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Leptin: The Key to Beef Heifer Puberty and Its Enhancement by Monensin*

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Introduction

Leptin is being investigated as a necessary component to attain reproductive efficiency in beef cattle. The effect of feeding monensin on leptin levels at puberty sheds light on the mechanism of action of leptin. Cows that calve early in the breeding season or have a calving interval of twelve months or less are more profitable than cows with longer calving intervals. For each 21-day heat-cycle a cow is late calving, her calf will weigh about 40 lb less at weaning. Cows that calve early in the breeding season as heifers will be more likely to calve early as cows, and in order for heifers to calve early, they must reach puberty early. The selection and management of replacement heifers influences the reproductive efficiency of the cattle industry by optimizing age at puberty. Heifers that mature sexually at an early age are more likely to settle earlier in a controlled breeding season and wean a heavier calf. These heifers tend to settle early each breeding season for the rest of their reproductive lives and have heavier weaning weights throughout their lifetime.

With this economic value placed on reproduction, ways to measure, improve and predict reproductive efficiency in cattle are critically important. Age, nutritional status and genetics are factors that control the onset of puberty in beef heifers. Nutritional status of beef heifers and reproduction are intimately related. A target weight of 65% of mature weight at breeding is critical for a successful breeding program. Monensin is an ionophore feed supplement used to increase weight gain and decrease age at puberty in beef and dairy heifers. The mechanism of action to decrease age at puberty has not been fully determined. Pre-pubertal heifers fed monensin produced larger corpora lutea, larger follicles and exhibited increased response to administration of gonadotropins compared to control heifers fed to achieve equal weight gains.

Leptin is a peptide produced by adipocytes, released into the serum, and crosses the blood- brain barrier where it attaches to receptor sites, initiating a cascade of events that result in altered appetite and initiation of puberty in pre-pubertal animals. Increases in nutritional levels and energy reserves of cattle results in increased serum leptin. In addition monensin has been shown to increase the transport of leptin across the blood brain barrier. Leptin attachment to receptor sites in the hypothalamus affects the production and/or release of neurotransmitter neuropeptide Y and subsequently affects the control of lutenizing hormone, insulin and growth hormone.

Lutenizing hormone production and pulse frequency are the keys to initiating puberty in heifers. Thus, leptin appears to be a key element in partitioning of energy resources in direct response to energy availability. Energy partitioning in the bovine allocates available energy first to body maintenance, and as more energy becomes available, to growth, then to lactation and lastly to reproduction. Fat reserves accumulate as energy becomes abundant. The production of leptin by adipocytes affects leptin concentration at the neuro-receptor site level, and that determines how energy resources are partitioned. If this concept is accurate, then a threshold level of leptin, greater than that required to maintain body homeostasis and provide for growth, must be available to initiate the onset of puberty in beef heifers.

Materials and Methods

Ninety 10 to 12-month-old, nulliparous heifers were divided into three feed management groups. Each of these groups received different supplemental feed as well as free choice silage and grazing (see Table 1). Within each feed management group one-half of the heifers were randomly assigned to be given free choice mineral containing 1620 grams of monensin per ton, and the second half were the control group given the same mineral with no monensin. Paired groups were placed in matching pastures. The rate of mineral utilization resulted in an average consumption of 105 mg monensin per heifer per day for those heifers receiving monensin, verses no monensin, for the control groups. During a 114-day feeding trial, weight, serum leptin levels, and reproductive tract scores were determined.

Results and Conclusions

Based on the information described above, it seems reasonable to propose that the decrease in age of puberty in heifers fed monensin may be partly associated with an effect of monensin on serum leptin and/or the ability of monensin to facilitate the transport of leptin across the blood-brain barrier. Heifers fed monensin gained weight more rapidly and attained higher serum leptin levels. The heifers fed monensin gained an average of 17.47 lbs more during the 114-day trial (P=.0001). Leptin levels increased over time as the cattle gained more weight, and the rate of leptin increase was greater for the heifers fed monensin by 1.88 ng/ml as compared to control heifers during the 114-day feeding trial (P=.0010) (see Table 2). The increased weight gain appears to be due to increased adipose tissue, resulting in increased leptin production. Since leptin has such a profound impact on age at puberty, the inference is that feeding monensin decreases age at puberty in developing beef heifers. The heifers fed monensin attained a three-plus reproductive tract score (RTS) (attained puberty) when the serum leptin level reached 6.5 ng/ml, while the control heifers did not reach a RTS of three-plus until serum leptin levels reached 11.8 ng/ml. These data indicate that a threshold level of leptin is necessary for a beef heifer to attain puberty, and this threshold level can be reduced by feeding monensin. The mechanism for reducing the threshold may be due to the ability of monensin to transport leptin across the blood-brain barrier and/or an increase in leptin production from increased adipose tissue. Monensin consumption was only 105 mg per heifer per day. That is approximately one-half of the recommended dose for developing beef heifers.

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*Rumensin®, Elanco Animal Health, Eli Lilly Co., Indianapolis, IN

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Table 1. Feed management groups.

Group 1a	1% body weight dry corn gluten per day with monensin
Group 1b	1% body weight dry corn gluten per day with no monensin
Group 2a	1% body weight corn and soybean meal per day with monensin
Group 2b	1% body weight corn and soybean meal per day with no monensin
Group 3a	1 % body weight corn per day with monensin
Group 3b	1 % body weight corn per day with no monensin

Table 2. Mean Weight Gains with SD and Mean Leptin Changes with SD.

Monensin 114 day feeding trial	Weight gain (lb) During 114 day test	SD wt gain (lb) During 114 day test	Leptin (ng/ml) change During 114 day test	SD Leptin (ng/ml) change During 114 day test
Lot 4 Sil/Glu/No Monensin	260.00	23.15	7.01	2.37
Lot 5 Sil/Corn/SBM/No Monensin	266.00	22.45	6.18	3.43
Lot 8 Sil/Corn/No Monensin	235.05	27.94	3.15	2.22
Lot 9 Sil/Glu/No Monensin	250.60	35.68	3.76	2.16
Average No Monensin	252.91	27.30	5.03	2.55
Lot 3 Sil/Glu/Monensin	274.75	41.97	6.44	2.04
Lot 6 Sil/Corn/SBM/Monensin	269.25	38.13	7.57	2.52
Lot 7 Sil/Corn/Monensin	252.32	31.12	7.46	2.98
Lot 10 Sil/Glu/Monensin	285.20	32.88	6.17	2.13
Average with Monensin	270.38	36.02	6.91	2.42