Association Between Blood Levels of Calcium, Magnesium and Phosphorus and Fertility in Post-partal Cross-bred dairy Cows in the Sudan.

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ABSTRACT

A total number of 206 crossbred dairy cows (Zebu x Holstein Friesian) in five different dairy farms were selected for this study. Blood profiles of calcium, magnesium and phosphorus were established. Blood samples were collected monthly from each cow. Blood levels of the above mentioned macrominerals were determined by using a standard methods. Data were presented as means ± standard deviations and ANOVA followed by Fisher’s Protect Least Significance were used for comparison between means of the five herds. Herd was found to have a significant effect on the blood levels of the three metabolites (P<0.05). The metabolites were measured in different seasons of the year and in different stages of lactation. The relationships between the blood levels of calcium, magnesium and phosphorus and the duration of postpartum period and the number of services per conception were established. Correlation coefficient was calculated using ANOVA followed by regression blots. Blood levels of calcium and magnesium had no effects on the durations of postpartum period, but the trait was significantly affected by the blood levels of phosphorus. The number of services per conception was significantly affected by the blood levels of calcium, but neither by blood levels of magnesium nor phosphorus.

The aim of this study is to correlate the serum concentrations of calcium, inorganic phosphorus and magnesium with fertility traits of cross bred dairy cows in the Sudan.

INTRODUCTION

Calcium, Magnesium and inorganic phosphorus are macrominerals that are very important in terms of production and reproduction of dairy cows (Parra et al., 1999). Phosphorus and calcium deficiencies reduce reproductive efficiency in cattle and phosphorus supplementation increases fertility of cattle grazing in phosphorus deficient area.

Low dietary intake of phosphorus associated with anestrus and with irregular estrous cycle and increased services per conception (Noller et al., 1977). Many studies investigated the relationship between many blood metabolite levels and infertility with regard to energy, protein and minerals. These studies indicated that high or low serum phosphorus (Hewett, 1974) and other mineral imbalances (Butler et al., 1989) can all be related to fertility problems. In the Sudan, such study is lacking.
MATERIALS AND METHODS

A total number of 206 crossbred dairy cows (Zebu x Holstein Friesian), aged 3-8 years in five different dairy herd (H1, H2, H3, H4 and H5) were used in this study. The animals in four herds were housed in pens constructed from iron poles and corrugated iron sheets, but in one herd, the ranch was constructed from local materials with inadequate shade. The sheds were provided with clean drinking water, tanks, and troughs for concentrates. Each dairy cow in each herd was identified by a numbered ear-tag and their history was fully recorded regarding the number of parity, date of last calving and the dates of estrus. The cows in herd one were let out doors for grazing every day from 7:00 a.m. to 9:00 a.m. This exercise was not practiced for the other herds. Cows in the five herds were milked twice daily, early in the morning and at the afternoon. Home made concentrates were supplied to cows in the five herds with daily allowance of 4-8 kg per cow according to milk yield, and at the end of the dry period. The ingredients of the concentrate mixtures of the different five herds comprised of crushed sorghum, groundnut cake, wheat bran, lime stone and sodium chloride with varying percentages. Mal practicing, such as providing only groundnut cakes or wheat bran alone, was also found. The analysis of the feed was not performed except for crude protein which ranged between 20.7 and 42.2%. Green fodder mainly sorghum grass (Abu 70) and or Barseem were fed to all cows. The cows were divided into five groups:
1. The early lactating cows (From the day of calving to the 90th day of lactation).
2. The cows in mid-lactation (from the day 90 of lactation to the day 150).
3. The cows in their late stage of lactation (from day 150 of lactation to the day of drying off).
4. The cows in the dry period before providing concentrate ration (8th month of pregnancy).
5. The dry cows after providing concentrate ration (9th month of pregnancy (Closed-up dry period)).

Blood samples were collected monthly from each cow in each herd by Veno-puncture of the jugular vein. Samples were collected in sterile plain vacutainer tubes. Serum was harvested after centrifugation, and stored at -20°C till used for biochemical analysis. Biochemical analysis for serum samples was achieved by using the colorimetric method to analyze serum calcium, inorganic phosphorus and magnesium.

Statistical Analysis

Data were presented in means ± standard deviations. The results were statistically analyzed by using ANOVA Followed by Fisher’s Protect Least Significance (PLSD). Differences at probability of P< 0.05 were considered to be statistically significant. Data for correlation were analyzed by using ANOVA followed by regression blots. Correlation was considered significant when r ≥ 0.1.

RESULTS

In this study, the mean blood levels of calcium, inorganic phosphorus and magnesium were determined in five different dairy herds in the Sudan. The result is illustrated in table 1. Herd had a significant effect (P< 0.0001) on blood levels of the
three macrominerals measured in this study. The level of calcium was significantly lower in H2 (P>0.05) than the blood levels of H1, H3, H4, and H5. But there was no significant difference between blood levels of calcium of H1, H4 and H5. Blood level of calcium of H4 was significantly higher than that of H3. The level of inorganic phosphorus was significantly lower in H5. There was no significant difference between the blood levels of phosphorus of H1, H2 and H3, but the blood levels of phosphorus of H5 was significantly lower than the blood levels of the other herds. The blood level of magnesium of H1, was significantly lower (P < 0.05) than the blood levels of H2, H3, H5, but not of H4. The blood level of magnesium of H4 was significantly lower than the blood levels of H2 and H3, but there was no significant difference between this herd and H1 and H5 regarding the blood levels of magnesium.

The effect of the three seasons of the year (summer, autumn and winter) on blood levels of calcium, inorganic phosphorus and magnesium was studied. The result is shown in table 2. Season had no significant effect on blood levels of calcium and magnesium, but had a significant effect on the level of inorganic phosphorus. (P>0.05), although the blood level of calcium in autumn was significantly higher (P<0.05) than that of winter. The level of inorganic phosphorus was significantly lower in winter but there is no significant difference in the levels in summer and autumn.

The effect of stages of lactation on blood levels of the three metabolites was also studied (table 3). Blood levels of calcium are significantly affected (P<0.0001) by the stages of lactation. The level was significantly lower in the early stage of lactation and in the dry period. The levels were significantly higher in the mid-lactation, (7.4+1.5mg/dl) and in the closed-up dry period (7.3 + 1.3mg/dl) mg/dl. There was no significant difference between the blood levels of calcium in the dry period (6.3 + 1.0 mg/dl) and in the early lactation (5.9 + 0.7 mg/dl) and late lactation (6.7 + 0.9 mg/dl). The mean blood level of phosphorus was significantly affected by the stages of lactation (P<0.0001). The level in the early stage of lactation (5.1 + 1.2 mg/dl) was significantly higher than the levels in the other stages. Also the level in the dry period (4.4 + 1mg/dl) was significantly higher than the levels in the mid-lactation (4.0 + 0.5 mg/dl) and in the closed-up dry period, (4.0 + 0.8 mg/dl). The mean blood levels of magnesium in the different stages of lactations were significantly different (P<0.0001). The blood level in the dry period (2.8 + 1.3 mg/dl) was significantly lower than the levels in the other stages of lactations. The level in the closed-up dry period (3.7 + 1.3 mg/dl) was significantly higher than the levels in the late stage of lactation (3.0 + 0.5 mg/dl), but the level in the closed-up dry period was not significantly different from the levels in the early stage of lactation (3.3 + 0.8 mg/dl) and in the mid-lactation (3.4 + 0.7 mg/dl).

In this study, the relationship between the blood levels of calcium, inorganic phosphorus and magnesium postpartum, and the length of postpartum period and number of services per conception were established. Eighty crossbred dairy cows which at the early postpartum periods were selected. The result is shown in figures 1, 2, 3, 4, 5 and 6.
Calcium levels during the postpartum period had no effect on the duration of postpartum period, but there was a negative relationship between these levels and the number of services per conception (Y > 0.1). Blood levels of inorganic phosphorus reported in this study had a negative relation with the duration of postpartum period (Y = 0.1) but there was no relation between them and the number of services per conception. Blood magnesium levels reported in this study has no relationships between neither the postpartum period nor the number of services per conception (Y < 0.1).

Table 1: Mean Blood Levels of Calcium, Inorganic Phosphorus and Magnesium in Different Five Dairy Herds.

<table>
<thead>
<tr>
<th>Herd No.</th>
<th>Calcium (mg/dl)</th>
<th>Phosphorus (mg/dl)</th>
<th>Magnesium (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>7.0±0.6</td>
<td>4.8±0.6</td>
<td>2.5±0.5</td>
</tr>
<tr>
<td>H2</td>
<td>6.2±0.2</td>
<td>4.7±0.5</td>
<td>3.4±0.8</td>
</tr>
<tr>
<td>H3</td>
<td>6.6±0.4</td>
<td>4.8±0.3</td>
<td>4.0±0.6</td>
</tr>
<tr>
<td>H4</td>
<td>7.2±0.3</td>
<td>3.7±0.5</td>
<td>2.9±0.3</td>
</tr>
<tr>
<td>H5</td>
<td>6.9±0.9</td>
<td>4.1±0.8</td>
<td>3.3±0.7</td>
</tr>
</tbody>
</table>

Table 2: Mean Blood Levels of Calcium, Inorganic phosphorus and Magnesium in the three seasons of the years.

<table>
<thead>
<tr>
<th>Season</th>
<th>Calcium (mg/dl)</th>
<th>Phosphorus (mg/dl)</th>
<th>Magnesium (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>6.8±0.7</td>
<td>4.6±0.7</td>
<td>3.3±0.6</td>
</tr>
<tr>
<td>Autumn</td>
<td>7.0±0.6</td>
<td>4.6±0.5</td>
<td>3.5±0.7</td>
</tr>
<tr>
<td>Winter</td>
<td>6.6±0.7</td>
<td>3.9±0.7</td>
<td>3.1±0.8</td>
</tr>
</tbody>
</table>

Table 3: Mean Blood Levels of Calcium, Phosphorus and Magnesium in Different Stage of Lactation

<table>
<thead>
<tr>
<th>Stage of Lactation</th>
<th>Calcium mg/dl</th>
<th>Phosphorus (mg/dl)</th>
<th>Magnesium (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Lactation</td>
<td>5.9±0.7</td>
<td>5.1±1.2</td>
<td>3.3±0.8</td>
</tr>
<tr>
<td>Mid-lactation</td>
<td>7.4±1.5</td>
<td>4.0±0.5</td>
<td>3.4±0.7</td>
</tr>
<tr>
<td>Late Lactation</td>
<td>6.7±1.0</td>
<td>4.4±1.2</td>
<td>3.1±0.5</td>
</tr>
<tr>
<td>Dry Period</td>
<td>6.3±1.0</td>
<td>4.4±1.2</td>
<td>2.8±0.7</td>
</tr>
<tr>
<td>Closed-up Dry Period</td>
<td>7.3±1.4</td>
<td>4.0±0.8</td>
<td>3.7±1.3</td>
</tr>
</tbody>
</table>
Fig. 1: Relationship between Blood Levels of Calcium and the Duration of Postpartum Period.

\[ Y = 83.283 + 0.598 \times X; R^2 = 0.001 \]

Fig. 2: Relationships between Blood Levels of Calcium and the Number of Services Per Conception

\[ Y = 5.695 - 0.441 \times X; R^2 = 0.18 \]
**Fig. 3:** Relationships between Blood Levels of Phosphorus and the Duration of Postpartum Period

\[ Y = 111.351 - 5.404 \times X; \ R^2 = .092 \]

**Fig. 4:** Relationship between Blood Levels of Phosphorus and the Number of Services Per Conception

\[ Y = 2.36 + .009 \times X; \ R^2 = .005 \]
Fig. 5: Relationship between Blood Levels of Magnesium and the Duration of Postpartum Period

\[ Y = 93.054 - 1.775 \times X; R^2 = .011 \]

Fig. 6: Relationship between Blood Levels of Magnesium and the Number of Services Per Conception:

\[ Y = 3.125 - .107 \times X; R^2 = .009 \]
DISCUSSION

Metabolic profile test had been widely used to estimate the nutritional status of dairy herds, to evaluate the fertility of the herds and to predict the occurrence of certain metabolic diseases so that control measurements can be taken (Payne et al., 1970 and Williams et al., 1970). In this study, herd had a significant effect on blood levels of inorganic phosphorus, but not on blood levels of calcium and magnesium. This implies that blood metabolites affected by the location of the herd, the feeding practice and the management system. This result is in accordance with that of Payne et al. (1970) who stated that differences of blood chemistry among herds and even within one herd are common. The effect of season on the blood metabolites levels was comprehensively reviewed (Lee et al., 1978). In this study, season had no effect on blood levels of calcium, magnesium but blood levels of inorganic phosphorus were significantly affected. Although many researchers reported that blood metabolites tend to be higher in humid summer and lower in the cold season (Eicher et al., 1998), but in this study, this effect was not clear because, probably, due to two factors, firstly, the mal practicing in feeding system in which only one ingredient, such as groundnut cake or wheat bran may be provided either for economic reasons or to reach the maximum level in milk yield, and the second factor was that the length of the day lights in different seasons of the year is not big in Sudan. The effect of stage of lactation had also been reviewed by Lee, et al. (1978). In this study, blood metabolites tended to be lower in early stage of lactation, due to negative energy balance resulting from the great in-appetence, and during the dry period, due to low daily allowance of feed. However the levels increased during the period of positive energy balance and during the closed-up dry period. The results of this study were in close agreement with those previously reported.

Inorganic phosphorus is a blood mineral which was significantly higher in early stage of lactation and during the dry period in this study. The explanation of this result seems to be difficult because phosphorus, calcium and magnesium are interrelated metabolites so that factors lead to fluctuation on level of one of them should be affect the others, but probably, the increase of blood levels of phosphorus in early stage of lactation and during the dry period along with calcium and magnesium levels without being affected, may be due to presence of materials such as phytic acid, which is available in grain, and form complexes with calcium and magnesium and prevent the intestinal absorption, so that the interrelation of calcium, phosphorus and magnesium metabolism is interrupted.

In this study, the relationships between blood metabolites during the early postpartum period and the reproductive performance of dairy cows were well reviewed (Payne et al., 1970, Jordan and Swanson, 1979 and Jones et al., 1991, Seifi et al., 2005). The relations between blood levels of calcium, inorganic phosphorus and magnesium during the early postpartum period were also established. Although calcium had been reported as an important factor in all body functions including reproduction, but in this study, calcium had no effect on duration of postpartum period, this may be due to other factors needed to be investigated. However, number of services per conception was found to be negatively related to blood calcium levels.
This means that high blood levels of calcium decrease the number of services per conception and consequently reduce the open period resulting in short calving interval, since calcium is responsible for the myometrial contraction. Calcium deficiency could be responsible for retardation of uterine involution thus increases the postpartum period. Blood inorganic phosphorus was found to affect the duration of postpartum period. Phosphorus, along with calcium, are important factors in metabolic pathways including reproductive tract secretions and metabolism. The involvement of phosphorus in the phospholipids and cAMP synthesis may be a key to its effect on reproduction (Hurley and Doane, 1989).

The blood levels of magnesium had no effect on the reproductive performance of crossbred dairy cows in this study. The role of blood magnesium levels alone on reproductive performance in this study was not obvious.

REFERENCES


Acknowledgements

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