Insulin-like growth factor I (IGF-I) as an indicator trait for genetic evaluation of feed efficiency

Genetic Selections Committee

Beef Improvement Federation Meeting
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TAMU, Idaho, TAMU, Ohio State, Cornell and Kentucky

Residual Feed Intake--Background

- ✓ **RFI is a feed efficiency trait that quantifies variation in intake beyond requirements needed to support maintenance and growth**
- ✓ **RFI is genetically independent of growth rate and mature BW**
- ✓ **RFI is moderately heritable ($h^2 \approx 0.30$ to 0.40)**
- ✓ **Genetic improvement in RFI would be of economic value to both the breeding and finishing sectors of the industry**

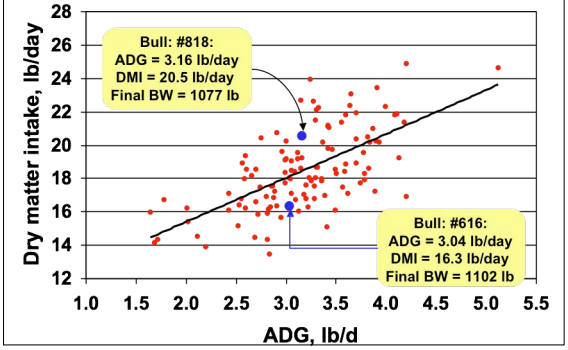
How is RFI measured?

- ✓ **RFI is measured as the difference between an animal's actual feed intake and the amount of feed an animal is expected to eat based on its size and growth rate**

  Expected intake = $\beta_0 + \beta_1$(mid-test BW$^{.75}$) + β_2(ADG) + residual

- ✓ **Calves that eat less than expected for their weight and ADG will have negative RFI**
- ✓ **Calves that eat more than expected for their weight and ADG will have positive RFI**

Results from test conducted at the Beef Development Center in Navasota, Texas



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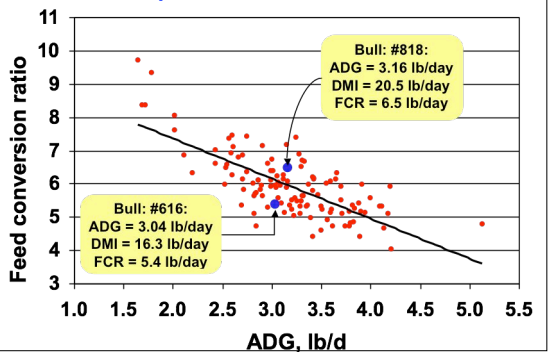

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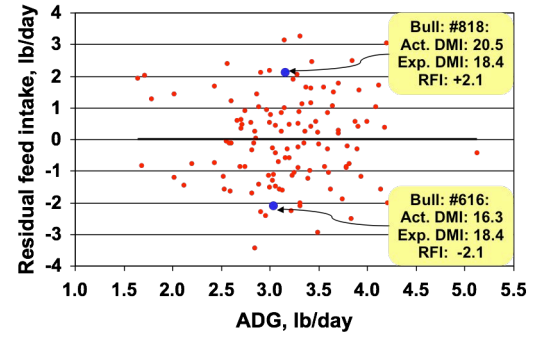
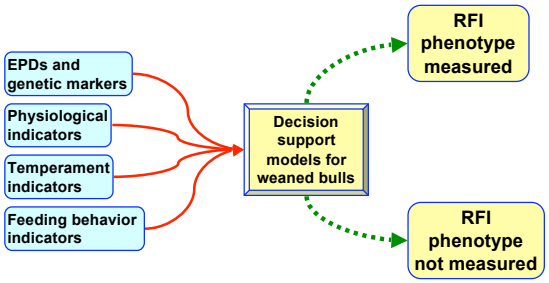


Challenges to implementation of RFI technologies

- ✓ **Measuring feed intake in cattle is expensive**
- ✓ **Challenges to measuring feed intake in central bull tests:**
  - ***limited number of test stations equipped with individual intake measurement instrumentation***
  - ***health concerns of commingling calves***
- ✓ **Genetic or physiological biomarkers of RFI will facilitate early identification and(or) more accurate selection of calves with superior genetic merit for RFI**

Use of genetic or physiological biomarkers to predict RFI genetic potential

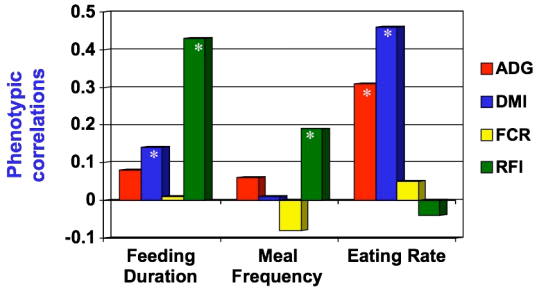


RFI is linked to biological traits associated with efficiency of feed utilization

Trait	RFI	FCR	Reference
Heat production (calorimetry)	**0.68**	**0.37**	Nkrumah et al. 05
Heat production (slaughter balance)	**0.56**	NR	Basarab et al. 03
Methane	**0.44**	NS	Nkrumah et al. 05
DM digestibility	**-0.43**	-0.11	Krueger et al. 06
Feeding duration	**0.43**	0.01	Lancaster et al. 05
Meal frequency	**0.19**	0.08	

Correlations in bold are significantly different from zero; P < .05

Feeding behavior measurements as indicator traits for RFI in growing bulls†



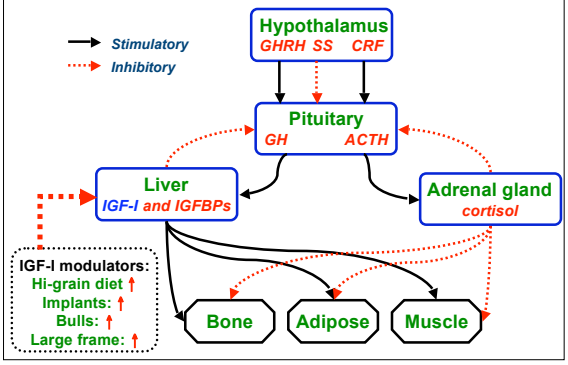
*†Data from 240 Angus & Brangus bulls; *Correlation differed from zero, P < 0.05.*

Overview of IGF-I

Insulin-like Growth Factor-I (IGF-I):

- **Naturally occurring protein synthesized by most tissues in the body (Liver primary source of IGF-I)**
- **Referred to as an anabolic hormone**
- **Biological actions of IGF-I:**
  - ✓ **Increases amino acid transport and protein synthesis in muscle tissue**
  - ✓ **Promotes glucose uptake and utilization in adipose tissue**
  - ✓ **Promotes mineralization of bone tissue**
- **IGF-I is a major regulatory link between nutrient intake and utilization and tissue growth responses**

Overview of growth hormone (GH) insulin-like growth factor I (IGF-I) axis regulation of growth



Australian RFI research

- ✓ In 2002, Animal Genetics and Breeding Unit introduced EBVs for RFI based on phenotype measurements (BREEDPLAN)
- ✓ Currently, the Angus and Hereford breeds have sufficient well-linked data to report EBVs for RFI
- ✓ In 2004, introduced use of plasma IGF-I as an indicator trait for RFI in computing EBVs for RFI
- ✓ Primegro Ltd. currently markets IGF-I test for beef cattle

Overview of IGF-I as a physiological indicator trait

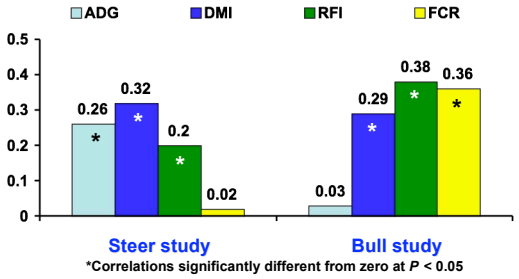
Insulin-like growth factor-I (IGF-I):

- IGF-I is moderately heritable in beef cattle (0.25 to 0.35; Davis et al., 2003; Johnston et al., 2005)
- IGF-I is genetically correlated with growth and carcass traits in beef cattle (Johnston et al., 2002; Davis et al., 2003; Moore et al., 2005)
- IGF-I is genetically correlated with reproductive traits (Yilmaz et al., 2004; Yilmaz et al., 2005)
- IGF-I is genetically correlated with feed efficiency in and beef cattle (Johnston et al., 2002; Moore et al., 2005)

IGF-I as a physiological indicator trait for RFI

Study	Breed	Age @ start of RFI test	Genetic correlations: IGF-I and RFI	Genetic correlations: IGF-I and ADG
Johnston et al. (2002)	Multiple breeds†	19	0.56	ADG -0.20
	Angus	9	0.39	ADG -0.23
Moore et al. (2005)	Angus	11	0.41	200-d BW -0.17

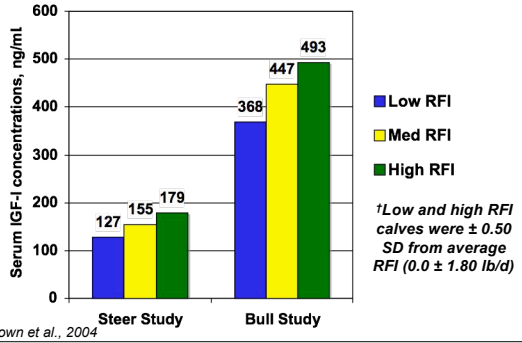
Phenotypic correlations between serum IGF-I concentrations and performance traits



*Correlations significantly different from zero at $P < 0.05$

Brown et al., 2004

Effect of RFI classification† on serum IGF-I concentrations



†*Low and high RFI calves were ± 0.50 SD from average RFI (0.0 ± 1.80 lb/d)*

Brown et al., 2004

Ohio State IGF-I selection study (Davis et al.)

- ✓ Study initiated in 1989
- ✓ Fall and spring calving herds
- ✓ 50 LOW IGF-I and 50 HIGH IGF-I cows maintained in each herd
- ✓ Blood samples collected from progeny (days 28, 42 and 56 postweaning) and assayed for serum IGF-I
- ✓ Four bulls with highest and lowest IGF-I used for breeding
- ✓ Heifers with highest and lowest IGF-I used for replacements
- ✓ Currently about six generations of selection

Ohio State IGF-I selection study (Davis et al.)

Trait	genetic correlation
• Weaning BW	0.11
• Off-test BW	0.28
• ADG	0.29
• Backfat thickness	-0.28
• REA	0.17
• Quality grade	-0.57
• Yield grade	-0.28

Davis and Simmen, 2000, 2006

Effects of IGF-I selection line on growth efficiency in Angus bulls and heifers: Study I--High roughage diet

	Heifers		Bulls			Selection
High-roughage diet study	High IGF-I	Low IGF-I	High IGF-I	Low IGF-I	SE	line P-value
No. calves	13	9	8	9	--	--
Initial IGF-I, ng/mL	185[a]	151[b]	328[a]	242[b]	13	0.01
Initial BW, lb	621	643	790	823	13	0.15
ADG, lb/d	2.0	2.2	2.8	3.0	0.1	0.21
DMI, lb/d	24.4	24.8	26.2	26.1	0.8	0.87
FCR, feed/gain	12.0	11.6	9.4	8.8	0.3	0.24
RFI, lb/d	0.33[x]	-0.48[y]	0.73[x]	-0.66[y]	0.5	0.09

[a,b]Means within gender differ P < .01

[x,y]Means within gender differ P < .10

Lancaster et al., 2007

Effects of IGF-I selection line on growth efficiency in Angus bulls and heifers: Study II--High grain diet

	Heifers		Bulls			Selection
High-grain diet study	High IGF-I	Low IGF-I	High IGF-I	Low IGF-I	SE	line P-value
No. calves	20	9	12	15	--	--
Initial IGF-I, ng/mL	159[a]	117[b]	251[a]	234[b]	13	0.01
Initial BW, lb	570	548	657	653	18	0.49
ADG, lb/d	2.8	2.9	4.0	3.8	0.1	0.70
DMI, lb/d	20.3	20.4	23.2	21.8	0.5	0.35
FCR, feed/gain	7.2	7.0	5.8	5.8	0.2	0.50
RFI, lb/d	-0.13	0.26	0.46	-0.37	0.24	0.61

[a,b]Means within gender differ P < .01

Lancaster et al., 2007

Effects of IGF-I selection line on ultrasound composition in Angus bulls and heifers

Item	High IGF-I line	Low IGF-I line	SE	P-value
Study I--high rouage diet	21	18	--	--
12th rib fat thickness, in	0.37	0.33	0.04	0.17
REA, in^2	10.7	10.9	1.4	0.69
Intramuscular fat, %	4.39	4.37	0.13	0.67
Study II--high grain diet	32	24	--	--
12th rib fat thickness, in	0.30	0.24	0.04	0.02
REA, in^2	10.1	10.5	1.5	0.58
Intramuscular fat, %	3.75	3.36	0.14	0.51

Lancaster et al., 2007

Camp Cooley Brangus heifer project

- ✓ RFI measured in 348 Brangus heifers over three years
- ✓ Initial BW = 600 lb
- ✓ Initial age = 7.5 months
- ✓ Roughage-based diet
- ✓ Feed intake measured for 70 days

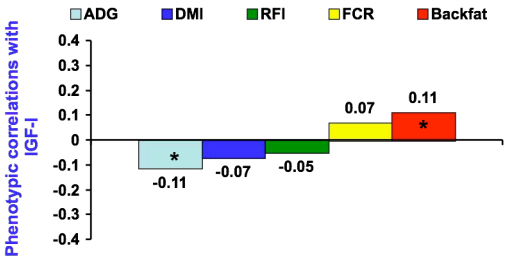
Lancaster et al., 2007

Performance and efficiency traits of Brangus heifers with low and high RFI[a]

Trait	Low RFI	High RFI	SE	P-value
No. of heifers	112	98	----	----
RFI, lb/day	-1.72	1.91	0.04	.001
Weaning BW, lb	531	519	1.3	.24
Initial BW, lb	612	609	1.5	.82
ADG, lb/day	2.13	2.16	0.02	.52
DMI, lb/day	18.6	22.4	0.10	.001
FCR, feed/gain	8.92	10.63	0.16	.001

[a]Heifers with low and high RFI were <0.5 and >0.5 SD from the mean RFI.

Phenotypic correlations between weaning IGF-I concentrations and performance and efficiency traits in Brangus heifers: Three year summary



Lancaster et al., 2007 ***Correlations significantly different from zero at $P < 0.05$**

IGF-I as a physiological indicator trait for RFI

Study	Breed	Time of IGF-I sample	Genetic correlations (IGF-I & RFI)
Wolcott et al. (2006); Calves were first backgrounded. During RFI test fed finishing diet and implanted	Brahman	Postweaning IGF-I	-0.12
		start of test IGF-I	0.03
	Tropical composites	Postweaning IGF-I	-0.80
		start of test IGF-I	-0.51

IGF-I as a physiological indicator trait for RFI

- **IGF-I may have utility as an indicator trait when:**
  - ✓ ***Bos taurus* calves**
  - ✓ **IGF-I measured prior to or at weaning**
  - ✓ **RFI measured in postweaned calves**
- **Inconsistent results when:**
  - ✓ **Calves with *Bos indicus* breeding**
  - ✓ **RFI measured in yearling calves**
  - ✓ **RFI measured while fed a finishing ration**
  - ✓ **Growth implants are used**

National Beef Cattle Evaluation Consortium Recommendations:

- ✓ **Recommend that serum IGF-I not be used as an indicator trait for RFI at this time**
- ✓ **Recommend further research is warranted to fully examine possible genetic antagonisms between IGF-I and other ERT (e.g., reproduction, marbling)**
- ✓ **Recommend that more research be conducted to further evaluate phenotypic and genetic relationships between IGF-I and RFI:**
  - Bos indicus vs bos taurus
  - Growing vs finishing RFI
  - Type of ration fed during RFI measurements
  - IGF-I binding proteins