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COMPARISON OF THE SERUM MINERALS THAT PROMOTE BONE HEALING IN HEALTHY AND CLINICALLY SICK GOATS IN BANGLADESH

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ABSTRACT: Serum minerals such as calcium, phosphorous, and magnesium are essential for the skeletal system during bone formation and remodeling as well as fracture repair. Present study was intended to assess the serum biochemical parameters of three of the most important macro minerals (calcium, phosphorus, and magnesium), which are key minerals for bone healing or development in healthy and clinical sick goats. Serum samples were collected from a total of 200 goats (healthy=102, clinically sick=98) from a veterinary hospital and three farms of Chattogram, Bangladesh. The overall mean serum calcium level of healthy goats was 8.47±0.11 mg/dl and in sick goats it was 7.63±0.12 mg/dl, and the value was much lower than the reference value in sick goats. The serum phosphorus and magnesium levels did not vary between the two groups and were within (phosphorus) or close to (magnesium) the range of reference values. In healthy goats, their serum calcium level varied significantly considering age, body weight, sex, feeding type, and owner's income. However, the serum phosphorus and magnesium levels did not vary significantly across the different parameters tested, except for sex and owner's income in the case of phosphorus. Three sick goats had hypocalcemia, which means that their calcium and magnesium levels were lower than the standard values of 5.9±0.5 and 1.9±0.2 mg/dl, respectively. However, their phosphorus levels were normal across all groups of sick goats. In conclusion, the value of an important mineral for bone healing is lower in both sick and healthy goats, which is a frightening sign for bone problems. Most goats have low levels of calcium and magnesium but average levels of phosphorous. Based on these findings, sufficient calcium and magnesium can be added to feed and given orally to further prevent bone fracture.

Keywords: Calcium, Clinically sick animals, Feeding type, Indigestion problems, Magnesium, South Asian region.

INTRODUCTION

Calcium, phosphorus, and magnesium are essential minerals in animal feed, playing crucial roles in bone healing, glucose absorption, urine formation, protein metabolism, and pH regulation (Moniem et al., 2014; Yadav et al., 2024). In Bangladesh, research on the serum minerals and trace elements in goats is considerably less than that on sheep and cattle (Rahman et al., 2018; Hossion et al., 2020; Samaddar, 2022). Rahman and Haque (2001) found hypocalcemia in 15% of cattle, 9% of goats, 7% of sheep, and 12% of cows in Bangladesh. In India, researchers found hypocalcemia in 10% of cattle, 9% of goats, 8% of sheep, and 14% of buffalo (Roche and Berry, 2006). Researchers have identified species, age, sex, breed, and stage of the production period as potential risk factors for hypocalcemia in goats (Quader et al., 2017). Researchers observe the biochemical parameters to identify metabolic, parasitic, and viral infections in ruminants (Begum et al., 2021; Saleh et al., 2022).

These parameters help to evaluate management methods, nutrition, and health conditions in a more realistic way (Tekeli et al., 2024). Metabolic problems, such as pregnant toxemia, are associated with decreased calcium levels even in both clinical and subclinical conditions (Albay et al., 2014). The required quantities of calcium and phosphorus remain within the reference values for infectious diseases such as Peste des Petits Ruminants (PPR) (Begum et al., 2018). The total concentration of biochemistry and antioxidants in healthy animals can change based on their age, race, gender, the food they eat, their environment, stress, and other things. Therefore, creating reference intervals for each animal species, based on their specific age, is vital for obtaining more precise biochemical test findings (Gül and Biçer, 2021).

There are numerous reports available to investigate serum biochemical parameters like calcium and phosphorous in healthy goats. The study makes use of the small population sizes in India, Pakistan, Nepal, and Bangladesh, which are

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approximately (<100) individuals (Gharban and Al-Shaeli, 2021; Esraa et al., 2025; Tanvir-Ul-Alam et al., 2025). Research on serum biochemical factors, such as calcium, phosphorus, and magnesium, in sick goats is limited (Mbuh and Mbwaye, 2005; Begum et al., 2018). Understanding the biochemical markers that distinguish healthy from sick goats is vital for assessing their nutritional status, management methods, and overall health.

The central goal of this research is to furnish crucial information that can facilitate improved herd management practices and veterinary interventions, particularly concerning the healing of bone fractures in this vital livestock species. Furthermore, this study seeks to rectify the existing paucity of extensive data pertaining to goat biochemistry, specifically within the South Asian context.

MATERIAL AND METHODS

Study area and duration

This study was conducted in Chattogram district between July 2022 and December 2022 in the Teaching Veterinary Hospital of Chattogram Veterinary and Animal Sciences University, Bangladesh, and on three goat farms.

Animal sampling and data collection

A 5 mL sample of blood was collected from 98 clinically sick and 102 healthy goats. The sick goats were admitted to the hospital for treatment with several indications and symptoms, such as elevated body temperatures, bone fractures, urolithiasis, a pregnancy assessment, and diarrhea. The selection of healthy goats was based on well-organized data records and an adequate number of goats from different breeds. A standardized questionnaire was employed to record information about the goats, including their demographic particulars (species, age, sex, and breed), dietary patterns (grass, concentrate, or both), and farmer's income (low, middle, and high).

Sample processing and analysis

Aseptically, a standard technique was followed to collect five milliliters of blood from each goat's jugular vein. The samples for biochemical analysis were immediately processed at the Department of Medicine and Surgery (Clinical laboratory), Chattogram Veterinary and Animal Sciences University. The analysis was conducted using a biochemical analyzer (EA-200, E-LAB, Germany) following the manufacturer's instructions.

Statistical analysis

The recorded data were entered into a data recording spreadsheet of Microsoft Excel 2010. Subsequently, the data were uploaded to the statistical program JMP Pro-13 for analysis (Ye et al., 2000). Descriptive statistics analysis was conducted to summarize the data presented as mean ± SE. One-way ANOVA was used to estimate the effect of different features of serum biochemical parameters. In the present study, a p-value < 0.05 was considered statistically significant.

RESULTS

The overall mean serum calcium level of healthy goats was 8.47±0.11 mg/dl and in clinically sick goats, it was 7.63±0.12 mg/dl (P=0.001), and the value was much lower than the reference value in clinically sick goats. The two groups' serum concentrations of magnesium and phosphorus did not differ significantly from each other. The phosphorus levels were within the acceptable range, whereas the magnesium levels were near the reference values (Table 1).

In healthy goats, the serum calcium level of healthy goats varied significantly considering age (P=0.02), body weight (P=0.02), sex (P=0.01), feeding type (P=0.03), and owner's income (<0.001). However, the serum phosphorus and magnesium levels did not vary significantly across the different parameters tested, except for sex (P=0.003) and owner's income (<0.001) in the case of phosphorus (Table 2). In clinically sick goats, the serum calcium level was significantly lower in goats diagnosed with hypocalcemia, while the serum phosphorous level was lower in goats diagnosed with musculoskeletal defects, wounds, parasitic infestation, PPR and indigestion (Table 3).

Table 1 - Overall serum calcium, phosphorus, and magnesium levels in healthy and clinically sick goats.

Parameter	Healthy goats (N = 102) (LSM±SEM)	Clinical sick goat (N = 98) (LSM±SEM)	P-value	References Normal values (Pugh and Baird, 2011)
Calcium	8.47±0.11	7.63 ±0.12	0.001	8.9-11.7 mg/dl
Phosphorous	4.61±0.16	4.70 ±0.16	0.68	4.2-9.1 mg/dl
Magnesium	2.17±0.04	2.15 ±0.04	0.68	2.8-3.6 mg/dl

Table 2 - Serum calcium, phosphorus, and magnesium levels in healthy goats were determined using multiple parameters that were available in different farm goats.

Parameter	Categories	Calcium (LSM ± SEM)	Phosphorous (LSM ± SEM)	Magnesium (LSM ±SEM)
Age	<6month (n=8)	8.64±0.40	4.56±0.35	2.16±0.12
	>6-1year (n=20)	8.34±0.24	4.93±0.21	2.28±0.08
	>1-2year (n=22)	7.86±0.23	4.14±0.20	2.02±0.07
	>2-3year (n=22)	8.56±0.24	4.75±0.21	2.19±0.08
	>3year (n=30)	8.89±0.20	4.65±0.17	2.20±0.06
	P- value	0.02	0.10	0.21
Body weight	<10kg (n=3)	8.71±0.65	4.65±0.58	2.25±0.21
	>10-20kg (n=22)	8.28±0.22	4.77±0.20	2.22±0.07
	>20-30kg (n=34)	8.18±0.19	4.38±0.17	2.17±0.06
	>30-40kg (n=31)	8.55±0.20	4.58±0.18	2.10±0.06
	>40kg (n=12)	9.45±0.32	5.00±0.29	2.23±0.10
	P- value	0.02	0.37	0.75
Sex	Female (n=61)	8.25±0.14	4.37±0.12	2.13±0.04
	Male (n=41)	8.80±0.17	4.96±0.15	2.23±0.05
	P- value	0.01	0.003	0.17
Breeds	Barbari (n=3)	9.26±1.14	5.25±1.01	2.34±0.37
	Beetal (n=10)	9.25±0.34	5.13±0.30	2.28±0.11
	Cross (n=8)	8.16±0.34	4.41±0.30	2.04±0.11
	Gujri (n=2)	10.32±1.14	4.31±1.01	2.12±0.37
	JP (n=42)	8.25±0.17	4.41±0.15	2.11±0.05
	Local (n=13)	8.37±0.33	4.88±0.29	2.34±0.21
	Sirohi (n=3)	9.60±0.66	5.29±0.58	2.27±0.21
	Totapuri (n=21)	8.48±0.25	4.59±0.21	2.20±0.08
	P- value	0.06	0.35	0.45
Feed	Grass 30%+ concentrate70% (n=12)	7.87±0.25	4.20±0.21	2.15±0.08
	Grass 70%+ concentrate30% (n=8)	8.56±1.15	4.34±0.99	2.12±0.37
	Grass 50%+ concentrate50% (n=82)	8.62±0.12	4.72±0.10	2.18±0.04
	P- value	0.03	0.10	0.92
Income	Low income (n=32)	7.09±0.27	3.50±0.24	2.04±0.10
	Middle income (n=50)	8.90±0.11	4.93±0.10	2.20±0.04
	High income (n=20)	7.87±0.21	4.20±0.19	2.15±0.08
	P- Value	<0.001	0.00	0.34

Table 3 - Serum biochemical parameters in relation to different clinical conditions in goats presented in a teaching veterinary hospital (CVASU, Bangladesh).

Parameter	Calcium (LSM±SEM)	Magnesium (LSM±SEM)	Phosphorous (LSM±SEM)
Hypocalcemia (N=3)	5.90±0.50^{b}	1.93±0.20^{a}	8.66±0.87^{a}
Musculoskeletal (N=26)	7.87±0.24^{a}	2.26±0.10^{a}	4.70±0.42^{b}
Wound (N=22)	7.69±0.23^{a}	2.08±0.09^{a}	4.24±0.41^{b}
Parasites (N=18)	7.24±0.26^{ab}	2.21±0.11^{a}	4.28±0.46^{b}
Urolithiasis (N=5)	7.79±0.50^{ab}	2.41±0.20^{a}	5.30±0.87^{ab}
Anestrous (N=2)	7.06±0.79^{ab}	1.82±0.33^{a}	4.77±1.39^{ab}
Peste des Petits Ruminants (PPR) (N=11)	8.17±0.33^{a}	1.92±0.14^{a}	4.57±0.59^{b}
Indigestion (N=11)	7.97±0.33^{a}	2.23±0.14^{a}	4.37±0.59^{b}
P-value	0.012	0.307	0.003

$^{a, b}$ – values in rows with different letters differ significantly ($P < 0.05$)

DISCUSSION

The present investigation found that clinically sick goats had considerably lower calcium levels than reference values, supporting Karapinar et al. (2024)'s claim that adult sick cattle had lower calcium levels. Sick goats had lower calcium and magnesium levels than standard values. Their phosphorus levels were acceptable. Zhao et al. (2015) indicated reduced calcium, magnesium, and phosphorous in sick dairy cows. The present investigation revealed that goats exhibiting clinical symptoms presented with calcium concentrations that were notably diminished relative to the established normal range. This observation corroborates the findings of Karapinar et al. (2024), who documented decreased calcium levels in affected adult cattle. In addition, the sick goats exhibited reduced calcium and magnesium level when in comparison to expected values, while their phosphorus levels remained within the normal range. Zhao et al. (2015) similarly documented diminished calcium, magnesium, and phosphorus levels in afflicted dairy cows. Conversely, in healthy goats, the mean blood calcium levels were found to be lower than the reference value.

Phosphorus concentrations were deemed satisfactory; however, magnesium levels were only slightly below the reference range. Omidi et al. (2018) observed analogous findings, documenting a decrease in calcium and magnesium levels in captive settings, while phosphorus levels remained within the normal range. This discrepancy may have been attributable to a feed supply with inadequate calcium-to-magnesium ratios. The current investigation indicated that goats exceeding three years of age (n = 32) exhibited calcium, phosphorus, and magnesium levels within the reference values. Conversely, Antunović et al. (2019) reported that serum calcium levels in goats under one year of age were within normal limits, despite phosphorus levels being normal across all age groups. While this finding contradicted our study's results, it was consistent with the observation that phosphorus levels were standard across all ages.

Antunović et al. (2019) found that goats of all ages maintained normal calcium levels when given calcium-rich feed. In contrast, our study showed a decrease in calcium levels, suggesting that the calcium in the goat feed might not be enough. Also, our results showed that younger goats had higher phosphorus levels than older goats, which agrees with Poulsen's (1991) findings. Radostits et al. (2000) suggested that the decrease in blood phosphorus levels seen in adult goats is due to their reduced ability to absorb phosphorus from food. Moreover, it is important to note that growth hormone might increase phosphate levels in the blood of young animals by helping the kidneys reabsorb phosphate (Kaneko et al., 2008). This observation might explain why younger goats show higher phosphorus levels. In this study, adult and mature goats had magnesium levels below the expected range. However, Gwaze et al. (2012) suggest a possible link between magnesium and how the body uses this important mineral. Unlike the current study, differences in environmental conditions or the type of feed could explain this decrease.

Goats weighing more than 40 kg (N = 12) showed greater calcium levels than those weighing less than 40 kg, according to the present study. The present study supported by Samardžija et al. (2011) mentioned that goats with higher body weights have higher calcium levels. Bayoumi et al. (2021) confirmed the present study's finding that females are more prone to hypocalcemia than males, reporting that lower calcium levels are more common in females than in males. They explained that this was because females need more calcium during the periparturient phase. The present investigation found that females have lower phosphorus levels than males of the same age. Kaneko et al. (2008) found that male goats contain more phosphorus. Female may eat more and lose more phosphorus during pregnancy. The present investigation found that crossbred animals had more hypocalcemia than native breeds which support the present study by Quader et al. (2017) who found that crossbred goats have lower calcium levels than native breeds due to the greater loss of calcium during the milking process.

The goat raised semi intensively and fed with a died containing 30% grass and 70% concentrate exhibited lower calcium value, However, goats fed with 70% grass and 30% concentrate, and even those fed with 50% grass and 50% concentrate, had calcium values remarkably similar to the reference value. This finding corresponds to the findings of Adama and Moyosoluwa (2014), who reported that goats were in semi-intensive systems had lower serum calcium values. The current study revealed that goat owners with lower and higher incomes exhibited diminished levels of calcium, magnesium, and phosphorus in comparison to middle-income goat owners. Islam et al. (2018) support present study, demonstrating a statistically significant reduction in the correlation between income and the levels of calcium and phosphorus among lower-income goat owners. The lower-income segment can have financial problems supplying balanced goat feed. In the present study the standard serum concentrations of calcium and phosphorus were significantly lowered in goats presenting with different clinical diseases. The present observation is consistent with the work of Bandzaite et al. (2005), who documented similarly reduced calcium and phosphorus levels in diseased cows with a variety of diseases. Furthermore, the present study revealed that hypocalcaemia resulted in a return of magnesium levels to their baseline values. Present findings support the conclusions of Bayoumi et al. (2021), who suggested that nutritional deficiencies could precipitate increased excretion during vigorous contractions. The prsent study showed that during musculoskeletal problem, calcium level were lower then the nrmal value which support present study by Braun et al. (2009). The present study revealed that calcium leval was decreased during wound healing, which supported by Lansdown et al. (1999). Present study found that calcium and phosphorus levels decreased during infections like Peste des Petits Ruminants (PPR), a finding that differs from the results of Begum et al. (2021). As a result, a loss of appetite and diarrhoea might occur, which then leads the body to lose calcium.

The present results showed that calcium levels were lower than the standard range for goats with metabolic disorder, including digestion disorder cases. The present finding backs up by Ahn et al.'s (2023) hypothesis that indigestion affects the stomach's acidity, which then prevents calcium from turning into salt. If calcium is not absorbed, it is eliminated through feces. As a result, the calcium concentration decreases below the normal level.

CONCLUSION

Clinically sick goats exhibited significant variations in the concentrations of key mineral markers which help in bone healing when compared to their healthy goats. These differences, which were evident across various conditions, were modulated by factors including age, body weight, sex, dietary intake, and income in the healthy goat population. Conversely, the clinically sick goats presented a more restricted spectrum of mineral parameters.

DECLARATIONS

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Data availability
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Authors' contribution
Saroj Kumar Yadav: Investigation, Methodology and Writing-original draft, Sunil Yadav: data collection and sample test. MdAhaduzzaman: Formal analysis, Writing- review and editing. Monor Sayeed Pallab: Supervision, Writing-review and editing. Bibek Chandra Sutradhar: Supervision, Writing-review& editing. Bhajan Chandra Das: Supervision, Writing-review and editing.

Consent to publish
The publishing of this manuscript is approved by all authors.

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Ethical approval
The study was carried out in accordance with the rules established by the ethical council of Chattogram Veterinary and Animal Sciences University in Bangladesh; (EC of CVASU) Approval Number: Memo No. CVASU/Dir (R&E) EC/2022/435(1)/5.

Competing interests
No competing interests have been disclosed by the authors.

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