Does Scrotal Circumference Impact Female Fertility?

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Why Do We Care If It Does or Not?

Because…

- 1) Fertility is at least twice as economically important as any other suite of traits.
- 2) Female fertility data are generally hard to collect and/ or recorded late in life.
- Scrotal circumference is a potential indicator trait for female fertility that is easier to collect.
  - Benefits depend on the genetic correlation between it and the specific female fertility trait of interest.

Impact of Fertility on System Efficiency

- [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]. Dickerson (1970)
- *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)

Inversely Related

Trait	Heritability	Heterosis
Reproduction (fertility)	Low	High
Production (growth)	Moderate	Moderate
Product (carcass)	High	Low

Relative Economic Weights for Integrated Beef Firm

Reproduction:Growth:End Product

2:1:1



(Melton, 1995)

Advantages of the crossbred cow

Trait	Observed Improvement	% Heterosis
Longevity	1.36	16.2
Cow Lifetime Production:		
No. Calves	0.97	17.0
Cumulative Wean. Wt., lb.	600	25.3

Adapted from Cundiff and Gregory, 1999.

Who should care about the potential relationship between SC and female fertility?

- Seedstock Producers
  - Principal job is to increase (improve) additive genetic merit
- Commercial Producers
  - Select bulls based on additive genetic merit—Hopefully weighted economically
  - Place into a well structured crossbreeding system

Genetic Parameters—Scrotal Circumference

- 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 would respond favorably to selection.

Genetic Parameters—Heifer Pregnancy

- Heritability estimates from *Bos taurus* breeds are 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 for pregnancy status following the first breed season.
  - 0.14 for calving status following the first breeding season.
  - 0.12 for weaning status following the first breeding season.

Bos indicus Estimates

- 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.
  - Pregnancy rates from Eler et al. (2004) were less than 20%
  - Pregnancy rate from McAllister et al. (2011) was 85%.
  - Heifer pregnancy is a binary trait--genetic parameter estimates are sensitive to the incidence (pregnancy) rate.

Genetic Correlations—Scrotal Circumference and Age at Puberty

- 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).
- 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.

Genetic Correlations—Scrotal Circumference and Heifer Pregnancy

- Age of puberty in females is not an economically relevant trait, nor is scrotal circumference of males.
- 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.

Inferences

- These studies suggest that in *Bos taurus* cattle this relationship is null, while in *Bos indicus* cattle the relationship is low, and perhaps negligible.

Stop Collecting Scrotal Circumference?

- Kealey et al. (2006) estimated the genetic relationships between scrotal circumference and multiple semen characteristics.
  - If selection pressure was applied to scrotal circumference multiple semen traits would all improve.
  - 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.

Inferences

- 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.
- 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.

Alternative Approaches

What should we select on?

NBCEC Meeting in 2009

- Candidate Traits
  - Weaning Success
  - First Service Conception
  - Postpartum Interval
- Limitations
  - Recording Guidelines
    - i.e. age windows
  - Collection of Phenotypes
  - ROI

Trait Review

- Days to Calving
  - Censored
- Heifer Pregnancy
  - ECP
- First Insemination Success
  - Natural Service Data--Uncertainty

Trait Review

- Longevity
  - Reason for Culling
  - Long time delay
- Age at Puberty
- Novel Indicators (AFC)
  - Collection Cost

Current Evaluations

- Stayability
  - ASA
  - RAAA
  - AGA
  - AHA (Lifetime Productivity)
- Heifer Pregnancy
  - RAAA
  - AAA

Current Limitations

- Contemporary Grouping
- Quality Data
- Quantity of Data Turned In
  - Chicken or the egg argument

Suggestions--CG

- Yearling CG are not sufficient
- Need to know:
  - Breeding opportunity
  - Service Sire
  - Breeding Group

Suggestions--Traits

- Heifer pregnancy
  - Have a calf
- Days to calving
  - Conceive and do so early

Genomics

- Seedstock Producers
  - Examples
    - Red Angus– $rg_{MBV,HPG} = 0.60$
    - Simmental– $rg_{MBV,STAY} = 0.58$
    - Roughly 34-36% of the genetic variation explained
- Commercial Producers
  - Products available to sort commercial females
  - Assume $rg_{MBV,HPG} = 0.60$ and $h^2 = 0.15$
  - Explains ~ 5% of the phenotypic variation
  - Robustness across populations is still an unresolved issue

"Missing" Homozygotes

J Dairy Sci. 2011 Dec;94(12):6153-61.

Harmful recessive effects on fertility detected by absence of homozygous haplotypes.

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Abstract

Five new recessive defects were discovered in Holsteins, Jerseys, and Brown Swiss by examining haplotypes that had a high population frequency but were never homozygous. The method required genotypes only from apparently normal individuals and not from affected embryos. Genotypes from the BovineSNP50 BeadChip (Illumina, San Diego, CA) were examined for 58,453 Holsteins, 5,288 Jerseys, and 1,991 Brown Swiss with genotypes in the North American database. Haplotypes with a length of ≤ 75 markers were obtained. Eleven candidate haplotypes were identified, with the earliest carrier born before 1980; 7 to 90 homozygous haplotypes were expected, but none were observed in the genomic data. Expected numbers were calculated using either the actual mating pattern or assuming random mating. Probability of observing no homozygotes ranged from 0.0002 for 7 to 10^{-4} for 90 expected homozygotes. Phenotypic effects were confirmed for 5 of the 11 candidate haplotypes using 14,911,387 Holstein, 830,391 Jersey, and 68,443 Brown Swiss records for conception rate. Estimated effect for

Summary

- Culling open cows is not selection for fertility
- Scrotal Circumference seems most useful in *Bos indicus* as an indicator of female fertility
  - Does impact age at puberty in *Bos taurus* cattle
- Focus should be on direct measures of fertility
- A genomics approach could be useful
  - Quality, dense phenotypes will still be needed
- Commercial cattle producers should not forget the obvious
  - Crossbreeding