PEER REVIEWED

Scrotal circumference at weaning in beef bulls and subsequent ability to pass a breeding soundness examination as a yearling

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Abstract

Identifying bulls at weaning with higher likelihood of passing a breeding soundness examination as yearlings may improve management options to optimize production efficiency. The objective of this study was to evaluate the effect of weaning scrotal circumference and other factors collected at the time of weaning on the likelihood of passing a breeding soundness examination as a yearling. Data, at both weaning and time of breeding soundness examination, were collected from 1 operation (n = 466 bulls). A logistic regression model was used to evaluate the potential associations of relevant factors (actual weaning scrotal circumference, adjusted weaning scrotal circumference, weight per day of age at weaning, scrotal circumference per day of age at weaning, weaning weight, and breed) on the probability of passing a breeding soundness examination as a yearling. Overall, 92.3% of bulls passed the yearling breeding soundness examination on first evaluation. Weaning scrotal circumference was the only factor of those evaluated associated ($P < 0.01$) with the probability of passing the breeding soundness examination. No significant differences were found between the categories of weaning scrotal circumference. In the future, more research needs to evaluate predictive model development for weaning scrotal circumference and ability to pass breeding soundness examination.

Key words: bull, scrotal circumference, breeding soundness examination, BSE

Introduction

Producers developing bulls traditionally use criteria such as performance, genetic potential or phenotype when deciding to keep or cull bulls after weaning. The primary cause of yearling bulls' inability to pass a semen evaluation is a high percent of abnormal sperm.[3] The increased percentage of abnormal sperm is commonly a result of immaturity and associated low testosterone.[8,11] A reliable predictor of the onset of puberty is scrotal circumference, which may be a better indicator than age, weight or breed.[7] Increased testicular size generally indicates earlier puberty in half-siblings and daughters, increased percentage of normal sperm, and more total sperm.[1,10] Testicular size is highly heritable.[6] Little research has evaluated the impact of weaning age parameters on the likelihood of passing a yearling breeding soundness examination. Finding weaning criteria to help producers identify bulls with a lower likelihood of passing a semen evaluation as yearlings may provide an important advantage to producers. The objective of this study was to evaluate the effect of weaning scrotal circumference and other relevant factors collected at weaning on the likelihood of passing a breeding soundness examination as a yearling for a producer weaning approximately 450 bulls per year of 3 different breed types.

Materials and Methods

Animal Care

Bulls evaluated in the study were housed at a single purebred beef operation. All cattle were provided appropriate feed, water, and housing to ensure appropriate animal welfare. Veterinary care was provided by a licensed veterinarian.

Data Collection

Data were collected on 466 bulls from 1 operation at 2 different time points (weaning and yearling breeding semen evaluation) from 1 calf crop. Scrotal circumference measurements were taken by 2 trained individuals at weaning on April 17-20, 2017 using a steel tape.[a] Weaning weight, age, and breed were provided by the producer. Yearling breeding soundness evaluations were performed by a veterinarian on September 18-20, 2017. Twelve bulls were removed from the study for missing weaning data, and another 10 bulls were removed due to missing yearling data. A total of 444 bulls were included in the analysis (Figure 1).

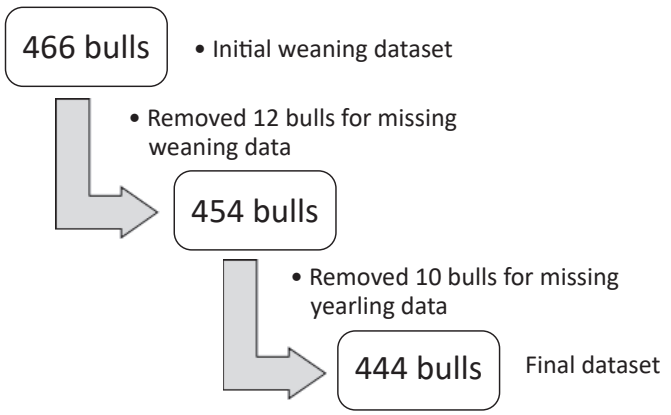

Figure 1. Flow chart depicting the number of bulls retained for each exclusion criteria set in place.

Breeding Soundness Evaluation

Yearling breeding soundness evaluations were performed by a veterinarian and registered veterinary technician following the 2016 revised guidelines set by the Society for Theriogenology. A physical examination evaluated body condition score, feet/legs, eyes, accessory sex glands, penis, scrotum, testes, and epididymis. Semen examination evaluated gross motility, and individual morphology with regards to normal sperm, abnormal sperm, and white blood cell/red blood cell percentages. Gross motility was assessed at 400x power, and individual morphology was assessed at 1000x (oil immersion) with eosin-nigrosin stain. Bulls were classified as 'satisfactory' if a semen sample was classified as having adequate motility and 70% or more morphologically normal sperm cells. Bulls who were deferred and unsatisfactory were classified together as unsatisfactory.

Categories Based on Factors Evaluated

Bulls were categorized based on their actual weaning scrotal circumference into 9 categories: <=24 cm; 1-cm increments between 25 and 30; and >=31 cm. Breeds were classified as Angus, Charolais or Angus x Charolais crossbred. Adjusted weaning scrotal circumference was calculated based on age and breed adjustment factors from the Beef Improvement Federation. Adjusted weaning scrotal circumference was divided into 15 categories: <=15 cm, 15-20 cm, 20-22 cm, 22-24 cm, 24 cm, 25 cm, 26 cm, 27 cm, 28 cm, 29 cm, 30 cm, 31 cm, 32-34 cm, 34-36 cm, and >= 36 cm. Bulls were categorized into 8 weaning weight categories: <=500 lb (227 kg), 50 lb (23 kg) increments between 500 and 800 lb (227 and 363 kg), and >= 800 lb (363 kg). Weight per day of age was calculated by dividing weaning weight by days of age at weaning. Weight per day of age was then divided into 13 categories in 0.1 lb (0.045 kg) increments, starting at 2.3 lb (1.04 kg) and ending at 3.3 lb (1.50 kg). Scrotal circumference per day of age was calculated by dividing the actual weaning scrotal circumference by days of age at weaning. Scrotal circumference per day of age was then categorized into 7 categories: <=0.085, 0.01 cm increments between 0.085 and 0.135, and >= 0.135. Days of age at weaning was categorized into 4 categories: <215 days, 215-230 days, 230-245 days, and > 245 days.

Statistical Analysis

Data Manipulation - Results from the breeding soundness examination were classified as either satisfactory or unsatisfactory. Any bulls classified as deferred or unsatisfactory were labeled as unsatisfactory.

Statistical Model - All statistical analyses were conducted in RStudio.[b] A logistic regression model was used to evaluate the effect of the relevant factors (actual weaning scrotal circumference, adjusted weaning scrotal circumference, weight per day of age at weaning, scrotal circumference per day of age at weaning, days of age at weaning, weaning weight, and breed) on the probability of passing yearling breeding semen evaluation for bulls with complete data (444 head). Factors were removed individually based on lack of statistical significance (p value > 0.05). The final model was iteratively developed until only significant variables or variables of interest remained. Breed was not significant, but deemed as a variable of interest. The final model included weaning scrotal circumference and breed. Interactions were evaluated using a type III Wald (chi-square) test.

Results

At weaning, the average scrotal circumference was 26 cm, with a range of 20 cm to 34 cm and standard deviation of 2.8. Weaning weight ranged from 359 lb (163 kg) to 911 lb (413 kg) with an average of 642 lb (291 kg), and standard deviation of 91.3 lb (41.4 kg). Bulls ranged from 155 days of age to 285 days of age, with an average of 231 days of age and standard deviation of 15.6. Average weight per day of age was 2.77 lb (1.26 kg) and standard deviation of 0.35 lb (0.16 kg), with a range from 1.41 to 3.68 lb (0.64 to 1.67 kg) per day of age. Scrotal circumference per day of age at weaning ranged from 0.07 to 0.15 cm, with an average of 0.11 and standard deviation of 0.01 (Table 1).

Overall, 92.3% of the bulls evaluated passed the yearling breeding soundness evaluation. Yearling scrotal circumference measurements ranged from 31 to 46 cm, with an average of 37 cm (Table 2).

Weaning scrotal circumference measurement was associated with the probability of passing the breeding soundness examination ($P < 0.01$). No significant difference was found between the categories of weaning scrotal circumference (Figure 2). Breed classification was not significantly associated ($P=0.53$) with the probability of passing the breeding soundness examination. Angus (n=258) bulls had a 93.3% probability of passing the breeding soundness examination, while Charolais (n=169) bulls had a 95.5% probability. The

Table 1. Mean, median and range for factors evaluated at the time of weaning.

Factor	Mean	Median	(Minimum, Maximum)
Scrotal circumference (cm)	26.9	27	(20,34)
Weaning weight (lb)	641.9	641.5	(359,911)
Days of age	231.4	232	(155,285)
Weight per day of age (lb)	2.77	2.74	(1.41,3.68)
Scrotal circumference per day of age (cm)	0.11	0.11	(0.07,0.15)

Table 2. Mean, median and range for factors evaluated at the time of breeding soundness examination.

Factor	Mean	Median	(Minimum, Maximum)
Scrotal circumference (cm)	37	37	(31,46)
% normal sperm	76	80	(0,90)
Scrotal circumference per day of age (cm)	0.09	0.09	(0.07,0.12)

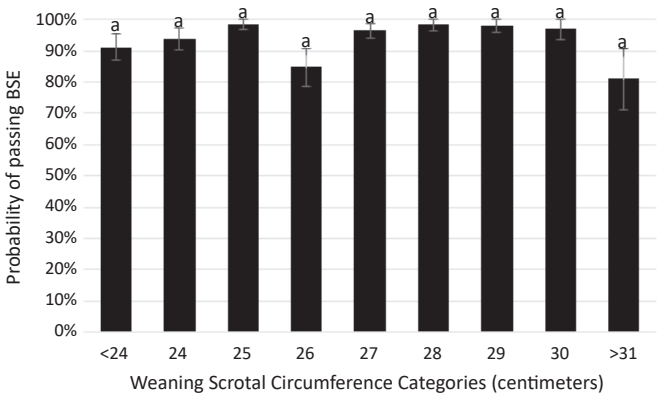

Figure 2. Probability of passing a breeding soundness examination (BSE) as a yearling by weaning scrotal circumference category (+/- 2 SE).

Angus x Charolais cross (n=17) bulls had a 96.3% probability of passing the breeding soundness examination.

Discussion

In this study, breed did not have a significant association with the probability of passing the breeding soundness examination. Prior research evaluating cut-off values for weaning scrotal circumference indicated that different cut-off values were needed based on the breed of the bull.[2,9] The lack of statistically significant different findings by breed in this project could be due to actual similar performance of breeds in this study, or due to difference in outcome of interest compared to other studies, lack of large numbers of bulls at the upper and lower ends of the variable distributions, or unequal distribution of breeds. Previous studies were interested in creating weaning scrotal circumference cut-off values rather than probability of passing breeding soundness examination.

Weaning scrotal circumference category was significantly associated with the probability of passing the breeding soundness examination; however, no pair-wise comparison of categories returned a significant difference. The lowest probability (80.9%) of passing the breeding soundness examination occurred in the >31 cm group of bulls. In previous research, bulls with weaning scrotal circumference above 23 cm had a 95% probability of reaching 34 cm by 12 months of age.[4] In the same study, bulls with less than 23 cm at weaning had only a 54% probability of reaching 34 cm by 12 months of age.[4] A study by Lunstra et al, reported that scrotal circumference was a more accurate measure of puberty as compared to age, weight or breed.[7] In this same study, the range in scrotal circumference at the time of puberty ranged from 25.9 to 30.1 cm and 97% of bulls measuring 30 cm or more had reached puberty.[7] In our study, bulls with weaning scrotal circumferences greater than 31 cm tended to have a reduced probability of passing the yearling breeding soundness examination. The bulls measuring over 31 cm at weaning were potentially over-conditioned (increased average weaning weight: 717 lb, 325 kg), which can have a negative impact on subsequent fertility.[5]

The high percentage of bulls that passed the breeding soundness examination in this study population likely reduced our ability to identify risk factors associated with failure to pass a breeding soundness examination that might be identified in different study populations. The high percentage passing in this population could be due to multi-generational selection for early puberty and ability to pass a yearling breeding soundness examination in this specific operation.

Conclusions

Within this dataset and using this logistic regression model, weaning scrotal circumference was associated with the probability of passing a yearling breeding soundness

examination, but did not implicate differences between scrotal circumference measurement categories. The data collected at weaning for this population of bulls was not useful for predicting the probability of failing to pass a breeding soundness examination at yearling age. More data needs to be collected in additional populations of beef bulls to evaluate predictive model development capabilities for identifying bulls with lower likelihood of passing the breeding soundness examination.

Endnotes

[a] Lane Manufacturing, Denver, CO
[b] RStudio, Version 3.3.3, Boston, MA

Acknowledgments

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The authors declare no conflict of interest.

References

1. Arteaga A, Baracaldo M, Barth AD. The proportion of beef bulls in western Canada with mature spermiograms at 11 to 15 months of age. *Can Vet J* 2001;42:783-787.
2. Barth AD, Ominshi KH. The relationship between scrotal circumference at weaning and at one year of age in beef bulls. *Can J Vet Res* 2000; 41:541-546.
3. Bruner KA, McCraw RL, Whitacre MD, van Camp SD. Breeding soundness examination of 1,952 yearling bulls in North Carolina. *Theriogeniology* 1995;44:129-145.
4. Coe PH, Gibson CD. Adjusted 200-day scrotal size as a predictor of 365-day scrotal circumference. *Theriogenology* 1993; 40:1065-1072.
5. Coulter GH, Kozub GC. Efficacy of methods used to test fertility of beef bulls used for multiple-sire breeding under range conditions. *J Anim Sci* 1989; 67:1757-1566.
6. Kastelic JP. Understanding and evaluating bovine testes. *Theriogenology* 2014; 81:18-23.
7. Lunstra DD, Ford JJ, Echternkamp SE. Puberty in beef bulls: Hormone concentrations, growth, testicular development, sperm production and sexual aggressiveness in bulls of different breeds. *J Anim Sci* 1978; 46: 1054-1062.
8. McLachlan RI, Wreford NG, O'Donnell L, deKretser DM, Robertson DM. The endocrine regulation of spermatogenesis: Independent roles for testosterone and FSH. *J Endocrinl* 1996; 148:1-9.
9. Pratt SL, Spitzer JC, Webster HW, Hupp HD, Bridges WC Jr. Comparison of methods for predicting yearling scrotal circumference and correlations of scrotal circumference to growth traits in beef bulls. *J Anim Sci* 1991; 69:2711-2720.
10. Smith BA, Brinks JS, Richardson GV. Relationships of sire scrotal circumference to offspring reproduction and growth. *J Anim Sci* 1989;67:2881-2885.
11. Weerakoon WWPN, Sakase M, Kawate N, Hannan MA, Kohama N, Tamada H. Plasma IGF-1, INSL3, testosterone, inhibin concentrations and scrotal circumference surrounding puberty in Japanese Black beef bulls with normal and abnormal semen. *Theriogenology* 2018; 114:54-62.

