Does Scrotal Circumference Impact Female Fertility?

Matt Spangler, Ph.D.
University of Nebraska-Lincoln

Introduction

It should be common knowledge that fertility is the most economically relevant suite of traits in beef cattle production, followed in order by growth and carcass merit. A rather simplistic, yet pragmatic, view of feed efficiency in beef cattle can be expressed in linear form as proposed by Dickerson (1970).

[Dam Weight*Lean Value of Dam + **No. Progeny***Progeny Weight*Lean Value of Progeny]
- [Dam Feed*Value of Feed for Dam + **No. Progeny***Progeny Feed*Value of Feed for Progeny].

The income component is comprised of output from harvesting the dam (or fraction of the dam accounting for death loss) and from harvesting progeny (again, accounting for death loss). The feed cost component accounts for the input of feed energy. The number of progeny per dam is in both components and, thus, increasing number of progeny will increase efficiency. *By simply increasing number of progeny per dam through either selection, heterosis from crossing, or better management, we will increase efficiency of production* (Nielsen et al. 2013).

Although for the commercial cattle producer improvements in fertility can be achieved in one generation via crossbreeding, there is still merit in improving the additive genetic component of fertility via within breed (or line) selection. The crux, however, is that most fertility traits are lowly heritable and can take a long time to measure (e.g. stayability). Consequently, there has been considerable interest in using indicator traits that are easier and cheaper to measure and that can be measured much earlier in life. One such trait is scrotal circumference of yearling bulls.

Genetic Parameters

In a review paper by Koots et al. (1994) the average heritability of scrotal circumference was 0.45. This estimate ranges in the literature between 0.32 to 0.71 (Morris et al., 1992; Evan et. al. 1999). The literature is firm on the fact that scrotal circumference in yearling bulls is at least moderately heritable and as a consequence would respond favorably to selection.

What is more variable in the literature is the heritability of heifer pregnancy. Generally speaking, heritability estimates from *Bos taurus* breeds is low. McAllister et al. (2011) estimated the heritability of heifer pregnancy to be 0.13 in Red Angus field data. Martinez-Velazquez et al. (2003) reported heritability estimates of 0.14, 0.14, and 0.12 for pregnancy status following the first breed season, calving status following the first breeding season, and weaning status following the first breeding season, respectively. Estimates from *Bos indicus* cattle seem to differ as compared to those from *Bos taurus*.

Eler et al. (2004) estimated the heritability of heifer pregnancy to be between 0.61 and 0.68 depending on the contemporary group definition. The larger estimates from *Bos indicus* cattle seem to be reflective of later puberty in *Bos indicus* cattle leading to greater genetic variability of heifer pregnancy. In example, the pregnancy rates from Eler et al. (2004) were less than 20% whereas the pregnancy rate from McAllister et al. (2011) was 85%. Given heifer pregnancy is a binary trait, genetic parameter estimates are sensitive to the incidence (pregnancy) rate.

Genetic Correlations

The targeted question of this paper (and corresponding presentation) is related to the genetic relationship between scrotal circumference and heifer pregnancy. The development and utilization of scrotal circumference EPD has principally been due to the early estimates showing a favorable relationship between age at puberty in females and scrotal circumference of sires. This, or course, precipitated the belief that increased scrotal circumference in sires lead to decreased age at puberty in daughters and in turn increased pregnancy rate of daughters. The negative (favorable) genetic correlation between scrotal circumference and age of puberty is well established. Martinez-Velazquez et al. (2003) estimated this genetic relationship to be -0.15. Other studies have estimated the relationship to be slightly stronger, in the range of -0.25 to -0.39 (Morris et al., 2000; Morris et al., 1992). Regardless, the correlation is low but favorable suggesting that selection for increased scrotal circumference will lead to a correlated response in decreased age of puberty in females.

Age of puberty in females is not an economically relevant trait, nor is scrotal circumference of males. What is economically relevant is pregnancy rate. Unfortunately in *Bos taurus* females the relationship between scrotal circumference and heifer pregnancy is near zero. McAllister et al. (2011) estimated this relationship to be 0.05, and Martinez-Velazquez et al. (2003) estimated the genetic correlation to be zero. Using Nellore field data, Eler et al. (2004) estimated the genetic correlation between scrotal circumference and heifer pregnancy to be 0.20. These studies suggest that in *Bos taurus* cattle this relationship is null, while in *Bos indicus* cattle the relationship is low, and perhaps negligible.

Even though the relationship between scrotal circumference and female reproductive traits (heifer pregnancy) is near zero, this does not necessarily suggest that scrotal circumference EPD are not needed. Kealey et al. (2006) estimated the genetic relationships between scrotal circumference and multiple semen characteristics. The authors concluded that if selection pressure was applied to scrotal circumference the traits of semen color, volume, concentration, swirl, motility, and percentages of normal, live, abnormal heads, abnormal midpieces, proximal cytoplasmic droplets, bent tails, coiled tails, distal cytoplasmic droplets, and primary and secondary abnormalities would all improve. Although it is obvious scrotal circumference is not economically relevant, and does not have a meaningful relationship to female fertility traits it may be a useful indicator of male fertility traits.

A Path Forward

If the objective of selection is to improve female fertility, the scientific literature suggests, particularly in *Bos taurus* animals, that scrotal circumference is not a useful indicator trait although it might still serve as a useful tool to improve male fertility. A better path forward would be to actually estimate and publish the EPD for economically relevant traits such as heifer pregnancy. Some breeds do this currently, but these EPD could be enhanced by using a multiple-trait model that also fits a trait like days to calving. In this scenario heifer pregnancy is an early indicator of fertility and days to calving is a repeated measure throughout the reproductive lifetime of the female. Whole herd reporting is needed to accomplish any genetic evaluation of fertility.

Genomic predictions also aid in the prediction of genetic merit for female fertility. For those breeds that publish a heifer pregnancy EPD, genomic predictors are incorporated into this prediction leading to increased accuracy at earlier ages. A potentially more promising approach is utilizing information from whole genome sequence information whereby "missing homozygotes" could be identified. The prevailing thought is that if a population does not exhibit an alternate homozygous animal at a locus, the genotype must be related to a lethal mutation potentially embryonic mortality. In other words, if a *AA* and a *Aa* genotype are observed at a locus in a population but *aa* is never observed that suggests that the genotype *aa* at that locus is lethal. This knowledge could inform EPD for fertility. However, the number of these unfavorable mutations is likely to be in the order of hundreds and decision support software will be needed to help mitigate genetic lethals and optimize production goals.

Literature Cited

Eler, J.P., J.A. II V Silva, J.L. Evans, J.B.S. Ferraz, F. Dias, and B.L. Golden. 2004. Additive genetic relationships between heifer pregnancy and scrotal circumference in Nellore cattle. J. Anim. Sci. 82: 2519-2527.

Evans, J.L., B.L. Golden, R.M. Bourden, and K.L. Long. 1999. Additive genetic relationships between heifer pregnancy and scrotal circumference in Hereford cattle. J. Anim. Sci. 77:2621-2628.

Kealey, C.G., M.D. Macneil, M.W. Tess, T.W. Geary, and R.A. Bellows. 2006. Genetic Parameter estimates for scrotal circumference and semen characteristics in Line 1 Hereford bulls. J. Anim. Sci. 84: 283-290.

Koots, K.R., J.P. Gibson, and J.W. Wilton. 1994. Analysis of published genetic parameter estimates for beef production traits. 2. Phenotypic and genetic correlations. Anim. Breed. Abstr. 62: 825-853.

Martinez-Velazquez, G., K.E. Gregory, G.L. Bennett, and L.D. Van Vleck. 2003. Genetic relationships between scrotal circumference and female reproductive traits. J. Anim. Sci. 81: 395-401.

McAllister C.M., S.E. Speidel, D.H. Crews, and R.M. Enns. 2011. Genetic parameters for intramuscular fat percentage, marbling score, scrotal circumference, and heifer pregnancy in Red Angus cattle. J. Anim. Sci. 89: 2068-2072.

Morris, C.A., R.L. Baker, and N.G. Cullen. 1992. Genetic correlations between pubertal traits in bulls and heifers. Livest. Prod. Sci. 31: 221-233.