Improving the Ability to Utilize Multiple Breeds in Commercial Beef Production: Breed Specific Heterosis and Across Breed Calving Ease EPD Adjustment Factors

Matt Spangler
University of Nebraska-Lincoln

Context

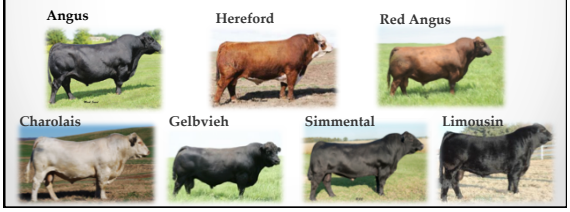
- Developing effective breeding programs requires:
  - Exploiting heterosis and breed complementarity
  - Selection of candidate sires across-breeds
- To refine these decisions, the following is needed:
  - Finer detail than global estimates of heterosis
  - Across-breed EPD adjustments need to be expanded to include all ERT
    - Not just indicators

Objectives

- Estimate breed-specific heterosis among the seven largest taurine breeds.
- Develop AB-EPD adjustments for CED and CEM.

Breed-Specific Heterosis

- Evaluate breed-specific heterosis on birth, weaning and yearling weights using 7 of the commonly used beef breeds in the US and the composite MARCIII



Population

- MARC III 1/4 Pinazgauer, 1/4 Red Poll, 1/4 Hereford, 1/4 Angus
- F_1: Hereford, Angus and MARCIII dams mated one of 8 potential sire breeds (HH, AN, AR, SM, LM, GV, CH and MARCIII)
- F_1^2: Females resulting from above were then mated to MARC III or the following F_1 sires:
  HH x AN, AN x HH, AR x HH, SM x HH or AN, GV x HH or AN, LM x HH or AN, CH x HH or AN

Breed Covariates

- Assigned based on pedigree information.
- Probabilities of heterozygosity partitioned into biological types (British or Continental).
  - MARCIII composites were assigned to biological type based on breeds represented in the composites (3/4 British, 1/4 Continental)
  - Fixed linear covariates
- Breed x breed random covariates nested within fixed classes above.
  - MARC III considered unique breed

Analysis

Breed x Breed random covariates nested within the biological types (BxB, BxC and CxC).

- Fixed effects: sex, breed (genetic groups), maternal heterosis (non-specific), contemporary group (birth year and season, location and age of dam)
- Random: direct and maternal additive effects, maternal permanent environment effect and a residual
- Overall direct heterosis was not included as the sum of the covariates accounting for heterozygosity = overall direct heterosis

Summary Statistics

Trait	N	Mean (lb)
BWT	6805	89.5 (10.6)
WT205D	6452	540.1 (75.6)
WT365D	6293	941.4 (146.4)

Genetic Parameters

Model item	BWT	WT205D	WT365D
Heritabilities			
h^2_a	0.42 (0.04)	0.22 (0.03)	0.38 (0.05)
h^2_m	0.05 (0.03)	0.17 (0.05)	0.05 (0.04)
c^2	0.04 (0.02)	0.23 (0.03)	0.10 (0.02)

Heterosis Estimates

Fixed Covariate	BWT, lb	WT205D, lb	WT365D, lb
BxB	0.99 (0.82)	13.25 (4.06)**	40.74 (9.57)***
BxC	1.65 (0.71)**	18.1 (3.88)***	30.95 (6.86)***
CxC	1.60 (1.19)	13.23 (6.26)**	20.55 (10.85)*
Maternal Heterosis	0.90 (0.68)	0.59 (4.06)	7.32 (5.89)

* = $P < 0.10$
** = $P < 0.05$
*** = $P < 0.01$

Contrasts among the fixed biological type covariates were not significant

Breed Specific Heterosis

- Not a significant source of variation
- Random breed x breed component
  - Explained 0, 1.07 and 1.57% of the phenotypic variance for BWT, WWT, and YWT, respectively.

Heterosis Summary

- Differences in biological type for birth, weaning and yearling weights.
- Using estimates of biological type heterosis more reasonable than global heterosis estimates.
- Current GPE program growing
  - Lack of power to estimate breed x breed effect
  - Estimation of these effects from field data simply not sensical
- Maternal heterosis not significant?
  - Some breed crosses under represented
  - Confounding effect of dam mated to her sire breed

Calving Difficulty

- Economic impact
  - Calf death loss or injury
    - Costs the industry ~ $274 million (USDA, 2011)
  - Increased calving interval
    - As calving difficulty scores increase there is a decrease in conception rate (Spangler et al., 2006)
- It is the ERT—Not BWT!
- Unfortunately we only have AB-EPD for BWT and not CED or CEM

Data

- 31,485 calving difficulty and birth weight records from GPE
- Animals removed
  - > Parity 1
  - Abnormal presentation
  - Cryptorchidism
  - Born founder female
  - Multiple births
  - Born before 1970 (spring) or 2007 (fall)
- After edits N = 4,579

Frequency of Calving Difficulty in 2 Year Old Females

Difficulty Score	Description	Frequency
1	No Difficulty	74.0%
2	Little Difficulty (by hand)	2.3%
3	Little Difficulty (mechanical)	5.7%
4	Slight Difficulty	12.0%
5	Moderate Difficulty	1.5%
6	Major Difficulty	2.6%
7	Caesarean Birth	1.7%

Calving Difficulty Scores

USMARC Score	Z score	Difficulty Level
1	-0.33	No assistance given
2	0.68	Little difficulty, assisted by hand
3	0.81	Little difficulty, assisted by calf jack
4	1.18	Slight difficulty, assisted by calf jack
5	1.62	Moderate difficulty, assisted by calf jack
6	1.86	Major difficulty, assisted by calf jack
7	2.35	Caesarean Birth

Analysis

- Bivariate linear-linear animal model
  - Birth Weight and Calving Difficulty (Z Scores)
- Fixed effects
  - Sex, contemporary group (year, season, and location at USMARC), and covariates of breed, direct and maternal heterosis
- Random effects
  - Animal, maternal effect, residual

Correlations and Heritability

Trait[ab]	BWT_d	CD_d	BWT_m	CD_m
BWT_d	0.34 (0.10)			
CD_d	0.64 (0.17)	0.29 (0.10)		
BWT_m	-0.16 (0.29)	0.43 (0.38)	0.15 (0.08)	
CD_m	0.11 (0.37)	0.10 (0.42)	-0.42 (0.53)	0.13 (0.08)

[a] Birth weight residual (BWT_r), calving difficulty residual (CD_r) birth weight direct (BWT_d), calving difficulty direct (CD_d), birth weight maternal (BWT_m), and calving difficulty maternal (CD_m).
[b]Heritability and standard error are on the diagonal and genetic correlations are on the off diagonal.

Across Breed Adjustments

Breed table factor (A_i) to add to the EPD for bull of breed i

$$M_i = USMARC(i)/b + [EPD(i)_{YY} - EPD(i)_{USMARC}]$$

$$A_i = (M_i - M_{Angus}) - (EPD(i)_{YY} - EPD(Angus)_{YY})$$

USMARC(i) is solution for effects of sire breed i from analysis of USMARC data

$EPD(i)_{YY}$ is the average within-breed 2012 EPD for breed i for animals born in the base year YY (which is two years before the update)

$EPD(i)_{USMARC}$ is the weighted average of 2012 EPD of bulls of breed i having descendants with records at USMARC

b is the pooled coefficient of regression of progeny performance at USMARC on EPD sire

i denotes sire breed i

Breed Adjustments

$$\frac{BreedSoln}{\sigma_a} \quad (1)$$

$$\frac{(EBV(i)_{2012} - EBV(i)_{USMARC}) \times (-1)}{\sigma_{a(i)}} \quad (2)$$

Breed Effects multiplied by the variance obtained from the current analysis

Problem…

- Scaling of CED and CEM
  - Correctly accommodating the differences in models used by various beef breed associations
  - All breeds use a multi-trait model fitting BWT but some use a linear-linear and some use a threshold-linear
    - Some breeds combine categories
    - For breeds using Probit function treating CD as a threshold character
      - Centering on the underlying scale differs
      - Mean incidence of difficulty (e.g. 50%, 80%, etc.)

Delivery Issues

- Existing across-breed EPD have been delivered through a table of additive adjustment factors
- Scaling differences between breeds makes the approach problematic for calving difficulty
- Updated delivery model would be required to effectively implement across-breed EBV for calving difficulty
  - Web-based

Summary and Next Steps

- Heterosis still exists.
- Use of biological type heterosis in refining breeding systems warranted.
  - Need to revisit breed specific-heterosis again
- AB-EPD needs to expand to include non-normally distributed traits.
  - CED and CEM
  - HP
  - STAY
- The delivery mechanism for AB-EPD needs to change.

Acknowledgements

- Lauren Schiermiester and Cashley Ahlberg
- Larry Kuehn, Warren Snelling, Mark Thallman

- Schiermiester, L.N., R.M. Thallman, L.A. Kuehn, S.D. Kachman, and M.L. Spangler. 2015. Estimation of breed-specific heterosis effects for birth, weaning and yearling weight in cattle. J. Anim. Sci. 93: 46-52.
- Ahlberg, C.M., L.A. Kuehn, R.M. Thallman, S.D. Kachman, and M.L. Spangler. 2014. Genetic parameter estimates for calving difficulty and birth weight in a multi-breed population. In Proc. 10th World Congress on Genetics Applied to Livestock Production.