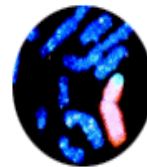
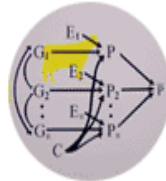


# Are more feed efficient pigs really less robust and more susceptible to disease?

Jack Dekkers

IOWA STATE  
UNIVERSITY

Animal  
Breeding &  
Genetics



ANIMAL  
SCIENCE



# Selection for Productivity has been very effective



**1972:**  
380 kg feed → 100 kg market pig



**2007:**  
325 kg feed → 125 kg market pig



Courtesy: Graham Plastow, Univ. Alberta

**Has selection for growth, leanness and efficiency made pigs less robust?**

**Does selection for feed efficiency result in pigs that have greater behavioral, physiological, and immunological problems, and that are more susceptible to stress and disease?**

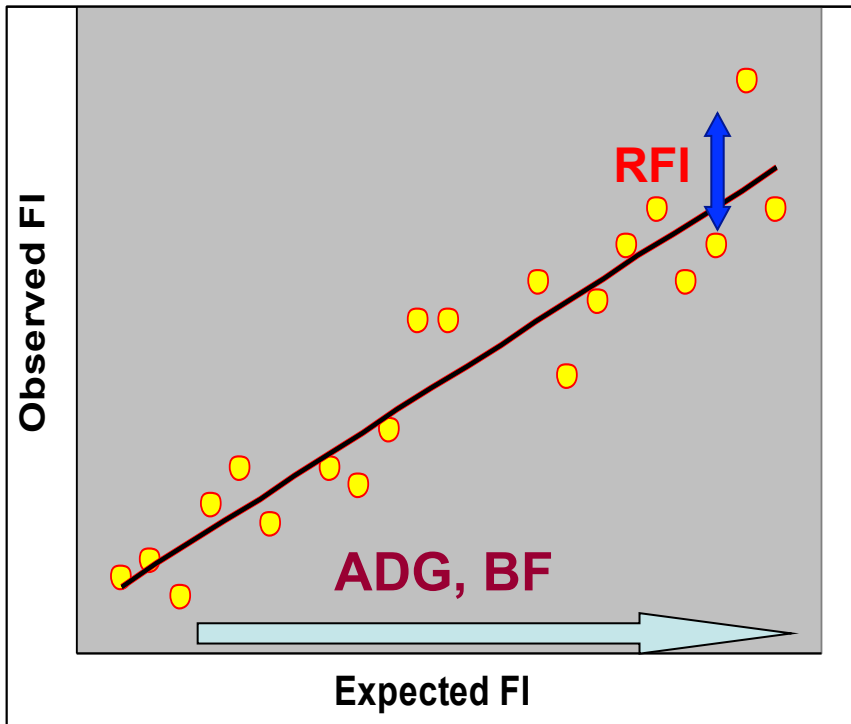
# Measures of Feed Efficiency

$$\text{FCR} = \text{Feed/gain}$$

$$\text{FE} = \text{Gain/Feed}$$



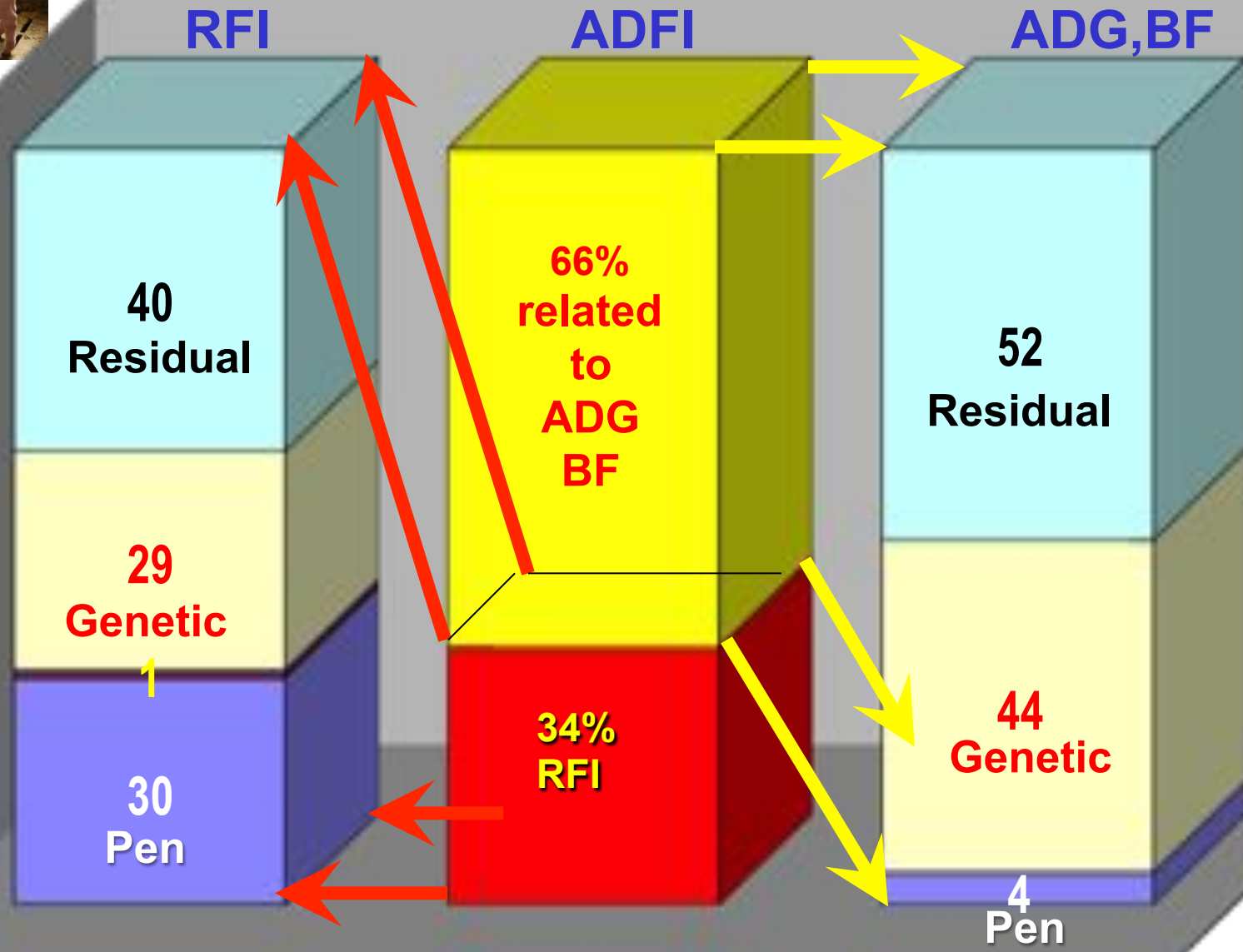
**Residual Feed Intake** = (Observed FI) – (Expected FI based on energy requirements for growth and maintenance)  
(Koch et al., 1963)



**Pigs with low  
(negative) RFI are  
more efficient**

$$\text{RFI} = \text{FI} - \beta_1 \text{ADG} - \beta_2 \text{BF}$$

# RFI - % of variation







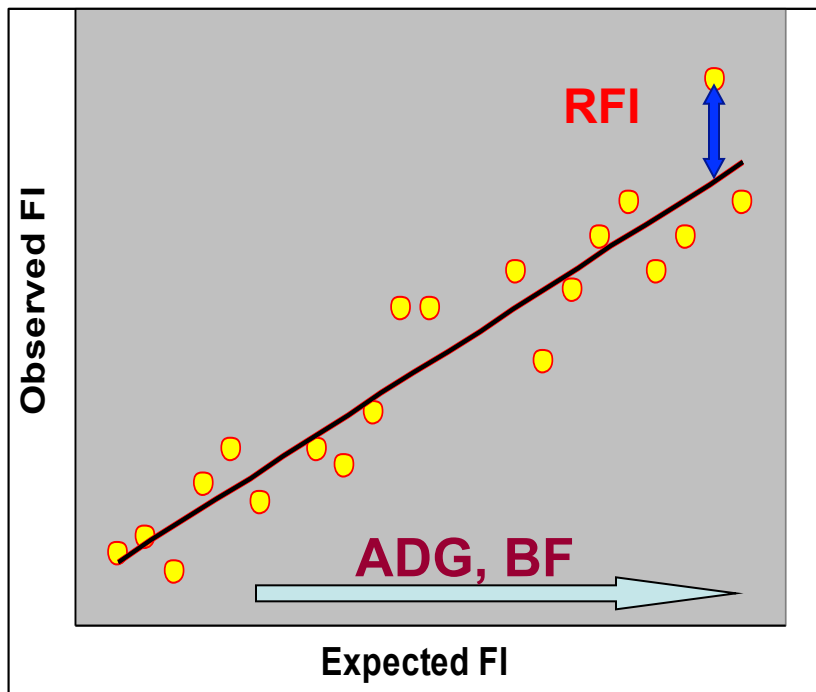
# Factors that contribute to RFI



**Residual Feed Intake** = (Observed FI) – (Expected FI based on energy requirements for growth and maintenance)

(Koch et al., 1963)

$$RFI = FI - \beta_1 ADG - \beta_2 BF$$



## Potential factors contributing to RFI

- Body composition
- Physical activity
- Maintenance requirements
- Digestibility
- Energetic efficiency
- Tissue turnover rates
- Immune response
- **Food wastage**
- **Measurement error**

# Residual Feed Intake Selection Lines



Est. 1999

IOWA STATE  
UNIVERSITY



Low RFI line

Hi RFI line

## Experimental Objectives

Develop lines that  
differ in Residual Feed Intake  
As a resource population to study the  
biological & physiological basis of  
feed intake & efficiency

Develop tools to improve feed efficiency

# Individual feed intake under group housing

**INRA**

**Acema 64**

**ISU**

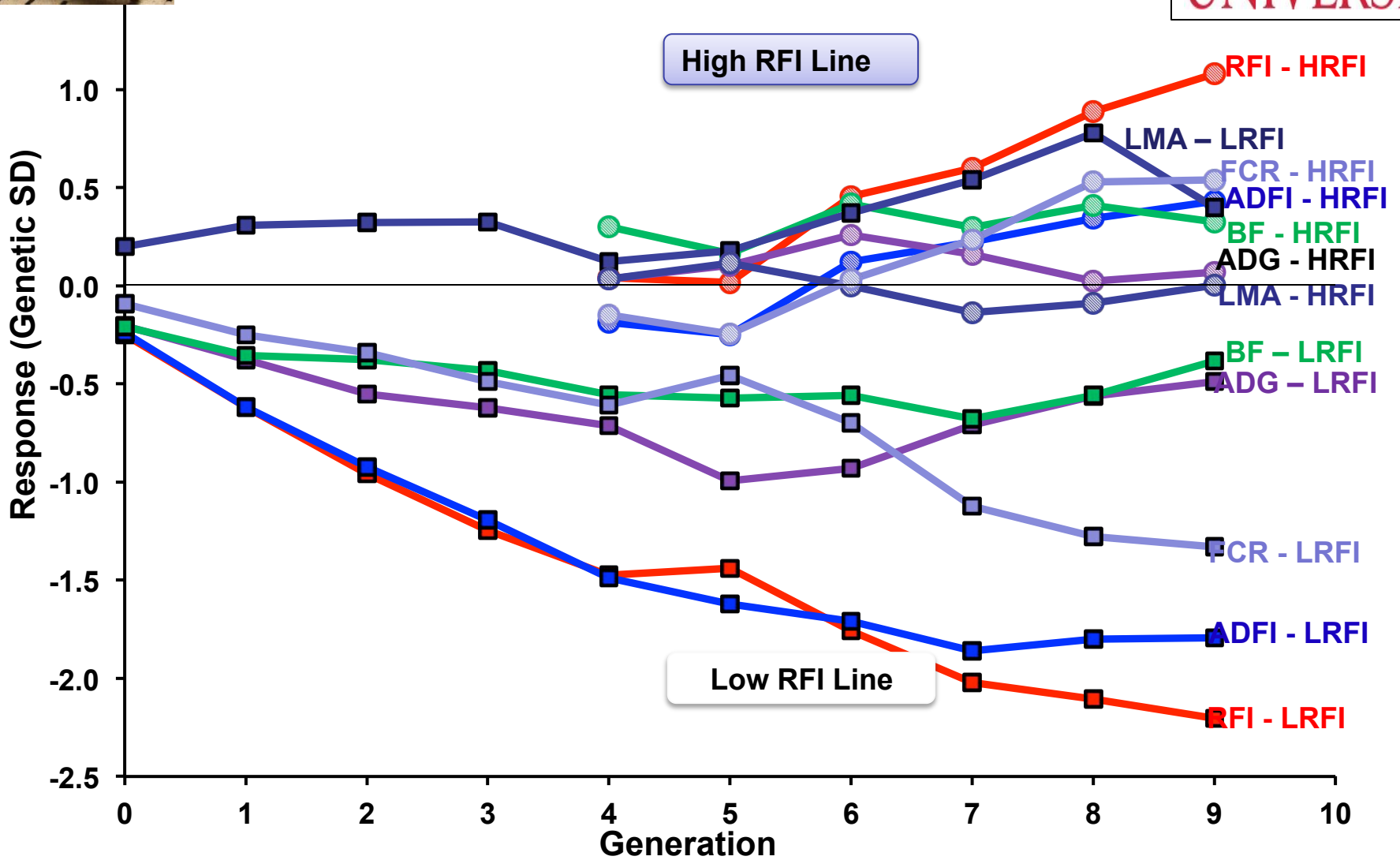
**FIRE<sup>©</sup>**





# Genetic Trends - ISU

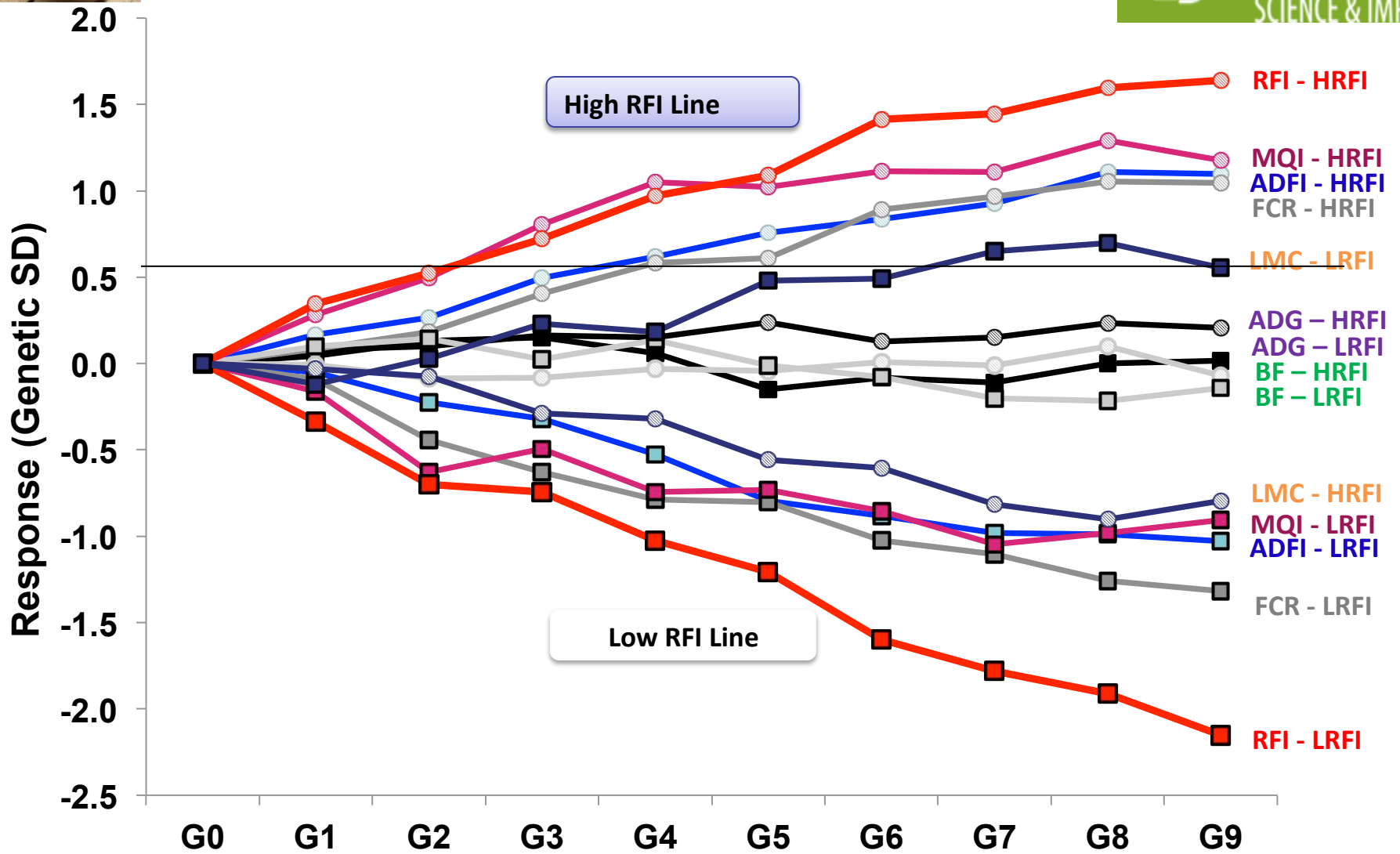
IOWA STATE UNIVERSITY





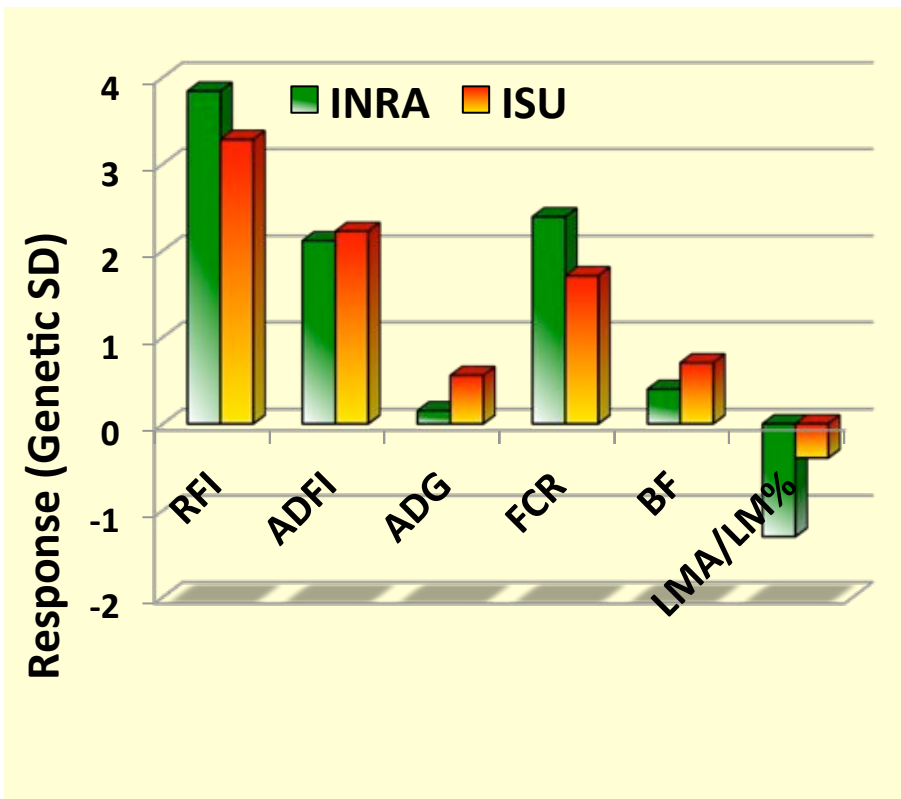


# Genetic Trends - INRA

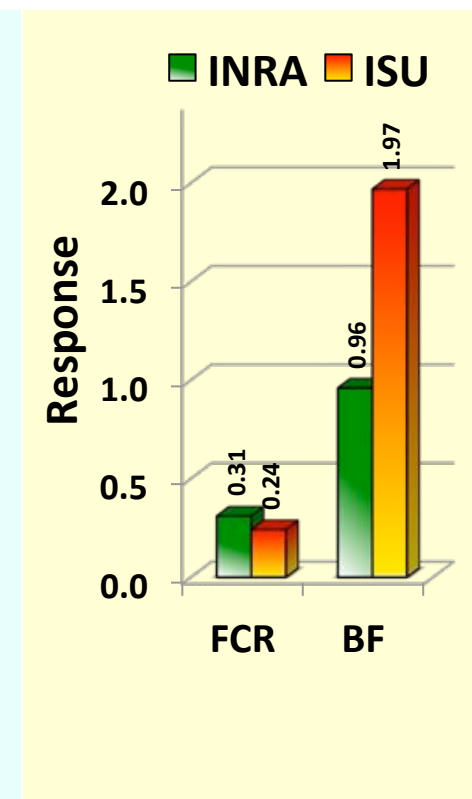
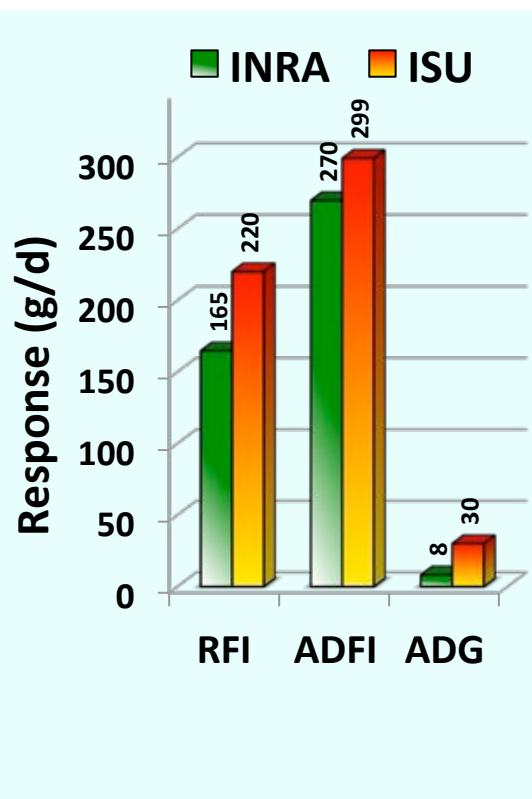


## HRFI – LRFI

### In Genetic SD

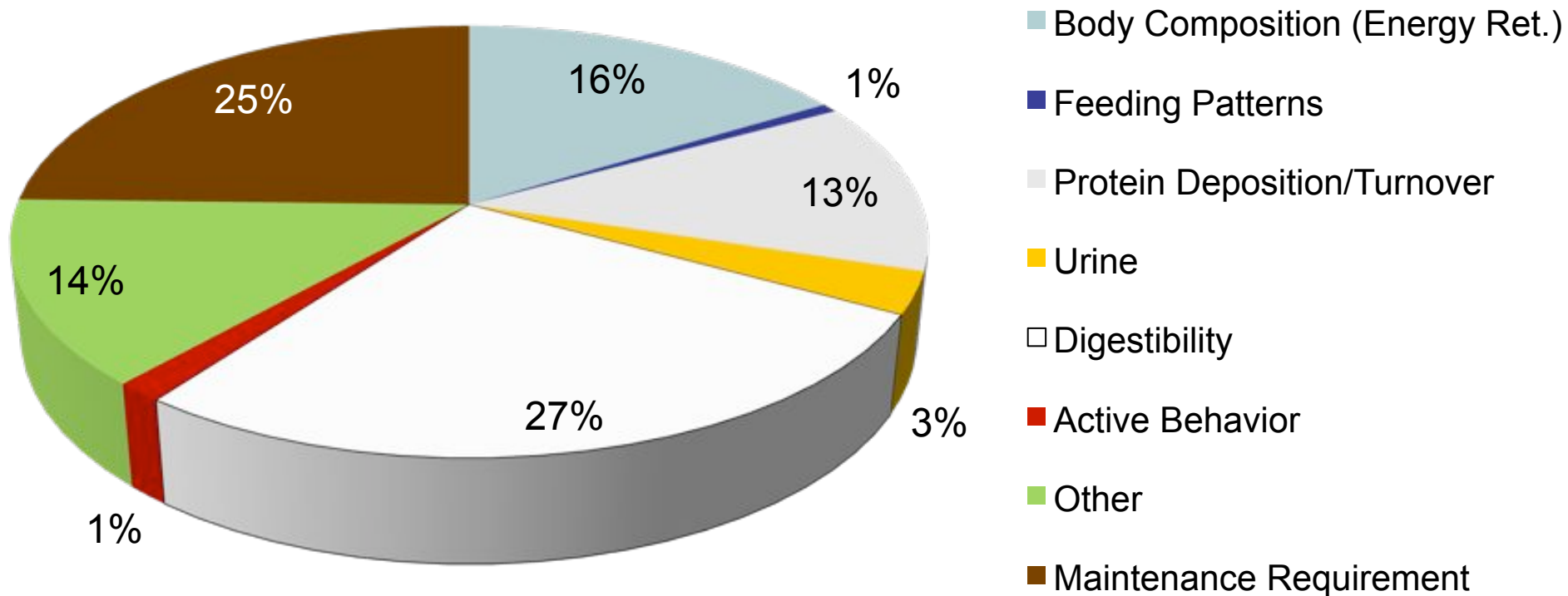


### In Trait Units



# Estimates of the contribution of different mechanisms to variation in RFI

Amanda Harris and Nick Gabler



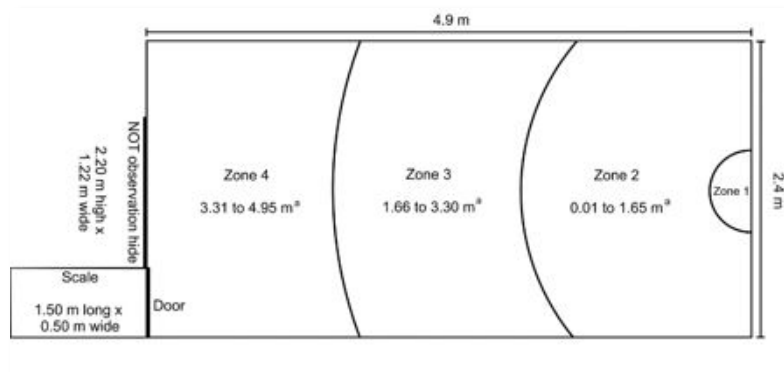
# Are efficient pigs less able to handle different types of stress?

- ◆ Behavioral stress
- ◆ Cortisol response to ACTH challenge
- ◆ Response to immune and inflammatory challenges
- ◆ Stress of gestation and lactation



# Behavioral stress

Jessica Colpoys  
Anna Johnson et al.



## Low-RFI pigs:

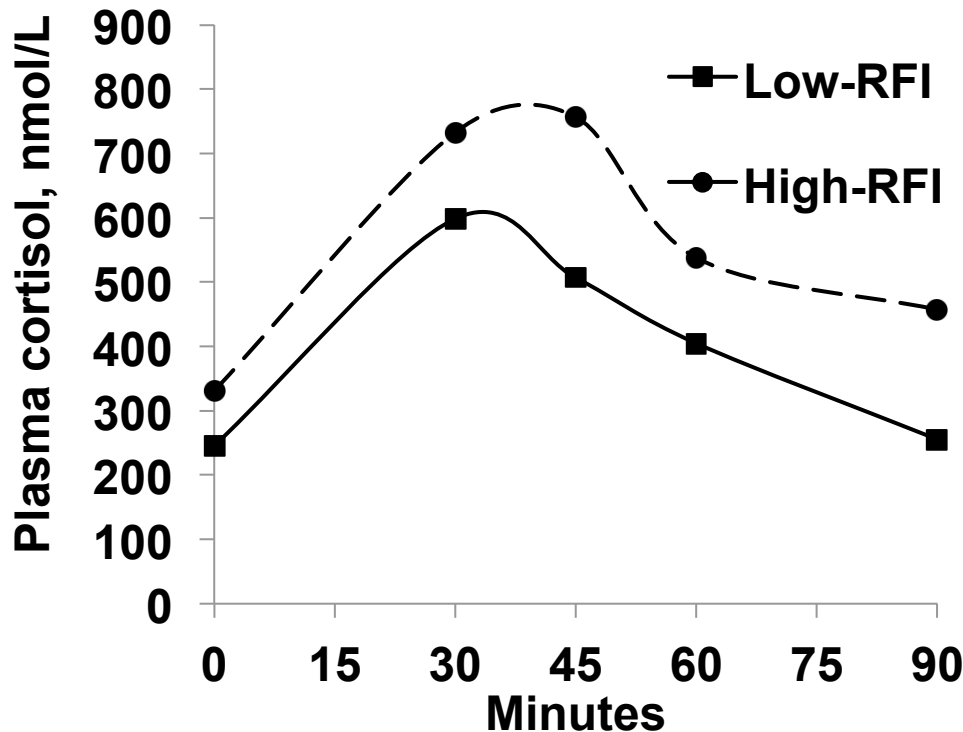
- ✓ Took longer to approach the human and cone
- ✓ Were calmer and less reactive to both tests

## Implications

- ◆ Improving feed efficiency (Low-RFI):
  - ◆ Did not compromise pig welfare
  - ◆ Less reactive to novel stimuli
  - ◆ May have effects on animal-human interactions and handling facilities

# Stress response – ACTH challenge

Jessica Colpoys  
Nick Gabler et al.

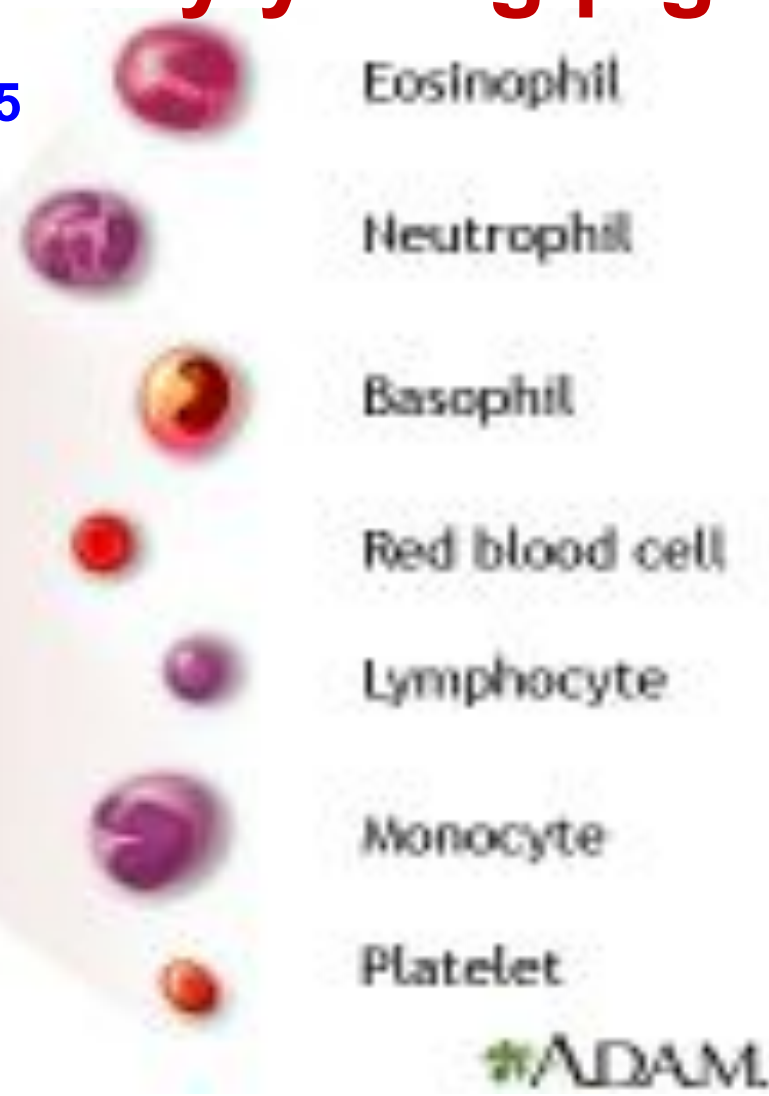


Factor	P-value
Line	0.03
Time	0.0006
Line*Time	0.53

**Low-RFI gilts had lower pre- and post-challenge cortisol levels**

# Blood Cell Counts in healthy young pigs

Mpetile, Tuggle et al. J. An. Sci. 2015



Eosinophil

Neutrophil

Basophil

Red blood cell

Lymphocyte

Monocyte

Platelet

ADAM

## Low RFI pigs had:

- **Higher Red Blood Cell counts**
  - Greater oxygen carrying capacity
- **Lower White Blood Cell counts**
  - Lower energy requirements for basal immune response

# Response to PRRS challenge



**KSU Rowland  
nursery pig model**

**Dunkelberger et al.  
Livestock Sci. 2015**



**~100 piglets / line infected with  
PRRS virus isolate NVSL97-7985**

**Acclimation**

Day post  
infection -7

0

4

7

11

14

21

28

35

40

Birth

Serum  
Antibiotics

Weight  
Serum  
Inoculation

Weight  
Serum

Weight  
Serum

Weight  
Serum

Weight  
Serum

Weight  
Serum

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Serum



# 2011-68004-30336  
United States  
Department of  
Agriculture  
National Institute  
of Food  
and Agriculture

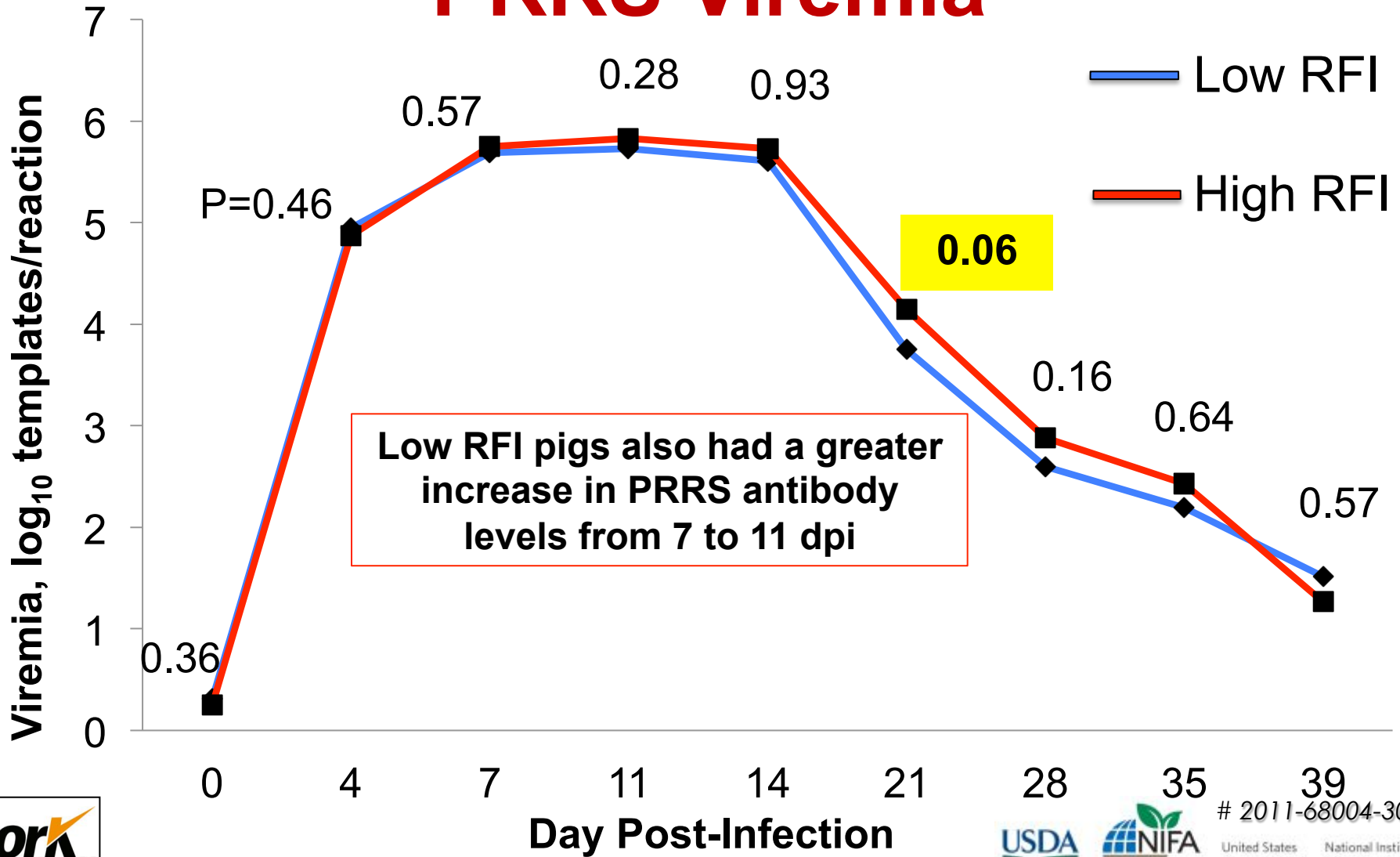
**IOWA STATE UNIVERSITY**



**Department of Animal Science**

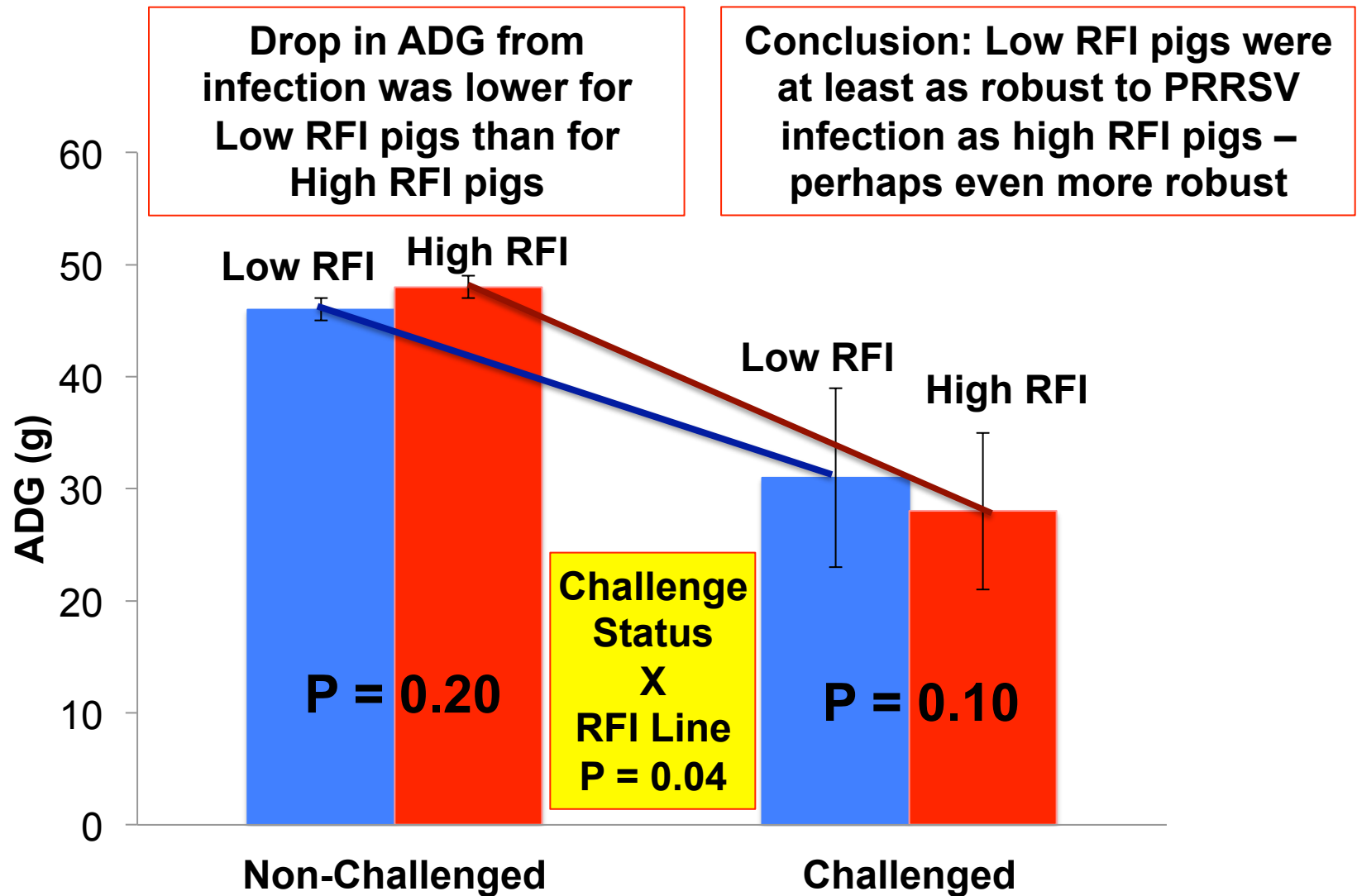


# PRRS Viremia



# 2011-68004-30336  
 United States Department of Agriculture  
 National Institute of Food and Agriculture

# Average Daily Gain



# EFFECT OF SELECTION FOR RFI ON SOW PERFORMANCE

**J. M. Young†, R. Bergsma‡, E. F. Knol‡, J. F. Patience†,  
J. C. M. Dekker†**

*† Department of Animal Science, Iowa State University, Ames, IA 50011*

*‡ Institute for Pig Genetics (IPG), Beuningen, the Netherlands*

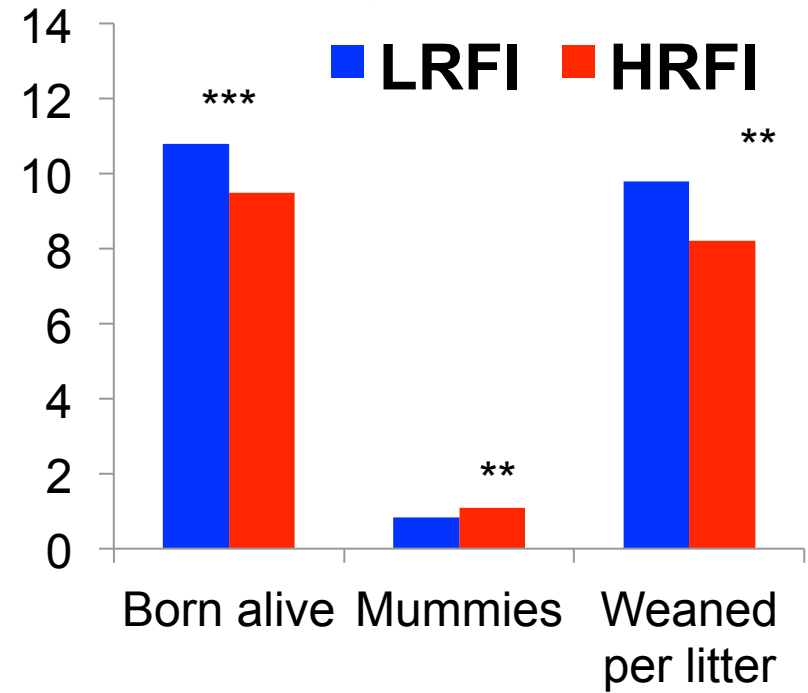
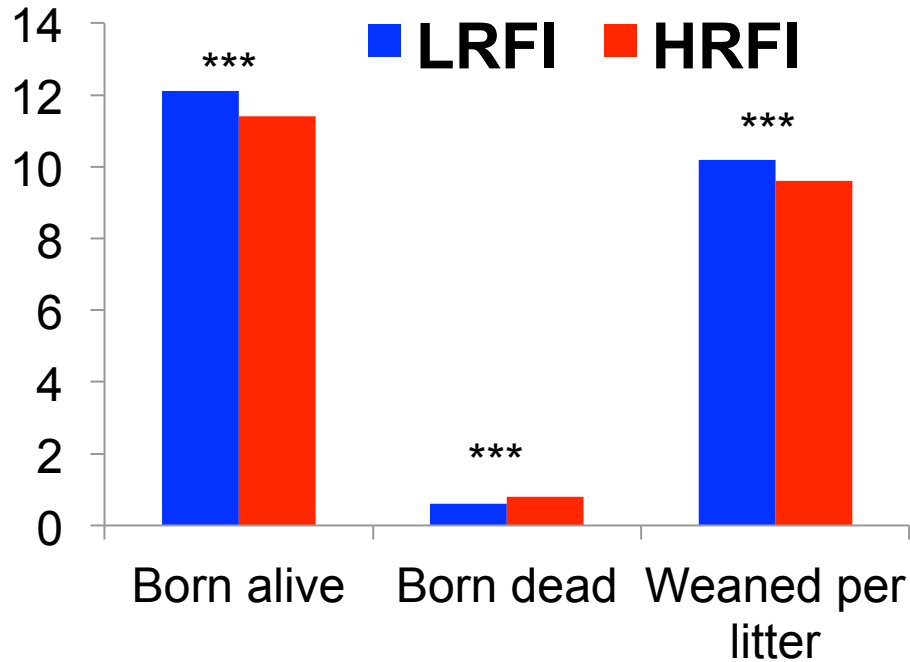
**H. Gilbert\*†, J.-P. Bidanel\*, P. Sellier\*, J. Noblet#, S. Hermescht ‡**

*\*INRA, F-78350 Jouy-en-Josas, France, †INRA, F-31326 Castanet-Tolosan, France*

*#INRA, F-35000 Rennes, France*

*‡AGBU, University of New England, Armidale NSW 2351, Australia*

# Litter Size

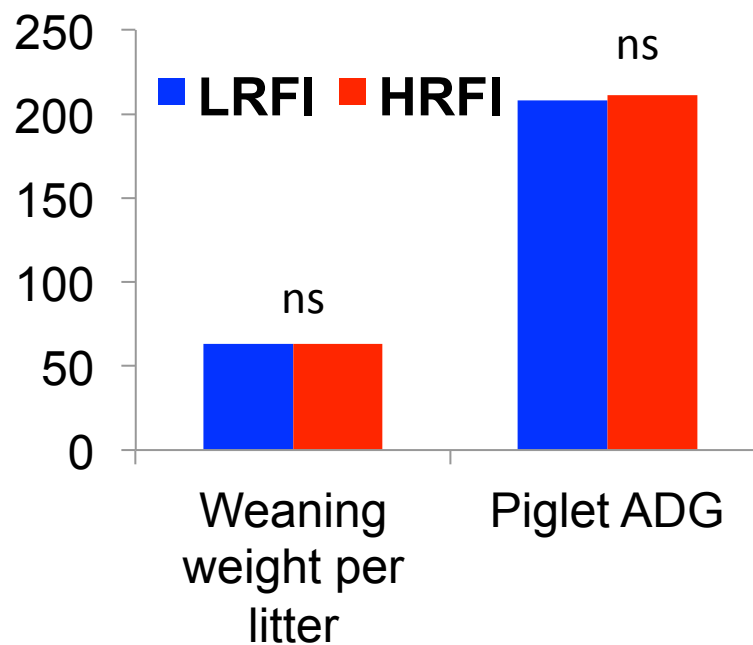
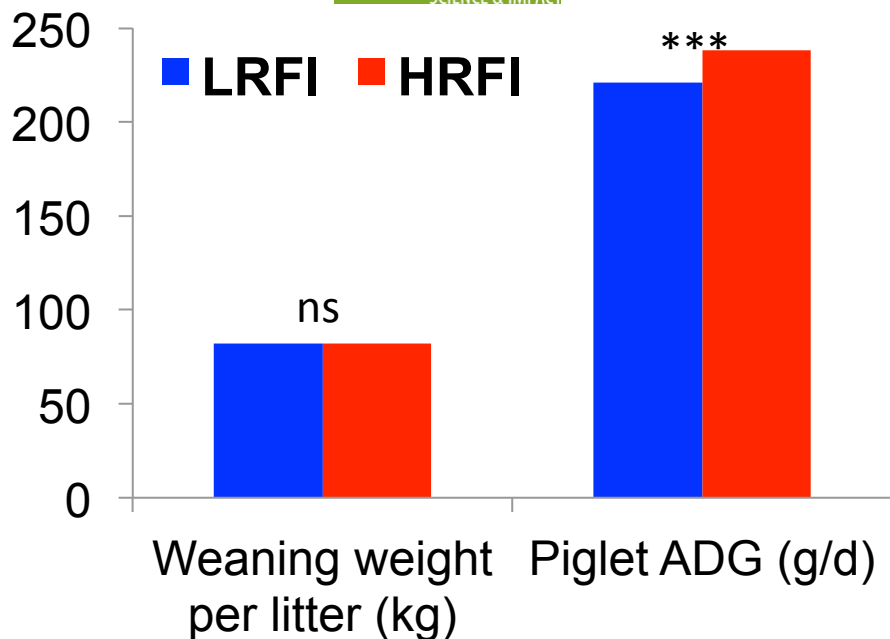


**Low RFI sows have**

higher number born alive  
higher number weaned



# Litter performance



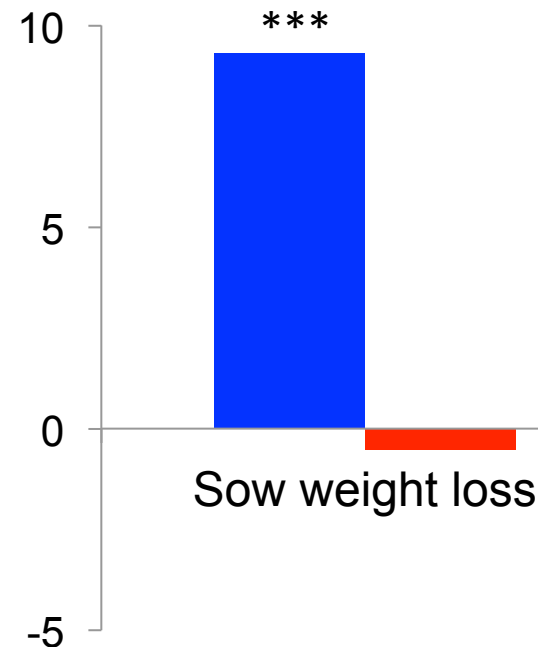
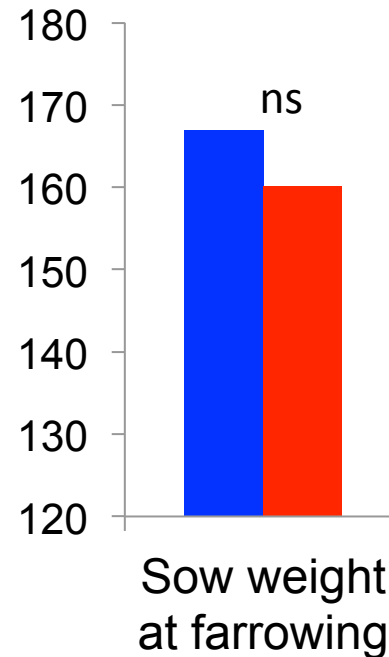
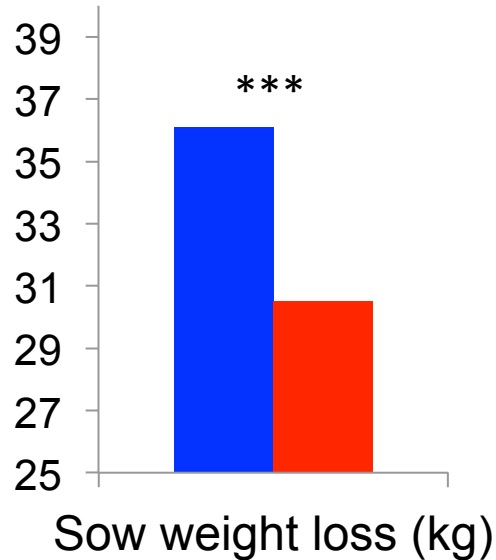
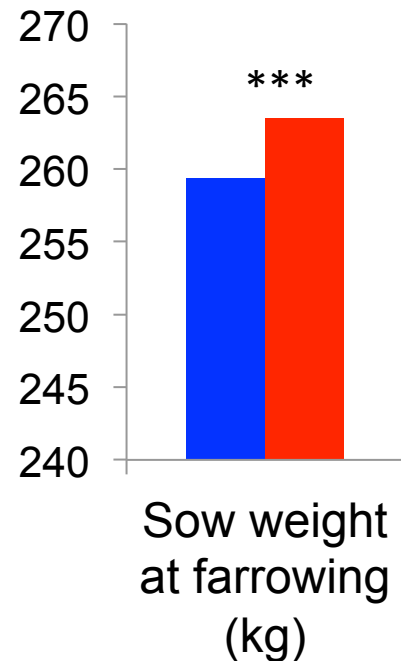
**Low RFI sows have**

similar litter and piglet weight at weaning

# Feed intake and body resources during lactation

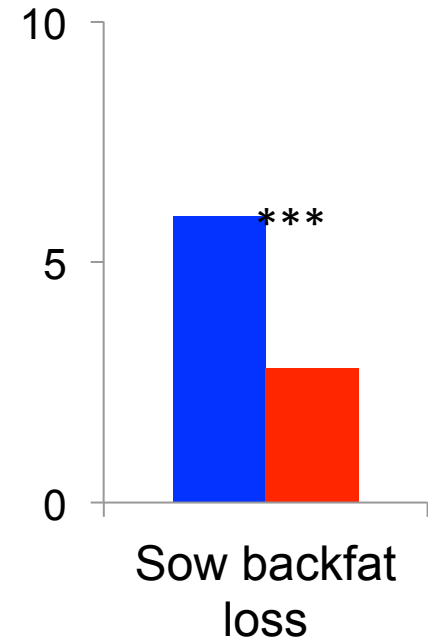
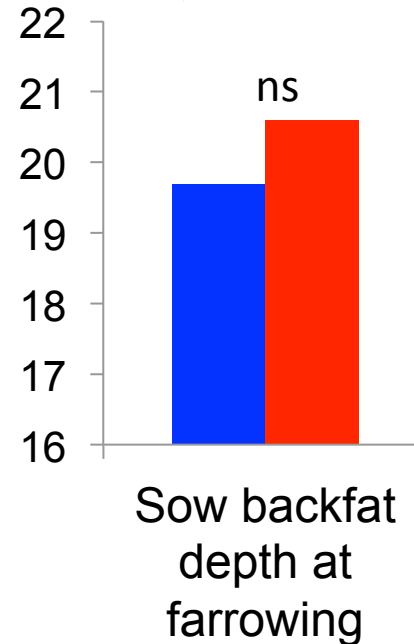
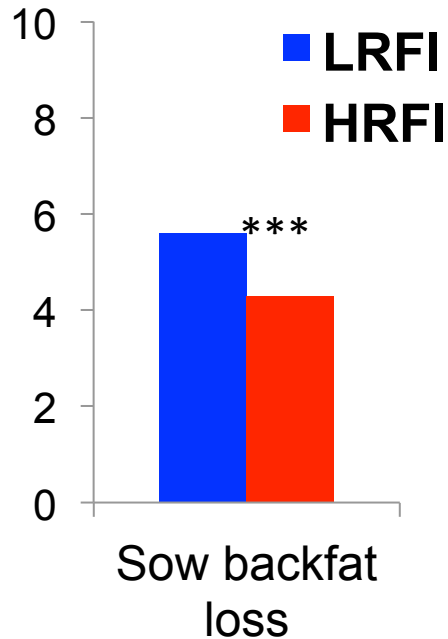
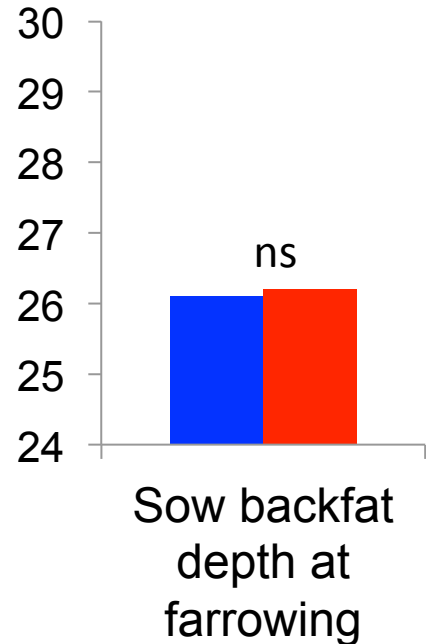


■ LRFI ■ HRFI



**Low RFI sows have greater weight loss during lactation**

# Feed intake and body resources during lactation

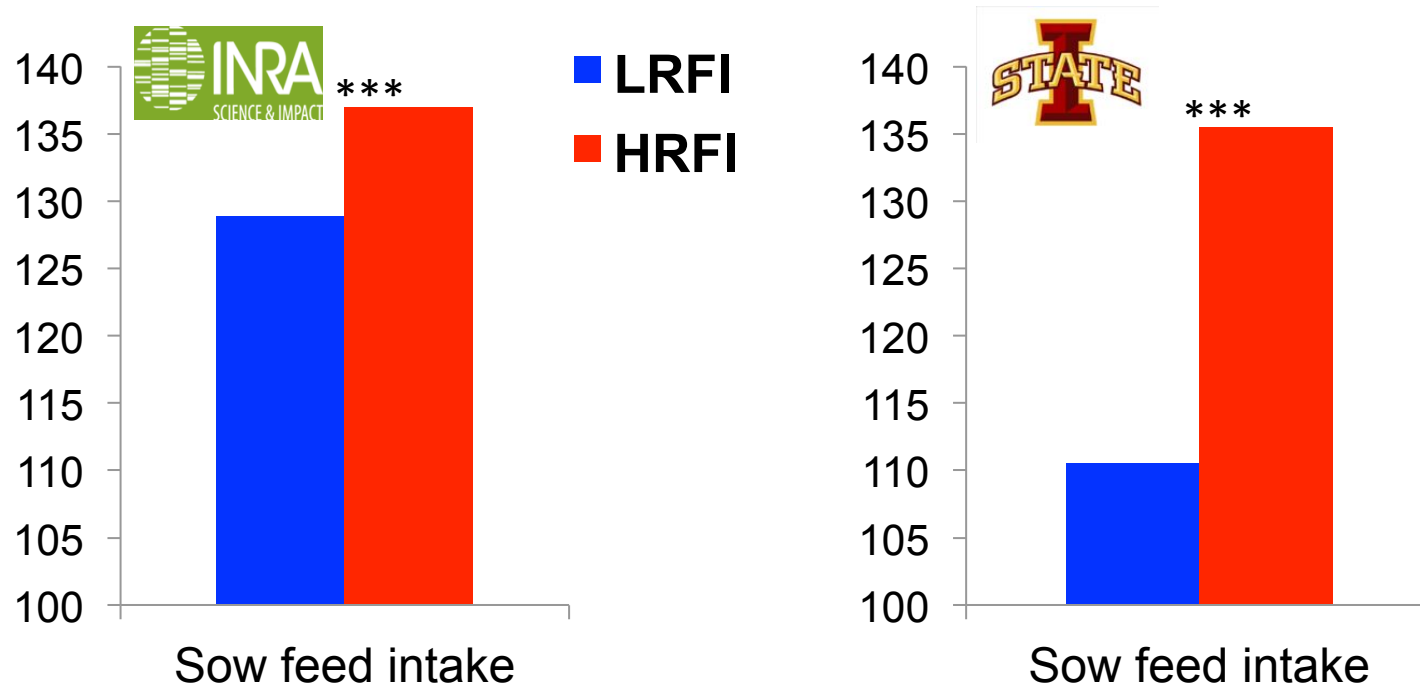


**Low RFI sows have**

higher weight loss during lactation

higher backfat loss during lactation

# Feed intake and body resources during lactation



## Low RFI sows have

- higher weight loss during lactation
- higher backfat loss during lactation
- lower feed intake during lactation

# Feed efficiency during lactation

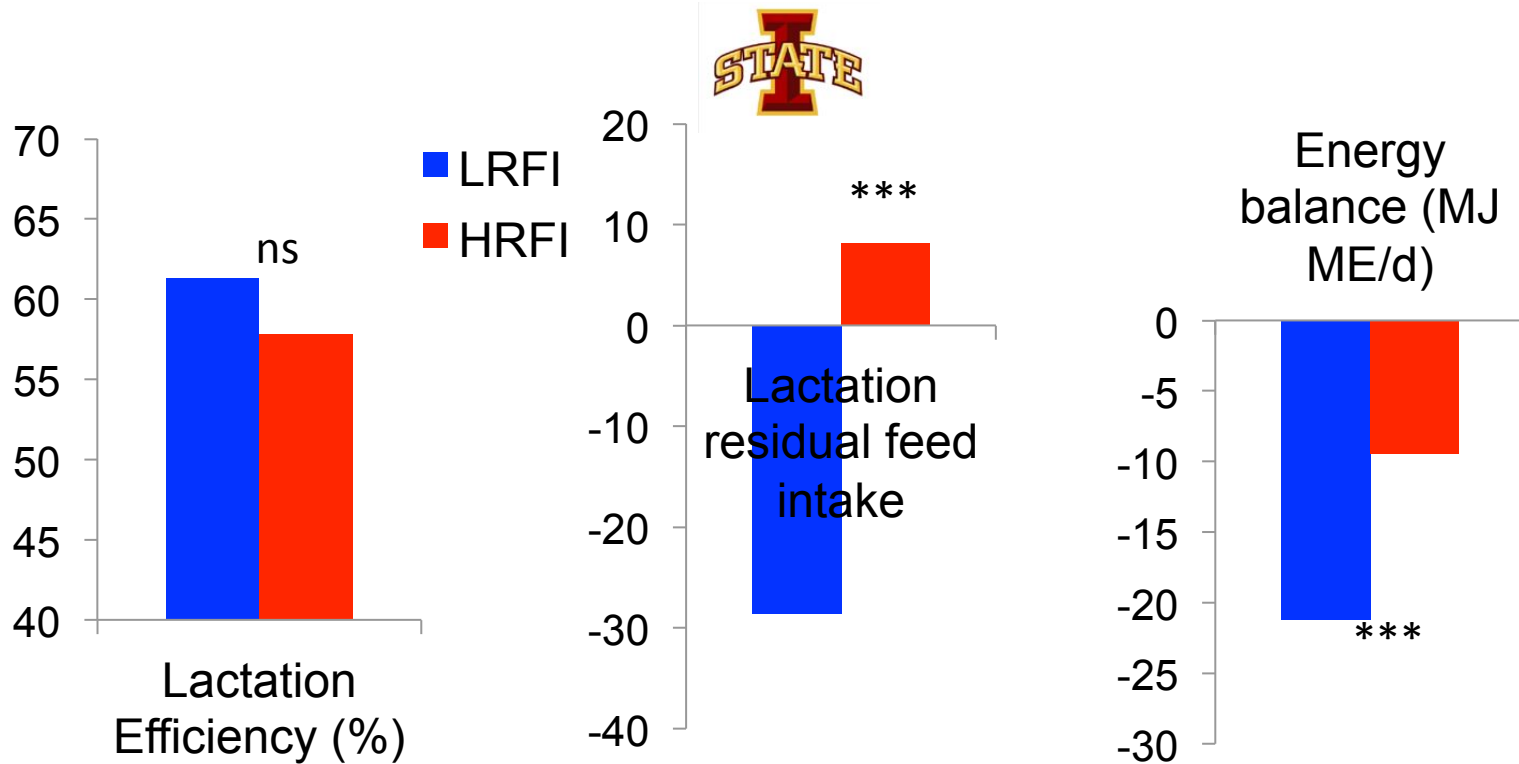
## LRFI sows have

- higher weight loss during lactation
- higher backfat loss during lactation
- lower feed intake during lactation

- higher number of born alive
- higher number of weaned
- similar weaning litter weight and piglet weight

➔ What about feed efficiency during lactation?

# Feed efficiency during lactation



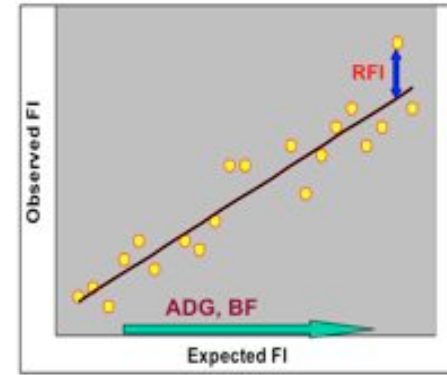
LRFI sows have

- higher (ns) lactation efficiency and higher energy inputs ( $P=0.09$ )
- lower lactation RFI (also at INRA)
- higher negative energy balance



# Conclusions

- ~35% of differences in feed efficiency are independent of growth and backfat = RFI
- RFI is a heritable trait and responds to selection
- Pigs that are selected for increased efficiency based on RFI do NOT have greater behavioral, physiological, and immunological problems, or are more susceptible to stress and disease?
- In contrast pigs selected for efficiency based on RFI:
  - Are calmer and less fearful
  - Are less responsive to physiological stress
  - Are less affected by PRRS infection
  - Appear to have a more effective efficient immune response
  - Are not more affected by heat stress
  - Are better able to withstand the stresses of gestation and lactation
  - Are better able to direct resources where needed – greater “metabolic flexibility”
  - Are less affected by environmental differences



# Feed efficiency during lactation

## LRFI sows have

higher weight loss during lactation  
higher backfat loss during lactation  
lower feed intake during lactation

greater number of born alive  
greater number of weaned  
similar weaning litter weight and piglet weight

→ No impairment of the lactation efficiency

→ What about rebreeding?



- Low numbers of rebreeding failures
- No difference observed between lines



# Acknowledgements



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### Nutrition

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### Physiology / Behavior

Anderson, Johnson

### Statistics

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### Computer Science

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### Nutrition

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### Physiology / Behavior

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Hélène Gilbert et al.



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National Institute of Food and Agriculture



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