SCROTAL MEASUREMENTS IN BEEF BULLS: HERITABILITY ESTIMATES, BREED AND TEST STATION EFFECTS

F. G. Latimer, L. L. Wilson and M. F. Cain

The Pennsylvania State University, University Park 16801

and

W. R. Stricklin

University of Maryland, College Park 20742

Summary

Heritability estimates for scrotal circumference and testicular tone at weaning (225 d) and yearling (365 d) were determined from records on 565 bulls from a purebred Angus herd; year, station and breed effects were determined from scrotal circumference records on 2,420 bulls at five test stations. Year, breed and breed x year effects on scrotal circumference, length, width and volume were determined from records on 347 bulls at one station. Heritability estimates (+ SE) were .60 ± .17, .28 ± .18 and .25 ± .18 for weaning scrotal circumference, right and left tone, and .38 ± .16, .72 ± .18 and .52 ± .17 for yearling scrotal circumference, right and left tone, respectively. With the exception of low negative correlations of 205-d weight and longissimus muscle area with weaning scrotal circumference (−.01 and −.02, respectively), correlations of growth and live-estimated carcass traits with weaning or yearling scrotal dimensions were low and positive (.08 to .35). In the second data set, Simmental and Angus had greater (P<.01) yearling scrotal circumferences than Charolais or Herefords; means were 35.3, 35.0, 33.7 and 33.5 cm, respectively. Station and station x breed effects were significant (P<.01), with the latter effect indicating that breeds did not rank similarly in scrotal circumference at different test stations. In the third data set, scrotal circumference and volume were essentially the same as scrotal length and width in ranking breeds. Year x breed interactions were nonsignificant for all scrotal traits, indicating that breeds were ranked similarly in different years with respect to scrotal dimensions. These results indicate that bulls of different breeds should not be compared to established standards; a more acceptable procedure would be the use of deviations from the respective breed-station-year means.

(Key Words: Beef Bulls, Scrotal Measurements, Heritability Estimates, Test Stations, Breeds.)

Introduction

Beef performance testing programs have emphasized rate and efficiency of gain and live estimates of carcass composition, with reproductive traits only recently receiving attention. However, it is difficult and expensive to obtain seminal evaluations on large numbers of bulls. Therefore, scrotal and(or) testicular measurements, which are simple and inexpensive to obtain, have been used to predict spermatozoal production and seminal quality. Testicular weight is highly related to spermatozoal production (Almquist and Amann, 1961; Schwark et al., 1972; Johnson et al., 1974). Scrotal circumference is also highly correlated with testicular weight (Foote et al., 1977; Almquist et al., 1976) and spermatozoal output (Almquist et al., 1976; Sitartz et al., 1977). Testicular tone (also referred to as consistency), measured with a spring tonometer, reflects testicular firmness and is an indicator of seminal quality (Hahn et al., 1969; Foote et al., 1970). Heritability estimates of .67 for scrotal circum-

1 Approved by the Director, PAES, as Paper No. 6132 in the Journal Ser.
2 Present address: College of Veterinary Medicine, Ohio State Univ., Columbus.
TABLE 1. NUMBER OF BULL RECORDS BY YEAR AND TEST STATION

<table>
<thead>
<tr>
<th></th>
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<tr>
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<td>100</td>
<td>127</td>
<td>114</td>
<td>96</td>
<td>79</td>
<td>49</td>
<td>565</td>
</tr>
<tr>
<td>WAPT&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>159</td>
<td>406</td>
<td>338</td>
<td>513</td>
<td>890</td>
<td>679</td>
<td>2985</td>
</tr>
</tbody>
</table>

<sup>a</sup>Summer and Winter Kansas Bull Tests, Beloit.
<sup>b</sup>Manitoba Bull Test, Douglas, Manitoba, Canada.
<sup>c</sup>Northeast Colorado Bull Test, Akron.
<sup>d</sup>Pennsylvania Meat Animal Evaluation Center, University Park.
<sup>e</sup>University of Maryland-Wye Angus Herd, Queenstown.

ference and .34 for testicular tone were reported by Coulter et al. (1976) for Holstein bulls ranging from 6 to 72 mo of age. More recently, Coulter (1979) obtained a heritability estimate of .68 for scrotal circumference of beef bulls. Coulter et al. (1975) concluded that Holstein testicular size was greater than that of Angus bulls to an age of approximately 3 yr. Coulter and Foote (1979) concluded that scrotal circumference was greatest for Simmentals, and least for Herefords, with Maine-Anjou, Shorthorn, Charolais and Angus intermediate. However, additional estimates of heritability for scrotal and testicular traits and the importance and additivity of such effects as station, breed and year are needed.

Therefore, the objectives of this study were to determine the heritabilities of scrotal circumferences and testicular tone, the effects of test station, breed and year and breed means from bulls tested in post-weaning central test stations.

Materials and Methods

The data for this study were obtained from five central bull test stations and one university purebred herd (table 1). The data sets and the three analyses which were conducted are described below.

Data from University of Maryland-Wye Angus Herd. Records on 565 purebred Angus bulls raised and tested from 1974 to 1979 in the University of Maryland-Wye Angus herd, Queenstown, were used to determine the heritability of scrotal circumference and testicular tone. All calves were weaned at 225 d of age and fed in individual pens for a 140-d performance test. Weaning and yearling weights were unshrunk. Adjusted weaning and yearling weights and average daily gain (ADG) were calculated at the conclusion of the test (BIF, 1976). Additionally, fat thickness and longissimus muscle area between the 12th and 13th rib were ultrasonically measured at the end of the test.

Testicular tone was recorded with a spring tonometer at the start and the end of the 140-d post-weaning test (Hahn et al., 1969). Scrotal circumference was taken as the greatest distance around the scrotum, measured with a cloth or flexible metal tape (Foote et al., 1970).

The number of sire-year combinations were 83, 104, 117 and 121 for weaning and yearling testicular tones and weaning and yearling scrotal circumferences, respectively. A sire represented in more than 1 yr was considered as a different sire for each year he was used. Heritability estimates were derived from a paternal half sib analysis of sire effects nested within years (Harvey, 1977).

Data from Five Central Test Stations. Data accumulated over a 6-yr period (1974 to 1979) on 2,420 bulls from five test stations were used in this analysis. The test stations involved were the summer and winter Kansas bull tests, Beloit; Northeast Colorado bull test, Akron; Manitoba bull test, Douglas, Manitoba, Canada;
and the Pennsylvania Meat Animal Evaluation Center, University Park. All bulls had to meet certain entry requirements to be eligible for participation in the central performance test. For entry to the test station, the bulls had to: (1) be within a specified age range (i.e., 160 to 265 d of age), (2) be from herds enrolled in on-farm preweaning performance tests, (3) meet certain subjective soundness minimums and (4) be eligible for registration with a recognized breed association. In addition, they must have had a minimum preweaning performance conforming to the specific station requirements, and/or a herd index ratio of 100 or more for 205-d adjusted weight. Therefore, the test station data used in this study were from bulls with weaning weights in the upper 50% of the seedstock herds in which they were born and raised. Most of the test stations used a 14- to 28-d adjustment period between delivery of the bulls to the station and start of the 140-d test. Starting and final test weights were obtained similarly to those in the University of Maryland-Wye Angus herd, and adjustments applied to the weights were those recommended by BIF (1976).

With the exception of the Pennsylvania Meat Animal Evaluation Center, the test stations represented in this data set recorded only scrotal circumference at the end of the 140-d test. There were 675 Angus (including Red Angus), 370 Charolais, 815 Hereford (including Polled Hereford) and 560 Simmental records available. In all test station data used in this study, Simmental bulls ranged from 3/4 to full Simmental breeding; Charolais were 15/16 or higher. A least-squares analysis (Harvey, 1977) was conducted, with breed, station and the breed × station interaction nested within years and starting age included as a continuous independent variable. Breed means were separated, within years, by Duncan's (1965) Modified Least Significant Difference Test.

Data from the Pennsylvania Meat Animal Evaluation Center. These data, obtained over 6 yr, were from 151 Angus, 79 Charolais, 74 Hereford (including Polled Hereford) and 43 Simmental bulls tested at the Pennsylvania Meat Animal Evaluation Center. Scrotal circumference and right and left scrotal lengths and widths were obtained on these bulls. Additionally, right and left scrotal volumes were calculated by the formula for the volume of a paraboloid (Fields et al., 1979); total scrotal volume was computed as the sum of the right and left scrotal volumes. These data were analyzed with a model containing year, breed and the year × breed interaction, with starting age included as a continuous independent variable. Duncan's (1965) Modified Least Significant Difference Test was applied to separate breed means. Correlations among traits were obtained on a residual variance basis.

Results and Discussion

Heritability Estimates. The means and heritability estimates (± SE) for weaning and yearling scrotal and testicular measurements are presented in table 2 (University of Maryland-Wye Angus herd). The heritability estimates for weaning and yearling scrotal circumferences were .60 ± .17 and .38 ± .16, respectively. Although the heritability estimates over-
When the standard errors of the respective estimates are considered, these results indicate that heritability of scrotal circumference may tend to decline between weaning and yearling ages. There was a small increase in the variance among sire groups detected in the analysis of weaning vs yearling data (.70 to .80, not presented), which indicates little change in the among sire variation from 225 to 365 d of age. However, there was a greater increase in the variance within sire groups (from 3.9 to 7.6), which more than offset the increased covariance of paternal half sibs. Differences between weaning and yearling scrotal circumference heritability estimates suggest that environmental differences in rates of testicular growth and maturation, within sire groups, may have less effect before weaning than from weaning to yearling ages. The tendency for heritability of scrotal circumference to decrease between weaning and yearling ages does not agree with the results of Coulter et al. (1976) who obtained estimates of .62 ± .09 and .78 ± .07 for Holstein bulls 6 to 11 mo and 12 to 17 mo of age, respectively.

Heritability estimates for right and left testicular tones at weaning were .28 ± .18 and .25 ± .18, respectively. Corresponding estimates for these same traits at yearling age were .72 ± .18 and .52 ± .17. Considering the standard errors of the estimate, heritability tended to increase for right tone (P<.05) and left tone (NS) between weaning and yearling ages. Coulter et al. (1976) derived an average estimate for testicular tone of .44 ± .12 for bulls 6 to 11 mo of age, with similar estimates for older age classes. The increase in heritability of testicular tone with age noted in the present study may indicate that rates of scrotal adipose tissue deposition or physiological maturation are more uniform within than among sire groups. Generally, these results suggest that scrotal circumference and testicular tone are moderately to highly heritable and that genetic improvement can be made by individual selection for these traits.

The residual variance (within sire-year) correlation between weaning and yearling scrotal circumferences was .28 (P<.01), indicating that only about 9% of the variation in yearling scrotal circumference was accounted for by variation in weaning scrotal circumference. Correlations of weaning right and left tones with yearling measurements of the same traits were nonsignificant. Since the weaning measurements were taken before puberty, the changes that occur with maturation of the testicular tissue may be the cause of low correlations between initial and final measurements. These effects should perhaps be more noticeable for testicular tone than for a dimension such as scrotal circumference. The correlations between weaning right and left tones was .58; that between yearling right and left tones was .43 (P<.01).

![Figure 1. Mean scrotal circumference for various breeds (five stations, 6 yr); within each year, means bearing different superscripts differ (P<.01).](image-url)
SCROTAL MEASUREMENTS IN BEEF BULLS

Table 3. Least-Square Breed Means (± SE) for Yearling Scrotal Measurements (PMAEC)

<table>
<thead>
<tr>
<th>Item</th>
<th>Hereford</th>
<th>Angus</th>
<th>Charolais</th>
<th>Simmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right scrotal length, cm</td>
<td>11.9 ± .12^b</td>
<td>12.1 ± .083^b</td>
<td>12.1 ± .12^b</td>
<td>12.9 ± .18^c</td>
</tr>
<tr>
<td>Left scrotal length, cm</td>
<td>12.0 ± .12^b</td>
<td>12.2 ± .081^b</td>
<td>12.2 ± .12^b</td>
<td>12.9 ± .17^c</td>
</tr>
<tr>
<td>Right scrotal width, cm</td>
<td>5.9 ± .066^b</td>
<td>6.3 ± .044^b</td>
<td>6.2 ± .065^c</td>
<td>6.7 ± .095^d</td>
</tr>
<tr>
<td>Left scrotal width, cm</td>
<td>6.0 ± .065^b</td>
<td>6.4 ± .043^c</td>
<td>6.4 ± .063^c</td>
<td>6.7 ± .095^d</td>
</tr>
<tr>
<td>Scrotal circumference, cm</td>
<td>34.0 ± .29^b</td>
<td>35.6 ± .20^c</td>
<td>35.3 ± .29^c</td>
<td>37.1 ± .42^d</td>
</tr>
<tr>
<td>Right scrotal volume, cm^3</td>
<td>330.4 ± 10.7^b</td>
<td>382.2 ± 7.2^c</td>
<td>377.8 ± 10.5^c</td>
<td>461.4 ± 15.4^d</td>
</tr>
<tr>
<td>Left scrotal volume, cm^3</td>
<td>342.7 ± 10.7^b</td>
<td>397.1 ± 7.2^c</td>
<td>403.5 ± 10.5^c</td>
<td>464.6 ± 15.4^d</td>
</tr>
<tr>
<td>Total scrotal volume, cm^3</td>
<td>673.2 ± 21.0^b</td>
<td>779.3 ± 14.1^c</td>
<td>781.3 ± 20.6^c</td>
<td>926.0 ± 30.2^d</td>
</tr>
</tbody>
</table>

^aBased on 347 bulls tested in 6 yr at the Pennsylvania Meat Animal Evaluation Center; model included year, breed and year x breed, with starting age as a linear covariate.
^b,c,dMeans of the same trait in the same row bearing different superscripts differ (P<.01).

Year, Station and Breed Effects on Scrotal Circumference (Five Test Stations). The breed within year means are presented graphically in figure 1. As indicated, with the exception of 1974, Simmental and Angus bulls had a greater (P<.01) mean yearling scrotal circumference than Hereford or Charolais. Over all years, Simmental, Angus, Charolais and Herefords averaged 35.3, 35.0, 33.7 and 33.5 cm. These results differ from those of Coulter (1979) who noted that Simmental and Charolais had greater mean scrotal circumferences than Herefords. However, Cates (1975), Coulter (1978, 1979) and Lunstra et al. (1978) also observed larger scrotal circumferences for Angus than for Herefords. The difference in results observed in the 1974 data, as compared to other years in the data set, can be attributed partially to the fact that records were available for only 57 bulls in 1974 (table 1). Considering the similarity in the ranking of breed means in different years, these estimates appear to be valid for comparison of bulls within breeds. However, station x breed interactions effects (P<.05) were also important; the interaction suggests that breeds were not ranked similarly across test stations. Therefore, bulls should be compared on a within breed-station-year basis rather than compared to absolute breed standards.

Station effects were also significant (P<.05) and are composed of many different genetic and environmental components, such as diet, general station management, disease severity, geographical location and sires, breeds and herds represented. Coulter et al. (1975) observed differences in the ranking of Holstein and Angus bulls among seven different artificial insemination bull studs, suggesting a station or location interaction with breed.

Effects on Scrotal Circumference and Other Scrotal Dimensions (Pennsylvania Meat Animal Evaluation Center Data). The data from the Pennsylvania Meat Animal Evaluation Center (PMAEC) included right and left scrotal widths, lengths, volume and circumference (table 3). Mean scrotal circumference for each breed compared relatively well with the analysis reported herein of a larger number of records from five test stations. The primary exception was that Angus and Charolais did not differ significantly. Simmental means were greater (P<.01), and Hereford less (P<.01) than means for Angus and Charolais. Scrotal lengths of Hereford, Angus and Charolais did not differ, although mean scrotal widths of Simmental were greater (P<.01) than those of Angus or Charolais. The results obtained with scrotal volume were similar to the results from the analysis of scrotal width, length and circumference.

Year influenced (P<.01) right and left scrotal lengths, but not right or left scrotal width or circumference. Coulter and Foote (1976) observed significant year effects on scrotal dimensions of Holstein bulls. Year affected (P<.05) individual and total scrotal volumes, which agrees with the significant year effects reported by Fields et al. (1979) for yearling beef bulls. In the present study, year x breed interaction effects were nonsignificant. Fields et al. (1979) observed significant year x breed interaction effects on scrotal volume of yearling beef bulls.

Correlations of Scrotal Measurements and
TABLE 4. PARTIAL CORRELATIONS OF GROWTH AND CARCASS TRAITS WITH YEARLING SCROTAL CIRCUMFERENCE

<table>
<thead>
<tr>
<th>Item</th>
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<tr>
<td>Starting age</td>
<td>.11**</td>
</tr>
<tr>
<td>Starting weight</td>
<td>.35**</td>
</tr>
<tr>
<td>205-d weight</td>
<td>-.01</td>
</tr>
<tr>
<td>140-d gain&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.13**</td>
</tr>
<tr>
<td>365-d weight&lt;sup&gt;a&lt;/sup&gt;</td>
<td>.14</td>
</tr>
<tr>
<td>Fat thickness&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>.08</td>
</tr>
<tr>
<td>Longissimus muscle area&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>-.02</td>
</tr>
</tbody>
</table>

<sup>a</sup>Residual variances and covariance correlations; starting age and weight included as continuous independent variables; n = 2,420.

<sup>b</sup>Live-estimated traits.

**P<.01.

Other Traits. In the combined data from the five test stations, yearling scrotal circumference was correlated at .11 and .35 (P<.01) with starting test age and weight (table 4). In the 347 records from the PMAEC, the various yearling scrotal dimensions were correlated .17 to .42 (P<.01) with starting age and .18 to .39 (P<.01) with starting weight (not presented). Since these are partial correlations, bulls which were older at the start of the test tended to have larger scrotal dimensions as yearlings regardless of their starting weight.

With the exception of a correlation of -.01 of 205-d weight with yearling scrotal circumference, growth traits (140-d gain and 365-d weight) were correlated at .13 and .14 (P<.01) with yearling scrotal circumference in the data combined over the five test stations. Live-estimated fat thickness and longissimus muscle area were not significantly correlated with yearling scrotal circumference. In the 347 records from the PMAEC station all yearling scrotal dimensions were positively correlated (.09 to .35) with weaning and yearling growth traits. Therefore, growth and scrotal traits were positively correlated on a constant starting age and weight basis. In the University of Maryland-Wye Angus data, scrotal dimension traits were also positively correlated (P<.05) with growth traits; however, neither weaning nor yearling testicular tones were significantly related with growth or weight traits.

**Literature Cited**


