Perspectives on Cow Efficiency from USMARC Research

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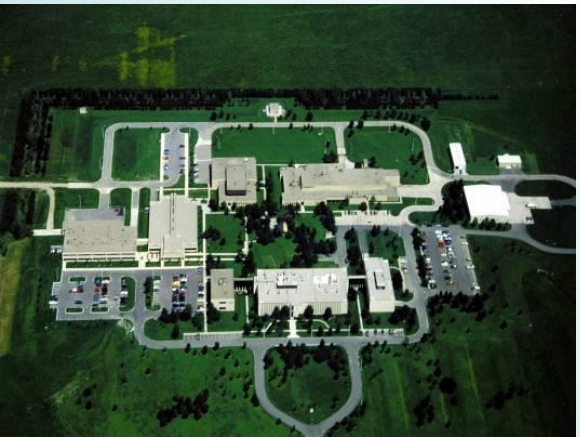
USDA, ARS, U.S. Meat Animal Research Center



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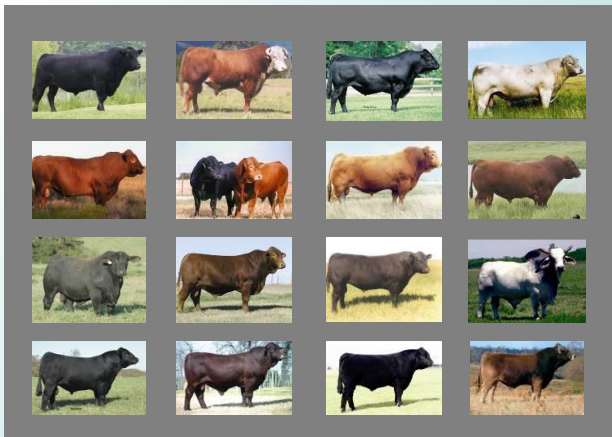


Cow efficiency

- Everybody wants it
  - But what is it?
  - Could be defined in multiple ways
    - Generally focused on biological at USMARC:
      - Calves weaned/cow exposed
      - Calves weaned/(unit energy * cow exposed)
      - Total weaning weight/(unit energy * cow exposed)
    - Most of these measures are ‘population based’
      - Traits on individuals affect expression

Components of cow efficiency

- Fertility
- Cow intake/energy requirements
  - Maintenance, lactation, gestation, immunity
- Calf survival
- Calf growth
- Calf intake
- Longevity

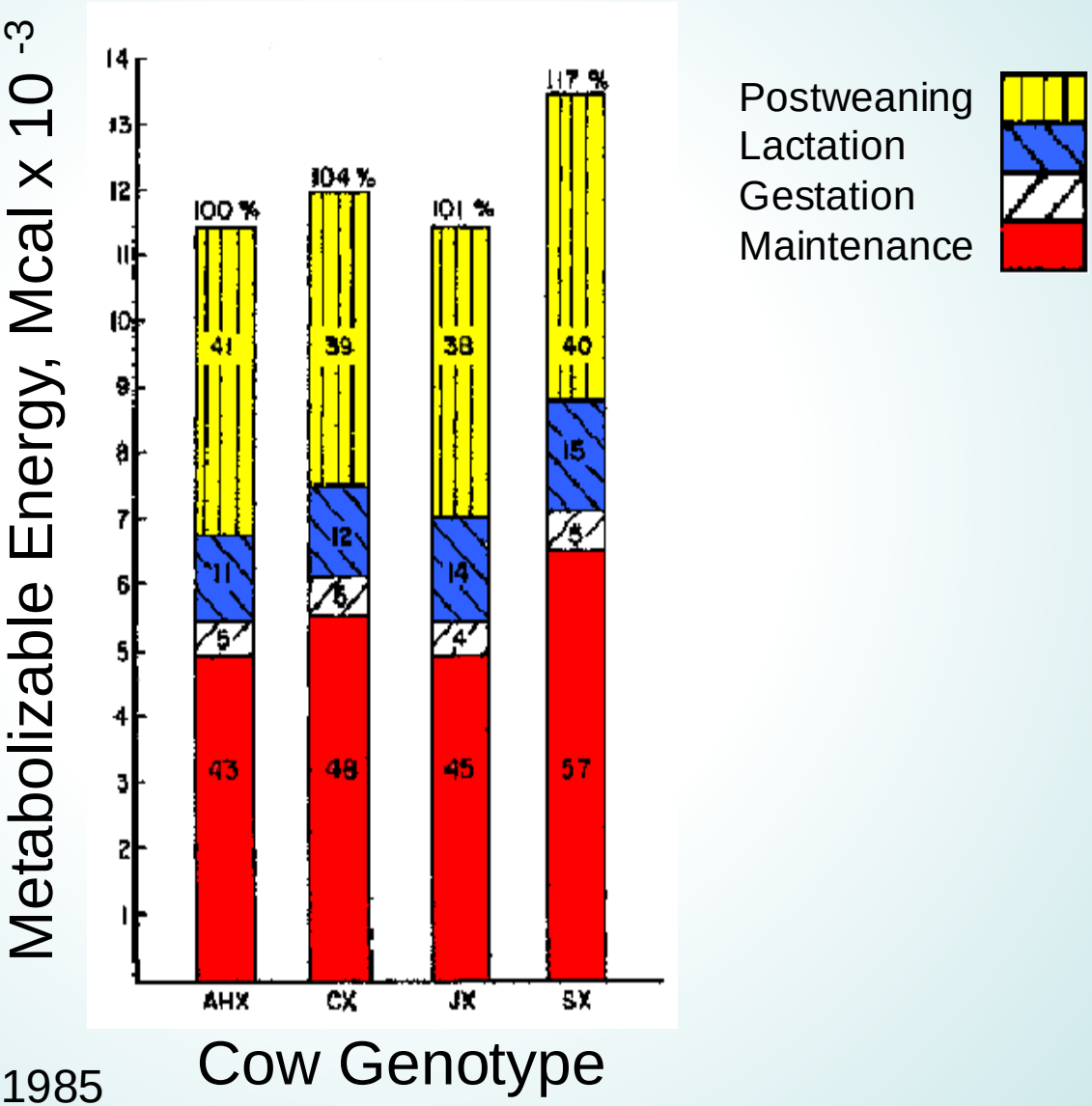
Most predicted by other indirect measures

Goals

- Review of some efficiency/lifetime productivity research at USMARC
  - Germplasm Evaluation Program (GPE)
  - Germplasm Utilization Study

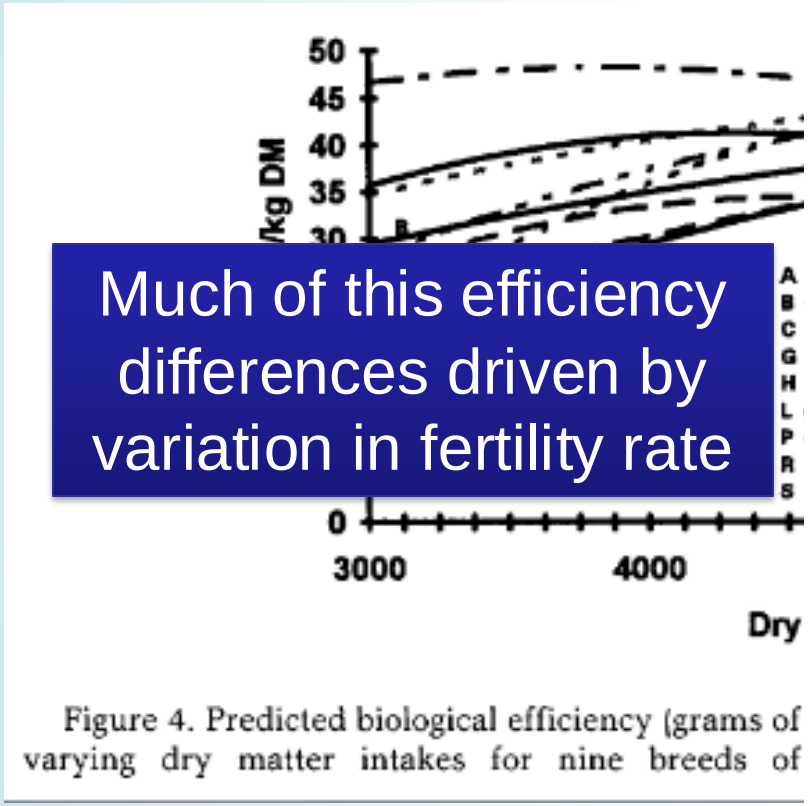
- Current results relative to adult cow weight and measurement of efficiency in the GPE

Estimated Total Metabolizable Energy Required For The Production of Calves to 455 Days of Age



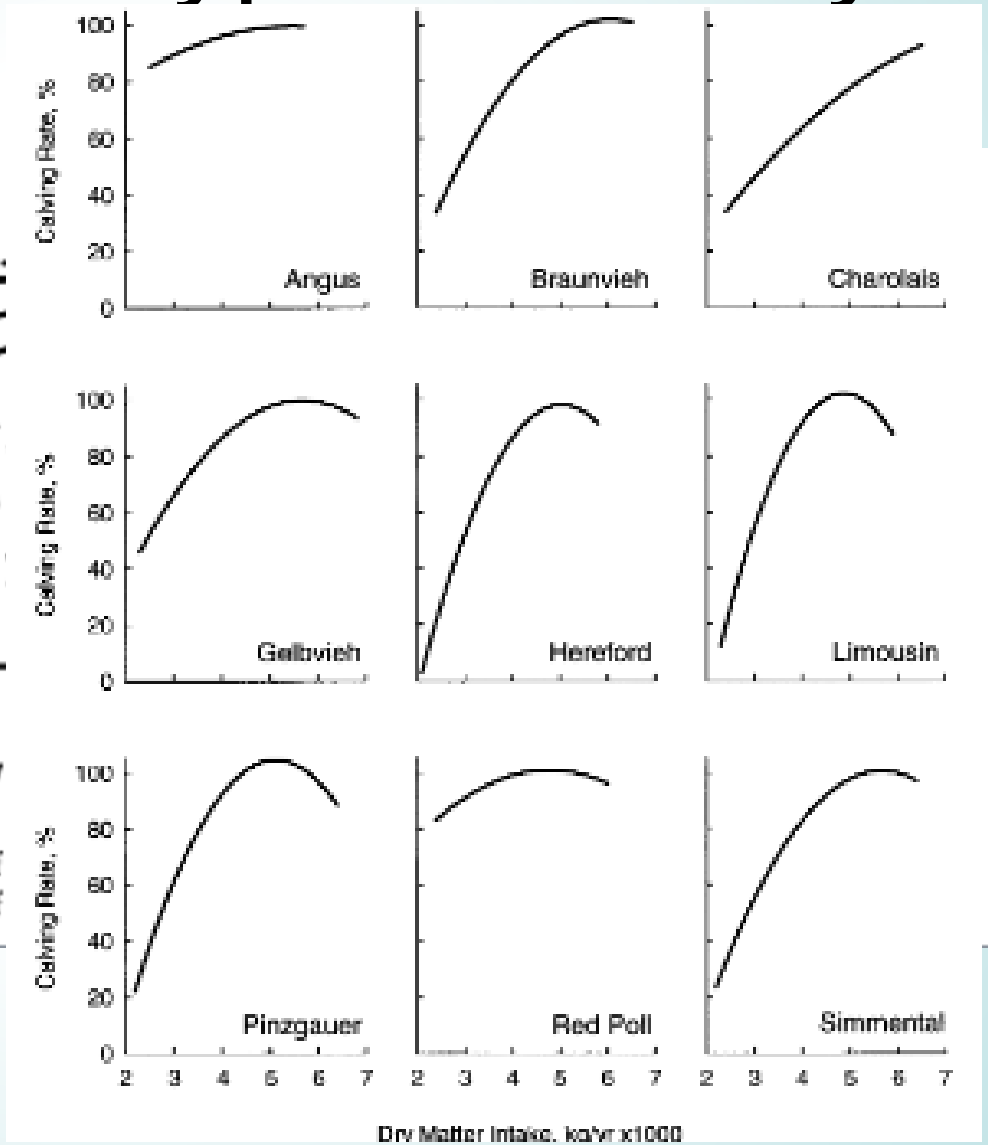
Ferrell and Jenkins, 1985

Breed/biological type efficiency



Much of this efficiency differences driven by variation in fertility rate

Figure 4. Predicted biological efficiency (grams of varying dry matter intakes for nine breeds of



Jenkins and Ferrell, 1994

OUTPUT/INPUT DIFFERENCES AMONG BOS TAURUS X BOS TAURUS F_1 COWS (JENKINS ET AL., 1991)

Item	Overall mean	Breed group[a] (ratio)					
		HAx	RPx	BVx	GVx	MAx	CIx
Progeny (138.5 days)							
Weight gain, lb	346	97	99	103	100	103	98
Energy consumed, Mcal ME	744	106	102	99	96	98	99
Dams (138.5 days)							
Milk production, lb/day	8.8	85	101	118	111	104	82
Cow weight, lb	1,138	98	91	97	100	107	107
Fat probe, in	.25	124	101	91	93	90	101
Energy consumed, Mcal ME	3,787	91	96	105	105	100	104
Efficiency (138.5 days)							
Progeny gain, lb/Mcal ME calf + dam	.077	103	103	99	97	103	95

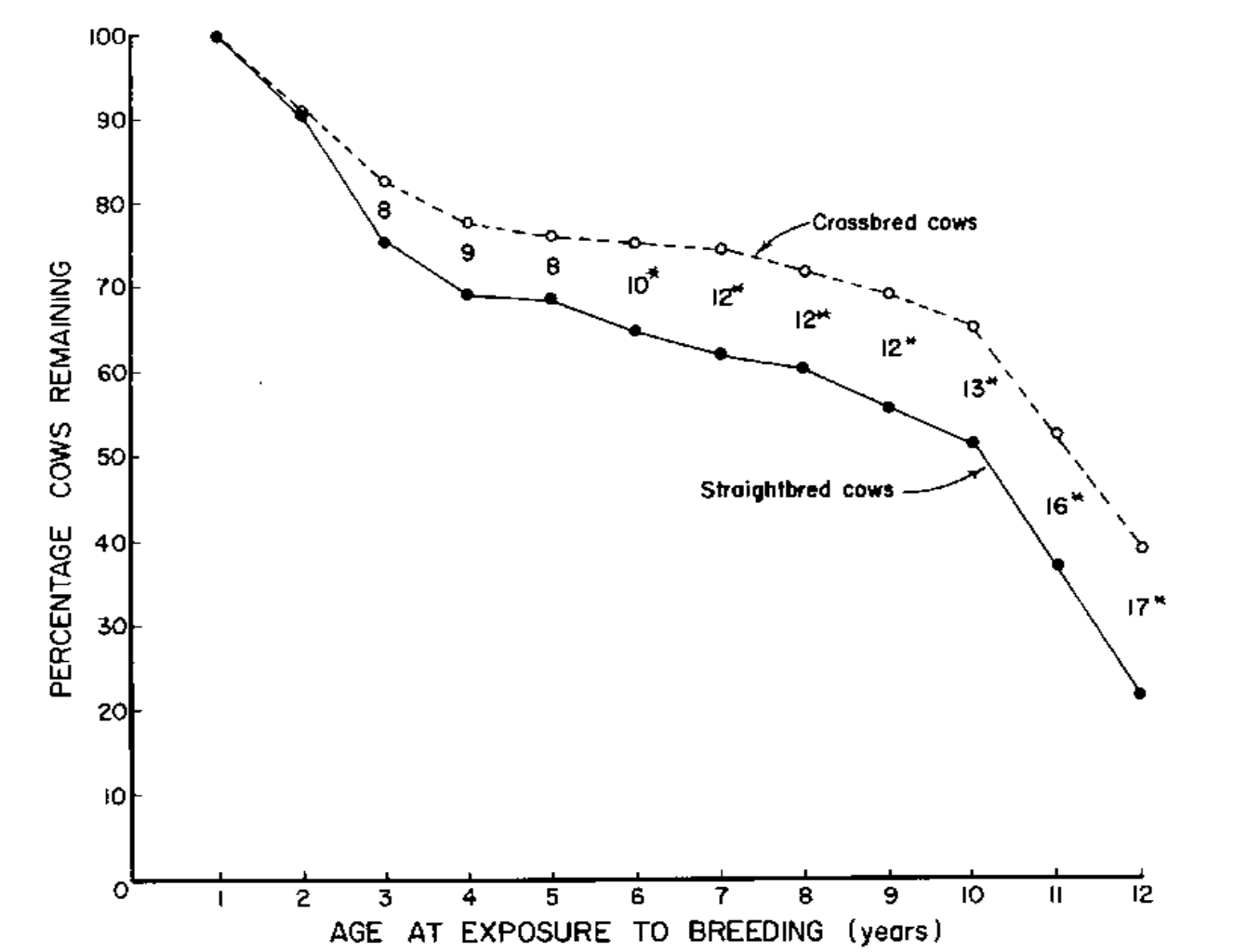
[a]HAx = Hereford or Angus, RPx = Red Poll, BVx = Brown Swiss, GVx = Gelbvieh, MAx = Maine Anjou, and CIx = Chianina sired F_1 crosses.

OUTPUT/INPUT DIFFERENCES AMONG BOS INDICUS X BOS TAURUS AND BOS TAURUS X BOS TAURUS F_1 COWS (GREEN ET AL., 1991)

Item	Overall mean	Breed group[a] (ratio, %)			
		HAX	PzX	BmX	SwX
Progeny (126 days)					
Weight gain, lb	284.3	92	99	108	103
Energy consumed, Mcal ME	592.2	112	102	92	94
Dams (126 days)					
Milk production, lb/day	15.5	90	103	105	101
Cow weight, lb	1,236	98	100	105	97
Fat probe, in	.31	91	95	102	112
Energy consumed, Mcal ME	3,292	93	104	106	97
Efficiency (138.5 days)					
Progeny gain, lb/Mcal ME					
calf + dam	.073	95	95	104	106

[a]HAX = Hereford -Angus, PzX = Pinzgauer, BmX = Brahman, and SwX = Sahiwal crosses.

Cow Longevity – USMARC Data



- Open heifers culled
- Through 9 yrs of age, cows open two successive years were culled
- Open cows $\geq$ 10 yr of age were culled

Effects of heterosis were greatest for

- Lifetime production (30%)
- Longevity or herd-life (15%)
- Annual income (23%)

LONGEVITY AND LIFETIME PRODUCTION TO 12 YRS OF AGE OF CROSSBRED AND STRAIGHTBRED COWS AMONG ANGUS, HEREFORD AND SHORTHORN
(Nunez et al. and Cundiff et al.)

Trait	Crossbred cows	Straightbred cows	Heterosis	
			units	pct
Longevity (herd life, years)	9.7	8.4	1.3	15
Breeding seasons, no.	8.2	7.1	1.2	16
Pregnancies, no.	7.7	6.0	1.2	20
Calves born, no.	6.6	6.0	1.0	10
Calves weaned, no	6.2	5.2	1.0	20
Cumulative 200 d wt weaned, lb	2,798	2,156	642	30
Annual income (100 cow herd)	$16,524	$13,468	$3,056	23

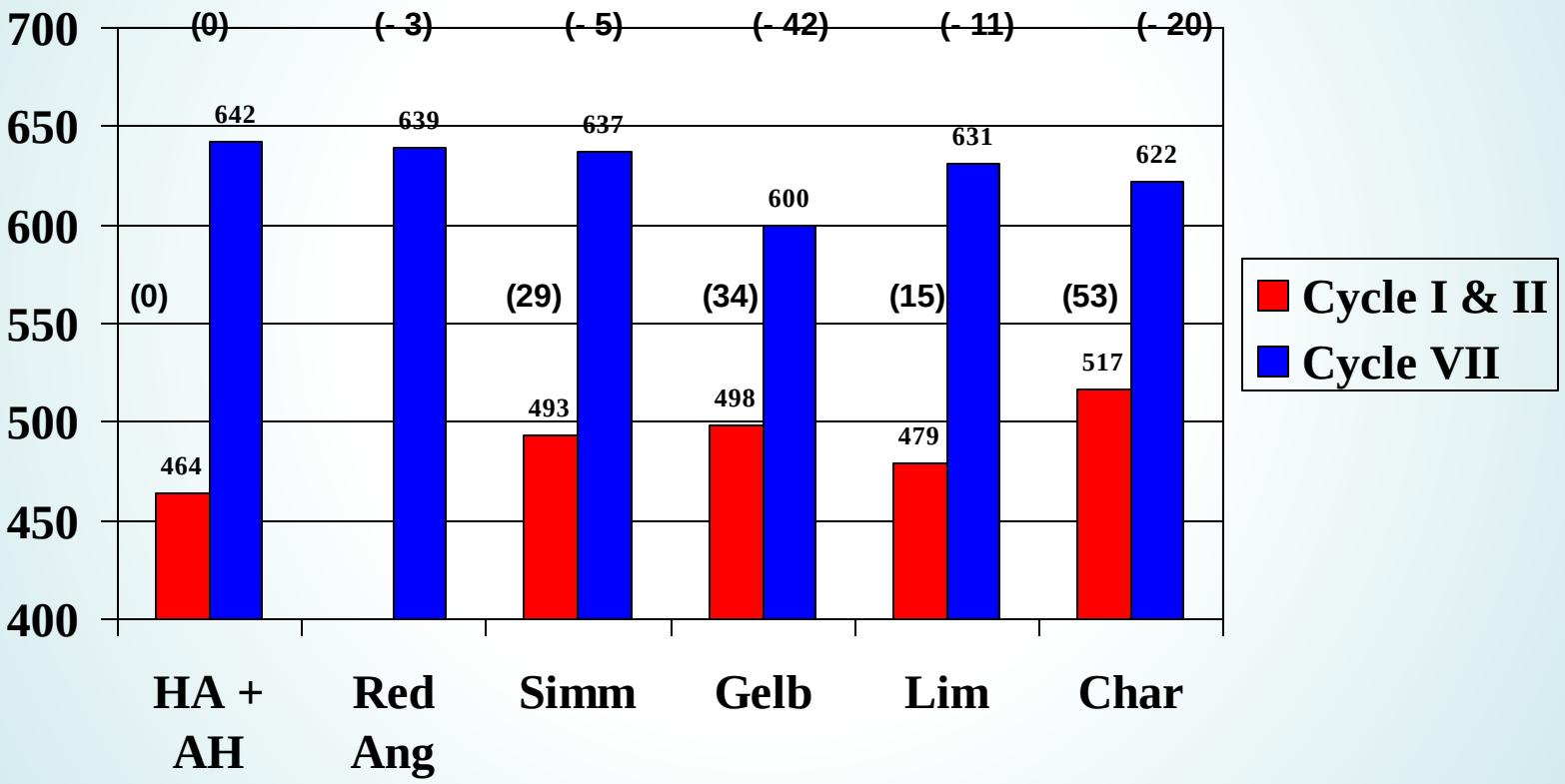
Matching potential to resources

- Legitimate question as to whether these same genetic resources exist (at least in the same breed types)
- Certainly, growth has changed energy inputs
- More time needed to evaluate longevity, survival, fertility

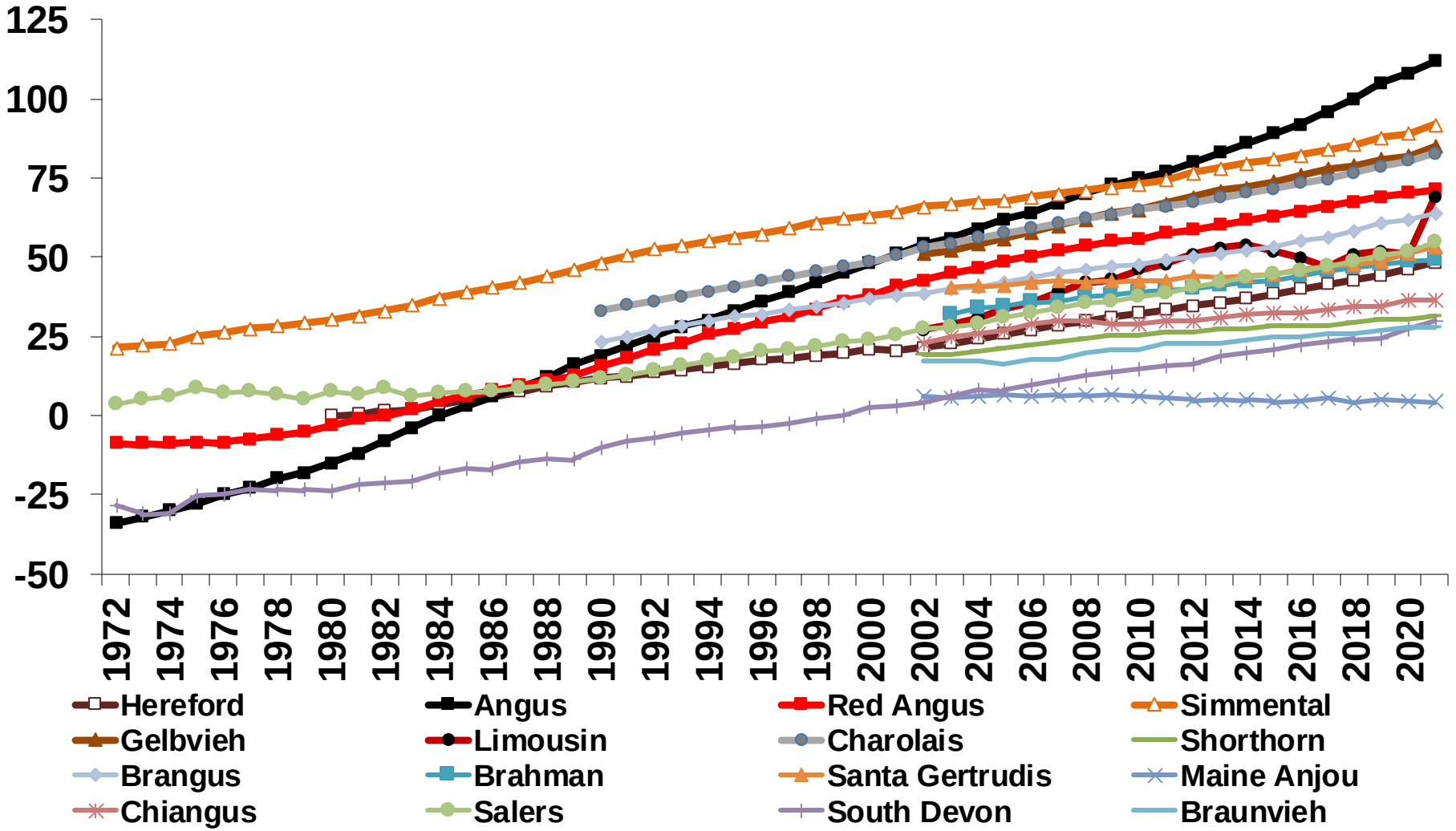
Differences in Cow Weights

Are we changing efficiency through selection for growth?

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



Genetic Trends for Yearling Weight, lb

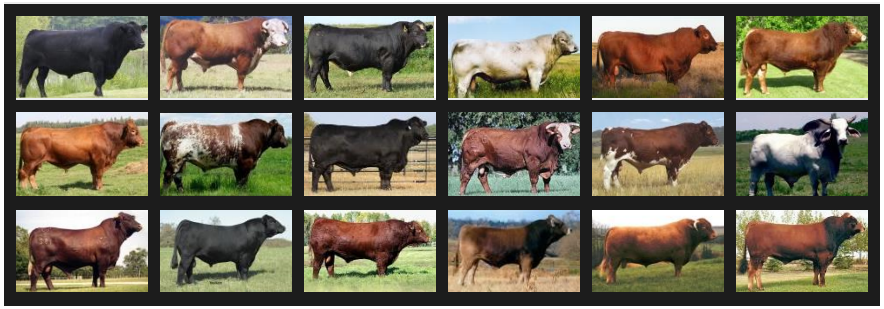


Adapted from Spring 2021 Genetic Trends from Breed Associations and 2021 AB-EPD factors

GPE Population Structure

AI Sires:
AN, HH, SM, CH, AR, LM, GV, SH, BN,
BM, MA, BR, CI, SG, SA, BV, SD, TA

Dams:
AN, HH, SM, CH, AR, LM, GV, SH, BN,
BM, MA, BR, CI, SG, SA, BV, SD, TA



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PB, BC & F_1 Steers

PB Bulls

×

PB, BC & F_1 Heifers

Natural Service PB, BC, & F_1 Steers & Heifers

Cow weight differences same?

- Compare continuous GPE breeds
  - ~8 years since cycle VII sampling
  - Mature weight limited
    - Earlier weights are a proxy (highly correlated)
    - Weights at 1280 d (~3.5 yr)
    - Data not precise yet but give an indication
    - Weight are adjusted to constant body condition

Mature Weight and Condition

(Ribeiro et al., 2022)

Breed	Mature Weight (lb)	Adj Mature Weight (lb)	Condition Score
Angus	0	0	0
Red Angus	-47.8 (20.5)	-53.8 (18.1)	0.04 (0.08)
Beefmaster	-76.1 (25.8)	-56.9 (22.7)	-0.13 (0.10)
Brahman	20.9 (30.0)	9.3 (26.5)	0.08 (0.12)
Brangus	-45.0 (24.7)	-27.3 (21.8)	-0.12 (0.10)
Braunvieh	-194.7 (29.3)	-113.5 (26.0)	-0.55 (0.11)
Charolais	14.3 (20.3)	14.3 (17.9)	0.004 (0.08)
Chiangus	-33.1 (26.5)	-7.9 (23.4)	-0.17 (0.10)
Gelbvieh	-71.2 (20.5)	7.1 (18.1)	-0.53 (0.08)
Hereford	-30.4 (19.2)	-14.3 (16.8)	-0.11 (0.07)
Limousin	-76.3 (20.3)	-17.4 (17.9)	-0.40 (0.07)
Maine-Anjou	-62.6 (26.0)	-19.8 (22.9)	-0.29 (0.10)
Salers	-20.1 (28.0)	9.5 (24.7)	-0.20 (0.10)
Santa Gertrudis	-33.1 (27.6)	27.3 (24.5)	-0.41 (0.10)
Shorthorn	-49.8 (24.7)	24.0 (21.8)	-0.50 (0.09)
Simmental	-17.0 (19.6)	15.4 (17.2)	-0.22 (0.07)

Cow Weights

- Some breeds have moderated while others are larger than at Cycle VII
- Seems to be a real opportunity for breed complementarity
- These results are preliminary
  - Will continue to evaluate as cows age in GPE

Cattle lifecycle – intake and gain

Growing **Cow production** **Finishing**

Traits difficult to measure on breeding animals at different phases

Potential antagonistic relationships between traits at different stages

Feed Intake and Gain (Retallick et al., 2017)

Breed	Steer ADFI (lb)	Steer ADG (lb)	Heifer ADFI (lb)	Heifer ADG (lb)
Angus	0	0	0	0
Hereford	-1.74 (0.63)	-0.08 (0.12)	-2.12 (0.59)	-0.05 (0.10)
Red Angus	-0.68 (0.61)	-0.15 (0.11)	-1.51 (0.56)	-0.19 (0.09)
Shorthorn	-2.20 (0.71)	-0.22 (0.13)	-2.25 (0.66)	-0.22 (0.11)
South Devon	-4.09 (1.47)	-0.60 (0.39)	-3.47 (1.41)	0.03 (0.24)
Beefmaster	-1.70 (0.76)	0.16 (0.15)	-3.43 (0.74)	-0.20 (0.12)
Brahman	-2.91 (0.77)	-0.27 (0.15)	-2.98 (0.70)	-0.41 (0.12)
Brangus	-0.38 (0.74)	-0.07 (0.14)	-1.29 (0.70)	-0.26 (0.12)
Santa Gertrudis	-1.25 (0.74)	0.05 (0.14)	-2.29 (0.67)	-0.25 (0.11)
Braunvieh	-3.28 (0.77)	-0.40 (0.15)	-4.06 (0.67)	-0.66 (0.11)
Charolais	-1.15 (0,64)	-0.04 (0.12)	-1.93 (0.60)	-0.17 (0.10)
Chiangus	-2.74 (0.74)	-0.18 (0.14)	-2.31 (0.65)	-0.26 (0.11)
Gelbvieh	-2.32 (0.61)	-0.16 (0.12)	-1.59 (0.56)	-0.25 (0.09)
Limousin	-2.73 (0.62)	-0.01 (0.12)	-3.24 (0.56)	-0.35 (0.09)
Maine Anjou	-3.63 (0.74)	-0.33 (0.14)	-2.43 (0.67)	-0.22 (0.11)
Salers	-2.67 (0.73)	-0.30 (0.14)	-2.59 (0.67)	-0.31 (0.11)
Simmental	-0.09 (0.63)	-0.04 (.12)	-1.17 (0.61)	-0.15 (0.10)
Tarentaise	-2.60 (1.49)	-0.33 (0.30)	-4.25 (1.25)	-0.69 (0.21)

Cow efficiency

- Have begun to look at correlations between heifer and cow efficiency measures
  - Based on Cycle VII breeds
    - Angus, Hereford, Red Angus, Charolais, Gelbvieh, Limousin, Simmental
- Cows measured at 5 years of age
  - Dry and unbred
  - Restricted feed for 112 d based on $BW^{0.75}$
  - Ad libitum for 98 d

Cow intake breed differences

Breed	Cow ADDMI	Cow ADG	Cow RFI	Cow RADG
Angus	0	0	0	0
Red Angus	−604 ± 940	−17 ± 143	−491 ± 760	51 ± 106
Charolais	−977 ± 1,046	−55 ± 163	−617 ± 882	56 ± 124
Gelbvieh	−1,070 ± 990	139 ± 153	−1,987 ± 824	260 ± 116
Hereford	−756 ± 1,003	37 ± 157	−1,003 ± 849	123 ± 119
Limousin	−1,327 ± 1,000	−67 ± 155	−882 ± 830	83 ± 116
Simmental	82 ± 1,030	265 ± 160	−1,662 ± 860	255 ± 121
*P*breed differed	0.74	0.27	0.22	0.15

- Breed difference for intake and gain in cows looked large, but were not statistically significant
- Still, rankings similar to heifers in magnitude

Freetly et al., 2020

Cow and heifer correlations

	Heifer ADDMI	Heifer ADG	Cow ADDMI	Cow ADG
Heifer ADDMI	0.84 ± 0.12	0.86 ± 0.07	0.84 ± 0.09	0.83 ± 0.14
Heifer ADG	0.05 ± 0.32	0.53 ± 0.12	0.66 ± 0.16	0.73 ± 0.19
Cow ADDMI	−0.08 ± 0.35	−0.08 ± 0.18	0.53 ± 0.12	0.86 ± 0.10
Cow ADG	−0.40 ± 0.36	−0.15 ± 0.16	0.43 ± 0.10	0.34 ± 0.11

- Genetic correlations above diagonal, residual below, heritability on diagonal
- Cow and heifer intake and gain had very high genetic correlations
  - Implies selection for efficiency traits in heifers will impact cow efficiency
- May be differences in free choice grazing

Freetly et al., 2020

Metabolizable energy for maintenance

- Knowing actual cost of maintaining body size would give a proxy for cow feed costs

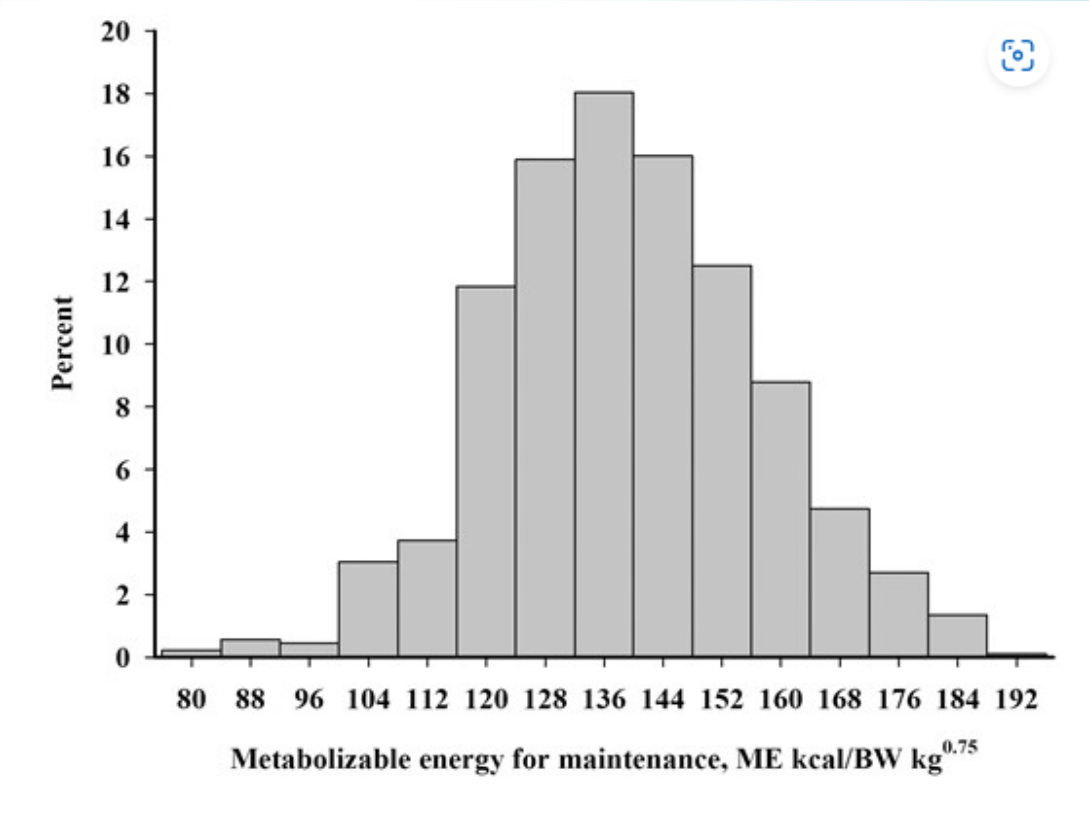
- If metabolizable energy required is heritiable, this knowledge could yield a new selection tool

Study

- Cows in first-second trimester fed at Calan Gates (GPE population)
  - Contemporary breeding groups
- Intake measured 84d – dry mater intake
- Weights every 3 weeks
- MEm = MEi – MEpreg - MEg
  - MEpreg a function of fetal age, calf birth wt
  - MEg a function of ADG and metabolic body size

Results

- Breed effects not different from zero
- Heritability 0.31 (.107)
- Heritable variation in maintenance energy after accounting for mature body size



Freetly et al., 2023

Next Steps

- Currently summarizing fertility and then longevity data in GPE population as individual traits
- Need to continue to identify heritable components
- Sustainability targets will also influence efficiency (positive or negative?)

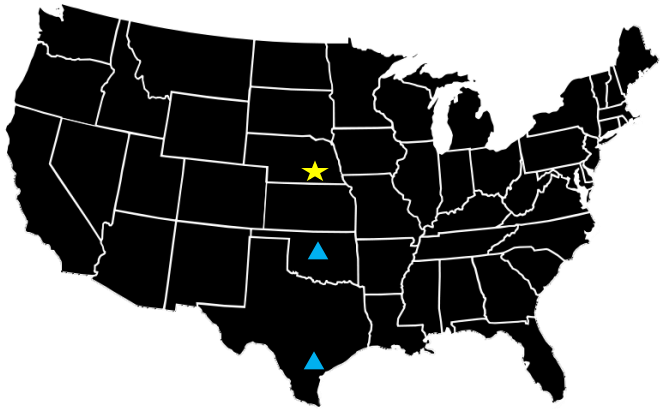
Further efficiency work

- Measures of longevity in the cow herd (stayability, sustained fertility)
  - Prototyped by Warren Snelling
  - Modeled number of pregnancies, calves born, calves weaned, weaning weight using as a cumulative productivity function by year
  - Allows data from all years to contribute and examines heritability and correlations at differing time points

Fed vs. grass intake in cows

- Eating behavior of cows on drylot likely different than on pasture
  - No selection
    - Energy and protein content less variable
    - Diet preference likely varies from animal to animal
  - Change in time spent eating
    - May be less opportunity on grass to overeat
  - Real need to validate similarities

Effects of different environments on production



Closing

- Cow herd efficiency remains important at USMARC and an important consideration in the future
  - Focus on cost of maintaining cow herd to increase chance of producing calves each year
  - Measures of income potential continue to be monitored as part of GPE
    - Weight, survival, fertility, longevity, growth, intake (feed efficiency complex), energy requirements

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Questions