Improving Dairy Cow Reproduction While Maintaining High Milk Production

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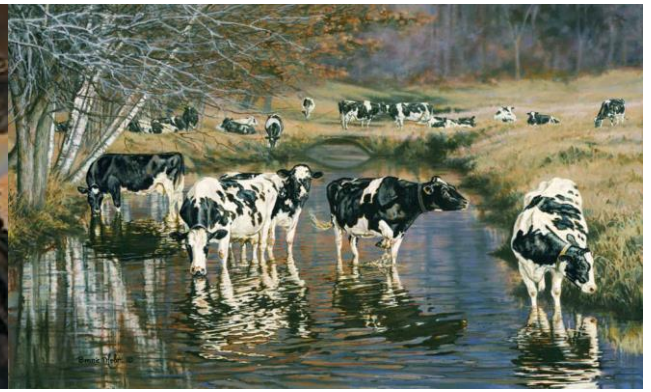


Pictures by Bonnie Mohr http://www.bonniemohr.com/

UNIVERSITY OF FLORIDA

Department of Animal Sciences

The Dairy Research Foundation's 2017 Symposium

THE UNIVERSITY OF SYDNEY

July 25 to 27, Port Macquarie, NSW

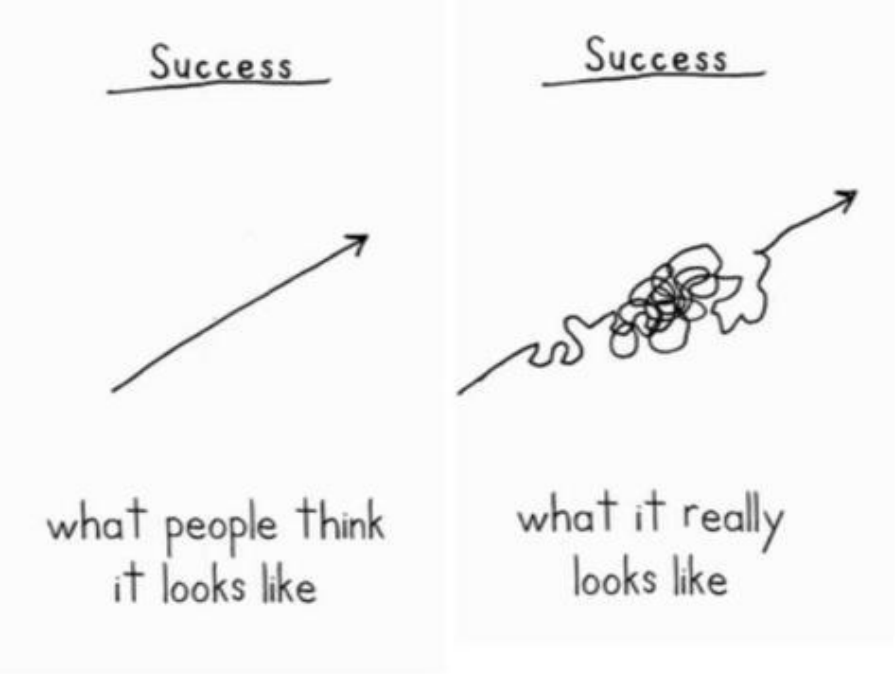
Outline

- I want to describe some of the evolution that has taken place in the dairy industry in the US

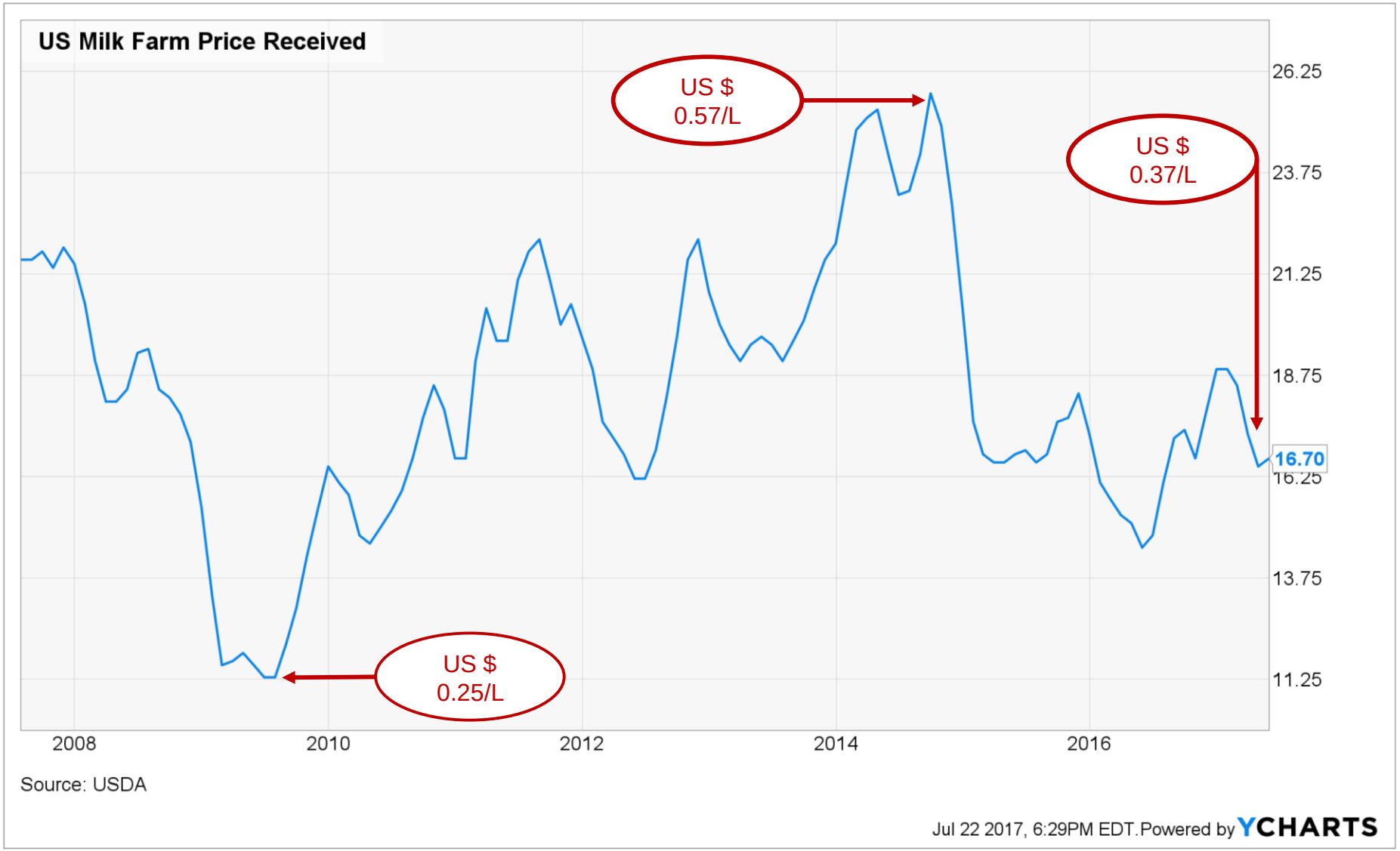
- The driving forces for improved reproduction in most dairy farms

- Provide a conceptual snapshot on a multitude of factors that influence reproduction on a dairy farm
  - ✓ Peripartum health
  - ✓ Reproductive programs
  - ✓ Genomics for genetic selection

(Hidden element → H-factor)



US Milk Price Received – Farm ($/45 kg) (Last 10 years)



Sources of Income for a Dairy Farm

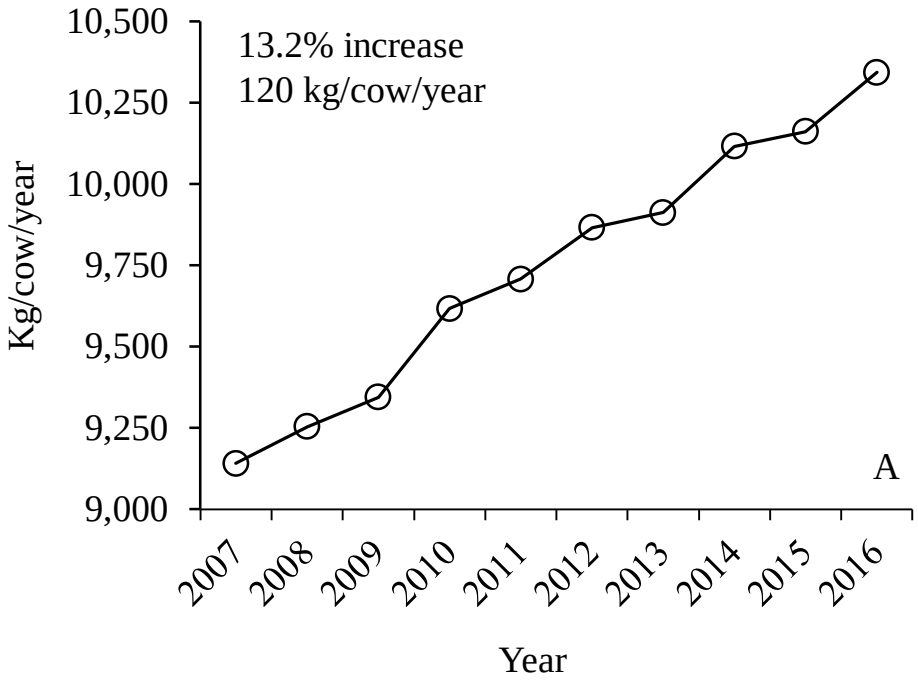
- Milk
- Sale of prepartum cows
- Sale of cows for dairy purposes
- Sale of cows for beef
- Sale of bull calves

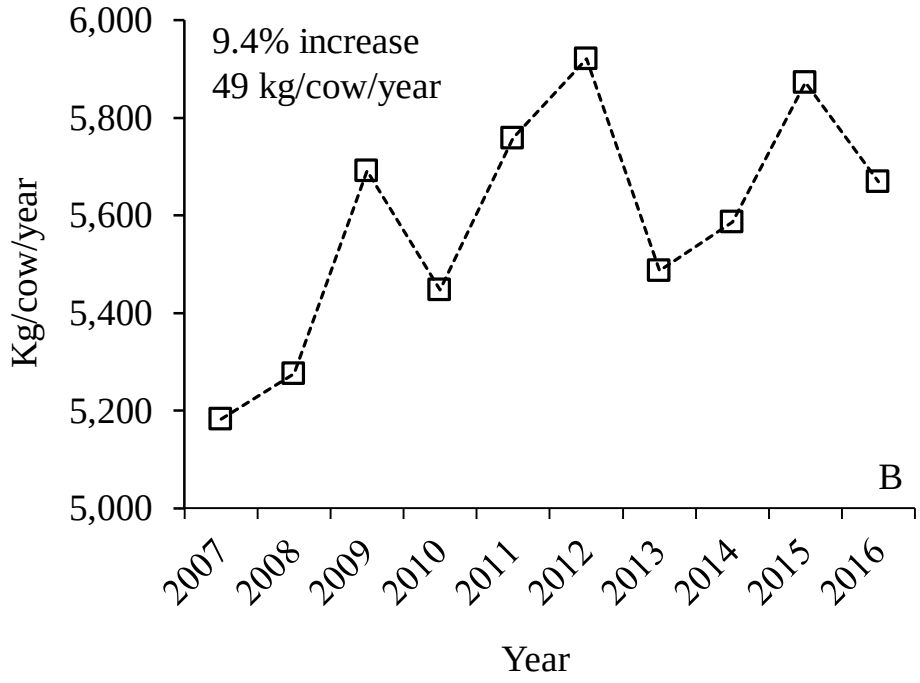
Data used (2 large high-producing dairy herds)

- Production per cow = 12,500 kg/year
- Price of milk = $ 0.30/Kg
- Value of a prepartum heifer = $2,000
- Value of a bull calf = $30
- Value of a cows sold to dairy = $1,600
- Value of cull cow = $600
- Mortality of cows = 5.7%
- Replacement = 28.1%
- Herd turnover = 33.8%
- Number of calvings/year = 132% of lactating herd
- Stillbirth = 8%

Santos et al. (2012) Soc. Reprod. Fertil. Suppl. 67:387-403

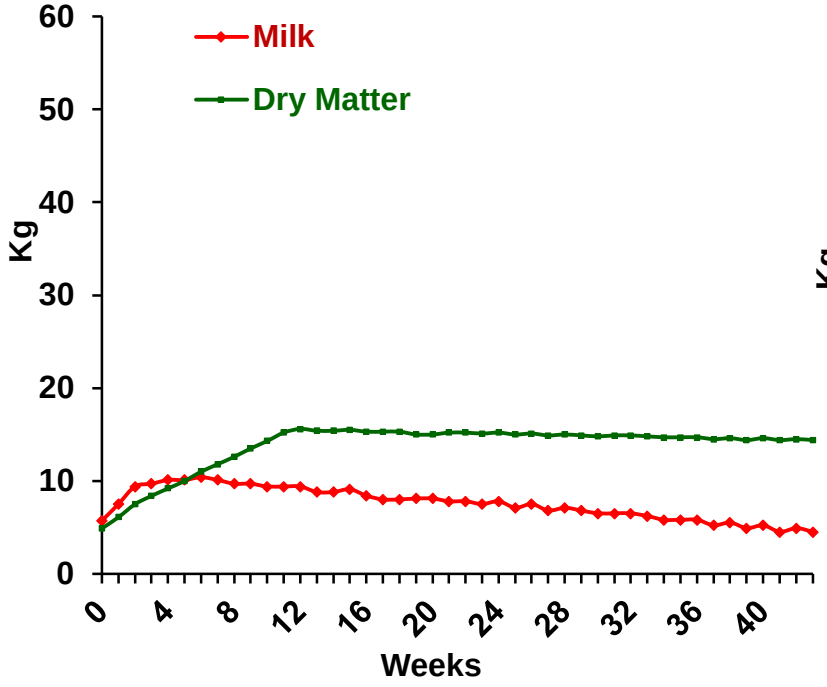
Changes in milk production per cow per year in the USA (A) and Australia (B) from 2007 to 2016

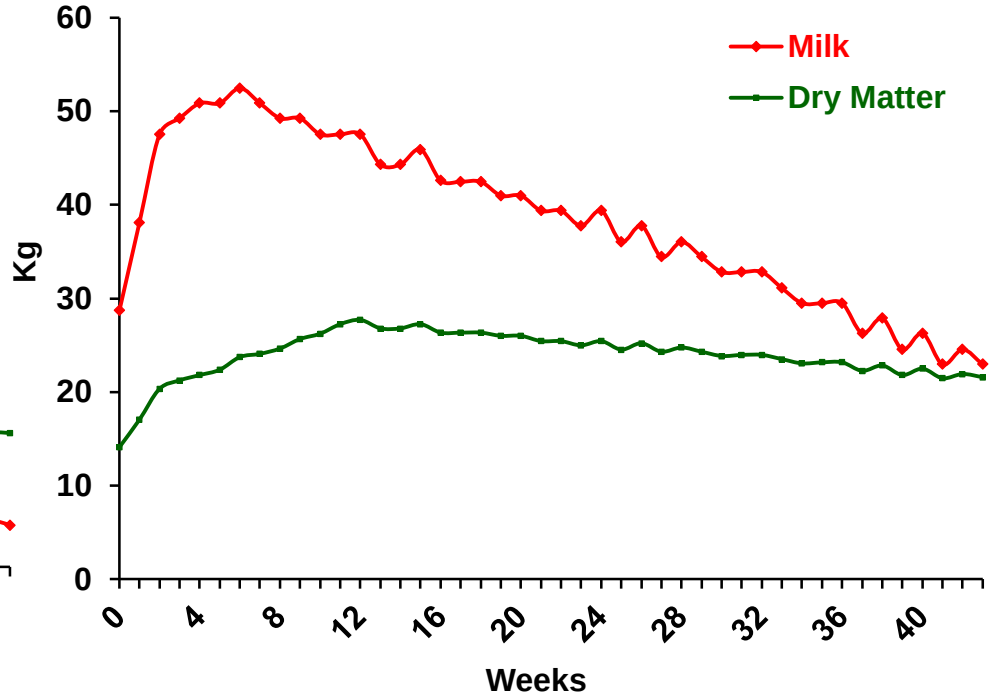




Sources: US Department of Agriculture and Dairy Australia

The Evolution of the Dairy Cow in the US Industry

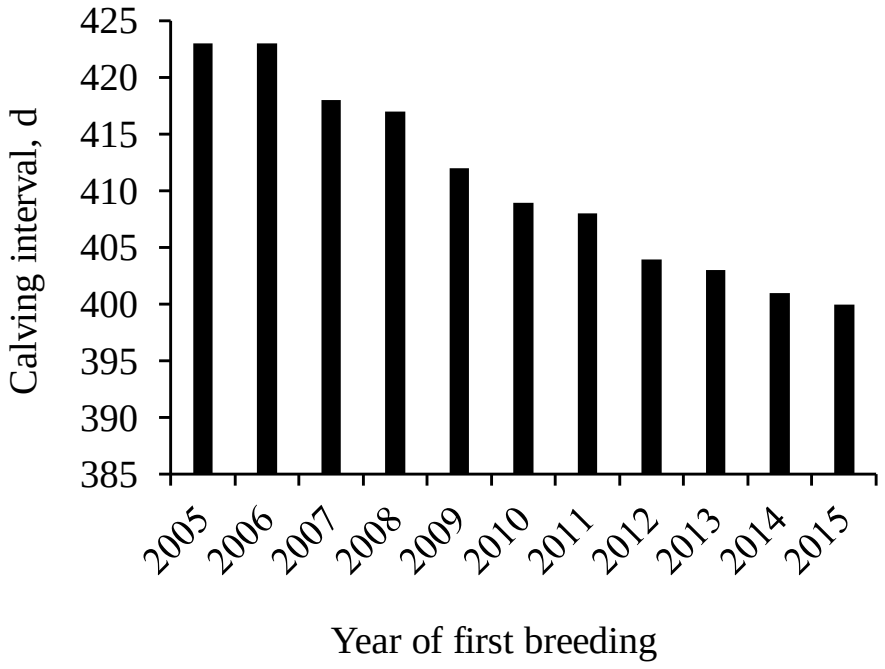


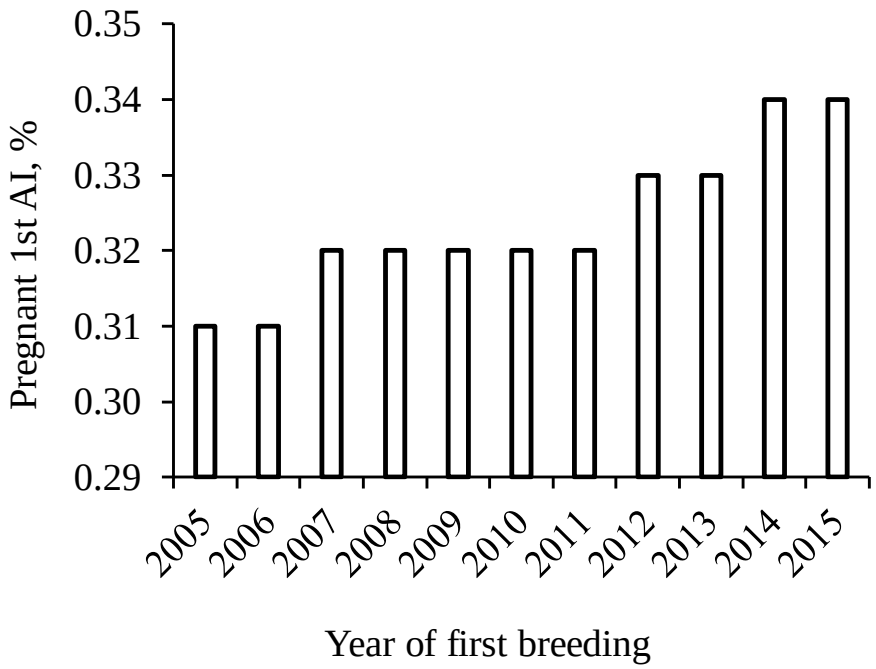


Current World Record (2017)

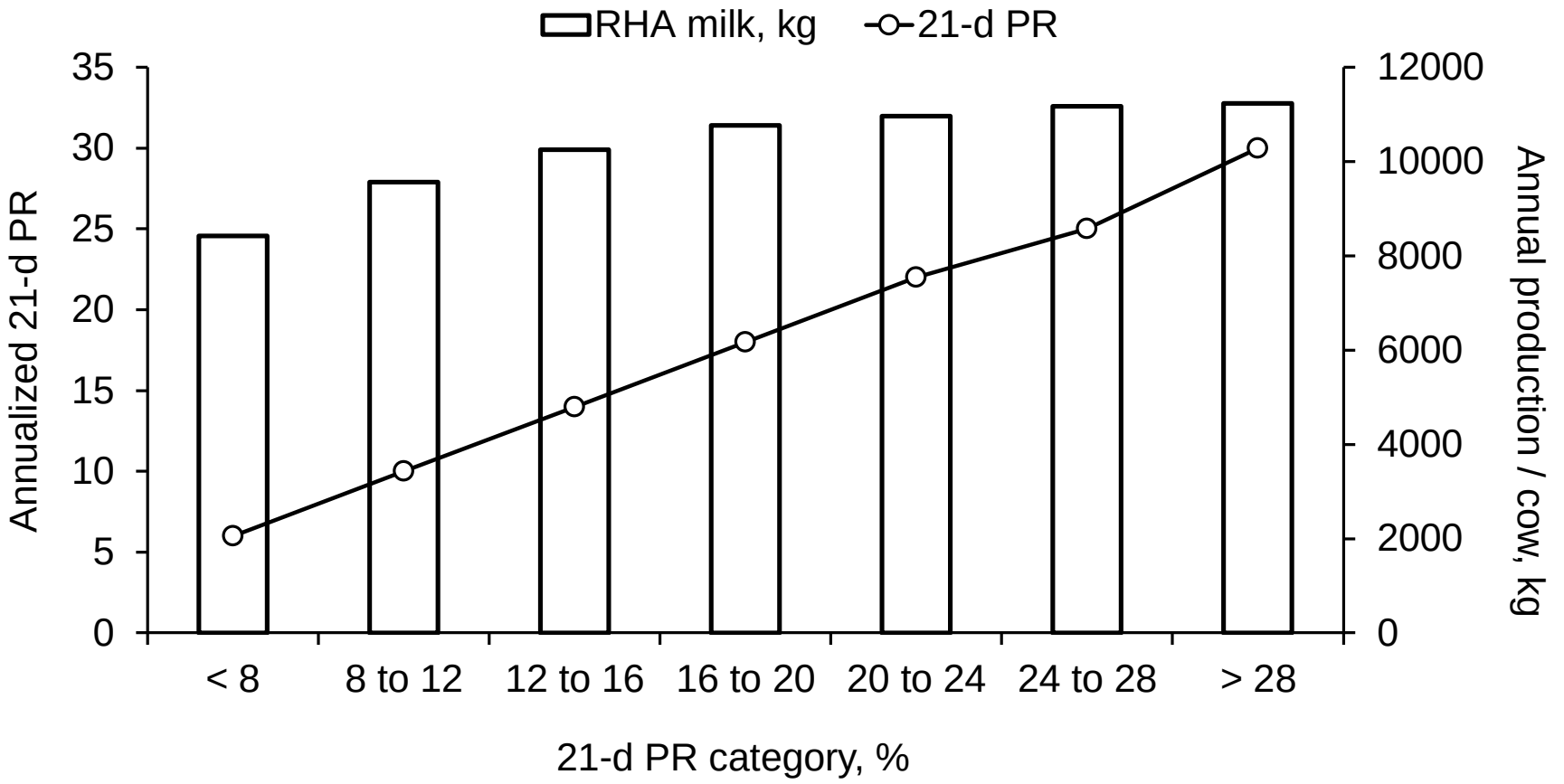
- **Ever-Green-View My Gold-ET** has set a new single-lactation world record for milk production
  - 365-day record of 35,144 kg in 365-d at 5-years of age (77,480 lbs)
  - 906 kg of fat
  - 934 kg of true protein
  - Her milk contained 2.57% fat and 2.65% true protein
    - She averaged 96.3 kg/d of milk, 2.50 kg/d of fat and 2.56 kg/d of protein

Evolution of Reproductive Performance in Dairy Cows in the Last Decade





21-d Pregnancy Rate and Milk Production of USA Herds



Source : DRMS, DairyMetrics, April 26th , 2011

Reproductive Indices

- Estrous detection rate = $\frac{\text{Number of cows detected in estrus}}{\text{Number of eligible cows to be in estrus}}$

  Insemination rate

- Pregnancy per AI = $\frac{\text{Number of pregnant cows}}{\text{Number of inseminated cows}}$

- Pregnancy rate = $\frac{\text{Number of pregnant cows}}{\text{Number of eligible cows to become pregnant}}$

True rate and it is typically evaluated at 21-d intervals

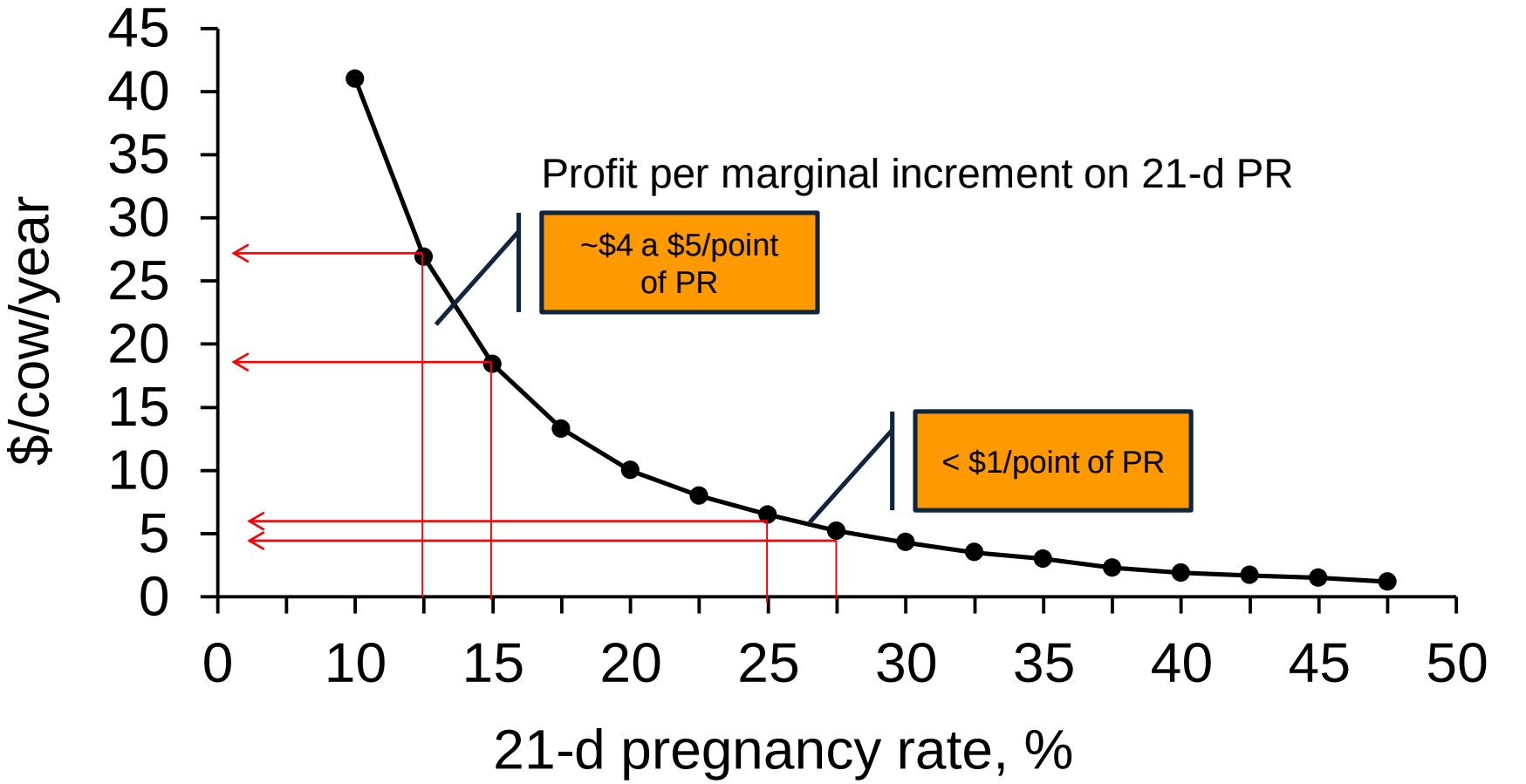
Santos (2008) Cattle Practice 16:5-14

Reproductive Indices: Estrous detection, Pregnancy per AI, and 21-d Pregnancy Rate

Interval	Elegible cows	Cows inseminated	ED, %	Cows pregnant	P/AI, %	PR 21-d, %
51-71	100	60	60.0	24	40.0	24.0

Santos (2008) Cattle Practice 16:5-14

The Economic Importance of Reproduction

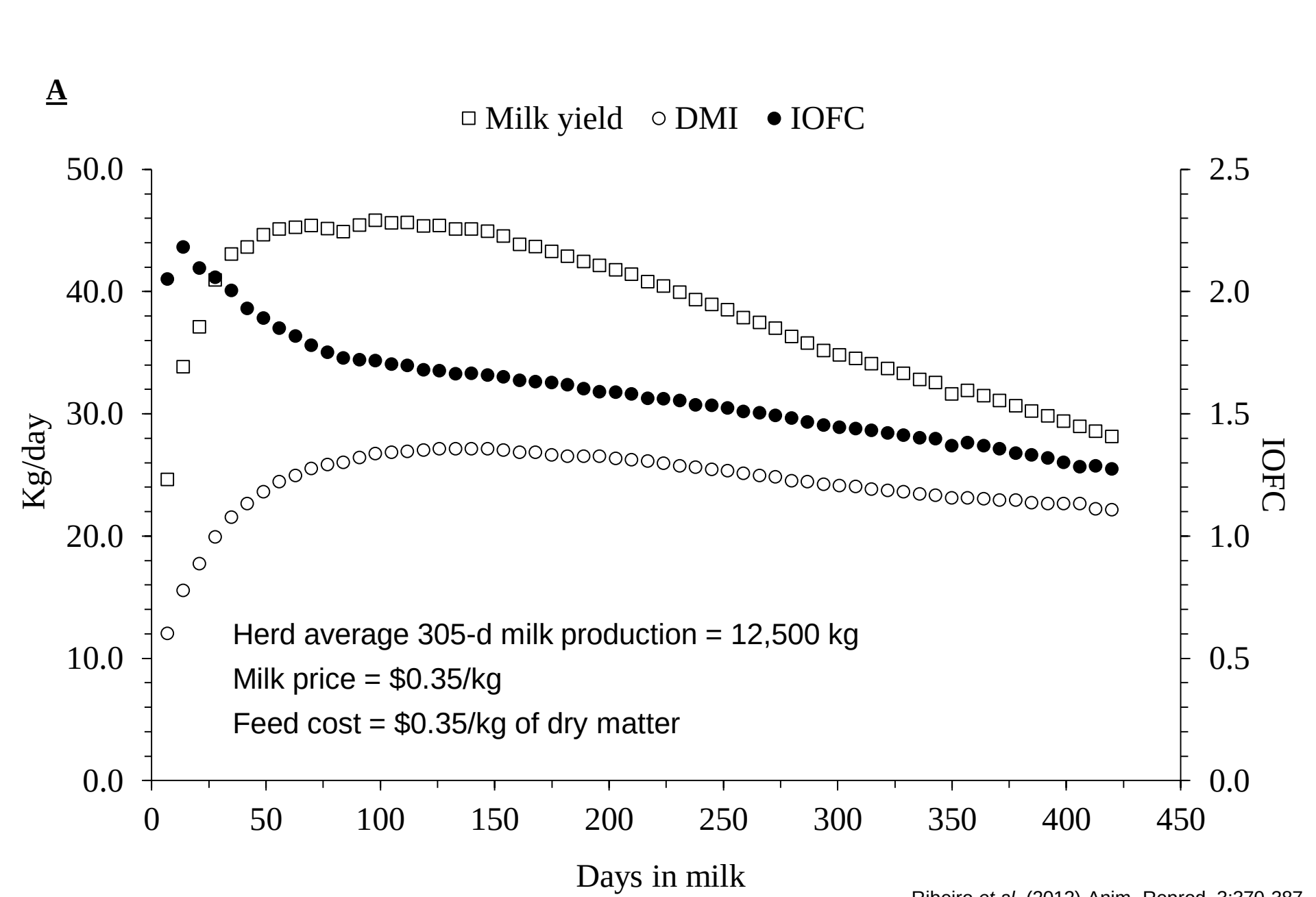


de Vries (2011)

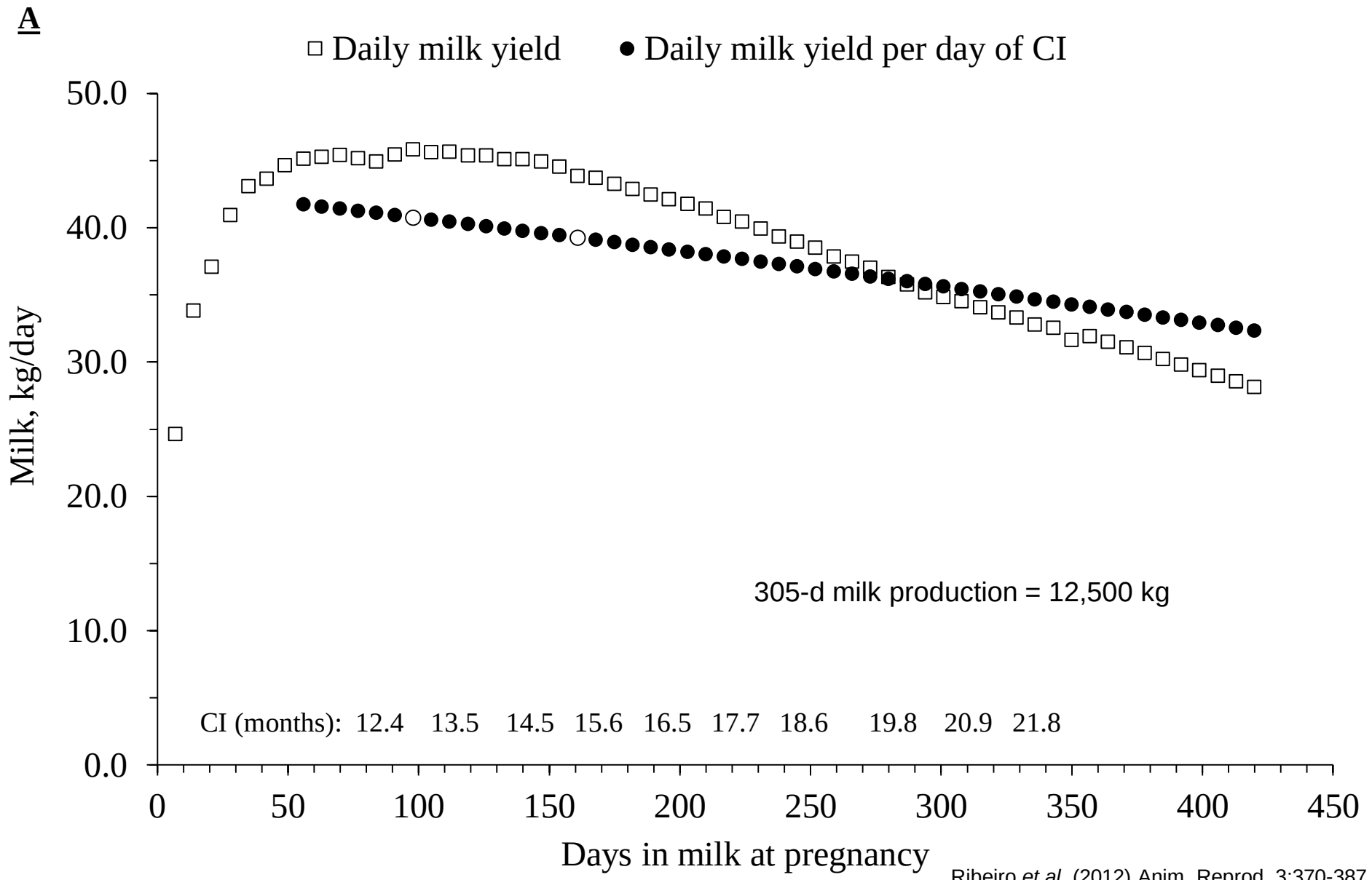
The Importance of Reproduction to the Economy of the Dairy Farm

- Improves milk production
  - Decreases the average days in milk of the herd
  - Alters parity distribution
  - Faster transition of primiparous cows to a more productive 2nd lactation
- Increases the number of replacement heifers
  - Allows greater genetic selection intensity
  - Allows the sale of heifers and cows for milk production
- Facilitates adequate culling policies (decision flexibility)
  - Culling of problem cows
  - Younger herd → better fertility, less mastitis, lameness, and increased genetic merit

Ribeiro *et al.* (2012) Anim. Reprod. 3:370-387

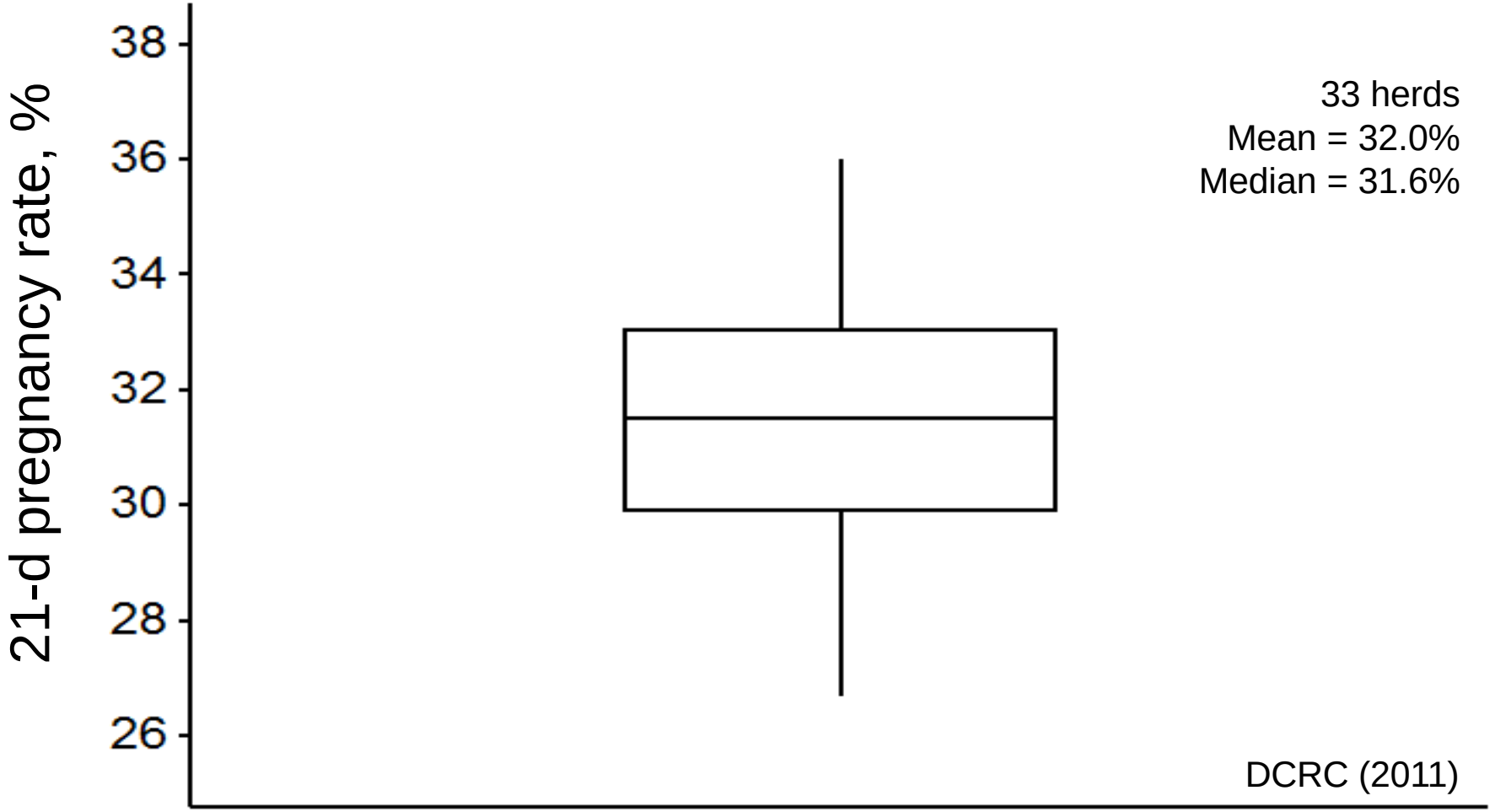


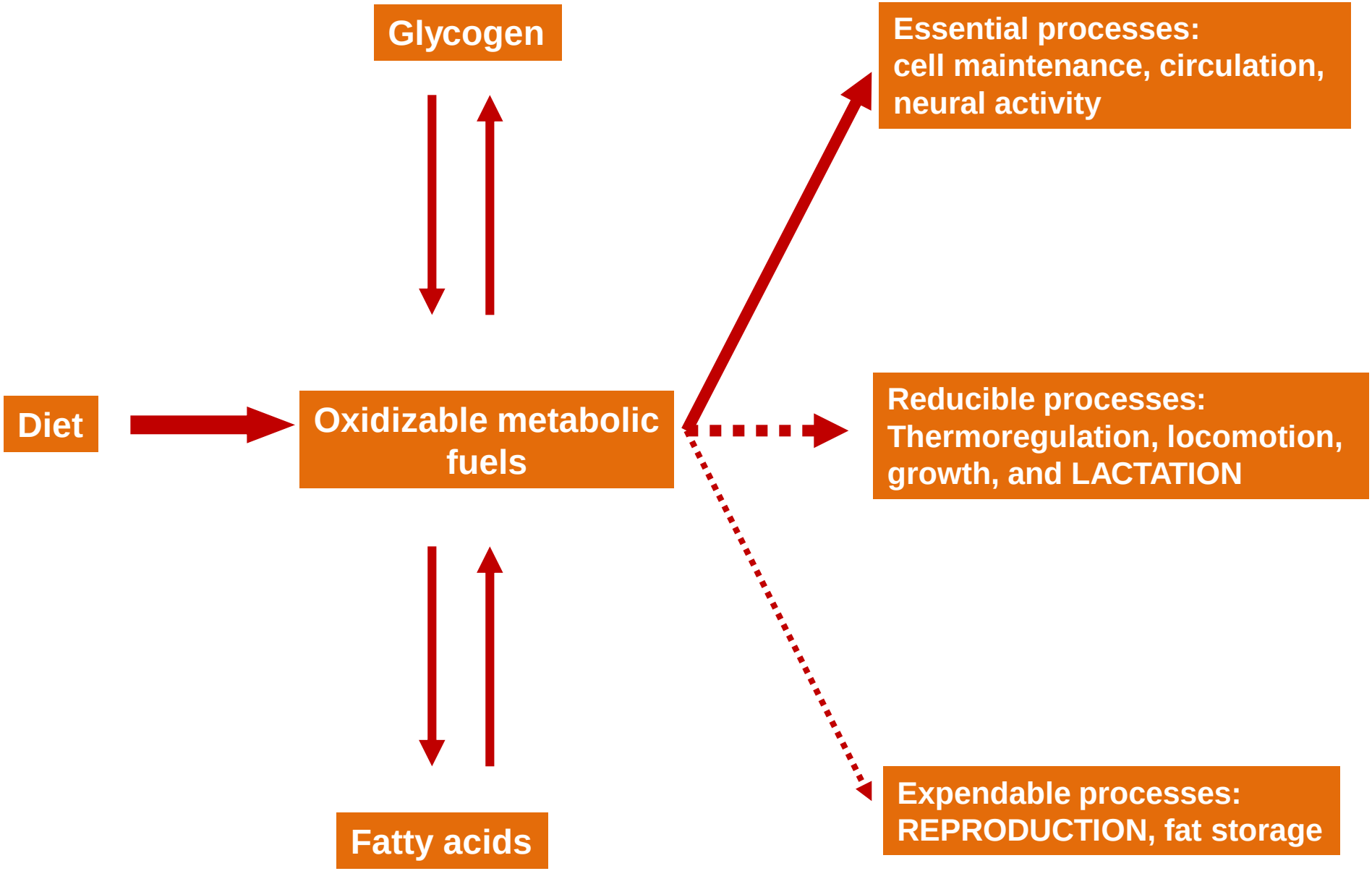
Ribeiro *et al.* (2012) Anim. Reprod. 3:370-387



Ribeiro *et al.* (2012) Anim. Reprod. 3:370-387

High Producing Herds with Excellent Reproduction





Partitioning of metabolic substrates according to priority

Wade and Jones (2004) Am. J. Regul. Integr. Comp. Physiol.

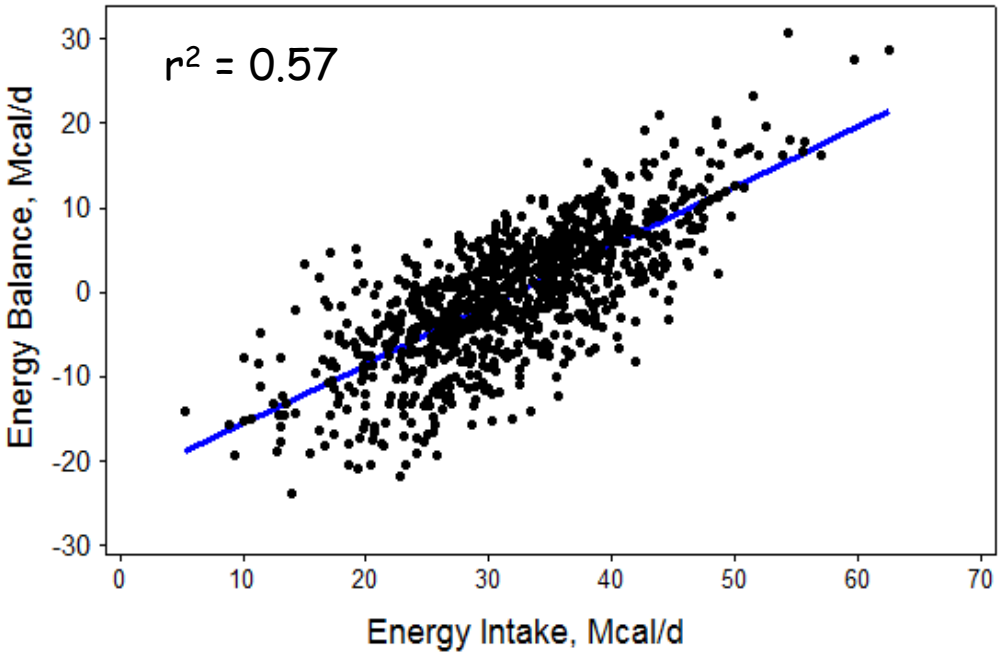
Risk factors for resumption of estrous cycles by 65 days postpartum and pregnancy at 1st AI in lactating dairy cows

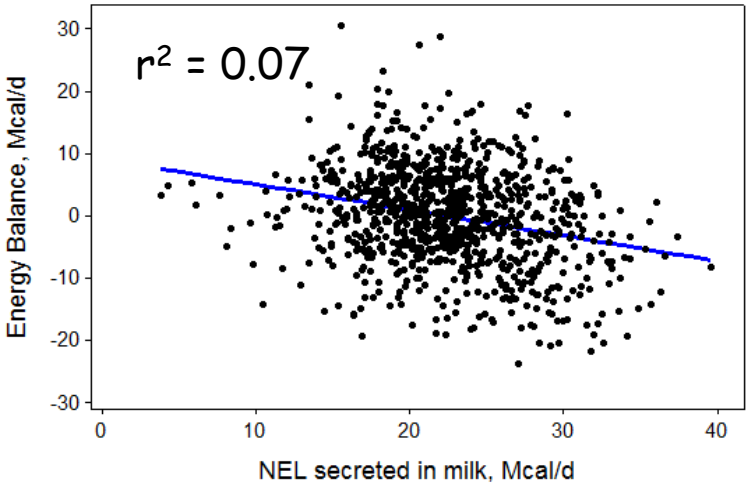
Variable	Cyclic, % (n/n)	Adjusted OR (95% CI)	*P* value
BCS change from calving to 65 DIM			
Lost 1 unit or more	58.7 (279/475)	Referent	-------
Lost < 1 unit	74.6 (2,507/3,361)	1.96 (1.52, 2.52)	< 0.001
No change	80.9 (2,071/2,560)	2.39 (1.74, 3.28)	< 0.001
Milk yield in the first 90 DIM			
Q1, 32.1 kg/d	72.7 (1,011/1,390)	Referent	------
Q2, 39.1 kg/d	77.6 (1,204/1,552)	1.34 (1.13, 1.60)	< 0.01
Q3, 43.6 kg/d	77.6 (1,350/1,739)	1.36 (1.15, 1.62)	< 0.001
Q4, 50.0 kg/d	75.3 (1,292/1,715)	1.21 (1.02, 1.43)	0.04

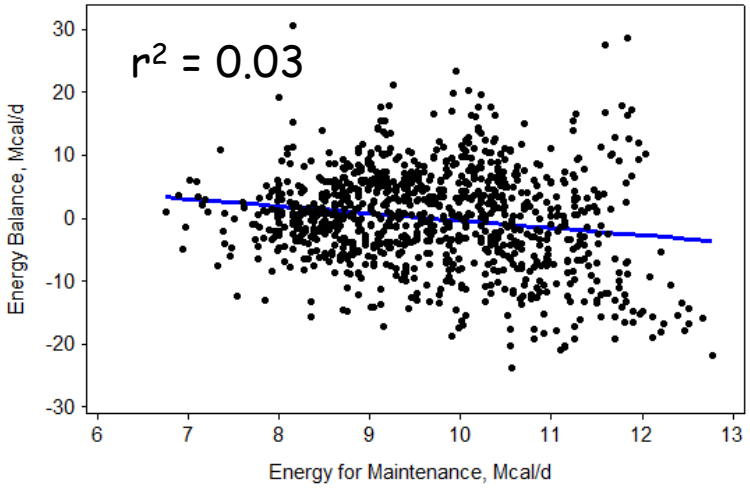
Variable	Pregnant, % (n/n)	Adjusted OR (95% CI)	*P* value
BCS change from calving to 65 DIM			
Lost 1 unit or more	28.9 (132/472)	Referent	------
Lost < 1 unit	37.3 (1204/3230)	1.42 (1.13, 1.79)	< 0.01
No change	41.6 (1008/2422)	1.69 (1.32, 2.17)	< 0.001
Milk yield in the first 90 DIM			
Q1, 32.1 kg/d	37.2 (496/1,334)	Referent	------
Q2, 39.1 kg/d	38.9 (576/1,481)	1.06 (0.91, 1.24)	0.42
Q3, 43.6 kg/d	39.3 (652/1,661)	1.09 (0.93, 1.26)	0.26
Q4, 50.0 kg/d	37.6 (620/1,648)	1.03 (0.88, 1.21)	0.65

Santos et al. (2009) Anim. Reprod. Sci. 110: 207–221

If Energy Balance is a Major Drive of Reproductive Success in the Dairy Cow, then the Focus Should be on Intake and not Milk Yield

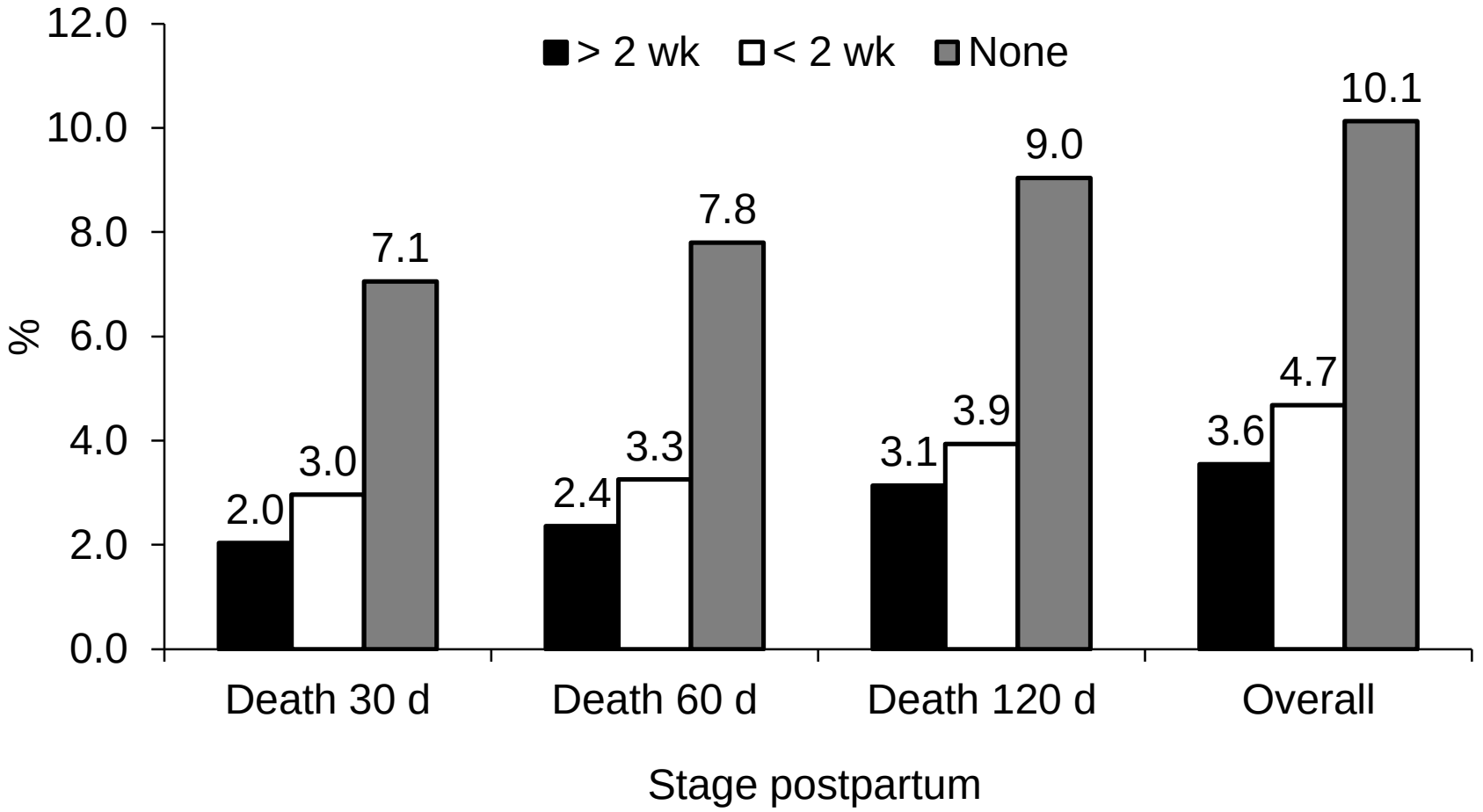




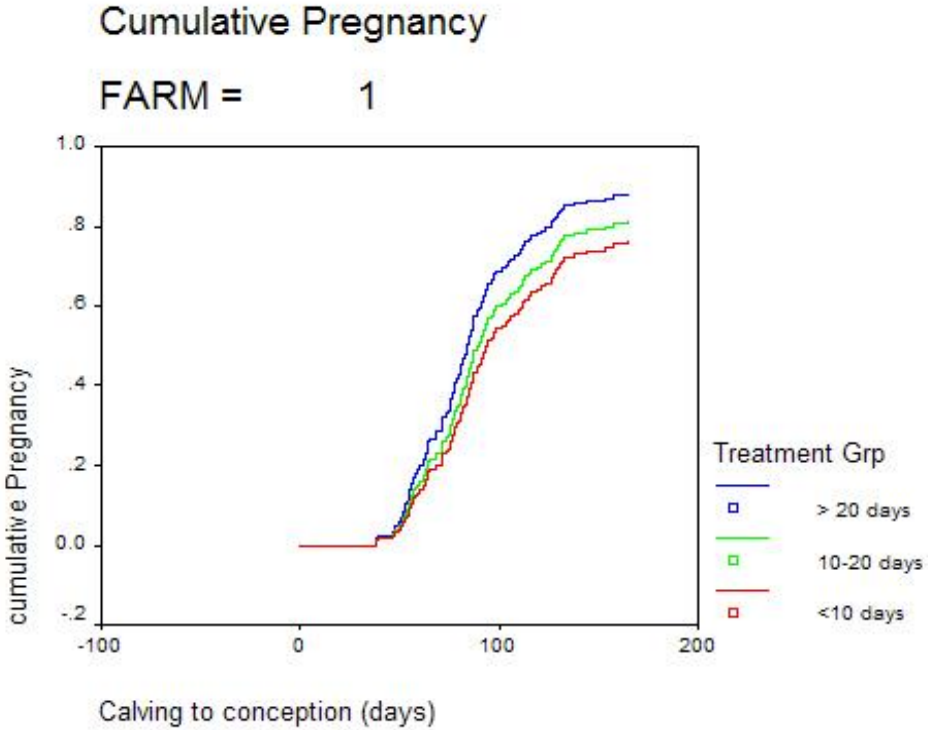


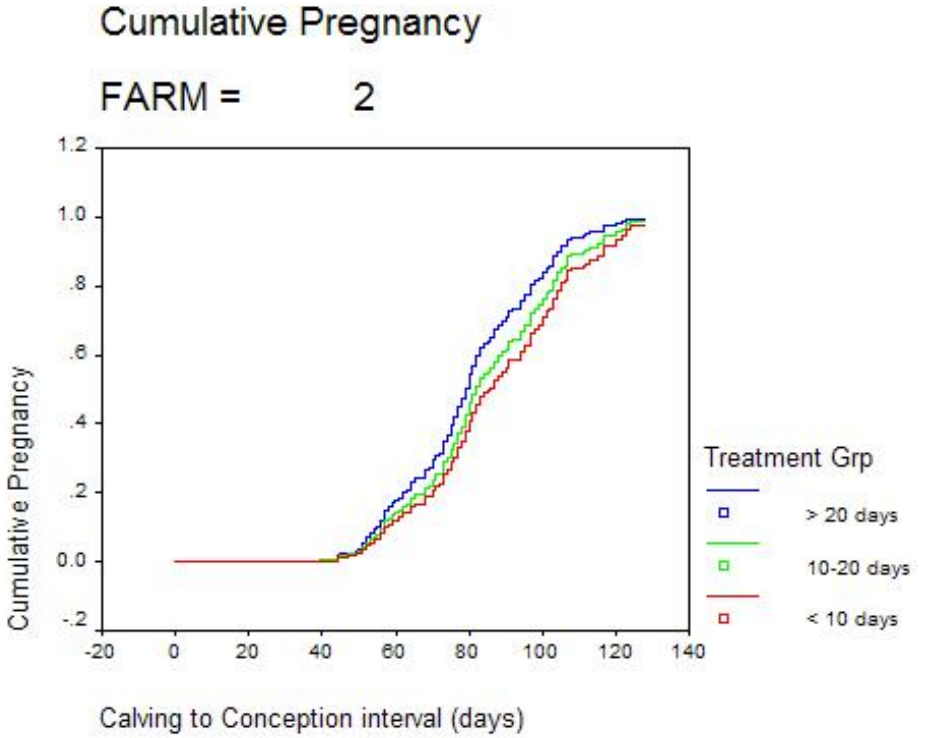
Santos *et al.* (2010) Soc. Reprod. Fertil. Suppl. 67:387-403

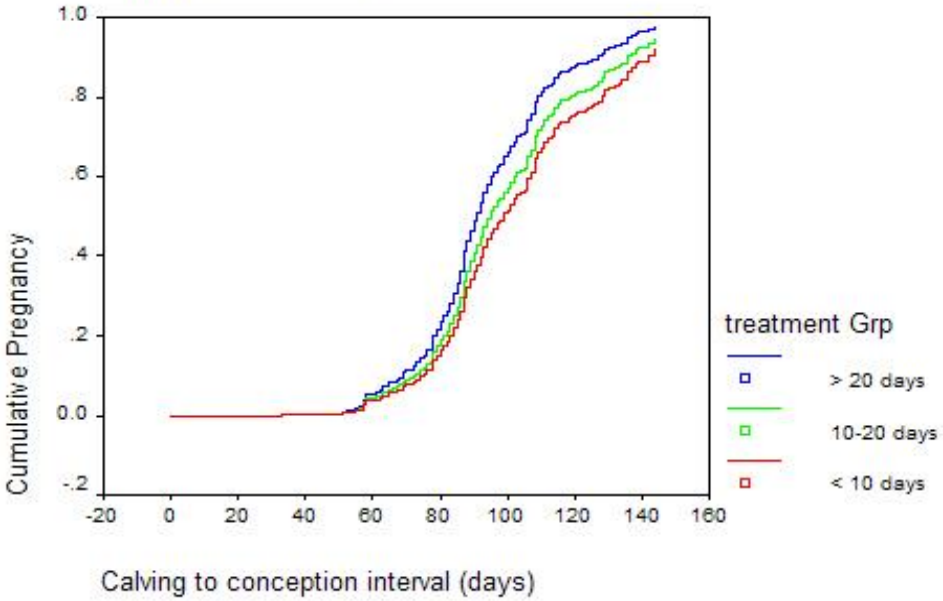
Mortality Based on Weeks in Prepartum Pen



Santos *et al.* (2013)







DeGaris et al. (2010) Aust. Vet. J. 88:189

Adequate Calving Assistance

Patience, hygiene and lots of lubrification

Dairy Dreams

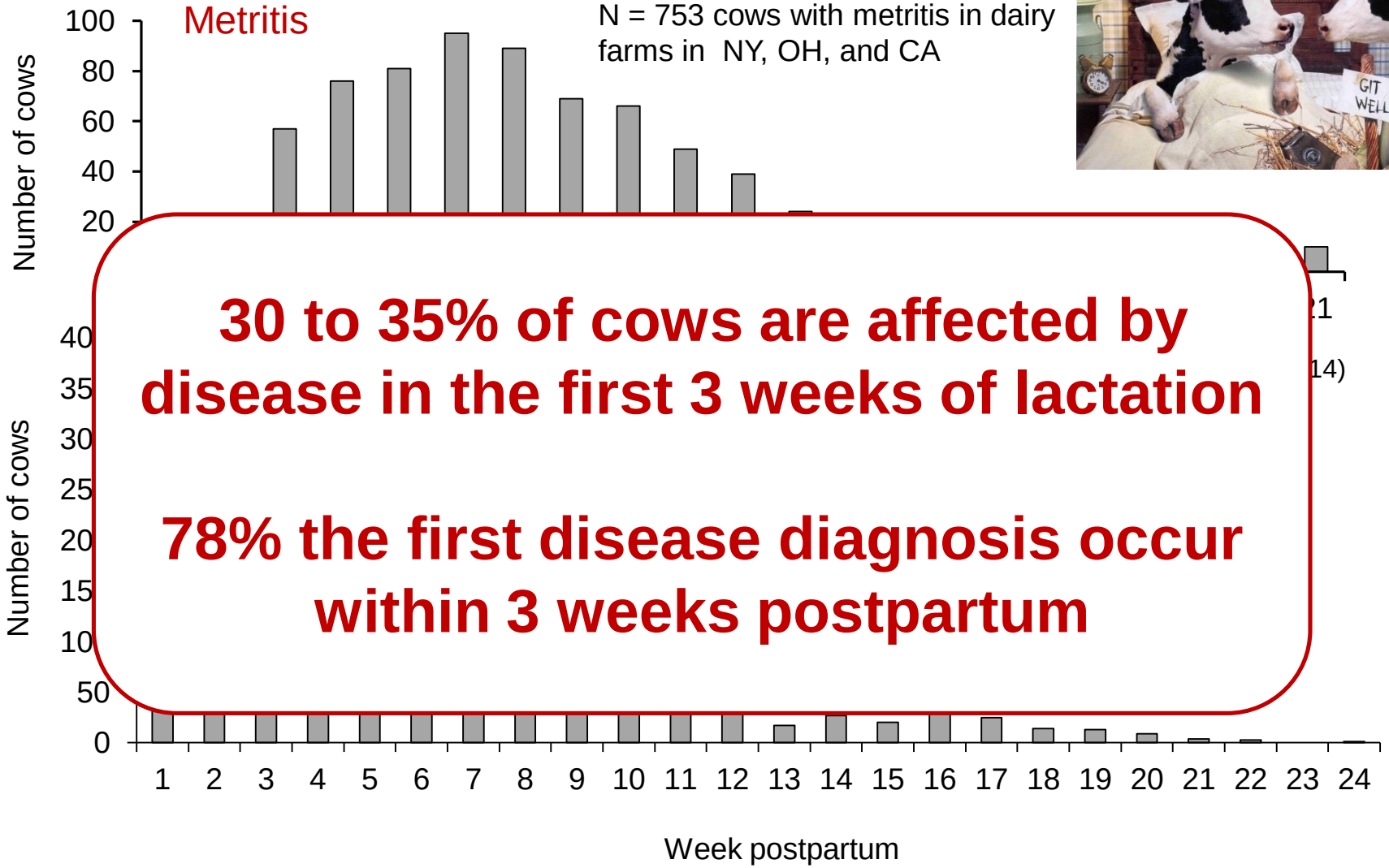
3,100 milkings cows

In 2016

- 41 kg/d of energy-corrected milk
  - 40 kg of milk/day
  - 3.80% fat
  - 3.30% true protein
  - Yearly average of 2.85 kg of milk solids
- Herd averaged 30% 21-d cycle PR
  - 65% 21-d cycle insemination rate
  - 46% pregnancy per AI

Industry Standards for Space and Comfort Oftentimes Are Inadequate for Transition Cows

Morbidity is a Problem of Early Lactation Cows



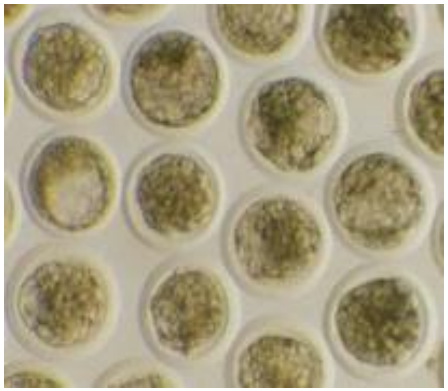
30 to 35% of cows are affected by disease in the first 3 weeks of lactation

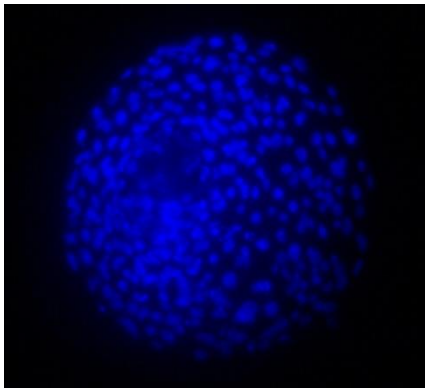
78% the first disease diagnosis occur within 3 weeks postpartum

Ribeiro et al. (2016) J. Dairy Sci. 99: accepted *in press*

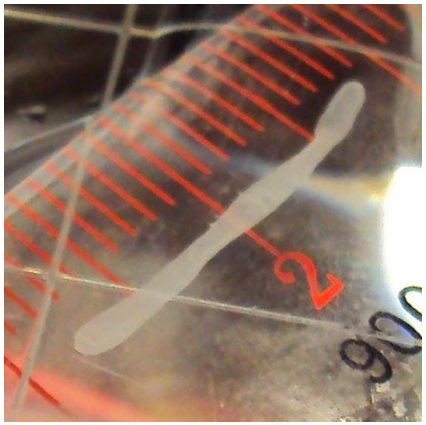
Disease Influences Early Embryo Development

- Data from 419 embryo-oocytes from single ovulating lactating dairy cows flushed on days 5-6 after AI were evaluated for:
  - ✓ Fertilization
  - ✓ Embryo quality
  - ✓ Cell number



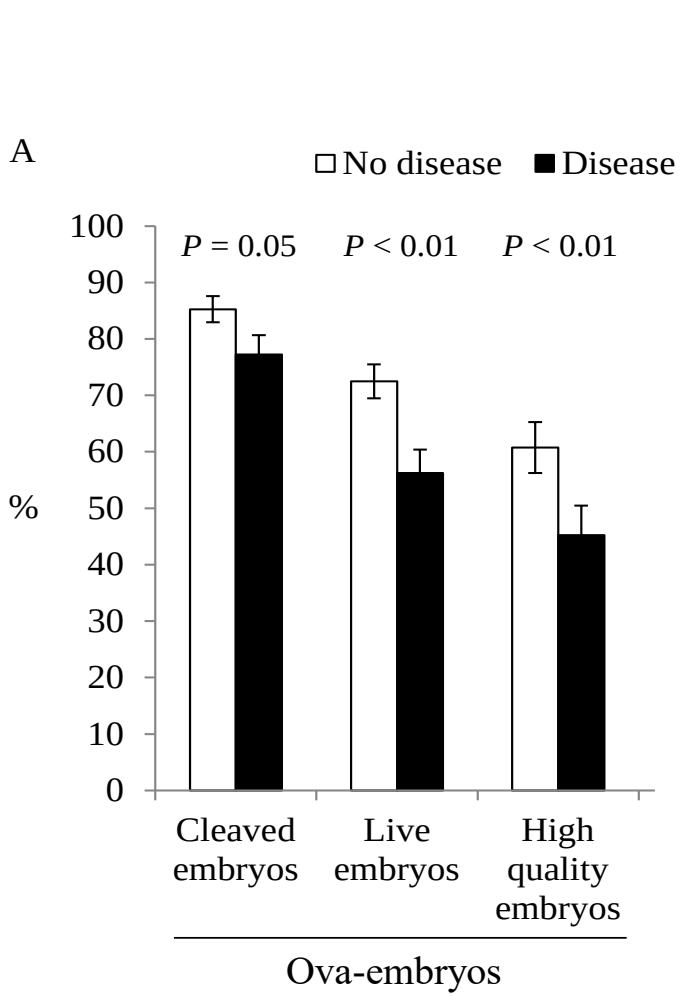


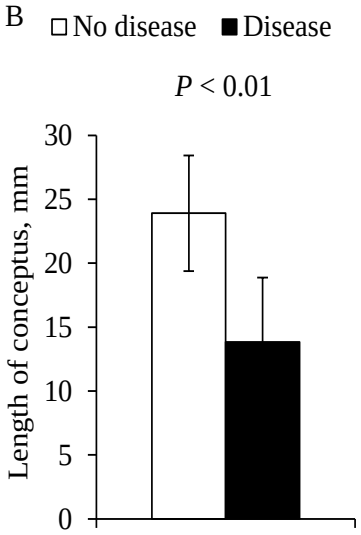
- Data from 148 lactating dairy cows flushed on days 15-16 after AI were evaluated for:
  - ✓ Pregnancy
  - ✓ Embryo shape and length
  - ✓ Interferon-tau concentration
  - ✓ Transcriptome

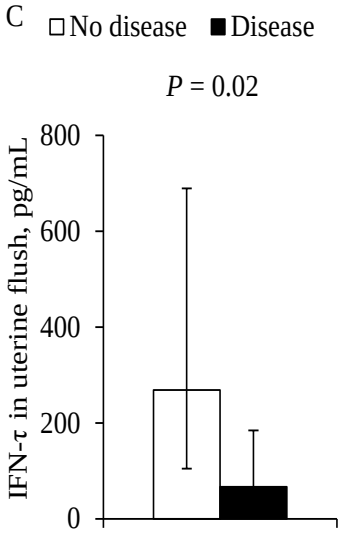


Ribeiro et al. (2016) J. Dairy Sci. 99: accepted *in press*

Disease Influences Development to Morula

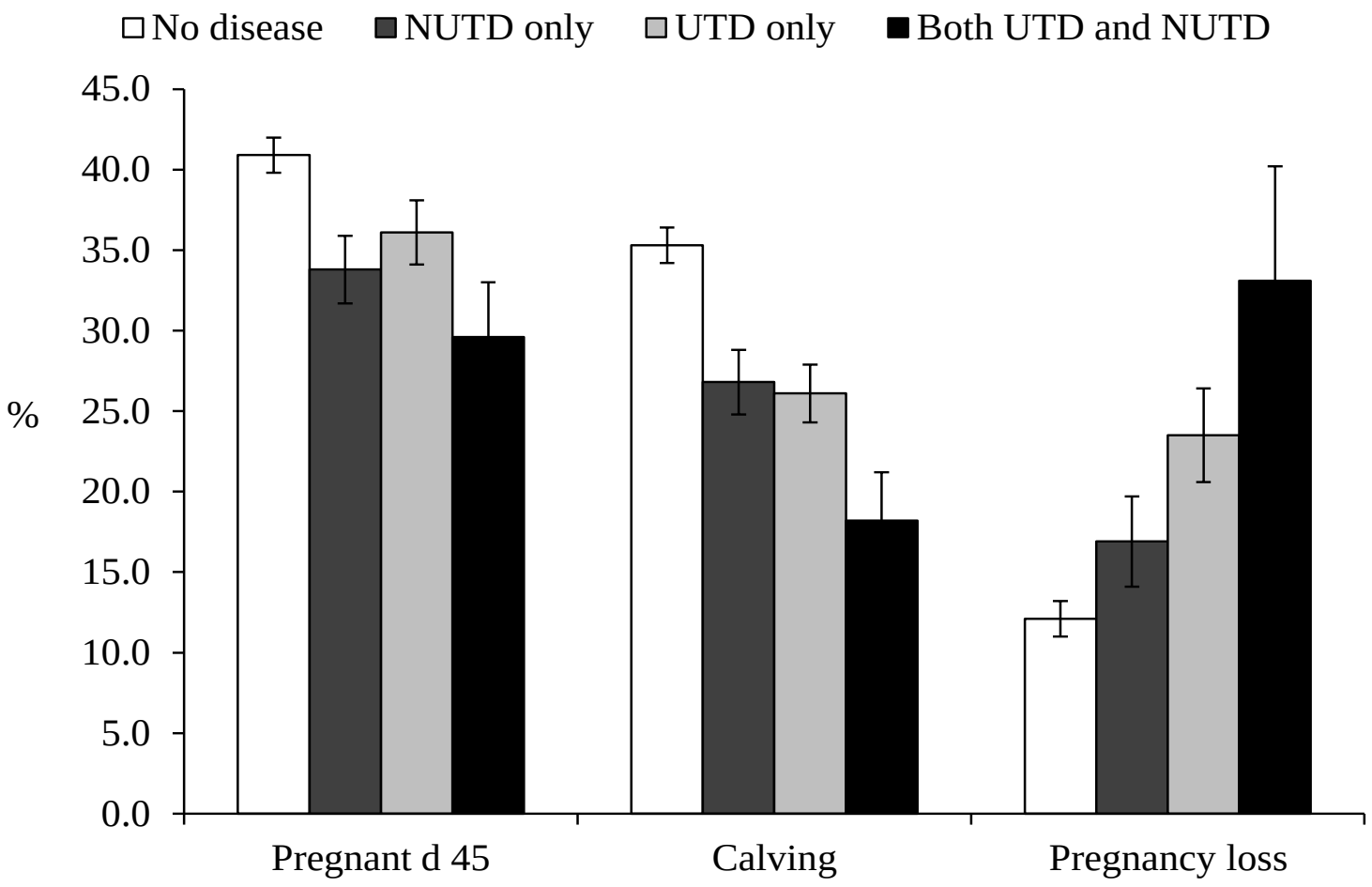






Ribeiro et al. (2016) J. Dairy Sci. 99:2201–2220

Additive Impacts of Diseases on Fertility



UTD = 0.05
NUTD < 0.01
INT = 0.96
ADD = 0.16

UTD < 0.01
NUTD < 0.01
INT = 0.79
ADD = 0.02

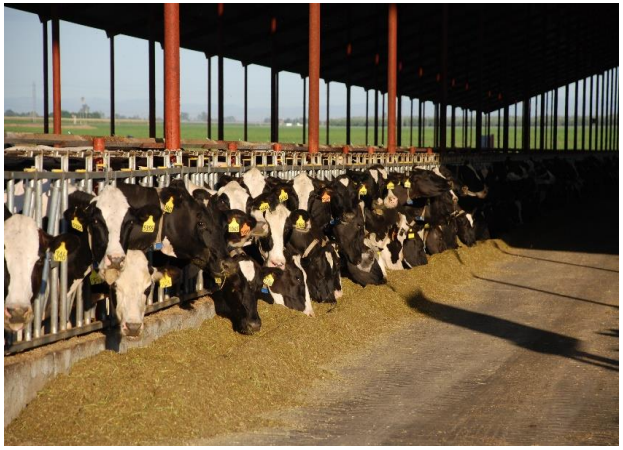
UTD < 0.01
NUTD = 0.04
INT = 0.83
ADD = 0.05

Ribeiro et al. (2016) J. Dairy Sci. 99:2201–2220

What Strategies Are Used to Correct and Reverse Low Reproductive Efficiency

- Improve the environment of the cow
  - Cow comfort
- Improve how employees deal with cows
  - Implement pro-active prevention and therapeutic programs
- Implement management practices that minimize diseases
  - Transition cow nutrition
- Implement reproductive management that impact insemination rate and pregnancy per AI
  - Programs should improve pregnancy rate
- Implement genetic selection program for improved health and fertility

Improve Cow Comfort and Implement Programs that Result in Improved Animal Health and Fertility



Timeline Management of Dairy Cows For Successful Transition

Provide Proper Comfort and Heat Abatement

1. Dry off

- 230 days of gestation
- Proper body condition
- Control of mastitis
- Routine hoof trimming
- Vaccination program
- Proper diet to avoid over and under consumption of nutrients

2. Close up

- Move based on days pregnant - 255 days of gestation
- Proper grouping
- Vaccination program
- Feed diets to minimize metabolic disorders in early lactation

3. Early Postpartum

- Monitor health for early diagnosis of diseases and treatment
- Feed diets that do not limit intake
- Control ketosis

4. High group

- Feed diets that maximize milk production and recovery of body condition

- 45 d | -21 d | Calving | 21 to 28 d | > 28 DIM

3.Parturition

- Training of personnel
- Minimize intervention
- Reduce calving related disorders

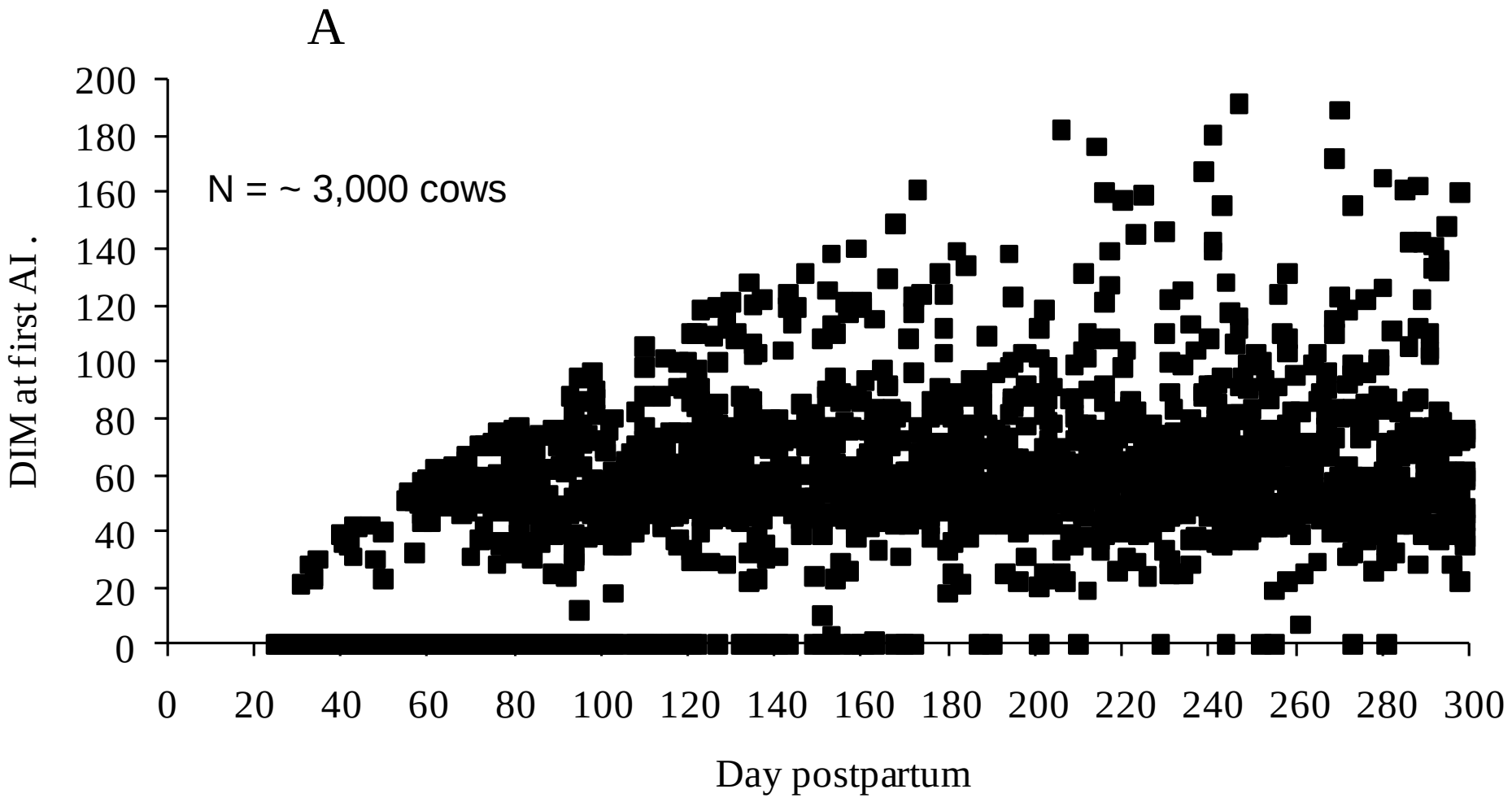
Day Relative to Calving

Breeding Programs in US Dairy Farms

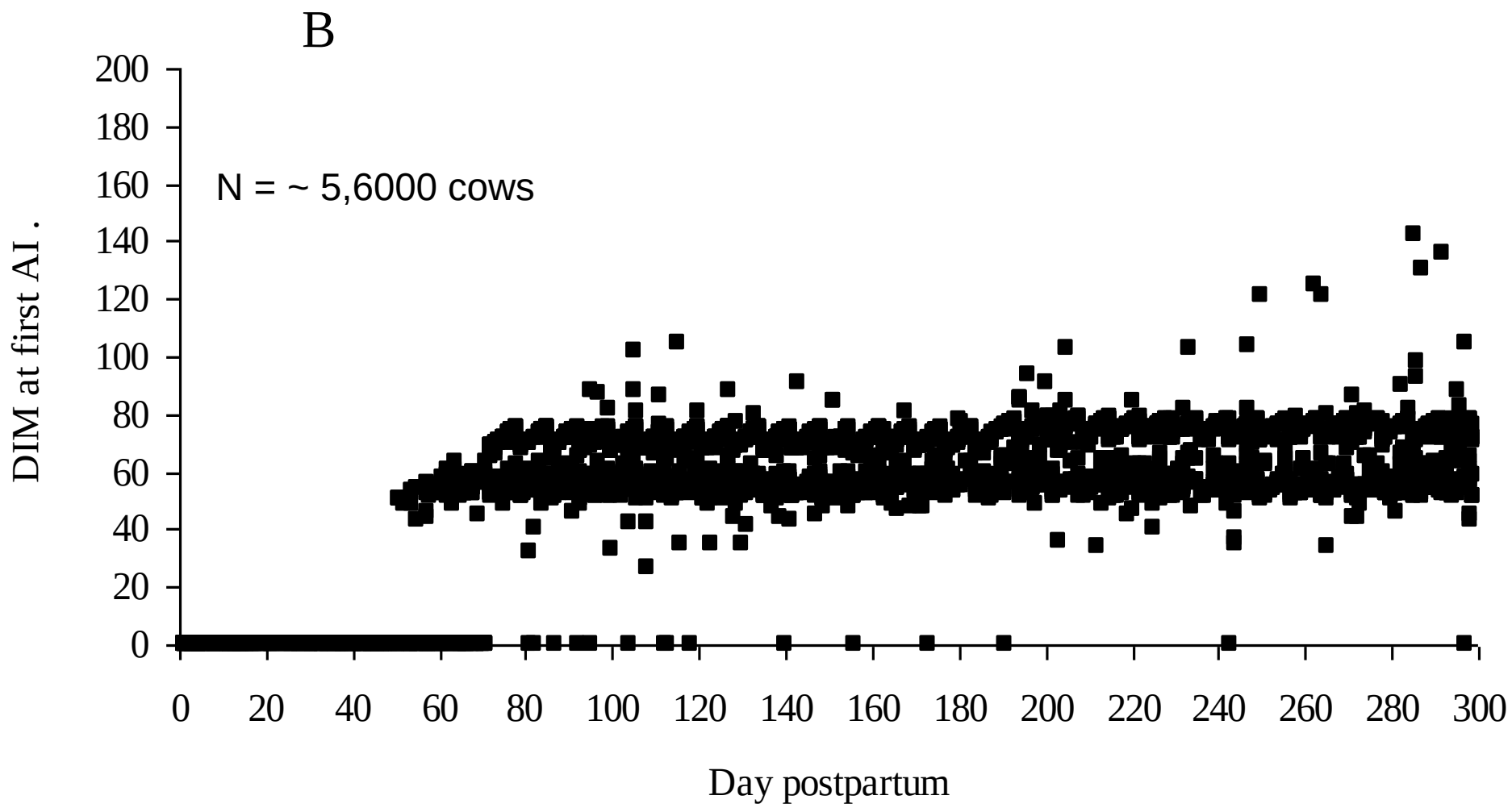
- Most dairy producers in the US inseminate cows using a combination of AI on estrus and timed AI
- Multitude of programs available for producers to bred cows on estrus or implement synchronization of estrus and ovulation
- In most farms, the goal is to achieve:
  - ✓ 100% AI within 3 weeks after the end of the voluntary waiting period
  - ✓ Reinseminate nonpregnant cows at an average of 28-30 d intervals:
    - ✓ ~50 to 70% of the nonpregnant return to estrus before pregnancy diagnosis
    - ✓ ~30 to 50% resynchronized and reinseminated within 10 d of the nonpregnancy diagnosis
  - ✓ Begin insemination between 60 and 80 DIM and have 50-60% of the herd pregnant by 110-120 DIM

Santos (2008) Cattle Practice 16:5-14

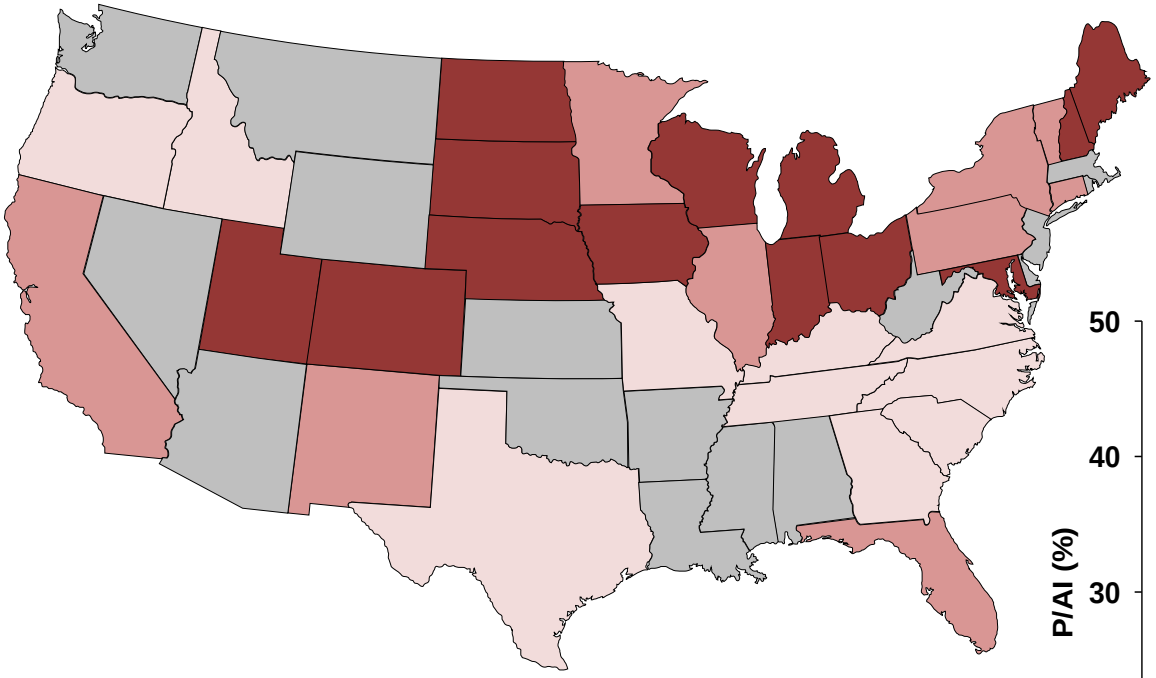
Herd with Little Control Over First AI



Herd with Excellent Control Over First AI

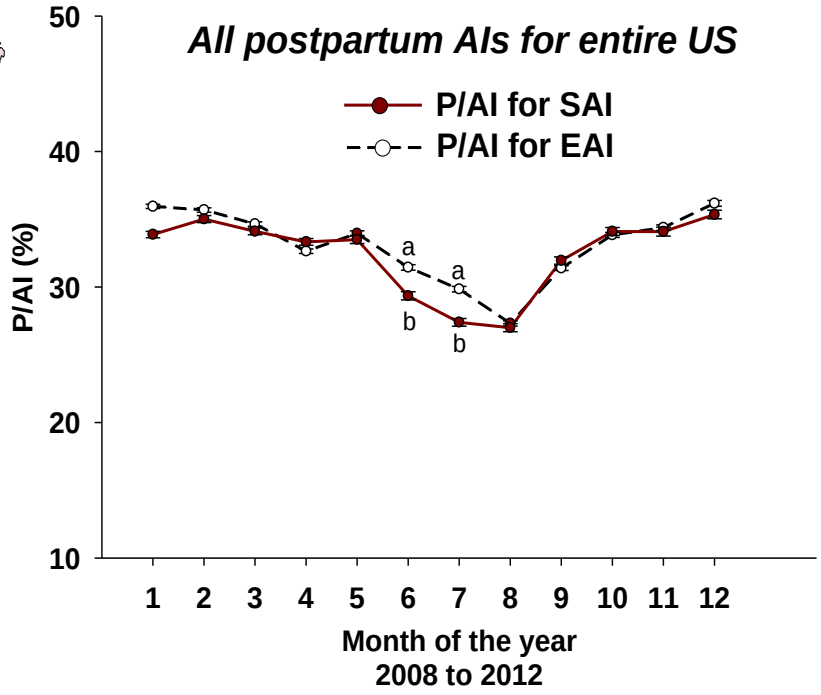


Use of Synchronized AI in Dairy Herds in the US and Pregnancy per AI



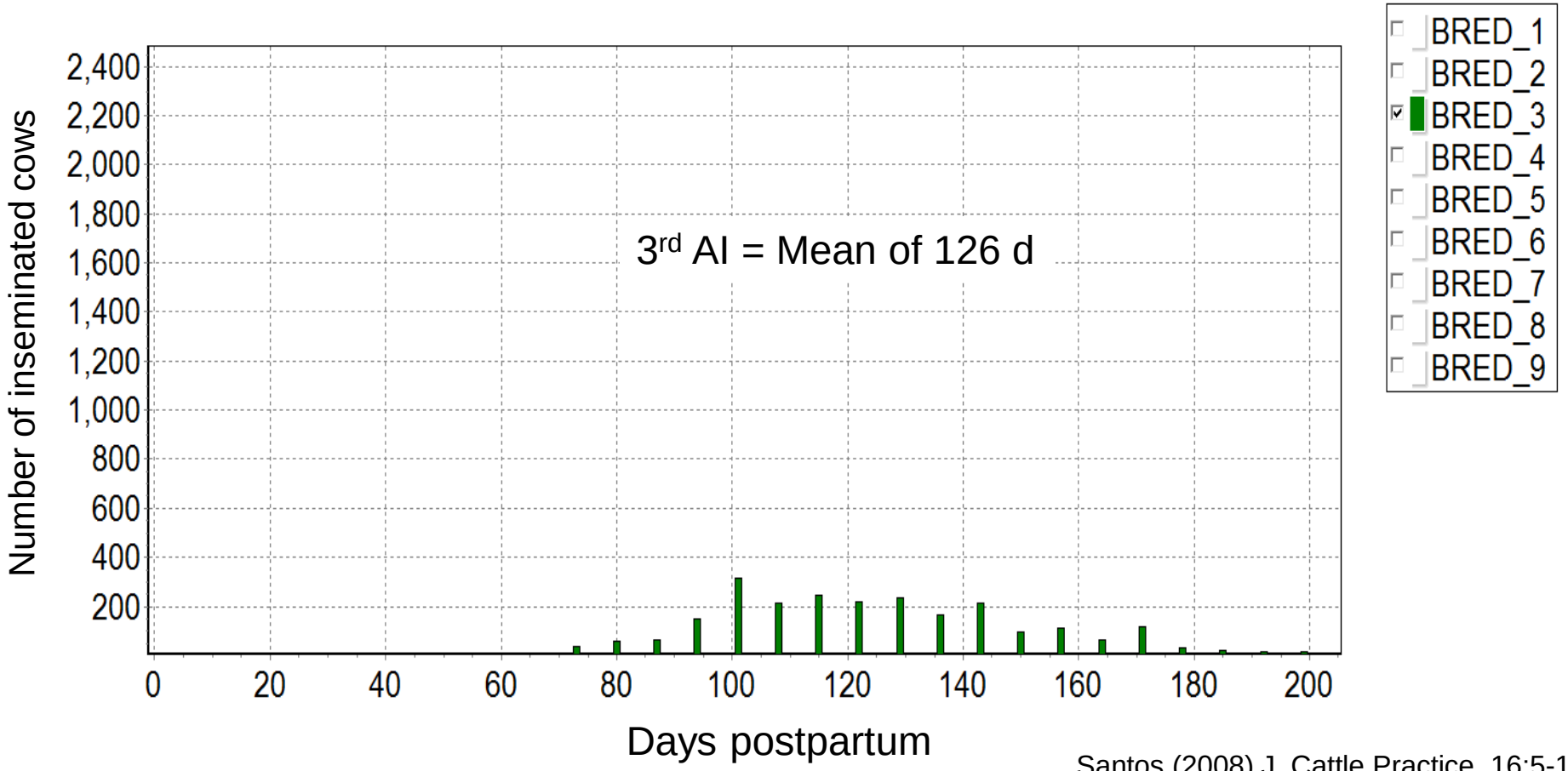
1.14 million breeding records from US dairy herd

* States in USA reporting < 1,000 AI records not used in the analysis and colored in grey (unknown frequency of SAI)



Souza *et al.* (2013) J. Dairy Sci. 96(Suppl. 1) Abstr.

Days in Milk at Each AI



Santos (2008) J. Cattle Practice 16:5-13

Timed AI Should Be Considered for Management of First Insemination in Grazing Farms

Reference	Timed AI protocol[1]	Cows	Pregnancy/AI, %	Pregnancy loss, %
Herlihy et al. (2011)	Ovsynch	370	47.0	NR
Herlihy et al. (2011)	Ovsynch with P4	383	54.0	NR
McDougall et al. (2010)	Ovsynch	553	33.9	NR
McDougall et al. (2010)	Ovsynch with P4	551	45.7	NR
McDougall et al. (2010)	Cosynch	560	39.0	NR
Ribeiro et al. (2011)	Presynch-5d timed AI	632	49.1	8.1
Ribeiro et al. (2011)	G6G-5d timed AI	625	49.9	12.9
Ribeiro et al. (2012a)	5-d timed AI with P4	178	34.3	14.8
Ribeiro et al. (2012a)	G6G-5d timed AI	185	45.4	11.9
Ribeiro et al. (2012b)	Presynch-5d timed AI	872	59.1	11.3
Ribeiro et al. (2012b)	Double Ovsynch-5d timed AI	882	56.8	7.6

Bisinotto et al. (2014) Animal 8:s1:151–159

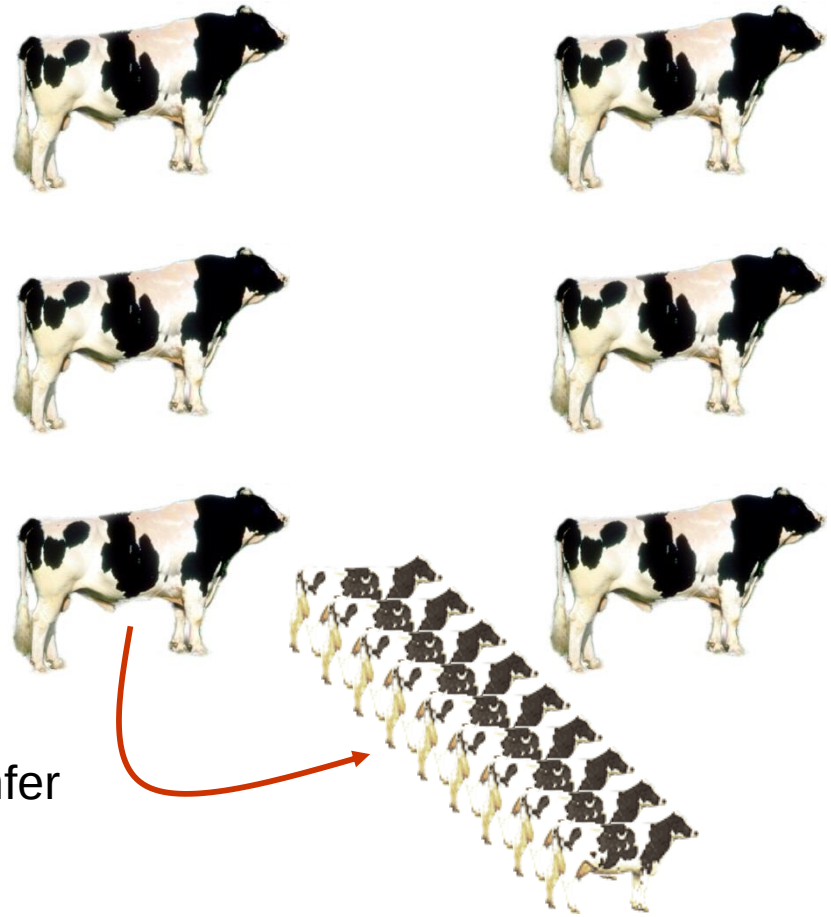
Considerations for TAI Programs in Grazing Dairies

- Pregnancy early in the breeding season results:
  - ✓ Longer lactation and greater milk production
  - ✓ Reduced risk of culling
  - ✓ Greater profitability

- Timed AI on the first day of breeding season
  - 100% submission and 50% P/AI on the 1st day of the season
  - 65 to 70% of cows pregnant by day 30
  - 80 to 85% of cows pregnant by day 60
  - 90% of cows pregnant by day 100

- Factors affecting fertility are exactly the same as for confinement dairies

Traditional Genetic Selection Progeny Testing



Don’t know the genes responsible for the trait (milk yield)

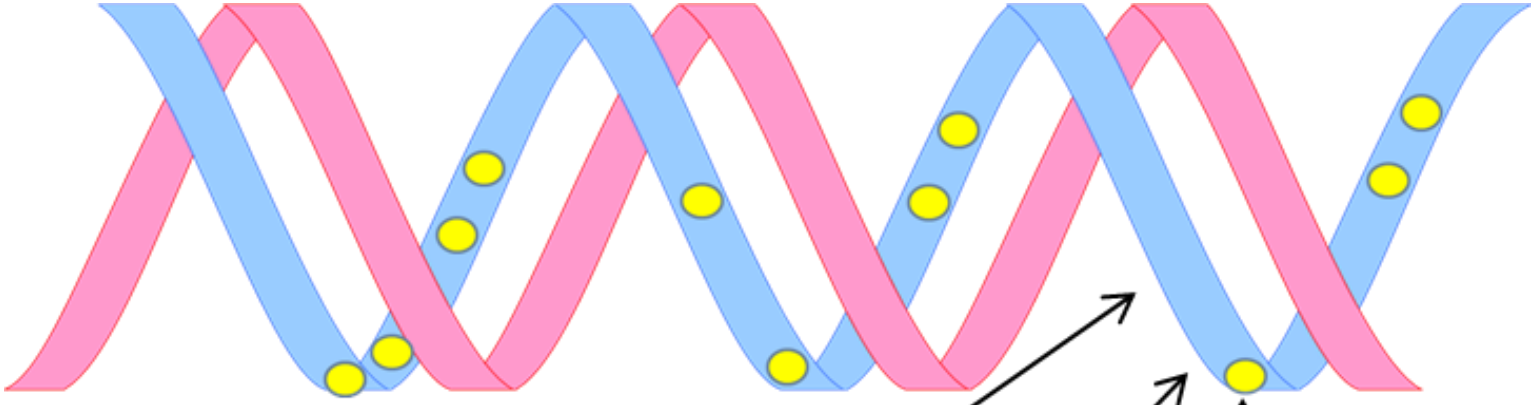
We know that bulls with daughters that produce more milk are more likely to have the genes that confer higher milk production

reliability

Estimated genetic value - - - - - - - - True genetic value

Gene – a blueprint that tells the cell how to make a protein (~22,000 in cow)

Protein – the main work horses in a cell or animal



Most SNP are not on the chip
Bovine HD chip -777,000 SNP

777,000 SNP
3,000,000,000 bases

SNP far from gene
Not related to trait

SNP near gene
related to trait

SNP in gene
strongly related to trait

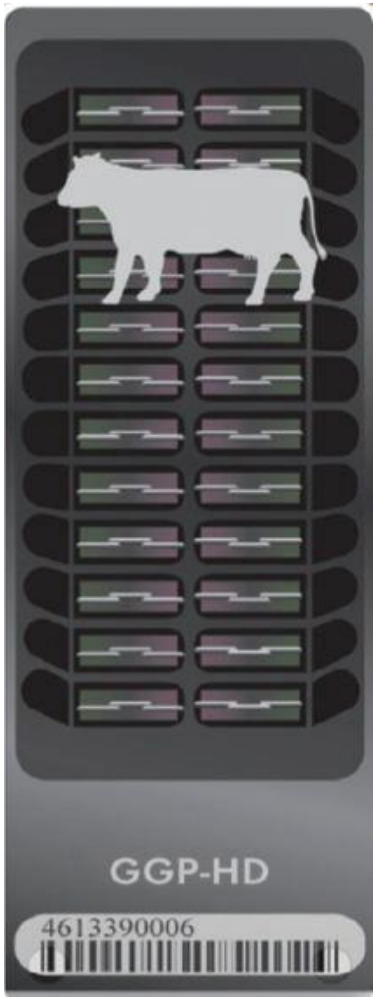
SNPs in a gene or close to a gene explains some of the genetic variability in a trait

Genomic Selection

Based on identification of mutations in the DNA that change the regulation of a gene or the function of the protein encoded by the gene

- Accelerates genetic gain:
  - Cut the generation interval → probably the biggest advantage now
  - Greater accuracy of predicted genetic merit for young animals → second biggest advantage
  - Identify carriers of bad things (carriers of recessive lethal genes that can be removed from the breeding groups)
  - Select females not only sires

Haplotype	Frequency in the Holstein population	Reduction in conception rate
HH1	4.5	-3.1
HH2	4.6	-3.0
HH3	4.7	-3.2
HH4	0.7	-3.0
HH5	4.8	-3.5



Impact of a Sire in the Holstein Breed

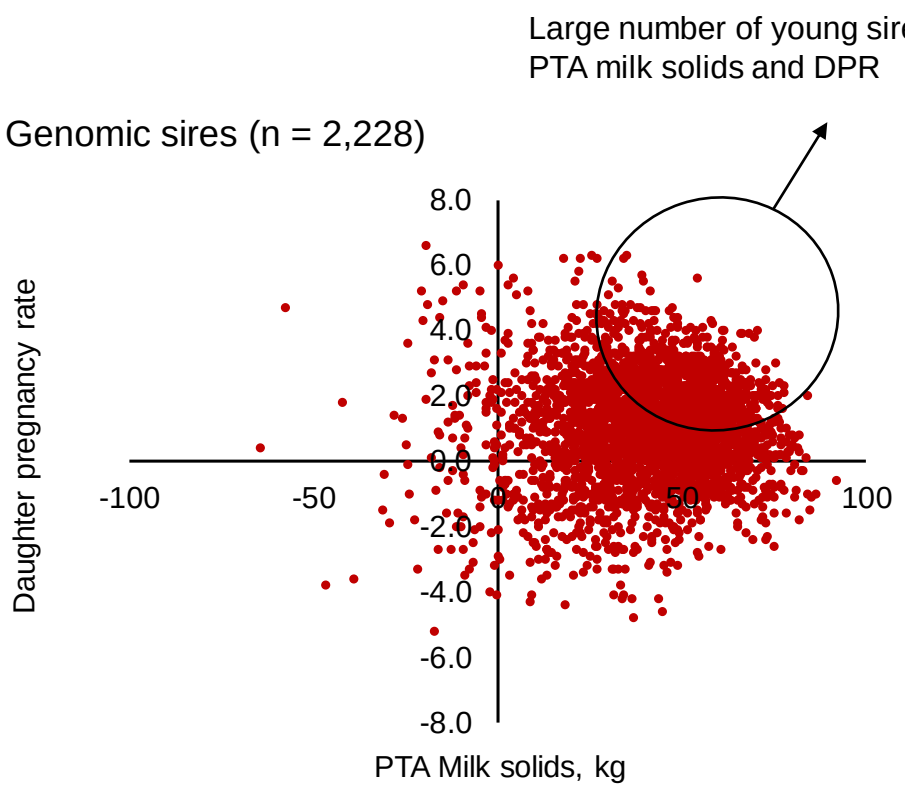

Pawnee Farm Arlinda Chief

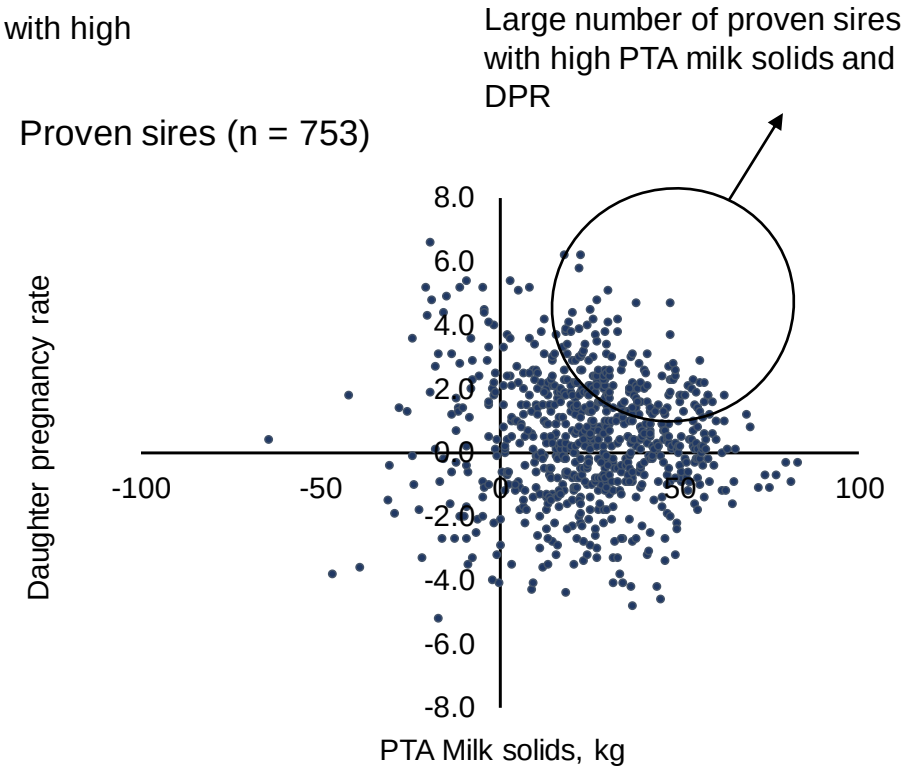
- **Pawnee Farm Arlinda Chief** (born in 1962)
  - ✓ Contributed 14% of the global Holstein genes
  - ✓ 16,000 daughters and 500,0000 granddaughters, and many sires
  - ✓ $25 billion value of increased milk yield
  - ✓ $500 million cost of HH1 mid-term abortions
  - ✓ Caused by 1-base mutation in *APAF1* gene

Adams et al. (2016) J. Dairy Sci.

Apoptotic protease activating factor 1

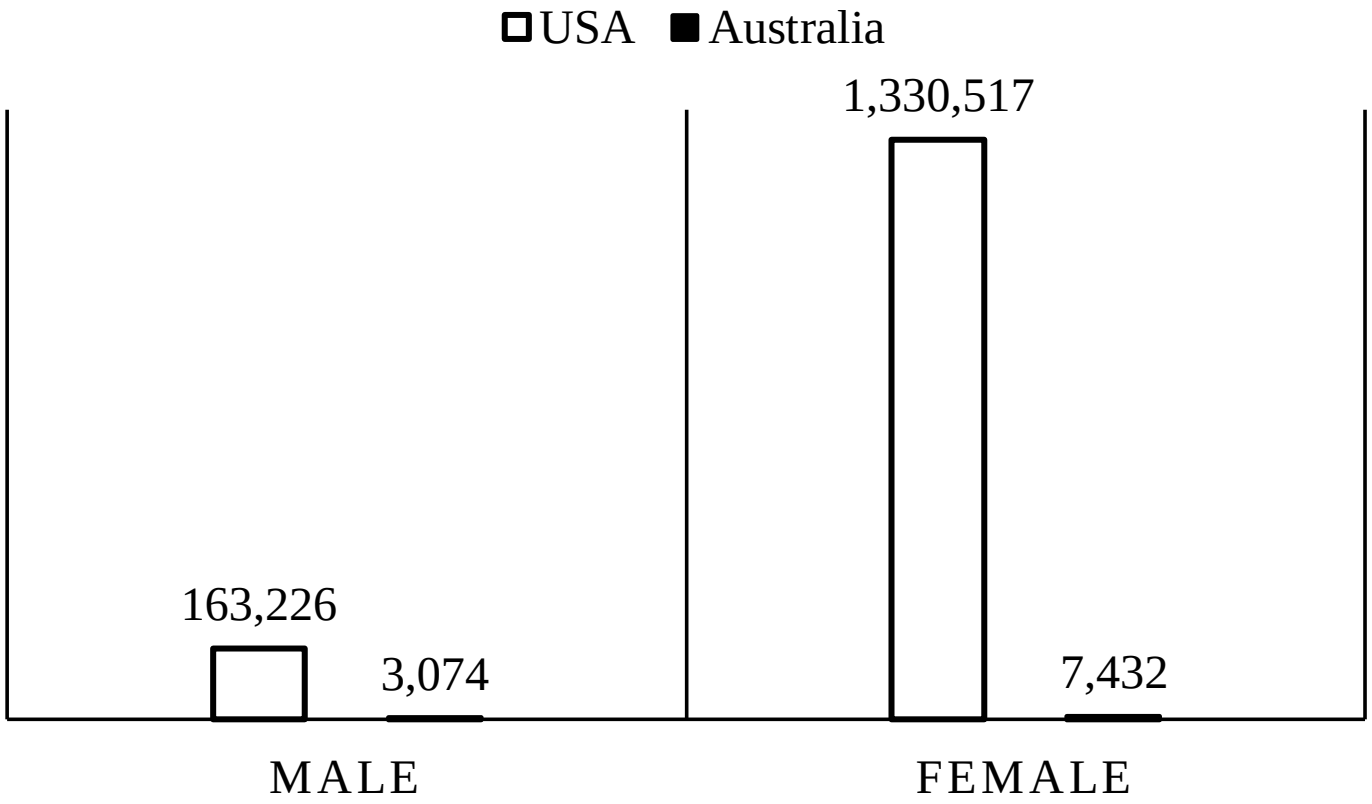
Sires Available in the US





CDCB Accessed June 2017 -https://www.uscdcb.com/eval/summary/activeai_menu.cfm

Number of Males and Females Genotyped

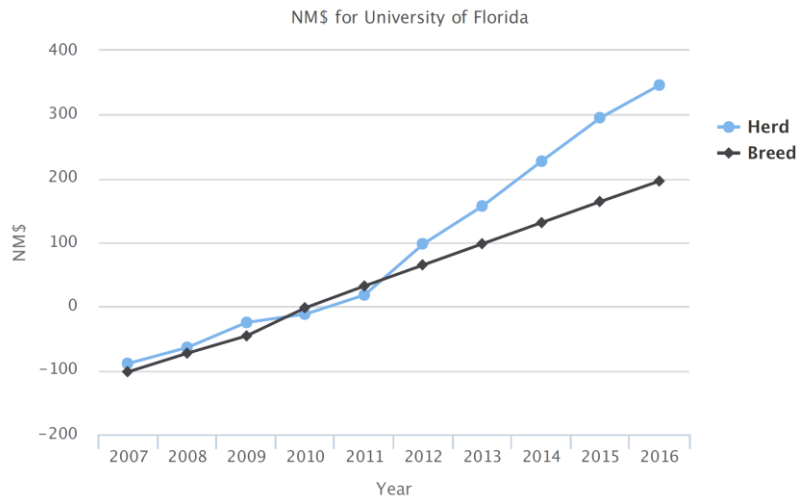


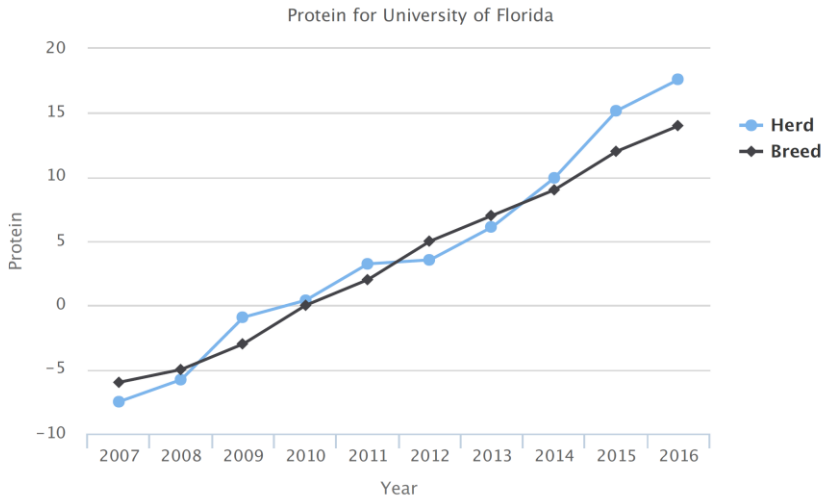
1.85 million dairy cattle genotyped (80.5% from the USA)

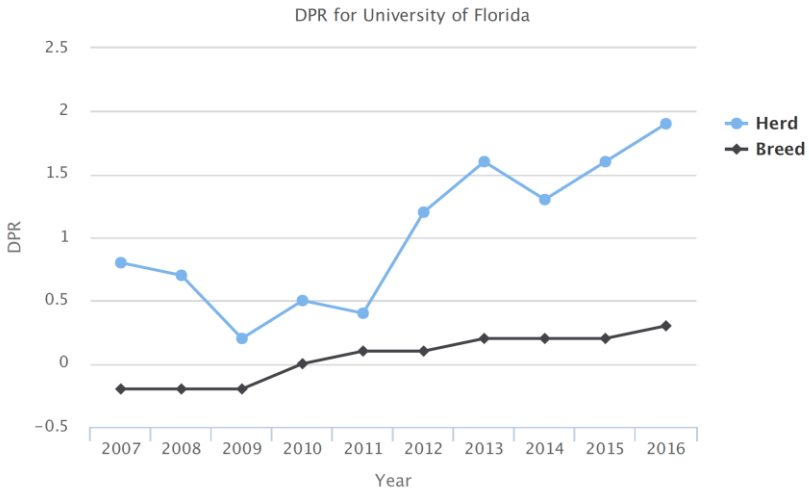
CDCB Accessed June 2017 - https://www.uscdcb.com/Genotype/cur_ctry.html)

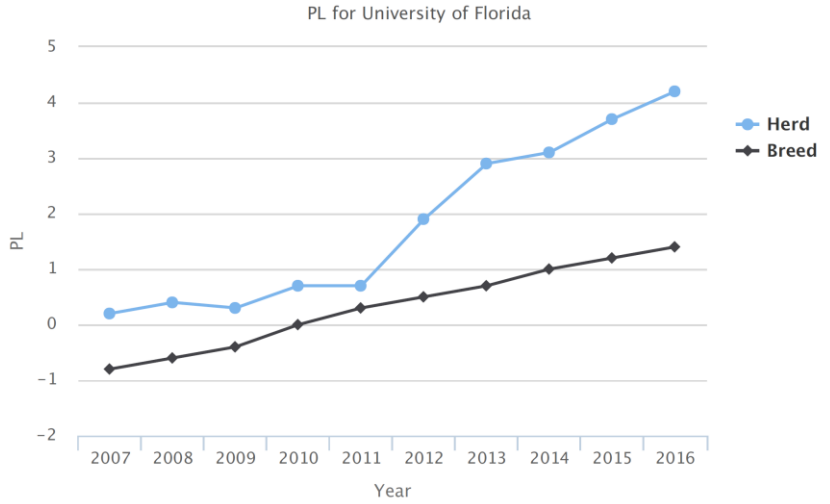
University of Florida Dairy Research Unit Example

Changes in Breeding Values with Changes in Selection Decision









Develop a Plan for Reproduction

- Transition cow management
  - Dry off program, housing, maternity, nutrition, health
- Define the breeding program for the entire herd
  - Voluntary waiting period
  - Program for 1st AI
  - Program for subsequent inseminations (resynchronization program)
- Devise a genetic selection program that includes reproductive traits
  - Focus on quantitative measures that include yields of milk components, fertility, and health

Good Reproduction Requires a Real Team Effort…..

- ✓ Dairy Management / Staff
- ✓ Consulting team (veterinarian, nutritionist)
- ✓ Focus on what is really important
  - ✓ Healthy cows
  - ✓ Proper nutrition/health program
  - ✓ Sound reproductive program
  - ✓ Selection for fertility without neglecting production


Thank you
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