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Effect of supplemental trace mineral level and form on peripubertal bulls☆

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ABSTRACT

Objectives were to determine if supplemental trace mineral levels and/or forms (sulfate and metal amino acid complexes) influence age at puberty, semen quality, endocrine status, and scrotal circumference in peripubertal bulls. Fifty peripubertal bulls were blocked by age and scrotal circumference and assigned to one of five treatments: (1) 1x sulfate form (1S); (2) 1x complexed form (1C); (3) 1S + 1C (2SC); (4) 1S + 2 × 1C (3SCC); and (5) 3 × 1S (3S). Each 1x supplementation level contained 360 mg Zn, 125 mg Cu, 200 mg Mn and 12.5 mg Co. Liver biopsies were collected on d −21 and 100, and scrotal circumference, semen, and blood samples were collected on d −14, 14, 42, 70, and 98. All bulls were deficient in Cu yet adequate in Zn on d −21. Following 100 d on treatment, liver Zn concentrations decreased ($P < 0.01$) and liver Cu concentrations increased ($P < 0.01$) in bulls regardless of treatment. Day 100 liver Zn concentrations were similar ($P = 0.50$) across treatments, but liver Cu concentrations were greater ($P = 0.07$) in 3SCC and 3S bulls compared to 1C and 1S bulls, whereas 2SC bulls were intermediate. Bulls fed complexed minerals tended to reach puberty after fewer ($P = 0.11$) days on treatment (43.9 ± 5.7 d) than bulls fed only sulfate minerals (58.5 ± 6.7 d). Supplementing complexed Cu and Zn to prepubertal bulls may lower the age at puberty, however, no differences ($P \geq 0.40$) in semen characteristics or scrotal measurements ($P \geq 0.11$) were observed.

1. Introduction

Producers use yearling bulls as a vital tool to accelerate genetic turnover of economically important traits. In addition, economic analyses of accumulated bull ownership and breeding costs associated with calf production per cow exposed, revealed greater profitability by using yearling bulls over 2-yr old bulls, given comparable genetic merit (Kasari et al., 1996).

In a review of 1276 Breeding Soundness Exam (BSE) records, 43% of bulls less than 15 months old were clas-

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sified as unsatisfactory breeders or classification deferred (Carson and Wenzel 1997). Elmore et al. (1975) re-evaluated 45 bulls less than two years of age that scored questionable or unsatisfactory on an initial BSE and reported 69% of these bulls' scores improved to satisfactory status 75 d later. This study concluded that the primary cause of these yearling bulls' failure to pass the initial BSE was due to immaturity.

Many of the factors that influence age of puberty in bulls are under direct control of management. Both Zn and Cu are involved in sexual maturity and reproductive development and maintenance of male ruminants (Hidiroglou, 1979). Assessing the correct Zn and Cu requirements for bull calves is important both from a production and economic standpoint. The current National Research Council (NRC, 2000) guidelines do not make adjustments in mineral requirements for cattle based on growth potential, levels of productivity, physiological status, stress levels, breed, or sex.

Due to the importance of Zn in male reproduction and the synergistic relationship of Cu with Zn, we felt that further investigation into the role of different levels and forms of trace minerals may be beneficial to producers. The objectives of this study were to determine if form and/or level of supplemental trace minerals fed to peripubertal bull calves influenced: (1.) liver trace mineral storage (2.) rate of sexual maturity (3.) quantity and quality of semen production and (4.) testicular development.

2. Materials and methods

2.1. Experimental design

This experiment was conducted at the USDA-ARS Livestock and Range Research Laboratory, Fort Keogh, in Miles City, MT. All procedures were approved by the Montana State University and Fort Keogh IACUC (IACUC No. 092702-1). Fifty crossbred bull calves, sired by one of four genetically similar Hereford sires, with an average initial body weight of 248 ± 31.5 kg were utilized. All bull calves had the same grandsire. Eighty-one days before initiation of the trial (d 0), all mineral supplements (free choice inorganic mineral) were removed from the bull calves and their dams. Bulls were weaned 47 d before the start of trial and were housed in feedlot pens to adjust to the basal diet. No mineral supplement was provided during this adjustment period. Bulls were allotted by puberty status, age (258 ± 8.9 d), and scrotal circumference (26.88 ± 2.3 cm) and assigned to one of five groups, of ten bulls each, to evaluate different trace mineral supplementation treatments: 1) 360 mg Zn, 200 mg Mn, 125 mg Cu, 12 mg Co in sulfate form (1S), 2) 360 mg Zn, 200 mg Mn, 125 mg Cu, 12 mg Co in complexed form (1C; Availa-4, Zinpro Corporation, Eden Prairie, MN), 3) 360 mg Zn, 200 mg Mn, 125 mg Cu, 12 mg Co in sulfate form plus 360 mg Zn, 200 mg Mn, 125 mg Cu, 12 mg Co in complexed form (2SC), 4) 360 mg Zn, 200 mg Mn, 125 mg Cu, 12 mg Co in sulfate form plus 720 mg Zn, 400 mg Mn, 250 mg Cu, 24 mg Co in complexed form (3SCC), and 5) 1080 mg Zn, 600 mg Mn, 375 mg Cu, 36 mg Co in sulfate form (3S).

Table 1
Nutrient composition of basal ration fed to bulls. Diet was formulated to provide a 1.2 kg per day gain. Diet contained 7% alfalfa hay, 10.5% corn, 75.5% corn silage, and 7% protein supplement.

DM, %	48.70
CP, %	13.70
NE_g, Mcal/kg	0.50
NE_m, Mcal/kg	0.70
TDN, %	66.60

Table 2
Trace mineral content (ppm) provided to bulls in 13.6 kg of basal diet plus respective supplement fed to peripubertal bulls.

	Zn	Cu	Mn	Co
Basal diet				
Alfalfa hay	1.3	0.5	1.5	<0.5
Corn grain	2.5	0.4	3.2	<0.5
Corn silage	3.3	3.3	24.3	<0.5
Total	7.1	4.2	29.0	<0.5
Treatment[a]				
1S	53	16	54	0.9
1C	53	16	52	1.1
2SC	76	22	56	1.5
3SCC	118	35	58	2.8
3S	115	32	74	2.7
Water[b]	0.17	0.01	0.02	–

[a] Treatments 1S and 3S provided Zn, Cu, Mn and Co in sulfate forms. Treatment 1C contained all complexed mineral (Availa-4®; Zinpro Corporation, Eden Prairie, MN). Treatments 2SC and 3SCC contained both complexed and sulfate forms of minerals.
[b] Water was available ad libitum that contained additional trace mineral and was high in sodium (499 ppm) and sulfur (23.3 ppm).

Beginning d 0 through d 100, supplements were measured and individually fed daily in 0.45 kg of wheat middlings before providing bulls with their basal diet. The basal diet of 75.5% corn silage, 10.5% corn, 7% alfalfa hay, and 7% protein supplement was fed to all bulls and was formulated to achieve 1.2 kg ADG. Basal diet nutrient composition was analyzed and is reported in Table 1. The mineral analysis of the basal diet was analyzed by Animal Health Diagnostic Laboratory (Michigan State University, East Lansing MI) using coupled argon-atomic emission spectroscopy (Braselton et al., 1997). The results are reported in Table 2.

Bulls were assigned to one of ten pens with all feed provided in Calan gates and one animal per treatment per pen following an initial collection (-14 d) of semen, blood, scrotal circumference, and body weights. Bulls were allowed a 14 d acclimation period to adapt to individual feeding gates and automatic waterers. Two bulls (both treatment 1C) died during treatment (both unrelated to treatment). Thus, two pens contained only four bulls.

Water was supplied free choice in automatic waterers from a common source. Water was analyzed for mineral content at the Animal Health Diagnostic Laboratory (Michigan State University, East Lansing MI) using coupled plasma-atomic emission spectroscopy (Braselton et al., 1997). Sodium concentration was above recommended