Net feed efficiency and its Relationship to Carcass Quality of Fed Cattle, and Wintering Ability of Cows

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New Technologies to Improve Feed Efficiency, Disease Detection and Traceability
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Western Forage/Beef Group

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Feed Efficiency in Beef Cattle: Why?

- **Maintenance requirements of beef cattle is largely unchanged over last 100 years** *(Johnson, Ferrell and Jenkins, 2003)*

- **>50% of total feed intake is used solely for body maintenance of adult and slaughter animals** *(Dickerson 1970)*

- **65-75% of the total dietary energy cost in breeding cows is required for maintenance** *(Ferrell & Jenkins 1985; NRC 1996)*

- **5% improvement in feed efficiency has an economic impact 4X greater than a 5% improvement in ADG** *(Gibb & McAllister 1999)*

Energetic Efficiency in growing beef cattle

1. **Feed Intake**

2. **Feed Conversion Ratio: DMI/ADG**

3. **Partial Efficiency of growth: ADG/(avg. DMI-expected DMI_m)**

   efficiency of growth after removing FI for maintenance

4. **Relative Growth Rate: 100 x [log end wt – log start wt]/days on test**

   Growth relative to instantaneous body size

5. **Kleiber Ratio: ADG/avg test period LWT0.75**

   weight gain per unit of metabolic body weight

All measures are related to body size, growth and composition of gain

6. Net Feed Efficiency (NFE) or Residual Feed Intake (RFI)

- **regression of mid-test wt and ADG on FI which gives expected FI; NFE=actual FI-expected FI**
- **is the difference between an animal's actual feed intake and its expected feed intake based on its size and growth over a specified test period.**
- **it is moderately heritable (h^2 = 0.29-0.46) & may reflect an animal's energy requirement for maintenance.**
- **is independent of body size and growth rate**

Advances in Technology

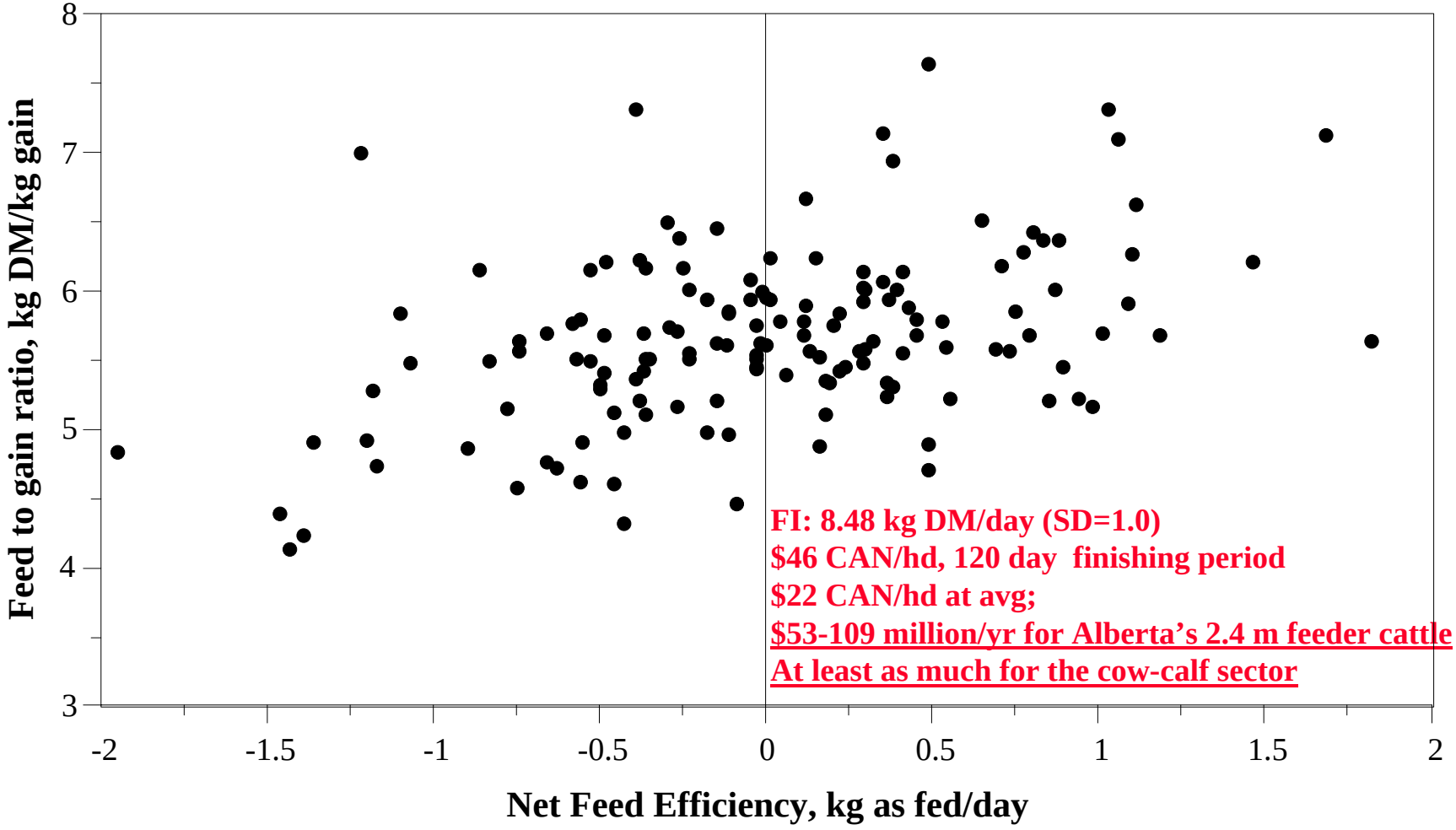
- Radio frequency (RF) identification, wireless communication, RF detection, software integration

- GrowSafe hardware & acquisition software combined with ***custom software*** resulted in 1-2% error in the calculation of meal & daily feed intake *(Basarab et al 2002).*

- Robust & accurate system for monitoring behaviour

1. Implications for feedlot cattle

Large variation & economic benefit (NFE in feeder steers)



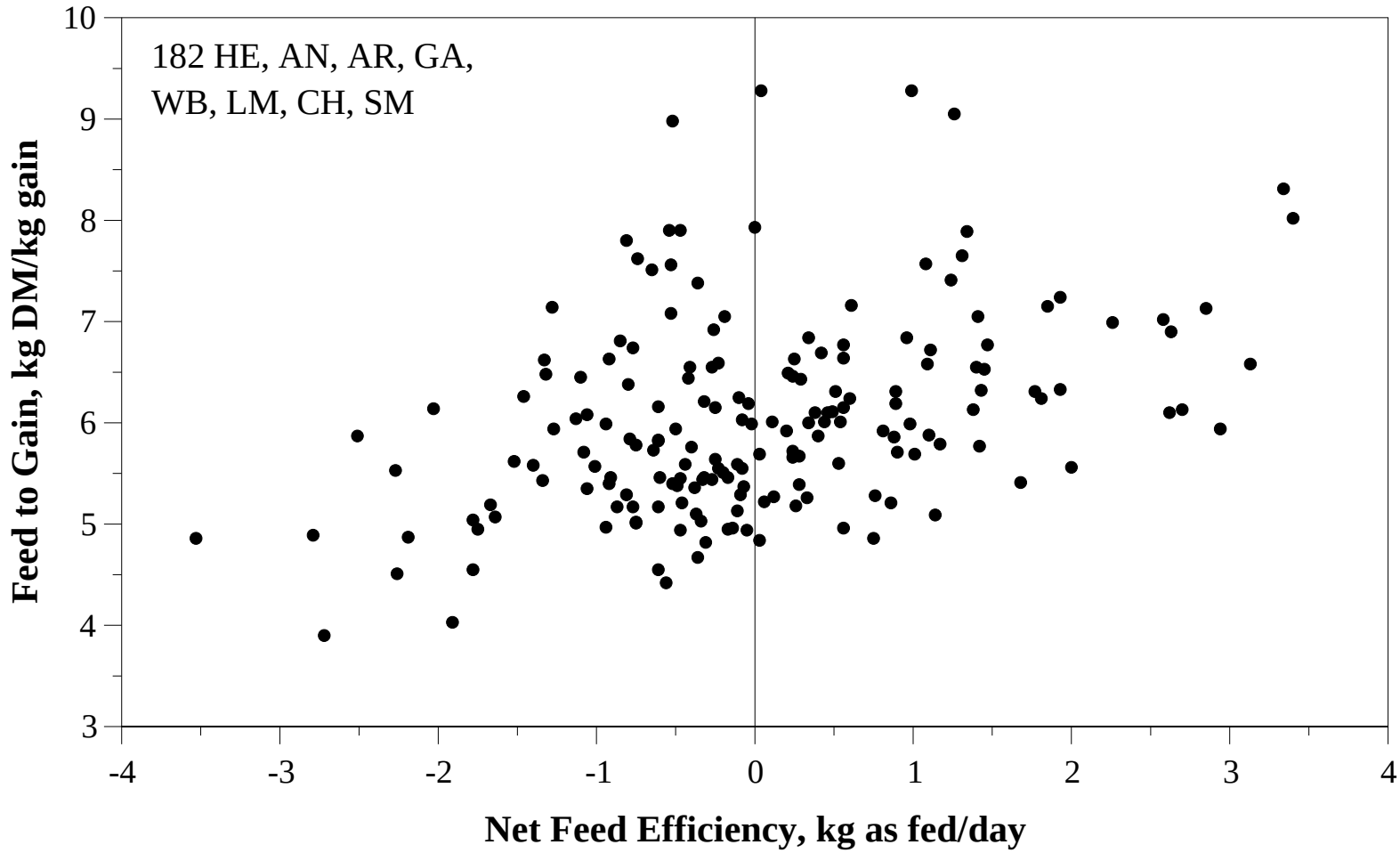
As feed intake increases, feed efficiency decreases (FI vs NFE, r=.43, n=148, P=.0001)

Range=-1.95 to +1.82 kg as fed/day (SD=0.66)

2. Implications for bull and heifer selection

Olds College NFE Bull Test - 2002-03 & 2003-04

Relationship between NFE and Feed:Gain Ratio

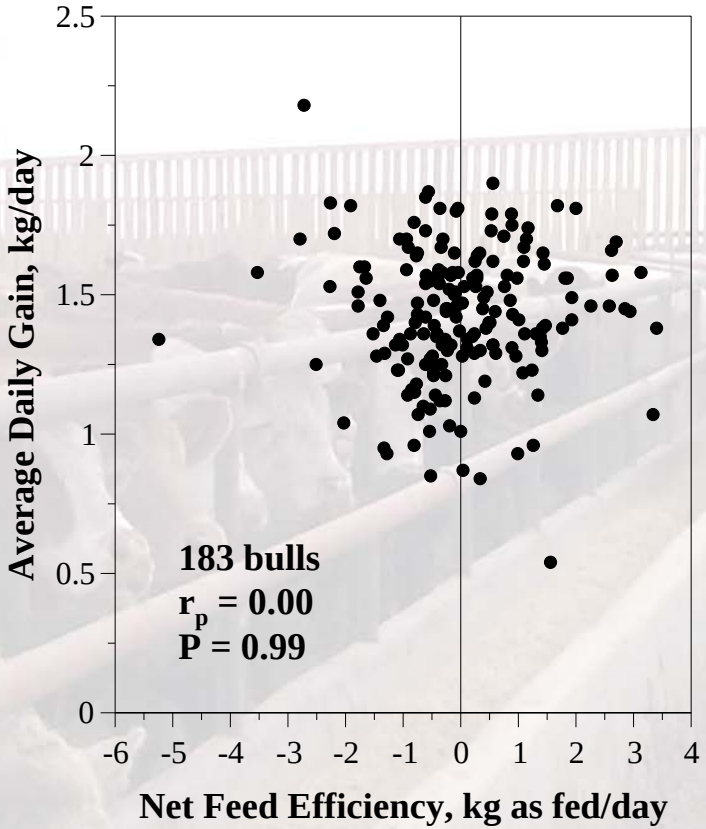


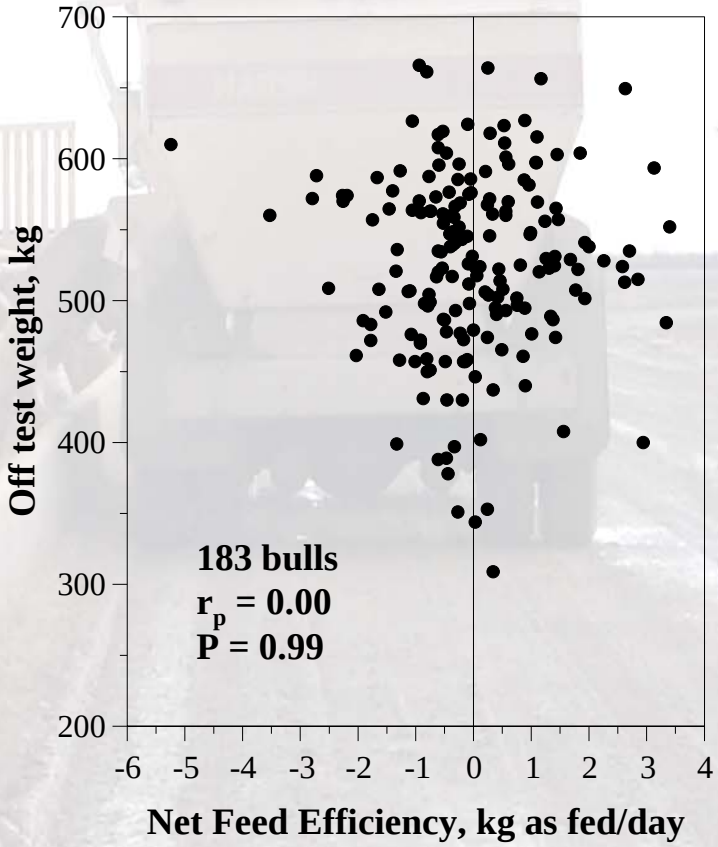
Selection for low NFE will:

have no effect on ADG or animal size

Phenotypic (r_p) & genetic correlations (r_g) are near zero

Arthur et al. 2001; Basarab et al. 2003; Crews et al. 2003; Jensen et al. 1992





183 bulls (HE, AN, AR, GA, WB, LM, CH, SM from Olds College NFE Bull test 2002-2004

Selection for low NFE will:

- **reduce feed intake by 10-12%** *(steers, repl. Heifers, cows).*
  Arthur et al. 2001; Basarab et al. 2003; Herd et al. 2002
  NFE vs. DMI, r_p = 0.60-0.72; NFE vs. DMI, r_g = 0.69-0.79

- **improve FCR by 9-15%**
  Arthur et al. 2001; Basarab et al. 2003, Herd et al. 2002
  NFE vs. FCR, r_p = 0.53-0.70; NFE vs. FCR, r_g = 0.66-0.88

Performance of progeny from low or high Net Feed Efficiency bulls and heifers after five years of selection.

Traits	Low NFE parents	High NFE parents	Yearly correlated response
Number of animals	62	73	
Net Feed Efficiency, kg/day	-0.54a	0.71b	0.25
365 day live weight, kg	384.3	380.7	0.72
Average daily gain, kg/day	1.44	1.40	0.01
Actual feed intake, kg/day	9.4a	10.6b	0.24
Feed conversion ratio, kg/kg	6.6a	7.8b	0.24

Adapted from Arthur et al. 2001, Proc. 14th Conf. Asc. Advance. Anim. Breed. & Gen., pp. 135-138
a,b means in the same rows differ, $P<0.05$

Selection for low NFE will:

- **lower heat production by 9-10% (*HP=NEm + HIF)***
  Basarab et al. 2003; Nkrumah et al. 2004

- **Lower methane emissions by 9-12% &**
  manure, N, P, K production by 15-17%
  Okine et al. 2001, 2002; Arthur et al. 2002;

Selection for low NFE may:

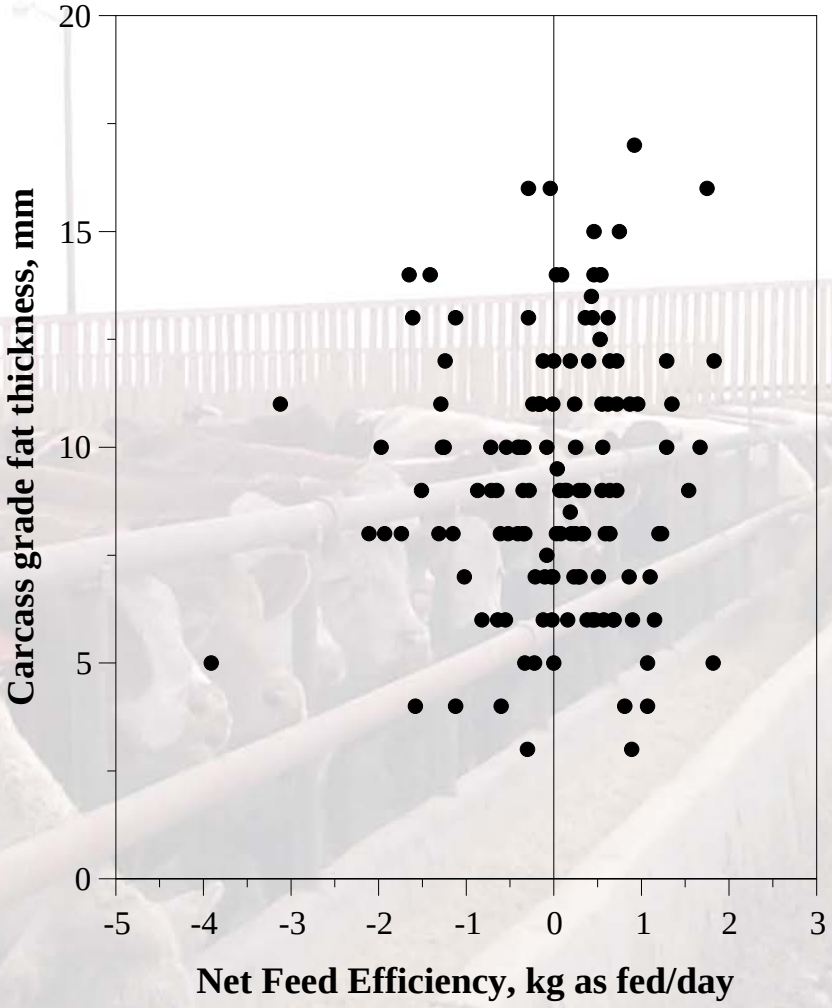
- **decrease carcass fat by 5%**
  Phenotypic (r_p) & genetic correlations (r_g) are inconsistent & near zero (0.20 to –0.20)
  (Richardson et al. 2001; Basarab et al. 2003)

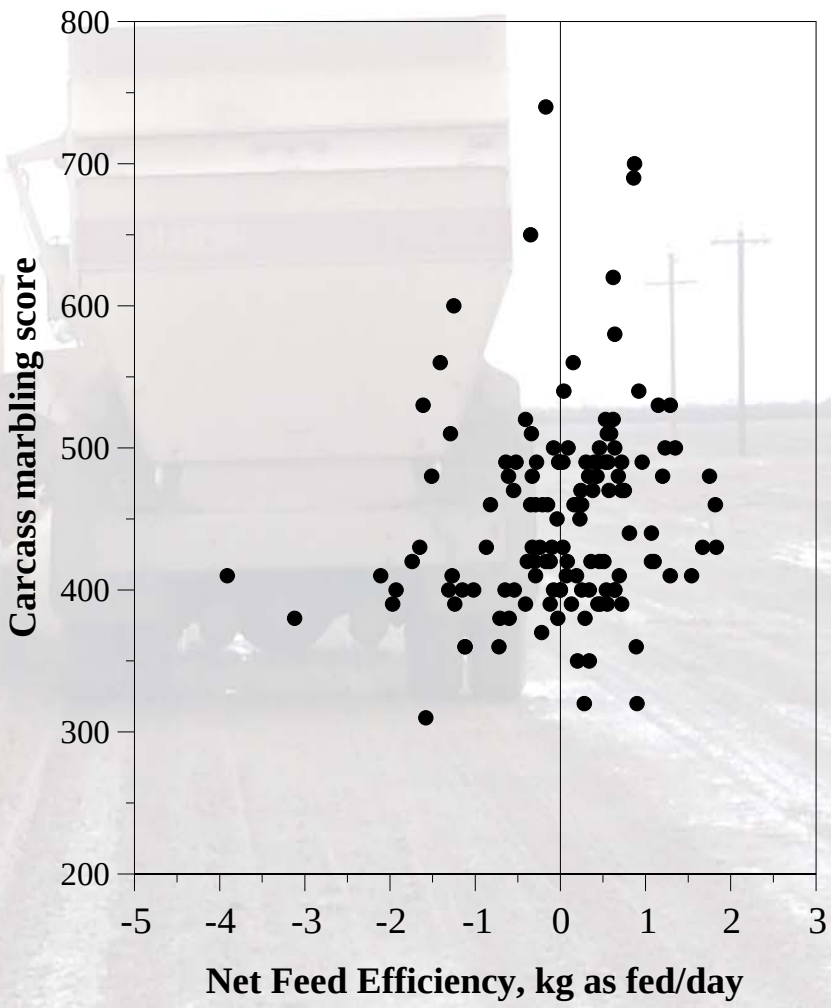
No difference in carcass composition of lean, bone and subcutaneous fat, but slightly <u>less inter-muscular fat and body cavity fat</u> in low NFE steers.

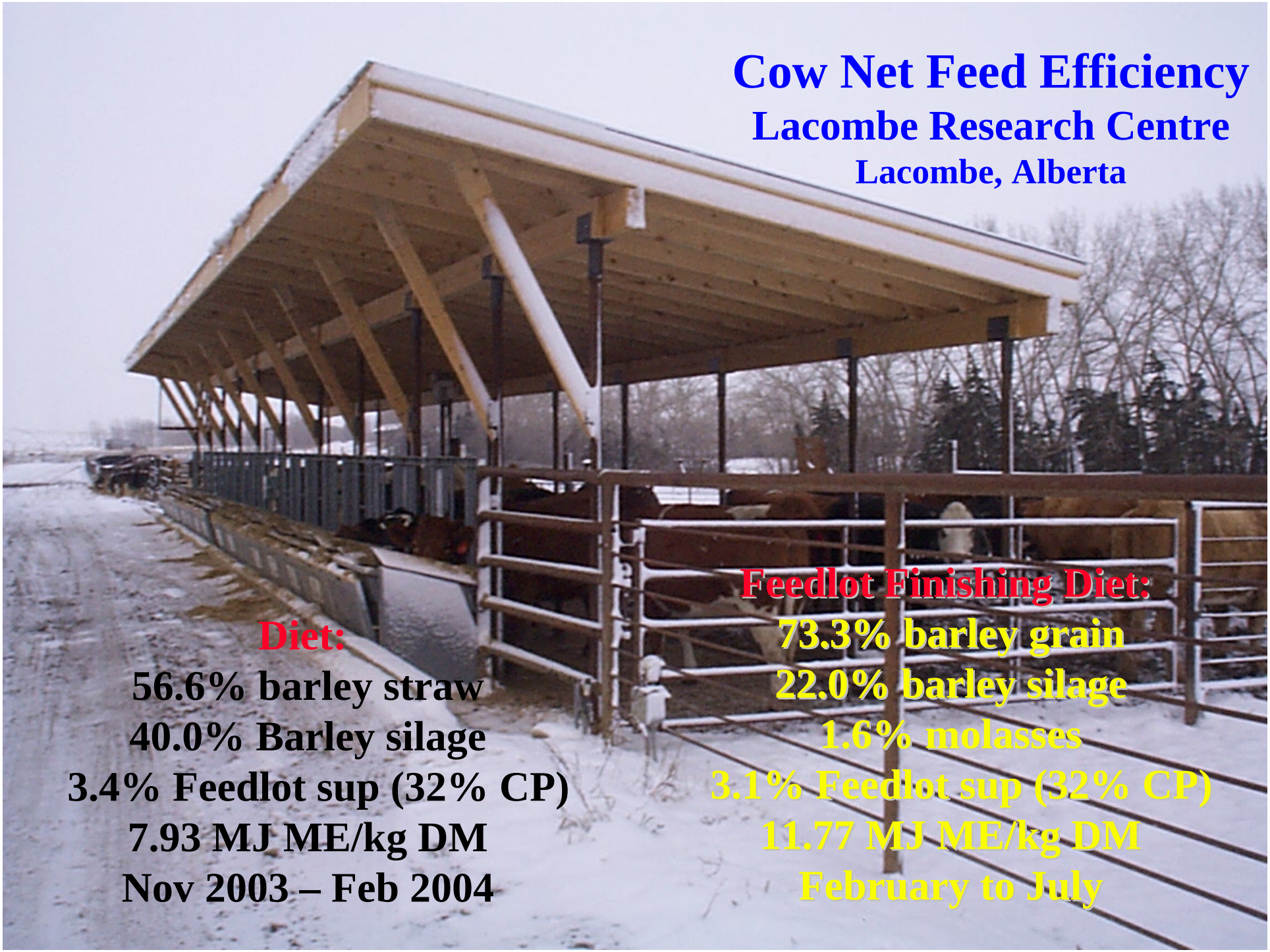
No relationships to the distribution of the nine wholesale cuts.

No difference in the composition of the wholesale cuts, except <u>less body cavity fat in butt & loin</u> for low NFE steers.

Relationship between net feed efficiency and carcass grade fat thickness and marbling score in 134 finished heifers and steers







Cow Net Feed Efficiency

Lacombe Research Centre

Lacombe, Alberta

Diet:

56.6% barley straw
40.0% Barley silage
3.4% Feedlot sup (32% CP)
7.93 MJ ME/kg DM
Nov 2003 – Feb 2004

Feedlot Finishing Diet:

73.3% barley grain
22.0% barley silage
1.6% molasses
3.1% Feedlot sup (32% CP)
11.77 MJ ME/kg DM
February to July

Feed intake, body weight, average daily gain and body condition score of HIGH AND LOW NFE cows

Trait	COW NFE Group			
	HIGH NFE	LOW NFE	SE	Sign. level
Number of cows	17	20		
NFE, kg as fed/day	2.68	-1.50	0.49	<0.001
Feed Intake, kg DM/day	16.5	13.1	0.4	<0.001
Body weight, kg	748	746	14	NS
ADG, kg/day	0.06	-0.05	0.05	NS
Body Condition score	3.6	3.6	0.1	NS
Age, years	5.4	5.8	0.4	NS

Effect of cow NFE on their progeny's performance

Trait	COW NFE Group			
	HIGH NFE	LOW NFE	SE	Sign. level
Number of progeny	17	20		
Progeny NFE, kg as fed/day	1.28	0.24	0.30	<0.05
Progeny feed Intake, kg DM/day	9.1	8.3	0.3	<0.05
Progeny weight, kg	545	523	17	NS
Progeny ADG, kg/day	1.28	1.32	0.05	NS
Progeny backfat, mm	7.7	6.8	0.5	NS

Progeny test: Diet = 22% barley silage, 73.3% steam rolled barley; 1.6% molasses & 3.1% Beef supplement (32% CP), 11.97 MJ ME/kg DM; Test Period = 72 days.

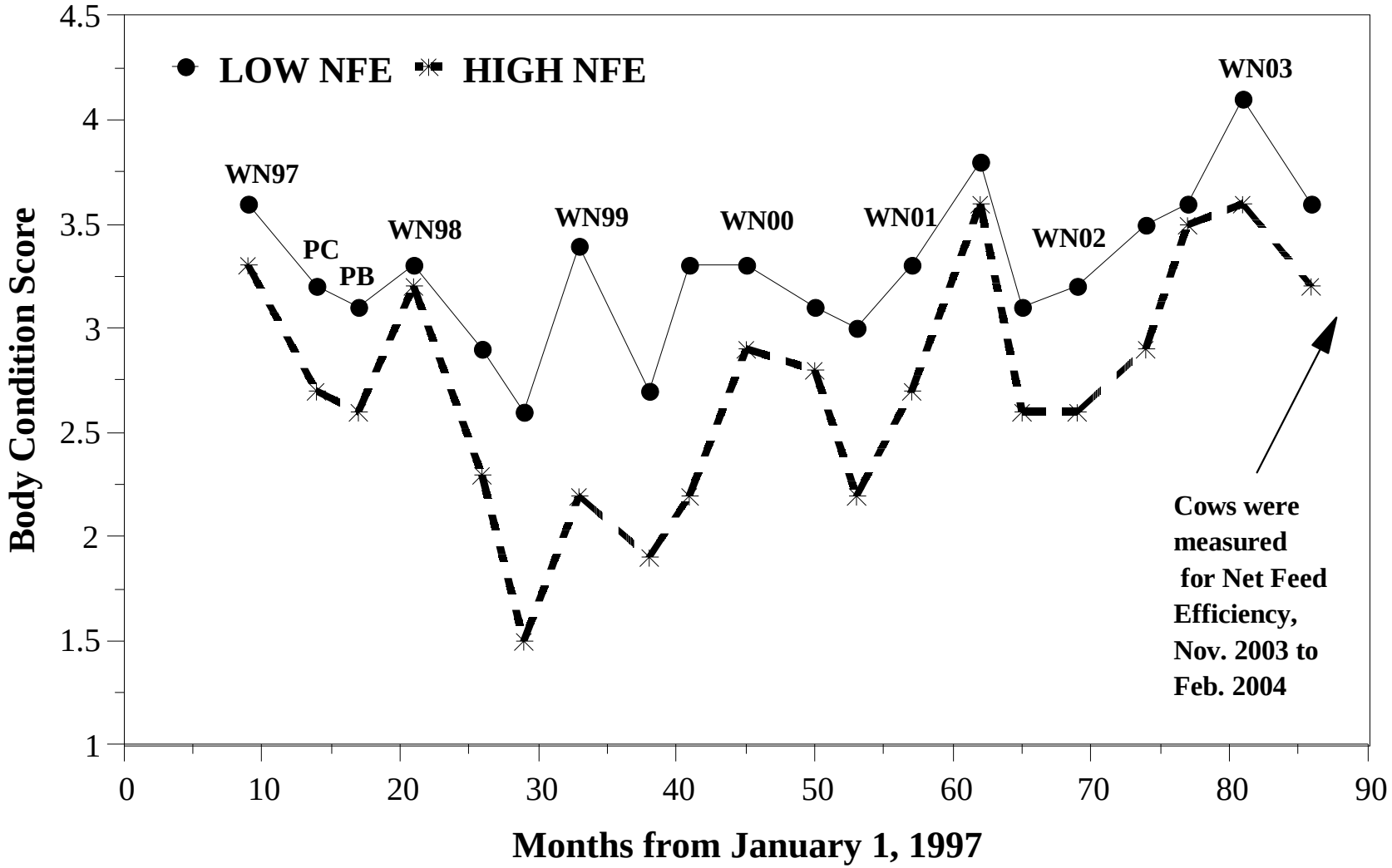
Effect of cow NFE on their progeny's carcass traits

Trait	Cow NFE Group			Sign. level
	HIGH NFE	LOW NFE	SE	
Number of progeny	17	20		
Carcass cutability, %	60.0	59.9	0.6	NS
Carcass grade fat, mm	11.4	10.0	0.9	NS
Yield grade	1.3	1.4	0.2	NS
Quality grade, A%	26.7	29.4		NS
AA%	60.0	52.9		NS
AAA%	6.7	11.8		NS
B4 %	6.6	5.9		NS

High Feed Efficiency cow J1042 (5 yr-old Hereford-Angus cow in the spring of 2004; NFE = -4.10 kg as fed/day; 2003 weight at weaning =787 kg).

Low Feed Efficiency cow J1016 (5 yr-old Hereford-Angus cow in the spring of 2004; NFE = +0.81 kg as fed/day; 2003 weight at weaning = 758 kg).

Body condition score in High and Low NFE cows at weaning (WN), pre-calving (PC) and pre-breeding from 1997 to 2003



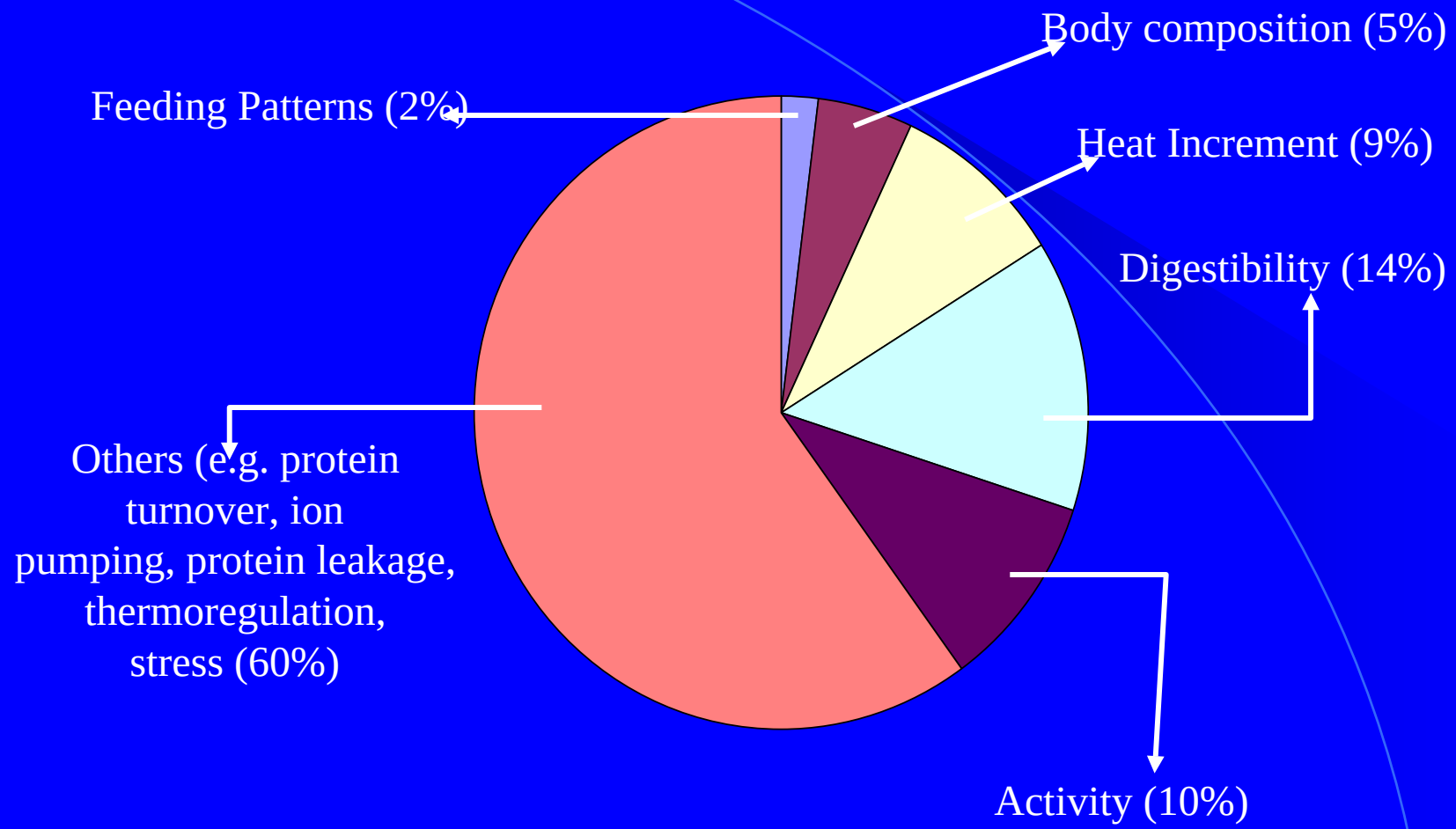
Key points:

- Large variation exists within breeds or biological types
- NFE is independent of body size and growth.
- NFE is moderately heritable & may reflect energy required for maintenance
- The advantage of NFE over FCR is that NFE allows breeders to place different emphasis on growth, size and feed efficiency

Key points:

- **reduce feed intake by 10-12%** *(steers, repl. Heifers, cows).*
- **improve FCR by 9-15%**
- **decrease body fat by 5%** *(mesentery, IM & body cavity; SQ & marbling??)*
- **Lower methane emissions by 9-12% & manure, N, P, K production by 15-17%**

Proposed contribution of different biological mechanisms to variation in NFE



Richardson and Herd, 2004
Herd et al., 2004

Conclusion

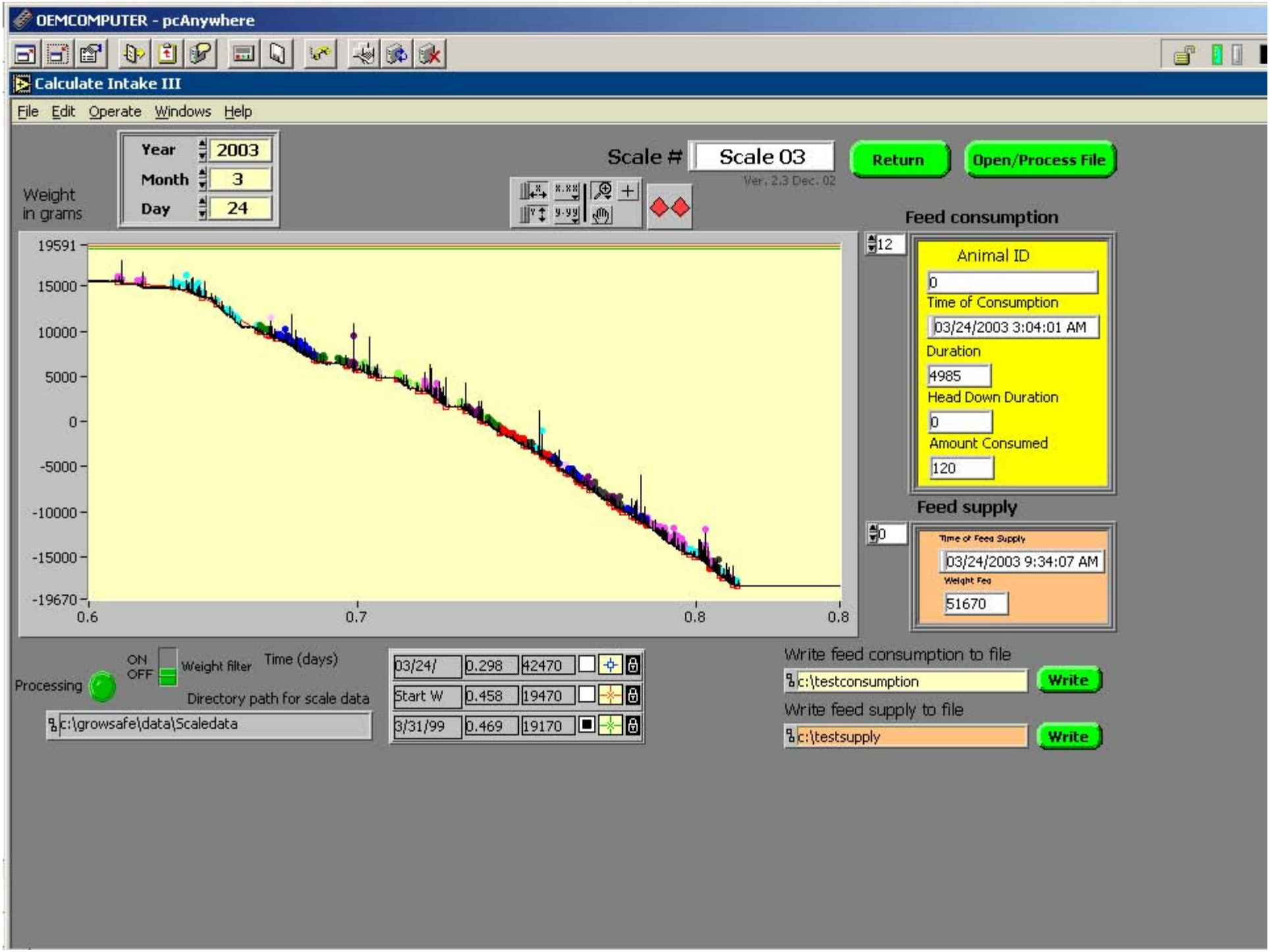
- **Only a small portion of the differences in NFE are due to differences in body composition. A larger portion was due to**

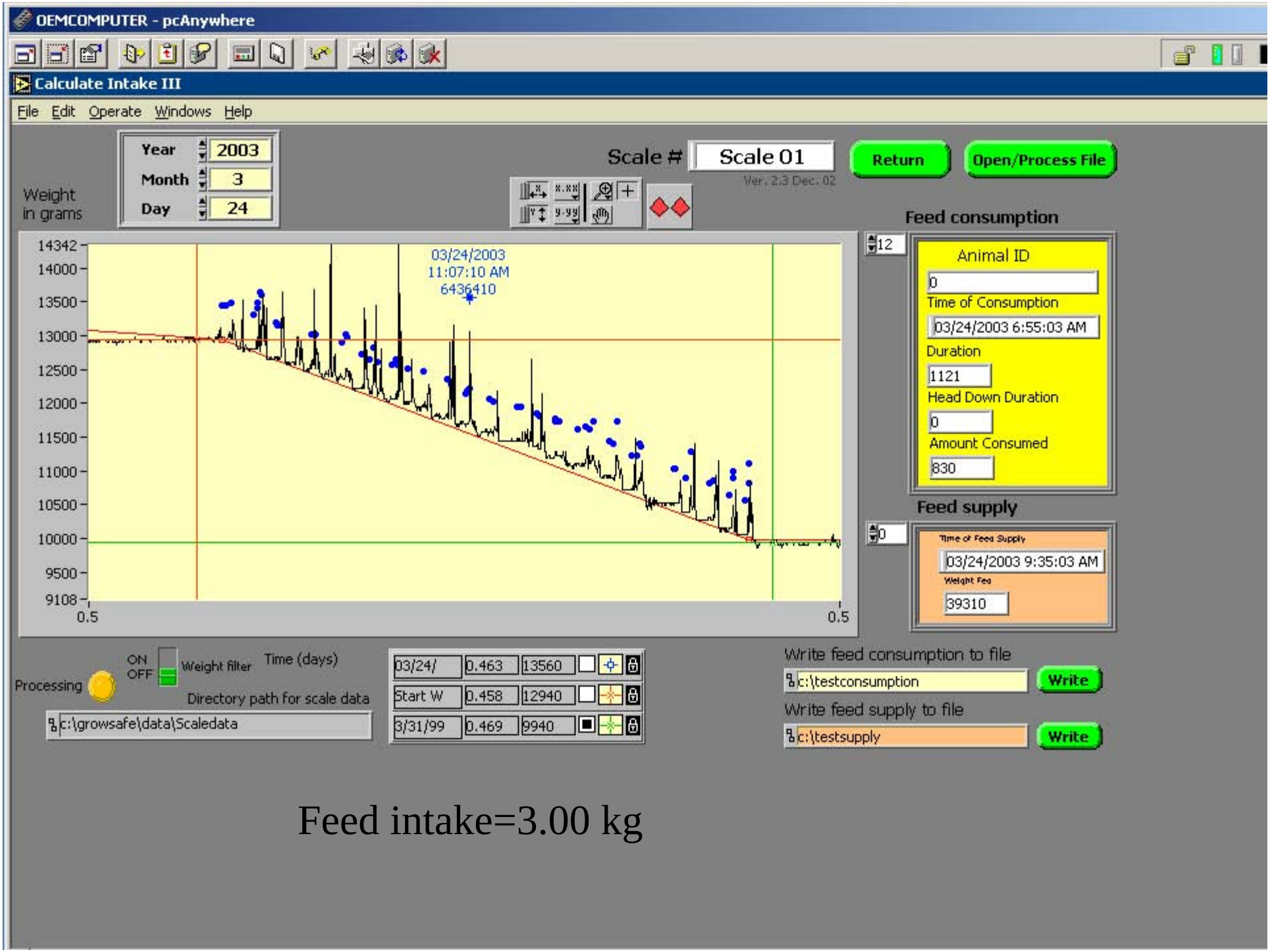
  i) differences in maintenance requirements & heat increment of feeding, and

  ii) inherit differences in metabolic processes associated with protein turnover & ion transport

Net Feed Efficiency Testing

Can. Operators:	Lacombe, Lethbridge, Kinsella, Olds College, Cattleland Feedyards
Cost:	Feed, yardage, wood chips, weighing, ultrasound, adm. plus $1/hd/day for NFE
Age criteria:	contemporary group, age range=60 days
Test length:	28 day adjustment period; 84-112 day test period, weigh every 14 days, UBF, UMAR, UREA, hip height & BCS every 28 days
Diet:	Fed ad libitum a diet containing 2.39-2.87 Mcal ME/kg DM Example: 55% barley silage; 39% rolled barley, 6% beef supplement (DM basis); ME=2.65 Mcal/kg DM; 14.2% CP
Info:	ADG, HH, UBF, UMAR, UREA, NFE Report monthly to seedstock producers/breed associations Internet site
Standards:	Animal Behaviour & Feed Efficiency Network (AAFRD,
Reliability:	AAFC, Univ. of Alberta, Univ. of Calgary, Olds College)

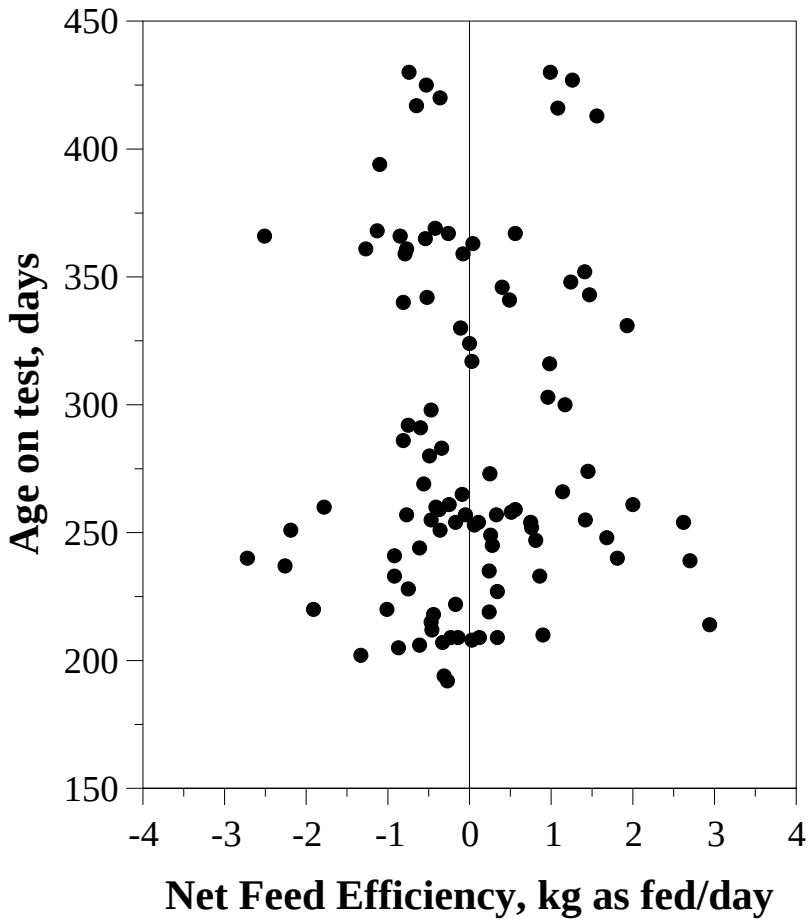

OEMCOMPUTER - pcAnywhere
Calculate Intake III
File Edit Operate Windows Help
Year 2003
Month 3
Day 24
Weight in grams
Scale # Scale 03
Ver. 2.3 Dec. 02
Return
Open/Process File
19591
15000
10000
5000
0
-5000
-10000
-15000
-19670
0.6
0.7
0.8
0.8
Feed consumption
12
Animal ID
0
Time of Consumption
03/24/2003 3:04:01 AM
Duration
4985
Head Down Duration
0
Amount Consumed
120
Feed supply
0
Time of Feed Supply
03/24/2003 9:34:07 AM
Weight Fed
51670
Processing
ON
OFF
Weight filter
Time (days)
Directory path for scale data
c:\growsafe\data\Scaledata
03/24/ 0.298 42470
Start W 0.458 19470
3/31/99 0.469 19170
Write feed consumption to file
c:\testconsumption
Write
Write feed supply to file
c:\testsupply
Write



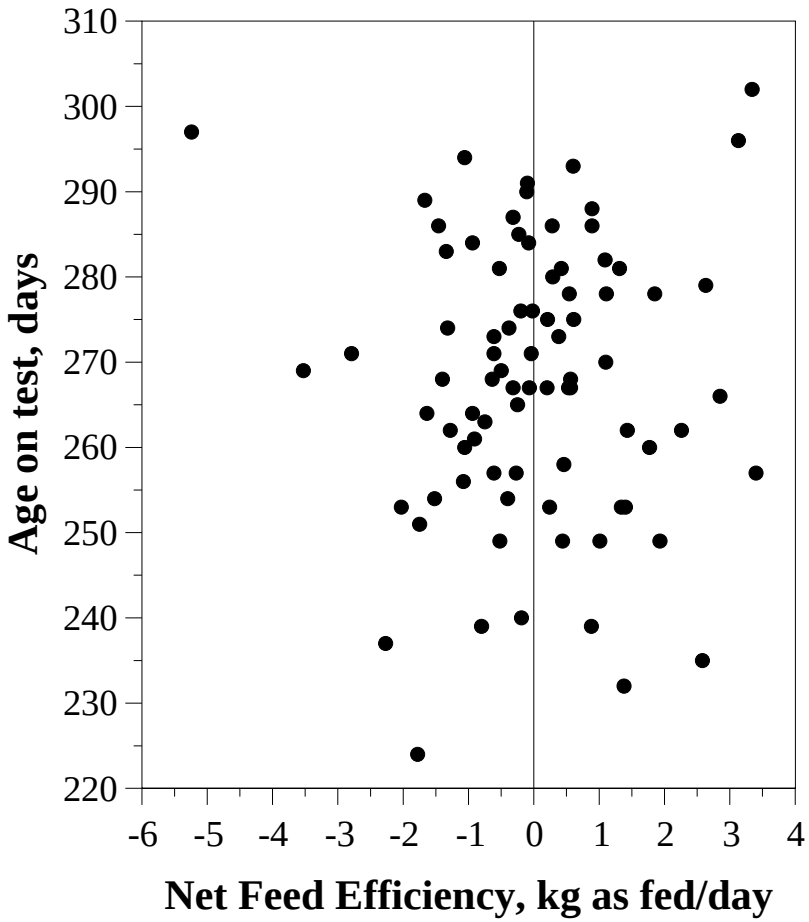
Feed intake=3.00 kg

Olds College NFE Bull Test - 2002-03 & 2003-04
Relationship between NFE and age on test

British Bulls, n=101, R_2 = 0.001

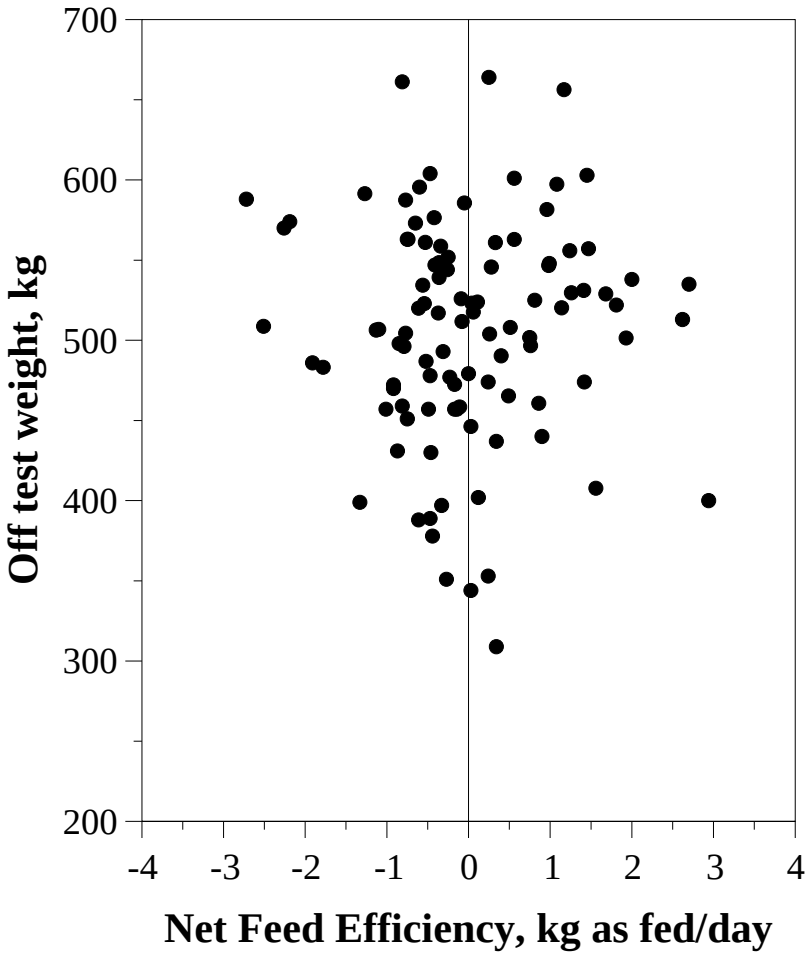


Continential Bulls, n=82, R_2 = 0.000

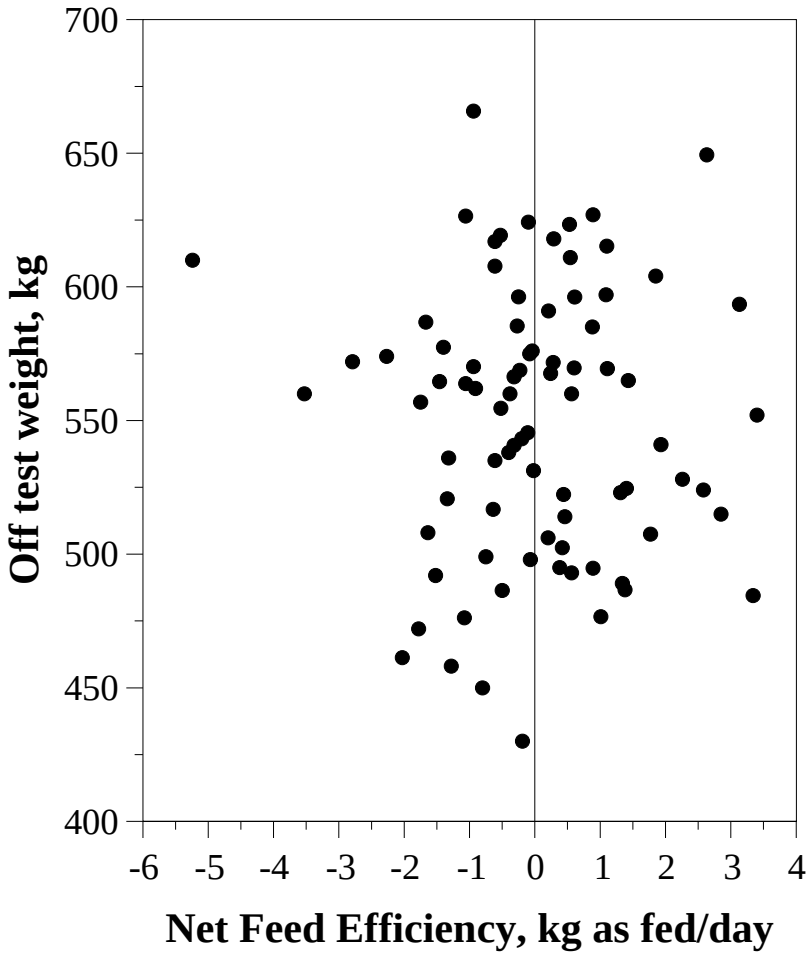


Olds College NFE Bull Test - 2002-03 & 2003-04
Relationship between NFE and off-test weight

British Bulls, n=101, R_2 = 0.000

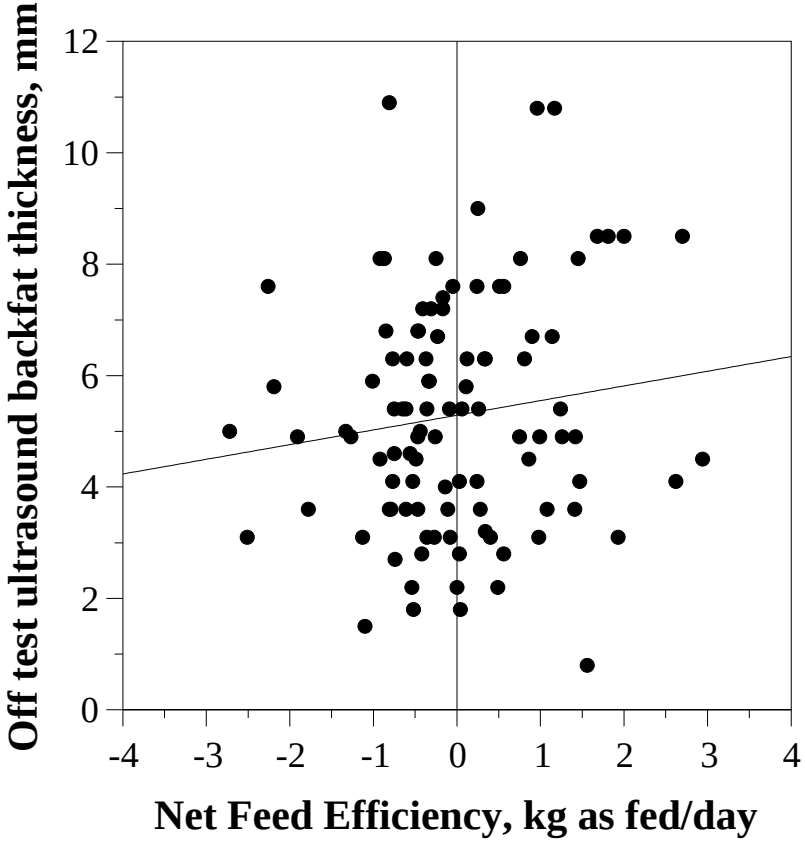


Continential Bulls, n=82, R_2 = 0.001



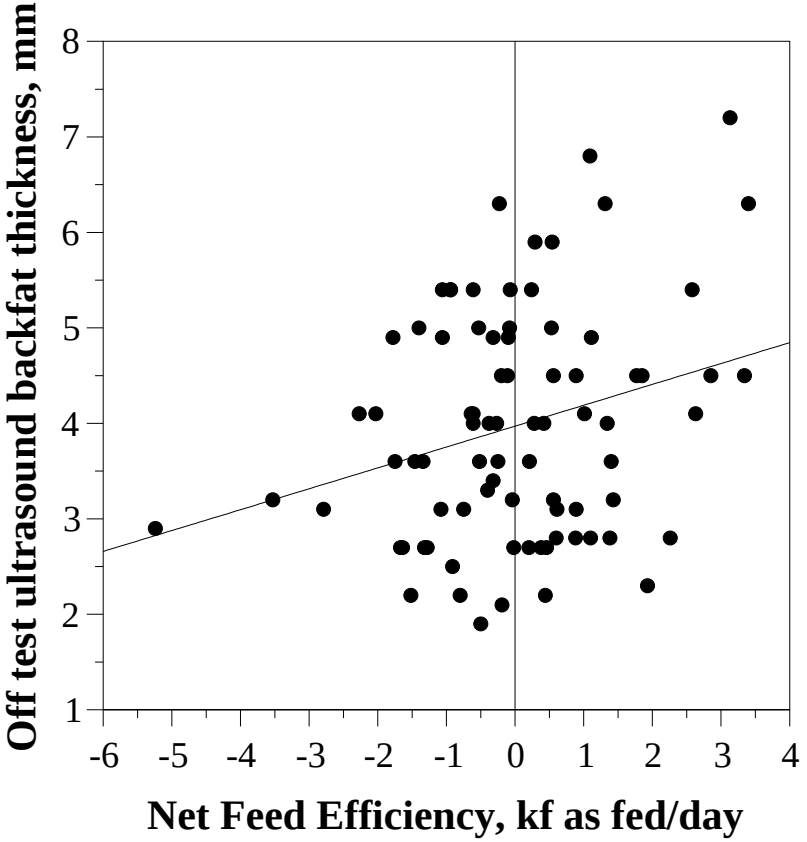
Olds College NFE Bull Test - 2002-03 & 2003-04
Relationship between NFE and off-test backfat thickness

British Bulls, n=101



R-square = 0.0176 # pts = 101
y = 5.29 + 0.263x

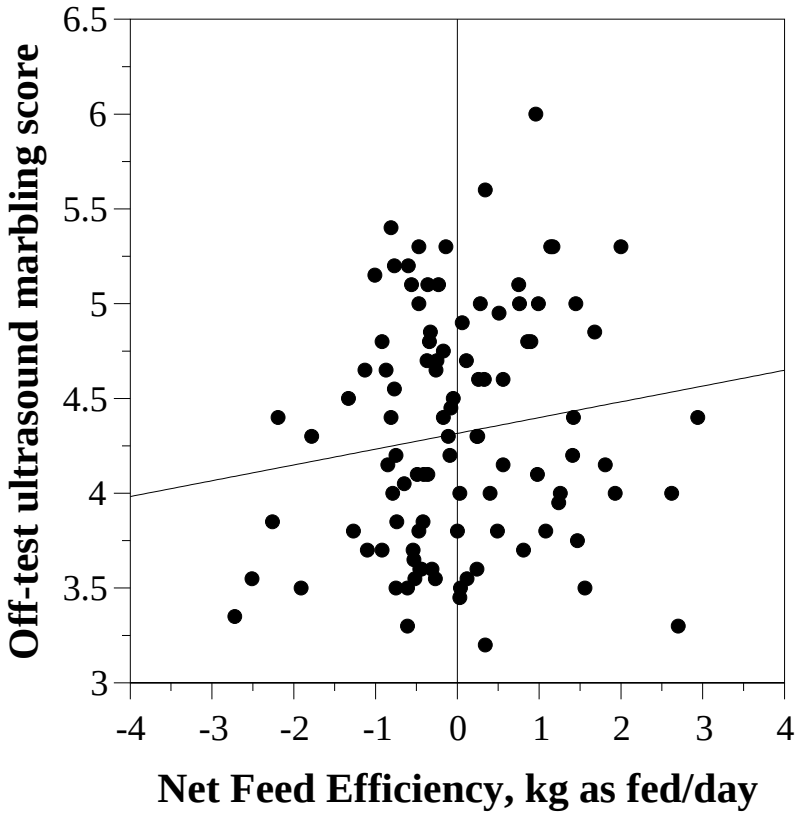
Continential Bulls, n=82



R-square = 0.0726 # pts = 82
y = 3.97 + 0.219x

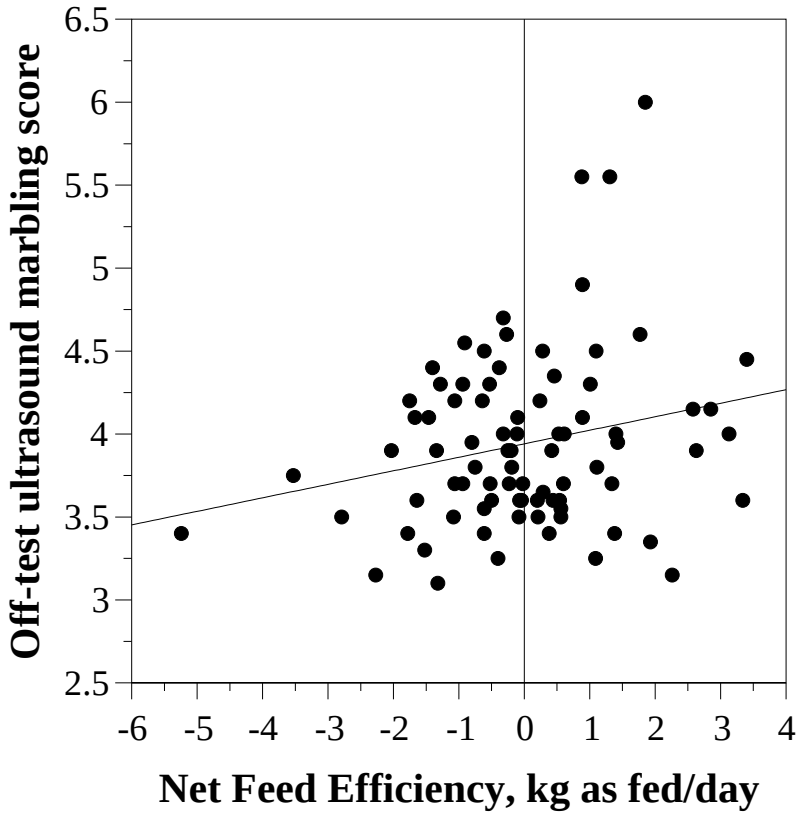
Olds College NFE Bull Test - 2002-03 & 2003-04
Relationship between NFE and off-test marbling score

British Bulls, n=101



R-square = 0.02 # pts = 101
y = 4.32 + 0.0832x

Continential Bulls, n=82



R-square = 0.0521 # pts = 82
y = 3.94 + 0.0814x

Relationship of energy gain (EG) and metabolizable energy intake (MEI)