Nutrient requirements of beef cattle, Seventh Revised Ed. National Academy Press, Washington, DC, p. 58-78.
8. NRC, 2005. Mineral tolerance of animals, Second Ed. National Academy Press, Washington, DC, p. 10-14.
9. SAS, 2008. Statistical Analytical Systems. SAS Institute, p. 4775-4795.
10. Yousef-Elahi, M., Khusro, A., Elghnadour, M.M.Y., Salem, A.Z.M., Lopez, S., 2019. Ruminal fermentation kinetics of nine halophytic tree species at different growth stages. Agroforestry Systems, 93, 1843-1852.
11. Najafı, T., Dehghani, M.R., Yousef-Elahi, M., 2014. Determining of nutritive value of *Cressa cretica* plant in different phenological growth stages with in vitro, in vivo and nylon bag methods in Sistan. Iranian Journal of Animal Science, 45, 143-152.
12. Golzarnia, S., 2014. Evaluation of nutritional quality of six species of forage plants in Sistan. The Thesis Submitted for the Degree of M.Sc. in the field of Animal Nutrition, Agriculture Faculty of Tehran University.
13. Shadnoush, G.R., 2007. Mineral determination of some range plants for grazing sheep in semi-arid areas of Chaharmahal & Bakhtiari province. Iranian Journal of Range and Desert Research, 13, 285-295.
14. Breves, G., Schroder, B., 1991. Comparative aspects of gastrointestinal phosphorus metabolism. Nutrition Research Review, 4, 125-140.

15. Gould, L. Kendall, N.R., 2011. Role of the rumen in copper and thiomolybdate absorption. Nutrition Research Review, 24, 176–182.
16. Yoshihara, Y., Mizuno, H., Yasue, H., Purevdorj, N., Ito, T.Y., 2013. Nomadic grazing improves the mineral balance of livestock through the intake of diverse plant species. Animal Feed Science and Technology, 184, 80-85.
17. Kandylis, K., 1984. The role of sulfur in ruminant nutrition. A review. Livestock Production Science, 11, 611-624.
18. O'Dell, B.L., Sunde, R.A., 1997. Handbook of Nutritionally Essential Mineral Elements. University of Missouri, Columbia, Marcel Dekker, Inc., p. 278-281.
19. Storey, R., Thomson, W.W., 1994. An X-ray microanalysis study of the salt glands and intracellular calcium crystals of Tamarix. Annals of Botany, 73, 307-313.
20. Van Ryssen, J.B., van Malsen, P.S.M., Hartman, F., 1998. Contribution of dietary sulphur to the interaction between selenium and copper in sheep. Journal of Agricultural Science, Cambridge, 130, 107-114.