Genetic Variation in Feed Utilization

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Beef compared to Chicken and Pork

Creating edible protein / feed energy input

Beef production ~1/3 as efficient as pork

Beef production ~1/5.5 as efficient as chicken

Differences in reproduction and body composition included.
But, part of beef feed energy input is from forage.

[Adapted from: Dickerson. AP, 1978]

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"System Efficiency" Perspective

Product Output/Feed Intake =

$$\frac{\text{Dam Prod.} * V_d + \text{No. Prog.} * \text{Prog. Prod.} * V_p}{\text{Dam Feed} + \text{No. Prog.} * \text{Prog. Feed}}$$

Thus, the "reproduction effect" on feed efficiency,
No need to measure feed to improve reproduction!

[Adapted from Dickerson. JAS, 1970]

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Individual Growing Calf Feed Efficiency : Output/Input

$$\frac{\text{Calf Weight Gain}}{\text{Feed for Maintenance} + \text{Feed Above Maintenance for Growth}}$$

= Production

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Individual Growing Calf Feed Efficiency : Gain/Feed

$$\frac{\text{Calf Weight Gain}}{\text{Feed for Maintenance} + \text{Feed for Production}}$$

If same Start & End Weights, but one animal gains more quickly than another, then less days and less Maintenance, so more efficient (Gain/Feed). Can occur with no difference in partial cost of maintenance or partial cost of gain.

It is "All Mathematical". Again, no need to measure feed!

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Reproducing Cow Basis: [Calf Wt + Cull Cow Wt]/Feed

$$\frac{\text{Calf Wt} + [\text{Cow Wt} * \text{Cull Rate}]}{\text{Feed for Maintenance} + \text{Feed for Production}}$$

Feed for Maintenance	Feed for Production
Cow	Cow – gestation
Calf	Cow – lactation
Part of Repl. Heifer	Calf – growth

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Life-Cycle Feed Utilization

Maintenance

Goal is Reduce

Production

Goal is to Not Reduce

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Maintenance Portion

Feed Energy for only Maintenance

function of body mass and activity level, stage of production, thermal environment

$= b_m BW^{0.75}$

b_m is the partial cost or feed energy/$kg^{0.75}$/day and has genetic variation—and we need to measure feed in order to practice selection.

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Nebraska Cattle Data

Estimates of b_m (kcal ME/$kg^{0.75}$/day) for cows and their calves similar in size but differing in level of milk

Production Stage	Milk Group		
	Low	Medium[1]	High
Gestating Cow	100	113	110
Lactating Cow	128	146	140
Feedlot Steers	130	146	147

[1]Most active, most nervous group

[Montaño-Bermudez et al. JAS, 1990]

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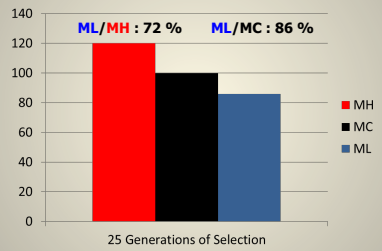
Nebraska "Heat Loss" Mice Lines Feed Intake (relative to MC = 100)



[McDonald & Nielsen. JAS, 2007]

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Feed Intake (g/$kg^{0.75}$/d) as a percentage of MC in Normal

Temperature	MH	MC	ML
Cold (12 C)	172	166	155
Normal (23 C)	112	100	97
Hot (31 C)	87	83	82

No line x environment interaction

[Kgwatalala et al. JAS, 2004]

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Partial Costs (energy/unit)

Demonstrated the large difference between MH and ML lines in energy for maintenance partial cost (b_m) but not partial costs of energy for components of growth. Yet, we still wonder about genetic variation in the partial costs for lean and fat growth.

[Eggert and Nielsen. JAS, 2006]

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Some Correlated Responses with Selection for Heat Loss

- Body mass : no response
- Litter Size: 2+ pup difference MH – ML
  totally explained by number of ovulations
- Fortunately, no difference in conception rate
- Fatness: MH leaner, ML fatter
- Milk production: MH > ML

[Nielsen et al. JAS, 1997] [McDonald & Nielsen. JAS, 2006]

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Longevity and Activity

- It appears that there are not major differences in longevity – needs more study
- Line differences in feed intake at advanced ages consistent with that observed at younger ages
- Locomotor Activity

  ML/MH = 47% ML/MC = 68%

  Activity explains 20% of difference between MH and ML in feed/BW

[Sojka, Miner, Nielsen, unpub]

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Growing Cattle (multiple breeds): Heritability Estimates (US MARC)

Trait	h^2 (se)
DMI	0.40 (0.02)
RFI	0.52 (0.14)
G:F	0.36 (0.10)

[Rolfe et al. JAS, 2011]

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Predicted Selection Responses (kg/i)/generation

Selection Criterion	DMI_{140}	$GAIN_{140}$
DMI_{140}	-56.7	-5.4
$GAIN_{140}$	+26.3	+7.5
RFI Phen. Index	-44.6	+1.9
RFI Geno. Index	-38.5	0
G:F	-27.5	+2.4
Ec. Index (DMI,MWT,Gain)	-12.4	+5.4
Ec. Index (RFI,Gain)	0	+7.7

[Rolfe et al. JAS, 2011]

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Genomic (SNP) Predictors

- US MARC Crossbred Steer Population
- BovineSNP50 Chip – best 96 SNPs for each measure of feed intake

	h^2_{Total}	h^2_{best96}	% V_A
DMI_{140}	0.40	0.33	82
RFI_P	0.56	0.34	61
RFI_G	0.44	0.33	75

[Snelling et al. JAS, 2011]

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Summary 1.

- Increasing female reproduction improves system feed efficiency.
- More output per unit time improves individual efficiency.
- Do not need measurement of feed intake to improve these.

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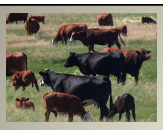
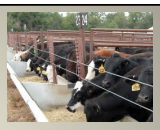
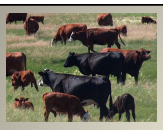


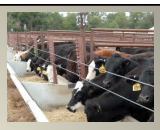
Summary 2.



- Measurement of feed intake to have data needed to decrease maintenance (b_m).
- Correlated responses to reducing maintenance in mice
  - undesirable for body fatness (?) and litter size, but not conception rate.

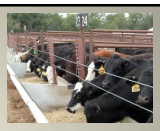


Summary 3.



- Maintenance cost/coefficients (b_m), although different with different stages of life, did not change in ranking of genetic groups. Needs more study to be conclusive.
- SNP panels and their accuracy will improve and look very promising as predictors of feed intake breeding value.

Summary 4.



- How much can we change feed requirements, just by reducing maintenance coefficient, ignoring any changes in reproduction?

For cattle, with maintenance comprising ~70% of feed energy, a reduction of 10% in life-cycle feed energy seems possible.