Mineral Nutrition and Early Embryonic Mortality in the Bovine Animal

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Introduction

Embryonic mortality (EM) is estimated to cause approximately 75 to 80 percent of the infertility problems in the bovine from conception to day 40.[6] Embryonic mortality refers to loss of embryos during the period extending from conception to completion of the stage of differentiation which occurs at approximately 45 days in the bovine (Committee on Reproductive Nomenclature 1972). An increase in the interval between insemination and return to estrus beyond the usual range of 17–25 days reflects the possibility of embryonic mortality.[10] A significant difference occurs in intervals between periods of estrus before and after insemination. Ninety percent of preinsemination cycles were of normal length, as compared with only 43.5 percent postinsemination cycles.[7]

Despite these significant findings there are strong objections to the use of increased estrous cycle intervals between insemination and the return to estrus as the main criteria for embryonic mortality. Estimations of progesterone levels in blood[1] and in milk[14] have shown that up to 20 percent of cows inseminated were probably not in estrus. Postinsemination inflammation or infection of the uterus may induce a persistent corpus luteum, therefore, delaying a sequential estrus.[12] It is known that the major portion of embryonic mortality occurs by day 15 postconception.[4,5,8] Death of the embryo occurs before its ability to prevent the secretion of luteolysin by the uterus. The cow returns to an estrus within the usual range of 17 to 25 days despite a conception.

Even though it is known that more embryonic deaths occur by day 15 postconception, especially in repeat breeders,[4,5] and that planned slaughter is the most reliable method for evaluating embryonic losses,[3] the present study selected the extended cycle lengths as its differentiating criteria. Embryonic losses from day 26 to day 55 or more were evaluated. The obvious reason for choosing the extended cycle lengths in this study was that a normal dairy herd setting with valuable animals was being used. A planned slaughter method was neither feasible nor practicable.

Factors that may cause embryonic mortality are classified into two main categories: (a) genetic factors—breed, family, inbreeding and blood groups;
(b) environmental factors—nutrition, age, climate, infections, hormonal imbalance and uterine environment.[3]

In recent years a surge of interest has been aroused concerning the bio-availability of both macro and microminerals for intestinal absorption and accessibility of these minerals at the intracellular level. What effects these minerals have on bovine fertility, especially embryonic mortality, has become an imperative concern.

Today the man-made dynamo, the dairy cow, has a genetic potential to produce more milk in one lactation than previously imagined. The demands, stresses and requirements of these animals for maintenance and milk production need to be reassessed, especially for the reproductive system. The Nutritional Requirements of Dairy Cattle, that have been used for many decades to balance dairy feed rations, were updated in 1978 and again in June 1987. This indicated concern that bio-availability of certain essential macro and microminerals at the intracellular level could possibly be less than optimum.

It is known that some minerals are bonded in the digestive tract, especially in the rumen and duodenum and then eliminated in the feces.[2] With this bonding these essential minerals, which are necessary in enzymatic and other metabolic reactions within the cell, do not actually reach the intracellular environment. Certain types of chelated minerals, Metalosates®, that are formed with two or more amino acids and a metal producing a heterocyclic ring compound, are able to bypass this bondage because they carry a neutral charge. These Metalosates®, with a molecular weight of less than 1,000, can be absorbed and metabolized as much as 300 to 500 percent more efficiently than the inorganic minerals.[2]

We became interested in the Metalosates® in conjunction with our study on the incidence and degree of endometrial histopathology in the bovine in the University of Maryland's 160 cow dairy herd. The bio-availability of the Metalosates® could possibly have an effect on their relationship to the postpartum involution process, delayed

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estrous cycles, ovulation, embryonic mortality, endometrial histopathology, and overall fertility in the bovine. Many cases of infertility and embryonic mortality in the University's herd and selected cases from veterinary practitioners could not be justified with clinical palpations and endometrial histopathology.[16]

Aware that optimal nutrition is vital in maximum milk production and reproduction in the dairy cow, the transfer of these nutrients and minerals to the reproductive organs and the embryo must play important roles in embryonic viability and overall bovine fertility.

An objective of this pilot investigation was to determine if the addition of the amino acid chelated minerals, Metalosates®, to the dairy ration had any effects on suspected and/or confirmed cases of embryonic mortality.

Materials and Methods

Forty first-calf Holstein heifers were selected from the University of Maryland dairy herd. The heifers were identically grouped, as closely as possible, according to their due dates. Twenty heifers were fed the standard prepartum ration for the herd and were considered the control group. The other twenty heifers received an amino acid chelated mineral supplement, Breeder Pac®, in addition to the standard prepartum diet. These animals were classed as the treated group. The supplement contained a complex proteinate of potassium and heterocyclic ring compounds of magnesium, manganese, iron, copper and zinc.

Each treated animal was fed 31.103 grams daily of the Metalosates for approximately 30 days prepartum. At parturition the amount of supplement was increased to 62.206 grams daily. This regime was continued until conception and pregnancy were diagnosed by rectal palpation.

Rectal palpations were performed routinely every 10 to 14 days. Detailed recordings were made of peripartum complications; i.e. dystocias, retained placentas, trauma, vaginal discharges, cervical and uterine size and tone, ovarian activity, estrous cycle lengths, insemination dates and services per conception.

Biopsies were taken from the left and right horns and body of the uterus between 30 to 80 days postpartum.[9,15] Sufficient tissue was procured from each site for histopathologic evaluations.[17] Swab samples were collected concurrently with the biopsies from the vagina, cervix and uterus for anaerobic and aerobic microbial identification.

Results

Conception occurred 45 days earlier on the average in the treated animals than in the control animals.

Extended lengths of the estrous cycle ranged between 26 to 38 days postinsemination.

Control group

- 11 of 20 (55%) showed extended estrous cycles.
- 5 of the 11 (45%) showed 2 or more 21 day cycle lengths plus 5 to 9 days over a normal cycle length.

Treated group

- 6 of 20 (30%) showed extended estrous cycles.
- 4 of the 6 (67%) showed 2 or more cycle lengths plus 5 to 14 days over a normal cycle length.

Assuming that the extended length of the estrous cycle indicates embryonic mortality, the control group had a suspected 55 percent embryonic mortality rate while the treated group showed a 30 percent rate.

Confirmed embryonic mortality between days 30 to 55 was 20 percent of the total control group. The treated animals indicated no confirmed cases of embryonic mortality.

Discussion

Metalosates® are amino acid chelated minerals, namely magnesium, manganese, iron, copper and zinc, in which each element is bonded to two or more amino acids forming a heterocyclic ring compound. Potassium was included in the supplement, Breeder Pac®, as a complex proteinate. These organic compounds carry neutral charges. Metalosates® are not broken down by the enzyme, pepidase, in the lumen of the intestine into two or more amino acids and free metal ions, but are absorbed as a dipeptide into the body tissues. The metal in the Metalosates® prevents the enzymatic action of pepidase.[13] The essential mineral is then released as needed from the organic bond within the endometrial cell to perform vital metabolic functions.[2]

These Metalosates® are more readily accessible at the intracellular level in the endometrial tissues than their inorganic counterparts.[2] The role that these minerals play intracellularly alone or by synergistic action to assist in maintaining a proper uterine environment for the developing embryo is not completely known.

It is highly possible that the milking dynamo does not have the necessary blood flow and nutrient supply to the reproductive system during her negative nutritional phase of her lactation cycle. The addition of amino acid chelated minerals above the recognized standard requirement for inorganic minerals indicate the possibility of several conditions:

1. that the inorganic minerals supplied in the balanced ration are inadequate for optimal reproductive performance;
2. that these inorganic minerals are theoretically adequate but excessive amounts are bonded as

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inert compounds in the rumen and intestines, therefore, not optimally accessible at the cell level;

3. that additional inorganic minerals for optimal reproductive performance could lead to toxic conditions;[11] whereas, chelated minerals have shown no toxicity at higher levels;[2]
4. that the amino acid chelated minerals are an adjunct to the inorganic minerals making both more accessible at the intracellular level; or
5. that the addition of amino acid chelated minerals alone are necessary for optimal reproductive performance.

These postulates need to be addressed in order to understand the exact effects that the Metalosates® have on reproductive efficiency in the bovine.

The suspected cases of embryonic mortality were definitely more prevalent among the control animals (55 percent) as compared to the treated group (30 percent). Confirmed embryonic mortality between days 30 to 55 was 20 percent of the total control group. The treated animals indicated no confirmed embryonic deaths.

Embryonic mortality was substantiated by rectal palpation of embryonic depressions in the uterine horns in each of the confirmed deaths. Each depression measured approximately 5 to 6 cm in length and 3 to 4 cm in width and was elliptical in shape. The walls of the depression were much thinner than the surrounding uterine tissue. It was estimated that the abortion occurred approximately 2 to 10 days prior to the palpation. The more distinct the demarcation between the depression and surrounding tissues, the more recent the abortion was thought to have occurred.

This pilot study conducted at the University of Maryland indicates that mineral bio-availability at the intracellular level is necessary for the maintenance of a viable embryo and overall bovine fertility.

Summary

Amino acid chelated minerals reduced embryonic mortality in First-Calf Holstein heifers. Each treated animal received 31.103 gms of Metalosates® daily for 30 days prepartum and 62.206 gms daily postpartum until pregnancy was confirmed. Each animal was examined rectally every 10—14 days postpartum for ovarian activity and uterine condition. Between 35–55 days confirmed embryonic mortalities (EM) were found in 20% of the control group, while none were found in the treated animals. Diagnosis of confirmed EM was determined by estrous cycle lengths and embryonic depressions in the uterine horns. The suspected cases of EM were indicated in 30% of the treated animals and 55% of the control group. Extended estrous cycle lengths were the criteria in these suspected cases.

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