Os desafios da cadeia de produção de leite: da reprodução à produção

José Eduardo P. Santos
Department of Animal Sciences
University of Florida

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

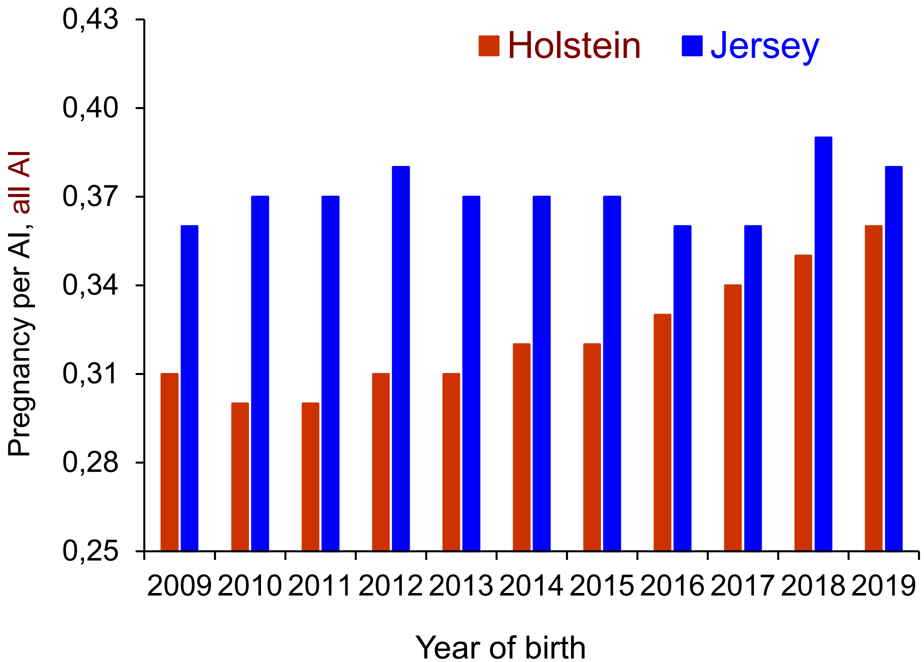
UF UNIVERSITY of FLORIDA

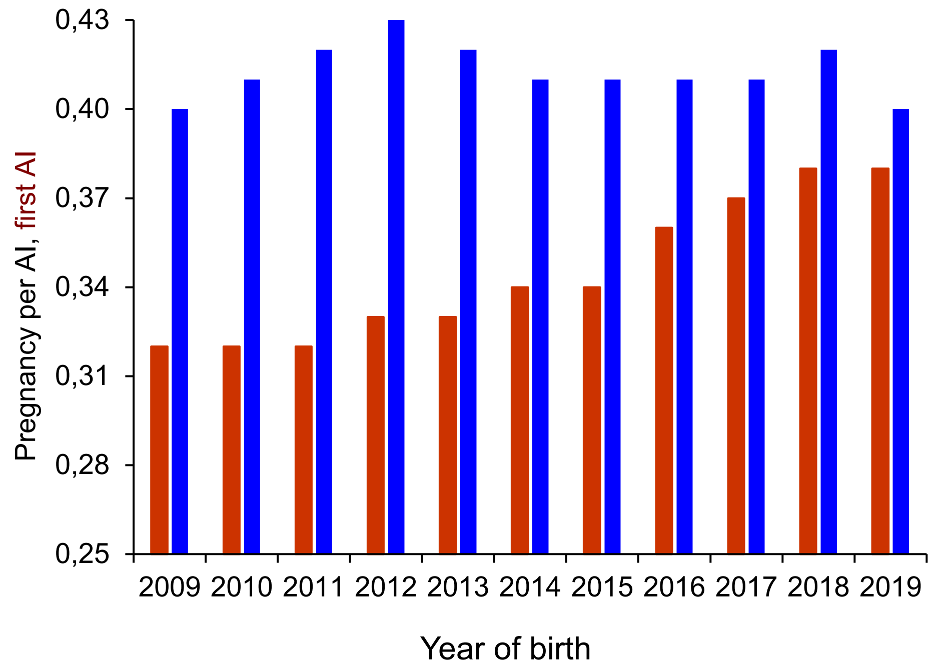
9º SIRAA
SIMPÓSIO INTERNACIONAL
DE REPRODUÇÃO ANIMAL APLICADA

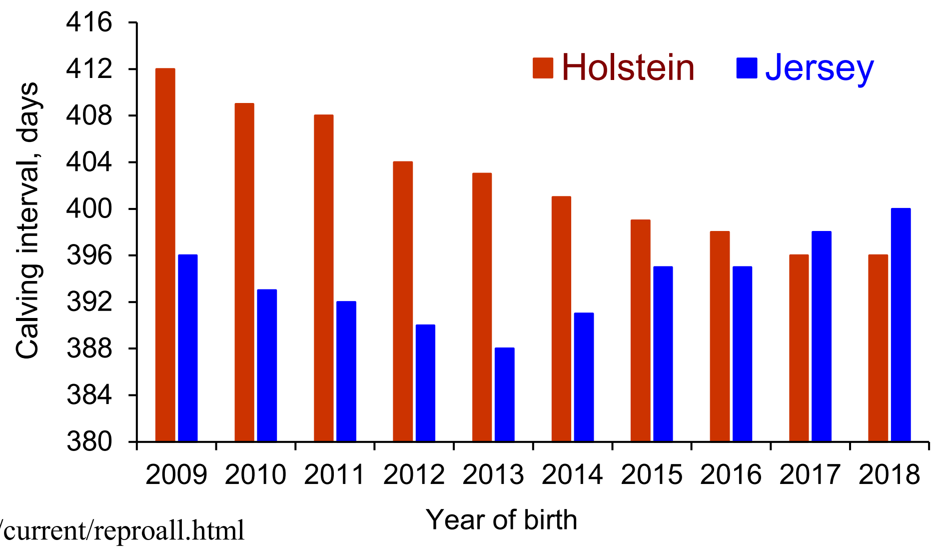
CONEXÃO PECUÁRIA
DISSEMINANDO CONHECIMENTO E NOVAS TECNOLOGIAS.

27 E 28 DE JULHO
TEATRO RIO VERMELHO
GOIÂNIA (GO)

Recent Evolution of Reproduction in Holsteins and Jerseys in the USA







US Dairy producers increased P/AI 6-percentage points and reduced calving interval 16 days in the last 10 years in Holsteins

CDCB Accessed November 2021 – https://queries.uscdcb.com/publish/dhi/current/reproall.html

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 - <u>255 days of gestation</u>
   - Proper grouping
   - Vaccination program
   - Feed diets to minimize metabolic disorders in early lactation.

3. **Parturition**
   - Training of personnel
   - Minimize intervention
   - Reduce calving related disorders

4. **Early Postpartum**
   - Monitor health for early diagnosis of diseases and treatment.
   - Feed diets that do not limit intake.
   - Control ketosis.

5. **High group**
   - Feed diets that maximize milk production and recovery of body condition

- 45 d	-21 d	Calving	0 to 28 d	> 28 DIM

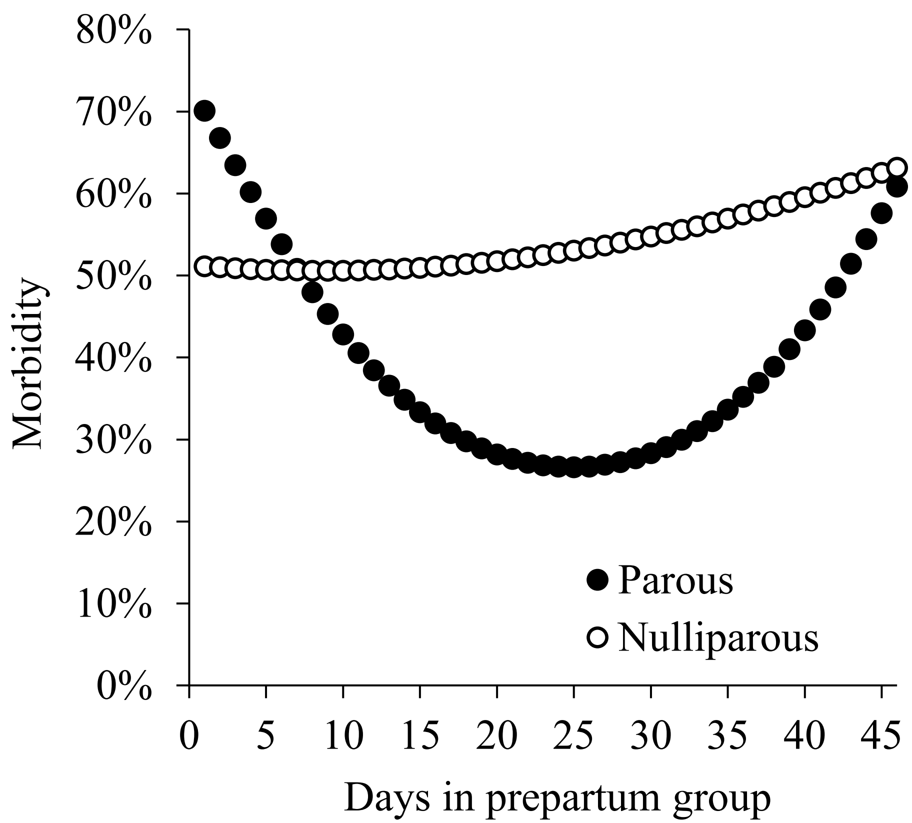
Day Relative to Calving

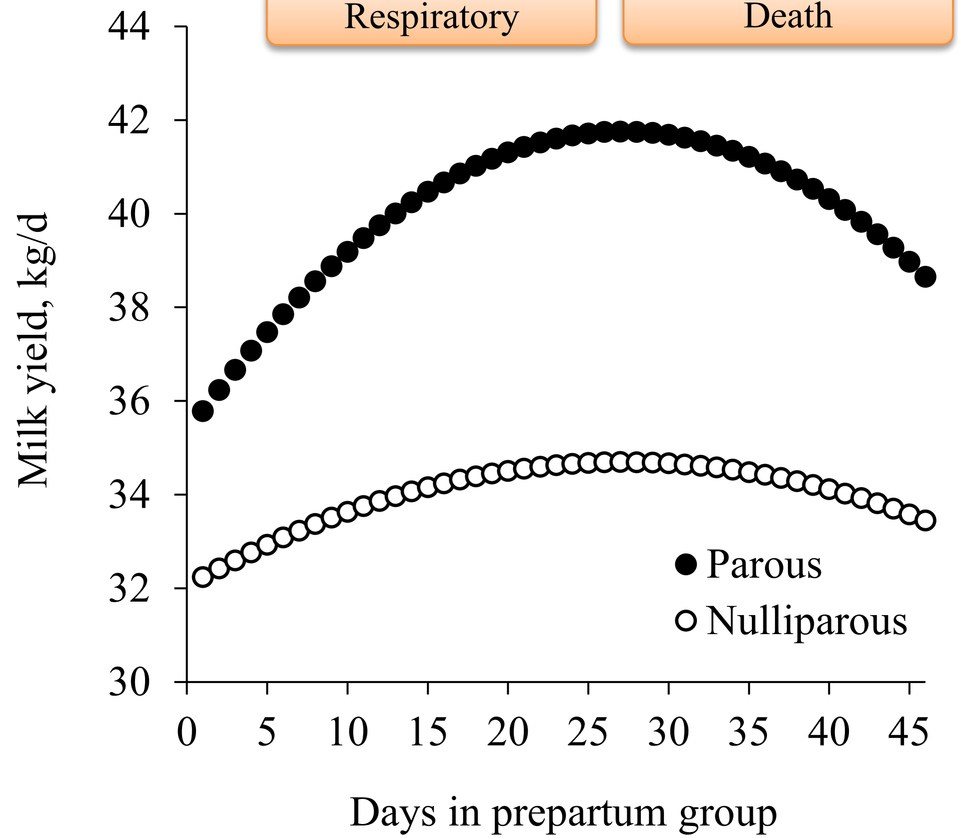
Days in Close Up Pen and Morbidity

18,657 Holstein cows

2 herds, 3 calendar years

Calving Problems	Mastitis
RFM	DA
Metritis	Digestive
Respiratory	Death





Vieira-Neto et al. (2021) J. Dairy Sci. 104:5964–5978

Holstein Cows at Peak Production

Average Holstein cow peaks at 45 kg/day

- Maintenance energy required: 15 Mcal/d of ME
- Energy for milk synthesis 55 Mcal of ME/d
- Total energy needed = 70 Mcal of ME/d
- **Therefore, consuming at 4.6 times maintenance**

Selz-Pralle Aftershock peaked at 123 kg/day

- Maintenance energy required: 16 Mcal/d of ME
- Energy for milk synthesis 134 Mcal of ME/d
- Total energy needed = 150 Mcal of ME/d
- **Therefore, consuming at 9.3 times maintenance**

Santos et al. (2010) Reprod. Dom. Rum. VII:387-404

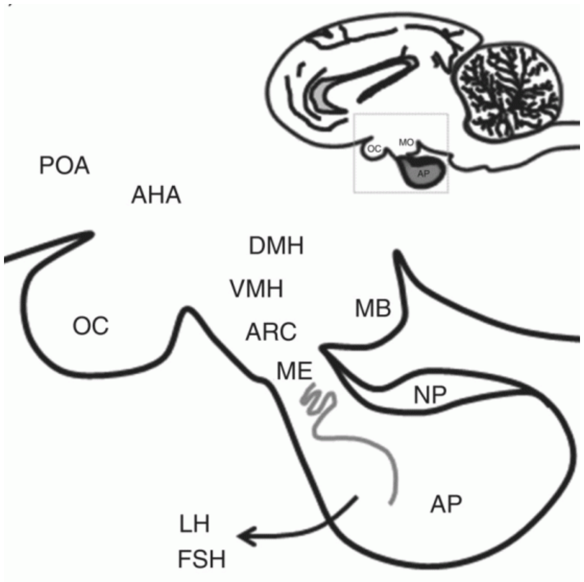
Risk factors for resumption of estrous cycles by 65 days postpartum and pregnancy at 1st AI in lactating dairy cows

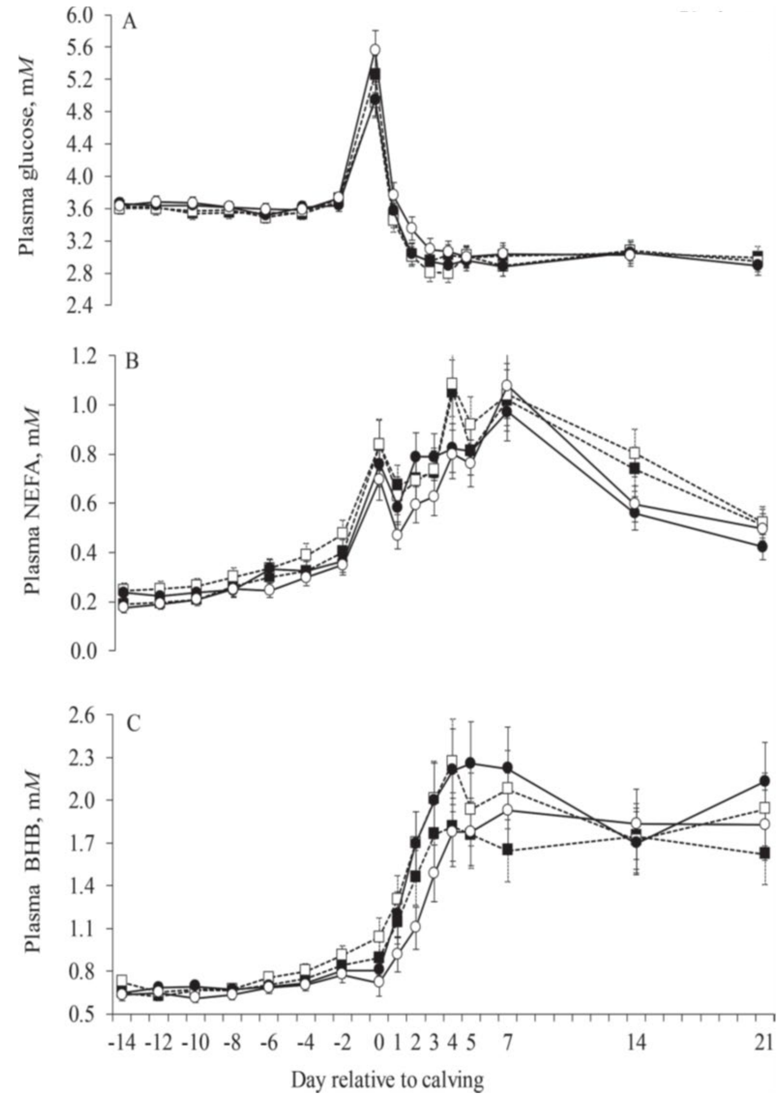
Variable	Cyclic, % (n/n)	Adjusted OR (95% CI)	*P* value
BCS change from calving to 65 DIM			
Lost 1 unit or more	58.7 (279/475)	Referent	-------
Lost < 1 unit	74.6 (2,507/3,361)	1.96 (1.52, 2.52)	< 0.001
No change	80.9 (2,071/2,560)	2.39 (1.74, 3.28)	< 0.001
Milk yield in the first 90 DIM			
Q1, 32.1 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

Cells in the Hypothalamus Require Glucose

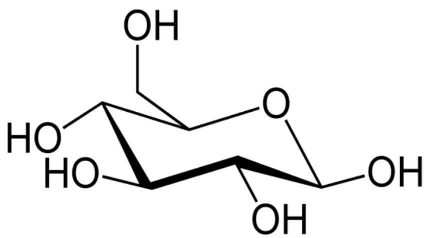


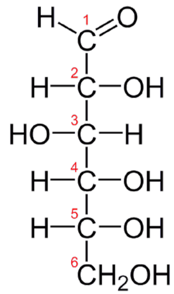


Drawing by Marcel Amstalden and Gary L. Williams, Texas A&M University

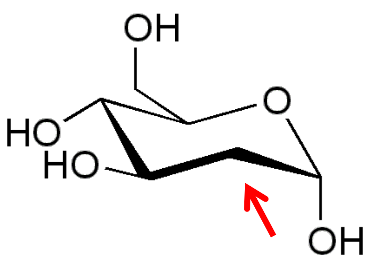
Lopera et al. (2018) J. Dairy Sci. 101:7907–7929

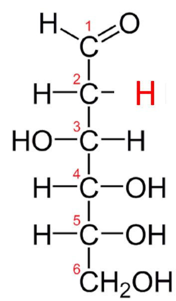
Plasma LH Pulsatility in Sheep Infused with 2-Deoxy-D-Glucose or Saline in the 4th Ventricle





Glucose

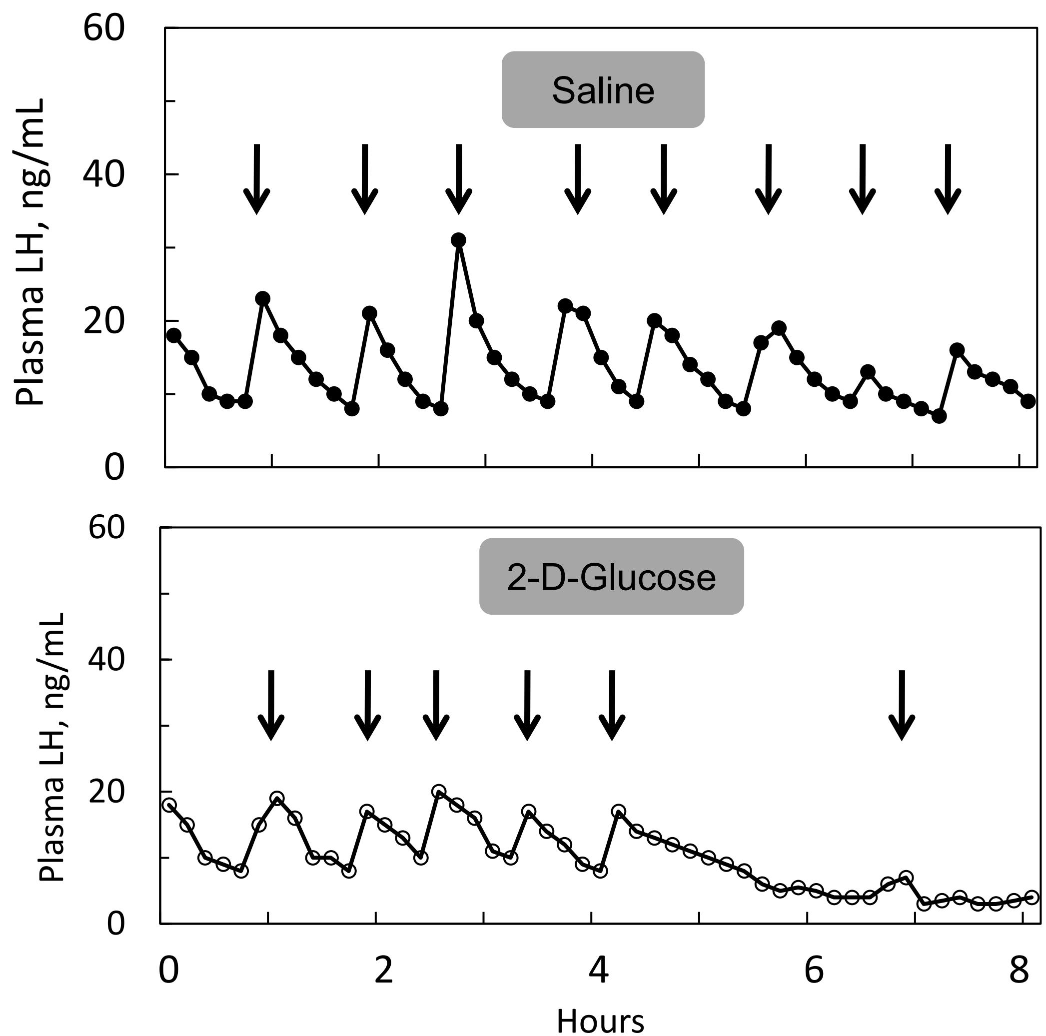


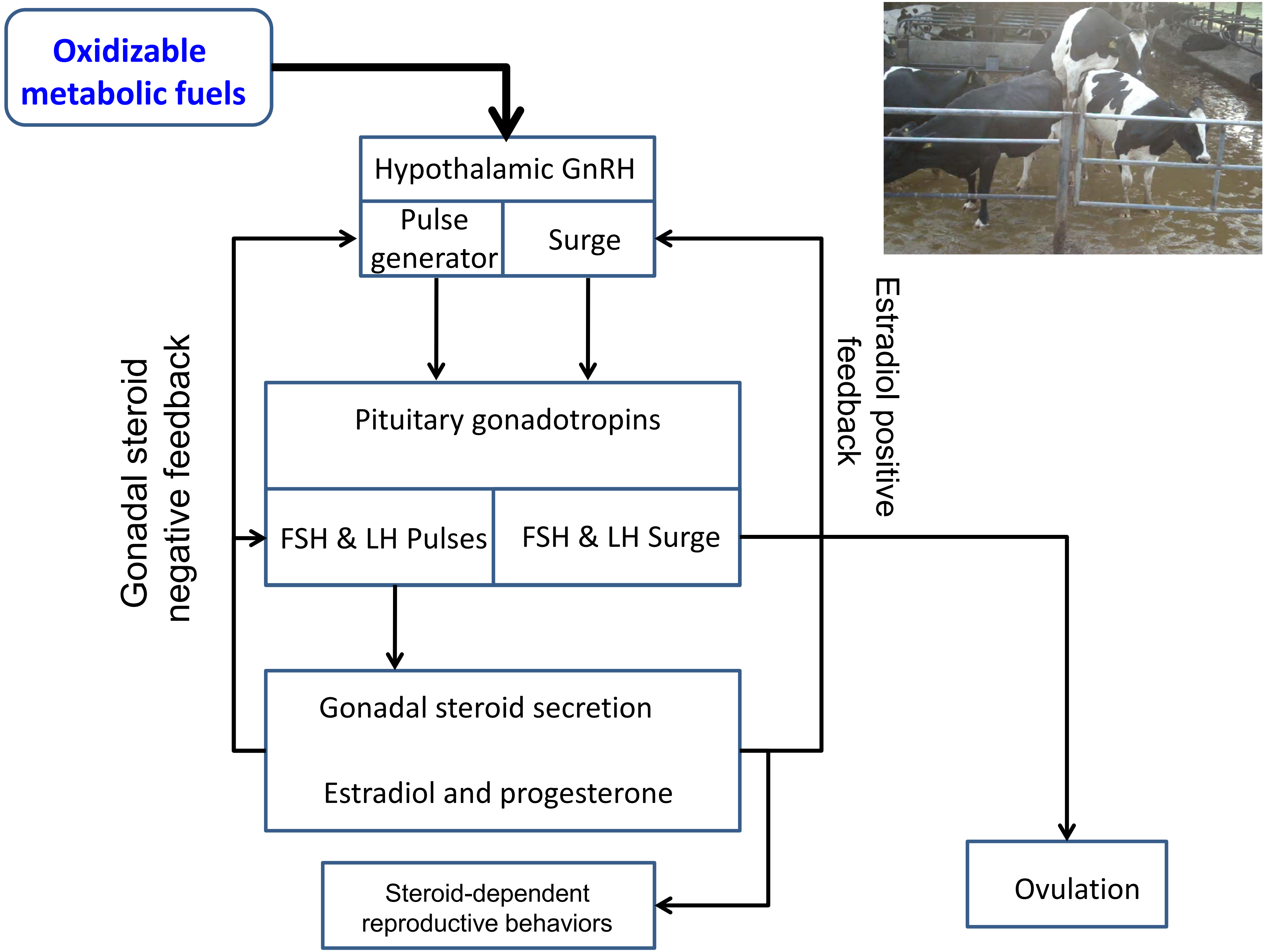


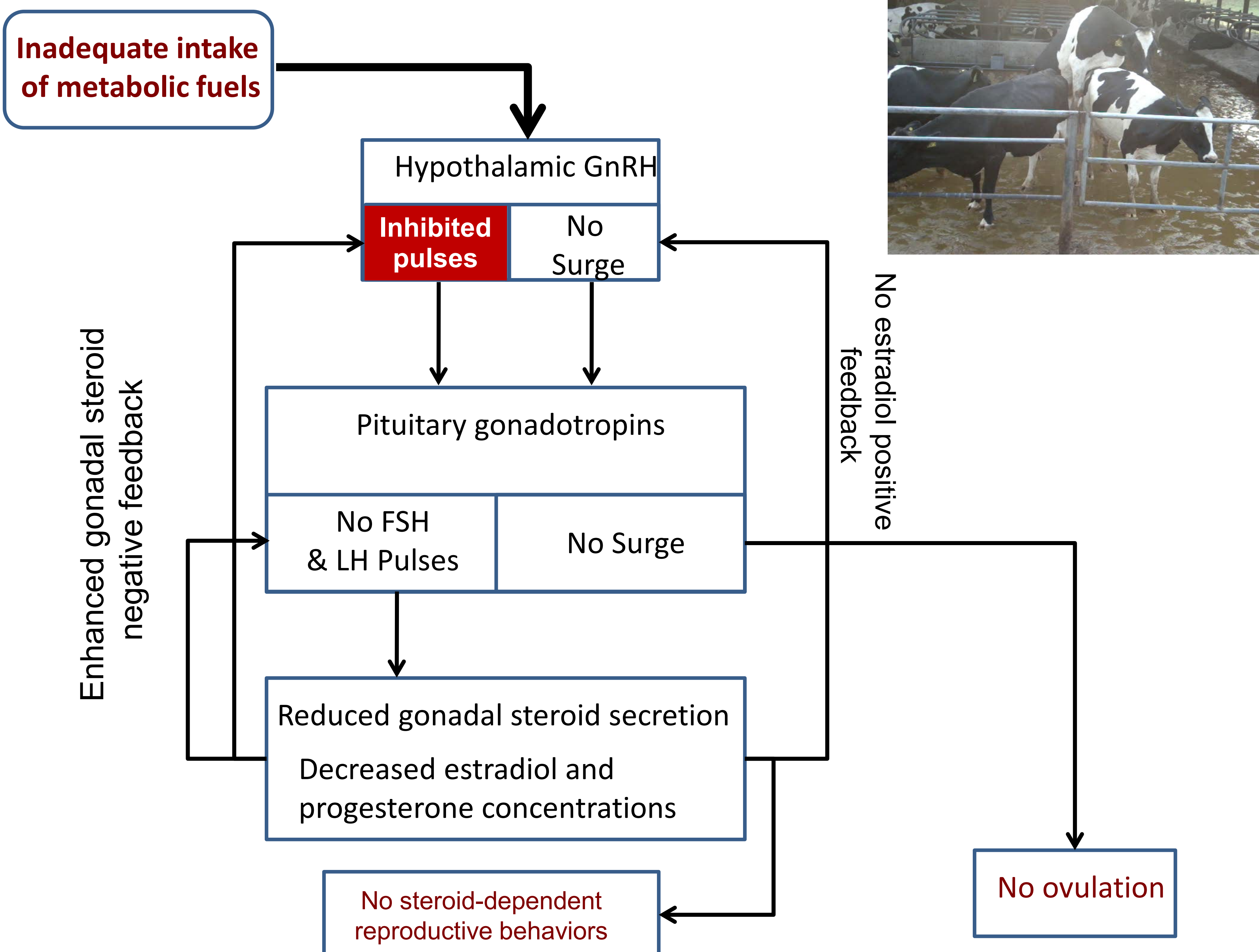
2-Deoxy-D-Glucose

2-Deoxy-D-Glucose is a glucose molecule that has the 2-OH group in glucose replaced by H.

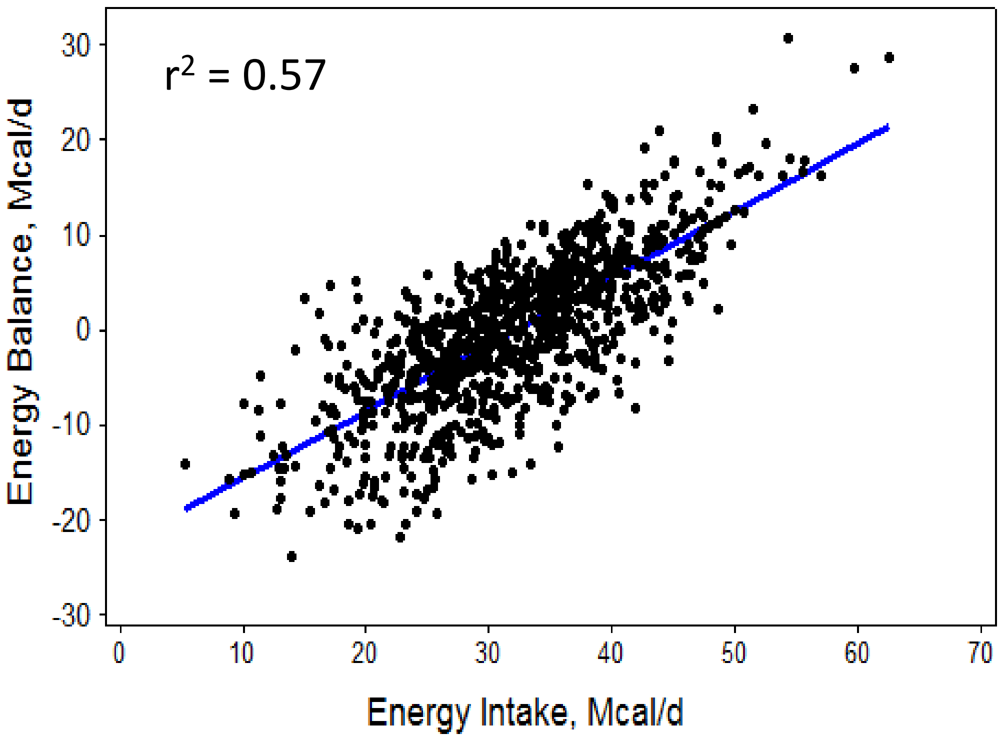
This substitution inhibits glycolysis and ATP synthesis

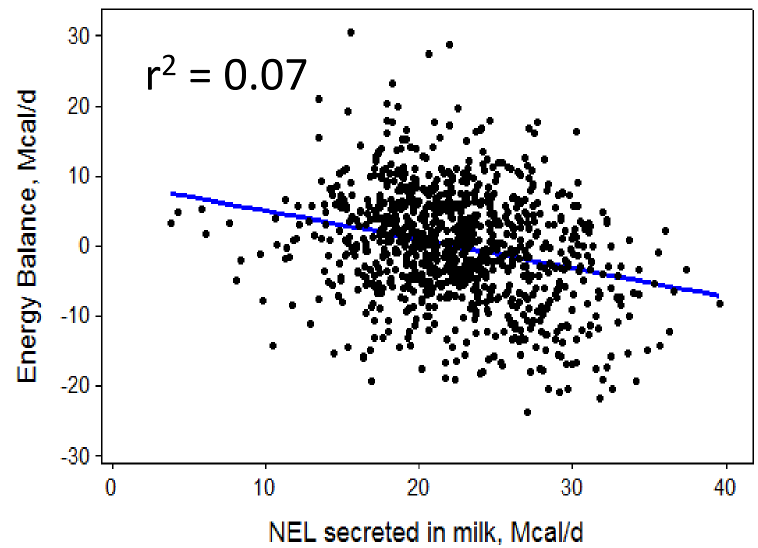


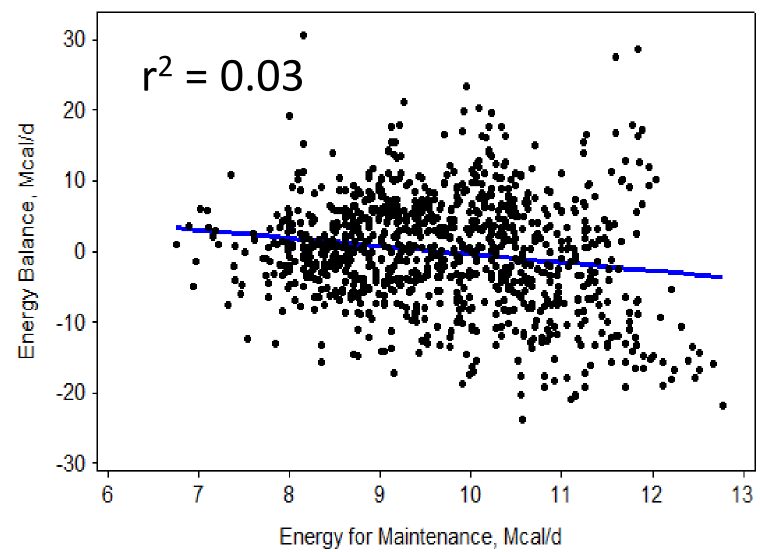

Oxidizable metabolic fuels
Hypothalamic GnRH
Pulse generator
Surge
Pituitary gonadotropins
FSH & LH Pulses
FSH & LH Surge
Gonadal steroid secretion
Estradiol and progesterone
Steroid-dependent reproductive behaviors
Ovulation
Gonadal steroid negative feedback
Estradiol positive feedback


Inadequate intake of metabolic fuels
Hypothalamic GnRH
Inhibited pulses
No Surge
Pituitary gonadotropins
No FSH & LH Pulses
No Surge
Reduced gonadal steroid secretion
Decreased estradiol and progesterone concentrations
Enhanced gonadal steroid negative feedback
No estradiol positive feedback
No steroid-dependent reproductive behaviors
No ovulation

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





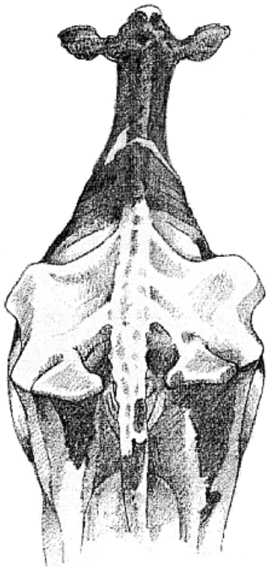


Santos et al. (2010) Soc. Reprod. Fertil. Suppl. 67: 387-403

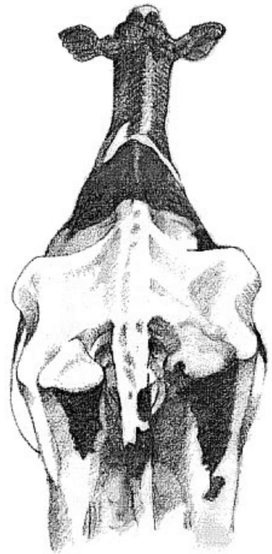
Take Home Message

- ✓ Avoid excessive body condition loss with the onset of lactation
  - ✓ Ideally, cows should not lose more than 0.5 units of body condition from the week before calving to first AI

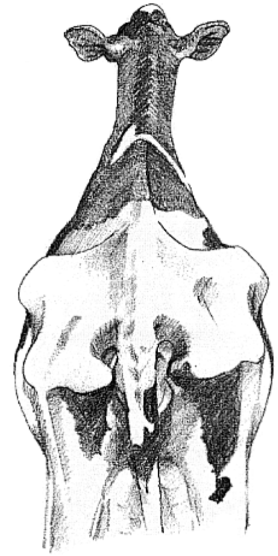
Important that cows and heifers do not calve overconditioned



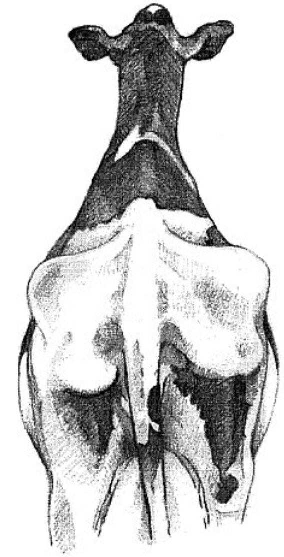
2.00



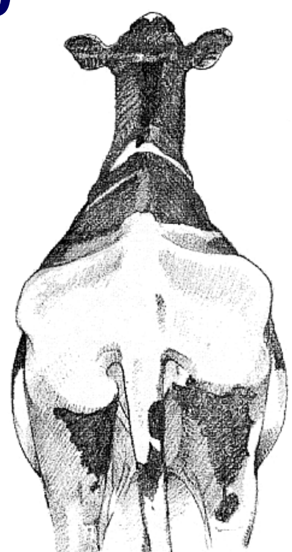
2.50



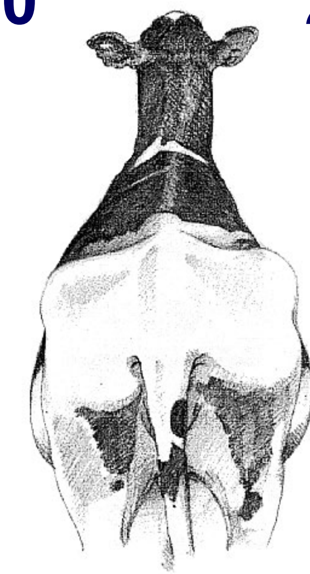
2.75



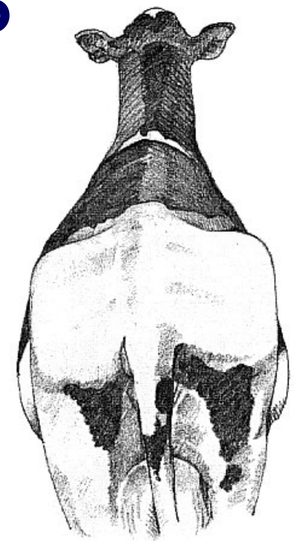
3.00



3.25

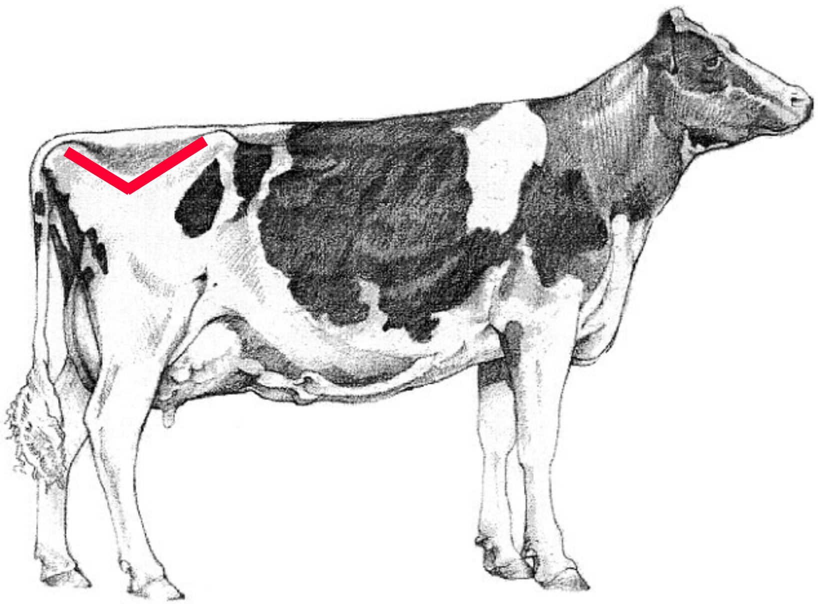


3.50

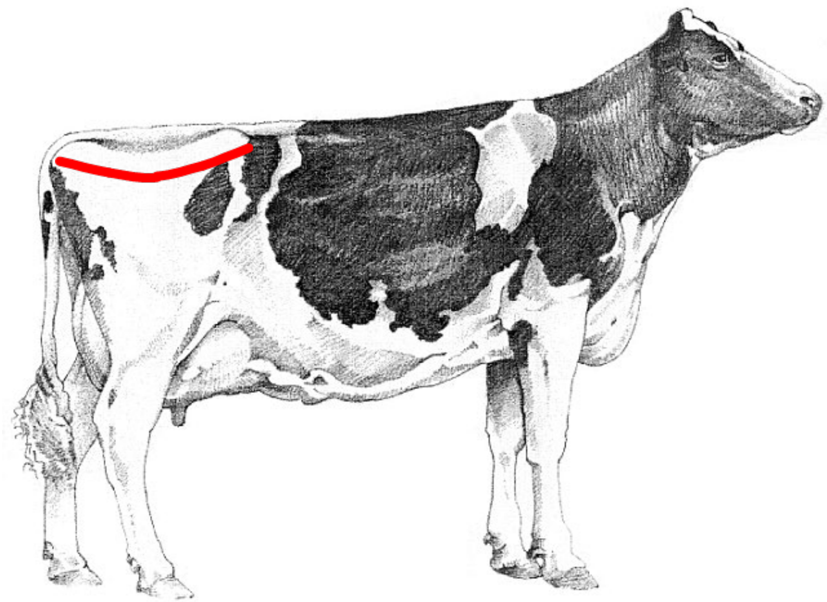


3.75

ECC – Área Pélvica Vista de Lado

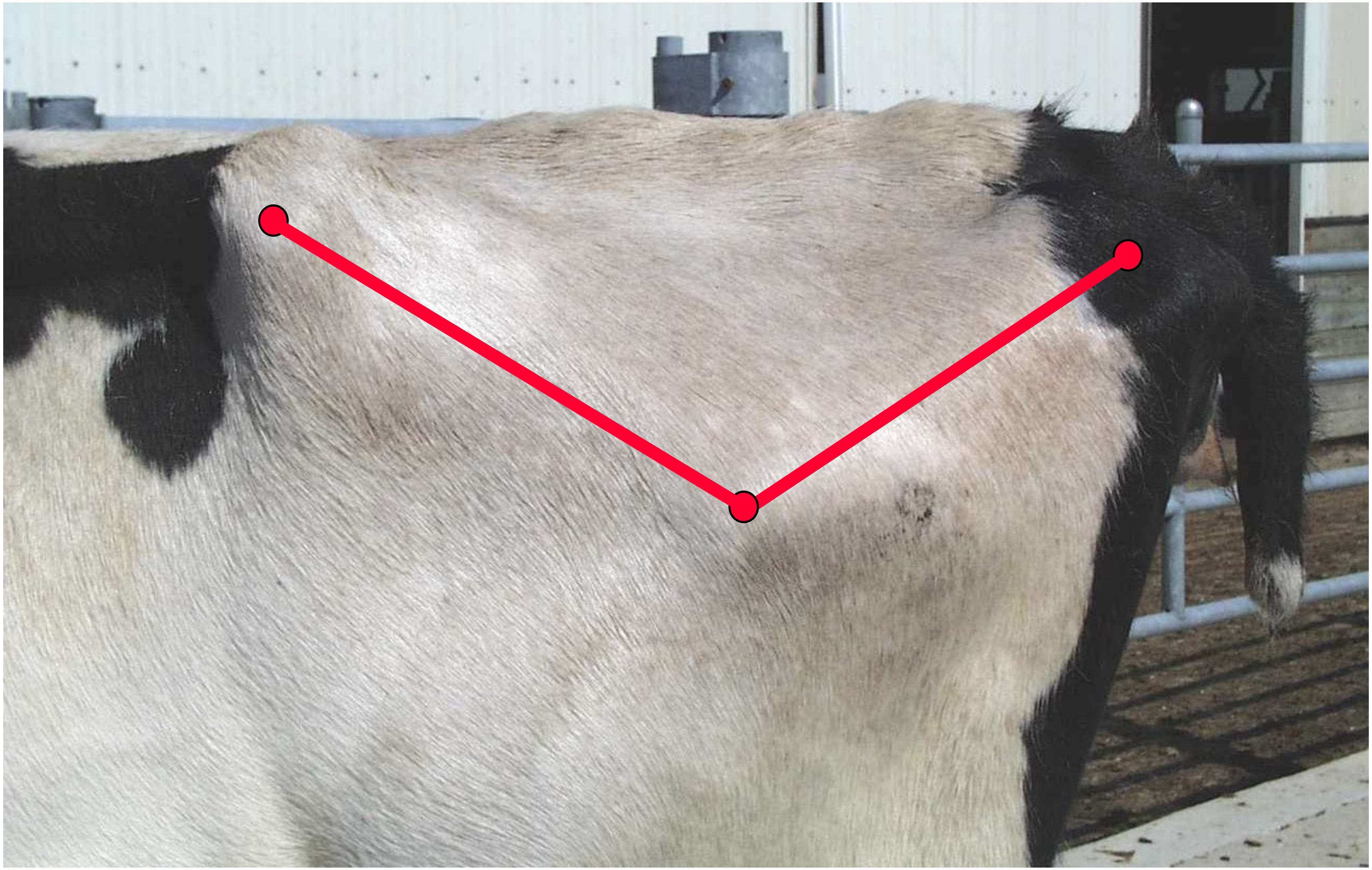


3.00 ou menos



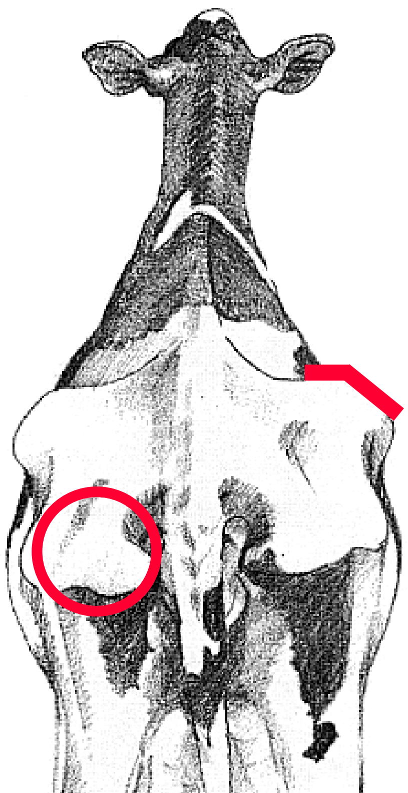
3.25 ou mais

ECC – Área Pélvica Vista de Lado



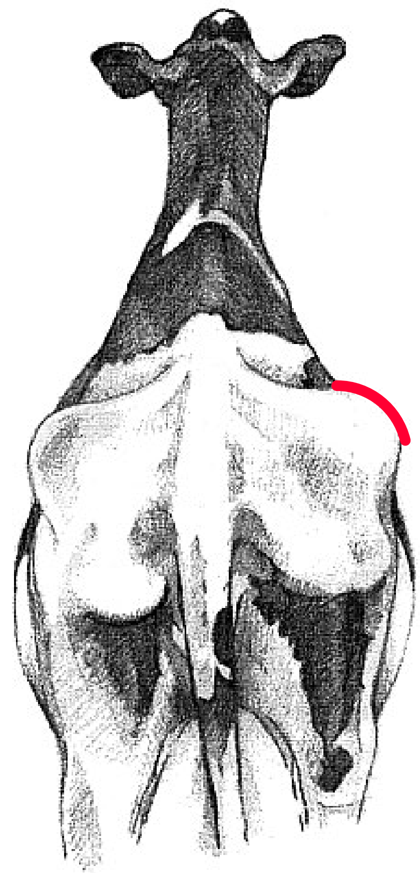
ECC – Área Pélvica Vista de Trás

Ílio angular
ECC ≤ 2.75

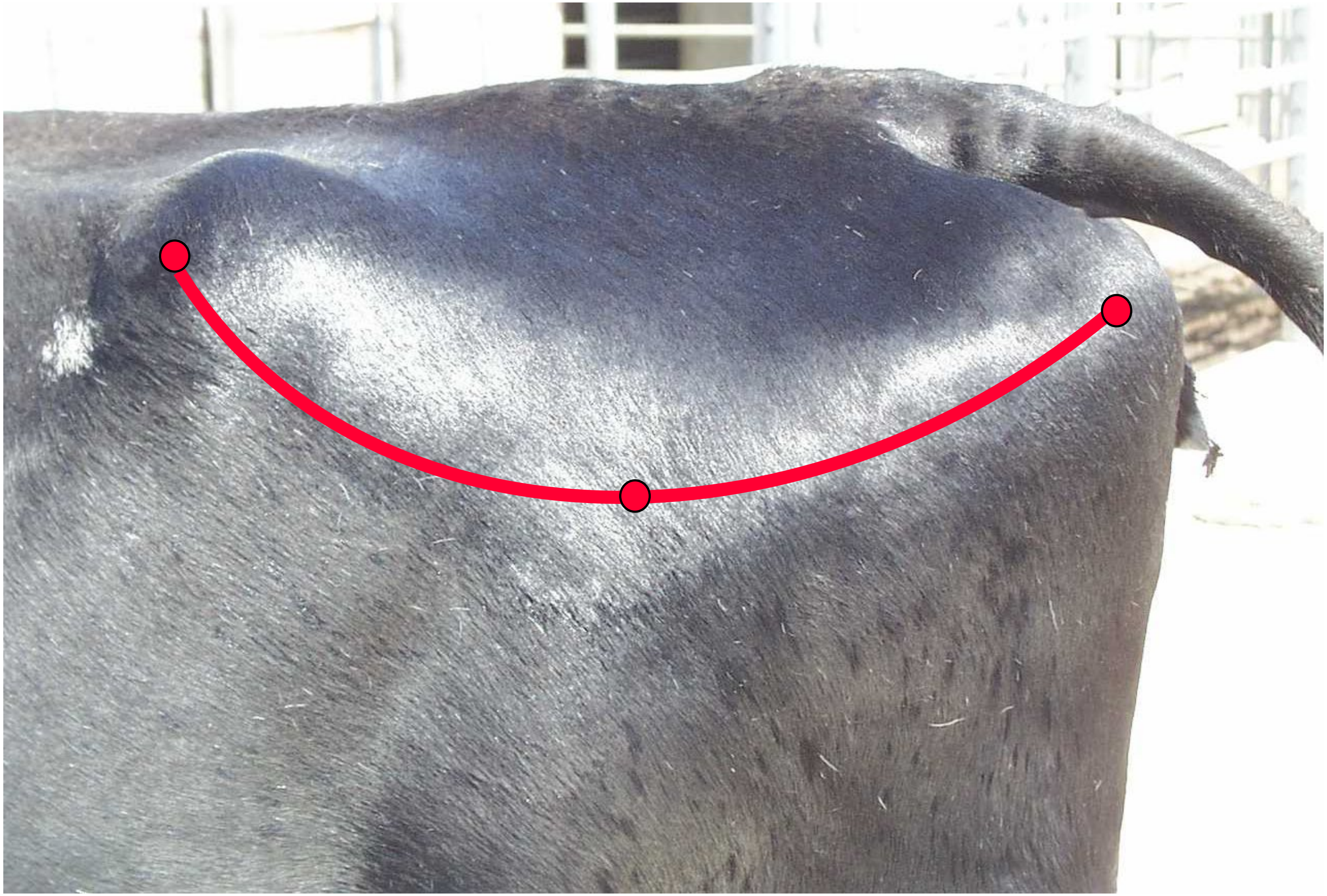


Ísquio com gordura
ECC = 2.75

Ílio arredondado
ECC = 3.00

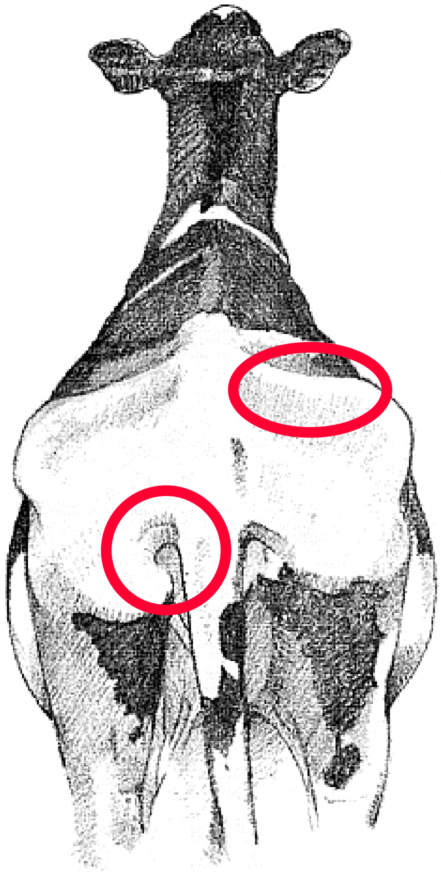


ECC – Área Pélvica Vista de Lado

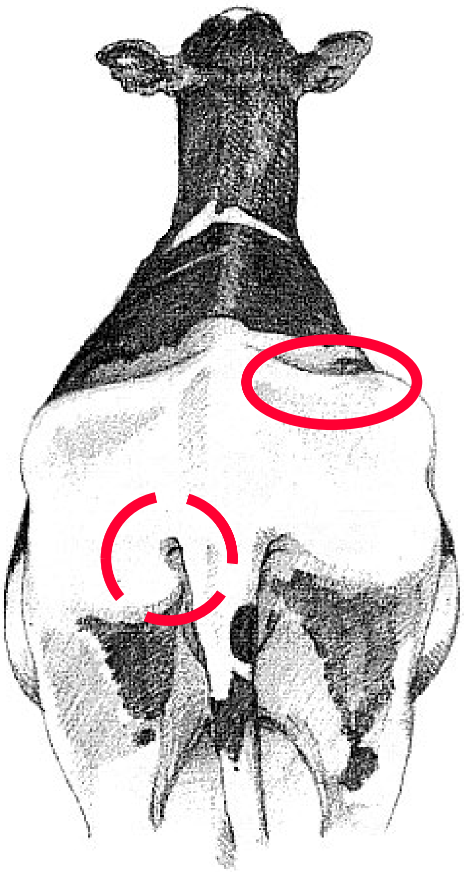


ECC – Área Pélvica Vista de Trás

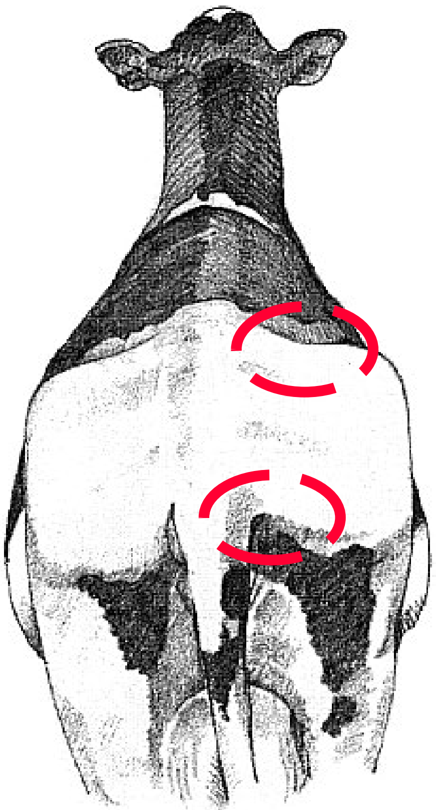
Ligamentos Sacral e Caudal Visíveis
ECC = 3.25



Ligamentos Sacral e Caudal Pouco Visíveis
ECC = 3.50

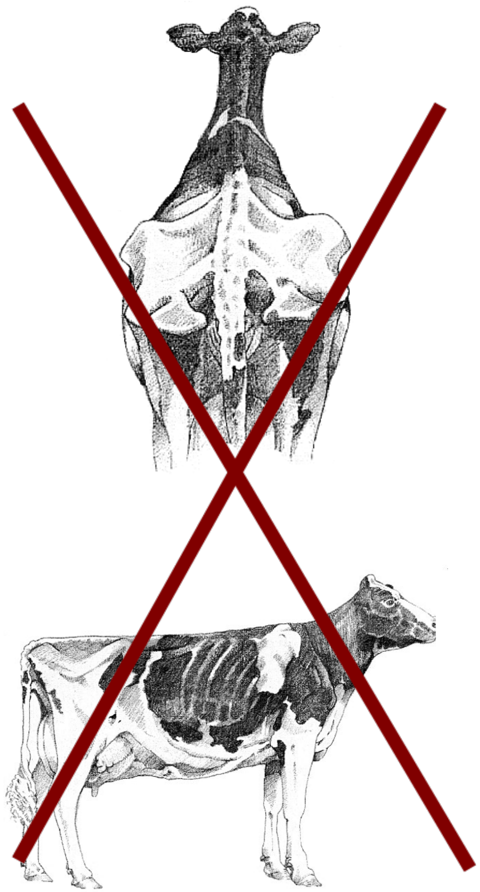


Sacral pouco visível e o caudal não visível
ECC = 3.75

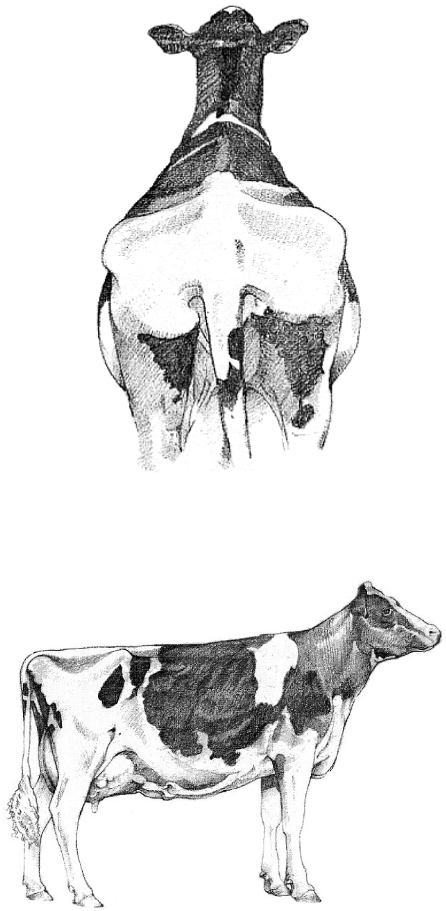


Se ambos não visíveis
ECC = 4.00

Escore de Condição Corporal



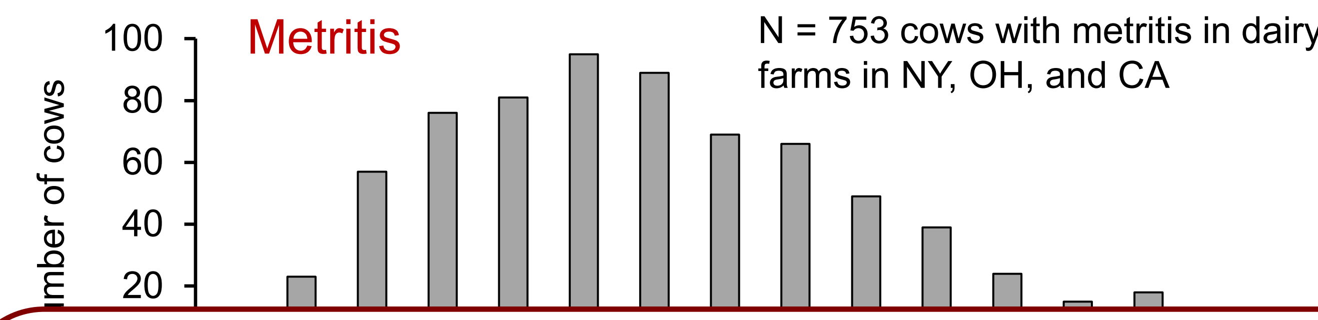
Muito magra



Ideal
3.00 a 3.50

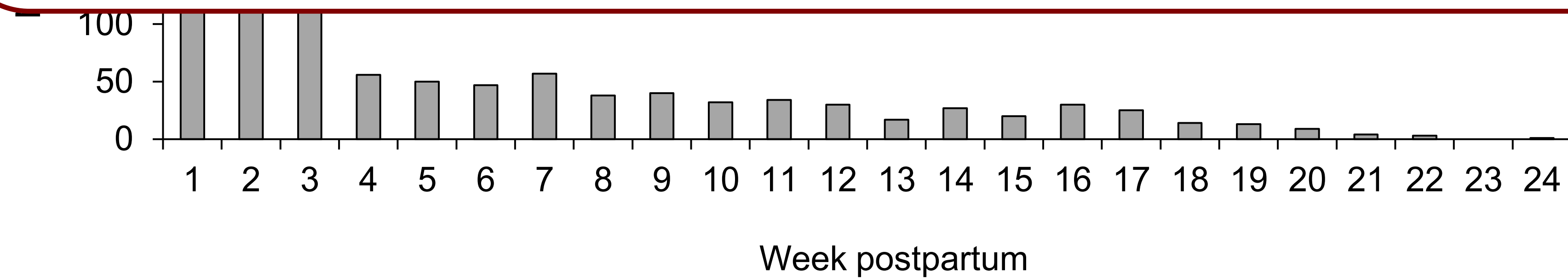
Muito gorda

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 occurs within the first 3 weeks postpartum



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

Por Que a Incidência de Doenças é Alta em Vacas Leiteiras?





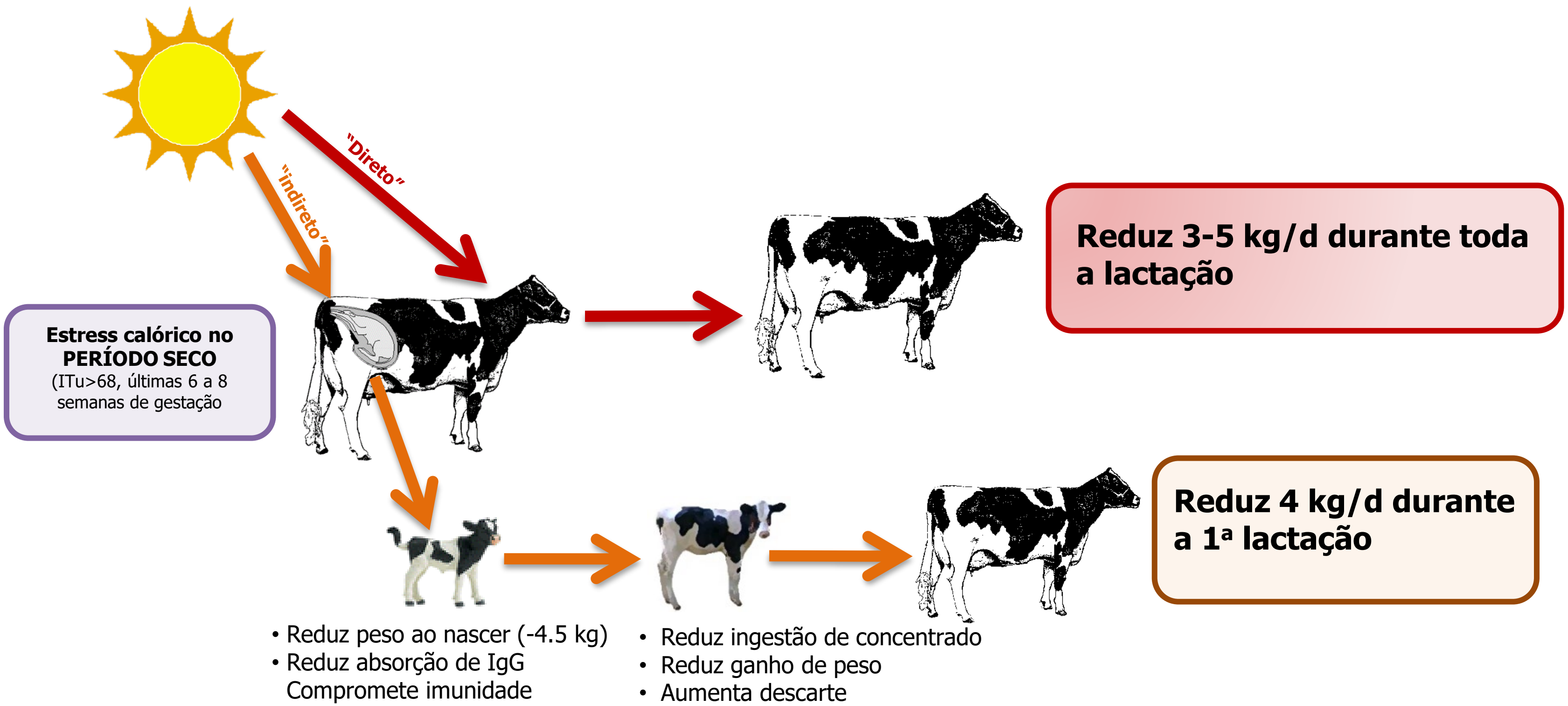
48

Vacas no Período de Transição Têm que ser Alojadas em Lotes Subpopulados

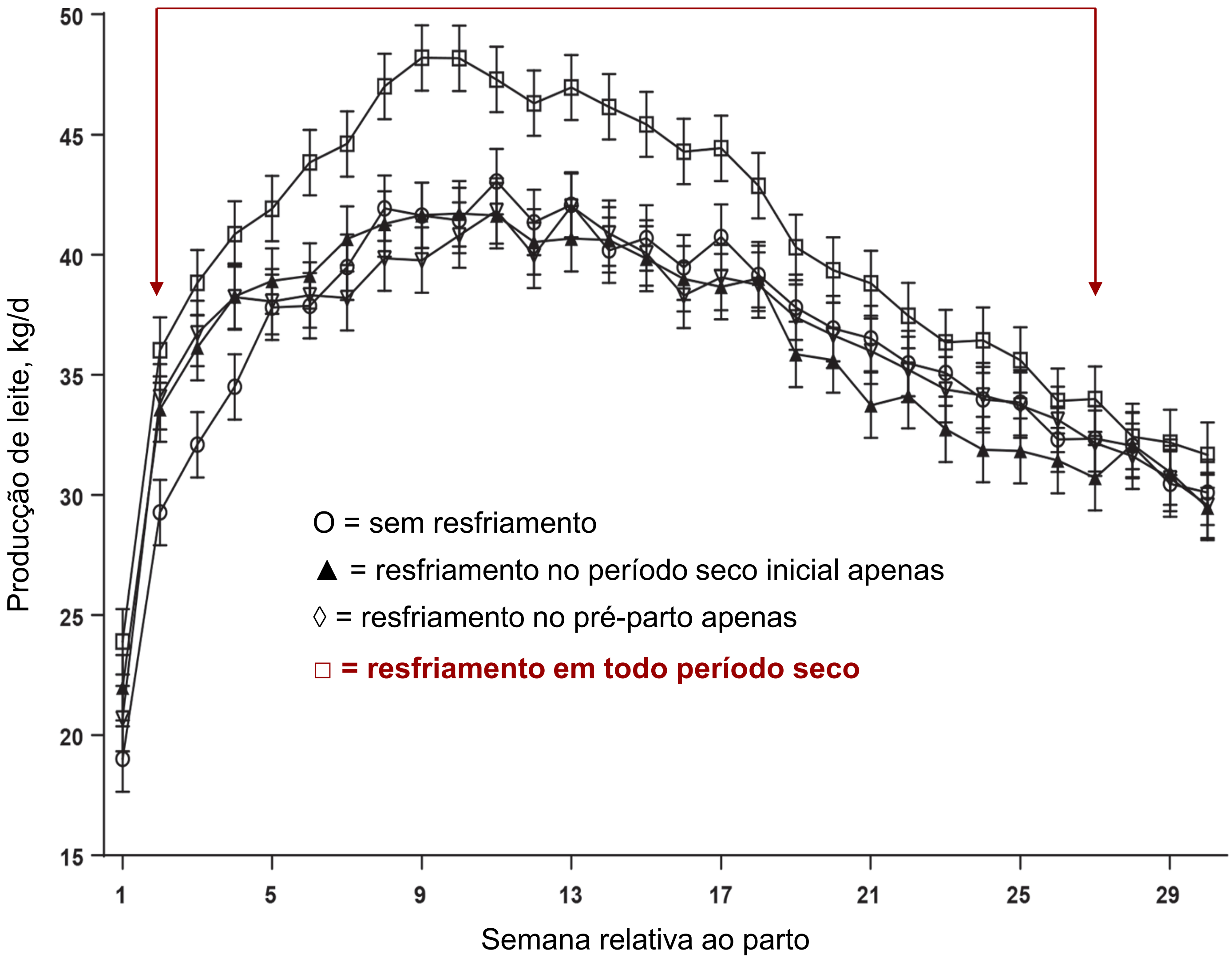
Filmes

Estresse Calório Durante o Período Seco

Estresse Calórico e Hipertermia Durante o Período Seco Resulta em Inúmeros Efeitos Deletérios na Vaca e na Bezerras

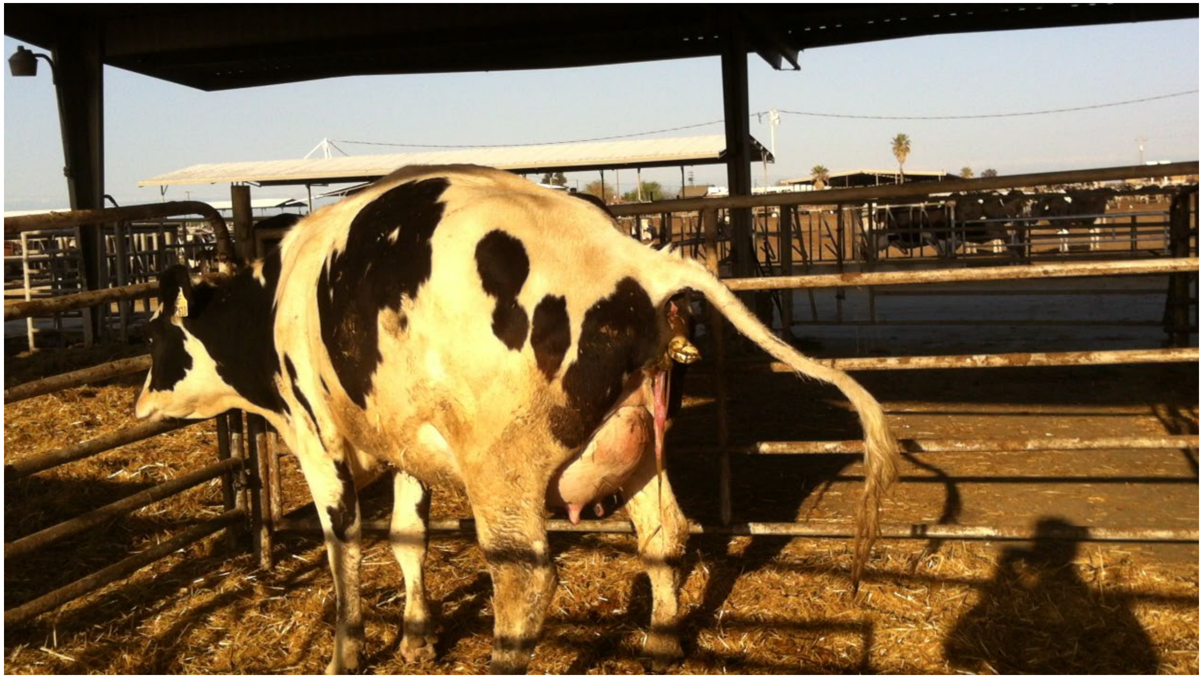


Tao et al., 2011; Tao and Dahl, 2013; Monteiro et al., 2016; Laporta et al., 2017



Fabris et al. (2019) J. Dairy Sci. 102:5647–5656

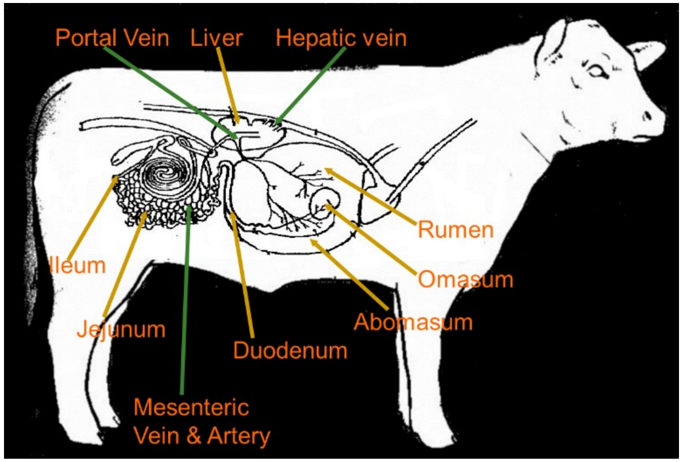
Distocia



Lóquia Normal e Descarga Uterina em Caso de Metrite

Credit to Dr. Segundo Casaro

Disease Reduces Nutrient Balance



✓ Control/Fed

- Fed *ad libitum* and not challenged

✓ Control/Fasted

- Fasted for 72 h (-14 to +58 hours relative to challenge) and not challenged

✓ Challenge/Fed

- Fed *ad libitum* and underwent intra-tracheal challenge with *M. haemolytica*

✓ Challenge/Fasted

- Fasted for 72 h (-14 to +58 hours relative to challenge) and underwent intra-tracheal challenge with *M. haemolytica*

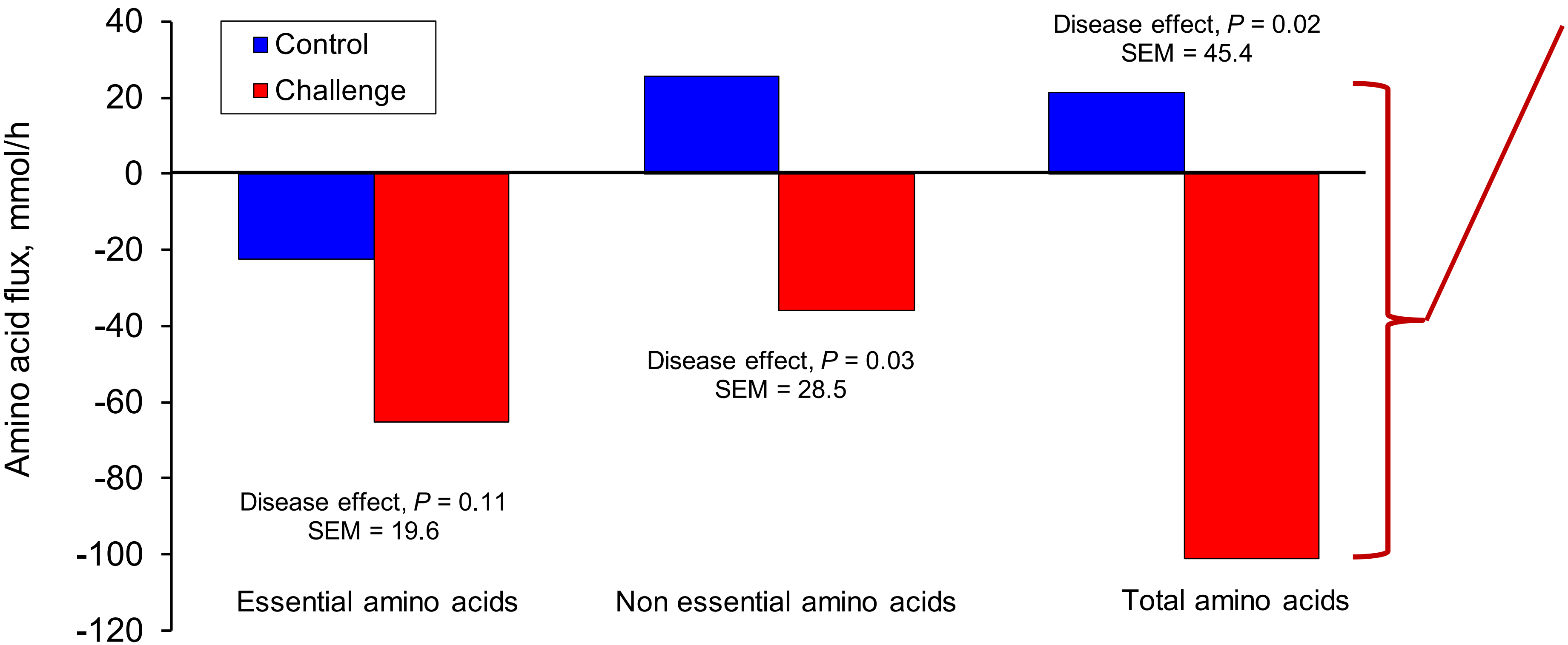
Burciaga-Robles PhD Dissertation (2009)

Two Conditions that Induce Systemic Inflammatory Responses

Amino Acid Hepatic Flux in Steers Without (Control) or with (Challenge) an Intratracheal Challenge with *M. haemolytica*

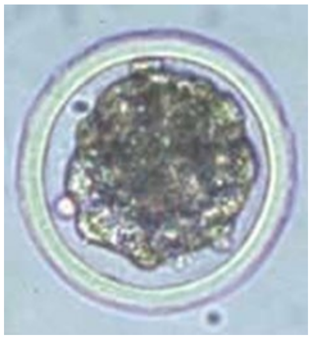
At 0.67 efficiency, this is equivalent to the true protein in 8 kg of milk (18 lbs)

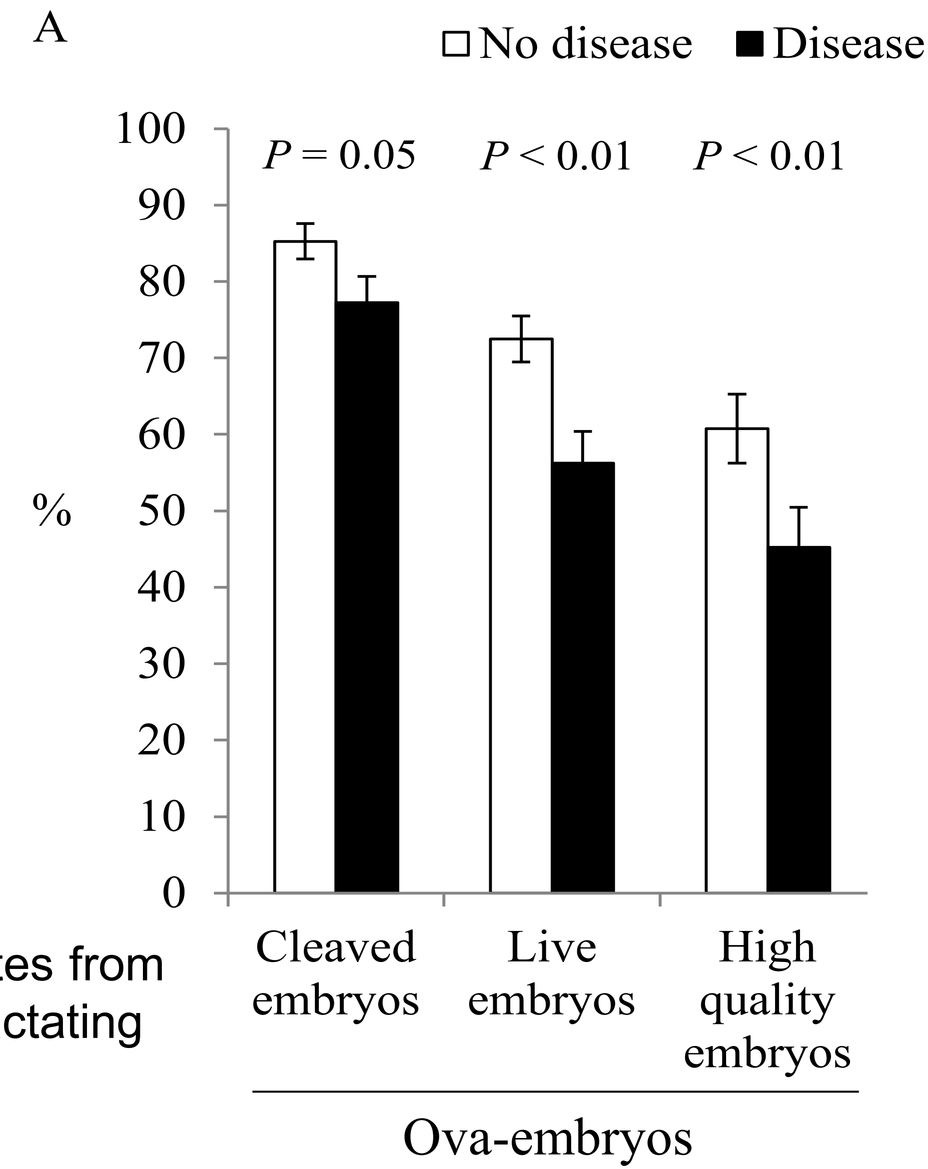
Difference of 2.6 moles/day → ~ 380 g of AA for a 400 kg steer



Burciaga-Robles PhD Dissertation (2009)

Disease Influences Development to Morula





419 embryo-oocytes from single ovulating lactating Holstein cows

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

Effect of treatment on endometrial polymorphonuclear cells, incidence of endometritis, rectal temperature, and conceptus development in lactating Holstein cows receiving artificial insemination

	Treatment[1]			
Item	CON	INF	SEM	P-value
Polymorphonuclear cells,[2] %	8.2	19.8	1.8	< 0.01
Subclinical endometritis,[3] %	20.9	81.9	6.7	< 0.01
Rectal temperature, °C	38.5	38.5	0.1	0.65
Pregnant d 16,[4] %	53.9	57.3	13.6	0.85
Conceptus length,[5] cm	14.7	8.9	1.6	0.02
Interferon-τ in uterine flush, µg/mL	269.7	57.4	109.3	0.05

[1] Holstein cows at 26 ± 3 days postpartum were blocked by parity and genomic breeding value for cow conception rate and, within block, assigned randomly to remain as controls (CON; n = 23) or to receive an intrauterine infusion of 5.05×10^8 colony-forming units (CFU) *Escherichia coli* and 3.65×10^8 CFU *Trueperella pyogenes* during a luteal phase to induce endometrial inflammation (INF; n = 34). Concepti recovered on d 16 of pregnancy were 8 CON and 11 INF.

[2] Polymorphonuclear cells in endometrial cytology collected on d 2 and 7 after treatment.

[3] Based on > 10% of polymorphonuclear cells in endometrial cytology.

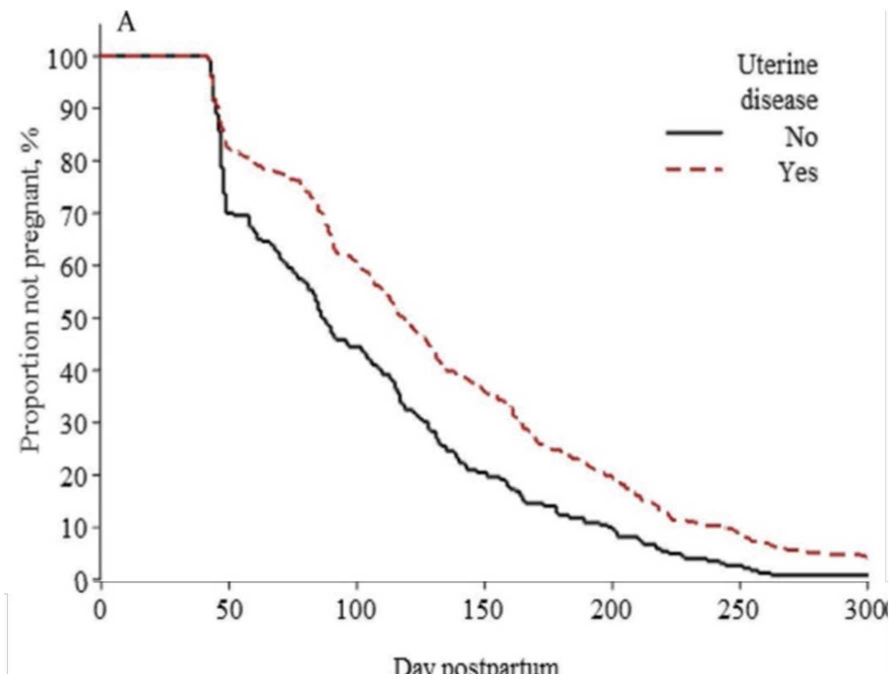
[4] Pregnancy per AI on d 16, based on detection of interferon-tau in the uterine flush fluid.

[5] Length of the intact conceptuses recovered.

Husnain et al. (2022) Biol. Reprod. (submitted)

Impact of uterine diseases on reproduction in cows receiving only embryo transfer (ET)

Item	Disease		P-value
	No uterine disease	Uterine disease	
Cows, n	269	464	----
21-d service rate	61.9 (496/801)	54.9 (1065/1938)	0.007
Pregnancy per ET	46.4 (229/494)	36.2 (386/1065)	0.02
21-d pregnancy rate	28.6 (229/801)	19.9 (386/1938)	< 0.001



Median days to pregnancy and 95% CI

No UTD = 87 (81 to 102)
UTD = 119 (111 to 128)
Adjust HR = 0.65 (0.55 to 0.77)

Edelhoff et al. (2020) J. Dairy Sci. 103:11970–11987

Take Home Message

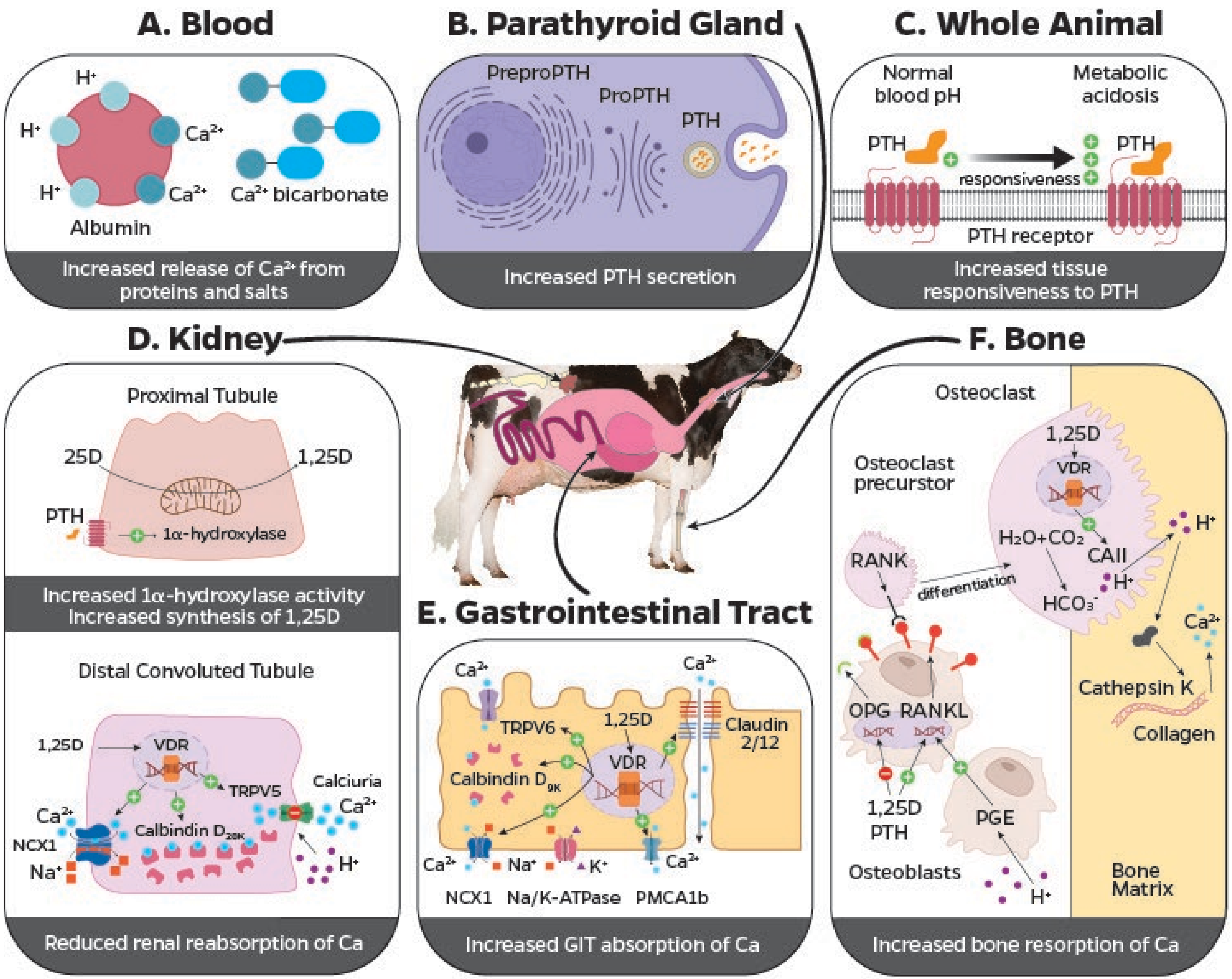
- ✓Stimulate DM intake
  - ✓ Intake influences nutrient balance that is critical for resumption of ovarian cyclicity
  - ✓ Cyclic cows have increased estrous expression, pregnancy per AI, and improved maintenance of pregnancy
- ✓Minimize disease
  - ✓ Disease causes inflammation and tissue damage, which alters function
  - ✓ Alters partition of nutrients to favor control of infection and tissue repair in place of tissue accretion
  - ✓ The priority shifts from production/growth to survival
  - ✓ Creates long-term negative effects on reproduction

Diet Formulation to Improve Reproduction

Focus on 2 important concepts

- ✓Formulate diets that reduce the risk of diseases
- ✓Supplement diets with nutrients shown to benefit reproduction in cows

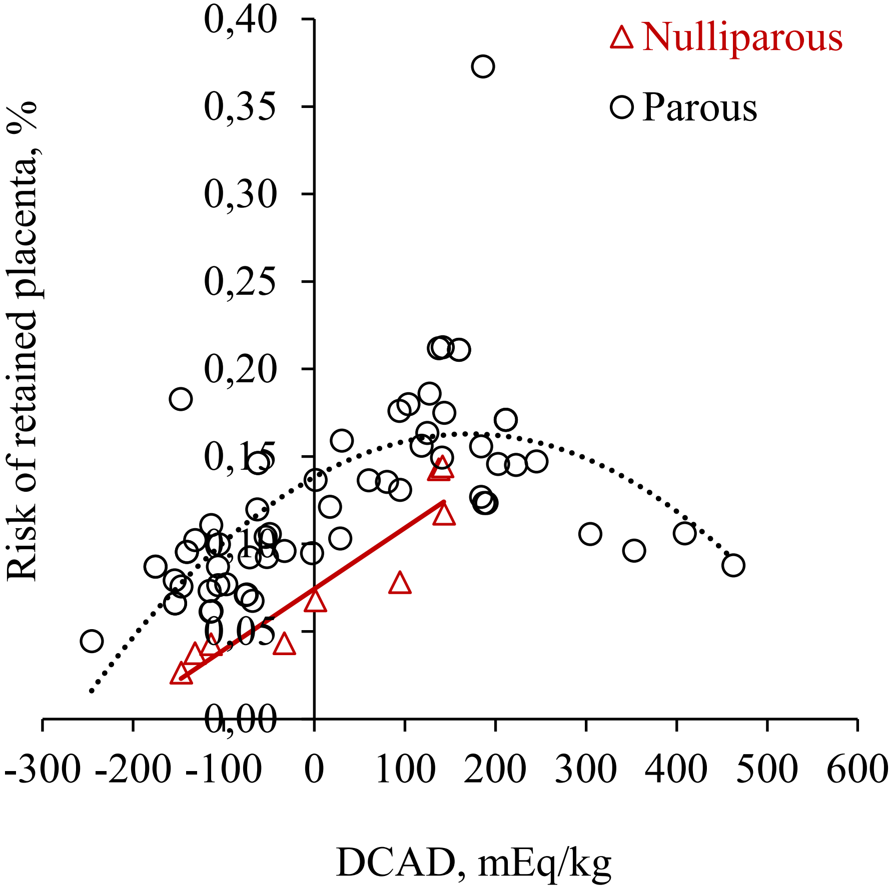
Mechanisms of Acidogenic Diets to Prevent Hypocalcemia



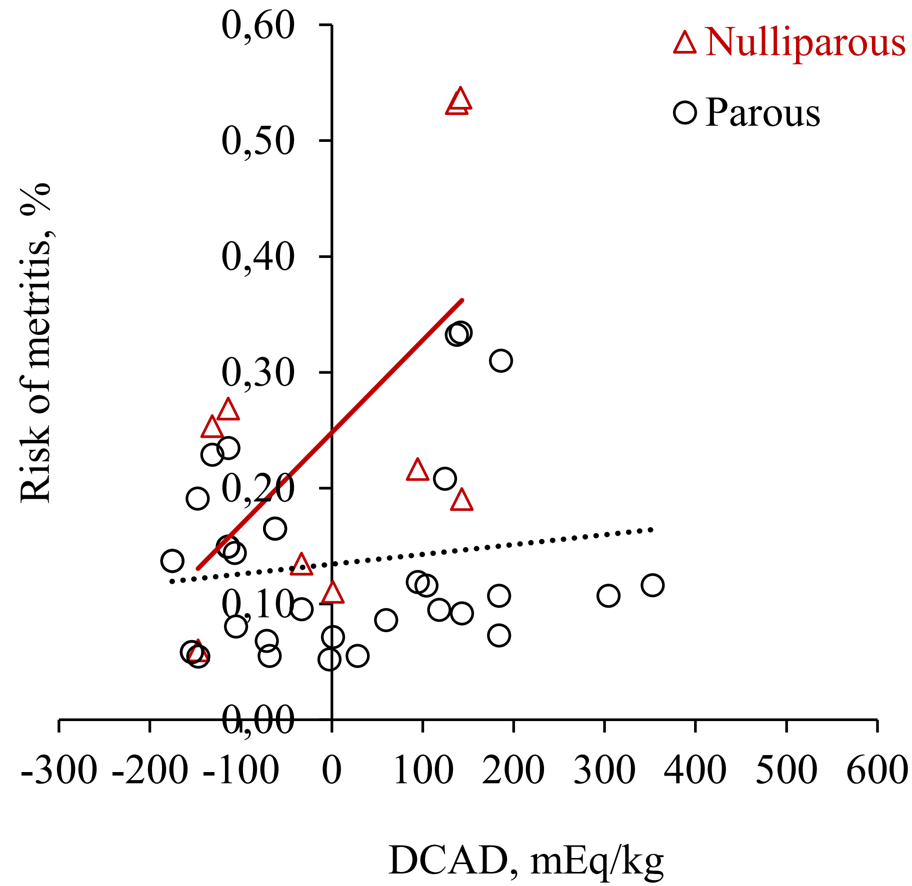
Vieira-Neto et al. (2021)

Effect of DCAD on Risk of Retained Placenta or Metritis

DCAD: *P* = 0.05
DCAD x parity: *P* = 0.61



DCAD: *P* = 0.02
DCAD x parity: *P* = 0.34



Santos et al. (2019) J. Dairy Sci. 102:2134–2154

Typical Lactating Cow Diet

24 kg of dry matter intake (53 lb/d)

Each rectangle represents 1 or 0.5 kg of DM of the diet

Production of 41 kg of milk with 3.70% fat and 3.20% protein (95 lbs of ECM)

Low quality forage → inclusion is limited

<table>
<tr><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td></tr>
<tr><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td></tr>
<tr><td colspan="2">Forage</td><td colspan="2">Forage</td><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td></tr>
<tr><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td><td>Byprod
uct</td></tr>
<tr><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td></tr>
<tr><td>Prot</td><td>Prot</td><td>Prot</td><td>Prot</td><td>Prot</td><td>Prot</td><td>Prot</td><td>MinVit</td></tr>
</table>

Typical Lactating Cow Diet

24 kg of dry matter intake (53 lb/d)

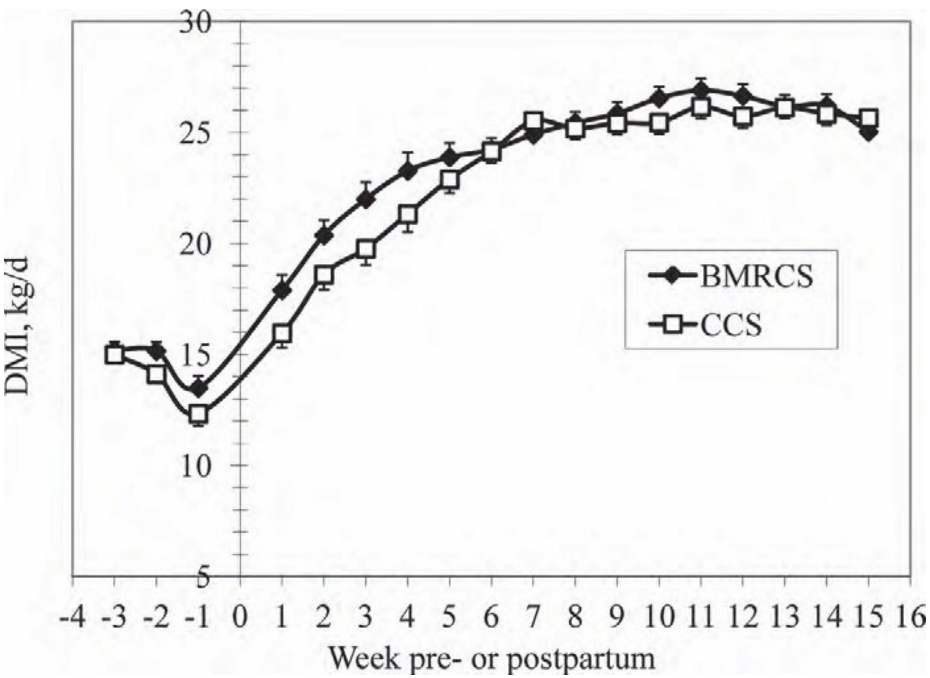
Each rectangle represents 1 or 0.5 kg of DM of the diet

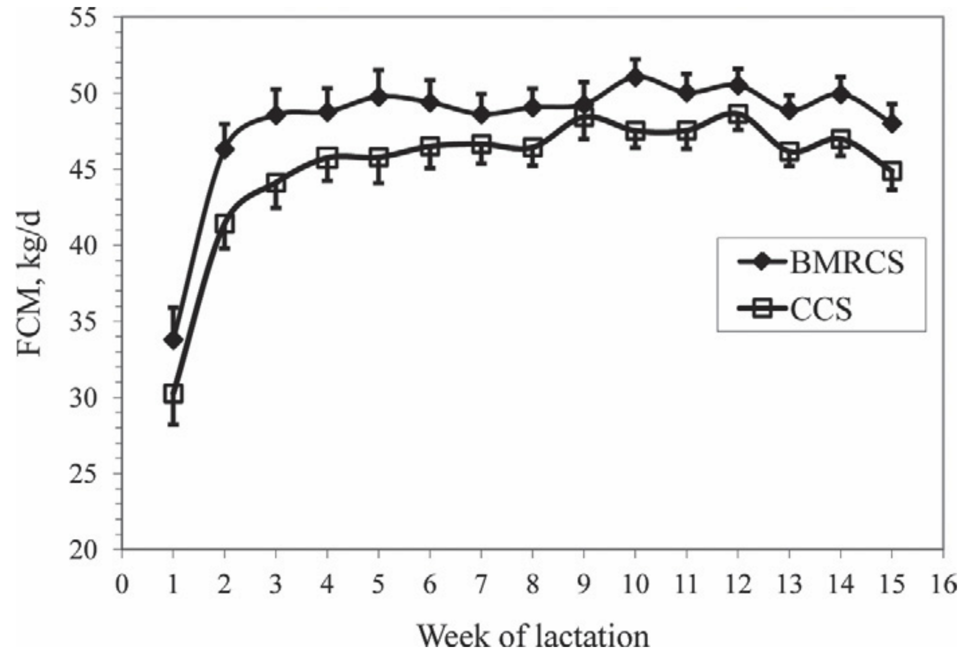
Production of 41 kg of milk with 3.70% fat and 3.20% protein (95 lbs of ECM)

High-quality forage → feed 50 to 60% of the TMR as forage

<table>
<tr><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td></tr>
<tr><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td></tr>
<tr><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td><td colspan="2">Forage</td></tr>
<tr><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td><td>Corn</td></tr>
<tr><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td><td>Byprod
uct</td></tr>
<tr><td>Prot</td><td>Prot</td><td>Prot</td><td>Prot</td><td>Prot</td><td>Prot</td><td>Prot</td><td>MinVit</td></tr>
</table>

Corn Silage Quality in Transition Cow Diets





Wk 1 to 3
20.1 vs. 18.1

Wk 4 to 15
25.4 vs. 25.0

Wk 1 to 3
42.9 vs. 38.8

Wk 4 to 15
49.4 vs. 46.7

BMR corn silage vs. conventional corn silage from 3 wk pre- to 3 wk postpartum

Stone et al. (2012) J. Dairy Sci. 95 :6665–6676

Meta-Analysis of Lipid Supplementation During the Transition Period

- ✓ 17 experiments and 26 comparisons with 1,385 cows
- ✓ 7 different fat sources
- ✓ Effects of lipid supplementation
  - ✓ 27% increase in risk of pregnancy per AI (e.g. 32 vs. 40%)
  - ✓ Days open tended to be reduced
  - ✓ Milk yield tended to increase
  - ✓ Concentration of milk fat unchanged and milk protein tended to decrease
  - ✓ Body weight unchanged

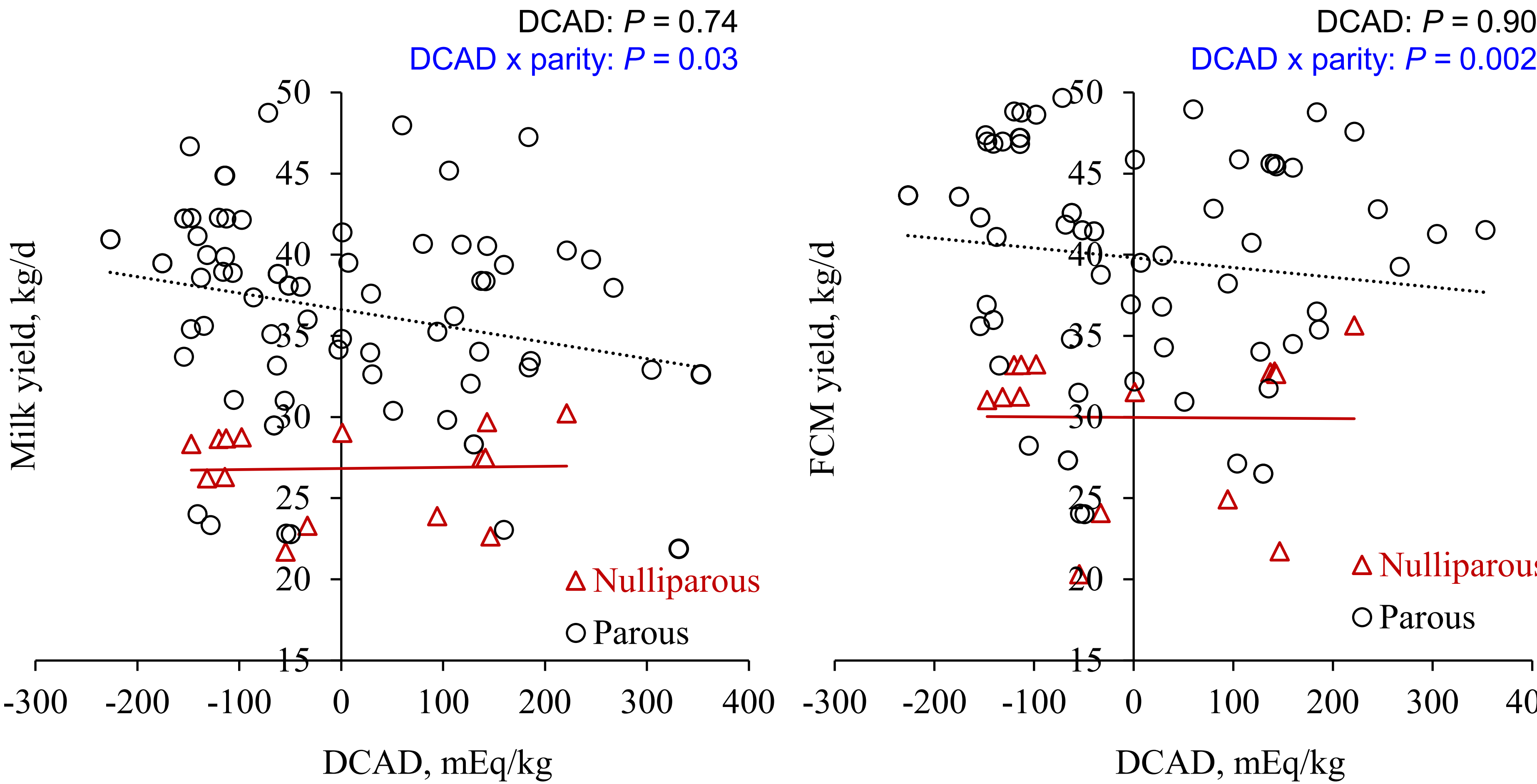
Diets for early lactation cows should contain 1 to 1.5% supplemental fat to result in 4 to 5% total fatty acids (DM basis)

Rodney et al. (2015) J. Dairy Sci. 98:5601-5620

Thank you

Jepsantos@ufl.edu

Effect of DCAD on Yields of Milk and FCM According to Parity

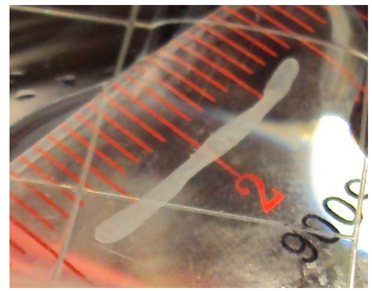


Santos et al. (2019) J. Dairy Sci. 102:2134–2154

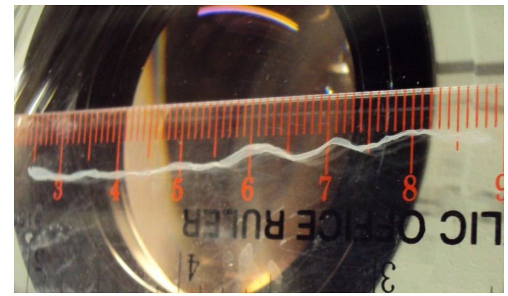
Bovine Conceptus Changes its Gene and Protein Expression to Allow Maintenance of Pregnancy

Ovoid

Tubular



Filamentous

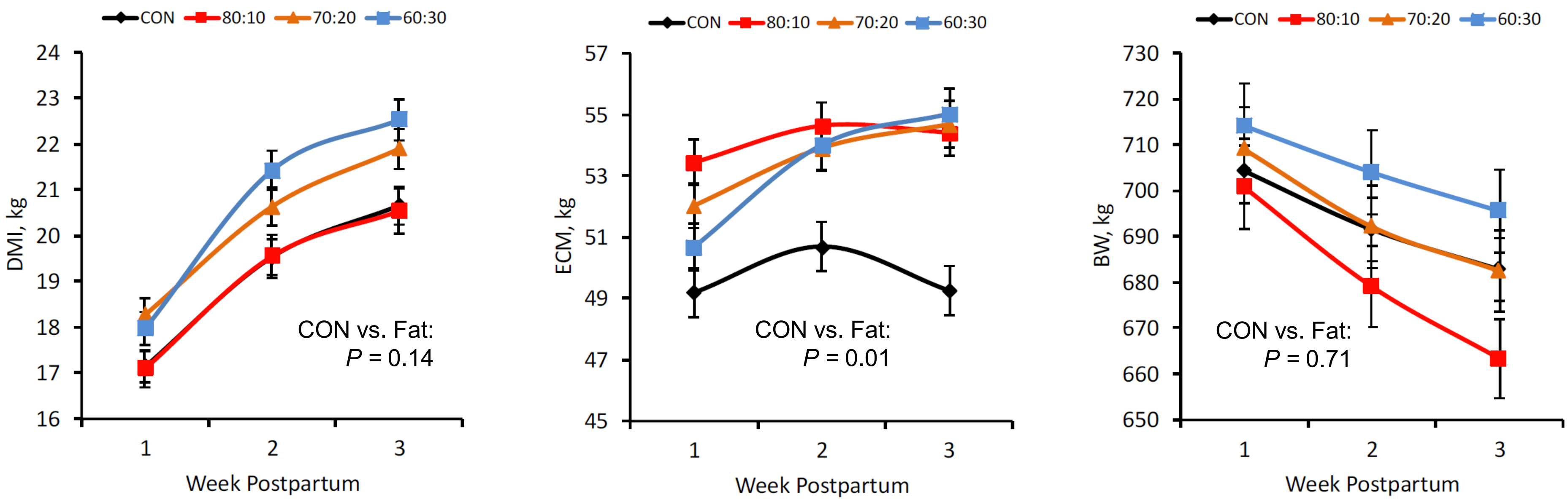


Downregulation of genes that alert the maternal immune system

Tolerance to conceptus alloantigens

Ribeiro et al. (2016) Biol. Reprod. (2016) 94(4):97, 1–18

Supplement Moderate Amounts of Fat to Postpartum Diets



56 cows, 14/treatment

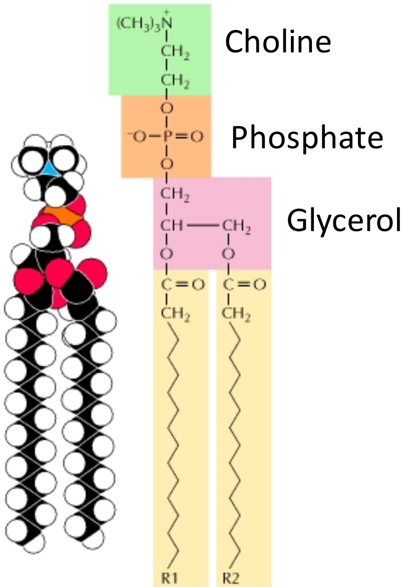
CON = control, no fat supplementation

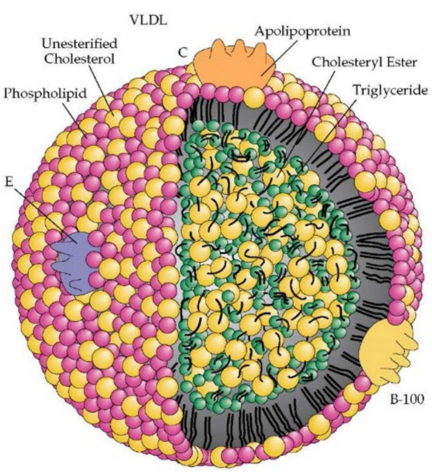
Fatty acids supplemented at 1.5% of diet DM with different ratios of C16:0 to C18:1

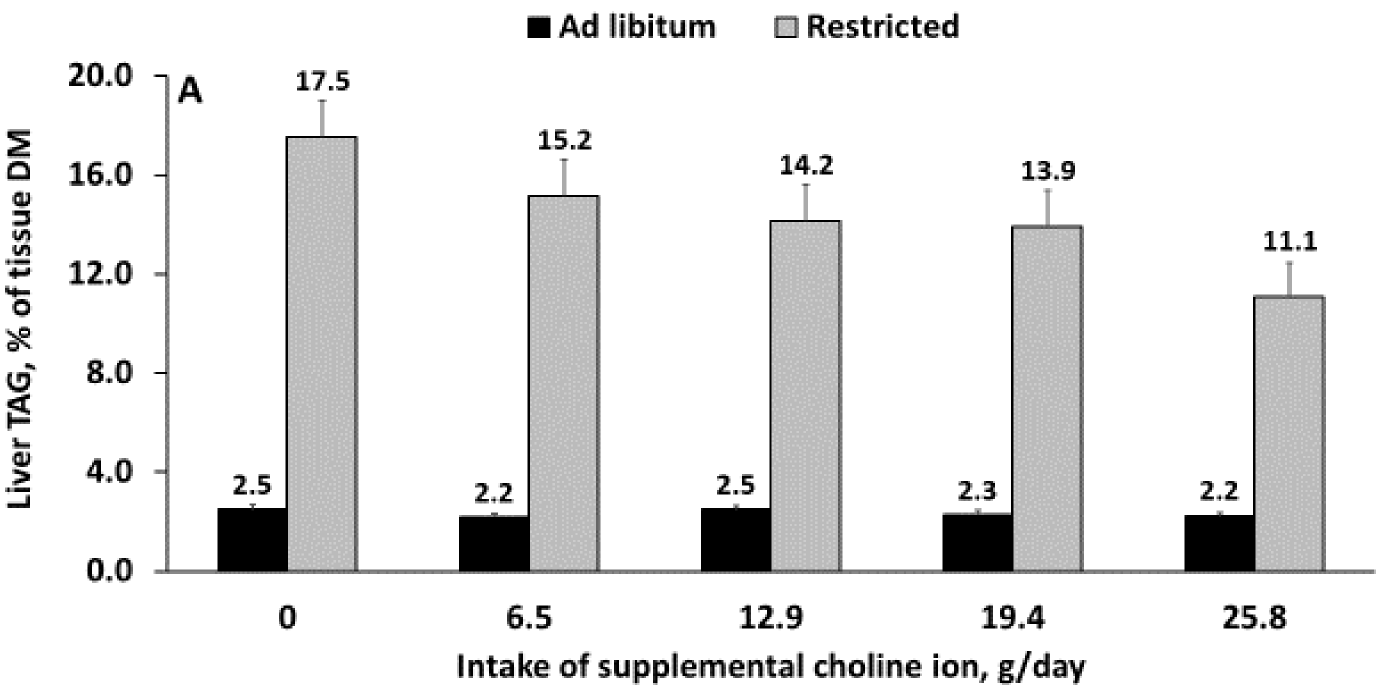
Diets fed for the first 21 DIM

de Souza et al. (2021) J. Dairy Sci. 104:2896-2909

Choline Reduces Fatty Liver

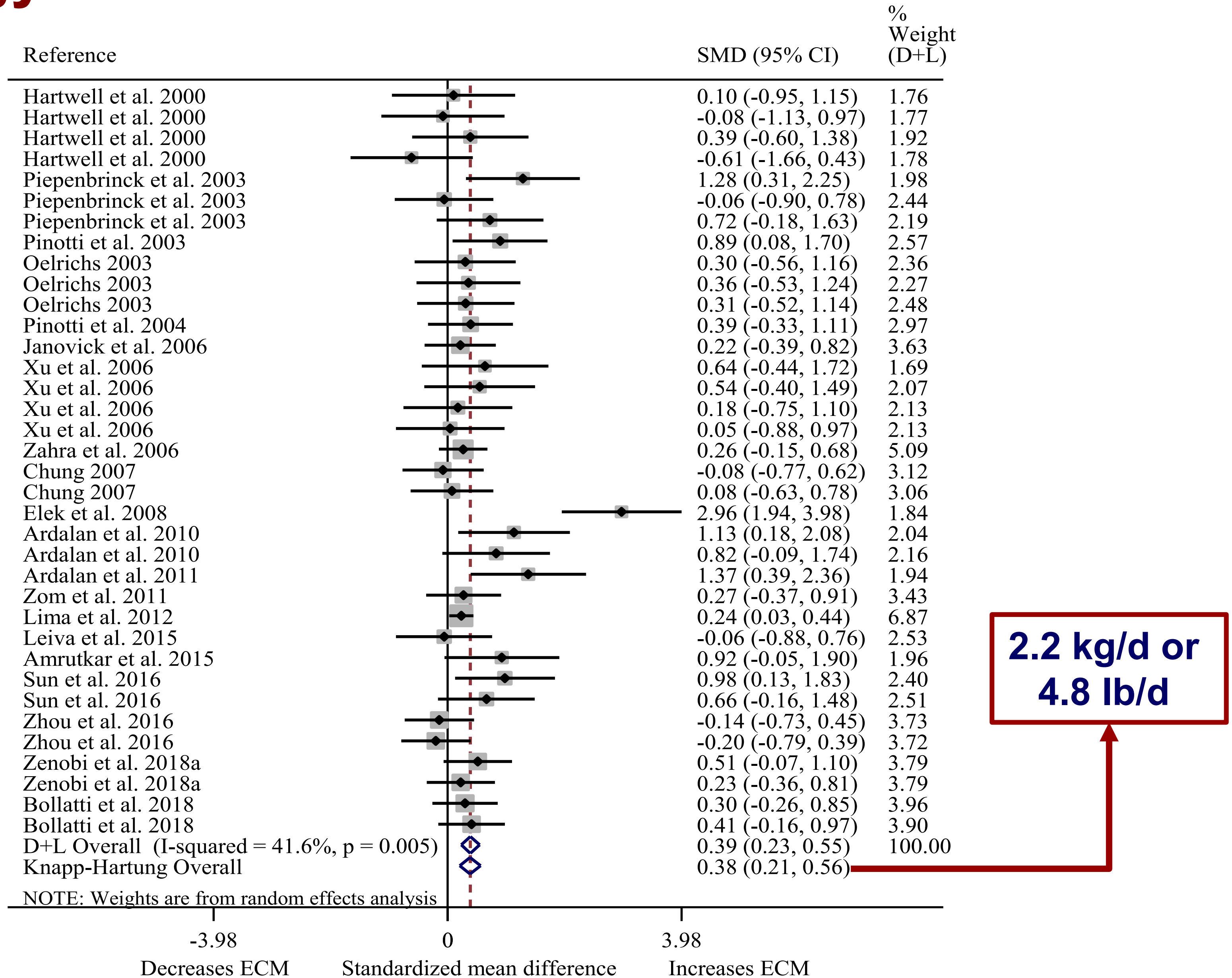






Zenobi et al. (2018) J. Dairy Sci. 101:5902–5923

Energy-Corrected Milk Yield – Effect of Choline



WMD = 0 z = 5.63 *P* = 0.0001

Arshad et al. (2020) J. Dairy Sci. 103:282–300

Summary of Diet Manipulations

Prepartum

- ✓ Feed prepartum diets to supply 17 Mcal of NE/d (~ 1.45 Mcal/kg or 0.65 Mcal/b)
- ✓ Supplement rumen-protected choline pre- and early postpartum
  - ✓ At least 13 g of choline ion
- ✓ Formulate prepartum diets with a DCAD of ~ -100 mEq/kg for parous cows
  - ✓ Plan for 3 weeks in the close-up pen (move at 255 d of gestation)
- ✓ Formulate prepartum diets for parous and nulliparous cows separately
  - ✓ Nulliparous need more MP prepartum (~ 1,100 g/d) which is achieved with diets with 14 to 15% CP
  - ✓ Parous cows require less MP (~ 800 to 900 g/d), which can be achieved with 12 to 13% CP

Postpartum

- ✓ Prioritize high-quality forages during the transition period
  - ✓ Better, healthier, and often cheaper
- ✓ Watch the protein content of early lactation diets
  - ✓ 17 to 18% CP (12-12.5% MP), 2.5% of MP as methionine and 7.1% of MP as lysine
- ✓ Supplement moderate amounts of FA to improve fertility (1 to 1.5% diet DM in early lactation)
  - ✓ Effects differ with source of FA fed
  - ✓ Source of FA rich in omega-6 and omega-3 seem the most bioactive