# HETEROSIS IN COW HERDS: LESSONS FROM THE PAST THAT APPLY TODAY

Matt Spangler
UT Martin
(University of Nebraska soon)

## Crossbreeding Why?

- Breed Complementarity
- Capturing dominance and epistasis
- Heterosis

First must come the blinding realization that no one breed excels in all areas that lead to profitability

## Choosing a breed

- Production and marketing goals
- Production environment
- Available resources (both feed and labor)

## Choosing a breed

| Production Environment | | | Traits | | | | |
|---|---|---|---|---|---|---|---|
| Feed Availability | Stress | Milk | Mature Size | Ability to store energy | Resistance to stress | Calving ease | Lean yield |
| High | Low | M-H | M-H | L-M | M | M-H | H |
| | High | M | L-H | L-H | H | H | M-H |
| Low | Low | L-M | L-M | H | M | M-H | M |
| | High | L-M | L-M | H | H | H | L-M |

Adapted from Bullock et al., 2002.

## MARC data

| Breed | Birth wt. | Weaning wt. | Yearling wt. | Milk |
|---|---|---|---|---|
| Angus | 0.0 | 0.0 | 0.0 | 0.0 |
| Charolais | 9.6 | 40.9 | 48.7 | 3.5 |
| Gelbvieh | 4.4 | 7.0 | -21.2 | 6.2 |
| Hereford | 2.7 | -3.1 | -12.7 | -15.7 |
| Limousin | 4.0 | -1.3 | -24.0 | -12.6 |
| Red Angus | 2.5 | -4.7 | -0.7 | -5.1 |
| Saler | 4.2 | 30.7 | 43.5 | 12.8 |
| Shorthorn | 7.0 | 32.5 | 46.1 | 16.6 |
| Simmental | 5.7 | 24.4 | 17.0 | 13.7 |

Adapted from Kuehn and Thallman , 2007.

## Example
## Determining biological types

| | | | | |
|---|---|---|---|---|
| Simm. Bull act EPD | 2.3 | 34.0 | 57.0 | 6.0 |
| Simm. Adj. | +5.7 | +24.4 | +17.0 | +13.7 |
| | 8.0 | 58.4 | 84.0 | 19.7 |
| Heref. Bull act EPD | 3.8 | 35.0 | 60.0 | 13.0 |
| Heref Adj. | +2.7 | -3.1 | -12.7 | -15.7 |
| | 6.5 | 31.9 | 47.3 | -2.7 |
| Diff | 1.5 | 26.5 | 36.7 | 22.4 |

## Crossbreeding systems

- Two breed terminal
- Three breed terminal
- Two breed rotation
- Three breed rotation

- These systems are dependant on:
  - Production goals
  - Herd size
  - Available resources (land and labor)

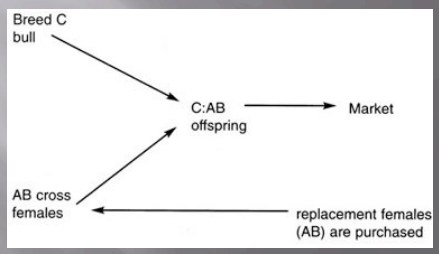
## Two breed terminal

Straight bred cows Breed "A" X Bull Breed "B"

A x B calves

Only capture heterosis in calf

## Three breed terminal




## Two breed rotation

Breeding Group 1 — Replacements → Breeding Group 2

Females bred to Bull of Breed "A" Example: Angus bulls

Females bred to Bull of Breed "B" Example: Hereford bulls

Replacements

Requires 2 sires, 2 pastures & minimum 50 cows

## Three breed rotation

Replacements

Breeding group 1 → Breeding group 2

Females bred to Bull of Breed "A" Example: Angus bulls

Females bred to Bull of Breed "B" Example: Hereford bulls

Females bred to Bull of Breed "C" Example: Gelbvieh bulls

Replacements

Replacements

Requires: 3 Bull breeds, 3 separate pastures, a minimum of 75 cows

## Crossbreeding systems Compared

| Type of system | | Advantage | Retained heterosis |
|---|---|---|---|
| 2-breed rotation | A*B rotation | 16 | 67 |
| 3-breed rotation | A*B*C rotation | 20 | 86 |
| Terminal cross | T*A | 8.5 | 0 |
| Terminal cross | T*(A*B) | 24 | 100 |

Adapted from Ritchie et al., 1999 ; Gregory and Cundiff 1980.

## The goal of a crossbreeding system should be the optimization of labor (inputs) and heterosis gained (outputs).

Minimizing inputs or maximizing outputs alone will not lead to a PROFITABLE or SUSTAINABLE system.

## Heterosis

- Hybrid Vigor
- Superiority of a crossbred animal as compared to the average of its straightbred parents
- More divergent parental lines = more heterosis

## % Heterosis

$$\frac{\text{Crossbred Avg.} - \text{Parental Breeds Avg.}}{\text{Parental Breeds Avg.}} \times 100$$

## Example Weaning weight

- Sire breed avg. = 550 lbs.
- Dam breed avg. = 450 lbs.
- Crossbred calf crop avg. = 525 lbs.

$$\% \text{ Heterosis} = \frac{525 \text{ lbs.} - 500}{500} \times 100$$

$$= 5\%$$

## Types of heterosis

- Individual
  - Expressed in the crossbred calf
- Maternal
  - Expressed in the cow
- Paternal
  - Expressed in the sire

## Advantages of the crossbred calf

| Trait | Observed Improvement | % Heterosis |
|---|---|---|
| Calving rate | 3.2 | 4.4 |
| Survival to weaning | 1.4 | 1.9 |
| Birth weight | 1.7 | 2.4 |
| Weaning weight | 16.3 | 3.9 |
| ADG | 0.08 | 2.6 |
| Yearling weight | 29.1 | 3.8 |

Adapted from Cundiff and Gregory, 1999

## 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.

## Advantages of the crossbred sire

- Fertility
- Longevity
- Easier crossbreeding systems

## Heterosis and heritability

- Inversely related
- Why?
  - P = G + E
  - G = A + D + I
  - $h^2$ = A/P
- That's good for us
  - EPDs do a good job when $h^2$ is moderate to high
  - Need something else (crossbreeding) when $h^2$ is low

## Inversely related

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

## Retained heterosis

- Mating of crossbred animals leaves you with 0 heterosis…WRONG
- Heterosis is retained in future generations
- Related to the probability of alleles from different breeds pairing together
  - Note that expected and realized heterosis may differ due to the relationship of breeds
  - Heterozygosity and heterosis are not linearly related

## Composites

- DEVIL ANIMALS!
- Seriously….they provide a multitude of benefits
- A new (?) way to inject heterosis into a breeding scheme
  - Good example of breed complementarity
  - Also good for breed promotion

## Examples

- Balancer
- Hybrid Simmental
- Lim-Flex
- American breeds
  - Brahman derivatives

## Crossbreeding Small cow herds

- Two breed terminal
- Three breed terminal
- Unrelated F1 bulls
  - Continental x British bulls bred to British or Continental Cows
  - Continental x British bulls bred to British x Continental cows

## Context

- Average cow herd size in TN is 24
- The majority of feeder calves produced in TN are crossbreds
- Systematic crossbreeding? NO
- Heterosis? Yes
- Breed complementarity?
  - Identifiable?

## Larger herd sizes

- Easier to maintain than some systems
- Easier keeping 'terminal' bulls

## Disadvantages

- Most are man made
  - More variation
  - Unknown genetics/pedigree
  - Within breed selection is critical (both sire and dam breeds)
  - Whole herd reporting followed by a multi-breed evaluation would be helpful

## Advantages

| | Advantage | Retained heterosis |
|---|---|---|
| A*B*C rotation | 20 | 86 |
| T*(A*B) | 24 | 100 |
| F1 Bulls | | |
| A*BxA*B | 12 | 50 |
| A*BxA*C | 16 | 67 |
| A*BxC*D | 19 | 83 |

Adapted from Ritchie et al., 1999 ; Gregory and Cundiff 1980.

## Variation

| Trait | Purebreds | Composites |
|---|---|---|
| Birth weight | 0.12 | 0.13 |
| Wean weight | 0.10 | 0.11 |
| Carc. weight | 0.08 | 0.09 |
| Retail Product % | 0.04 | 0.06 |
| Marbling | 0.27 | 0.29 |
| Shear Force | 0.22 | 0.21 |

Adapted from Gregory et al., 1999

## Take home

- Crossbreeding does what EPDs cannot
- Stringent selection within parental lines is critical
- Breed complementarity is why we crossbreed
  - Heterosis is our reward

## More to take home

- Crossbred sires, just like crossbred dams, are a valuable tool
- Choose a system that makes you money and that you can maintain!
- Good crossbreds require good straightbreds
  - One does not endanger the other!

"The native cattle are extinct, but the island is full of artificial breeds. The agriculturalist Bakewell created sheep and cows and horses to order, and breeds in which everything is omitted but what is economical. The cow is sacrificed to her bag; the ox to his sirloin."

*Ralph Waldo Emerson*

Thank you!
Questions…either now or at the bull pen