Crossbreeding…What Commercial Firms Do

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Why Crossbreed?

* Breed Complementarity
  * There’s not a breed that’s the best at everything
* Capture dominance and epistasis
  * Heterosis (hybrid vigor)
* Dramatically improve production efficiency at the cow-calf level

Heterosis

* Hybrid Vigor
* Superiority of a crossbred animal as compared to the average of its straightbred parents
* More divergent parental lines = more heterosis
* NOT available from within breed matings

Crux of Straight-breeding

* Do the benefits of selection for economically important/convenience traits within breed (straight-breeding) outweigh the improvement of lowly heritable traits via heterosis (especially maternal)?
* Selection should be for **BOTH** additive and non-additive genetic merit.

Inversely Related

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

Heterosis Example

	Breed A	Breed B	Average	A × B	Heterosis
Trait 1	96	104	100	107	7%
Trait 2	102	98	100	100	0%
Trait 3	105	95	100	120	20%

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

Individual Heterosis *taurus x indicus*

Trait	Heterosis Units
Calving Rate, %[1]	4.3
Calving Assistance, %[1]	4.9
Calf Survival, %[1]	-1.4
Weaning Rate, %[1]	1.8
Birth Weight, lb.[1]	11.4
Weaning Weight, lb.[1]	78.5

[1]Adapted from Franke et al., 2005; numeric average of Angus-Brahman, Brahman-Charolais, and Brahman-Hereford heterosis estimates.

What about end-product traits?

* Highly heritable so little effect of heterosis
* Some breeds compliment each other very well
* "Combination of quality and yield grade"

Sire Breed	% YG 1&2	% Choice & Prime	YG 4	Standards
British (AN,AR,HF)	33.7	86.1	22.9	0.0
Continental (SM,GV,LM,CH)	69.8	57.6	3.3	0.3

Cundiff et al., 2004

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

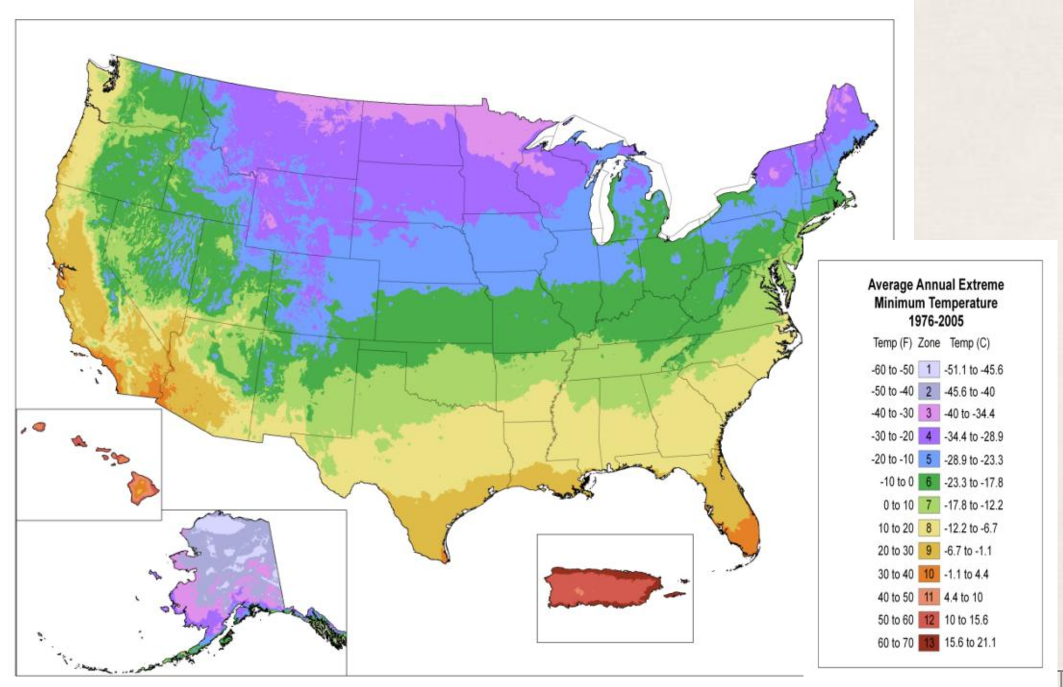
Adapted from Gregory et al., 1999

Advantages of the Crossbred Cow

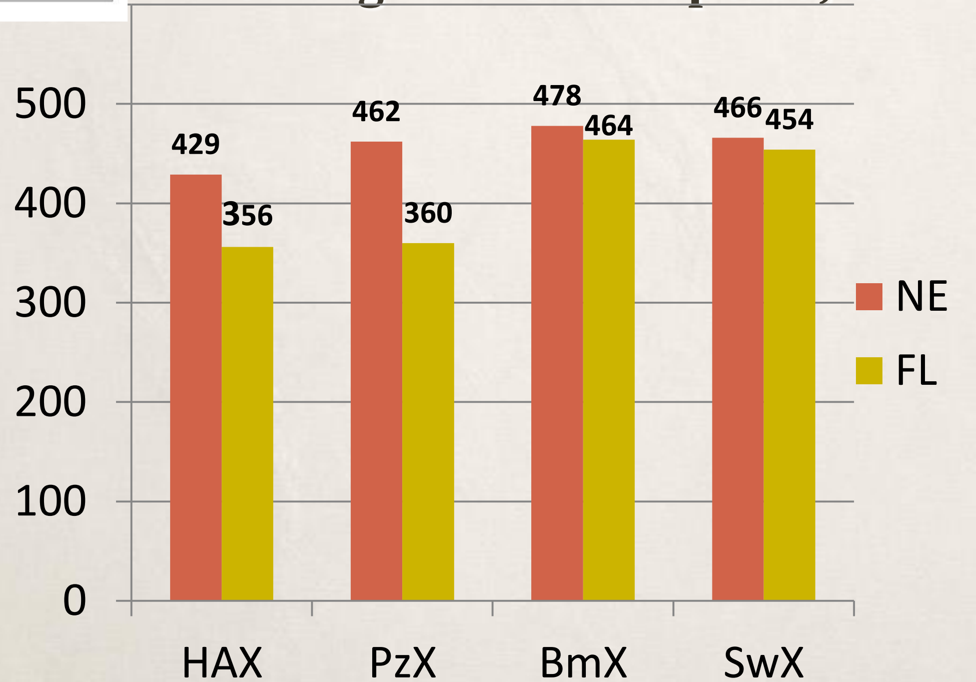
Trait	Observed Improvement	% Heterosis
Longevity	1.36	16.2
Cow Lifetime Production:		
No. Calves	0.97	17.0
Cumulative Wean. Wt., lb.	600	25.3

Adapted from Cundiff and Gregory, 1999.

Matching Genetic Potential to the Climatic Environment
(Olson et al., 1991)



Weaning Wt / Cow Exposed, lb

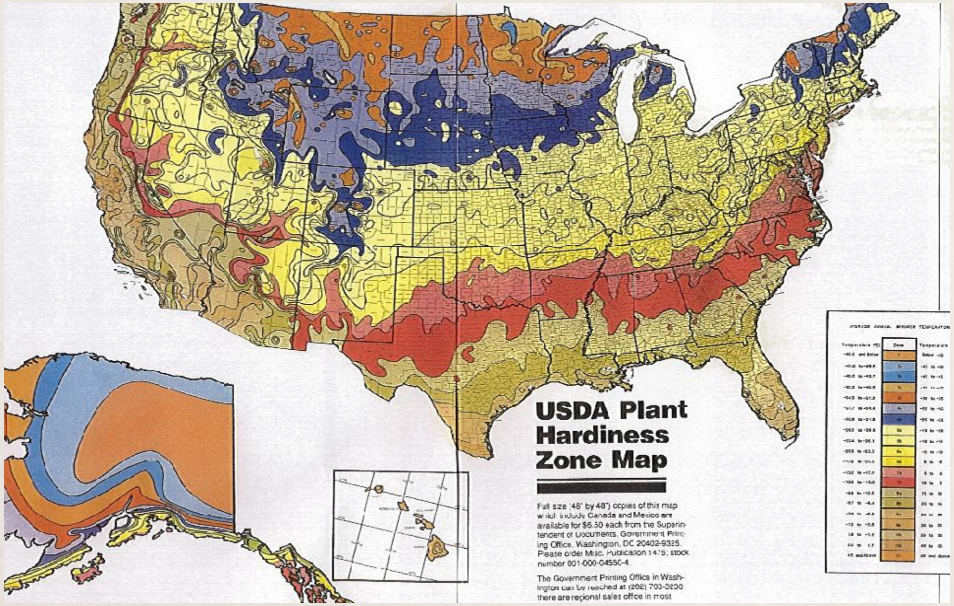


Environment Matters

* In GPE Cycle III, the existence of GxE interactions for reproduction and maternal performance of *Bos indicus* X *Bos taurus* F_1 cross and *Bos taurus* X *Bos taurus* F_1 cross females in a temperate (Nebraska) and subtropical (Florida) environment were evaluated.

* Findings from this experiment showed that birth weight of calves produced by *Bos indicus* X *Bos taurus* cross females were significantly lighter at birth.

* Weaning weight per cow exposed was significantly (28% in Florida and 5.8% in Nebraska) greater than for *Bos taurus* X *Bos taurus* cross females.



Matching Genetic Potential to the Climatic Environment

- **In more intermediate subtropics, cattle with ~25% tropically adapted germplasm may be optimal.**

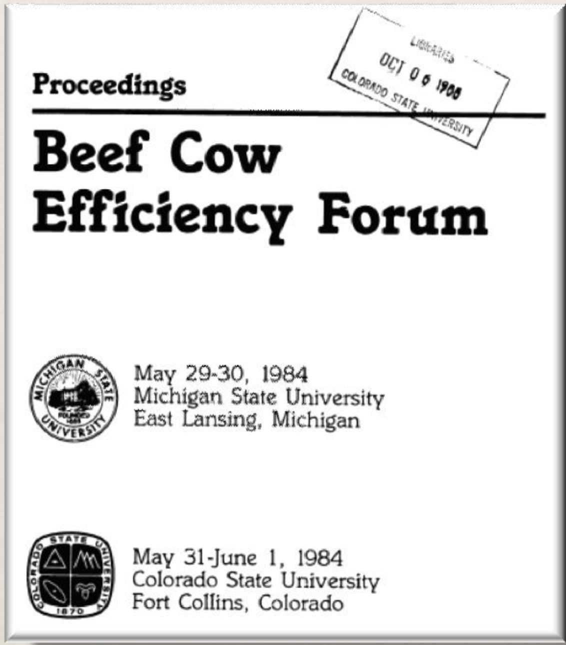
- **In hotter more humid subtropical climates of the gulf coast cattle with ~ 50% tropically adapted germplasm may be optimal.**

- **In harsher tropical climates between the tropic of cancer and capricorn, 75% tropically adapted germplasm may be more optimal.**

Maternal Heterosis
taurus x indicus

Trait	Heterosis Units	Heterosis Percentage (%)
Calving Rate, %[1]	15.4	--
Calving Assistance Rate, %[1]	-6.6	--
Calf Survival, %[1]	8.2	--
Weaning Rate, %[1]	20.8	--
Birth Weight, lb.[1]	-2.4	--
Weaning Weight, lb.[1]	3.2	--
Weaning Wt. per Cow Exposed, lb.[2]	91.7	31.6

[1]Adapted from Franke et al., 2005; numeric average of Angus-Brahman, Brahman-Charolais, and Brahman-Hereford heterosis estimates.
[2]Adapted from Franke et al., 2001



"Thus, as we strive to improve growth rate in the cattle industry and to make the commercial cow more efficient from the standpoint of utilizing nutrients, we must insure that we do not deviate from the goal of maintaining an optimum level of reproductive efficiency."
--Dr. Larry R. Corah, K-State

“Missing” Homozygotes

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

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

VanRaden PM, Olson KM, Null DJ, Hutchison JL.

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Abstract

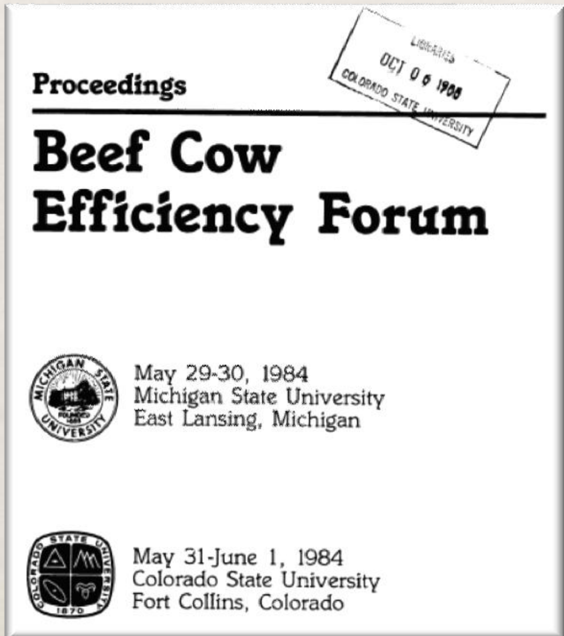
Five new recessive defects were discovered in Holsteins, Jerseys, and Brown Swiss by examining haplotypes that had a high population frequency but were never homozygous. The method required genotypes only from apparently normal individuals and not from affected embryos. Genotypes from the BovineSNP50 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^{-45} 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

Relative Economic Weights for Integrated Beef Firm

Reproduction:Growth:End Product

2:1:1

(Melton, 1995)



"Anytime the matter of cow efficiency becomes overwhelmingly complex, we should revert to basics...

Profit = Wean. Wt. x % calf crop x $/lb X # of cows – annual cost of cow-calf operation"

--Dr. Robert Totusek, Oklahoma State University

Improving 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].

- By simply increasing number of progeny per dam through either selection, heterosis from crossing, or better management, we will increase efficiency of production.

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

Examples

* 1/2 Simmental 1/2 Angus bull mated to 1/2 Simmental 1/2 Angus cows
    * 1-[(1/2*1/2)+(1/2*1/2)]=.5 or 50%
* 1/2 Limousin 1/2 Angus bull mated to Angus cows
    * 1-[(1/2*0)+(1/2*1)]=.5 or 50%

Biological type

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 Gosey 1994.

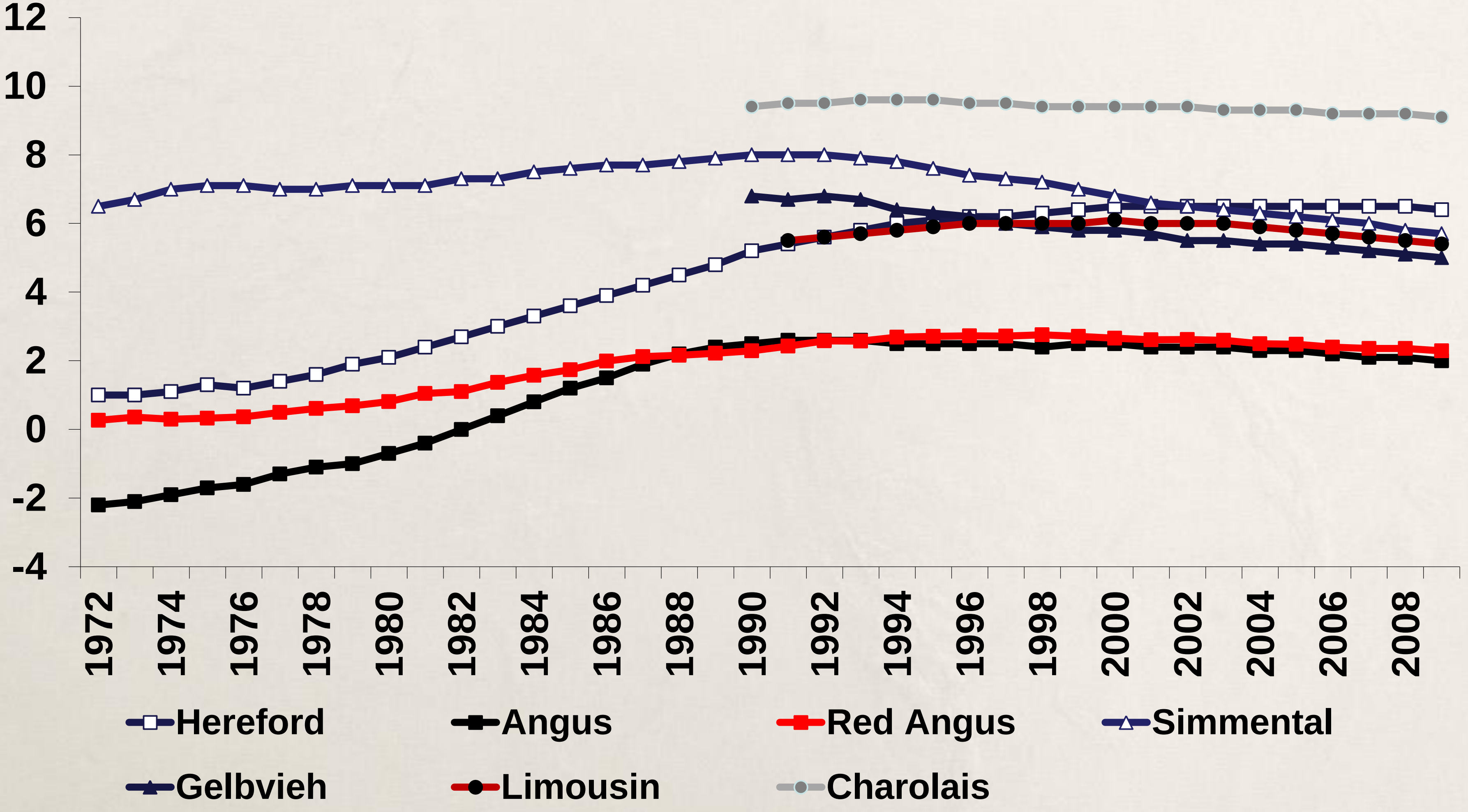
Semen Use

Breed	2009	2008	% of Total
Angus	903,450	950,864	75
Simmental	102,260	89,203	8.5
Red Angus	69,622	73,318	5.8
Hereford	55,705	48,727	4.6
Charolais	14,111	14,854	1.2
Gelbvieh	4,547	5,369	0.4
Limousin	2,249	2,592	0.2
Total	1,203,855	1,276,369	

30 Year Changes

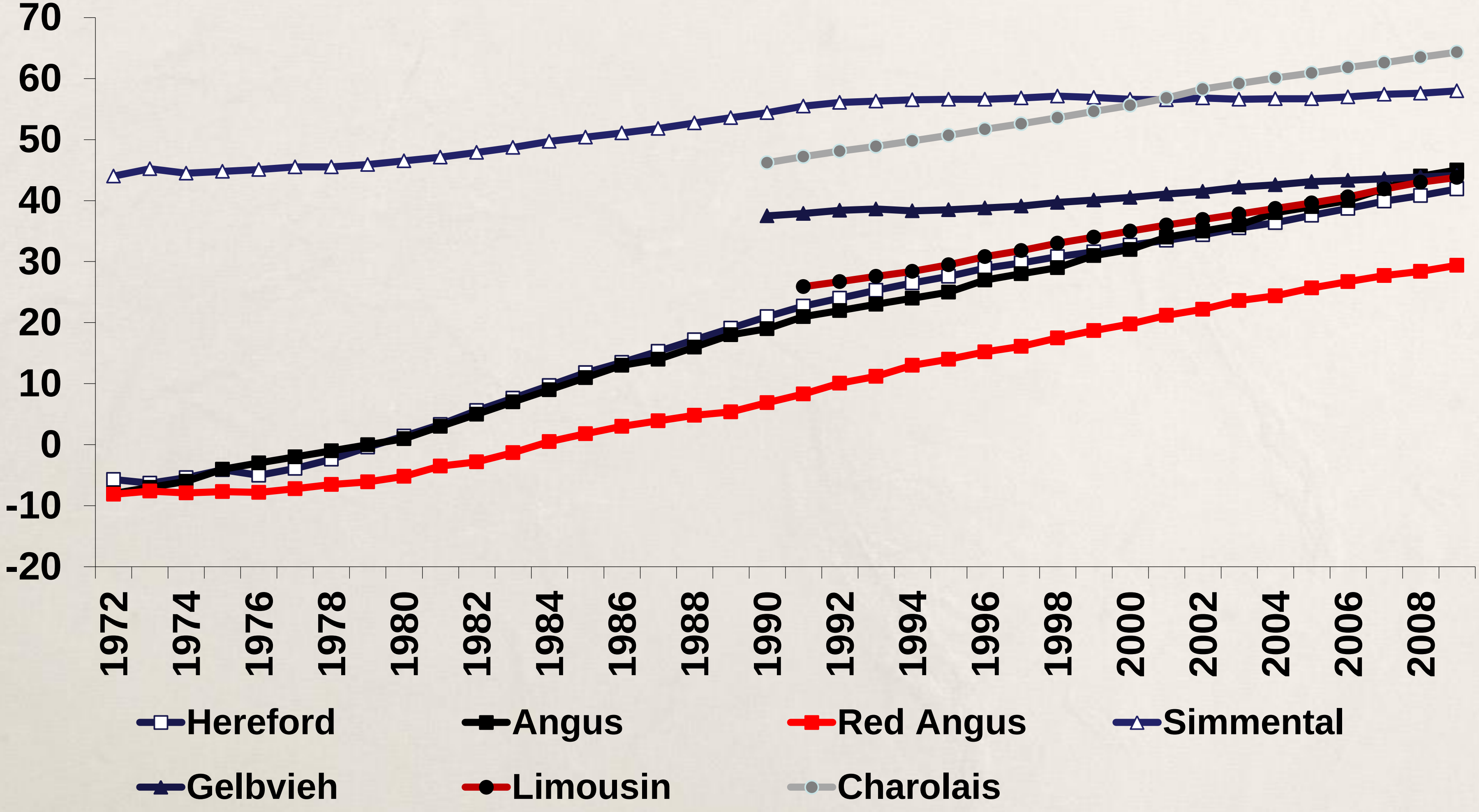
Breed	2009	1980	% of Total
Angus	903,450	416,896	40.3 (75)
Simmental	102,260	192,058	18.6 (8.5)
Red Angus	69,622	28,896	2.8 (5.8)
Hereford	55,705	205,744	19.9 (4.6)
Charolais	14,111	27,776	2.7 (1.2)
Gelbvieh	4,547		
Limousin	2,249	30,026	2.9 (.2)
Total	1,203,855	1,034,824	

Genetic Trends for Birth Weight, lb



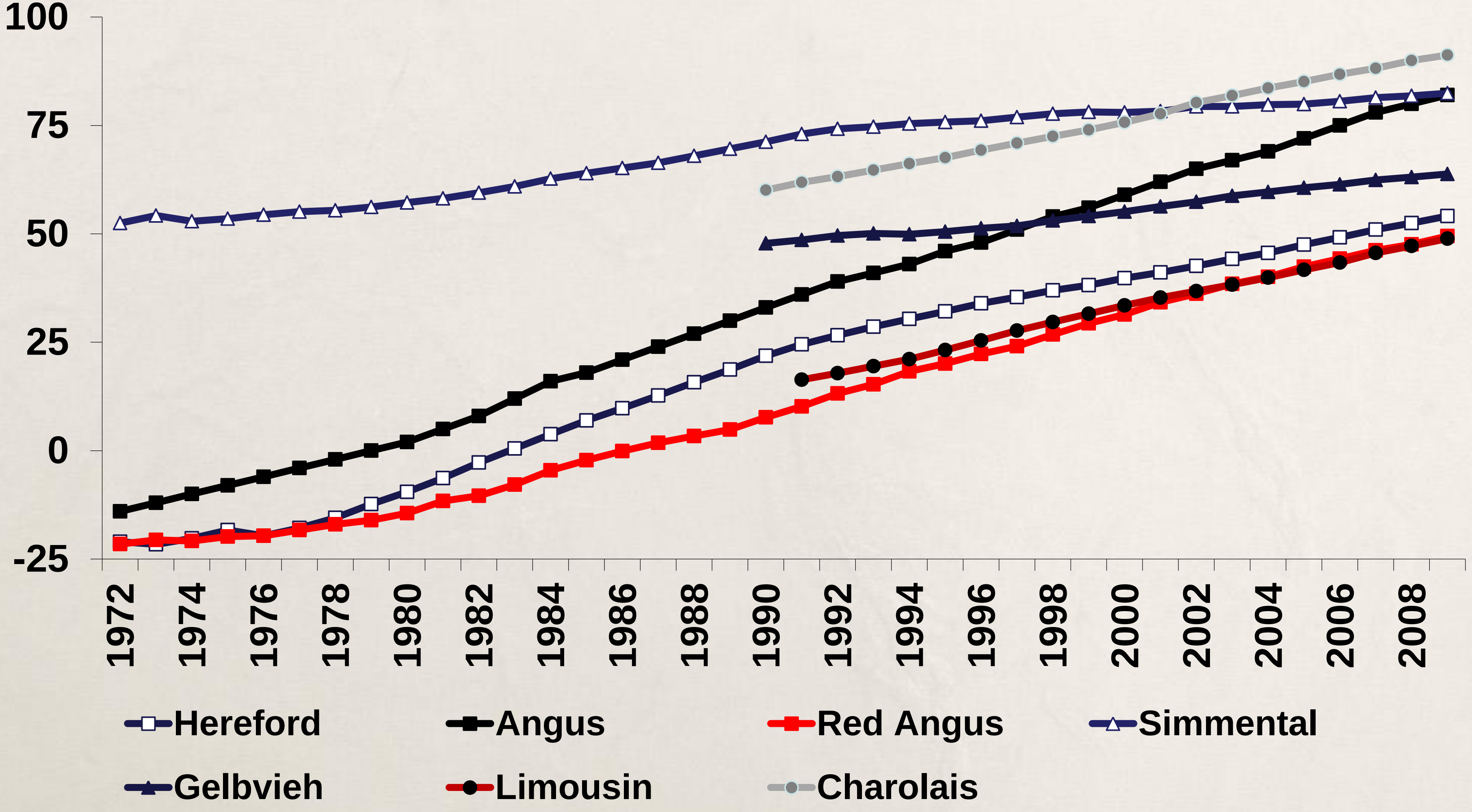
Adapted from Spring 2009 Genetic Trends from Breed Associations and 2011 AB-EPD factors

Genetic Trends for Weaning Weight, lb



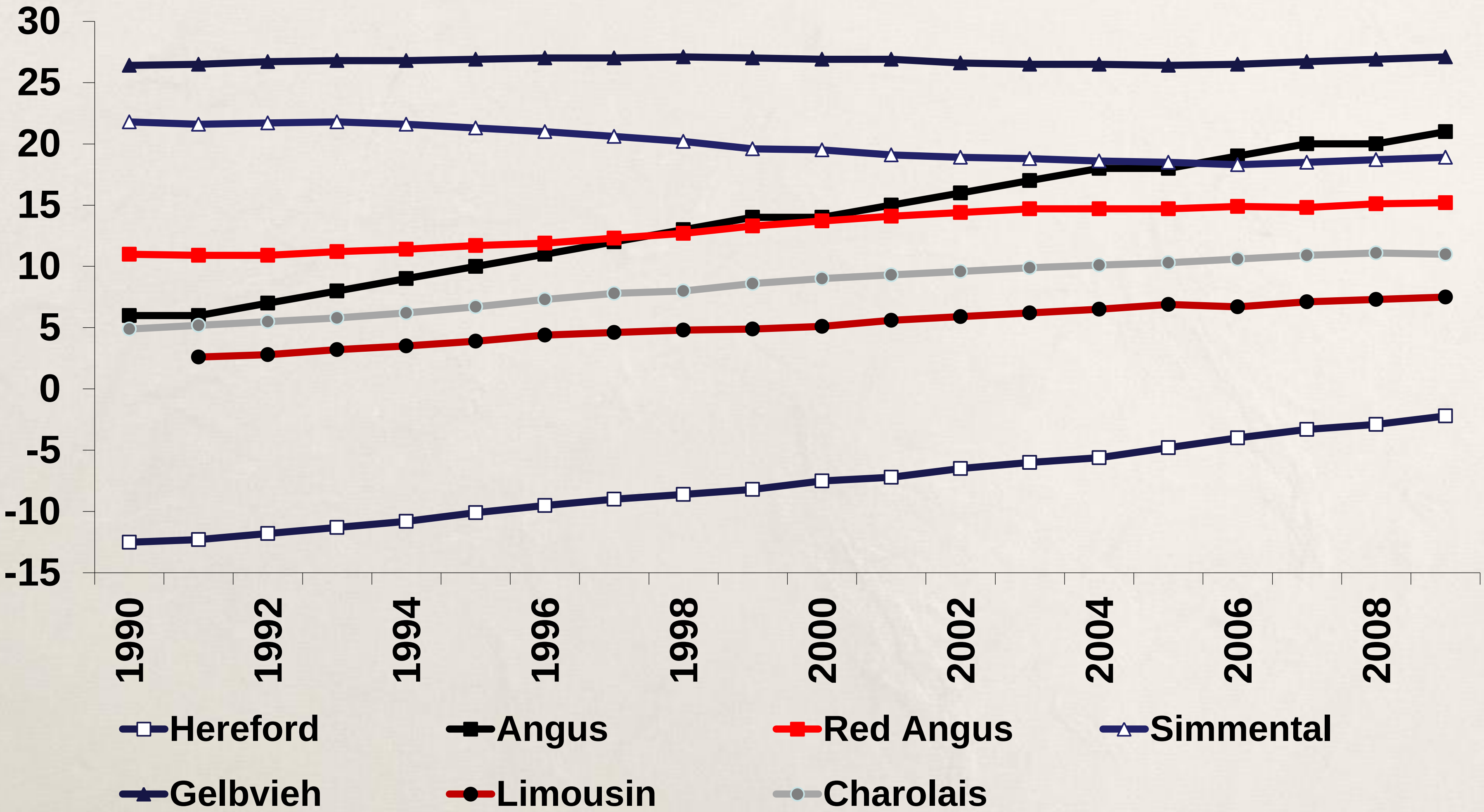
Adapted from Spring 2009 Genetic Trends from Breed Associations and 2011 AB-EPD factors

Genetic Trends for Yearling Weight, lb



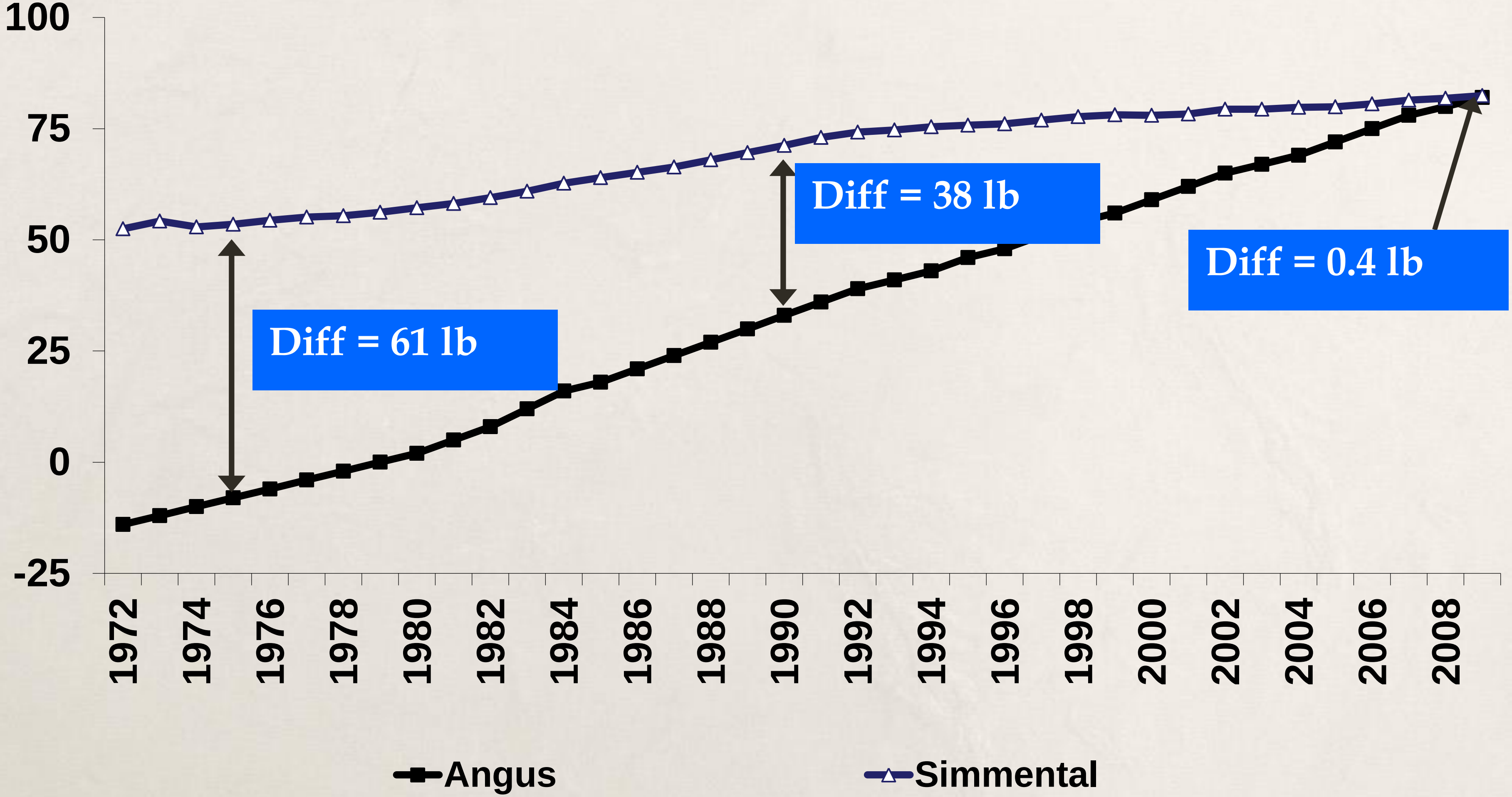
Adapted from Spring 2009 Genetic Trends from Breed Associations and 2011 AB-EPD factors

Genetic Trends for Maternal Milk, lb



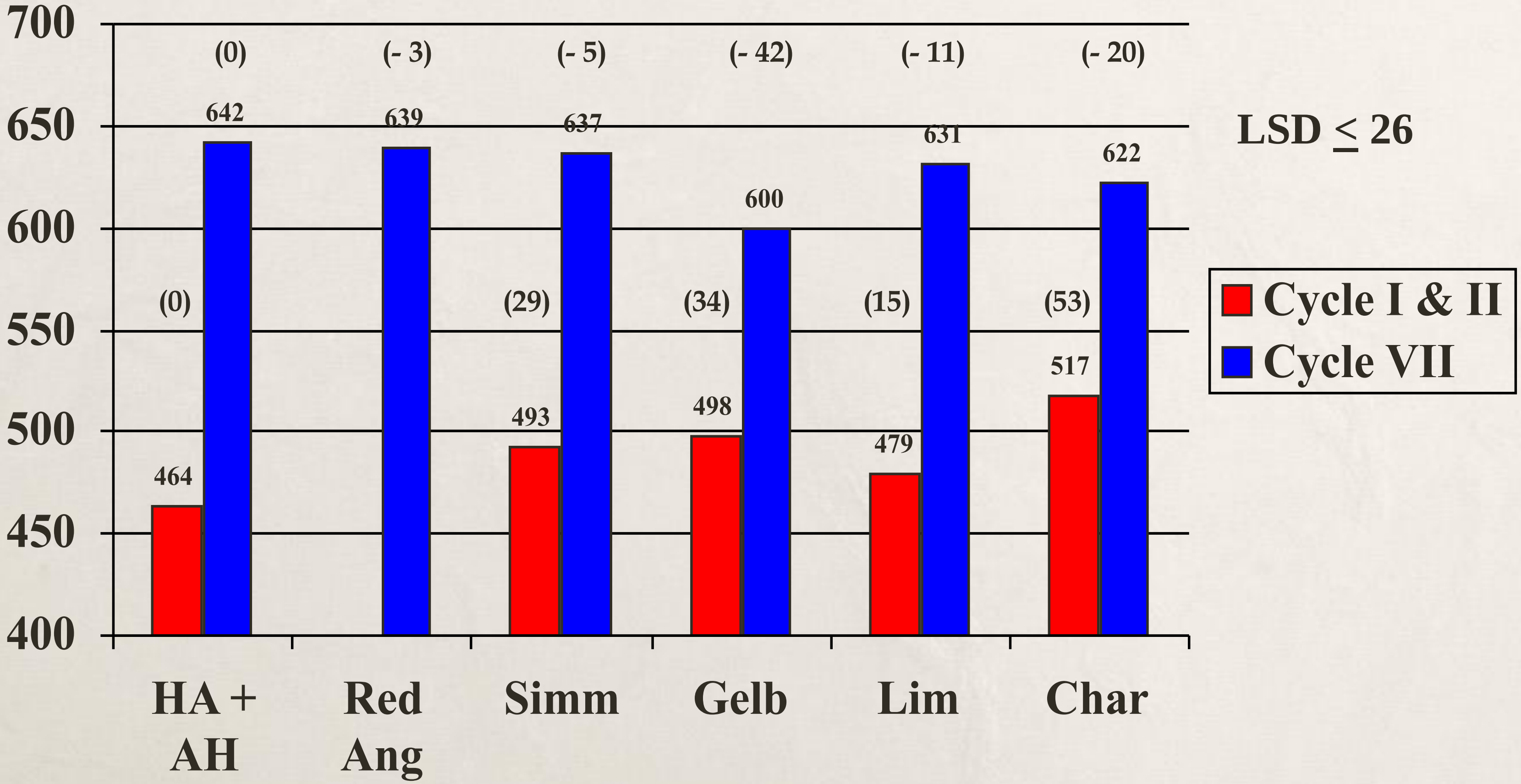
Adapted from Spring 2009 Genetic Trends from Breed Associations and 2011 AB-EPD factors

Genetic Trends for Yearling Weight, lb

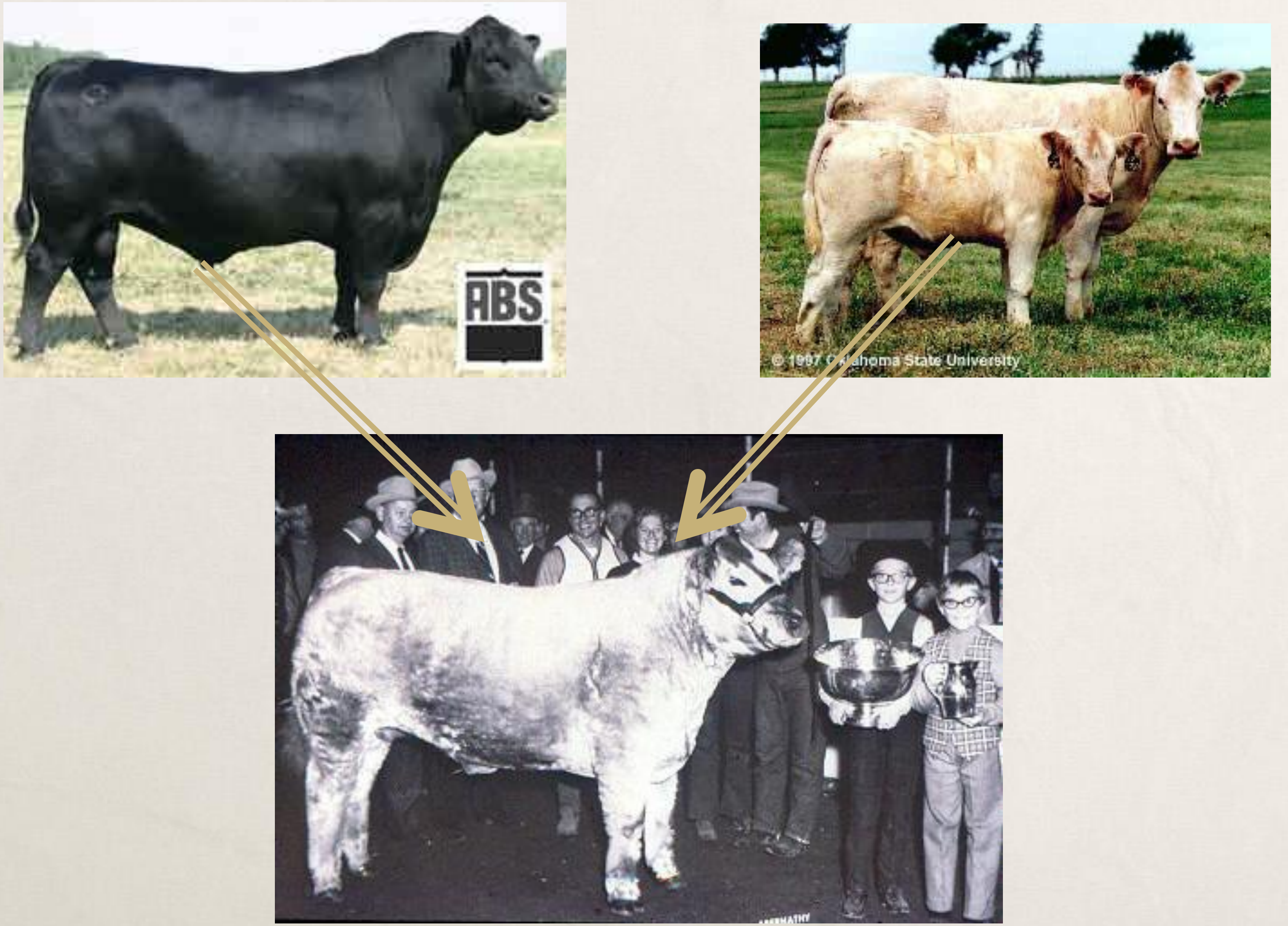


Adapted from Spring 2009 Genetic Trends from Breed Associations and 2011 AB-EPD factors

BREED GROUP MEANS (DEVIATIONS FROM HA & AH) FOR MATURE WEIGHT (ADJUSTED TO CONDITION SCORE OF 5.5) OF F1 CROSS COWS IN CYCLES I AND II (BIRTH YEARS: 1970-74) COMPARED TO CYCLE VII (BIRTH YEARS 1999-2000), KG



Predicting Crossbred Animals



Crossbreeding Done RIGHT!

- Build a plan – set attainable goals
- Considerations
  - Marketing end points
  - Replacement females (cows must have heterosis)
  - Environment
  - Management
- Stick to it!

Points to Ponder

- Mature weight
  - Weaning and yearling weight moderately to highly correlated to mature weight
    - Increased yield comes at a cost in the cow herd
    - Important to use terminal bulls on moderate cows
  - Common breeds have all increased mature weight
    - Use selection tools to moderate maternal lines

Points to Ponder

- Heterosis in crossbred cows should increase their culling age, reduce replacement costs, and increase chances for a profitable herd
- The notion that beef breeds should be all-purpose is common, but counterproductive
  - Breeds are too similar, need to define a purpose
- Heterosis is important and underutilized, but it is not a "free lunch"
  - Greater production comes at the expense of higher inputs

Thank You!

* http://beef.unl.edu
* www.nbcec.org
* www.beefefficiency.org

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