Recent advances in nutrition for optimizing performance of growing swine

Denise Beaulieu, John Patience and Pascal Leterme

Prairie Swine Centre, Inc. Saskatoon, SK

XXXI Reunión Científica Anual de la

Asociación Peruana de Producción Animal

APPA 2008

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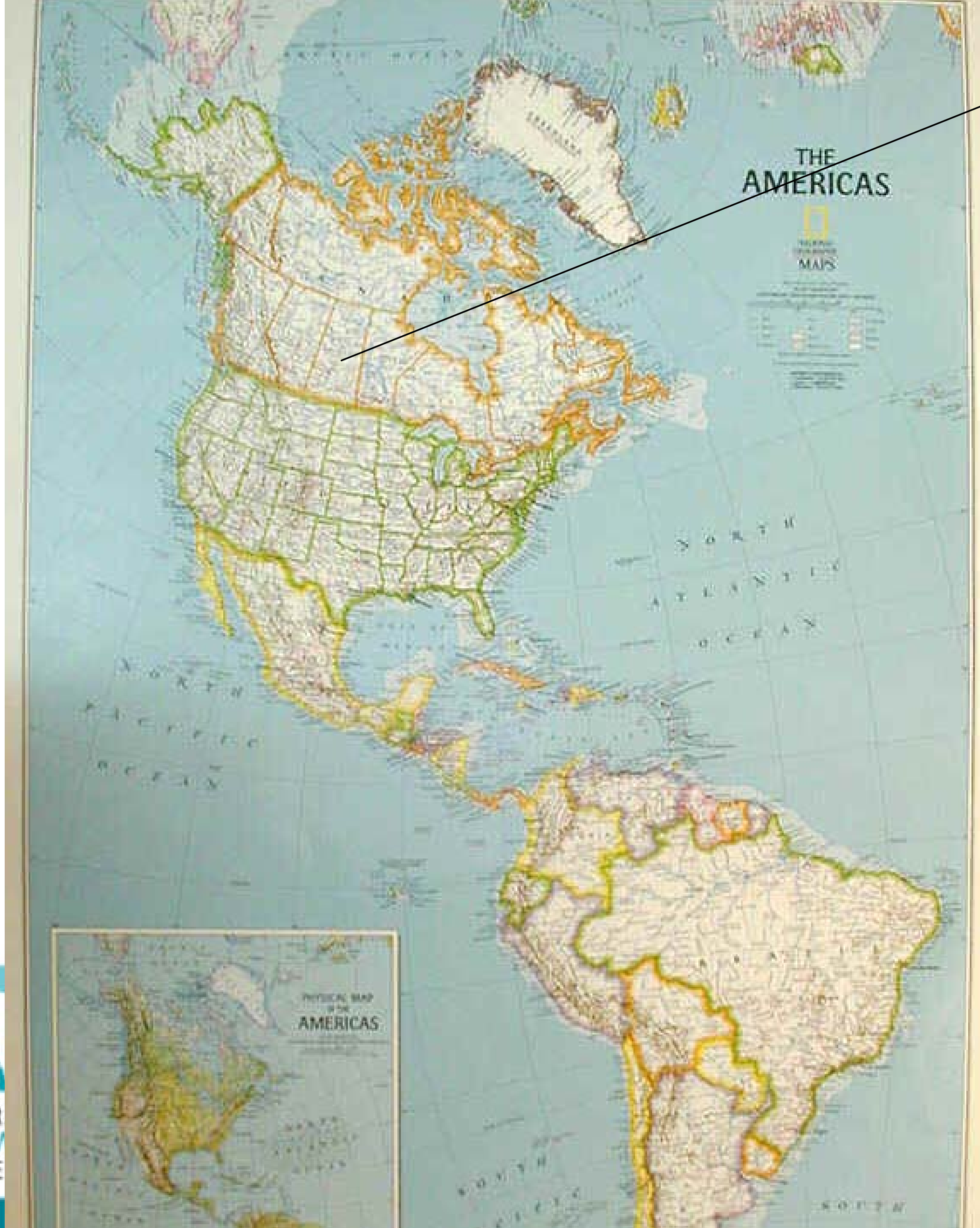
Objective

Discuss the recent advances in growing pig nutrition with a focus on research which impacts financial profitability of commercial swine operations

Outline

- Introduction
- Energy concentration in the diet
- Energy systems
- Alternate ingredients
- Variability of energy content in ingredients



Saskatoon, Saskatchewan

Saskatchewan

- 651,000 km^2

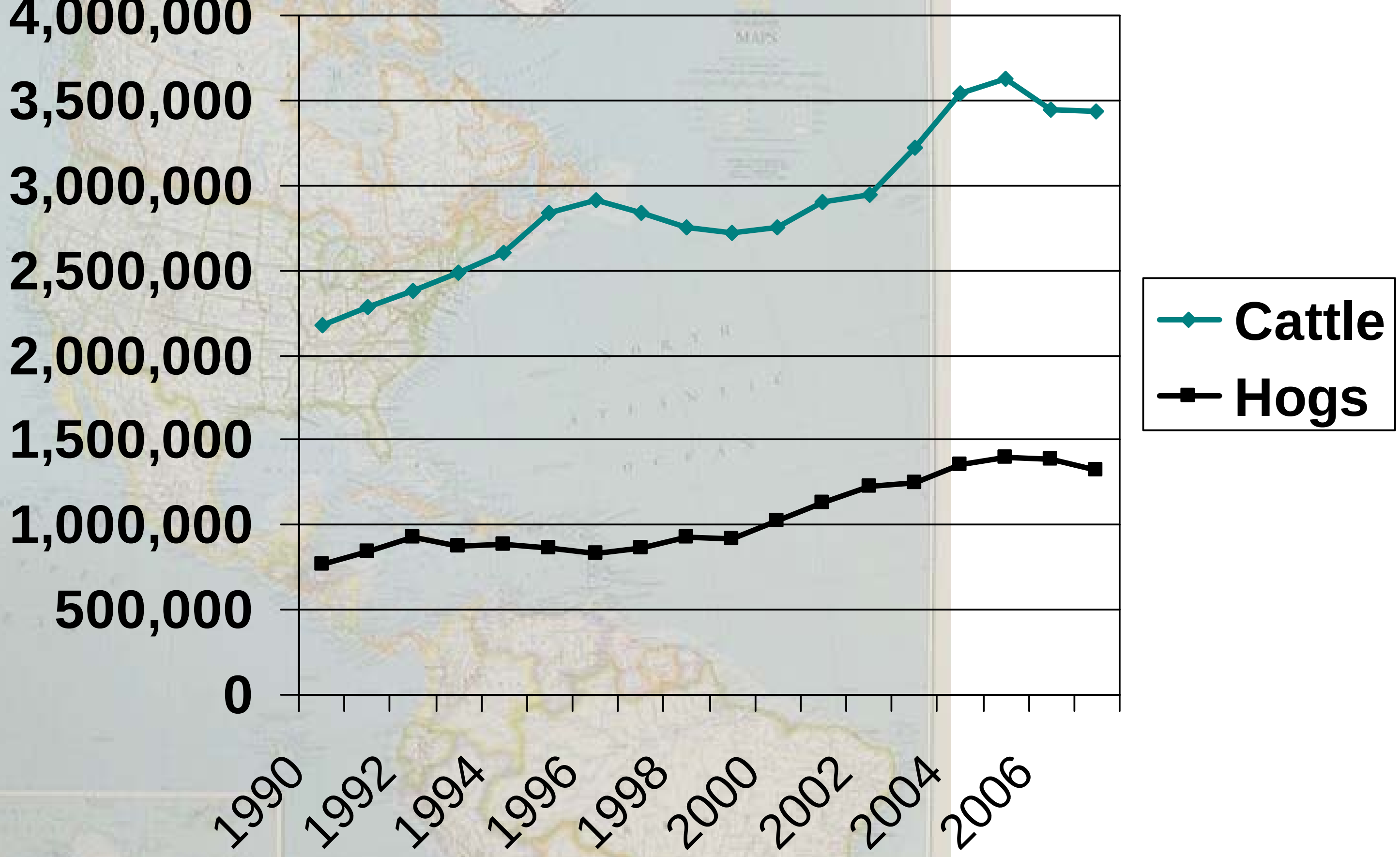
(Peru = 1,285,220 km^2)

- water = 9 %
- 1,000,000 residents

Climate

- extreme
- 30 – 45 cm precipitation

Livestock in Saskatchewan



Prairie Swine Centre, Inc.
Saskatoon, Saskatchewan

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WHO WE ARE

- Non-profit corporation, affiliated with the University of Saskatchewan, incorporated in 1991
- Operate 300 sow farrow-to-finish research herd (PSCI) and a 600 sow farrow-to-finish commercial research herd, off-site unit and feed mill (PSCE) (operations suspended, 2008)

- Research disciplines: nutrition, engineering and ethology

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Ingredients in common use in western Canada

- Wheat
- Barley
- Corn
- Wheat middlings
- Hulless barley
- Field peas
- Canola oil
- Tallow
- Fababeans
- Lentils
- Full fat canola seeds
- Distillers grain

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Recent advances in nutrition for optimizing performance of growing swine

But ……………………

How do we define performance???

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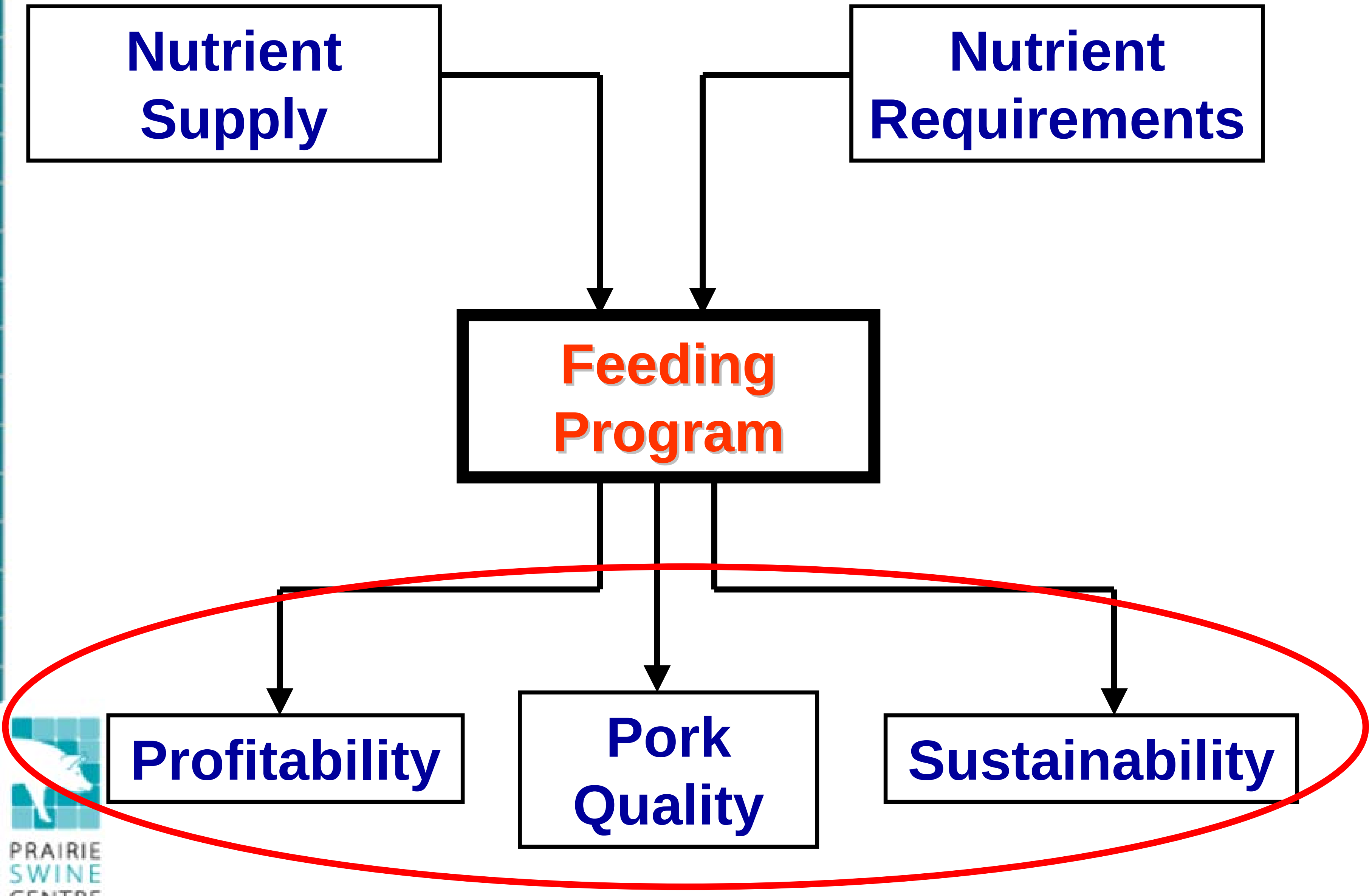
MAXIMIZING NET INCOME



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Feed is a major cost component

Supplies	2
Breeding	6
Maintenance	2
Feed	45-60
Personnel	10
Utilities	5
Office	6
Amortization	13
Interest	6
Taxes/insurance	2
Management fees	3
TOTAL	100 %

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Feed energy is a major cost component!!

Supplies	2
Breeding	6
Maintenance	2
Feed	45-60
Personnel	10
Utilities	5
Office	6
Amortization	13
Interest	6
Taxes/insurance	2
Management fees	3
TOTAL	100

Energy = 53% of feed

>>24% of the total cost of production can be attributed to meeting the energy specifications of feed

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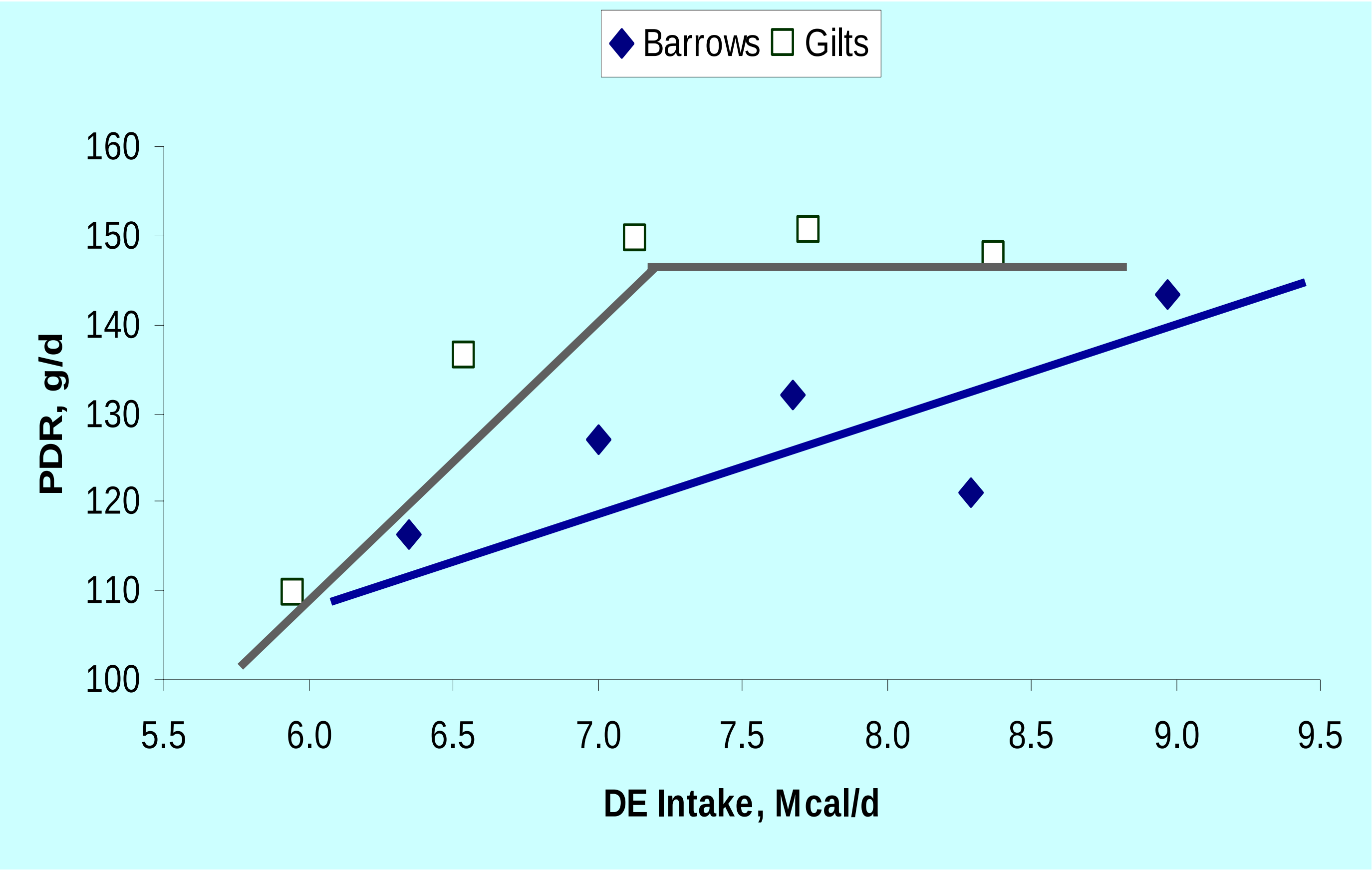
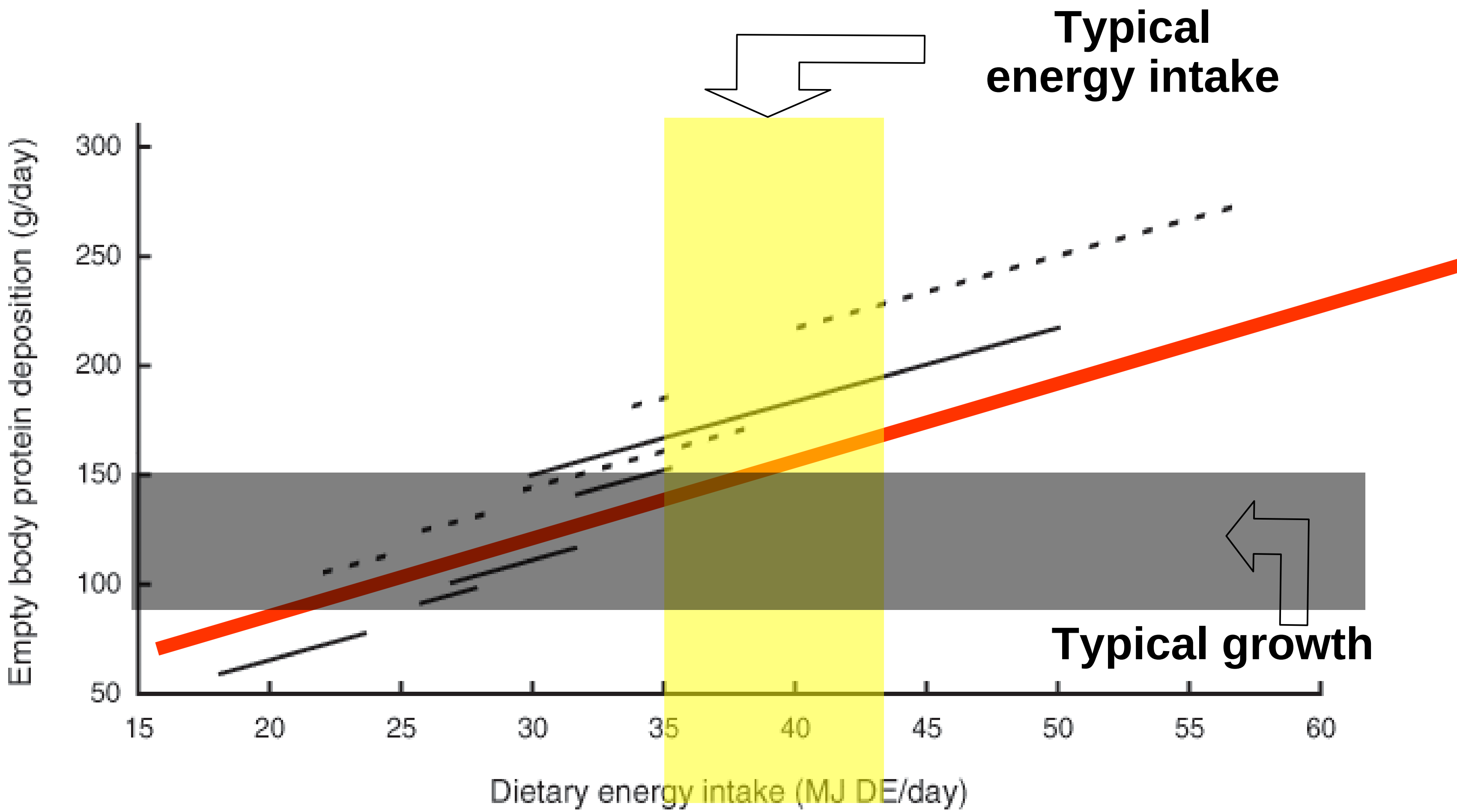
Energy affects pig performance



Pigs were fed from 25 to 120 kg bodyweight, at either ad libitum or at 93%, 86%, 79% or 72% of ad libitum. PDR is the mean throughout the study period.

Patience et al., 2002

Relationship between energy intake and protein deposition in gilts (solid) and boars (dotted)



Boars and gilts of a common genotype fed from 55 to 100% of ad libitum intake over the weight range of 80 to 120 kg LW. **King et al., 2004**

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Determining the appropriate energy concentration in the diet

Increasing energy concentration in grow-finish: Prairie Swine Centre Research Barn

DIET DE, Mcal/kg	3.09	3.24	3.34	3.42	3.57
Initial wt., kg	31.2	31.1	31.5	31.2	31.1
Final wt., kg	115.1	115.3	115.1	115.0	115.5
Daily gain, kg	1.00	1.01	1.03	1.03	1.03
Daily feed, kg	2.80	2.66	2.64	2.61	2.47
Feed:gain[1]	2.78	2.63	2.56	2.56	2.38
Gain: feed	0.36	0.38	0.39	0.39	0.42
Fat, mm	16.8	17.8	18.3	18.6	19.4
Loin, mm	61.7	60.6	62.7	60.3	61.1

[1]Feed efficiency was improved ($P < 0.05$) with increasing DE in the diet

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Beaulieu et al. 2006

Increasing energy concentration in grow-finish: St. Denis Stock Farm

DIET DE, Mcal/kg	3.12	3.30	3.43
NE, Mcal/kg	2.21	2.32	2.43
Initial wt., kg	37.4	36.6	36.5
Final wt., kg	118.6	118.0	119.0
Ave. daily gain, kg	0.99	0.98	1.00
Ave. daily feed, kg[1]	2.94	2.85	2.77
Feed:gain[1]	2.94	2.94	2.78
Gain:feed[1]	0.34	0.34	0.36
Tail-enders, n	48	45	37

[1]Feed efficiency was improved with increasing DE in the diet

Source: Patience et al., 2005

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Conclusion:
increasing energy concentration in the diet

Improved feed efficiency

but. . .

Regardless of whether conducted in a research or a commercial facility

…. or using prices for feed and pork from 2005 or 2008

… or modelling the facility as "all-in-all-out" or marketing when pigs reach 120 kg BW

- **Profitability was improved with the lowest dietary energy concentration**

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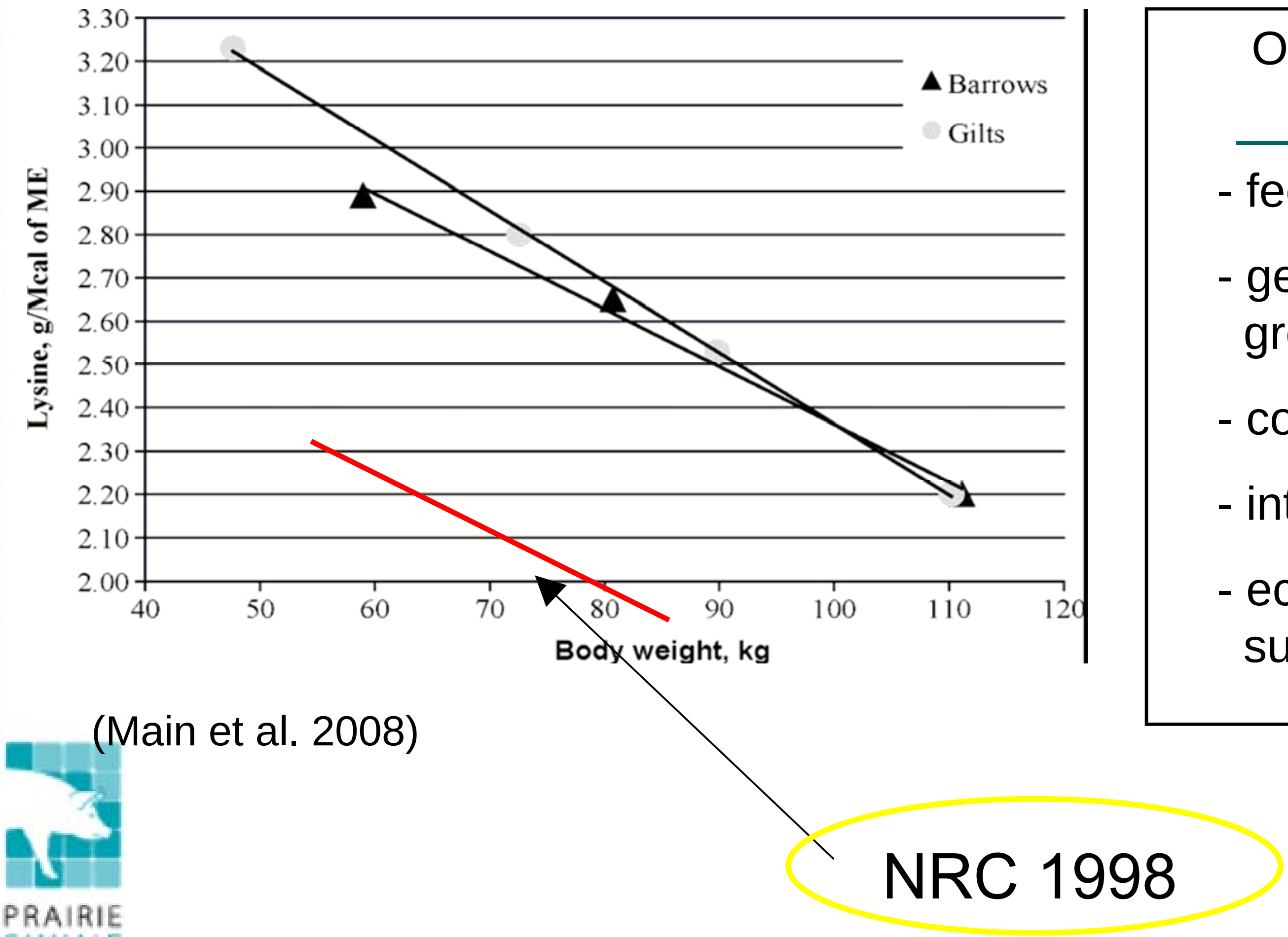
These economics, however, require constant re-evaluation

The requirement for lysine is typically expressed as a ratio to energy

Optimal total Lys:calorie ratios to maximize income over feed cost



(Main et al. 2008)

Optimal Lys:cal ratio is affected by:

- feed intake
- genetic potential for lean growth
- composition of growth
- interpretation of response
- economic indicator of success

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Need for energy systems

To define the quantity of energy supplied by an ingredient or a blend of ingredients (feed)

To formulate diets to achieve an animal performance target

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ROLE OF AN ENERGY SYSTEM

- **Define the energy content of ingredients**
  - Support ingredient pricing and trade
  - Facilitate diet formulation
- **Define the energy requirement of the pig**
  - Support feed pricing and trade
  - Facilitate diet formulation

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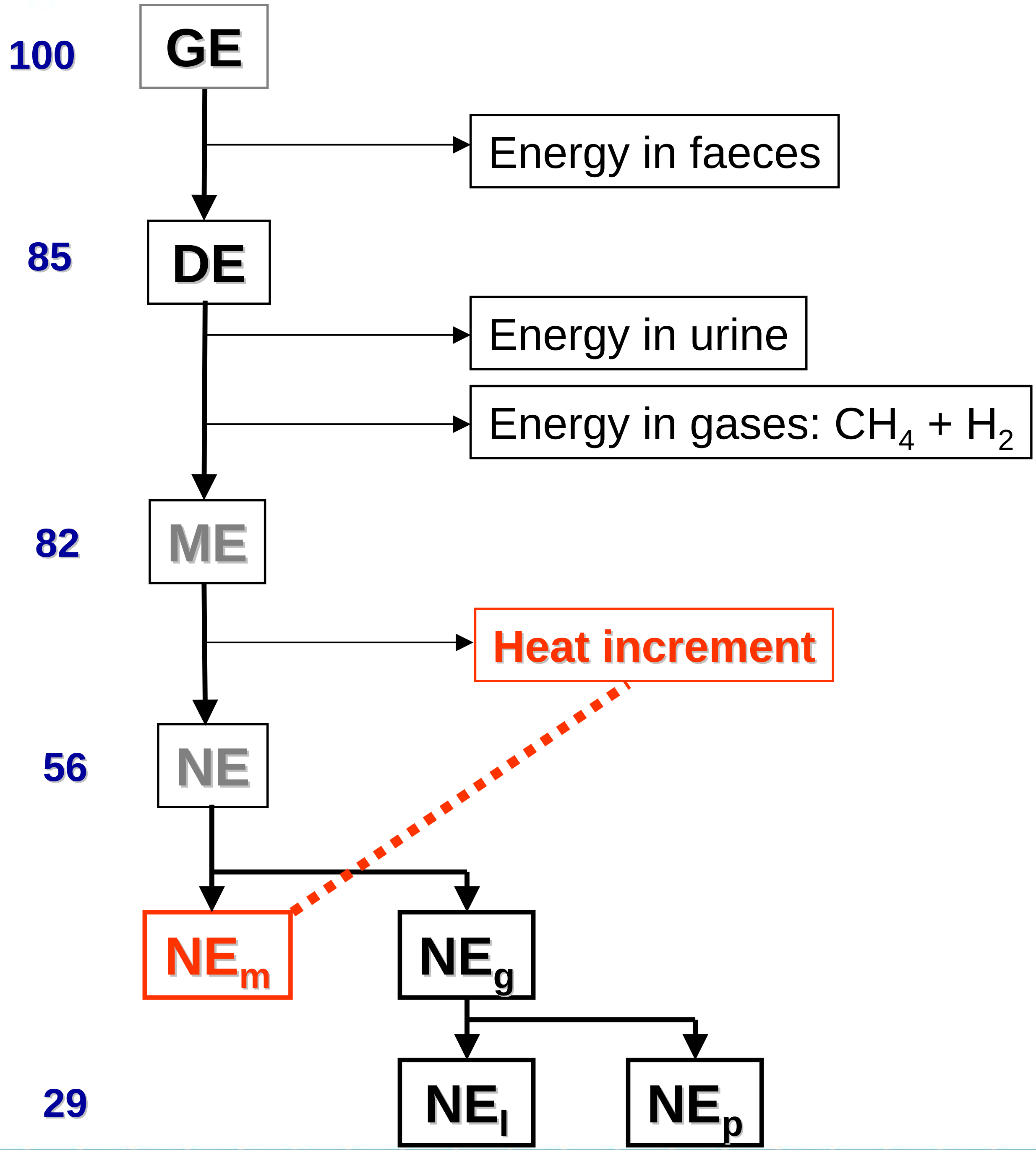

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ENERGY CONTENT

Ingredient	D.E.		M.E.		N.E.	
	Kcal/kg	R.V.	Kcal/kg	R.V.	Kcal/kg	R.V.
Barley	3,100	89	3,050	91	2,200	96
Canola meal	3,000	86	2,800	84	1,490	64
Corn	3,550	102	3,500	105	2,550	109
Field peas	3,475	100	3,340	100	2,340	100
Soybean meal	3,675	106	3,350	100	1,950	83
Wheat	3,425	99	3,340	100	2,350	100

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DE overvalues high protein ingredients

Effect Of Changing DE at Constant NE On Grow-Finish Pig Performance

	High	Medium	Low
N.E., Mcal/kg	2.30	2.31	2.31
D.E., Mcal/kg	3.40	3.37	3.33
Crude protein, %	21.0	20.0	18.9
dLysine, %	0.88	0.88	0.87
dMethionine, %	0.27	0.26	0.26

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Effect Of Changing DE at Constant NE On Grow-Finish Pig Performance

	High	Medium	Low
Initial wt., kg	32.9	32.7	33.0
Final wt., kg	114.5	114.1	114.7
Daily gain, g	957	955	964
Daily feed, g	2,696	2,642	2,690
Feed:gain	2.81	2.79	2.76
Gain:feed	0.356	0.359	0.362

Constant performance at constant NE and changing DE suggests NE is a better predictor of pig performance

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Correlation coefficient between DE_i & NE_i and weanling pig performance

	Correlation	
	DE_{intake}	NE_{intake}
Daily gain	0.56	0.55
Feed conversion	-0.58	-0.51
Protein deposition rate	0.36	0.36
Lipid deposition rate	0.33	0.42
LD:PD ratio	0.19	0.29

NE predicted lipid deposition with greater precision than DE, however, neither DE nor NE were "good predictors"

Source: Oresanya et al., 2005

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However, -

- The digestibility of energy (DE) is a major factor affecting the utilization of energy (NE)

Regardless of the “energy system” used, digestibility of energy is important

Variation in digestibility limits our confidence in fully utilizing available by-products

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Measuring (estimating) DE is important

- DE of barley varies by at least 15%
  - 2,870 to 3,330 kcal DE/kg
- DE of wheat varies by at least 15%
  - 3,170 to 3,680 kcal DE/kg
- DE of field peas varies by at least 22%
  - 3,130 to 3,870 kcal DE/kg

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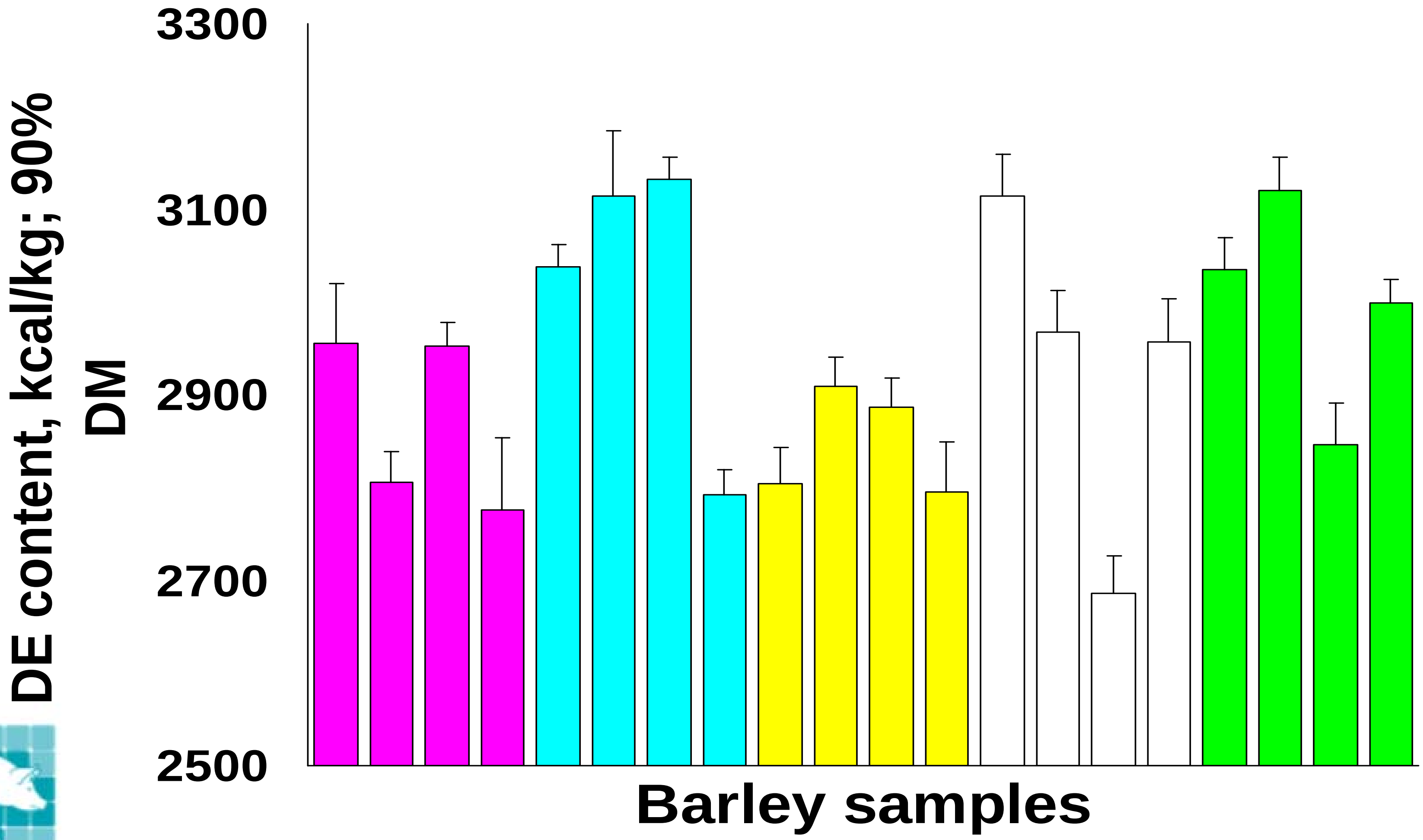
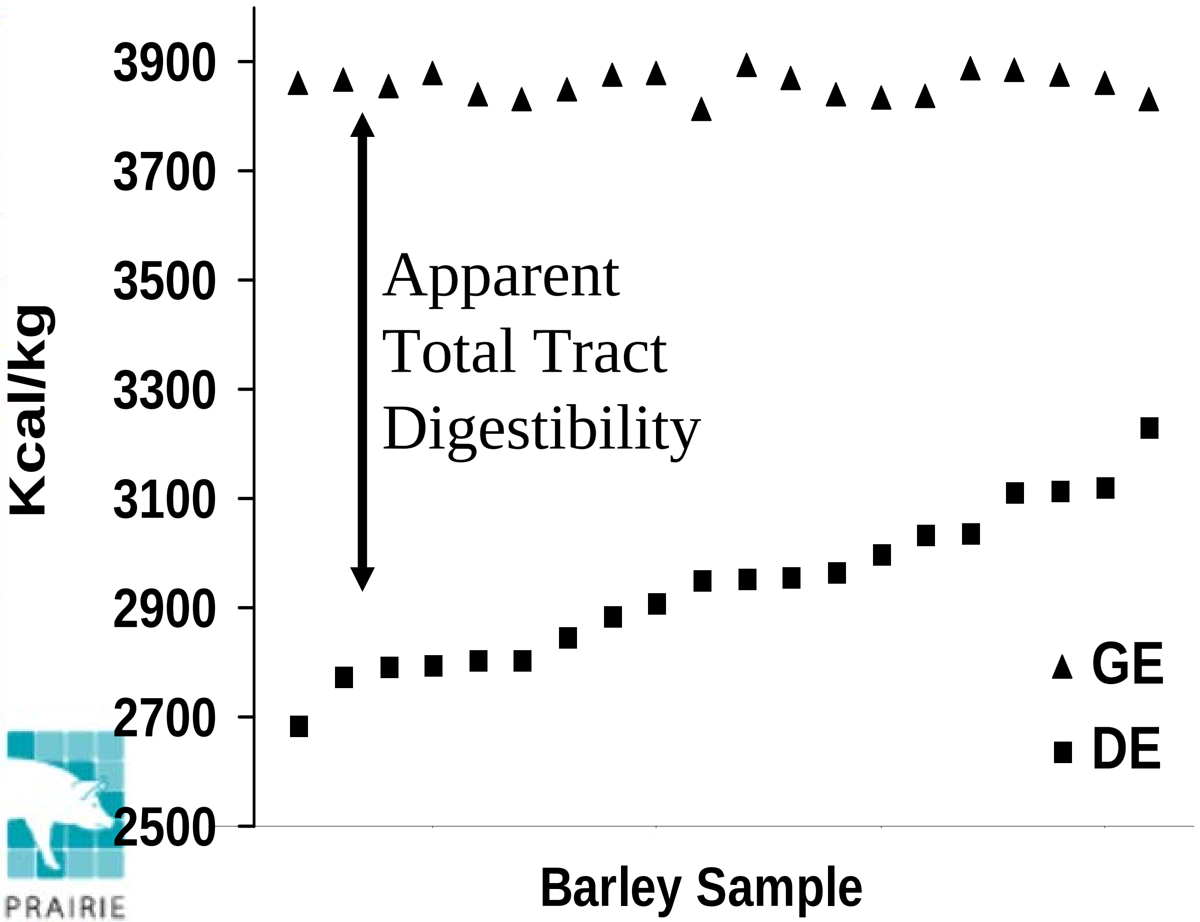
VARIATION IN DE CONTENT WITHIN AND AMONG BARLEY CULTIVARS

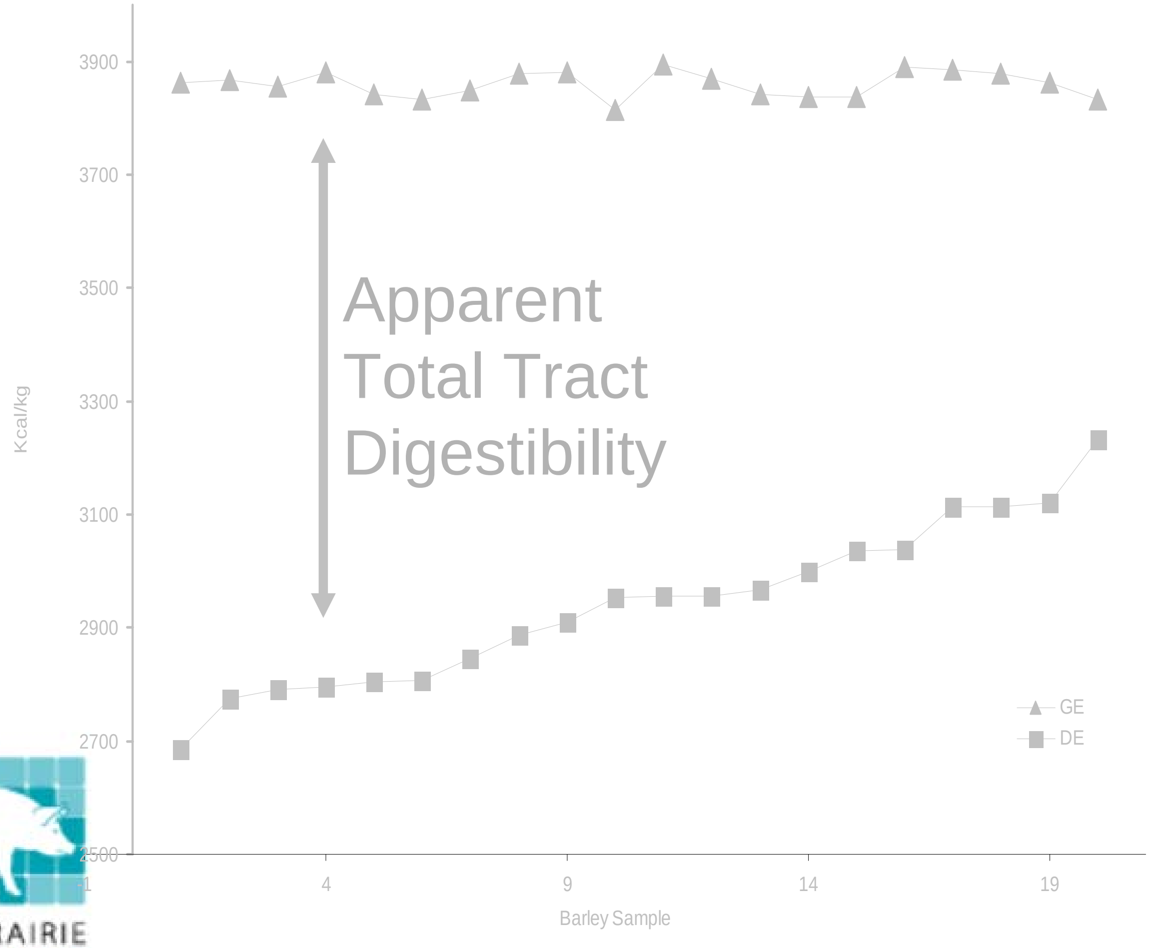


Source: Fairbairn et al., 1999

Barley GE and DE Content



Barley GE and DE Content



Prediction of DE:

- Accept/reject or keep/sell
- Price adjustment
- Feed to specific group of pigs
- Re-formulation to equal diet DE
- Processing to increase DE

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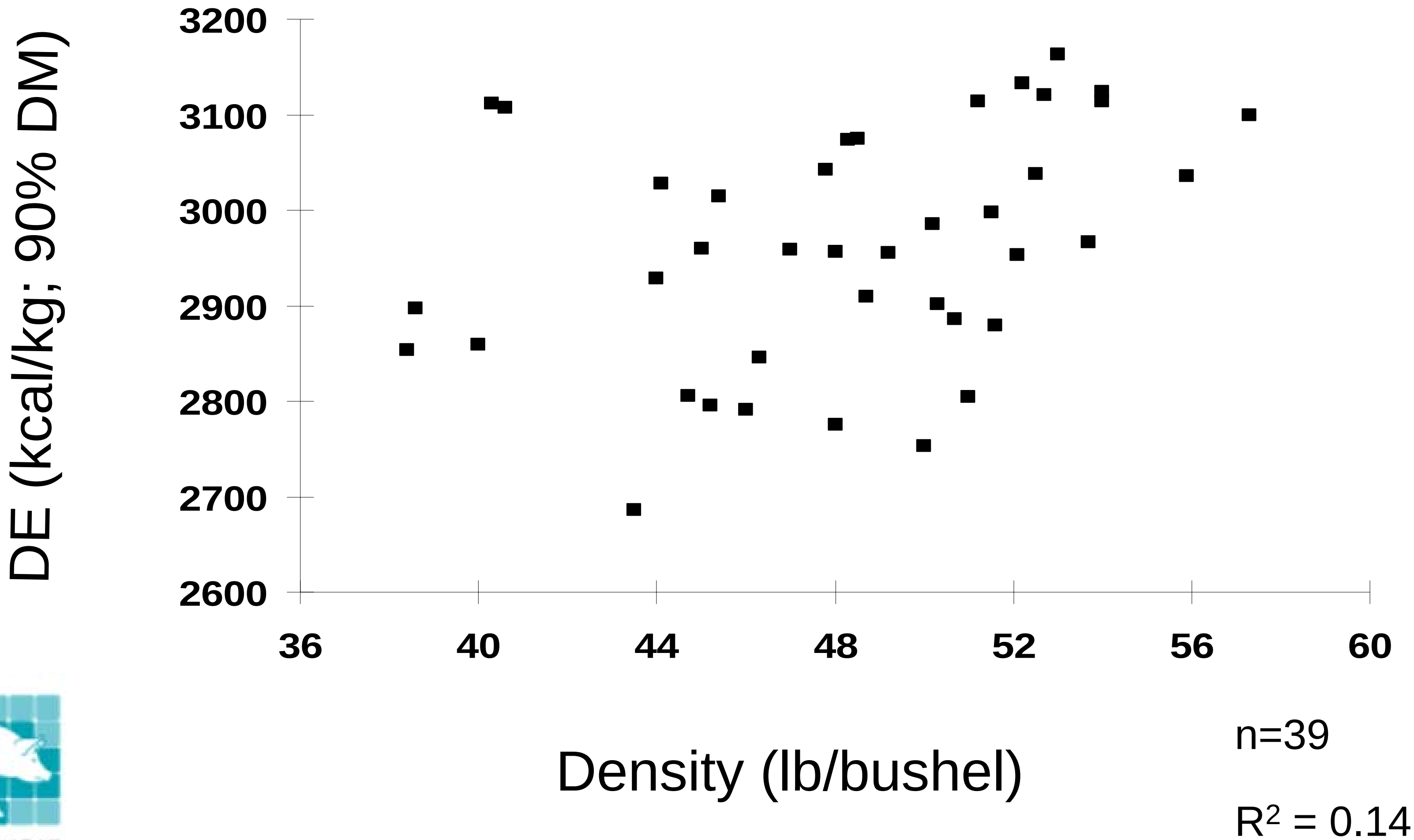
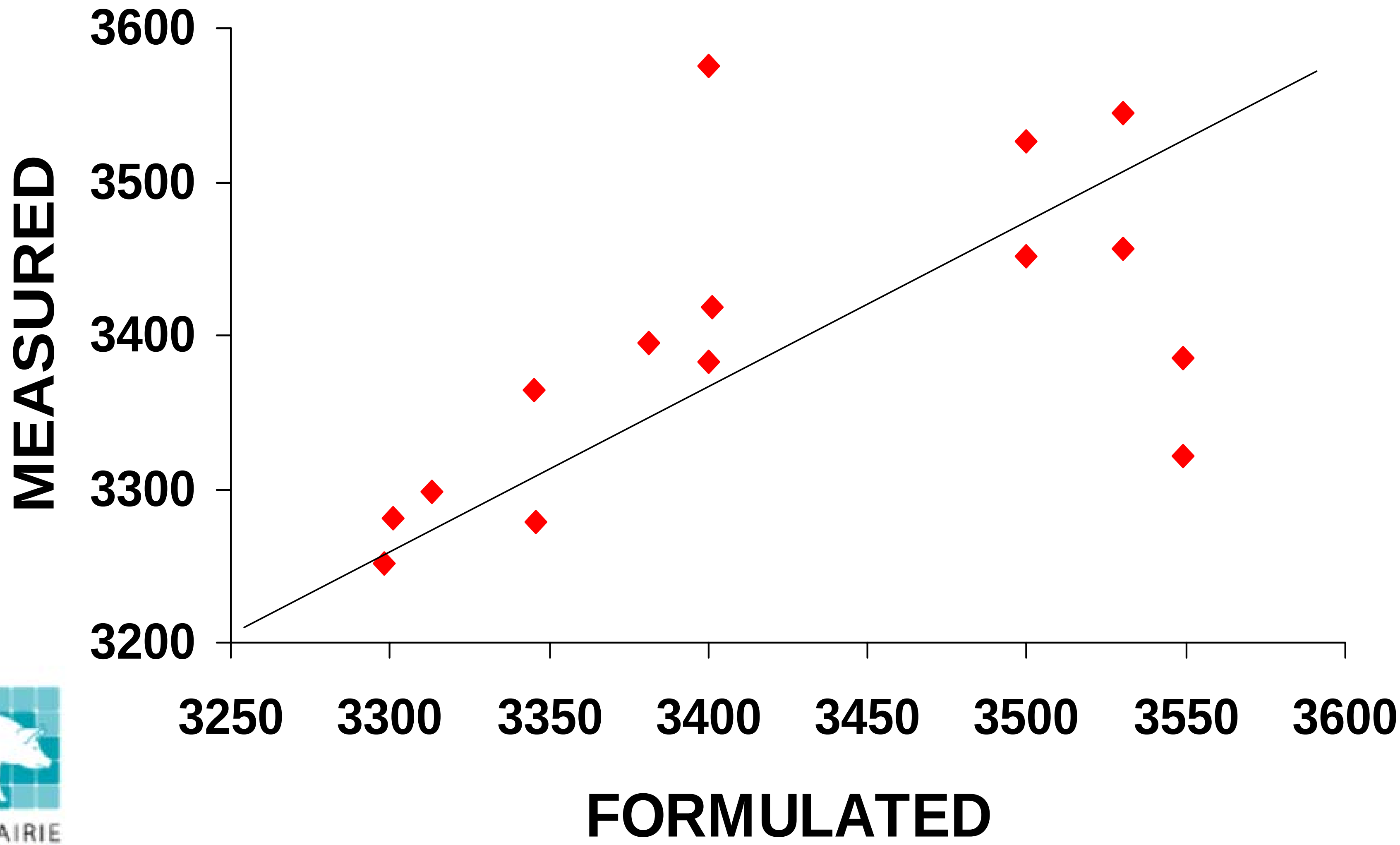
Grain density and DE content



"Formulated" vs. "Measured" DE content (kcal/kg): grow-finish pigs



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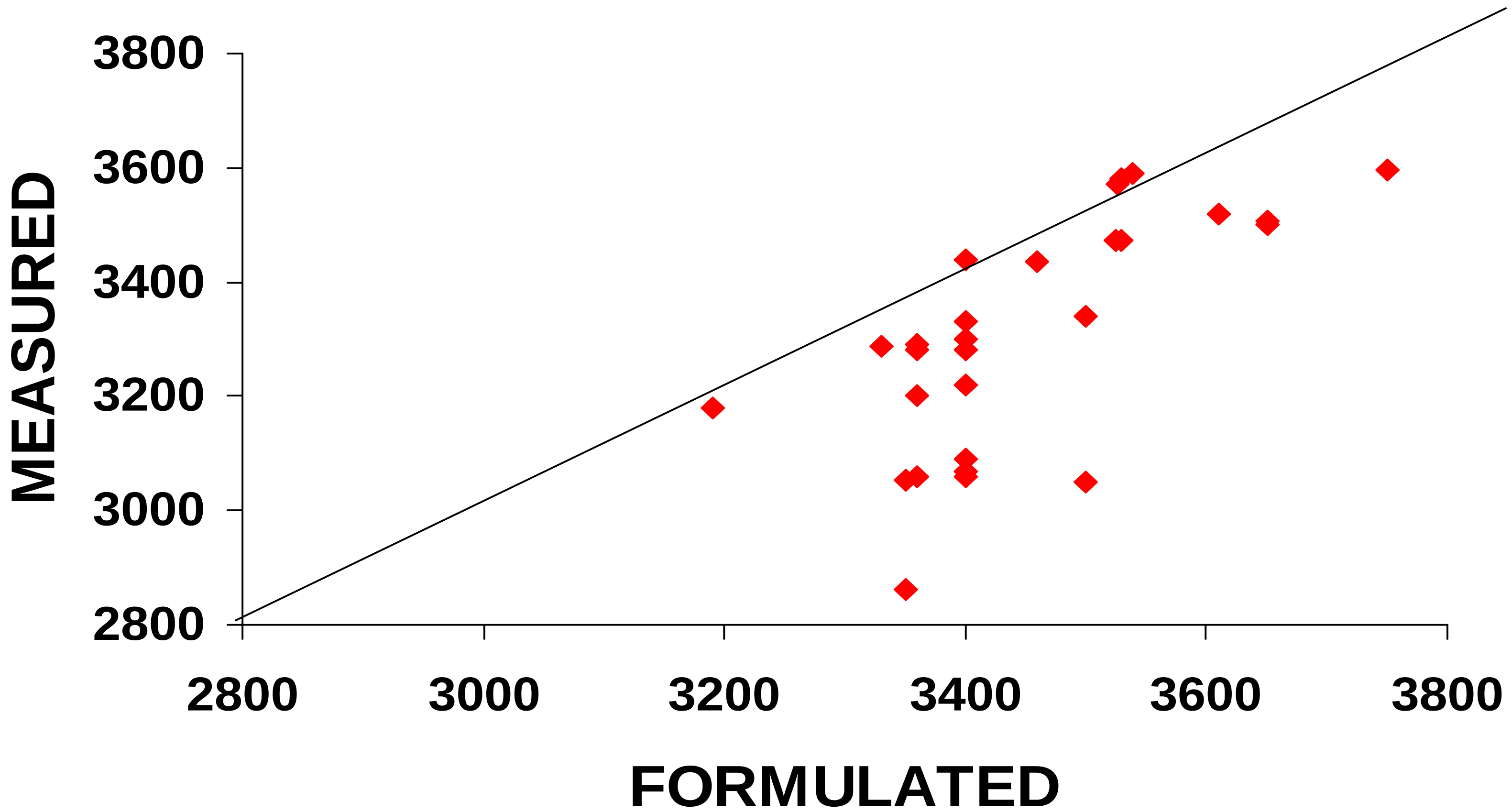
"Formulated" vs. "Measured" DE content (kcal/kg): weanling pigs



Ultimately, we will need to develop separate ingredient matrices for younger and for older pigs

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Predicting grain energy

Barley

$$DE = 3526 - 92.8 * ADF\ (\%) \qquad R^2 = 0.86$$

Adjust DE according to actual ADF value; 1% ADF equals 95 kcal)

Wheat

$$DE = 3584 + (38.3 \times \%CP) - (16.0 \times \%NDF) \qquad R^2 = 0.86$$

Adjust DE according to actual CP and NDF value

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All values expressed on 90% DM basis

DE content

If we know the DE, we can adjust our diets and obtain predictable performance

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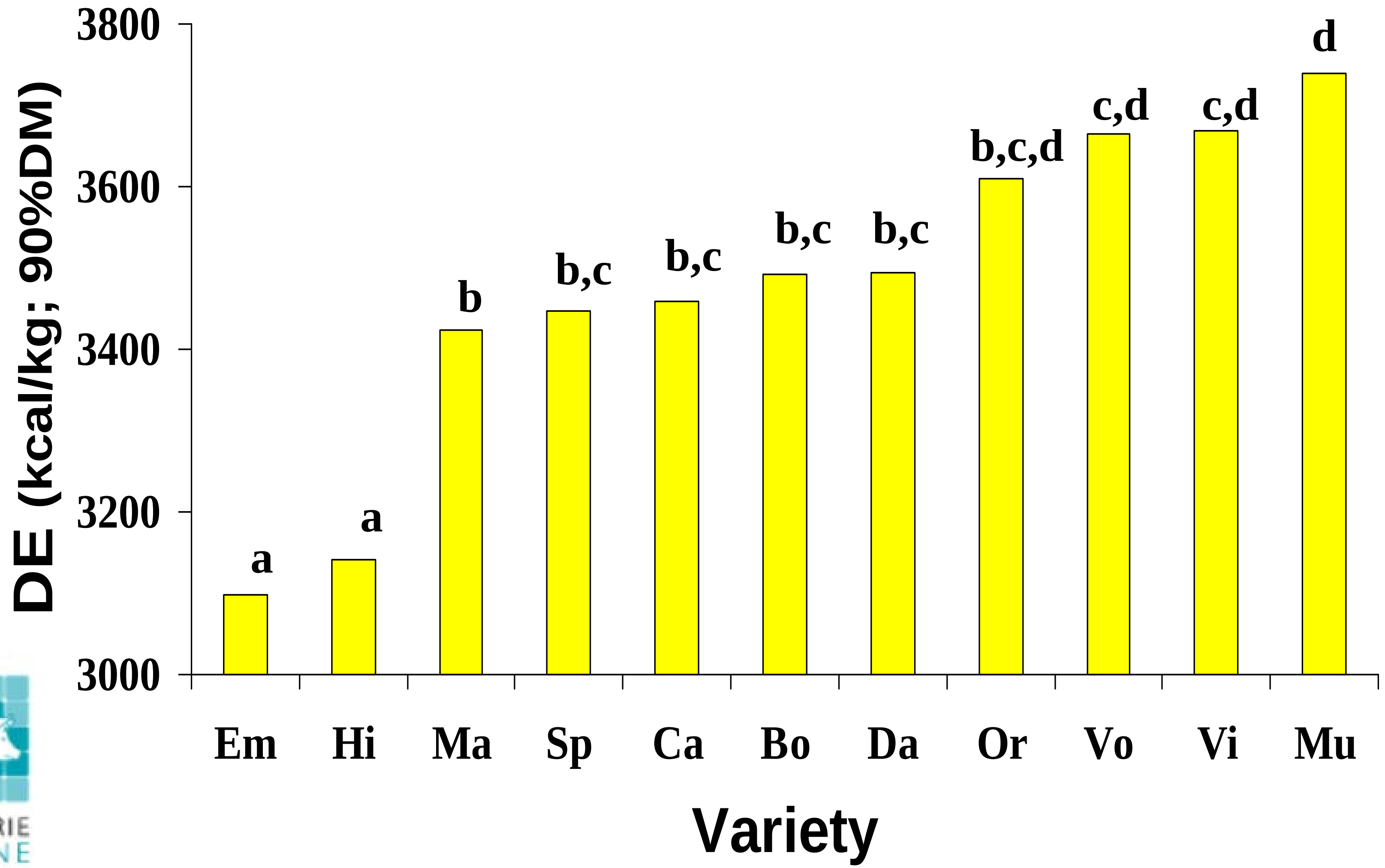
DE CONTENT OF 11 FIELD PEA SAMPLES



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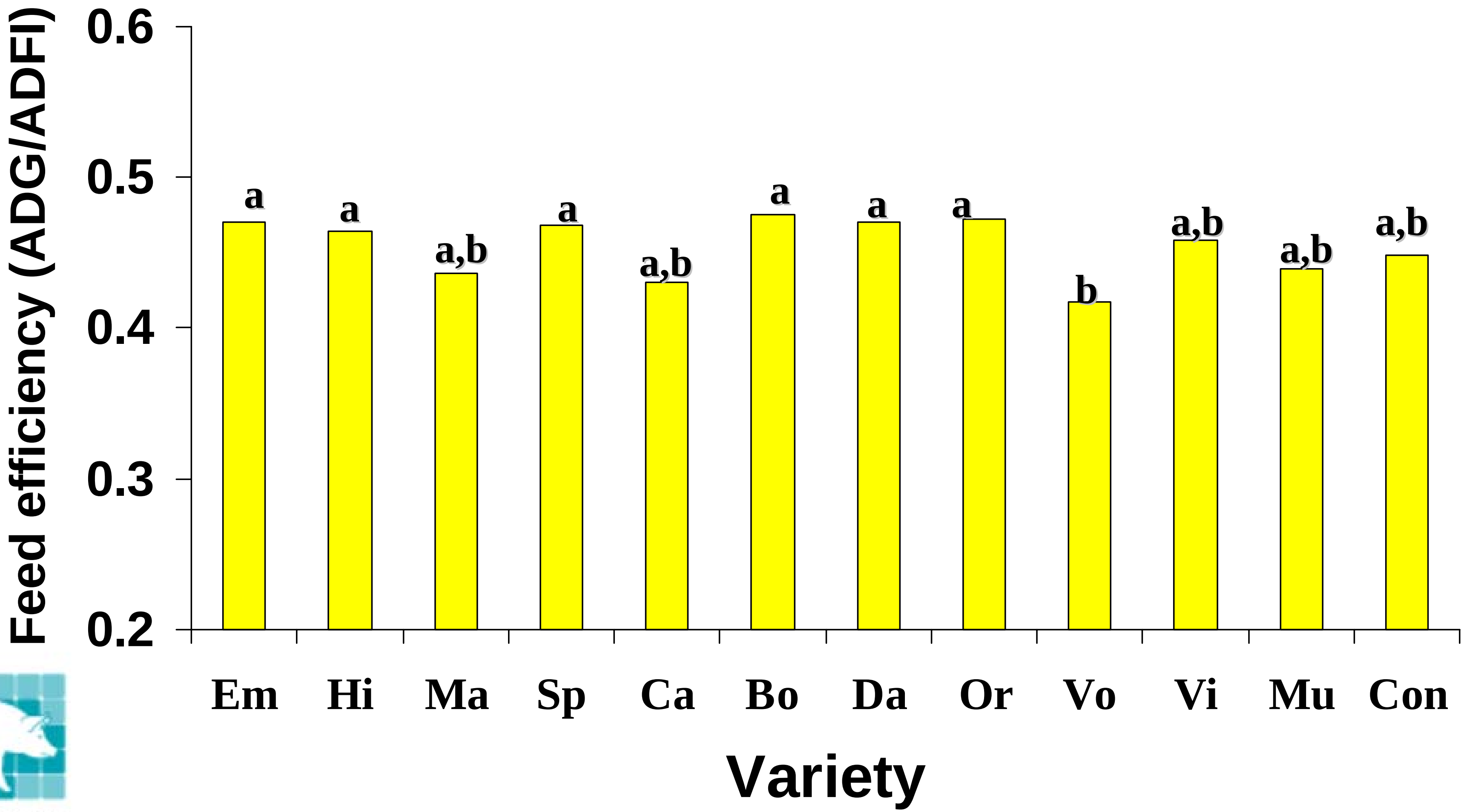
FEED EFFICIENCY OF PIGS FED DE-CORRECTED DIETS



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Conclusions

- Increasing the energy density of the diet will improve feed efficiency, however, profitability must be determined
- The "energy requirement" for pork production is the DE concentration which maximizes profits
- DE (and ME) systems over-value high protein ingredients
- The lysine requirement may need to be increased for high lean genetics
- Alternate ingredients can be successfully utilized in swine diets, - but variability in energy content may result in unpredictable performance
- Increased use of alternate ingredients supports the use of NE systems

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MAXIMIZING NET INCOME

What we do

- Develop practical, new information for application by the pork industry to improve profitability, maintain global competitiveness and address important sustainability issues in animal welfare and the environment

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Optimal Lys:calorie ratio that met the requirements for growth and optimized return over feed costs (Main et al. 2008)

BW	Lys:cal ratio g Lys:Mcal ME	Dietary Lys %	TID Lys g/d	TID Lys g/kg gain
------------------------------ Barrows ------------------------------				
59	2.89	1.04	19	19
81	2.65	0.96	20	21
111	2.20	0.80	18	20
------------------------------ Gilts ------------------------------				
48	3.23	1.16	20	21
73	2.80	1.01	20	21
90	2.53	0.91	20	22
110	2.20	0.80	17	19

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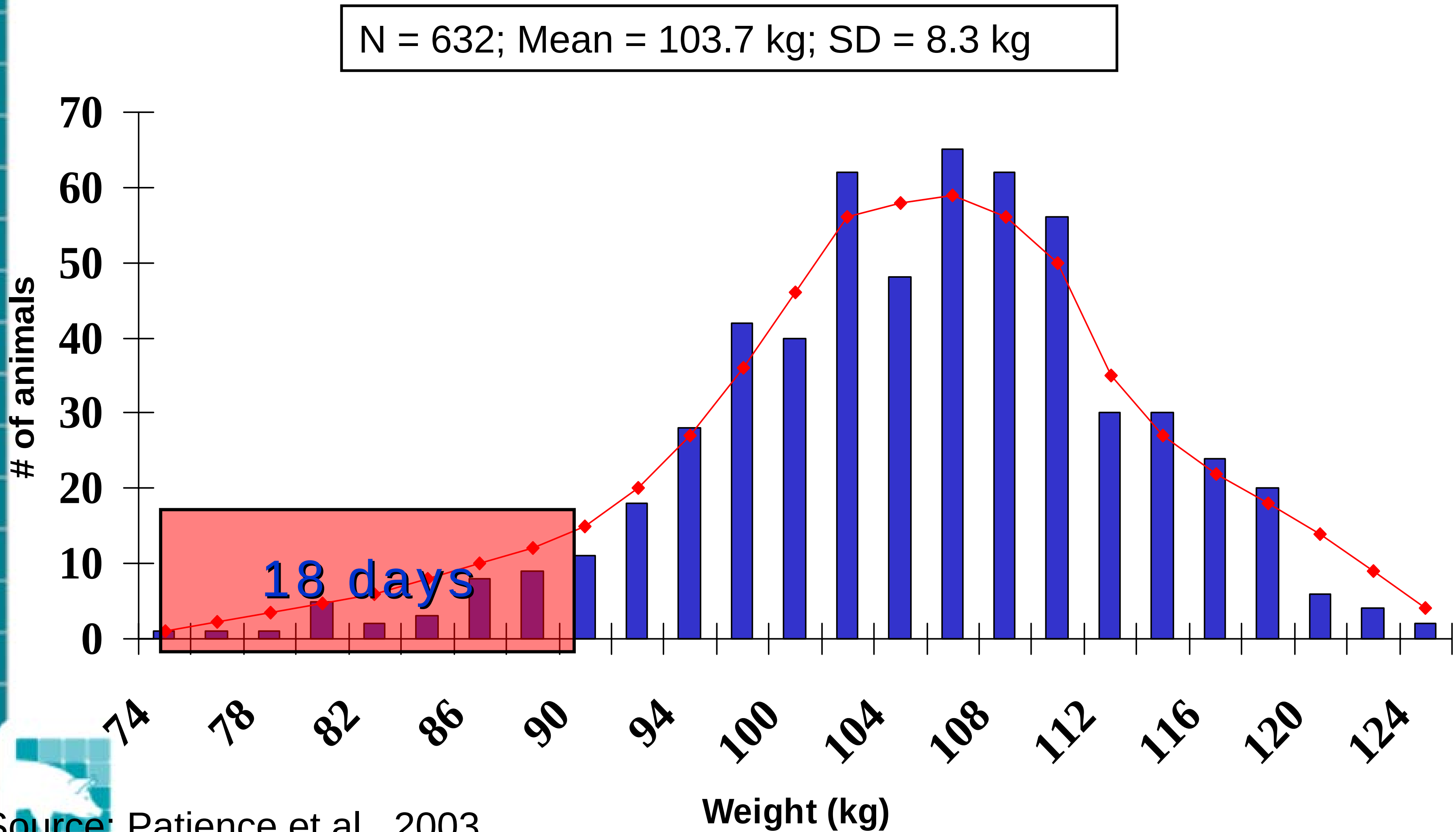
BW	Lys:cal ratio g Lys:Mcal ME		Dietary Lys %	TID Lys g/d	TID Lys g/kg gain
Barrows					
59	2.89		1.04	19	19
81	2.65		0.96	20	21
111	2.20		0.80	18	20
Gilts		NRC*			
48	3.23	2.80	1.16	20	21
73	2.80	2.51	1.01	20	21
90	2.53	2.31	0.91	20	22
110	2.20	2.08	0.80	17	19

*Nutrient Requirements of Swine, NRC 1998

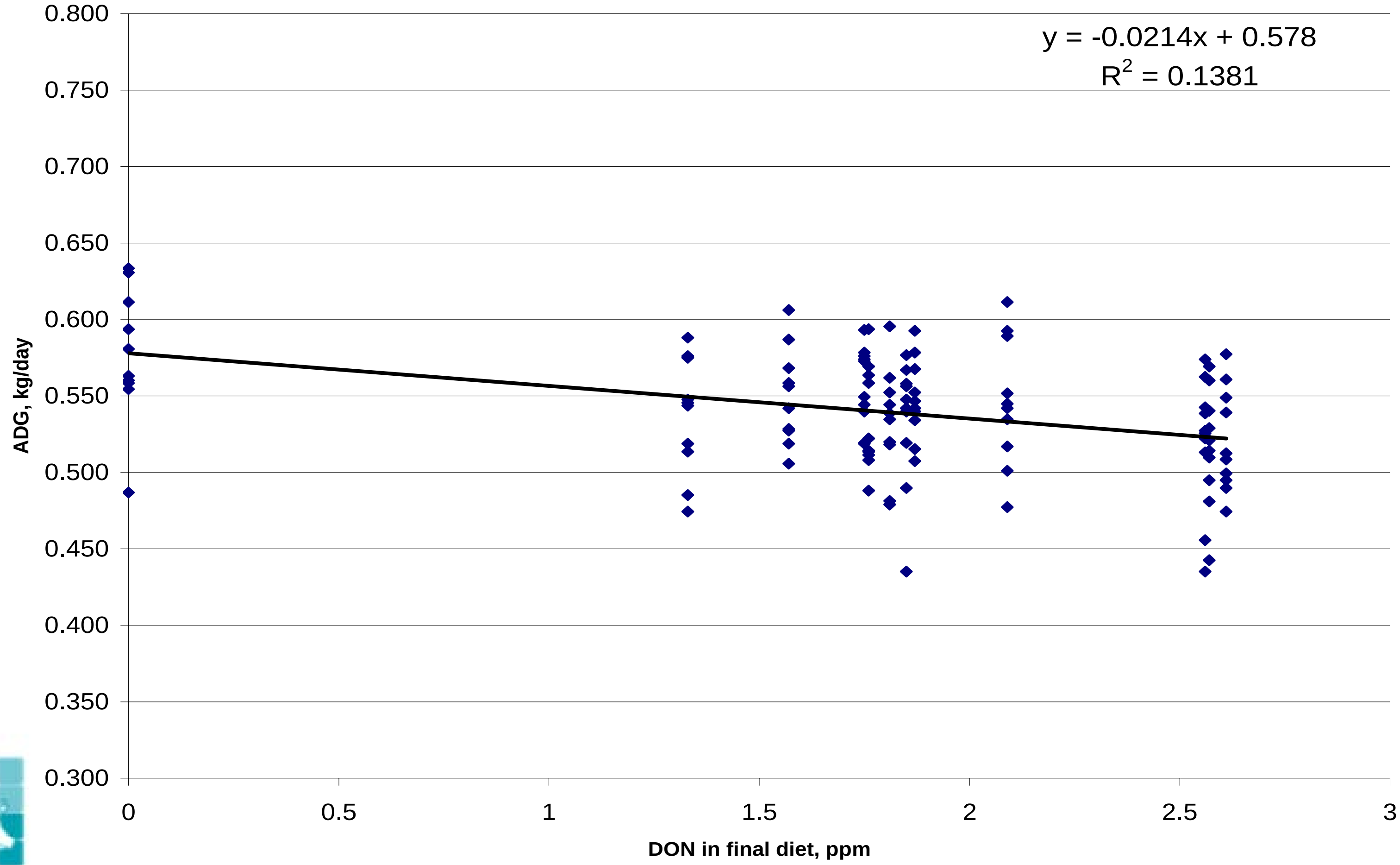
Distribution Of Weights At 20 Weeks Of Age



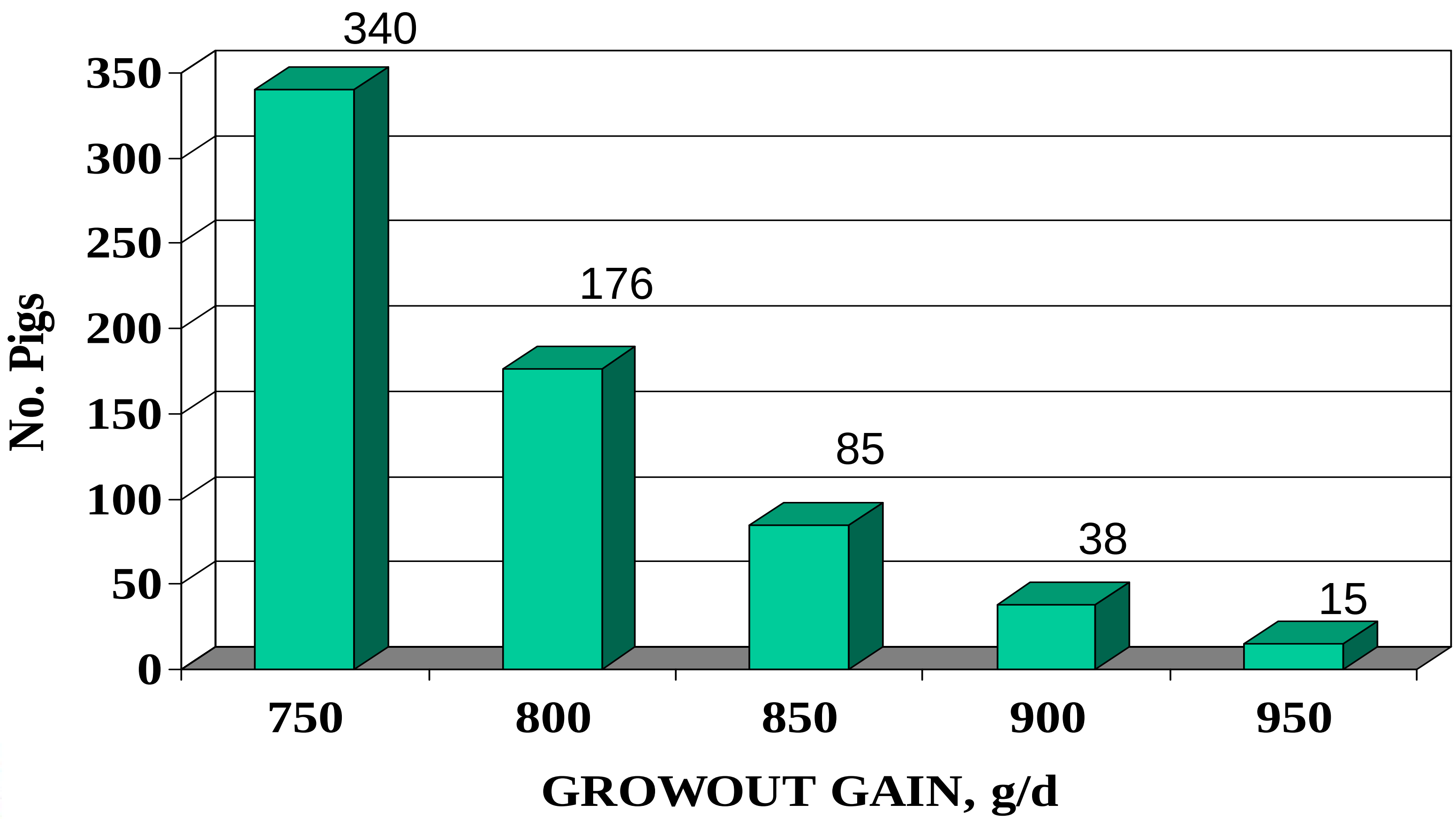
Source: Patience et al., 2003

Tail-enders represent a huge cost – or a significant opportunity!!

Effect of DON in diet on ADG



Increase overall growth curve



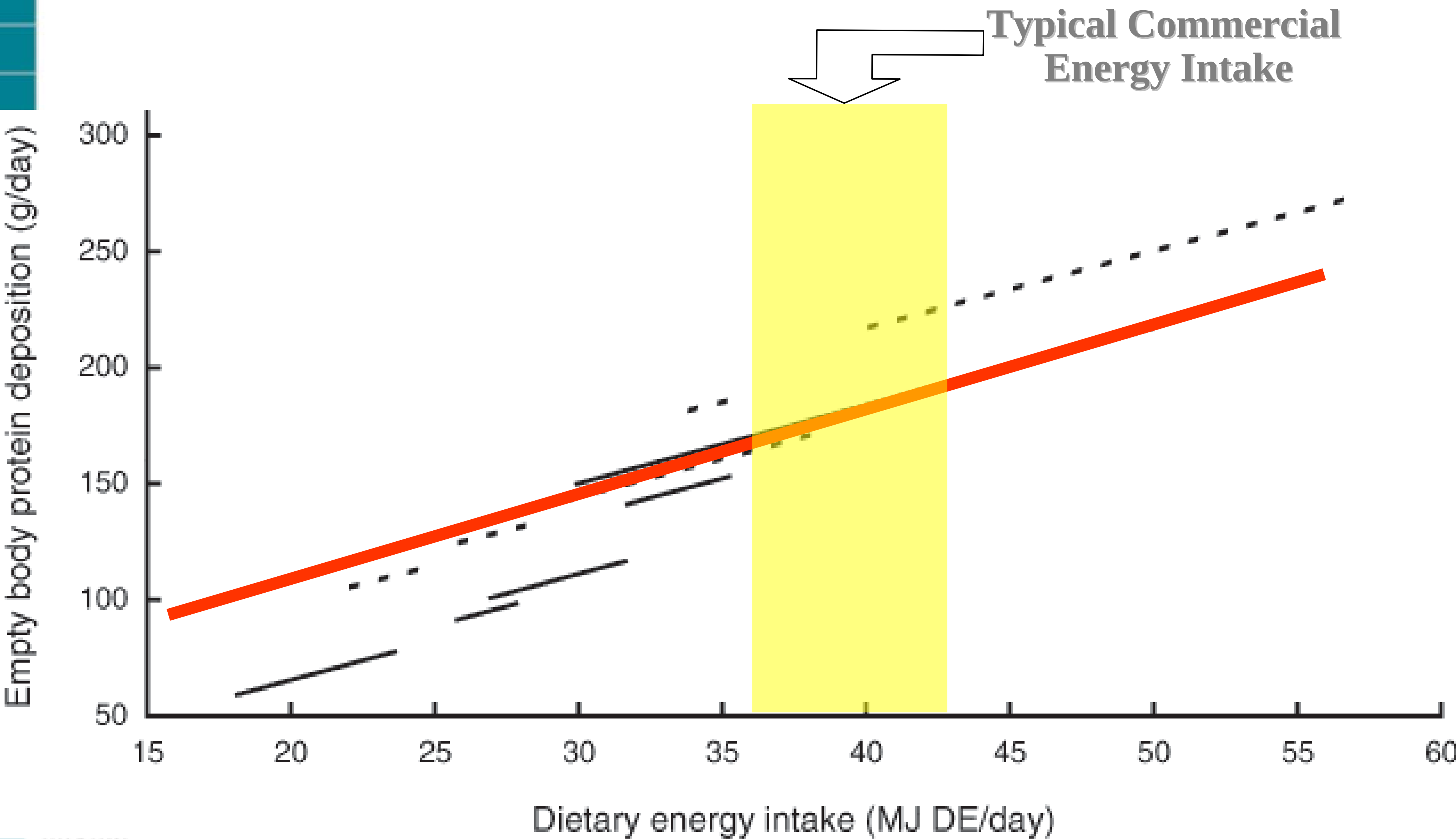
Tail-enders expressed as number of pigs per 1,000 head finished which, at 15 weeks, fall below minimum target market weight of 108 kg (85 kg dressed)

Water balance: Growing pig

Intake, g/d		Excretion, g/d	
Drinking	5,500	Urinary	2,839
Metabolic	*1,002*	Faecal	289
Feed	194	*Residual*	*3,303*
		Growth	*266*
TOTAL	***6,697***		***6,697***

Estimated water balance in a pig growing from 35 to 50 kg, growing 1 kg/d and consuming 2 kg/d of a typical, practical diet. Estimated protein deposition was 149 g/d. Residual calculated as the difference between the total measured and estimated water intake, that excreted as urine and faeces and that retained in body tissues. Wastage was considered to be virtually nil. Source: Shaw et al., 2003.

Relationship between energy intake and protein deposition in gilts (solid) and boars (dotted)



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Boars and gilts of a common genotype fed from 55 to 100% of ad libitum intake over the weight range of 80 to 120 kg LW. King et al., 2004

Performance of sub-groups of pigs within an overall population

	Weaning wt., kg	Nursery exit wt., kg
From the lightest		
-12th percentile	4.1	26.7
-25th percentile	4.5	27.7
-50th percentile	5.0	29.1
From the heaviest		
-100th percentile	5.9	31.5
-50th percentile	6.9	33.8
-10th percentile	8.1	36.5

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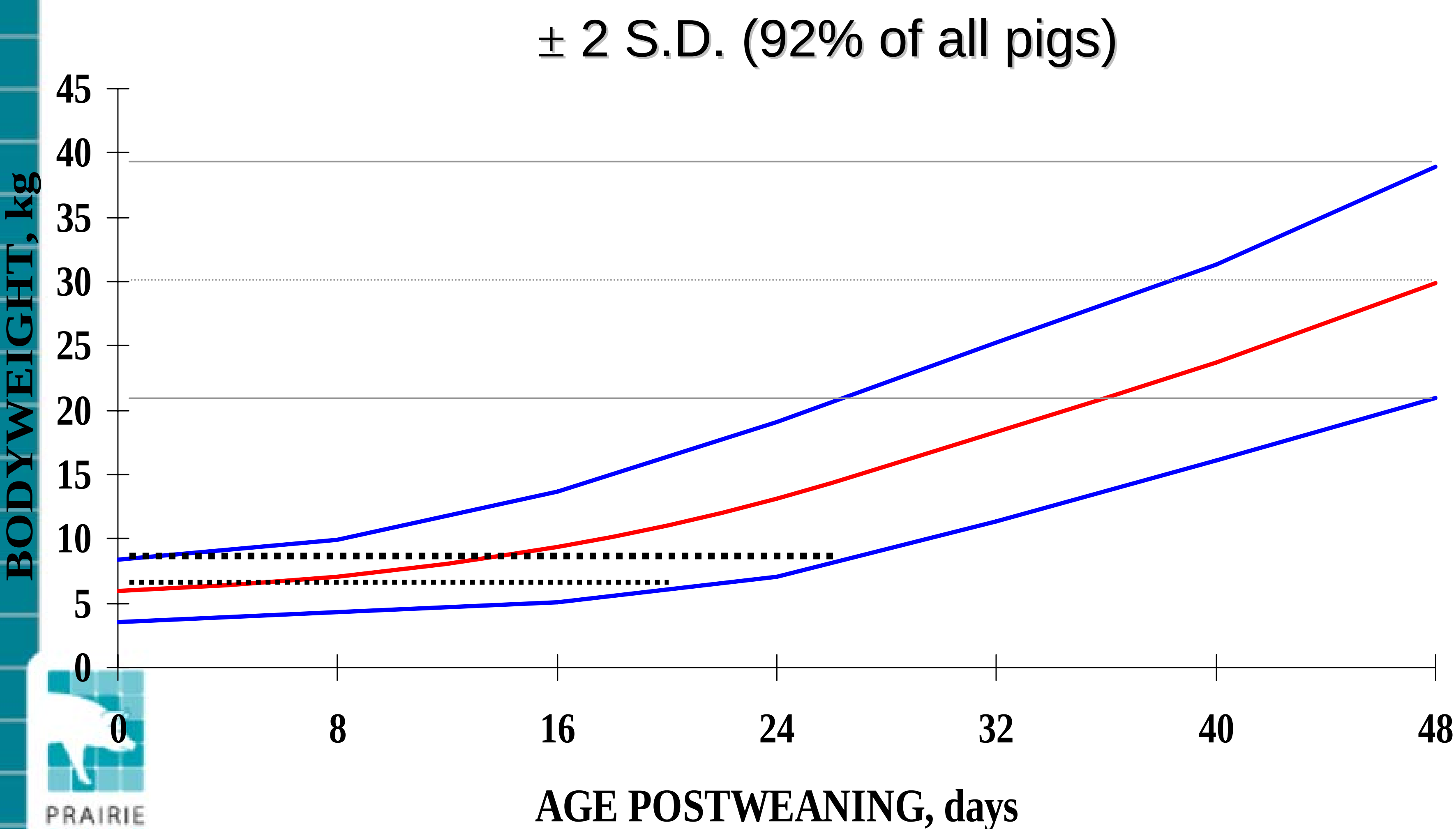
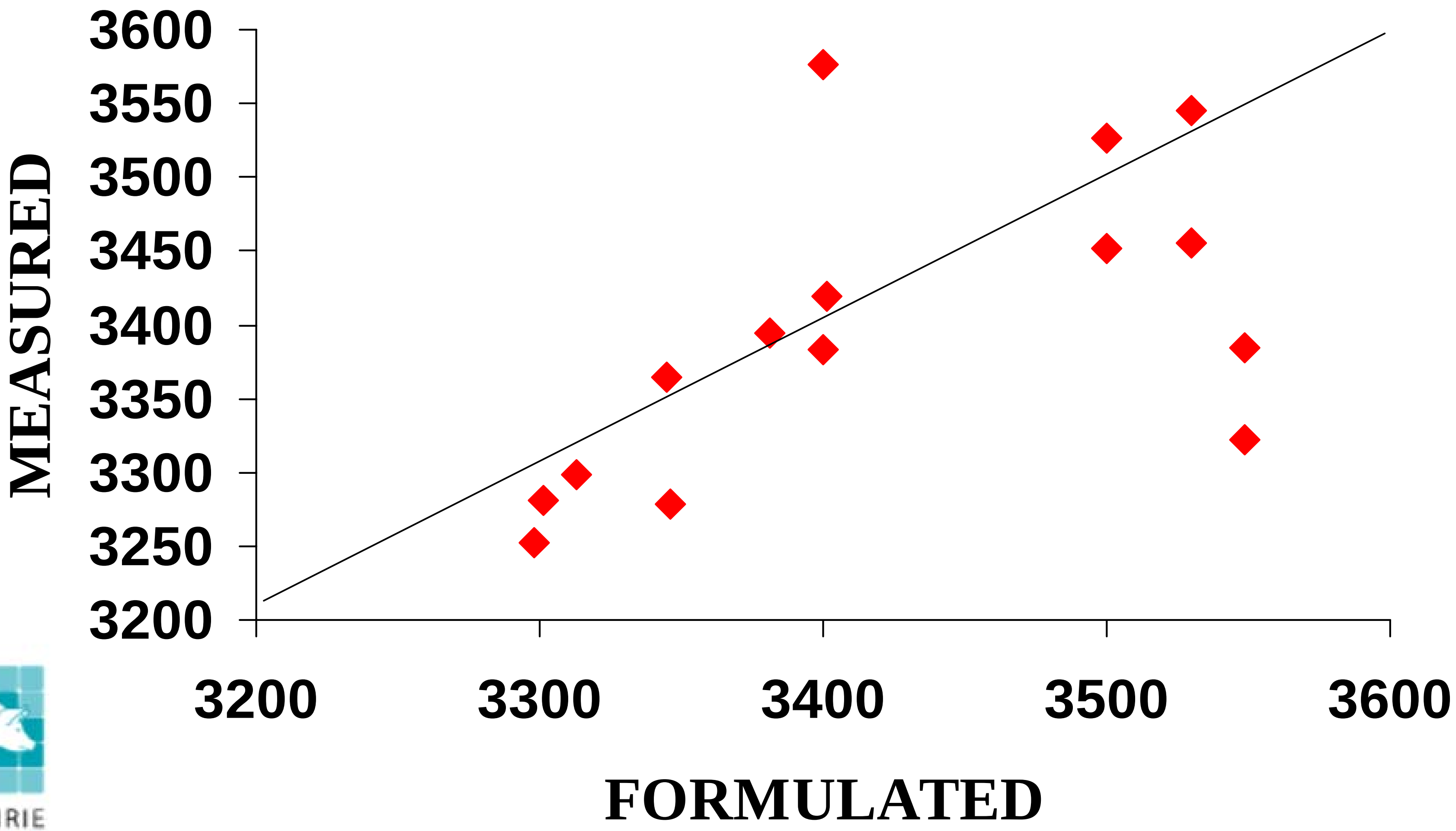
Typical nursery growth curve

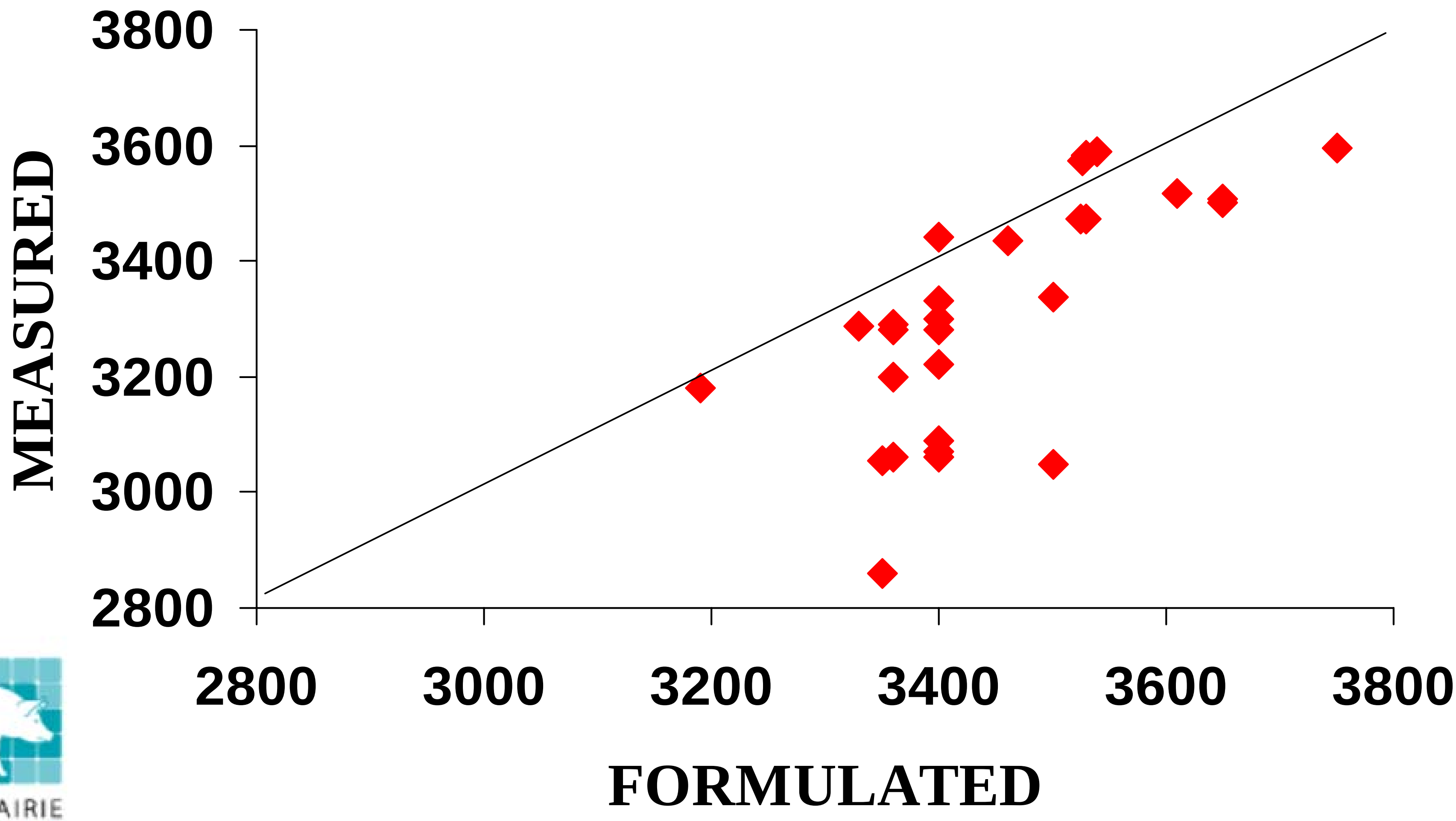


Formulated versus measured DE content (kcal/kg) of diets fed to growout pigs



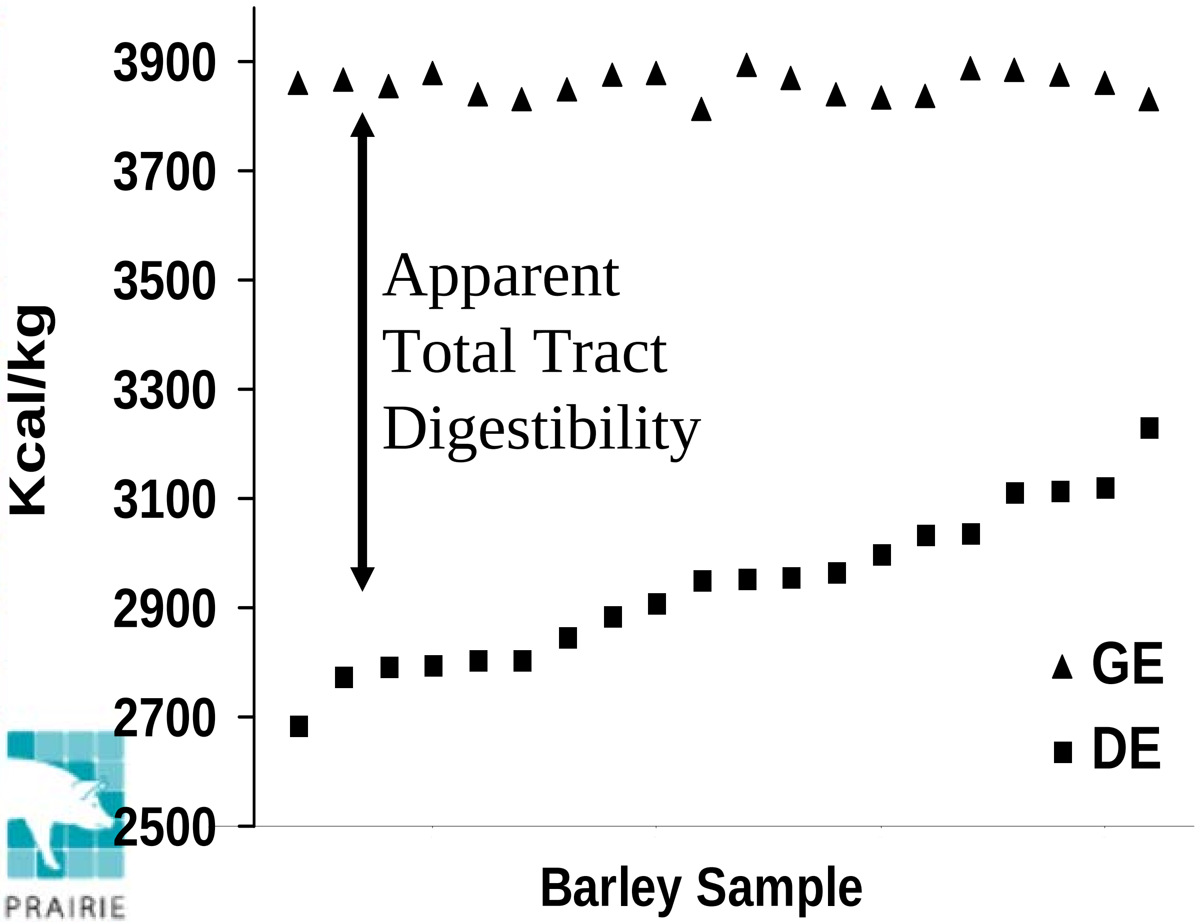
Sources: Lorschy, 1998; Ekpe, 2000

Formulated versus measured DE content (kcal/kg) of diets fed to weanling pigs



Sources: Levesque, 2001; Oresanya, 2003

Barley GE and DE Content



Prediction of DE:

- Accept/reject or keep/sell
- Price adjustment
- Feed to specific group of pigs
- Re-formulation to equal diet DE
- Processing to increase DE

Chemical, biological or physical contamination

- Inherent contamination
  - Due to genetic origin of the ingredient
- Inadvertent contamination
  - May occur during production, processing, storage or transportation
- Intentional contamination
  - Familiarity with the history of the product

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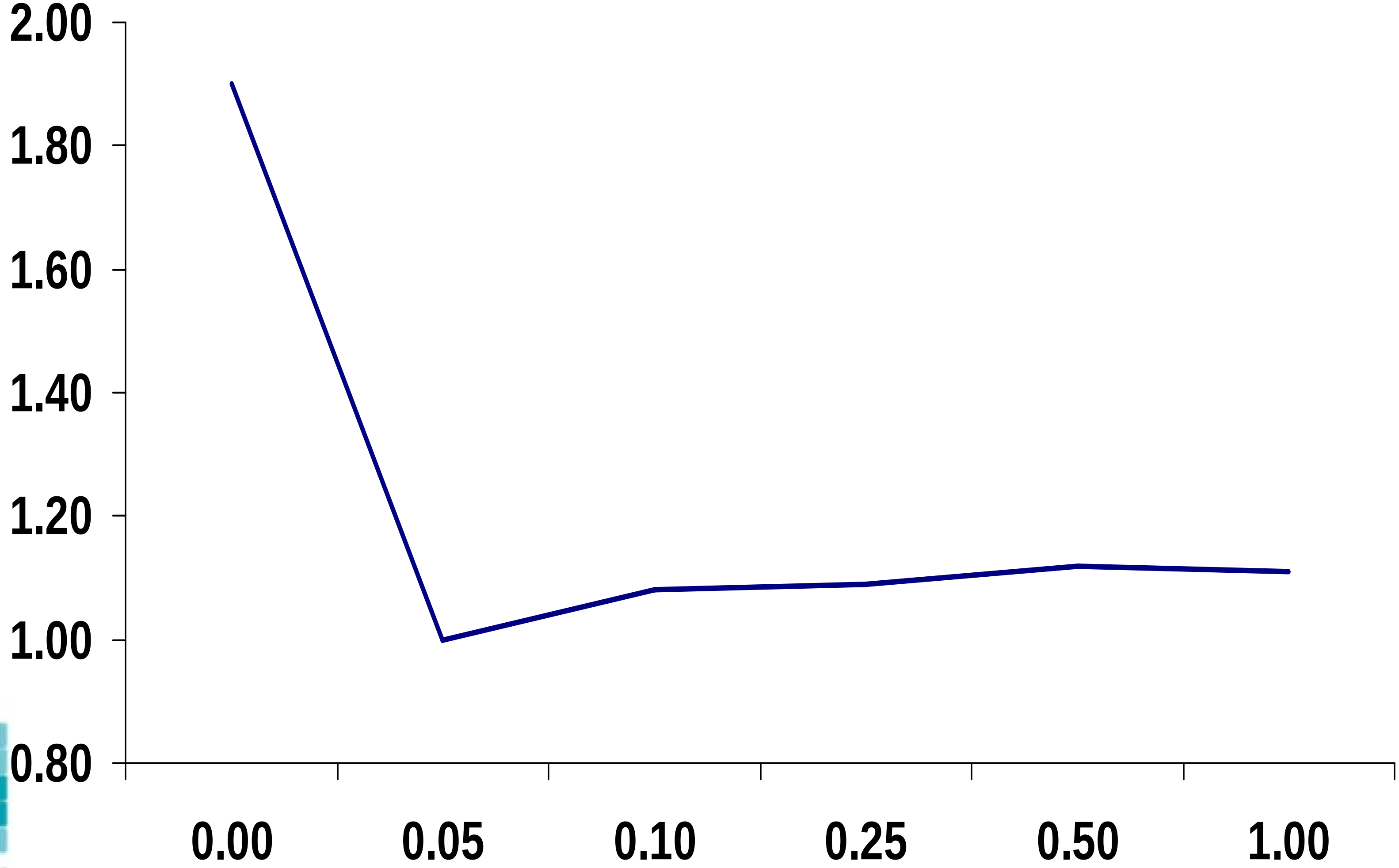
Effect of ergot on prolactin



Source: Oresanya et al., 2003

Effect Of Changing Crude Protein At Constant NE On Grow-Finish Pig Performance

	High	Medium	Low
# pigs	209	216	208
#pens	10	10	10
Initial wt., lb	73	72	73
Final wt., lb	252	251	253
Daily gain, lb	2.11	2.10	2.12
Daily feed, lb	5.94	5.82	5.93
Feed:Gain	2.81	2.79	2.76

Constant performance at constant NE and changing DE suggests NE is a better predictor of pig performance

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EFFECT OF DIETARY CRUDE PROTEIN ON CARCASS PARAMETERS

	High	Medium	Low
Dressed wt., lb	196	196	196
Index	110.7	110.8	110.9
Fat, mm	20.1	20.0	20.6
Loin, mm[1]	59.8	59.3	61.8

[1] Effect of diet significant, $P<0.05$

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Variation In Bodyweight At 3 Ages

	Average Age, d		
	19	68	140
No. of pigs	1,264	700	632
Mean, lb	11.9	64.1	228.5
Minimum, lb	5.3	52.5	164.0
Maximum, lb	20.3	90.1	275.3
Range, lb	15.0	37.6	111.3
Range, % of mean	121	59	48
Standard deviation, lb	2.7	8.2	18.3
Coefficient of variation, %	22	13	8

The degree of variation amongst pigs surprises all of us by its magnitude

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Producers can use C.V. as a management tool to answer the questions:

Should I seek to reduce variability?

Should I seek to manage variability?

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Producers can use C.V. as a management tool to answer the questions:

Should I seek to reduce variability?

Should I seek to manage variability?

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C.V. Guidelines

If C.V. is above guideline, management can seek to reduce variability.

Weaning wt.: CV = ~20%

Nursery exit wt.: C.V. = 12 to 15%

First pull (growout): C.V. = 8 to 12%

If C.V. is at the guideline, management should seek to manage variability.

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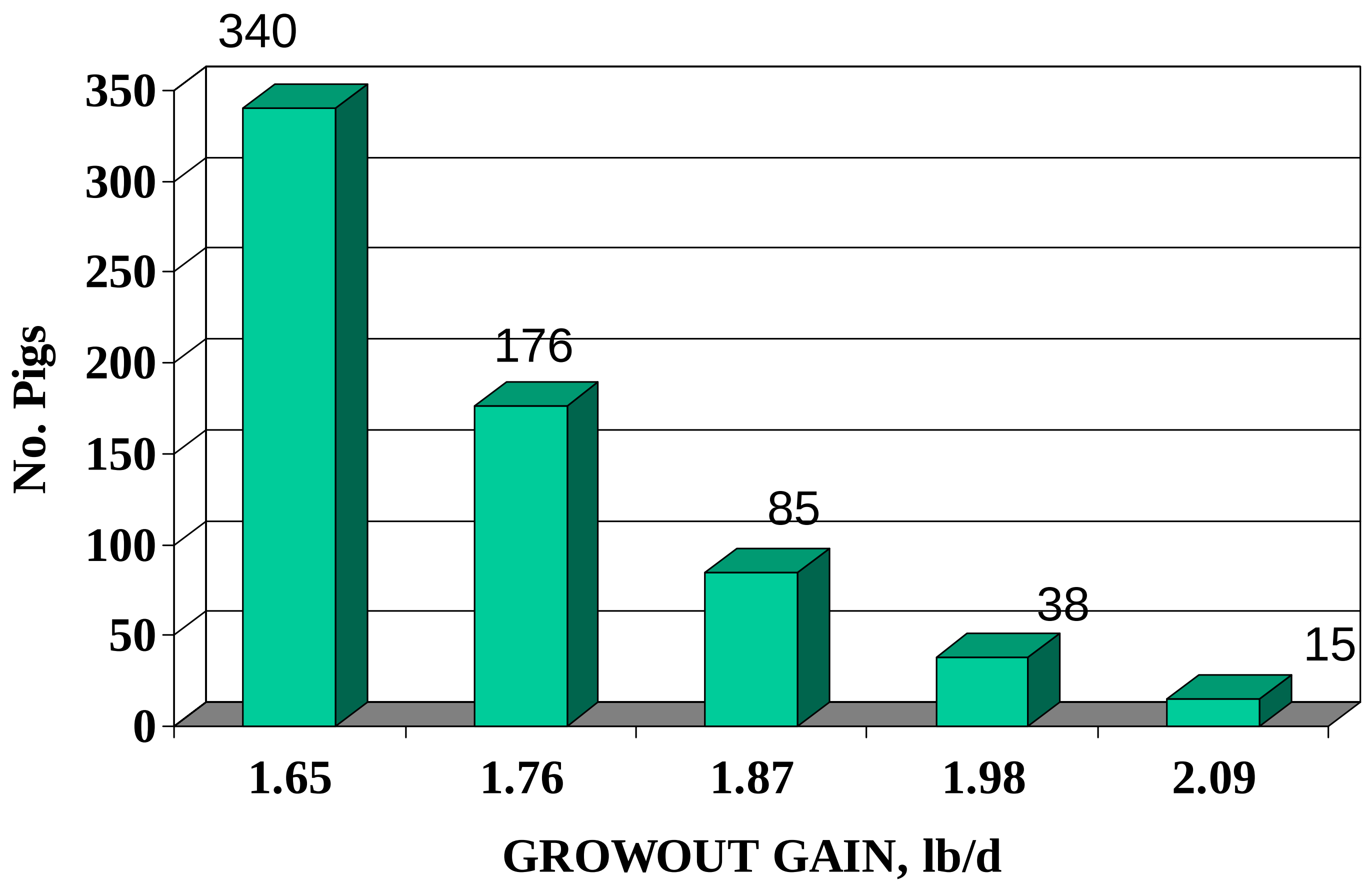
Increase Overall Growth Curve



Tail-enders expressed as number of pigs per 1,000 head finished which, at 15 weeks, fall below minimum target market weight of 238 lb (187 lb dressed)

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Every 0.11 lb/d increase in ADG reduces tail-enders by 50%

Ingredient Research in the Future

Nutrient Composition

Palatability

- **DE & NE**
- **Amino acids**
- **Other?**
- **Variability**

- **Processing**
- **Enzymes**
- **Other**

- **Rapid Testing**
- **In Vitro**
- **NIR**

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MISSION STATEMENT

"to provide a centre of excellence in research, graduate education and technology transfer all directed at the enhancement of efficient, sustainable pork production."

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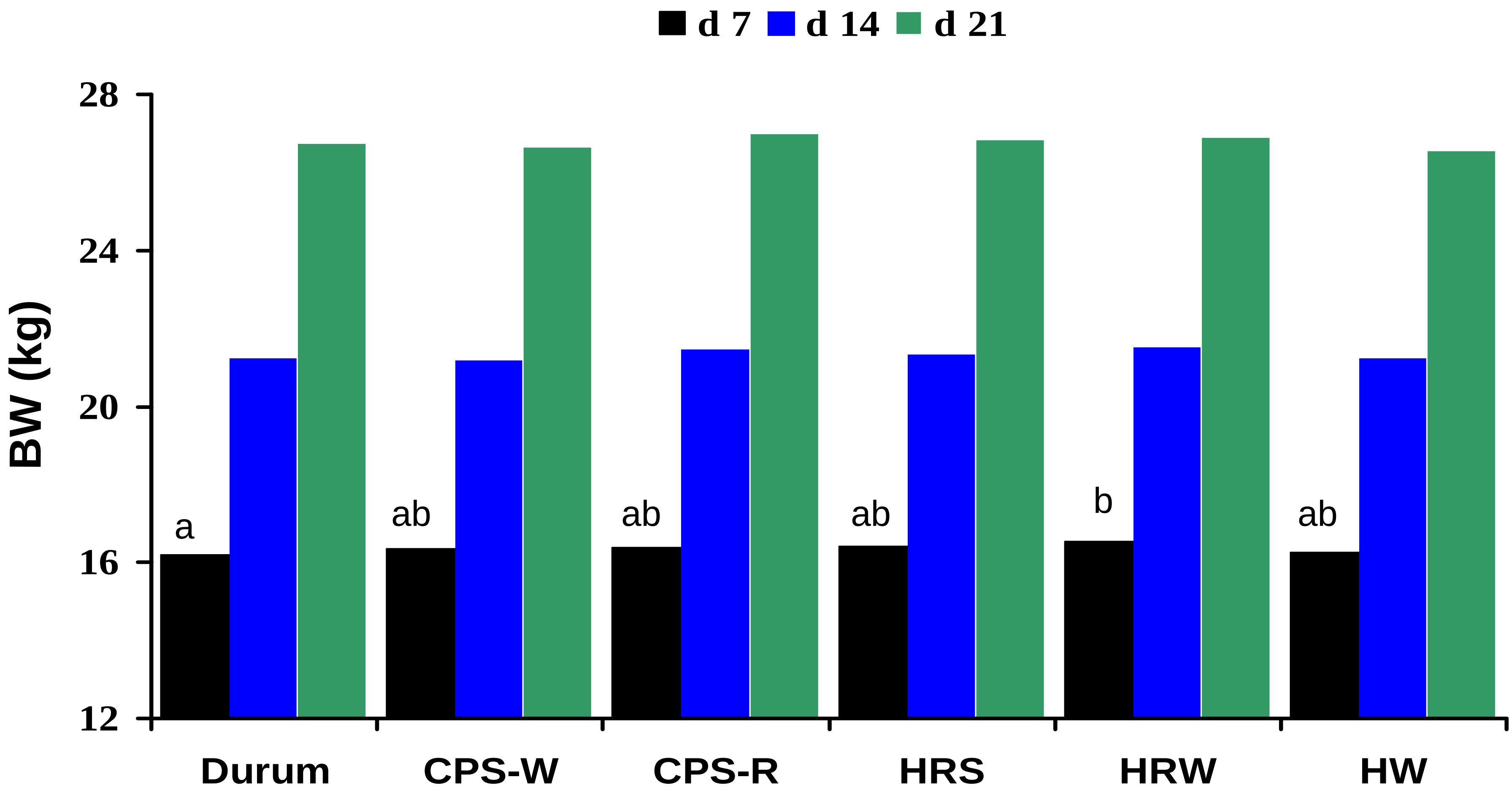
Impact of Class of Wheat on Weanling Pig Growth



Performance of weaned pigs was similar across wheat classes, including CPS and durum

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