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Mineral status of animals in relation to different physiological stages in Haridwar District of Uttarakhand*

Tiwary M. K.[1], Akhilesh Pandey[2], Tiwari D.P.[3]
[1]Touring Veterinary Officer, Bengabad, Giridih (Jharkhand)
[2]Department of Animal Genetics and Breeding, C.O Vs. Jabalpur, India
[3] Department of Animal Nutrition, C.V. A. Sc., G. B. P. U. A. & T., Pantnagar, UA, India

Abstract- An experiment was conducted in four villges from two tehsils, namely Roorkee and Laksar of Haridwar district of Uttarakhand. Two villages from each tehsil were indentified from where minimum 10-15 farmers of different categores in each village were selected. Blood samples from cattle and buffaloes of different physiological status viz., lactating, dry, heifer, pregnant and other reproductive health were collected from jugular vein in sterilized and vacuumized test tube. During analysis the serum samples with equal volume of concentrated HNO_3 were kept for overnight in a digestion tube followed by low heat (70-80^{0}C) digestion with di-acid mixture. The final content was filtered through Whatman's filter paper No. 1 (Kolmer *et al.,* 1951). Minerals such as Ca, Mg, Zn, Fe, Cu and Mn were estimated by using AAS (Atomic Absorption Spectrophotometry). Phosphorus in blood serum (Fiske and Subbarow, 1925) using Autozyme Phosphorus kit*, (ACCUREX Biomedical Pvt. Ltd.)* was estimated colorimetrically. The overall blood serum mineral concentration for Ca (10.43±022 mg/dl), Mg (1.65±0.14 mg/dl), Zn (1.54±0.11 ppm), Fe (1.97±0.19 ppm) and Mn (0.54±0.02 ppm) in cattle and buffaloes of different physiological status were found above their respective critical levels whereas, Ps (3.79 ± 0.21 mg/dl) and Cu (0.46 ± 0.07 ppm) concentrations in blood serum of animals were below the respective critical levels. The average serum Ca, Mg, Zn and Fe differ significantly ($P<0.05$) between the Roorkee and Laksar tehsils of Haridwar district of Uttarakhand. There was significantly ($P<0.05$) higher serum Ca, Mg, Zn and Fe levels in animals of Laksar tehsil (10.82±0.31 mg/dl, 1.88±0.16 mg/dl, 1.92±0.14 ppm and 2.44±0.29 ppm, respectively) than in animals of Roorkee tehsil (10.03±0.25 mg/dl, 1.42±0.22 mg/dl, 1.16±0.06 ppm and 1.49±0.14 ppm, respectively). Most of the animals were found to have reproductive problems, which could be attributed to deficiency of different important minerals in this region. To overcome the deficiency, strategic dietary supplementation of minerals with better bioavailability could be a suitable approach.

Introduction

In the plain area of Uttarakhand state, the most common livestock species are cattle and buffalo. Low productivity of animal may occur as a result of complex climatic, social and economic problems but under-nutrition is a common factor and marked responses affecting growth and reproduction of the animals are observed because the livestock in this region are mostly reared on crop residues, which are nutritionally poor in protein, minerals and vitamins, but these are abundantly available for feeding of ruminants. These crop residues are used in combination with locally available greens and concentrates but in low quantity leading to under nutrition and imbalanced feeding practices. Generally, these animals do not receive mineral mixture supplementation in their basal diet. The mineral elements are solid, crystalline chemical substances and are not decomposed or synthesized by ordinary reactions. Typically, calcium represents about 46%, phosphorus about 29% and potassium, sulphur, sodium, chlorine and magnesium together account for about 25%, while essential trace elements constitute less than 0.3% of the total body minerals of the animals (Sharma *et al*., 2002). Minerals act as structural components of body organs and tissues, constituents of body fluids and tissues as electrolytes and catalysts in enzyme and hormone systems. The most obvious function of the mineral elements is to provide structural support (skeleton) for the body and for efficient reproductive performance. Unlike other nutrients, living organisms can not synthesize mineral elements and availability of minerals also

decreases with maturity of fodder (Kumar, 1993). Therefore, to overcome the detrimental influences on animal performances, mineral supplementation is essential to the livestock (Underwood, 1981). Farmers of the studied area are reluctant to supplement mineral mixture in basal feed fed to their livestock. Thus, livestock production is often badly influenced by mineral deficiencies and/or imbalances. The deficiencies and/or imbalances of micro-nutrients affect the productive and reproductive performance of animals through, reduced feed conversion efficiency, delayed maturity, increase in age at first calving and inter-calving intervals etc. The essentiality of minerals for health, growth, production, reproduction, as well as for carrying out normal physiological functions by animal's body is well documented (Chew, 2000). Feeding plays an important role in any livestock development and also for optimum expression of genetic potential of livestock. Though the production and reproduction abilities of animals depend on their genetic potential, it is always prudent to feed them with optimum quantities of different macro as well as micro-nutrients to exploit their maximum productive and reproductive potentials. Under the tropical Indian condition, the metabolic and/or deficiency diseases in animals are quite common which are mainly due to non-availability of balanced diet and also deficiency of specific minerals.

MATERIALS AND METHODS

An experiment was conducted in four villages, two namely Subhash Nagar and Salenpur from Roorkee Tehsil and two namely Dabkikalan and Maheshwari from Laksar Tehsil of Haridwar district of Uttarakhand. Minimum 10-15 farmers in each village were selected. Blood samples from cattle and buffaloes of different physiological status viz., lactating, dry, heifer, pregnant and other reproductive health status were collected from jugular vein in sterilized and vacuumized test tube without any anti-coagulant. The test tube containing blood was kept in slanting position at room temperature for serum collection. The serum was centrifuged and stored at 4^0C in plastic vials in a refrigerator until analysed. During analysis the serum samples with equal volume of concentrated HNO_3 were kept for overnight in a digestion tube followed by low heat (70-80^0C) digestion with di-acid mixture (3 parts concentrated nitric acid and 1 part 70% hypochloric acid) until the digested samples became watery clear and emitted white fumes. The final content was filtered through Whatman's filter paper No. 1 (Kolmer *et al.,* 1951). Minerals such as Ca, Mg, Zn, Fe, Cu and Mn were estimated by using AAS (Atomic Absorption Spectrophotometry). Phosphorus in blood serum (Fiske and Subbarow, 1925) using Autozyme Phosphorus kit*, (ACCUREX Biomedical Pvt. Ltd.)* was estimated colorimetrically. The data on mineral contents were subjected to statistical analysis for mean, standard error and test of significance (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

The overall blood serum mineral concentration for Ca (10.43±0.22 mg/dl), Mg (1.65±0.14 mg/dl), Zn (1.54±0.11 ppm), Fe (1.97±0.19 ppm) and Mn (0.54±0.02 ppm) in cattle and buffaloes of different physiological status viz; lactating, dry, heifer, anoestrus and repeat breeder were found above their respective critical levels whereas, P and Cu concentrations in blood serum of animals were below the respective critical levels. Cattle and buffaloes in this region exhibited low values of P (3.79±0.21 mg/dl) and Cu (0.46±0.07 ppm) in the blood serum (Table 1).

Macro-mineral content in blood serum of livestock

Calcium (Ca)

The values of serum calcium levels in different categories of animals are given in Table 1. The mean serum calcium levels in lactating, dry, heifers, anoestrus and repeat breeder animals of Subhash Nagar village of Roorkee Tehsil were 10.18 ± 0.64, 8.82 ± 2.25, 10.10 ± 1.44, 10.62 ± 0.81 and 9.46 ± 0.24 mg/dl whereas in village Salenpur of same Tehsil, the mean serum calcium in lactating, dry, heifers, anoestrus and repeat breeder animals were 10.73 ± 0.21, 10.20 ± 0.63, 10.92 ± 1.44, 10.58 ± 0.09 and 8.69 ± 2.39 mg/dl, respectively. The average value

for Roorkee Tehsil was 10.03 ± 0.25 mg/dl. There was no significant (P≥0.05) difference in blood serum calcium level in animals between two villages whereas, the mean serum calcium concentration in lactating, dry, heifers, anoestrus and repeat breeder animals were 10.24 ± 2.66, 11.50 ± 0.59, 11.50 ± 0.36, 11.48 ± 0.34 and 11.68 ± 0.29 mg/dl, respectively in Dabkikalan village and 10.95 ± 0.56, 10.24 ± 0.66, 11.97 ± 1.41, 8.80 ± 2.50 and 9.92 ± 0.45 mg/dl, respectively in Maheshwari village of Laksar Tehsil with an average value of 10.82 ± 0.31, mg/dl). There was no significant (P≥0.05) difference in serum calcium values between both the villages. There was significantly (P≤0.05) higher serum calcium level in animals of Laksar Tehsil (10.82 ± 0.31 mg) than in animals of Roorkee Tehsil (10.03 ± 0.25 mg/dl. The overall average levels of calcium in serum were 10.53 ± 0.19, 10.19 ± 0.55, 11.12 ± 0.40, 10.37 ± 0.56 and 9.94 ± 0.63 mg/dl in lactating, dry, heifers, anoestrus and repeat breeder animals, respectively of district Haridwar, with an average level being 10.43 ± 0.22 mg/dl, irrespective of categories of the animals. Serum calcium values for animals with different physiological status were above the critical level of <8.0 mg/dl. The serum calcium level in this zone was found to be above its critical level (<8 mg/dl). The trend obtained was in agreement with that of Das *et al.* (2002). It may be due to farmers being more reluctant to supplement only calcium as mineral mixture and it was also found that rapeseed meal *(lahi)*, an important concentrate ingredient fed to the livestock contained good percentage of calcium ranging from 6.0 to 7.5 g calcium per kg DM (Underwood and Suttle, 1999). Lower level of calcium in repeat breeder animals might be due to its less gut absorption (Kaneko *et al.* 1997). Low serum calcium prevents release of matured ova during estrus by inefficient muscular contraction.

Phosphorus (P)

The data for mean phosphorus concentration in serum of animals have been presented in Table 1. The mean serum phosphorus levels in lactating, dry heifers, anoestrus and repeat breeding animals were 4.57 ± 0.38, 3.83 ± 1.02, 4.80 ± 0.36, 3.48 ± 0.29 and 2.93 ± 0.06 mg/dl, respectively for Subhash Nagar village and 4.46 ± 0.27, 3.92 ± 0.21, 4.46 ± 0.93, 3.44 ± 0.37 and 2.31 ± 0.67 mg/dl, respectively for Salenpur village of Roorkee Tehsil with an average value 3.82 ± 0.25 mg/dl. There was no significant (P≤0.05) difference in the serum phosphorus values of animals between the two villages of Roorkee Tehsil. Similarly the mean serum phosphorus levels were 4.85 ± 0.59, 4.71 ± 0.17, 4.58 ± 0.93, 4.45 ± 1.05 and 1.54 ± 0.05 mg/dl in lactating, dry, heifers, anoestrus and repeat breeder animals of Dabkikalan village respectively, whereas the phosphorus levels in sum of corresponding animals of Maheshwari village of Laksar Tehsil were 3.63 ± 0.11, 4.22 ± 0.15, 4.29 ± 0.33, 2.67 ± 0.86 and 2.72 ± 0.52 mg/dl, respectively with an average serum phosphorus level of 3.77 ± 0.35 mg/dl. There was no significant (P≤0.05) difference in serum phosphorus level in animals between the two villages except in case of repeat breeders level, where serum phosphorus level of repeat breeding animals of Dabkilalan village was significantly low as compared to animals of Maheshwari village. There was also no significant difference in average serum phosphorus of animals between the two Tehsils. The lactating animals of village Maheshwari (Laksar), dry animals of Subhash Nagar (Roorkee), anoestrus animals of Subhash Nagar and Salenpur of Roorkee Tehsil and Maheshwari (Laksar) and repeat breeding animals of Salenpur (Roorkee) and Dabkikalan and Maheshwari of Laksar Tehsil were found far below the critical level (<4 mg/dl). The overall average levels of phosphorus in serum were 4.38 ± 0.26, 4.17 ± 0.20, 4.53 ± 0.11, 3.51 ± 0.36 and 2.38 ± 0.31 mg/dl in lactating, dry, heifers, anoestrus and repeat breeding animals, respectively of Haridwar, with an average level of 3.79 ± 0.21 mg/dl which was below the critical levels (<4 mg/dl). Most of the anoestrus and repeat breeding animals showed serum phosphorus level deficient as compared to lactating, dry and normal heifer animals. Similarly, Tandle *et al.* (1997) reported higher levels of serum phosphorus in normal oestrus cow (4.71 ± 0.44 mg/dl) than in anoestrus cows (3.09 ± 0.09 mg/dl).

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Magnesium (Mg)

The values for mean concentration of blood serum magnesium have been given in Table 1. Mean serum magnesium concentration in lactating, dry, heifers, anoestrus and repeat breeding animals were 1.00 ± 0.00, 1.16 ± 0.00, 2.50 ± 1.03, 2.96 ± 1.02 and 1.01 ± 0.00 mg/dl, respectively, in village Subhash Nagar, and 1.07 ± 0.04, 1.29 ± 0.01, 1.18 ± 0.08, 1.11 ± 0.09 and 0.91 ± 0.00 mg/dl, respectively, in village Salenpur of Roorkee Tehsil with an average value of 1.42 ± 0.22 mg/dl. There was no significant (P≥0.05) difference in these values between the animals of two villages. In Laksar Tehsil, the serum magnesium concentration in lactating, dry, heifers, anoestrus and repeat breeder animals were 2.88 ± 0.97, 1.66 ± 0.39, 1.46 ± 0.27, 1.11 ± 0.09 and 2.46 ± 1.18 mg/dl, respectively, in village and 1.71 ± 0.28, 1.78 ± 0.01, 2.18 ± 0.66, 1.90 ± 0.01 and 1.61 ± 0.57 mg/dl, respectively in village Dabkikalan and 1.88 ± 0.16 mg/dl, respectively in village Maheshwari. The average value of serum magnesium was 1.88 ± 0.16 mg/dl. No significant (P≥0.05) difference was observed in magnesium levels in animals except, anoestrus animals, where there was significantly (P≤0.05) low magnesium level in serum in animals of Dabkikalan villages of Laksar Tehsil. Significantly (P≤0.05) lower average serum magnesium levels were observed in animals of Roorkee Tehsil than the animals of Laksar Tehsil. The overall average levels of magnesium in serum were 1.67 ± 0.44, 1.47 ± 0.15, 1.83 ± 0.31, 1.77 ± 0.44 and 1.50 ± 0.36 mg/dl in lactating, dry, heifers, anoestrus and repeat breeding animals respectively, in Haridwar with an average level of 1.65 ± 0.14 mg/dl which was above the critical level. The values were within normal range as reported by Sharma *et al.* (2003). Significant (P≤0.05) difference for serum magnesium level between two Tehsils might be due to different feeding practices (Das *et al.*, 2002). The hypomagnesaemia mostly occurs in stall fed animals (Underwood and Suttle, 1999) which might be another reason for low magnesium level in animals of Roorkee Tehsil as compared to those of Laksar Tehsil**.** Lower level of serum magnesium in anoestrus and repeat breeding animals were observed in both the Tehsils. Eltohamy *et al.* (1989) pointed out that low calcium, phosphorus and magnesium levels in serum are responsible for infertility.

Micro-mineral content in blood serum of livestock

Zinc (Zn)

The mean values for zinc concentration in serum of animals are shown in Table 2. In Roorkee Tehsil, the average serum zinc concentration were 0.97 ± 0.13, 0.90 ± 0.21, 1.41 ± 0.24 1.21 ± 0.21 and 1.52 ± 0.30 ppm in village Subhash Nagar and 0.97 ± 0.15, 1.20 ± 0.01, 1.23 ± 0.15, 1.15 ± 0.22 and 1.02 ± 0.33 ppm, respectively in village Salenpur for lactating, dry, heifers, anestrous and repeat breeder animals with an average serum zinc value of 1.16 ± 0.06 ppm for Roorkee Tehsil. There was no significant difference in the zinc level in serum of animals between two villages. In Laksar Tehsil, the serum zinc concentration in lactating, dry, heifers, anoestrus and repeat breeder animals were 2.04 ± 0.66, 2.24 ± 0.72, 2.68 ± 0.46, 2.47 ± 0.25 and 1.77 ± 0.44 ppm, respectively, for village Dabkikalan and 1.57 ± 0.15, 1.95 ± 0.06, 1.53 ± 0.36, 1.61 ± 0.44 and 1.37 ± 0.18 ppm, respectively for village Maheshwari, with the average zinc serum concentration of 1.92 ± 0.14 ppm. No significant difference was observed in the zinc concentration in serum of animals between two villages. However, significant (P≤0.05) difference was discerned in average serum zinc levels in animals between the Tehsils. The overall average levels of zinc in serum were 1.39 ± 0.26, 1.57 ± 0.31, 1.71 ± 0.33, 1.61 ± 0.30 and 1.42 ± 0.16 ppm in lactating, dry, heifers, anoestrus and repeat breeding animals, respectively for Haridwar, district with an average level of 1.54 ± 0.11 ppm and all the animals had serum zinc level above the critical level (<0.6 ppm). Similar findings have been reported by Das *et al.* (2003b) and Biswas and Samanta (2002). No animal regardless of any physiological status was found deficient in serum zinc level. It may be due to fact that majority of feed samples contained zinc level within normal range. Contrary to the findings, Gowda *et al.* (2001), Ramana *et al.* (2001) and Sharma and Joshi (2004) reported low plasma zinc levels in a majority of animals.

Iron (Fe)

The average values for iron concentration in blood serum of animals are shown in Table 2. In Roorkee Tehsil, the serum iron level in lactating, dry, heifers, anoestrus and repeat breeding animals was 1.03 ± 0.24, 0.96 ± 0.22, 1.28 ± 0.24, 1.62 ± 0.32 and 1.23 ± 0.01 ppm, respectively of village Subhash Nagar and 1.32 ± 0.12, 1.82 ± 0.25, 2.03 ± 0.38, 2.28 ± 0.85 and 1.37 ±0.29 ppm, respectively of village Salenpur with an average value of 1.49 ± 0.14 ppm. No significant (P≥0.05) difference was observed in serum iron values of animals between two villages, however, serum iron level in heifers of Salenpur village was significantly (P≤0.05) higher than that of Subhash Nagar village. In Tehsil Laksar, the serum iron level in lactating, dry, heifers, anoestrus and repeat breeding animals were 3.13 ± 0.77, 2.62 ± 0.45, 2.96 ± 1.26, 3.79 ± 2.09 and 3.59 ± 1.22 ppm, respectively in village Dabkikalan while the serum iron level in corresponding animals was 1.63 ± 0.18, 2.21 ± 0.41, 1.43 ± 0.37, 1.46 ± 0.42 and 1.57 ± 0.07 ppm, respectively in village Maheshwari. The average serum iron concentration of animals of Laksar Tehsil 2.44 ± 0.29 ppm. There was no significant (P≥0.05) difference observed in serum iron concentration values of animals values of animals between the two villages. The serum iron concentration in animals of Laksar Tehsil (2.44 ppm) was found to be significantly higher (P≤0.05) than that of Roorkee Tehsil (1.49 ppm). The overall average levels of iron in serum were 1.78 ± 0.47, 1.90 ± 0.35, 1.93 ± 0.38, 2.29 ± 0.53 and 1.94 ± 0.55 ppm in lactating, dry, heifers, anoestrus and repeat breeding animals, respectively, of Haridwar, with an average iron level of 1.97 ± 0.19 ppm. No animals' serum iron level except dry animals of village Subhash Nagar (Roorkee) was found below the critical level (<1.0 ppm). Most of the animals under all categories were found within normal range of serum iron concentration. This may be due to the abundance of iron in soil as well as in feeds and fodders of the selected area (Das *et al.,* 2003a). Similar findings were reported by Yadav *et al.* (1998) and Samanta and Samanta (2002). They reported that the serum iron level in animals of different physiological status ranged from 1.44 ± 0.32 to 2.93 ± 0.56 ppm.

Copper (Cu)

The average values of copper in blood serum of animals are presented in Table 2. In Roorkee Tehsil, the serum copper concentration in lactating, dry, heifers, anoestrus and repeat breeding animals was 0.98 ± 0.03, 0.28 ± 0.08, 0.27 ± 0.02, 0.28 ± 0.01 and 0.25 ± 0.05 ppm, respectively of village Subhash Nagar whereas, in village Salenpur, the corresponding values were 1.10 ± 0.05, 0.35 ± 0.01, 0.29 ± 0.01, 0.32 ± 0.02 and 0.27 ± 0.07 ppm, respectively with an average value of 0.44 ± 0.10 ppm. The lactating and anoestrus animals differed significantly (P≤0.05) in copper concentrations between the villages of Roorkee Tehsil. In Laksar Tehsil, the values of serum copper concentration in lactating, dry, heifers, anoestrus and repeat breeding animals were 1.10 ± 0.10, 0.30 ± 0.06, 0.29 ± 0.01, 0.35 ± 0.02 and 0.42 ± 0.05 ppm, respectively, of village Dabkikalan and 1.05 ± 0.05, 0.31 ± 0.05, 0.28 ± 0.01, 0.29 ± 0.07 and 0.35 ± 0.02 ppm, respectively of village Maheshwari with average value of 0.47 ± 0.01 ppm. The overall average levels of copper in serum were 1.06 ± 0.03, 0.31 ± 0.01, 0.28 ± 0.0, 0.31 ± 0.02 and 0.32 ± 0.04 ppm in lactating, dry, heifers, anoestrus and repeat breeding animals, respectively, in Haridwar, with an average level of 0.46 ± 0.07 ppm. The lactating animals exhibited serum copper concentration above its critical level (<0.65 ppm) while animals under the other categories showed deficient serum copper concentration. The findings were supported by Yadav *et al.* (1998) and Gowda *et al.* (2001). Likewise, Sharma and Joshi (2004) observed deficient serum copper level in animals from Garhwal region of Uttaranchal. This might be due to several factors such as less availability of copper in feeds and fodders and decreased gut absorption as well as increased excretion of copper (Mc Dowell, 1985). Blood serum copper level was found highest in lactating animals ranging from 0.98 ± 0.03 to 1.10 ± 0.05 ppm in all the villages of Haridwar. Similar findings were observed by Das *et al.* (2003b) and Biswas and Samanta (2002). This might be due to better feeding practices

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adopted for milch cattle and it was also observed that serum copper concentration increased with the advancement of age (Vanakan *et al.,* 1991). The result of this study revealed deficient condition of P and Cu and mild deficiency for Mg in animals of plain region of Uttarakhand whereas Fe and Mn were in excess. Based on present data, strategic dietary supplementation of minerals with better bioavailability could be a suitable approach.

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Table 1- Macro mineral profile in blood serum of cattle and buffaloes of different physiological status in Haridwar district of Uttarakhand

Minerals	Critical level[f]	Category of animals	Roorkee		Average	Laksar		Average	Overall mean
			Subhash Nagar	Salenpur		Dabkikalan	Maheshwari		
Ca (mg/dl)	<8.00	i) Lactating (17)	10.18±0.64	10.73±0.21	10.46±0.27	10.24±2.66	10.95±0.56	10.60±0.35	10.53±0.19
		ii) Dry (13)	8.82±2.25	10.20±0.63	9.51±0.68	11.50±0.59	10.24±0.66	10.87±0.62	10.19±0.55
		iii) Heifer (10)	10.10±1.44	10.92±0.25	10.51±0.40	11.50±0.36	11.97±1.41	11.74±0.23	11.12±0.40
		iv) Anestrus (11)	10.62±0.81	10.58±0.09	10.60±0.02	11.48±0.34	8.80±2.50	10.14±1.32	10.37±0.56
		v) Repeater (11)	9.46±0.24	8.69±2.39	9.08±0.36	11.68±0.29	9.92±0.45	10.80±0.86	9.94±0.63
		Average*	9.84±0.31	10.22±0.40	10.03^{b}±0.25	11.28±0.26	10.38±0.53	10.82^{a}±0.31	10.43±0.22
P (mg/dl)	<4.00	i) Lactating (17)	4.57±0.38	4.46±0.27	4.52±0.05	4.85±0.59	3.63±0.11	4.24±0.60	4.38±0.26
		ii) Dry (13)	3.83±1.02	3.92±0.21	3.88±0.04	4.71±0.17	4.22±0.15	4.47±0.24	4.17±0.20
		iii) Heifer (10)	4.80±0.36	4.46±0.93	4.63±0.17	4.58±0.93	4.29±0.33	4.44±0.14	4.53±0.11
		iv) Anestrus (11)	3.48±0.29	3.44±0.37	3.46±0.02	4.45±1.05	2.67±0.86	3.56±0.87	3.51±0.36
		v) Repeater (11)	2.93±0.06	2.31±0.67	2.62±0.30	1.54^{b}±0.05	2.72^{a}±0.52	2.13±0.58	2.38±0.31
		Average	3.92±0.34	3.72±0.40	3.82±0.25	4.03±0.63	3.51±0.35	3.77±0.35	3.79±0.21
Mg (mg/dl)	<1.20	i) Lactating (17)	1.00^{a}±0.00	1.07^{b}±0.04	1.04±0.03	2.88±0.97	1.71±0.28	2.30±0.57	1.67±0.44
		ii) Dry (13)	1.16±0.00	1.29±0.01	1.23±0.06	1.66±0.39	1.78±0.01	1.72±0.06	1.47±0.15
		iii) Heifer (10)	2.50±1.03	1.18±0.08	1.84±0.65	1.46±0.27	2.18±0.66	1.82±0.35	1.83±0.31
		iv) Anestrus (11)	2.96±1.02	1.11±0.09	2.04±0.91	1.11^{b}±0.09	1.90^{a}±0.01	1.51±0.39	1.77±0.44
		v) Repeater (11)	1.01±0.00	0.91±0.00	0.96±0.05	2.46±1.18	1.61±0.57	2.04±0.42	1.50±0.36
		Average*	1.73±0.42	1.11±0.06	1.42^{b}±0.22	1.91±0.33	1.84±0.10	1.88^{a}±0.16	1.65±0.14

* Values bearing different superscripts in a row differ significantly ($p<0.05$)

Figures in parentheses indicate the number of samples analyzed.

[f] Miles and McDowell, 1983

Table 2- Micro mineral profile in blood serum of cattle and buffaloes of different physiological status in Haridwar district of Uttarakhand

Minerals	Critical level[f]	Category of animals	Roorkee		Average	Laksar		Average	Overall mean
			Subhash Nagar	Salenpur		Dabkikalan	Maheshwari		
Zn (ppm)	<0.60	i) Lactating (17)	0.97±0.13	0.97±0.15	0.97±0.00	2.04±0.66	1.57±0.15	1.81±0.23	1.39±0.26
		ii) Dry (13)	0.90±0.21	1.20±0.01	1.05±0.15	2.24±0.72	1.95±0.06	2.10±0.14	1.57±0.31
		iii) Heifer (10)	1.41±0.24	1.23±0.15	1.32±0.09	2.68±0.46	1.53±0.36	2.11±0.56	1.71±0.33
		iv) Anestrus (11)	1.21±0.21	1.15±0.22	1.18±0.03	2.47±0.25	1.61±0.44	2.04±0.42	1.61±0.30
		v) Repeater (11)	1.52±0.30	1.02±0.33	1.27±0.25	1.77±0.44	1.37±0.18	1.57±0.20	1.42±0.16
		Average*	1.20±0.12	1.11±0.05	1.16^{b}±0.06	2.24±0.16	1.61±0.10	1.92^{a}±0.14	1.54±0.11
Fe (ppm)	<1.00	i) Lactating (17)	1.03±0.24	1.32±0.12	1.18±0.14	3.13±0.77	1.63±0.18	2.38±0.74	1.78±0.47
		ii) Dry (13)	0.96±0.22	1.82±0.25	1.39±0.42	2.62±0.45	2.21±0.41	2.42±0.20	1.90±0.35
		iii) Heifer (10)	1.28^{b}±0.24	2.03^{a}±0.38	1.66±0.37	2.96±1.26	1.43±0.37	2.20±0.75	1.93±0.38
		iv) Anestrus (11)	1.62±0.32	2.28±0.85	1.95±0.32	3.79±2.09	1.46±0.42	2.63±1.14	2.29±0.53
		v) Repeater (11)	1.23±0.01	1.37±0.29	1.30±0.07	3.59±1.22	1.57±0.07	2.58±0.99	1.94±0.55
		Average	3.92±0.34	3.72±0.40	3.82±0.25	4.03±0.63	3.51±0.35	3.77±0.35	3.79±0.21
Cu (ppm)	<0.65	i) Lactating (17)	0.98^{b}±0.03	1.10^{a}±0.05	1.04±0.06	1.10±0.10	1.05±0.05	1.08±0.02	1.06±0.03
		ii) Dry (13)	0.28±0.08	0.35±0.01	0.32±0.03	0.30±0.06	0.31±0.05	0.31±0.00	0.31±0.01
		iii) Heifer (10)	0.27±0.02	0.29±0.01	0.28±0.01	0.29±0.05	0.28±0.01	0.29±0.00	0.28±0.00
		iv) Anestrus (11)	0.28^{b}±0.01	0.32^{a}±0.02	0.30±0.02	0.35±0.02	0.29±0.07	0.32±0.03	0.31±0.02
		v) Repeater (11)	0.25±0.05	0.27±0.07	0.26±0.01	0.42±0.05	0.35±0.02	0.39±0.03	0.32±0.04
		Average*	0.36±0.14	0.42±0.15	0.44±0.10	0.45±0.15	0.40±0.15	0.47±0.01	0.46±0.07

[*] Values bearing different superscripts in a row differ significantly ($p<0.05$)

Figures in parentheses indicate the number of samples analyzed.

[f] Miles and McDowell, 1983