CASE STUDY: Scrotal Circumference in Beef Bulls—Prediction of Measures at 365 Days of Age from Measures at 240 Days of Age with Data from the Tucumcari Bull Test

J. E. Decker,*1 P. Luna-Nevarez,∗ A. M. Encinias,† R. M. Enns,‡ PAS, and M. G. Thomas*2, PAS
*Department of Animal and Range Sciences, and †Department of Extension Animal Sciences and Natural Resources, New Mexico State University, Las Cruces 88003; and ‡Department of Animal Science, Colorado State University, Fort Collins 80523

ABSTRACT

Measurement of scrotal circumference (SC) is included in a breeding soundness exam for bovine cows. A minimum of 30 cm of SC is recommended for yearling bulls (Kennedy et al., 2002). Objectives were to evaluate the association of SC adjusted to 240 d of age with SC adjusted to 365 d of age using data from the Tucumcari Bull Test (n = 2,514). Scrotal circumference adjusted to 240 d of age was also used to assess its effectiveness to predict 365-d SC of at least 30 cm. Bulls with 365-d SC greater than or equal to 30 cm (n = 2,418) had 240-d SC of 26.9 ± 0.1 cm, and bulls with 365-d SC less than 30 cm (n = 96) had 240-d SC of 22.1 ± 0.5 cm. Correlation of 0.7 (P < 0.01) was detected between adjusted 240- and 365-d SC, and phenotypic trend slightly increased (linear; P < 0.01) from 1982 to 2006 for these traits. Initial SC was a significant (P < 0.01) effect in prediction of 365-d SC. Plotting of the lower 95% confidence limit of the predicted 365-d SC regression line suggested a 240-d SC of 22.5 cm as a culling level to achieve SC of at least 30 cm. Probability estimated (P < 0.01) by standard-normal distribution revealed that a minimum of 22 cm was needed at 240 d of age to achieve 365-d SC of at least 30 cm. Nonetheless, yearling bull breeding soundness exam failure rate due to insufficient SC was less than 4% in these data.

Key words: bovine, bull, prediction, performance test, scrotal circumference

INTRODUCTION

Breeding soundness examination (BSE) procedures for bovine bulls, which include measurement of scrotal circumference (SC), are recommended (Kennedy et al., 2002). A minimum of 30 cm of SC is recommended for yearling bulls. Scrotal circumference is measured because it is highly associated with testes weight and size, sperm producing ability, and age of puberty in heifer progeny (Gipson et al., 1985; Gargantini et al., 2005; Kealey et al., 2006). A frequent reason for failing BSE in some bull tests is inadequate SC (Coe and Gibson, 1993; Kennedy et al., 2002).

Several studies have investigated the relationship of SC measurement at 365 d of age with SC measured at an earlier age (Pratt et al., 1991; Barth and Ominski, 2000; Mwansa et al., 2000). These studies reported positive associations of the 2 measures, but varied levels of the strength of the relationships as well as varied probability levels for achieving a culling level of ≥30 cm at 365 d of age.
Garcia et al. (2004) described phenotypic trends in postweaning growth traits and SC in the Tucumcari Bull Test in New Mexico. This public bull test station initiated data collection in 1961 and currently has records on more than 5,500 bulls. Collection of SC data commenced in 1982 and included SC measurement at the initiation of a test (i.e., at about 240 d of age) and a final measurement (i.e., at about 365 d of age). Data collected at 365 d of age were presented to the public in final reports, bull sale catalogs, or both.

Given the cost of consigning bulls to performance tests, and due to previous reports relative to the relationship of early life and later SC measurements, and the potential for yearling bulls to be eliminated from public sales, data from the Tucumcari Bull Test were used herein to achieve 3 objectives. The initial objective was to evaluate the association of SC adjusted to 240 and 365 d of age. Associations of measures of SC with growth performance trait levels were also evaluated. The third objective was to assess the use of SC adjusted to 240 d of age to predict adjusted 365-d SC of at least 30 cm.

**MATERIALS AND METHODS**

**Animal Description and Management**

The Tucumcari Bull Test in east-central New Mexico was conducted in accordance with Guidelines for Uniform Beef Improvement Programs for postweaning gain as described by the Beef Improvement Federation in Garcia et al. (2004). In brief, bulls were managed in pens of 4 or less and grouped according to breed, producer, and sire. Bulls were fed twice daily and had ad libitum access to feed and water, although rations varied among year. Data were recorded on 28-d increments with reports presented to the public and consignors at d 56 and 112 of the test. High indexing bulls were eligible for sale by auction approximately 1 mo after the test was completed. From 1982 to 2006, beef producers consigned 2,885 weaning bulls of 16 breeds. Bulls had to be born between January 5 and April 15 of the year they were consigned to the test and had an adjusted 205-d BW of at least 215 kg. Of these bulls, 2,514 had complete data records of SC and other growth performance traits. These bulls were entered by breeders from states of New Mexico, Colorado, Texas, Kansas, and Oklahoma.

**Trait Measurements and Adjustments**

Bulls were weighed upon arrival to determine delivery BW. After a 3-wk adjustment period, bulls were weighed twice to determine initial BW of the gain test; thereafter, bulls were weighed every 28 d during the 112-d period. On this day, bulls were again weighed twice for a final BW, which was adjusted to 365-d of age. Scrotal circumference was measured when bulls were delivered to the gain testing facility by massaging the testes into the scrotum and using a flexible measuring tape to measure circumference at the largest part of the scrotum. Initial SC data were collected to verify each bull had 2 anatomically normal testes. This trait was described as 240-d or initial SC. Breeding soundness exams were performed (Kennedy et al., 2002) at the completion of the gain test (i.e., bulls were about 365 d of age). This exam included collection and calculation of the 365-d adjusted or final SC measure as described by Kennedy et al. (2002). The traits of birth weight and 205- and 365-d BW were adjusted according to the guidelines of the Beef Improvement Federation (2006). Initial SC was adjusted to 240 d of age using methods of Coe and Gibson (1993). Average daily gain and SC daily gain (SCDG) were also calculated according to Beef Improvement Federation (2006) guidelines and calculations described by Coe and Gibson (1993).

**Statistical Analyses**

Statistical analyses were performed using SAS (2006). Assumptions of normality were tested among independent variables by year using PROC GPLOT (i.e., evaluation of data points ± 2 SD from the mean). Simple statistics were estimated and means were generated from least squares procedures. Bulls were also assigned a pass or fail score within their BSE by whether they had final SC ≥ 30 cm, and these data were evaluated with chi-square analyses.

The initial objective was to evaluate the association of SC adjusted to 240 and 365 d of age. Associations of measures of SC with growth performance trait levels were also evaluated.

These objectives were achieved as measures of SC were regressed against year of test using PROC REG and procedures within general linear models (GLM; Littell et al., 2002). Linear, quadratic, and cubic coefficients from these procedures were tested for significance ($P < 0.05$). Association among adjusted 240- and 365-d SC and growth traits recorded in this 112-d gain test were estimated using Pearson’s correlations. Partial correlations were also estimated between 240- and 365-d SC using initial age and BW as covariates.

Association analyses to predict adjusted 365-d SC was conducted using a mixed-effects model (i.e., PROC MIXED; Littell et al., 1996). The model was $y_{ijkl} = \mu + A_i + B_j + C_k + D_{jk} + E_{il} + e_{ijkl}$, where $y_{ijkl} =$ phenotypic value adjusted to 365 d of age, $\mu =$ population mean, $A_i =$ covariate of SC adjusted to 240 d of age, $B = $ fixed effect of breed, $C_i =$ fixed effect of year, $D_{jk} =$ interaction of breed × year, $E_{il} =$ random effect of sire nested within breed (i.e., mean = zero, variance = $\sigma^2$; $Z$ statistic used to test if $H_0: \sigma^2 = 0$), and $e_{ijkl} =$ random residual error (mean = zero, variance = $\sigma^2$).

Simple forms of the model were also executed with PROC GLM as to obtain the coefficient of variation ($R^2$; Littell et al., 2002). This model used...
explanatory variables adjusted 240-d SC, year, or breed, which outputted the percentage of variation attributed to the explanatory variable. In an effort to evaluate other covariates that could have influenced adjusted 365-d SC, SC gain (i.e., final SC – initial SC), and SCDG were fitted in this model as substitutes for adjusted 240-d SC; however, we will not report these results as these effects did not appear to be different than the current model. Initial age and initial BW were not fitted in this model because of their relationship ($r \geq 0.42$, $P < 0.05$) with adjusted 240-d SC.

In addition to testing the model in analyses involving all bulls in the data set, the model was also executed for each of the following breed groups: Angus, Bos indicus-influenced, Charolais, Continental, and Hereford. The $B. indicus$ group consisted of Brangus, Santa Gertrudis, Simbrah, and Beefmaster ($n = 193$). The Continental group, not including Charolais, consisted of Simmental, Salers, Romagnola, Limousin, Maine Anjou, Gelbvieh, and Tarentaise ($n = 342$). Breed groups of Angus, Charolais, and Hereford had greater than 500 experimental units. If breed group and year were found to be significant sources ($P < 0.05$) of variation in the primary model of this study, then independence of slopes of regression lines among breeds was tested using the procedures of Steele et al. (1997). These analyses were previously used by Garcia et al. (2004) to compare different phenotypic trends among breed groups for growth traits measured in the Tucumcari Bull Test. These analyses would determine if the phenotypic trend (i.e., slope of the lines) differed among breed groups for the traits of adjusted 240- and 365-d SC.

To achieve the final objective of this study (i.e., assess the use of SC adjusted to 240 d of age to predict adjusted 365-d SC of at least 30 cm), a minimum adjusted 240-d SC was estimated by graphing the lower 95% confidence limit of predicted adjusted 365-d SC and finding the intercept at 30 cm. The probability of a bull reaching 30 cm at 365 d of age with a particular 240-d SC level was estimated using standard-normal distributions using procedures of Pratt et al. (1991). Specifically, $P$ was estimated by $\left[Z > \left(30 - \mu_{SC}\right)/\sigma_{SC}\right]$, where $\mu_{SC} = 240$-d SC + (365 – initial SC measurement) $\times$ SCDG, and $\sigma_{SC} = SD$ for 365-d SC. Values tested as initial SC were 17, 18, 19, 20, 21, and 22 cm using 112 d and SCDG of 0.08 cm/d. When the probability value in the procedure became 1.00, that SC value was considered the 240-d culling level.

**RESULTS AND DISCUSSION**

Garcia et al. (2004) reported that bulls in the Tucumcari Bull Test from 1961 to 2000 were typical of range bulls in the southwestern United States as they had moderate increases in growth performance without great increases in birth weight. One hundred forty-one beef producers consigned bulls used in the current study (i.e., 1982 to 2006). Sixteen breeds were represented and variance for the traits evaluated had normal distribution across year. Simple statistics for measures of performance, including SC, are reported in Table 1.

When bulls were separated into groups of adjusted 365-d SC $\geq 30$ cm or $< 30$ cm, only 3.82% of the bulls failed a BSE based on this portion of the exam ($P < 0.01$; Table 2). Adjusted 240- and 365-d SC appeared to slightly increase linearly across year from 1982 to 2006 (Figure 1). Cumulatively, these results suggested producers that consigned these bulls did not have a need to place strong selection pressure on the trait of SC.

The first 2 objectives of this study were to evaluate the association of SC adjusted to 240 and 365 d of age and the associations of measures of SC with growth performance trait levels. While achieving these objectives, we learned that the phenotypic correlation between adjusted 240- and 365-d SC was moderate to strong ($r = 0.7; P < 0.01$). Partial correlation between initial and final SC measurement of the bull test with age as the covariate was 0.52 ($P < 0.01$), whereas the partial correlation with initial BW as the covariate was 0.34 ($P < 0.01$). Scrotal circumference gain and SCDG were weak to moderately ($r = 0.25; P < 0.05$) associated with adjusted 365-d SC; however, BW at 365 d of age and ADG appeared moderately to strongly correlated with adjusted 365-d SC ($r = 0.68; P < 0.05$). These results parallel a study from the Angus, Brangus, and Brahman research herds of the New Mexico Agricultural Experiment Station (Thomas et al., 2002).

In mixed model prediction analyses, explanatory variables adjusted 240-d SC, year, breed, interaction of year $\times$ breed, and sire were significant ($P < 0.01$) effects in predicting SC adjusted to 365 d of age. Nonetheless, testing for independence

### Table 1. Simple statistics of adjusted scrotal circumference (SC) and growth performance traits in beef bulls in the Tucumcari Bull Test 1982 to 2006

<table>
<thead>
<tr>
<th>Trait</th>
<th>n</th>
<th>Mean</th>
<th>SE</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>240-d SC, cm</td>
<td>2,879</td>
<td>26.7</td>
<td>0.10</td>
<td>11.5</td>
<td>35.5</td>
</tr>
<tr>
<td>365-d SC, cm</td>
<td>2,516</td>
<td>35.5</td>
<td>0.08</td>
<td>20.6</td>
<td>48.8</td>
</tr>
<tr>
<td>SC gain, cm</td>
<td>2,514</td>
<td>9.8</td>
<td>0.06</td>
<td>0.0</td>
<td>20.5</td>
</tr>
<tr>
<td>SCDG, cm/d</td>
<td>2,514</td>
<td>0.1</td>
<td>0.01</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>240-d BW, kg</td>
<td>2,872</td>
<td>349.4</td>
<td>1.41</td>
<td>152.7</td>
<td>628.6</td>
</tr>
<tr>
<td>365-d BW, kg</td>
<td>2,811</td>
<td>516.7</td>
<td>1.54</td>
<td>283.8</td>
<td>801.6</td>
</tr>
<tr>
<td>ADG, kg/d</td>
<td>2,807</td>
<td>1.6</td>
<td>0.01</td>
<td>0.4</td>
<td>2.6</td>
</tr>
</tbody>
</table>

$^{\dagger}$SCDG = scrotal circumference daily gain.
of regression lines for measures of SC across year suggested slopes were similar among breeds groups (i.e., Angus, Bos indicus-influenced, Charolais, Continental, and Hereford). Thus, results presented in Tables 1 and 2 and Figure 1 involved analyses of data from all bulls of the 16 breeds consigned to the test from 1982 to 2006. The coefficient of determination from prediction analyses using GLM with these data suggested adjusted 240-d SC accounted for a slight to modest amount of variation in adjusted 365-d SC (R² = 0.27; P < 0.01). Use of SC gain (i.e., final SC − initial SC) and SCDG in these predictions suggested these variables accounted for even less of the variation in adjusted 365-d SC (R² = 0.20; P < 0.01).

The 2 procedures used to estimate a culling level for initial SC suggested a value of 22.5 or 22 cm, respectively. These analyses were conducted to achieve the third objective of the study, which was to assess the use of SC adjusted to 240 d of age to predict adjusted 365-d SC of at least 30 cm. In brief, Figure 2 allows visualization of the lower 95% confidence limit in predicting adjusted 365-d SC with adjusted 240-d SC. Note the intersection of the plotted line with the x-axis at 30 cm. These results suggest that an adjusted 240-d SC measure of 22.5 cm was needed to achieve 30 cm of SC at 365 d of age in data from the Tucumcari Bull Test. Table 3 reports results of standard-normal distribution probabilities tests from a culling level of SC adjusted to 240 d of age (i.e., 22 cm). There appears to be some inaccuracies from these statistical tests; specifically, if a culling level of 22 cm was imposed for adjusted 240-d SC, 11.3% of the bulls achieving 30 cm by 365 d of age would have been unnecessarily culled, and 40.6% of the bulls with SC less than 30 cm at 365 d of age would not have been culled. These results are congruent with studies analyzing data from other public bull tests (Pratt et al., 1991; Coe and Gibson, 1993; Barth and Ominski, 2000).

A public bull test, commonly defined as a central bull test, typically measure traits from bulls that have been preselected. For example, in the Tucumcari Bull test, each producer consigns 4 bulls to a pen; thus, the data collected does not have the range of distribution represented in the herd from which the bulls were consigned. Mwansa et al. (2000) reported dissimilar results to studies that used data from central bull tests (Pratt et al., 1991; Coe and Gibson, 1993; Barth and Ominski, 2000). The reason for these discrepancies is most likely attributed to the format of data collection. Specifically, Mwansa et al. (2000) used data from a composite breeding population maintained on an agricultural experiment station. Strong genetic correlations (r ≤ 0.86) were detected between SC measures at 8 and 10 mo of age and measures at 12 mo of age. In this study, there was minimal culling or selection of the bulls that were evaluated between 240 d (6 mo) and 365 d (12 mo) of age. Therefore, data and subsequent analyses involved the full range of distribution of trait measures from within the population. Also, it should be noted that Mwansa et al. (2000) only detected moderate associations using data from 6 mo (i.e., about 240 d of age) for association with SC at 12 mo of age. These limited associations at 6 mo of age (i.e., postweaning) were attributed to potential weaning stress or potential age of dam effects. Nonetheless, the study reported high heritability estimates for measures of SC. These heritability estimates computed from a single trait model were 0.45, 0.49, 0.57, and 0.66 for the ages of 6, 8, 10, and 12 mo, respectively. Comparable heritability estimates were reported in several other studies (Latimer et al., 1982; Gargantini et al., 2005; Kealey et al., 2006).

Latimer et al. (1982) described test station effects in measures of SC. The 5 test stations that supplied data for this study were from 5 different geographic regions in North America. Results indicated that breeds did not rank similarly in SC among test stations. Also, breed numbers and number of animals within a breed differed among year in data from these test stations, which was also the structure of data

| Table 2. Adjusted 240-d scrotal circumference (SC): Simple statistics from bulls in the Tucumcari Test from 1982 to 2006 that achieved or failed to achieve 30 cm of SC at 365 d of age |
|-----------------|-----|-----|-----|-----|-----|
| Trait           | n   | Mean| SE  | Minimum| Maximum |
| 365-d SC ≥30, cm| 2,418| 26.9| 0.10| 14.5   | 35.5    |
| 365-d SC <30, cm| 96   | 22.1| 0.45| 11.5   | 29.0    |

| Table 3. Results of testing for the probability of achieving 30 cm of scrotal circumference (SC) at 365 d of age using SC levels at 240 d of age |
|-----------------|-----|----------------|----------------|
| 240-d SC, cm    | SD  | Mean SC cm at 365 d of age | Probability achieving 30 cm |
| 17              | 3.2 | 26.6             | 0.29            |
| 18              | 3.7 | 26.2             | 0.30            |
| 19              | 3.0 | 26.3             | 0.22            |
| 20              | 2.9 | 28.0             | 0.48            |
| 21              | 2.9 | 29.4             | 0.83            |
| 22              | 2.6 | 31.3             | 1.00            |
from the Tucumcari Bull Test; thus, breed × year interactions detected in these analyses make breed comparisons challenging to interpret and are likely a result of subsampling of the available genetics represented by those bulls consigned to the test. Within the historic Tucumcari Bull Test data, Hereford was the predominant breed represented in early years of the data, whereas Angus and Charolais were most prevalent breeds in latter years (Garcia et al., 2004). There were 16 breeds represented in data herein and there was great variability in number of bulls per breed across years; thus, differences in the change in SC across years were not detected among breeds in adjusted 240- or 365-d SC; hence, data were presented with breeds pooled.

Three studies that used public or central bull test data to evaluate the relationships between 240- and 365-d SC reported weak to moderate associations of the 2 traits (Pratt et al., 1991; Coe and Gibson, 1993; Barth and Ominski, 2000). These 3 studies were conducted in regions of North America where small beef production systems are common. The Tucumcari Bull Test was conducted in a geographical region where large beef production systems are typical. In general, these data were collected from bulls that were selected from large herds, and because data were presented to the public as to sell the bulls in an auction, bulls consigned were likely highly selected for exceptional BW gain.

In summary, measures of SC adjusted to 240 and 365 d of age slightly increased linearly from 1982 to 2006 in the Tucumcari Bull Test. Adjusted 240-d SC was a significant predictor of adjusted 365-d SC, which was positively associated with growth. Prediction analyses suggested a potential culling level of about 22 cm; however, failure rate due to SC less than 30 cm when the bulls were 365 d of age was minimal in the Tucumcari Bull Test.

**IMPLICATIONS**

This study evaluated prediction of adjusted 365-d SC with adjusted 240-d SC using data from a public bull test station in New Mexico. The 2 traits were moderately associated and were positively associated with measures of growth; however, failure rate of the bulls to achieve 30 cm of SC by 365 d of age was minimal, even though statistical analyses suggested a culling level of about 22 cm. The Tucumcari Bull Test evaluated postweaning growth performance involving several beef cattle herds in the southwestern United States that consign a few select bulls each year. Thus, data structure appeared to limit the effectiveness of using a trait collected shortly after weaning (i.e.,

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**Figure 1.** Least squares means of scrotal circumference (SC) adjusted to 240 (upper panel) and 365 (lower panel) d of age using data from the Tucumcari Bull Test from 1982 to 2006. Pooled SE for adjusted 240- and 365-d SC were ±0.28 and 0.27 cm, respectively.

**Figure 2.** Plot of the lower 95% confidence limit from prediction of an adjusted 365-d scrotal circumference (SC) level of 30 cm from SC values adjusted to 240 d of age using data from the Tucumcari Bull Test from 1982 to 2006.
about 240 d of age) to predict a trait measured later in the animal’s life (about 365 d of age).

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**LITERATURE CITED**


