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Calving distributions of individual bulls in multiple-sire pastures

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ABSTRACT

The objective of this project was to quantify patterns in the calving rate of sires in multiple-sire pastures over seven years at a large-scale cow-calf operation. Data consisted of reproductive and genomic records from multiple-sire breeding pastures (n = 33) at the United States Meat Animal Research Center (USMARC) from 2007 to 2013. Calving intervals were analyzed in 21-day periods. A ranking system for each bull was developed based on the calving rate per pasture over the breeding season, with Rank 1 = the bull with greatest calving rate, Rank 3 = the bull with the least calving rate, and Rank 2 = all other bulls. A total of 179 bulls and 3703 calves were successfully genotyped over seven years. A uniform distribution described the expected percentage of calves sired per rank within pasture. Rank 1 bulls sired 113% greater calves than the expected pasture-average, Rank 2 bulls sired 6% less than expected, and Rank 3 bulls sired 81% less than expected. A rank by calving interval interaction effect was identified ($P < 0.05$). A Rank 1 bull in calving interval 1 produced a greater average percent of the total calf crop over the entire season, compared to a Rank 2 and Rank 3 bull. The calving rate for individual sires is not homogeneous and there is a large difference between bulls siring the greatest and least number of calves. More research is needed to determine how rank changes over multiple breeding years and its association with dominance, libido, and fertility.

1. Introduction

In commercial cow-calf operations in the United States, multiple bulls are utilized within individual breeding pastures. On average there are 24 cows per mature bull and 17 cows per yearling bull [1]. Bulls are expected to impregnate a high number of cows in a relatively short breeding season. Reproductive performance of bulls relies on the ability to detect cows in estrus, effectively mate cows, and successfully fertilize the oocyte to produce a viable fetus. The theory and practice of breeding soundness examinations is to screen bulls prior to the breeding season to assess some factors that impact reproductive success, such as sperm cell morphology and motility and musculoskeletal conformation [2,3]. The desire of a bull to actively seek cows in estrous in order to mate is described as libido [4]. The number of estrous cows successfully mated is thought to be influenced not only by libido, but also by other bulls within the hierarchical nature of the herd, more commonly known as social dominance [5,6]. Understanding and quantifying social dominance has been attempted, with little success to accurately predict reproductive performance based on social dominance [5,7,8]. Although commercial cow-calf managers do not have simple methods to identify bulls with high libido or high social dominance, there may be genetic and economic benefits for identifying these bulls.

Variability in the number of offspring born per bull exists between sires in multiple-sire pastures. The reasons for the variability are currently unknown, but have been speculated to be due to differences in libido, social dominance, or conception success among bulls [7,9]. If variability of reproductive success between

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bulls in multiple-sire pastures is due to libido or social dominance, an accurate understanding of bull behavior is needed. Serving capacity, as a proxy for libido, has been shown to be correlated with proportion of estrous cows mated by a bull in a single-sire pasture [10]. The effect of serving capacity on the number of offspring sired in a multiple-sire pasture may be mediated by the bull's hierarchical social ranking. If the number of cows in estrous is three or less, Blockey (1979) observed that a dominant bull is able to successfully prevent mating by other bulls, presumably regardless of competing bulls' libido [5]. If libido and social dominance rank are unrelated behavioral traits, then bulls with high libido and low social dominance or bulls with low libido and high social dominance are likely to negatively impact the number of calves sired by bulls with these characteristics in a multiple-sire pasture. Analyzing overall calving success by bull and patterns of calving success by 21-day intervals are necessary to investigate reasons for variability in progeny data. The objective of this study was to quantify patterns in the number of calves sired by bulls in multiple-sire pastures over multiple years at a large-scale cow-calf operation. We hypothesized that patterns of calving success by 21-day intervals during the calving season would show that bulls siring the greatest number of calves had different calving patterns than other bulls within that pasture.

2. Materials and methods

2.1. Herd description

Retrospective reproductive data were collected from cowherds housed at the United States Meat Animal Research Center (USMARC). Data consisted of reproductive and genomic records from multiple-sire breeding pastures (n = 33) from 2007 to 2013. Breeding began in June for each year analyzed and lasted for 63 days, and only one breeding season per year per bull was considered. Pastures consisted of cool and warm season grasses and ranged from 24.3 to 48.6 ha in size. Rotational grazing was utilized to insure adequate nutrition. Each breeding pasture contained 23 to 243 cows with an average of 16 cows per bull (range 8–26). Bulls within each pasture were the same age. Breed of cows and bulls consisted of purebred as well as composites of approximately 16 breeds (ranging from 100% to 6.25% of any given breed). Breed within each breeding pasture was selected to produce the desired breeds and sire lines for genetic evaluation projects unrelated to this project. Breeding lifetimes averaged two years for bulls at USMARC, with a range of one to six years. A bull was culled during or after a breeding season based on injuries, reproductive performance, and/or genetic selection purposes. If a bull was removed during the breeding year, the length of total days the bull was in the breeding year was recorded.

2.2. Genotyping

All cows, bulls, and calves were genotyped using the animal's blood or semen with the Bovine SNP50 BeadChip to determine parentage [11]. Genotyping was confirmed by pedigree as previously described [12,13]. Only sires with successfully genotyped calves were included in the dataset. If a calf was not successfully genotyped, the calf was removed from the analysis.

2.3. Calving intervals, rank classification, calving distributions

Calving intervals were analyzed in 21-day periods within the calving season; interval 1 consisted of days 0–21, interval 2 consisted of days 22–43, and interval 3 consisted of days 44–63. An individual bull's reproductive performance as measured by calving rate was calculated as number of calves sired divided by the days the bull was in the pasture for the breeding year. For example, if a bull sired 10 calves and was in the breeding pasture the entire 63 days, then the calving rate would be calculated as 10 calves/63 days = 0.159 calves per breeding-day. If a bull was in the breeding pasture for less than 63 days, this number was used to determine the calving rate. For example, if a bull sired 7 calves, and was in the breeding pasture for 27 days, the calving rate would be calculated as 7 calves/27 days = 0.259 calves per breeding-day. Based on this calving rate, a ranking system for each bull over the entire breeding season was developed, with Rank 1 = the bull with greatest calving rate, Rank 3 = the bull with the least calving rate, and Rank 2 = all other bulls. If two bulls had the same greatest calving rate, both those bulls received a “Rank 1” as their rank score. If two bulls had the same least calving rate, those bulls received a “Rank 3” as their rank score.

A uniform distribution was used to describe the expected percentage of calves sired per rank within a pasture. Observed percentage of calves sired was determined based on total calves sired by individual bull rank per pasture. The standardized rate between the observed and expected percentage of calves sired for each rank for all breeding seasons was calculated by the following formula [14]:

$$\frac{(\textit{Observed \% of calves sired per rank per pasture} - \textit{Expected \% of calves sired per rank per pasture})}{\textit{Expected \% of calves sired per rank per pasture}}$$

2.4. Statistical analysis

All descriptive analytics were performed in Excel (Microsoft Office Excel 2010, Microsoft Corporation, Redmond, WA). Statistical analysis was conducted to evaluate the overall calving distribution based on calving percent in each 21-day interval in each pasture, each year. The model was ran with the PROC GLIMMIX procedure (SAS Institute Inc., Version 9.4, Cary, NC, USA) and included the 21-day interval as a fixed effect and a random intercept term to account for clustering within pasture within year. Statistical analysis was conducted to evaluate differences between individual bull rankings within intervals of the total calving percent with the PROC GLIMMIX procedure (SAS Institute Inc., Version 9.4, Cary, NC, USA). The model included fixed effects for rank, interval, and a rank by interval interaction, a random intercept term was included to account for clustering within pasture within year, and a random residual term with compound symmetry covariance structure was included to account for repeated measures for each sire.

3. Results

3.1. Reproductive performance and calving distribution

A total of 3703 calves were successfully genotyped, and a total of 179 bulls were individually analyzed. Average calving success