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Scrotal circumference of Australian beef bulls

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ABSTRACT

Normal range for scrotal circumference in Australian beef bulls was established using more than 300,000 measurements of breed, management group, age, liveweight, and scrotal circumference. The data used were derived from Australian bull breeders and two large research projects in northern Australia. Most bulls were within 250 to 750 kg liveweight and 300 to 750 days of age. The differences between breeds and variances within breeds were higher when scrotal circumference was predicted from age rather than liveweight, because of variance in growth rates. The average standard deviation for predicted scrotal circumference from liveweight and age was 25 and 30 mm, respectively. Scrotal circumference by liveweight relationships have a similar pattern across all breeds, except in Waygu, with a 50 to 70 mm range in average scrotal circumference at liveweights between 250 and 750 kg. Temperate breed bulls tended to have higher scrotal circumference at the same liveweight than tropically adapted breeds. Five groupings of common beef breeds in Australian were identified, within which there were similar predictions of scrotal circumference from liveweight. It was concluded that liveweight and breed are required to identify whether scrotal circumference is within normal range for Australian beef bulls that experience a wide range of nutritional conditions.

1. Introduction

Measurement of scrotal circumference is a key component of a breeding soundness evaluation [1]. Scrotal circumference is a good indicator of daily sperm production, especially in young bulls in which daily production is fairly constant at approximately 9 to 12 $\times$ 10^6 per gram of testis [2]. When an appropriate technique is used, scrotal circumference is a highly repeatable measure [3] and highly heritable (up to 75%; [5]). Higher scrotal circumference is phenotypically and genetically correlated with both male and female reproductive traits including higher percentages of motile and morphologically normal sperm [3–5], earlier age at puberty in female relatives [5,6] and higher calf output in female relatives within tropically adapted cattle, especially *Bos indicus* cattle [7]. Further, scrotal circumference can be used as an indicator of bull puberty [8], which has been defined as able to produce an ejaculate with at least 50 million sperm with 10% or higher-motility [9].

For fair evaluation of bulls, an accurate measurement of scrotal circumference is a fundamental requirement to take best advantage of this measure. The technique for scrotal circumference measurement has been well established [10], although the tension of the measurement device was not fully standardized until the advent of the Coulter Scrotal Tape (Trueman Manufacturing, Edmonton, Alberta,

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Canada), and subsequently the Barth tape (Albert Barth, University of Saskatchewan, Saskatoon, Saskatchewan, Canada); the latter is a simpler device and has been readily adopted by cattle veterinarians as part of implementing Australian standards [11]. The minimum scrotal circumference standards are based on relatively sparse publications, mainly from Australian and North American research. It has been unclear what the expected normal range for scrotal circumference is in Australian bulls.

Our hypothesis was that scrotal circumference of Australian bulls is significantly affected by breed, age, and liveweight. To test this, we used data previously recorded by bull breeders across Australia for commercial breeding-value estimations, and data from previous research on bull reproductive genetics, development, and management.

2. Materials and methods

2.1. Ethics approval

The research was a secondary use of data drawn from available databases.

2.2. Sites, animals, and measurements

Most of the data were sourced from Australian beef cattle breed society pedigree and performance databases managed by the Agricultural Business Research Institute on behalf of bull-breeding members. Data for tropically adapted breeds were primarily sourced from Queensland and the Northern Territory and data for temperate breeds primarily from New South Wales, Victoria, Tasmania, South Australia, and Western Australia. The data available for each observation included bull identification, site, management group, (all anonymously coded to protect privacy) breed, birth date, measurement date, liveweight, and scrotal circumference. Data were restricted to that collected in the 2000 to 2012 period. Parallel data from previous research were also accessed from the Cooperative Research Centre for Beef Genetic Technologies database [12] and from databases developed for research reported by Holroyd, et al. [13,14].

As these data were collected by a vast array of people across Australia over an extended period, measurement protocols are certain to have varied. However, it is expected that in most cases, liveweight will be within 2% of a full paddock weight, as most bulls will have been weighed on the day of yarding. Those weighed on the following day will almost certainly have been offered water with or without feed. Scrotal circumference will have been measured using the Australian Cattle Veterinarians' standards [15] in most cases, although it is recognized that variation in technique (e.g., low tape tension, squeezing testes apart), confounded with site and management group, may have caused some overestimates.

2.3. Analyses

A data set was derived that included one record for each bull. When bulls had repeated measures, one measure was randomly selected. These data were primarily derived from the breed society pedigree and performance databases. Scrotal circumference was analyzed as a function of liveweight or age with or without breed or datasource using 13 different models. Liveweight and age could not be fitted together in one model because they were highly correlated (r = 0.70). The types of models used were either of the following:

$$\textit{Linear log}: sc = b + k^{*}\log 10(W) + e$$

$$\textit{Asymptotic}: sc = A(1 - \exp(-kW) + e)$$

$$\textit{Gompertz}: sc = A^{*}\exp(-\exp(-k(W - t))) + e$$

In these models; "sc" was scrotal circumference; "W" was liveweight which was replaced by age (days) in some analyses; "A" and "k" were estimated parameters, "A" being an asymptote or maximum, and "k" being a rate of increase relative to liveweight; and, "t" was an inflection point. In all cases, the curves were forced through zero.

The models were ranked on residual variance. The selected model explained maximum variance and achieved even distribution of bulls below the predicted fifth percentile.

A second data set from only tropically adapted breeds was derived in which there were five or more scrotal measures for each bull. These data were exclusively from databases other than those maintained by breed societies. A mixed-effects asymptotic model (NLMIXED procedure, SAS version 9.3) was fitted within breed to estimate variation due to animal fitting "k" as a fixed effect with a zero intercept assumed; it was not possible to also fit "A" in the same manner in the same model.

3. Results

The age and liveweight distribution of bulls by data source are shown in Figures 1 and 2.

Analytical models that allowed a nonzero intercept were tested using the repeated-measures data sets. Except for the very small data set for Belmont Red bulls (91 observations), the intercept was never significantly different from zero, thus validating the use of models in which the intercept was forced through zero.

Including breed in scrotal circumference prediction models increased the variance explained by ~10% units and reduced the residual standard deviation by ~5 mm (Table 1). Using liveweight as a scrotal circumference predictor rather than age had a similar effect (Table 1). The range in breed effects was doubled when scrotal circumference was predicted by age (100–160 mm between 250 and 750 days of age; Fig. 3) rather than by liveweight (50–70 mm between 250 and 750 kg; Fig. 4). Most of this effect appeared because of lower scrotal circumference of tropically adapted bulls as a function of lower average weight per day of age. Including data source in analyses did not change either variance explained or residual standard deviation (Table 1).

Irrespective of whether a linear log, asymptotic, or Gompertz model was used, prediction curves for average