Four-State Dairy Nutrition & Management Conference

Challenges of Barn Design and Performance in Automated Milking Systems

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2020
4-State Dairy Nutrition and Management Conference
Breakout Session

Challenges of Barn Design and Performance in Automated Milking Systems

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The US AMS Challenge:

- How do we design and manage an AMS unit to improve milk per cow per day and be labor efficient?

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UW Upper Midwest AMS Survey 2018

- 42 predominantly Holstein herds
- Mean time milking in AMS: 4.1 years (minimum >1yr)
- Mean herd size: 209
- 83% new, 17% retrofit
- 60% Lely, 31% DeLaval, 4% AMS Galaxy, 2% GEA, 2% BouMatic

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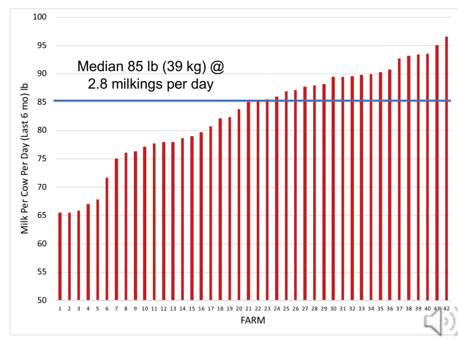
Milk per Cow (42 AMS herds)



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- Cows per robot
- Waiting Time
- Heifer Management
- Traffic System
- Flooring and Alleys
- Lameness
- Bedding
- Footbaths
- Ventilation
- Transition
- Feeding
- AMS Unit Design and Gating

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Theoretical Robot Capacity

- Robot availability 22 h per day
- Box time ~7 mins per cow – 60/7 = ~8 cows milked per hour
- 22 x 8 = 176 milkings per day
- At 2.8 milkings per day = 63 cows per robot

- BUT this forgets that cows are cows!

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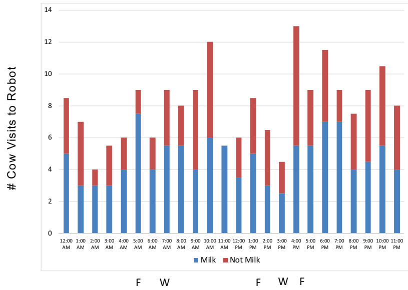
Daily Variation in Robot Visits



The desire to be milked is not constant throughout the day!

W=Robot washes
F=Fetch cows

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No threshold for cows per robot exists in the literature….

- Very little data to support planning to milk more than 60 cows per robot using current settings installed by manufacturer
- Mean cows per robot reported in literature in US and Canada ~49-56 cows
- Greater numbers decrease robot visits and increase fetch rates
- Cow behavior dictates that the theoretical maximum will not be achieved in practice!

- Plan for 55 cows per robot!

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Cows per robot
Waiting Time
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AMS Unit Design and Gating

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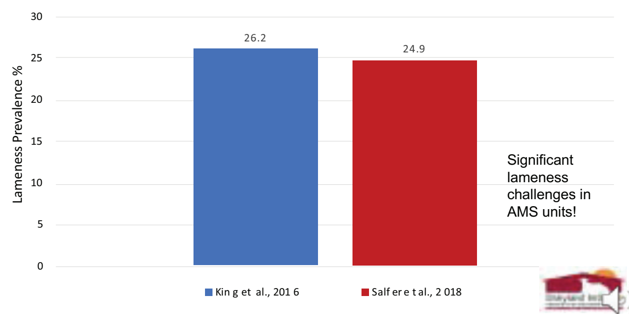
Lameness Prevalence in AMS Herds



Significant lameness challenges in AMS units!

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J. Dairy Sci. 100:4818–4828
https://doi.org/10.3168/jds.2016-12281

Cow-level associations of lameness, behavior, and milk yield of cows milked in automated systems

M. T. M. King, S. J. LeBlanc, E. A. Pajor, and T. J. DeVries

Lame cows compared to non-lame cows in 41 AMS facilities in Canada:

- Produced 1.6 kg (3.5 lb) /d less milk
- Milked 0.3 fewer milkings per day
- 2.2 time more likely to be fetched

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Easy access to a chute for individual cow attention is essential

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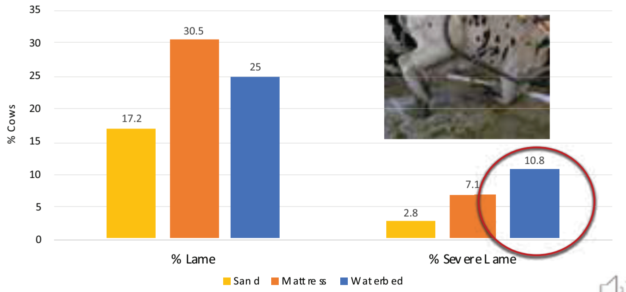
Impact of Stall Base on Lameness in AMS Units



Salfer et al., JDS 101:8586-8594, 2018 from 54 AMS units in Upper Midwest

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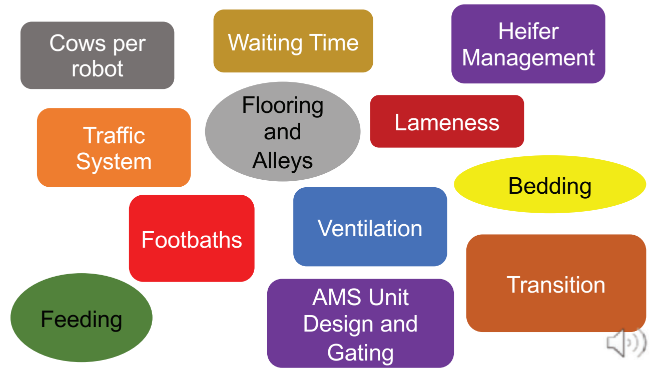

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Deep loose bedding is best for cows!

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Sand Challenges in Robots

- Precludes slatted flooring – GOOD!
- Requires V-shaped scrapers for bedding access (or manual scrape alleys)
- Sand wears the nylon retractor cables and pulleys in LELY units
- Sand scratches the camera lens in DELAVAL units
- ???? GEA units

- We believe most of these issues are manageable!

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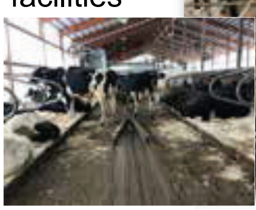
Bedding access and scrapers in AMS facilities



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UW AMS Survey 2018 – Stall Base

- 57% Sand, 24% Mattress, 17% Waterbed, 2% Manure Solids
- Mean milk per cow per day significantly different between deep bedding (sand/manure solids) and mattress (P<0.05), and deep bedding and waterbed (P<0.05)
  - Sand/manure deep bed 85.8 lb (39.0 kg)
  - Mattress 79.0 lb (35.9 kg)
  - Waterbed 78.1 lb (35.5 kg)

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Cows per robot

Waiting Time

Heifer Management

Traffic System

Flooring and Alleys

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AMS Unit Design and Gating

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The AMS Footbath Challenge

- Exit lane footbaths decrease robot attendance?
- Pushing cows through a footbath on a crossover has never worked well and producers don't bath frequently enough with this approach!

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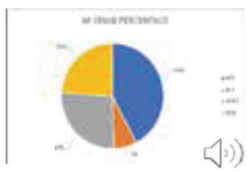
Voluntary footbaths ….
do not work!



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The Ideal Footbath

- 10' (3-3.7 m) long
- 24" (0.6 m) wide sloped to 3' (1 m) at 3' (1 m) high
- 10" (25 cm) high step

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Cows must be selected from the robot to walk through the footbath as they leave the robot area and/or return to the resting area

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Having to put the footbath in a cross alley is a significant drawback to the L-shape, cross-way and side installation designs!

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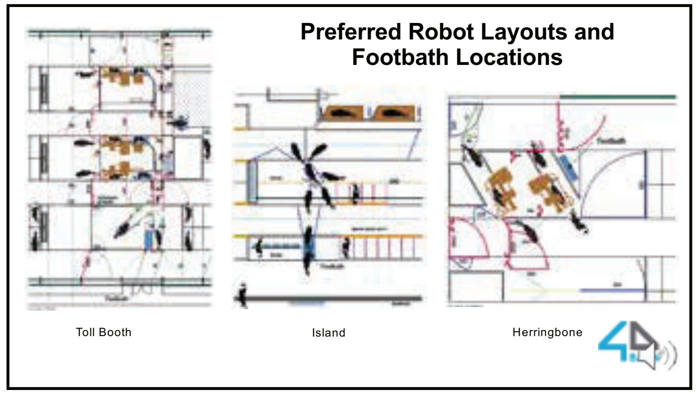

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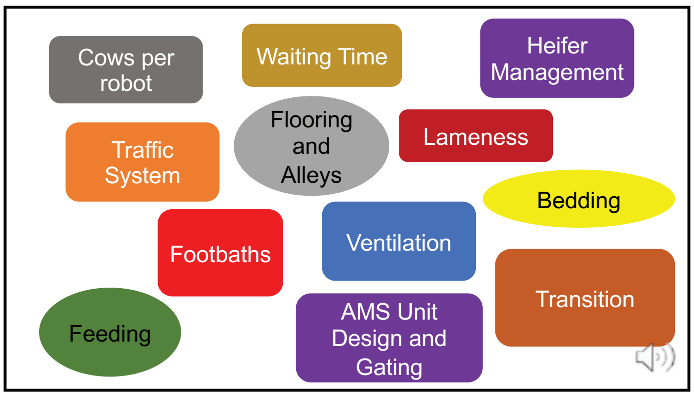

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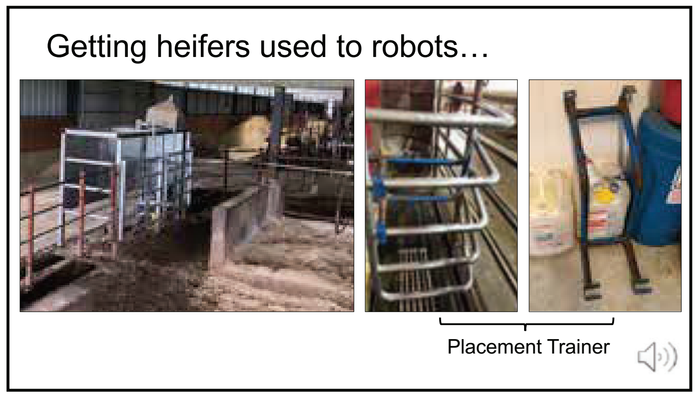

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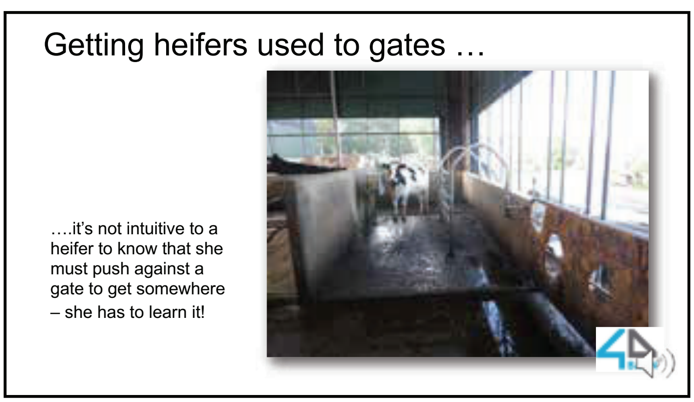

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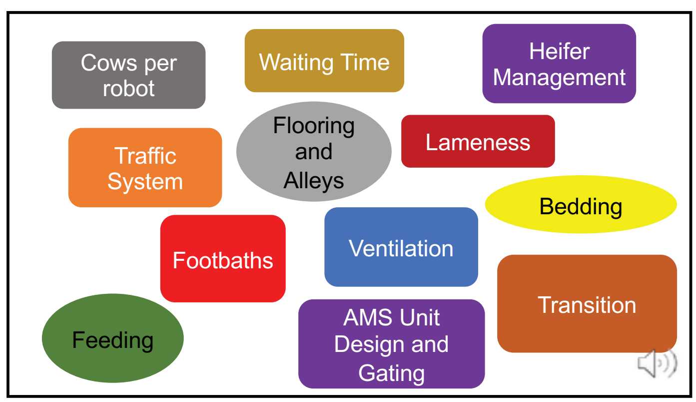

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UW AMS Survey 2018 – Fresh Cows

- Most AMS units don't separate fresh cows from other lactating cows for very long!
  - DIM fresh mature cows 0-30 (mean 5.1 days)
  - DIM fresh heifers 0-30 (mean 6.6 days)
- 38% of herds separate fresh cows from lactating cow group for 1 day or less (mean 81 lb (36.8 kg) milk per cow per day)
- 7% of herds separated cows for 14 or more days (mean 88 lb (40.0 kg) milk per cow per day)

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24/7 fresh cow access to the robot

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Cows per robot

Waiting Time

Heifer Management

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Alley space is incredibly important in an AMS unit – they allow cows to move toward the robot unhindered!

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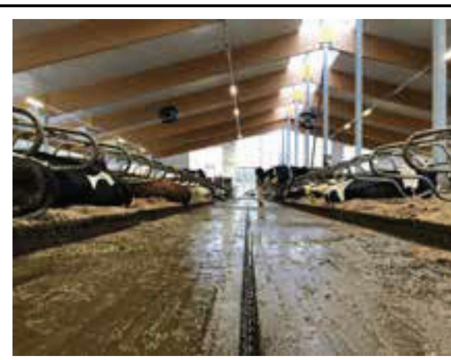

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Alley Width Recommendations

Alley Type	Recommended Alley Width feet (m)	
	Conventional	AMS
Stall Alley	10 (3.0)	11 (3.4)
Feed Alley	12 (3.7)	14 (4.3)
Feed and Stall Alley	13 (4.0)	15 (4.6)

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Traffic Systems

- Free-flow
- Guided-flow
- Hybrid (Semi-Guided-flow)

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Free- or Guided-Flow?

- Increased milk per cow with free-flow vs. guided-flow traffic (Tremblay et al., 2016), but in survey only 7% herds had guided-flow and all farms used Lely units, which are biased toward free-flow!
- Each strategy has pros and cons
- Individual farm circumstances should drive the decision
- Facilities can be designed so that both strategies can be adopted

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AMS Traffic Systems – Free-Flow

Pros

- Cows have the freedom to move around the pen – go to the bunk when fresh feed is delivered
- Lower cost – fewer sort gates
- Cows do not get trapped waiting to visit the robot
- Highest producing herds use free-flow

Cons

- Often herds feed more pellet in the robot
- Operation requires more fetching of cows
- Makes footbath use and gating more complex
- May need more FTEs to operate

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AMS Traffic Systems – Guided-Flow

Pros
- Easier to manage, potentially with less labor
- Less fetching of cows
- Feed less expensive pellet in the robot
- Sort options into VIC group/footbath when exiting commitment pen

Cons
- Cows may not be able to access fresh feed at the feed bunk (solved with Hybrid-Flow)
- Cows get trapped in commitment pen for longer periods (solved with alerts)
- Lower milk production being achieved on average
- Still have to fetch cows

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Cows per robot
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Wait Time for Milking in GF and FF Traffic Systems
(Solano et al., 2020 unpublished)

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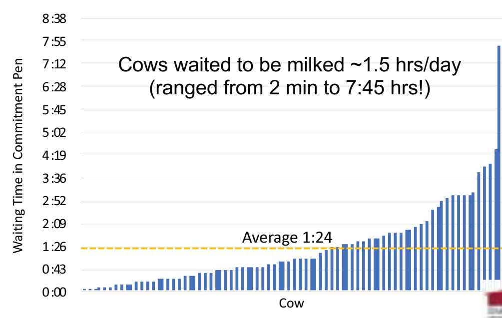
Daily waiting time (hh:mm per day) to be milked in a guided-flow



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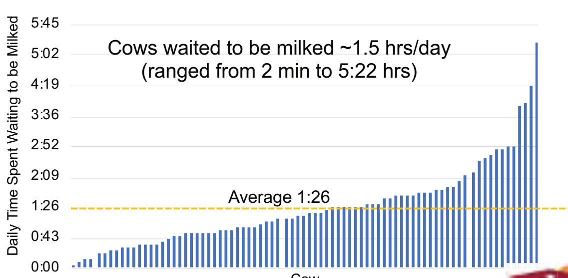
Daily waiting time (hh:mm per day) to be milked in a free-flow



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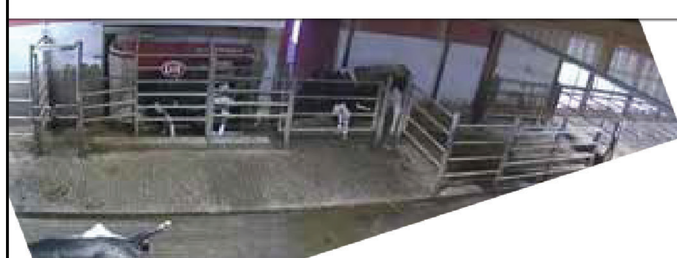

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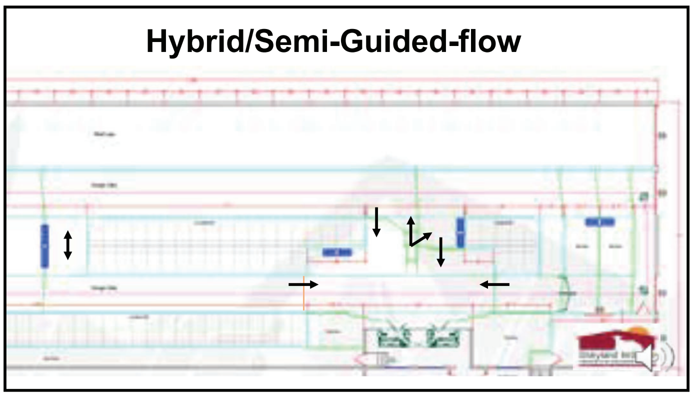

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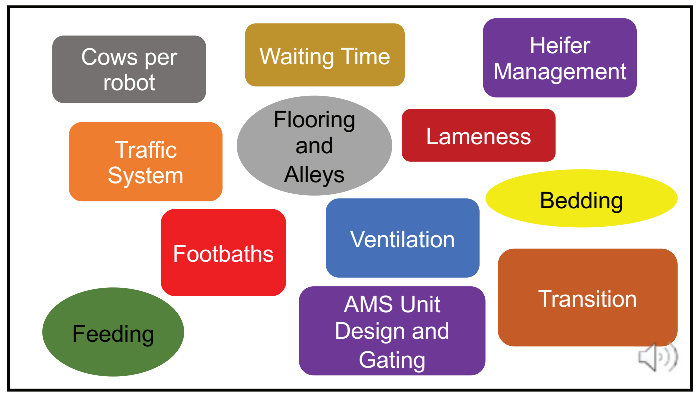

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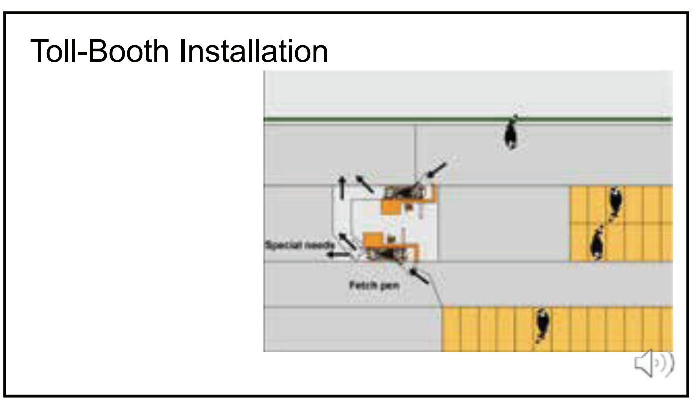

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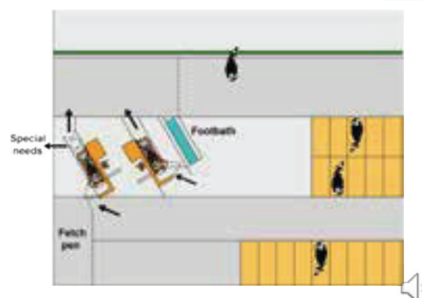
Herring-bone Installation



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AMS Ventilation Challenges

- Sideway installations block the sidewall inlet in natural barns
- Crossway installations block airflow in a tunnel barn
- The robot room blocks inlets and airflow in a cross barn
- Need for climate control around the robot

- While commonly used in AMS units, HVLS fans struggle to provide cooling air speeds!

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Specific AMS Solutions

- Dead air in robot room shadows
  - Deliberately make robot waiting area hostile – NO!
  - Provide recirculation fans to improve air flow – YES!
- Robot or milk room blocks inlet area or limits fan mounting area
  - Build inlets around side and top of milk/robot room
  - Positive pressure fans to force fresh air into areas with dead air movement

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Add fans to move air in the robot waiting area!

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Conventional vs. AMS Units

Conventional (Cook et al., 2016)	AMS (Salfer et al., 2018)	AMS (Halbach et al., 2019)
70% deep bedding	31% deep bedding	60% deep bedding
0% slatted flooring	22% slatted flooring	11% slatted flooring
73% manual manure removal	26% manual manure removal	2% manual manure removal
100% footbath mean 4.5 X per week	70% footbath and only 27% >3X per week	96% footbath and only 18% >3X per week
TMR fed	PMR fed with pellet in robot	PMR fed with pellet in robot
13% lameness	25% lameness	Not observed
~90 lb (41 kg) milk	~75 lb (34 kg) milk	~83 lb (38 kg)

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AMS General Design Priorities

- 55 cows per robot max to limit fetch rate and optimize robot visits, minimum 2 AMS units per pen
- Free-flow or Hybrid vs. Guided-flow
- Toll-booth, Herringbone or Island preferred designs with selection through a footbath
- Deep loose bedding – sand!
- Sufficient feedbunk space per cow – minimum 24” or 60 cm per cow in the main lactating cow pen
- 24/7 fresh cow access to robot for 10-21 days
- Heifer gate training
- Expert gating and flow modeling

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Dairyland Initiative

Sponsors

Mission

Saputo

Program

ZINPRO PERFORMANCE MINERALS

DAIRYLAND HOOF CARE INSTITUTE

Workshop

4D BARN

Artex

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DairylandInitiative
www.thedairylandinitiative.vetmed.wisc.edu
Email: nigel.cook@wisc.edu
Housing Module
The Guide to Welfare-Friendly Dairy Cattle Housing
Lifestep Lameness Module
A Lesion-Oriented, Life Cycle Approach to Lameness Prevention
Calf Health Module
Healthy Calves, Healthier Cows - Coming Soon!
Thank you!

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Road Map to Fatty Acid Balancing

Palmitic to Oleic Balance
Improve milk fat, milk & body condition

Palmitic 16:0 — ↑ milk fat more than milk yield

Oleic 18:1 — ↑ digestibility of all fatty acids, milk production & body condition

1% Palmitic and 1% Oleic for balanced energy partitioning (%DM)

Manage 18:2 & Rumen Exposure
Too much 18:2 = ↓ milk fat production

Linoleic 18:2 — Found in corn, corn silage, distillers, cottonseed
Too much unprotected 18:2 = ↓ milk fat

300+ grams is considered a milk fat risk factor

Omega-6 to Omega-3 Balance
Improve immune health, milk & repro

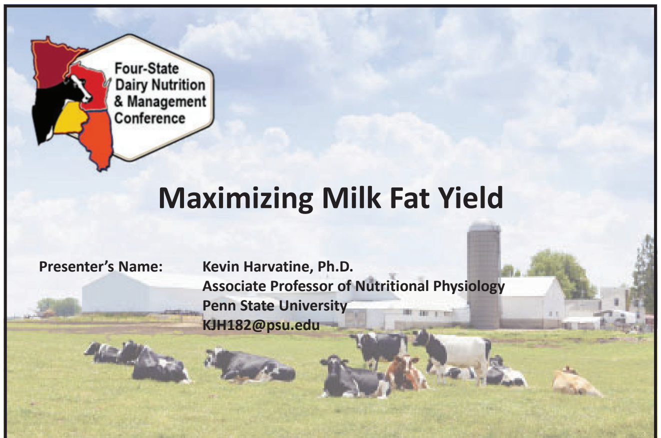
Omega-6 18:2 — Inflammatory = lost energy to immune

Omega-3 EPA DHA — Anti-inflammatory= ↑ milk & repro

5:1 or ↓ ratio for optimal results in lactating cows

Maximizing Milk Fat Yield

Kevin Harvatine, Ph.D.
Associate Professor of Nutritional Physiology
Penn State University
KJH182@psu.edu



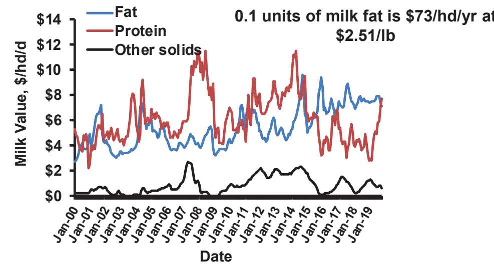
Four-State Dairy Nutrition & Management Conference

Maximizing Milk Fat Yield

Presenter's Name: Kevin Harvatine, Ph.D.
Associate Professor of Nutritional Physiology
Penn State University
KJH182@psu.edu

1

Milk fat and protein yield are the main drivers of cash flow ($/hd/d @80 lb of 3.7 fat & 3.05 protein)



Harvatine unpublished based on USDA NASS milk price

- Milk fat normally most profitable component.
Better to set goals based on Fat + Protein yield!!!

2

How to adapt to "Historic" times

- Production limits/reductions
  - Most are based on milk yield, not components
- Milk fat price bottomed out
  - Profitability depends on my cost to make it
  - Think about "marginal cost"
- Distiller's grains price has increased and corn and soybean meal have decreased
  - Changes risk/value proposition
  - Is rumen available fat cheaper from soybeans or cottonseed?
- Price and some supply changes with some dry fat products

3

We can have both fat and protein yield!

Maximizing microbial protein yield gets you:

- Optimal amino acid supply
- Normal biohydrogenation
- Optimal acetate yield
- Optimal energy intake
  - Drives milk flow
  - Drives milk protein synthesis
    - (Don't forget insulin-IGF-I story!)

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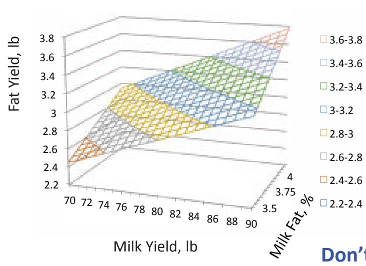
"Milk flow" is very important to component yield: You can't give up much yield when seeking to increase milk fat (especially when protein value is high!)



Milk, lb	Milk Fat, %	
	4.0	4.1
80	3.20	3.28
82.5	3.30	3.38

Milk lb

Don't forget protein and going to get protein with milk yield!

5

What should you be thinking about to maximize milk fat yield

1. Set your goal
   - Seasonal pattern
   - Genetics
2. Balance the diet
   - Unsaturated fat
   - Fermentability
   - Fiber digestibility
   - Fat supply
   - Additives
3. Manage the feeding system
   - Feed mixing and delivery
   - Reduce slug feeding
4. Monitor and adjust
   - Milk fat concentration
   - De novo and *trans*-10 C18:1
   - Responses in 7 to 10 d

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Milk fat is affected by many factors

Nutritional Factors

Inhibited by BH-induced milk fat depression
- Unsaturated fat
- Fermentability
- Acidosis
- Feeding strategies
- Ionophores

Increase by additional substrate
- Acetate (Forage quality)
- Palmitic acid
- High plasma NEFA

Milk fat

Non-nutritional Factors

These set our goals/expectations

- **Genetics**
- **Season**
- **Stage of lactation**
- **Parity**

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Milk fat is the most heritable production trait and PTA Fat gives an indication of genetic potential

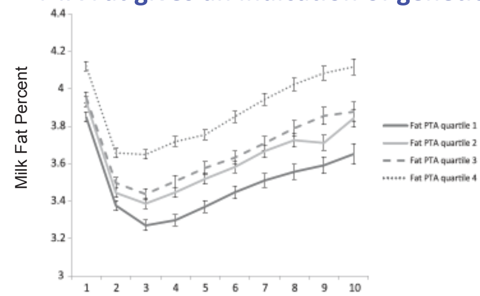

Fig. 2. The effect of sire predicted transmitting ability (PTA) for milk fat percentage quartile on milk fat percentage for the first 10 months of lactation. Data were analyzed using repeated measures ANOVA and the effect of animal nested within farm was controlled in the model as a random effect. Parity was also kept in the model as a fixed effect. Error bars represent 95% confidence interval of the mean.

Bicalho et al. 2014. Theriogenology. 81:257-265

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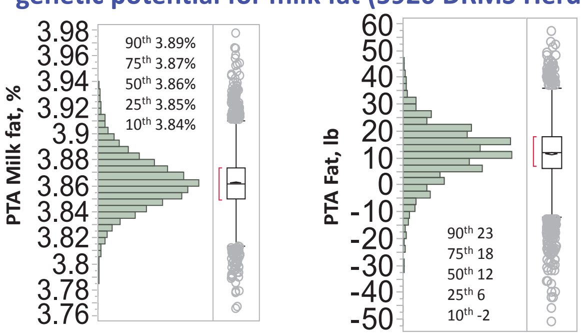
There is very little difference between herds for genetic potential for milk fat (5926 DRMS Herds)



PTA Milk fat % = [(PTAF + 1006) / (PTAM + 26995)] * 100

Harvatine Unpublished

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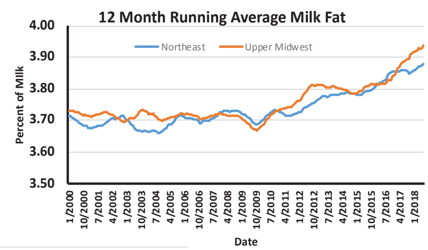
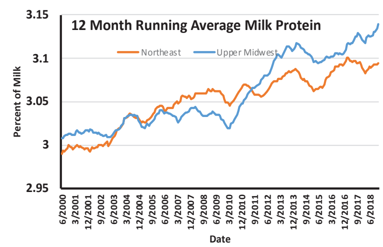
Milk fat and protein have been increasing





Why?
- **Genetics (Yes!)**
- **Jerseys & Crossbreds?**
- **Better nutritionists?**
- **Better DDGS?**
- **BMR Corn?**
- **Palmitic acid?**

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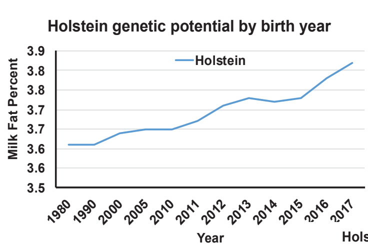
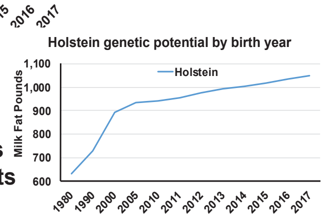
Milk fat genetic potential of Holsteins has increased ~0.17 units and 107 lb in 10 years



From Center for Dairy Cattle Breeding



Genetic potential of Jerseys has also increased ~0.15 units and 132 lb in <10 years

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Let's talk about nutrition: Milk fat can be decreased by BH-Induced Milk Fat Depression (MFD)

- **Diet and management risk factors result in a change in the rumen microbes that produces bioactive "*trans*-10" FA intermediates**
  - **Up to a 50% reduction in milk fat**
  - **Greater decrease in fatty acids made by the mammary gland (de novo)**

This is a very common cause of reduced milk fat yield, but is not meant to explain every change in milk fat!!!

Reviewed by Harvatine et al. 2009

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We must manage the risk factors that cause "Diet-Induced MFD"

- Dietary fatty acids
  - Level and profile
  - Rate of availability
- Diet fermentability
  - Carbohydrate profile
  - Rate and extent of fermentation
  - Effective fiber
- Adequate RDP/ Ruminal N balance
- Feeding strategies/management
- Ruminal acidosis
- Rumen modifiers- ionophore
- Silage fermentation/quality
- Forage types
- Individual cow effect (level of intake etc)

RUFAL: Rumen Unsaturated Fatty Acid Load (but C18:2 most important)

High producing cows normally most susceptible

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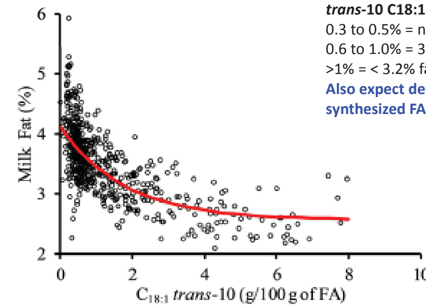
Can milk fatty acids be used to troubleshoot milk fat problems? Milk *trans*-10 18:1 & Milk Fat %



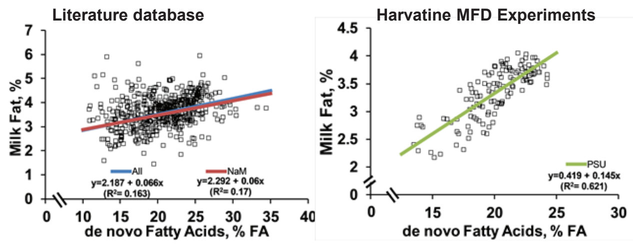
***trans*-10 C18:1**
0.3 to 0.5% = normal fat
0.6 to 1.0% = 3.2 to 3.5% fat
>1% = < 3.2% fat
Also expect decrease in de novo synthesized FA

N = 497

Matamoros Unpublished

14

There is also a relationship between milk fat and de novo FA, but is not specific for MFD

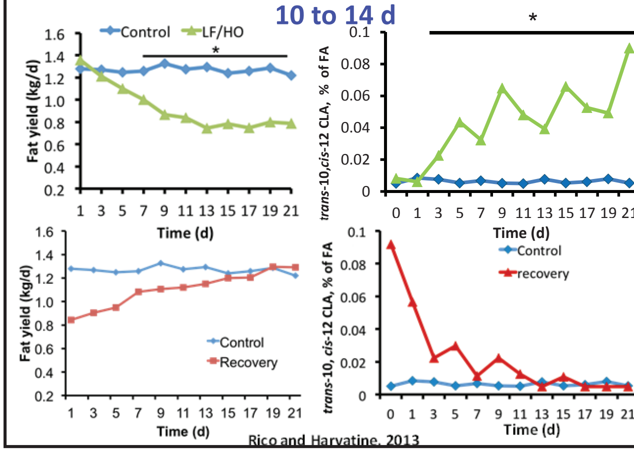


De novo (< 16 C) FA can be predicted by some DHIA labs.

Matamoros Unpublished

15

Diet-induced MFD occurs and can be fixed in 10 to 14 d



Rico and Harvatine, 2013

16

Unsaturated fatty acids are a big risk factor

1. Amount of unsaturated fatty acids
   - Fatty acid concentration and profile
   - 18:2 more important than 18:1 and 18:3
2. Rate of availability of the fatty acids
   - Cottonseed vs DDGS

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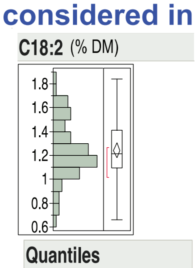
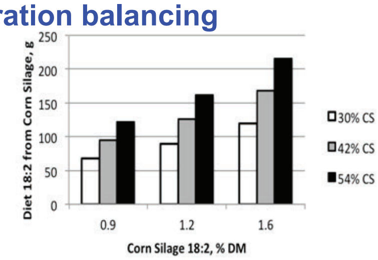
Corn silages differ in C18:2 and should be considered in ration balancing



Quantiles

90.0%		1.60384
75.0%	quartile	1.4094
50.0%	median	1.2167
25.0%	quartile	1.0954
10.0%		0.93576

67 Corn Silages from Test Plots



~60 to 90 g/d difference in C18:2 intake just in the corn silage

Baldin et al. JDS 2018

18

High oleic soybeans decrease risk of milk fat depression

Feedstuff (% FA)	16:0	18:0	18:1	18:2	18:3	20:1	22:1
Soybean	11	4	23	54	8	-	-
High Oleic Soy	6.5	4	75	7	2.5	-	-

https://www.plenish.com/food/oil-profile/

High oleic soybeans were lower risk for milk fat in previous experiments by Weld and Armentano (2018)

We observed that high oleic soybean increased milk fat ~0.2 units and 0.2 lb/d compared to conventional soybeans

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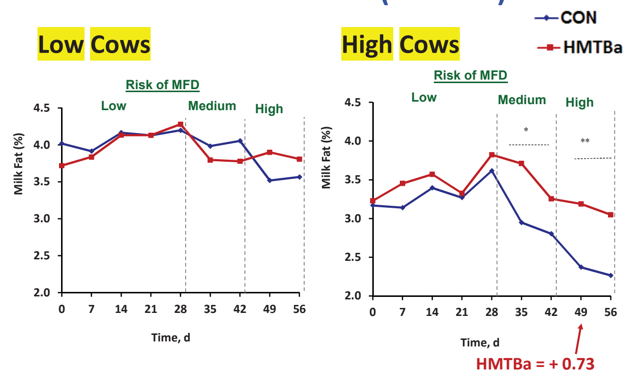
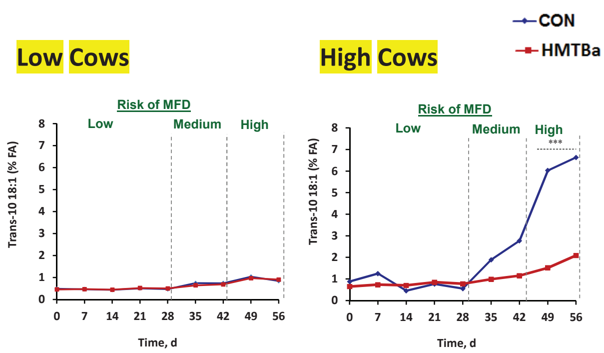
Example of feed additive that reduces risk of MFD: HMTBa (Alimet®)



Baldin et al., JDS 2018

20

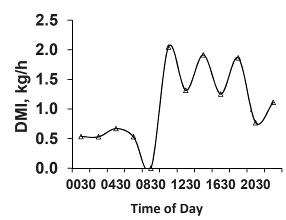
HMTBa prevented increase of *trans*-10 C18:1 in milk

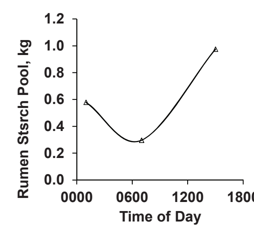


Baldin et al., JDS 2018

21

We need to think about when cows are eating over the day as this can disrupt rumen fermentation!





Timing of feed delivery is our best chance to impact this!

Goal is to spread intake more across the day. Feeding 2x and earlier in the day is best way to do this.

Ying et al. 2015

22

Other dietary effects with smaller impacts

- **Absorbed fat**
  - **Palmitic acid**
- **Acetate supply**
  - **Forage digestibility and rumen function**

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How much fat does a cow need to provide preformed fatty acids at 4% milk fat and 55% preformed FA at 55% transfer?

Milk, lb	Fat, lb	Milk Preformed, lb	DMI, lb	Diet Fat % Needed
60	2.4	1.3	45	5.3%
90	3.6	2.0	55	6.5%
120	4.8	2.6	65	7.4%
150	6	3.3	75	8.0%

Obviously, cows are making it work, but in some cases we might be limiting milk fat because of limited fat supply

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Effect of high oleic soybeans on milk fat when increasing risk of MFD

	Treatment Means[1]					P-Values[2]		
	Conv. Soybean		High 18:1 Soybean					Type*
Item	5%	10%	5%	10%	SEM	Type	Level	Level
Milk, lb/d	96.4	96.3	95.5	98.6	2.8	0.69	0.28	0.18
Milk Fat								
%	3.28	3.46	3.42	3.66	0.12	<0.05	0.01	0.69
lb/d	3.06	3.22	3.22	3.46	0.24	0.08	0.01	0.55
Milk Fatty acids, % FA								
>16C[5]	37.4	41.5	37.8	41.5	0.70	0.42	<0.001	0.57
*t*10 C18:1	0.79	0.89	0.62	0.63	0.13	0.01	0.96	0.67

25

Palmitic acid is the most consistent to increase milk fat, but others can also increase in some cases

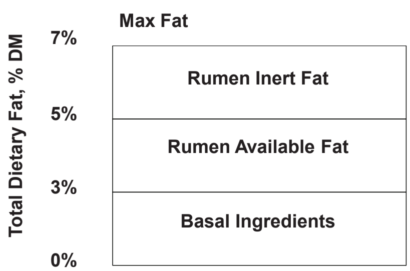
- May depend on concentration of FA in the basal diet, diet type, cow physiology, etc.

Biology of palmitic acid

- **Apparent transfer to milk ~15 to 20%**
- Old isotope data reported 40 to 70% of ^{14}C palmitic acid entered milk (Palmquist and Conrad, 1971)
- I think palmitic decreases the de novo portion of C16:0 in milk fat, but does not decrease de novo as much as C18 FA

26

Make sure you are managing all the fat sources in the diet!



27

Increasing acetate increases milk fat under normal conditions

	Acetate (g/d)					*P*-value	
	0	300	600	900	SE	Linear	Quad.
DMI, lb	59.9	62.2	60.0	59.5	2.2	-	-
Milk, lb	84.9	86.3	88.9	85.6	6.2	-	-
Milk Fat							
g	1382	1468	1582	1577	59	<0.001	-
%	3.64	3.87	4.03	4.10	0.20	<0.001	-

- 600 g/d of acetate increased milk fat by 200 g/d
- Mostly increase in de novo synthesized FA

How do we get more acetate?

Forage quality and good rumen fermentation!

Urrutia et al. J. Nutr. 2017

28

Nutrition is best practiced as an "Experiment in Progress"!!

- When milk fat is <u>Acceptable</u>
  - Inclusion of risk factors is advantageous to feed cost, production, and efficiency
- When milk fat is <u>Low</u>: Look For a Reason
  - When did it start and what happened ~7-10 d prior?
  - Is it a certain string or group of cows?
    - High producing cows are normally more susceptible
  - What season is it?
  - Is the sample a daily average?

29

The experiment in progress

1. Diet Polyunsaturated Fatty Acids
   - Concentration of C18:2
   - Source of C18:2
     - Very different rates of rumen release
     - Ca Salts are more slowly released, but are not inert
   - Fish oil is very potent (EPA and DHA)
   - Decreasing unsaturated fat has the lowest risk to losing milk yield!

30

2. Diet Fermentability

- Analyze carbohydrate profiles and effective fiber
- Experience with similar diets in the region is important

- Sugars may be beneficial
- Start to titrate down starch and increase fiber
- Switch rapidly fermentable sources for less rapidly fermentable sources
- Increase forage NDF and effective fiber

**Careful….. May Lose Milk!!

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3. Rumen Modifiers

- Rumensin®
  - Risk factor, but does not cause MFD by itself
  - Can be synergistic with other risk factors for induction
- DCAD
  - Increasing DCAD decreases MFD (both Na and K)
- HMTBa
  - Reduces the risk of MFD
- Yeast & Direct Fed Microbials
  - May reduce incidence of MFD in some cases
  - Have not tested their effect on recovery

**Remember we are dealing with many interactions!

32

4. Feeding Strategies

- Number of feeding times per day
- Slick bunks before feeding?
- Feeding times

* You can slug feed TMR!

5. Saturated Fat Supplements

- No risk for induction of milk fat depression
- High palmitic acid (C16:0) supplements may increase milk fat in some cases
- Milk fat depression will reduce the effectiveness of high palm supplements

Monitor milk yield and milk fat over time!!!

**Set Expectations for the Time Required

33

Lets review

Rumen environment is critical to milk fat yield and involves interactions of numerous dietary, cow, and environmental factors

1. Set your goal
2. Balance your diet
3. Manage feeding

Constant "Experiment in Progress" to maximize energy intake, milk yield, and milk fat yield

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Lab Members:

Cesar Matamoros, Beckie Bomberger, Alanna Staffin, Reilly Pierce, Ahmed Elzennary, and Rachel Walker.

Previous Lab Members:

Chengmin Li, Elle Andreen, Dr. Isaac Salfer, Dr. Daniel Rico, Dr. Michel Baldin, L. Whitney Rottman, Mutian Niu, Dr. Natalie Urrutia, Richie Shepardson, Andrew Clark, Dr. Liying Ma, Elaine Brown, and Jackie Ying

Disclosures

USDA United States Department of Agriculture National Institute of Food and Agriculture

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Thank You

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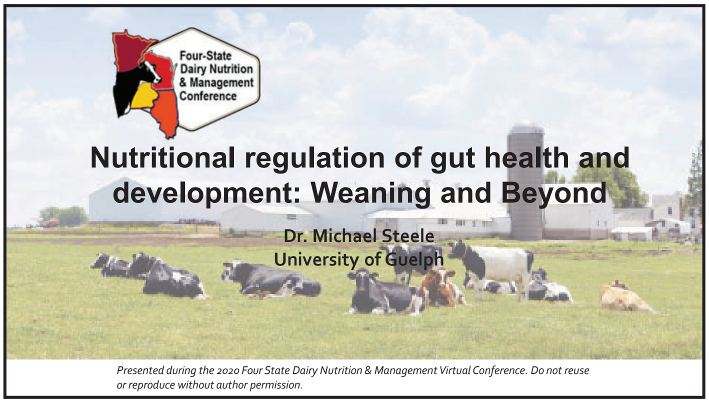
Nutritional Regulation of Gut Health and Development: Weaning and Beyond

Dr. Michael Steele

University of Guelph


Four-State Dairy Nutrition & Management Conference
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Dr. Michael Steele
University of Guelph
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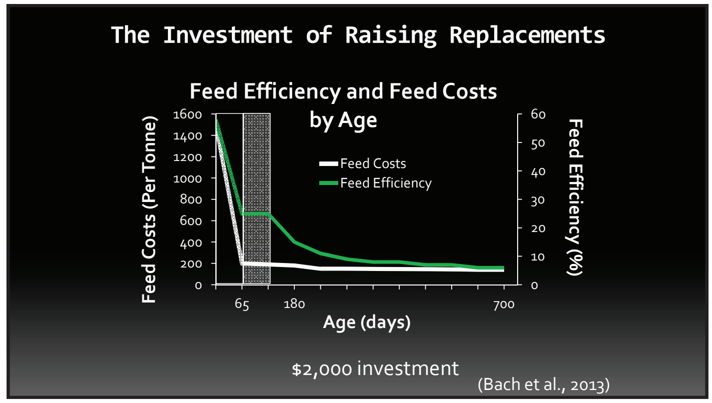
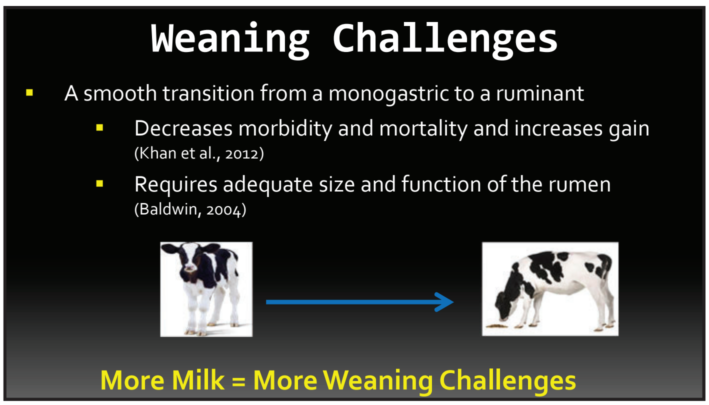
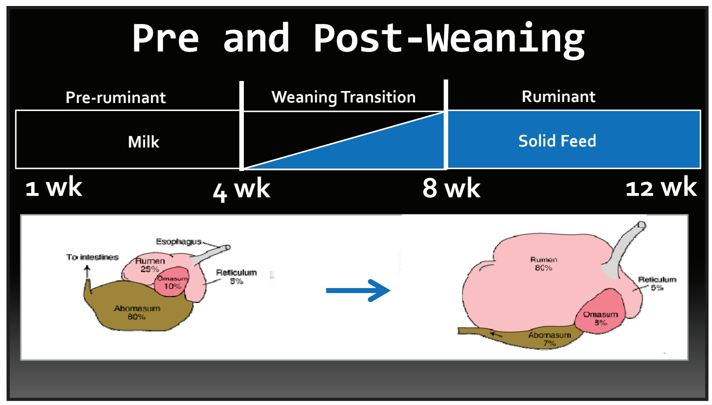
1


The Investment of Raising Replacements
Feed Efficiency and Feed Costs by Age
Feed Costs
Feed Efficiency
Feed Costs (Per Tonne)
Feed Efficiency (%)
0
200
400
600
800
1000
1200
1400
1600
0
10
20
30
40
50
60
65
180
700
Age (days)
$2,000 investment
(Bach et al., 2013)

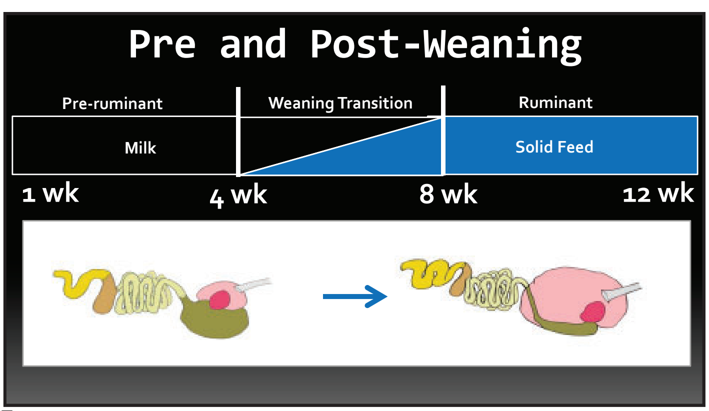
2


Weaning Challenges
A smooth transition from a monogastric to a ruminant
Decreases morbidity and mortality and increases gain
(Khan et al., 2012)
Requires adequate size and function of the rumen
(Baldwin, 2004)
More Milk = More Weaning Challenges

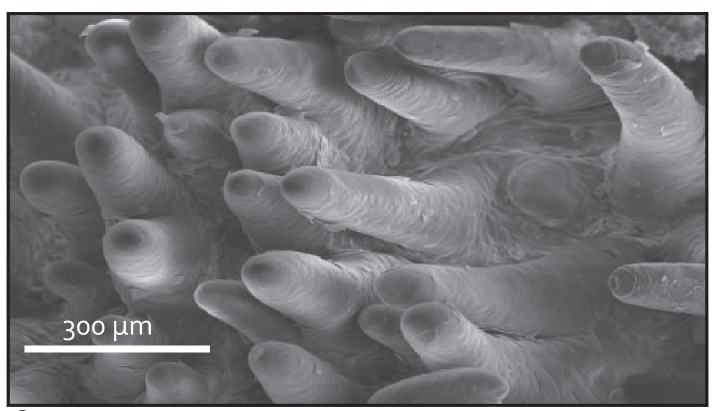
3


Pre and Post-Weaning
Pre-ruminant
Weaning Transition
Ruminant
Milk
Solid Feed
1 wk
4 wk
8 wk
12 wk
Esophagus
To intestines
Rumen 25%
Omasum 10%
Reticulum 5%
Abomasum 60%
Rumen 80%
Reticulum 5%
Omasum 8%
Abomasum 7%

4


Pre and Post-Weaning
Pre-ruminant
Weaning Transition
Ruminant
Milk
Solid Feed
1 wk
4 wk
8 wk
12 wk

5


300 µm

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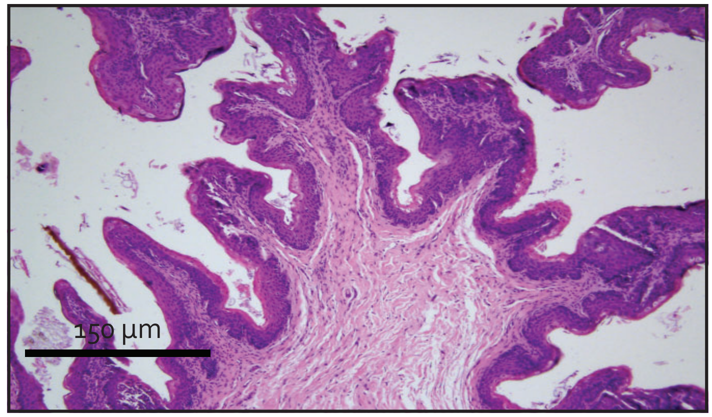
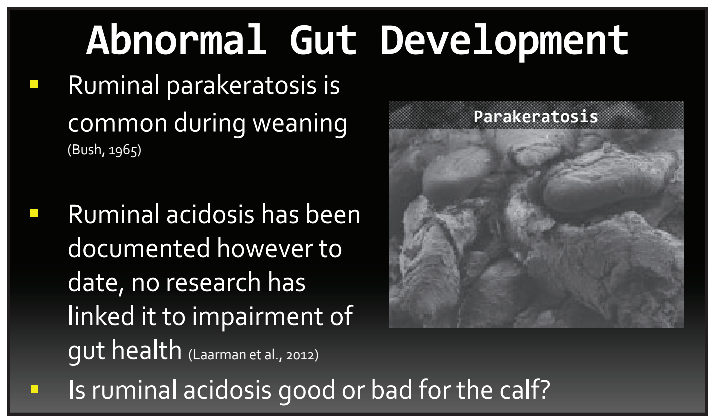


150 µm

8

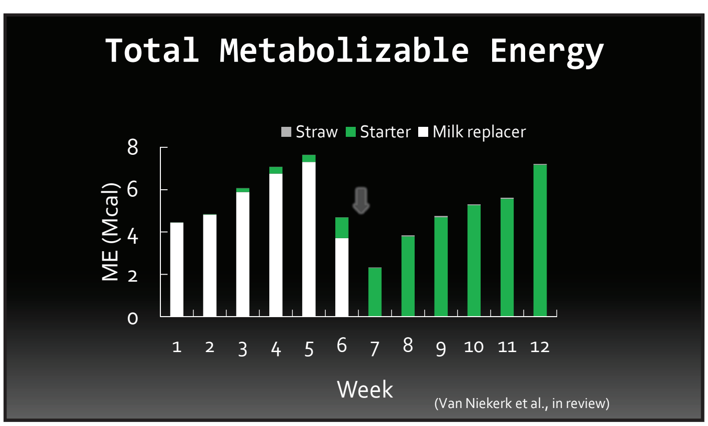
Rumen Papillae - Transition

9



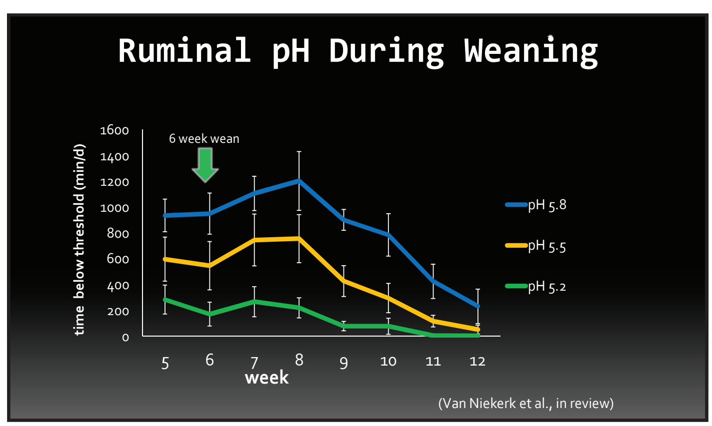
Abnormal Gut Development
Ruminal parakeratosis is common during weaning (Bush, 1965)
Ruminal acidosis has been documented however to date, no research has linked it to impairment of gut health (Laarman et al., 2012)
Is ruminal acidosis good or bad for the calf?
Parakeratosis

10



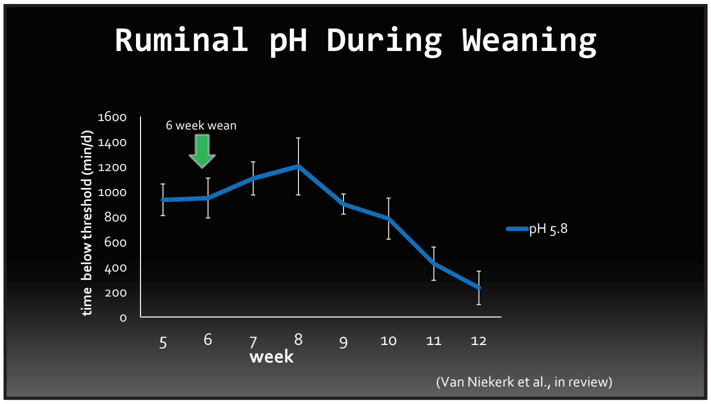
Total Metabolizable Energy
Straw
Starter
Milk replacer
ME (Mcal)
0
2
4
6
8
1 2 3 4 5 6 7 8 9 10 11 12
Week
(Van Niekerk et al., in review)

11



Ruminal pH During Weaning
6 week wean
time below threshold (min/d)
0
200
400
600
800
1000
1200
1400
1600
5 6 7 8 9 10 11 12
week
pH 5.8
pH 5.5
pH 5.2
(Van Niekerk et al., in review)

12



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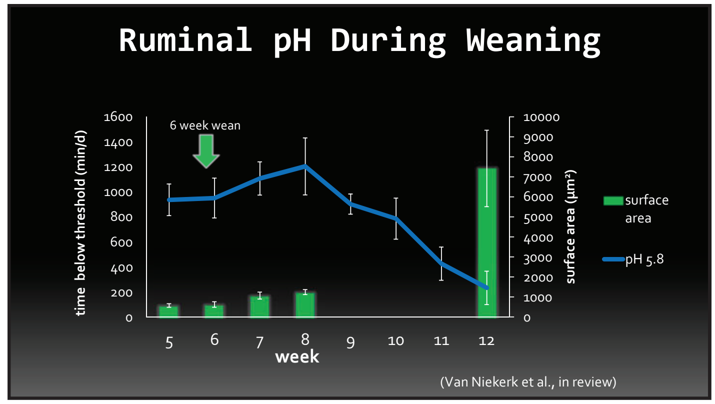

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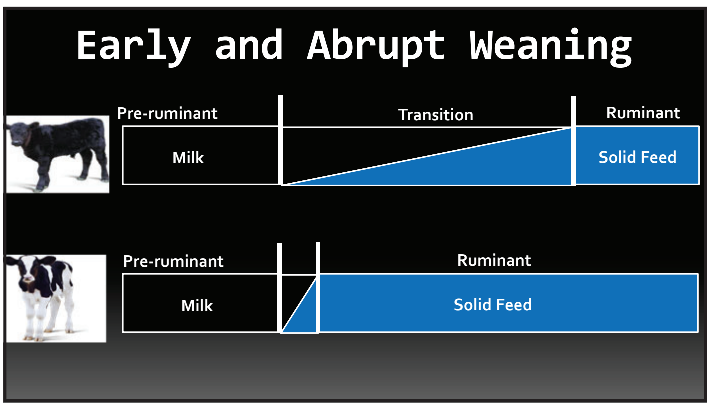

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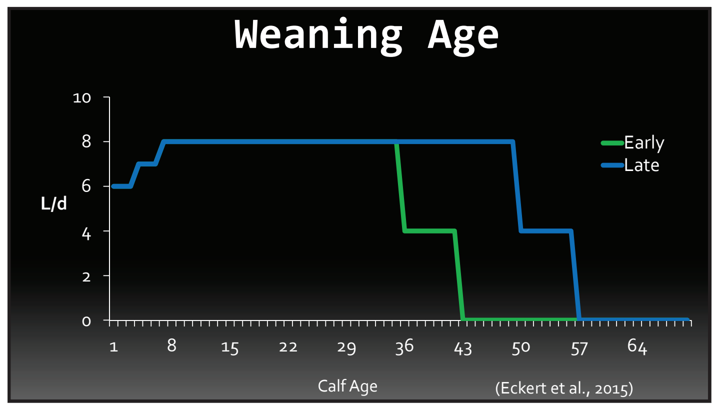

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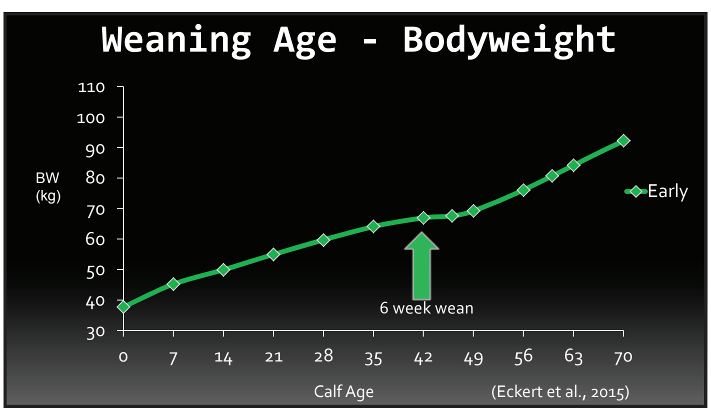

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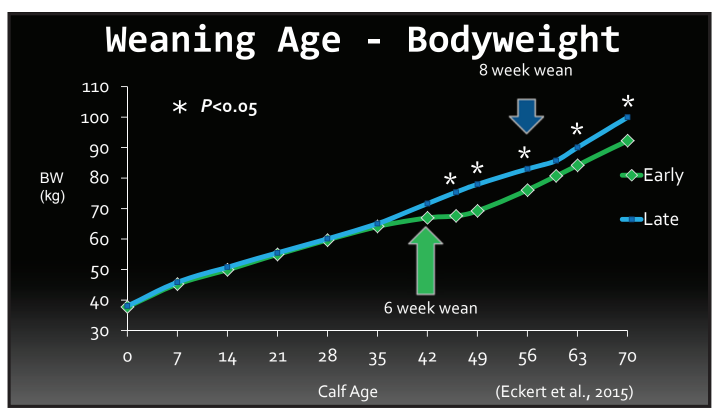

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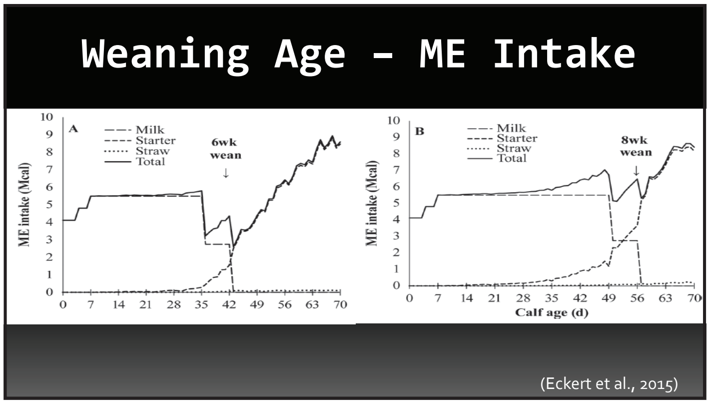

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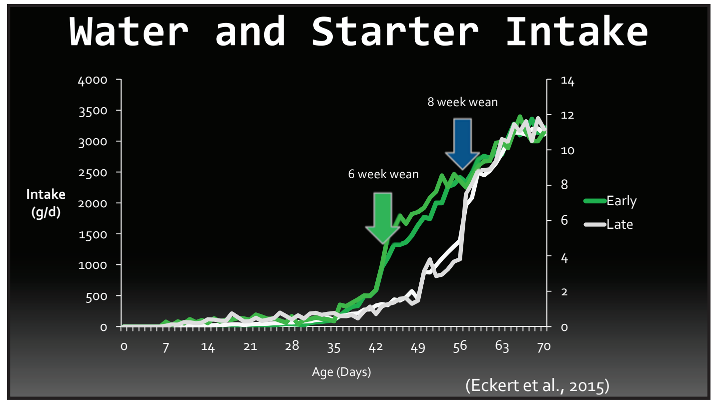

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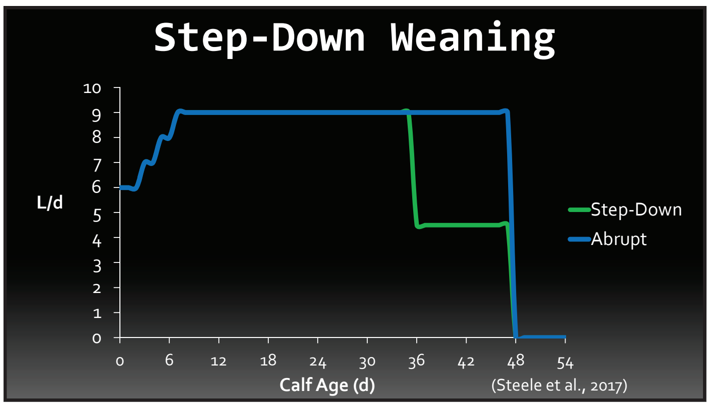

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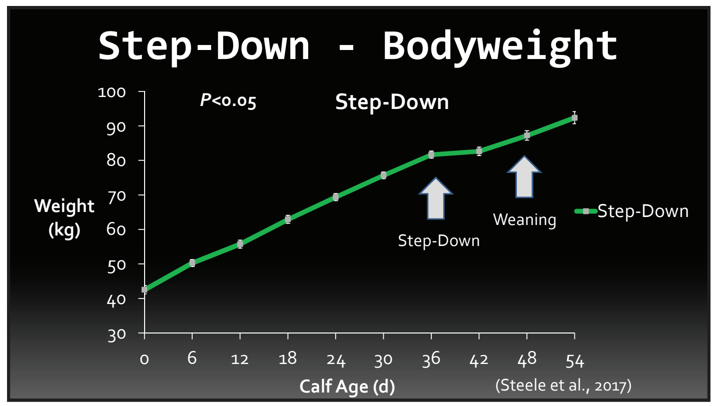

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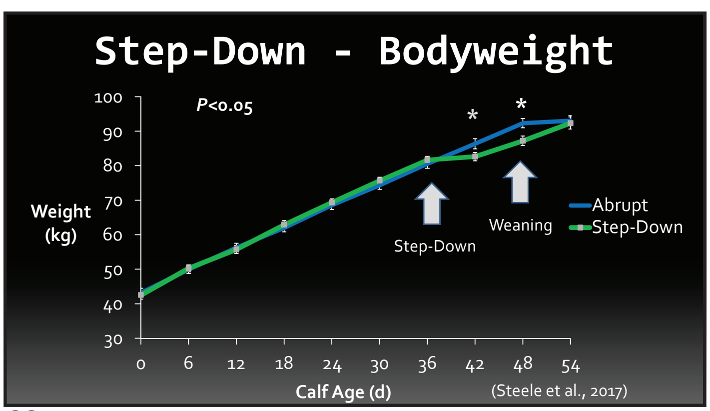

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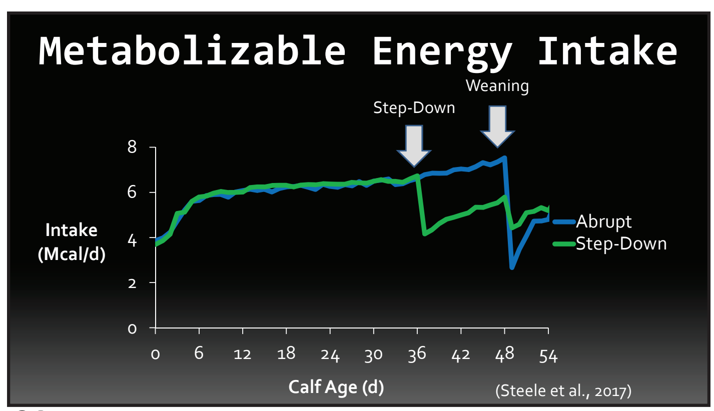

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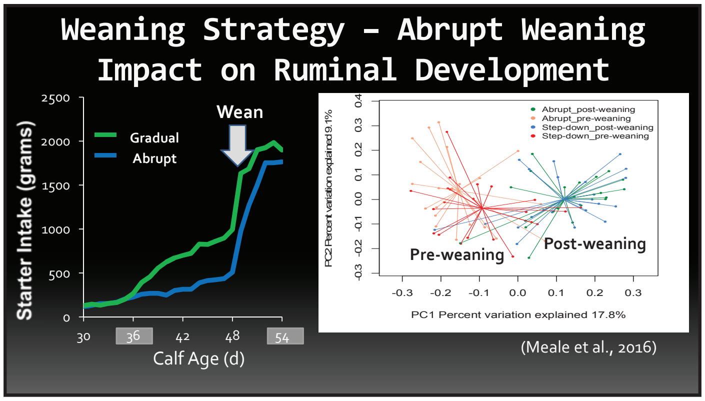

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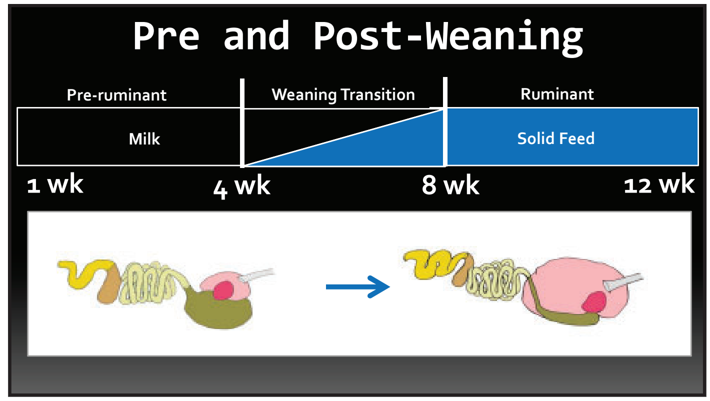

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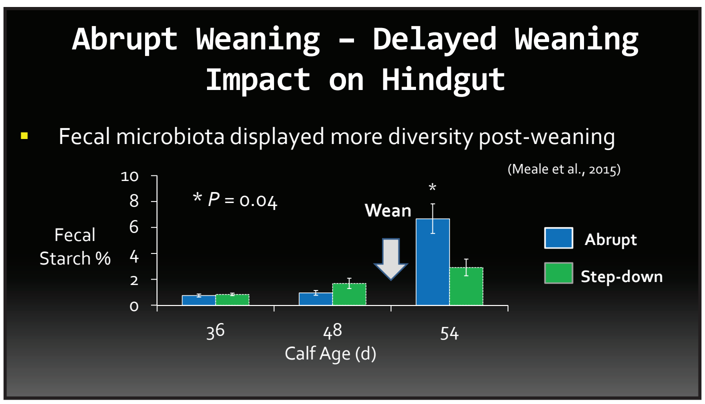

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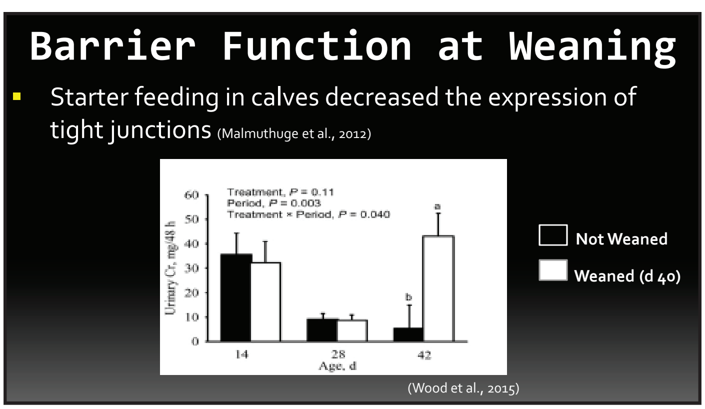

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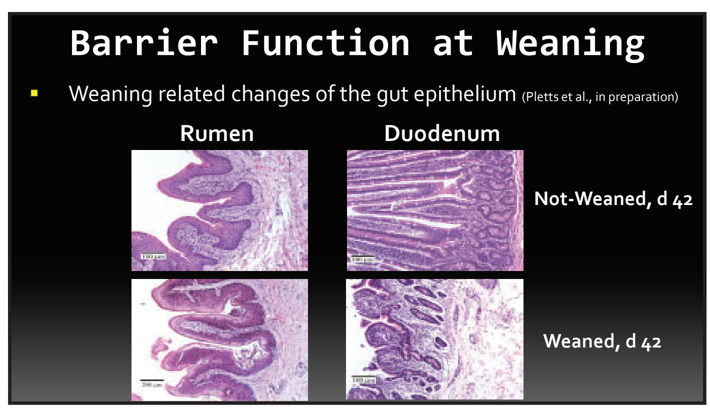

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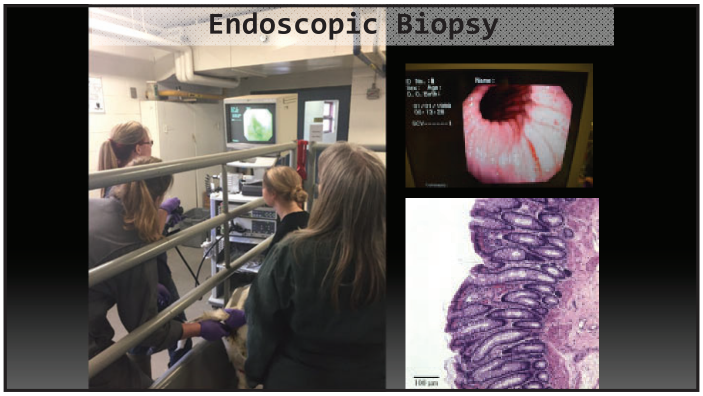

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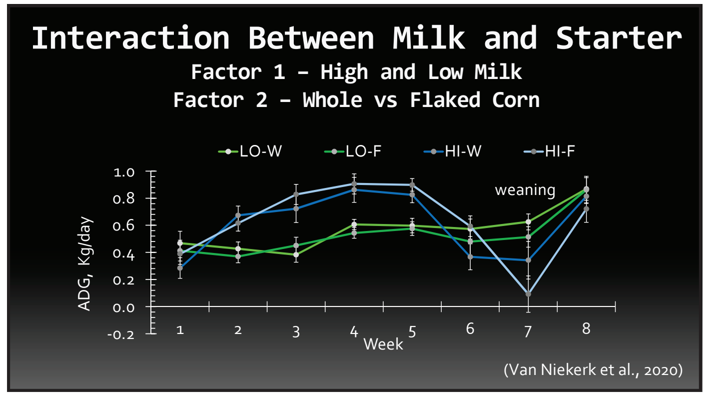

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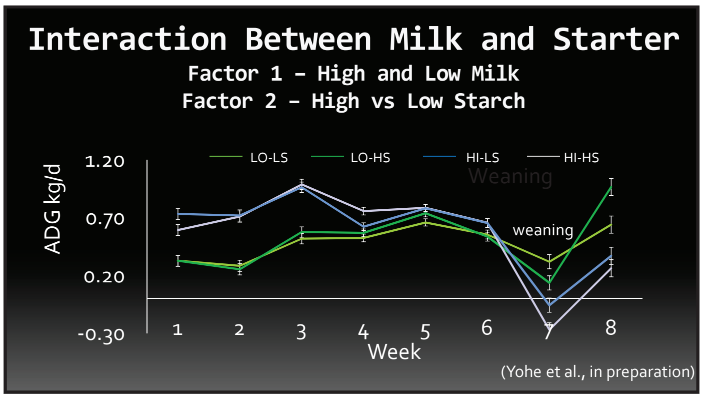

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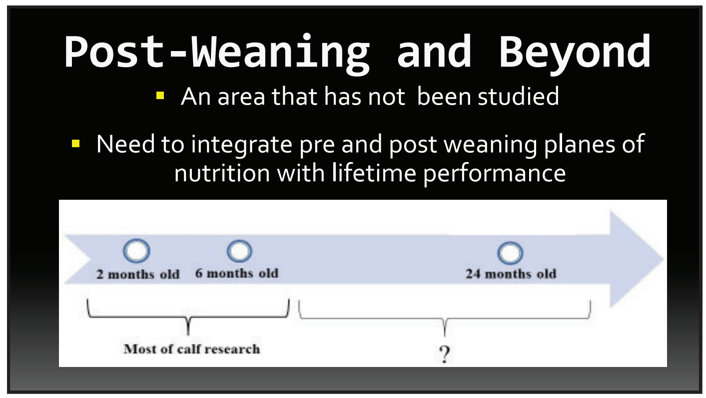

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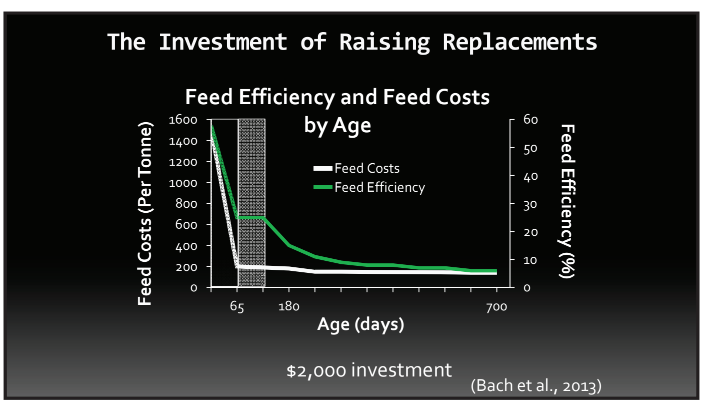

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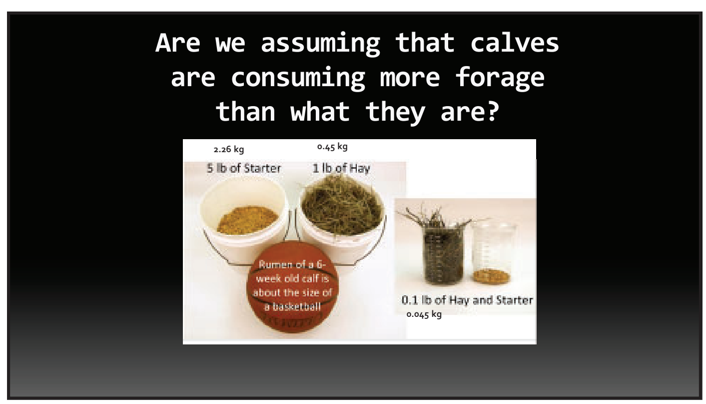

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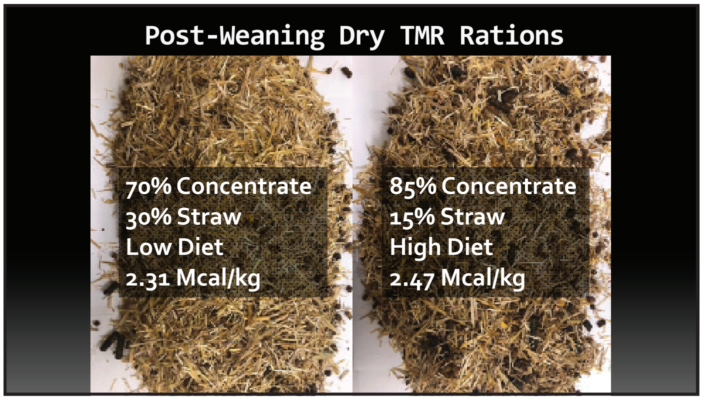

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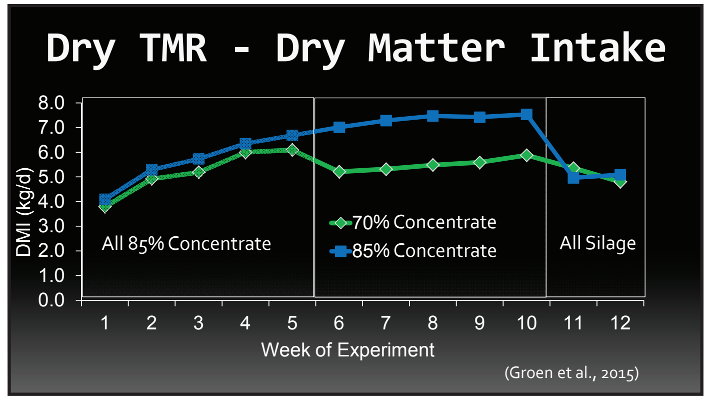

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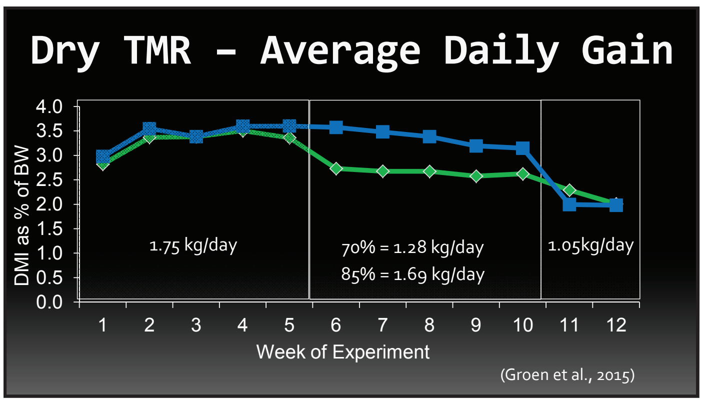

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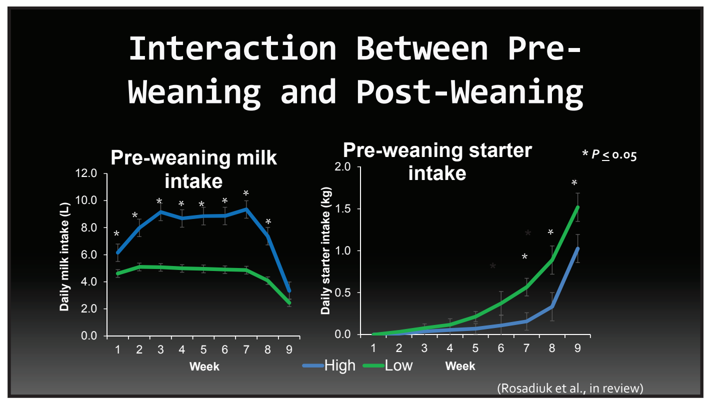

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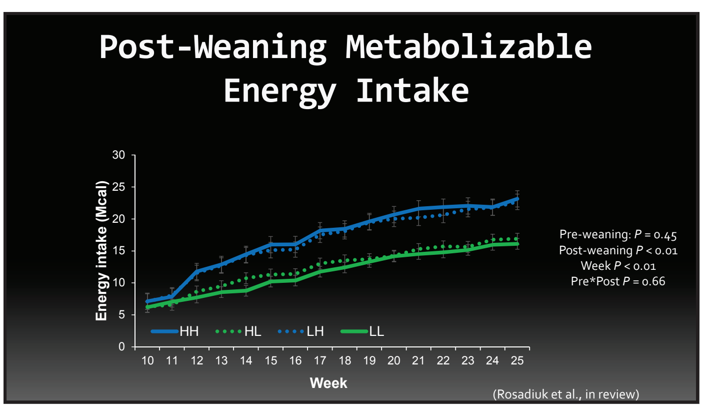

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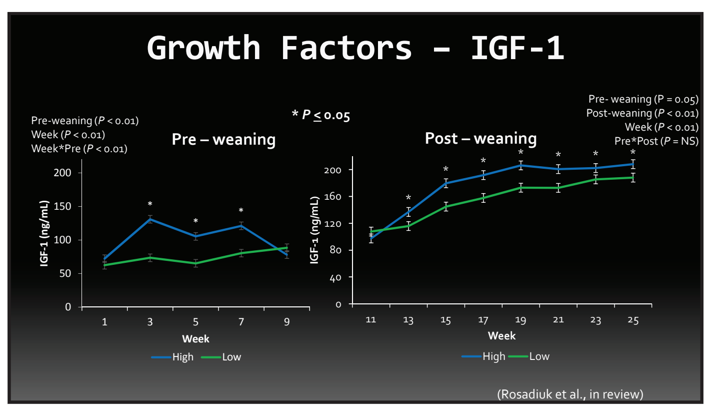
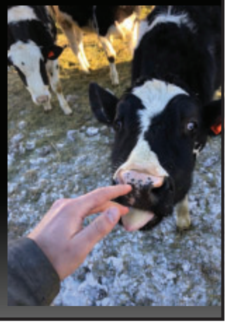


42

Reproductive Development

- Heifers offered the higher post-weaning plane of nutrition had:
  - Enhanced development of reproductive tract (larger uterus and ovarian follicles) before puberty
  - Higher chances of achieving puberty by 30 wk of age
  - Higher number of ovarian antral follicles during the estrous cycle after they achieved puberty (31 vs. 21 follicles, $P < 0.01$)



(Bruinjé et al., 2019)

43

Take Home Messages

- Weaning in dairy calves is one of the largest transformations of the gut in nature
- Milk feeding level has a large impact on weaning stress
- Weaning age and abruptness impact performance on high planes of milk nutrition – after 8 weeks with a two week stepdown
- Weaning is also associated with gut health problems – Leaky hindgut
- Post-weaning nutrition is another under-developed topic- forage inclusion is key more months post-weaning

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Industry Collaborators

45

Academic Collaborators

46

Thanks to my Team

Alberta, 2017

Guelph, 2019

47

DAIRY at GUELPH

Mike Steele
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48


Stay The Course
Steer clear of changes during high risk periods.
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Four-State Dairy Nutrition & Management Conference

The High Fertility Cycle

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The High Fertility Cycle

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SUMMARY

- Over the past two decades, a reproduction revolution has occurred in the dairy industry in which average 21-day pregnancy rates have more than doubled from around 14% to more than 30% in many herds.
- Much of this increase in reproductive performance has been driven by development and adoption of fertility programs.
- In spite of the dramatic increase in 21-day pregnancy rates, substantial variation exists among herds using the exact same reproductive management suggesting that factors other than fertility programs can affect fertility.
- Change in body weight or body condition score postpartum or during the periparturient period dramatically affects embryo quality, reproductive outcomes, and transition cow health.
- Although some cows lose body weight or body condition score after calving, some cows maintain, whereas some cows even gain body weight or body condition score during this time period.
- Surprisingly, milk production during early lactation is not affected based on body condition score change during the first 3 weeks postpartum; however, peak milk measured near 60 DIM was less in both primiparous and multiparous cows that either gained or maintained compared to cows that lost body condition during the 1st 30 DIM.
- The high fertility cycle coupled with the dramatic increases in reproductive performance due to the development and adoption of fertility programs is a new paradigm that we can now use to explain much of the variation in reproductive performance among herds.
- The high-fertility cycle: How timely pregnancies in one lactation may lead to less BCS loss, fewer health issues, greater fertility, and reduced early pregnancy losses in the next lactation.

INTRODUCTION

Over the past two decades, a reproduction revolution has occurred in the dairy industry. Twenty years ago, the 21-day pregnancy rate in U.S. dairy herds averaged about 14% with conception rates rarely exceeding 40%. In 1998, the annualized 21-day pregnancy rate goal was 20% which few herds could achieve. Today, the average 21-day pregnancy rate in the U.S. exceeds 21% with more than 60% of DRMS Holstein herds achieving 21-day pregnancy rates greater than 20% with average conception rates that exceed 50% in high-producing Holsteins. The development of fertility programs and their adoption by the dairy industry over the past decade has largely driven this reproduction revolution (Carvalho et al., 2018). Fertility programs, such as Double-Ovsynch or G6G protocols for first timed AI not only increase the AI service rate, but also increase pregnancies per AI (P/AI) beyond that achieved based on AI to a detected estrus (Santos et al., 2017). Despite this increase in reproductive performance, many veterinarians, nutritionists, and consultants observe dramatic variation in reproductive performance among herds that manage reproduction using the exact same reproductive management programs. Although on-farm protocol compliance with complex fertility programs that require multiple treatments across many days remains an issue, it cannot explain all of this variation among herds.

The "Britt Hypothesis"
In 1992, Dr. Jack Britt sorted 76 lactating Holstein cows based on whether they Lost (Lost, n = 30) or Maintained (n = 46) BCS during the first 5 weeks after calving (Britt, 1992). Body condition scores were recorded for the first 10 weeks after calving for these two groups of cows (Figure 1).

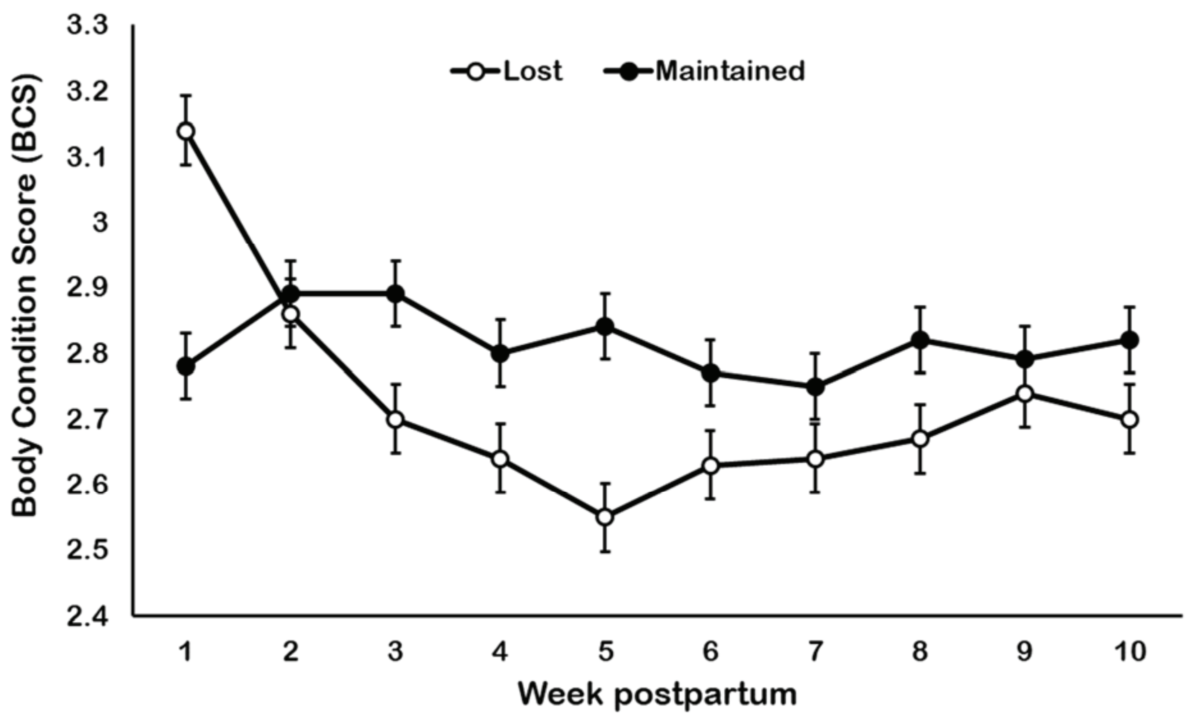

Figure 1. Change in body condition score (BCS) in Holstein cows (n = 76) during the first 10 weeks postpartum. Cows were sorted into two groups based on whether they Lost (Lost, n = 30) or Maintained (n = 46) BCS during the first 5 weeks postpartum. Adapted from Britt (1992).

Cows that maintained BCS post calving had a greater conception rate at first service than cows that lost BCS post-calving (Table 1). Based on these data, Dr. Britt speculated that high producing cows which experience severe weight losses during the first 3 to 5 weeks after calving presumably subject their developing follicles to adverse metabolic conditions associated with the rapid weight loss that compromises fertility later during lactation at first insemination (Britt, 1992). The results from three recent studies; two from the University of Wisconsin - Madison, and one from Michigan State University, support Dr. Britt's observation from 1992 and challenge the long-held assumption that all cows normally lose BCS after calving.

Table 1. Results of retrospective analysis of data from Holstein cows sorted based on BCS change during the first 5 weeks postpartum. Adapted from Britt, 1992.

Item	Lost	Maintained
n	30	46
BCS[1] change		
Week 1 to 5	-0.58[a]	+0.06[b]
Week 5 to 10	+0.17[a]	-0.02[b]
Interval to first ovulation (d)	23.3[a]	17.2[b]
Milk yield		
Mean during first 70 d (lbs)	60	58
Mean 305 d lactation (lbs)	18,198	17,941
Interval to first AI (d)	82.9	84.9
Conception rate		
First service (%)	25[a]	62[b]
All services (%)	42[a]	61[b]

[a,b]Items with different superscripts differ ($P < 0.05$)
[1]Body condition scores based on a 1 (thin) to 5 (fat) scale.

Effect of body weight change on embryo quality
The first study from the first paper (Carvalho et al., 2014) included an experiment in which lactating Holstein cows (n = 71; 27 primiparous and 44 multiparous) were weighed weekly from calving until 10 weeks postpartum. Cows were divided into quartiles based on percent body weight change from the first week after calving (Figure 2). The quartile analysis divided cows based on those that gained weight (First Quartile), maintained weight (Second Quartile), slightly lost weight (Third Quartile), and dramatically lost weight (Fourth Quartile), and the majority of the body weight change occurred during the first 3 weeks postpartum (Figure 2). Cows in the Fourth Quartile that dramatically lost weight had increased NEFA concentrations during the first 3 weeks after calving, whereas NEFA concentrations did not differ at 10 weeks postpartum when superovulation and embryo flushing was performed (Carvalho et al., 2014).

To assess embryo quality, cows were superovulated using a modified Double-Ovsynch protocol. All cows were inseminated and flushed by two technicians, and cows were inseminated twice at 12 and 24 h after GnRH treatment. Seven days after GnRH treatment, ova/embryos were recovered using a nonsurgical shallow uterine horn flushing technique. Embryo characteristics were affected based on body weight quartile in which cows in the Fourth Quartile that dramatically lost weight during the first 3 weeks postpartum had overall poorer embryo characteristics than cows in the other three quartiles (Table 2).

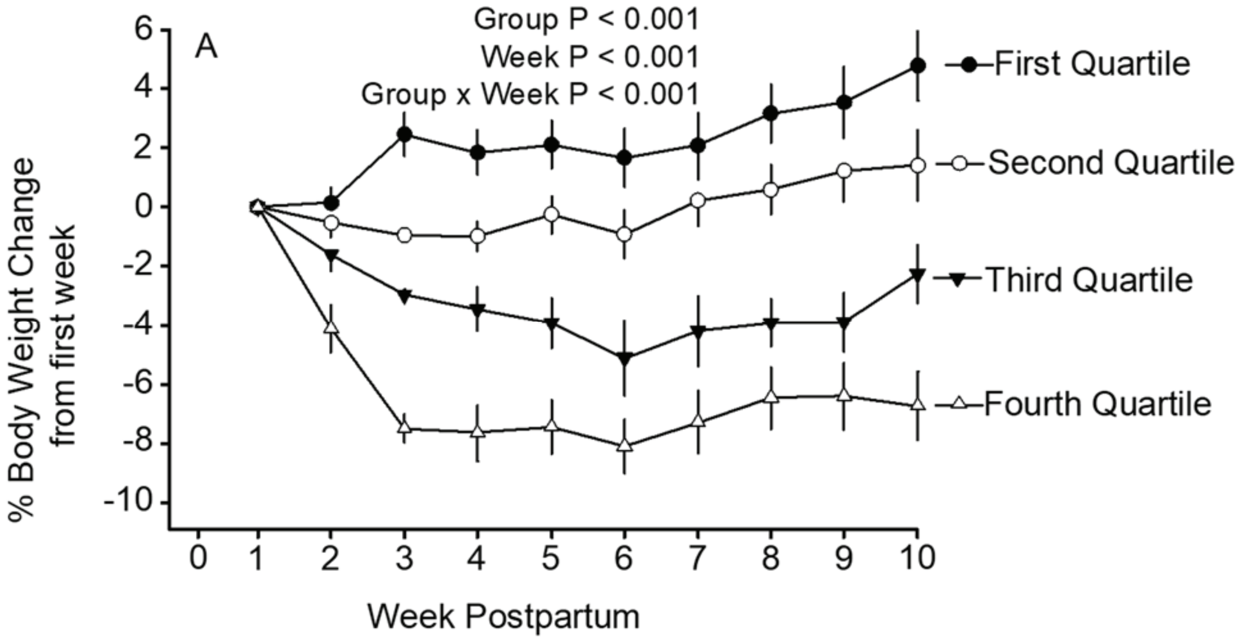

Figure 2. Quartile analysis of percent body weight change from the first week postpartum in Holstein dairy cows. Adapted from Carvalho et al. (2014).

Table 2. Embryo characteristics of lactating Holstein cows based on body weight change[1] from first to third week postpartum. Adapted from Carvalho et al. (2014).

Item	Fourth Quartile	Third Quartile	Second Quartile	First Quartile	*P*
CL (number)	18.4 ± 2.6	18.4 ± 1.7	19.0 ± 1.7	16.0 ± 2.0	0.67
Fert structures (#)	7.6 ± 2.1	7.3 ± 1.1	4.8 ± 1.1	5.8 ± 1.4	0.43
Deg embryos (#)	2.7 ± 0.7[a]	1.7 ± 0.7[ab]	0.7 ± 0.2[b]	0.6 ± 0.2[b]	0.02
Quality 1 & 2 (#)	4.2 ± 1.4	5.3 ± 0.9	3.9 ± 1.1	4.9 ± 1.4	0.47
Quality 1, 2 & 3 (#)	4.9 ± 1.6	5.6 ± 0.8	4.1 ± 1.1	5.3 ± 1.4	0.49
Fertilized (%)	76.9 ± 7.1	77.0 ± 6.6	77.6 ± 7.6	78.4 ± 7.1	0.99
Degenerate (%)	35.2 ± 8.5[a]	12.6 ± 4.6[b]	14.5 ± 6.3[b]	9.6 ± 3.7[b]	0.02
Quality 1 & 2 (%)	38.0 ± 8.7[b,B]	61.3 ± 8.2[ab,A]	60.6 ± 9.4[ab,A]	63.4 ± 8.6[a,A]	0.14
Quality 1, 2 & 3 (%)	41.7 ± 8.8[b,B]	64.4 ± 8.2[ab,A]	63.1 ± 9.3[ab,A]	68.9 ± 8.7[a,A]	0.13
Degen of Fert (%)	46.9 ± 9.6[a,A]	17.4 ± 6.4[b,B]	24.8 ± 9.3[ab,A]	16.2 ± 7.0[b,B]	0.04
1 & 2 of Fert (%)	48.4± 9.5[b]	78.3 ± 6.6[a]	72.6 ± 9.5[a]	77.7 ± 7.4[a]	0.05
1, 2 &3 of Fert (%)	53.2 ± 9.6[b,B]	82.6 ± 6.4[a,A]	75.2 ± 9.3[a,AB]	83.8 ± 7.0[a,A]	0.04
Recovery Rate (%)	45.6 ± 7.4	55.1 ± 6.9	35.4 ± 6.7	45.3 ± 5.8	0.25

[a,b]Items with different superscripts within the same row differ (P < 0.05).
[A,B]Items with different superscripts within the same row differ (P < 0.15).
[1]First quartile = gaining body weight; Fourth quartile = most body weight loss.

Effect of BCS change after calving on fertility

The second study from the first paper (Carvalho et al., 2014) included a retrospective analysis in which 1,887 Holstein cows from two commercial dairy farms in Wisconsin were submitted to a Double-Ovsynch protocol for first timed AI, and BCS was evaluated at calving and 21 days after calving. Overall, 42% of cows lost BCS, 36% of cows maintained BCS, and 22% of cows gained BCS during the first 3 weeks of lactation (Table 3).

Table 3. Effect of BCS change on pregnancies /AI (P/AI) for cows on Farm 1 and 2 classified as losing, maintaining or gaining BCS from parturition to three weeks postpartum. Adapted from Carvalho et al. (2014).

	BCS[2] change		
Item	Lost	Maintained	Gained
All cows			
% of cows, (n)	41.8 (789/1887)	35.8 (675/1887)	22.4 (423/1887)
P/AI at 40 d, % (n/n)	25.1 (198/789)[c]	38.2 (258/675)[b]	83.5 (353/423)[a]
P/AI at 70 d, % (n/n)	22.8 (180/789)[c]	36.0 (243/675)[b]	78.3 (331/423)[a]
Pregnancy Loss, % (n/n)	9.1 (18/198)	5.8 (15/258)	6.2 (22/353)
BCS at parturition	2.93 ± 0.01 [a]	2.89 ± 0.02 [b]	2.85 ± 0.02 [b]
BCS at 21 DIM	2.64 ± 0.01 [c]	2.89 ± 0.02 [b]	3.10 ± 0.02 [a]
ECM (kg/d)[1]	30.9 ± 0.4	31.5 ± 0.4	28.7 ± 0.4

[a,b,c]Items with different superscripts within the same row differ ($P < 0.05$).

[1]Mean Energy Corrected Milk from calving to 21 DIM.

[2]Body Condition Score was evaluated at calving and at 21 DIM based on a point 5 scale.

Similar to the experiment by Britt (1992), energy corrected milk (ECM) did not differ among cows based on BCS change (Table 3). Most impressively, P/AI 40 d after timed AI was only 25% for cows that lost BCS, 38% for cows that maintained BCS, and was 84% for cows that gained BCS. It is important to note that there were dramatic farms effects in this study in which one farm had most of the cows that gained BCS (Carvalho et al., 2014). Based on data presented thus far, the key question is: can we increase the proportion of cows that gain BCS after calving? The next study by Barletta et al. (2017) helps us to answer this question.

Effect of BCS change during the periparturient period on reproduction and health

In the second study (Barletta et al., 2017), BCS change was evaluated in 233 Holstein cows from 3 weeks before the expected date of calving until 3 weeks after calving (Table 4). Similar to the experiment by Carvalho et al. (2014), P/AI 30 d after AI for cows submitted to first timed AI was 18% for cows that lost BCS (28% of cows), 27% for cows that maintained BCS (23% of cows), and 53% for cows that gained BCS (49% of cows). Average milk production during the first 3 weeks of lactation did not differ among cows based on BCS change during the periparturient period.

Table 4. Effect of changes in body condition score (BCS) during the transition period on pregnancies per artificial insemination (P/AI) and pregnancy loss. Adapted from Barletta et al. (2017).

	Change in BCS[1]			
Item	Gained	Maintained	Lost	*P*-value
Cows, % (no./no.)	28 (69/245)	22 (54/245)	50 (122/245)	
P/AI 30 d, % (no./no.)	53.0 (35/66)[a]	26.9 (14/52)[b]	18.3 (21/115)[b]	< 0.01
P/AI 60 d, % (no./no.)	45.5 (30/66)[a]	25.0 (13/52)[b]	15.7 (18/155)[b]	< 0.01
Pregnancy loss, % (no./no.)	14.3 (5/35)	7.1 (1/14)	14.3 (3/21)	0.79

[a/c]Within a row, items with different superscripts differ (P < 0.05).
[1]BCS was evaluated during the transition period (-21 to 21 d) using a 5-point scale.

In addition to increased fertility, cows that gained BCS during the periparturient period were also healthier, with less than 40% of these cows experiencing more than one health event, whereas greater than 60% of cows that lost BCS after calving experienced more than one health event (Table 5).

Table 5. Effect of changes in body condition score (BCS) during the transition period (-21 to 21) on incidence (%) of retained placenta, mastitis, ketosis and pneumonia for cows that lost, maintained, or gained BCS. Adapted from Barletta et al. (2017).

	Change in BCS[1]			
Item	Gained	Maintained	Lost	*P*-value
n	66	52	116	
Metritis	19.70 (13/66)	21.20 (11/52)	23.30 (27/116)	0.85
Mastitis	16.70 (11/66)[b]	17.30 (9/52)[a,b]	29.30 (34/116)[a]	0.09
Ketosis	15.20 (10/66)	19.20 (10/52)	26.70 (31/116)	0.18
Pneumonia	9.10 (6/66)	11.50 (6/52)	14.70 (17/116)	0.55
> 1 Health problem	39.4 (26/66)[b]	46.2 (24/52)[b]	62.9 (73/116)[a]	0.007

In this study by Barletta et al. (2017), the major factor associated with BCS change during the transition period was BCS 3 weeks before expected calving. Only 34% of cows with BCS less than 3.0 lost BCS during the transition period, whereas 51% of cows with BCS = 3.0 lost BCS and 92% of cows with BCS > 3.0 lost BCS. So, how can we ensure that more cows gain BCS after calving? Nearly all of the cows in the study by Barletta et al. (2017) that gained BCS during the transition period had a BCS less than 3.0 3 weeks before calving. Thus, calving cows at a lower BCS was associated with less BCS loss, greater fertility, and fewer health issues. Based on data presented thus far, the next question is: how do I prevent calving cows with a high BCS? The final study provides the answer to this question.

The High Fertility Cycle
The final study evaluated BCS change within 1 week of calving until 30 days after calving in 851 Holstein cows on a commercial dairy farm in Michigan (Middleton et al., 2019). This study linked previous calving intervals of individual cows to BCS changes after calving. Calving interval is determined by the fixed interval of gestation length and the highly variable interval of calving to conception. Thus, cows with longer calving intervals during the

previous lactation took longer to get pregnant than cows with shorter calving intervals. In this study, cows with longer calving intervals in the prior lactation had greater BCS at calving and lost BCS during the first 30 days after calving. In agreement with the first two studies (Carvalho et al., 2014; Barletta et al., 2017), cows that maintained or gained BCS after calving had greater conception rates, less pregnancy loss, and were healthier than cows that lost BCS after calving (Middleton et al., 2019). Amazingly, even when cows with health problems were removed from the data set, differences in conception rates and pregnancy losses in favor of cows that maintained or gained body condition during the 1st 30 DIM were maintained. An excellent overview of the results from this study is captured by the title of the paper: The high-fertility cycle: How timely pregnancies in one lactation may lead to less BCS loss, fewer health issues, greater fertility, and reduced early pregnancy losses in the next lactation (Figure 3).

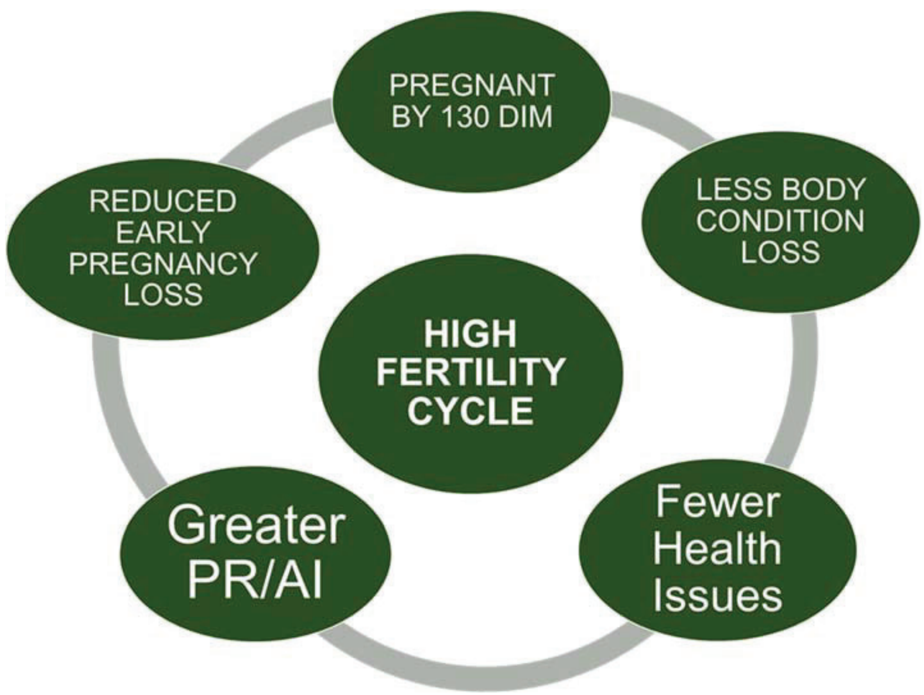

Figure 3. The high-fertility cycle: How timely pregnancies in one lactation may lead to less BCS loss, fewer health issues, greater fertility, and reduced early pregnancy losses in the next lactation. Adapted from Middleton et al. (2019).

CONCLUSION

Based on the collective results from these studies we can now clearly define a relationship in which herds that manage to get their cows pregnant rapidly after the end of the voluntary waiting period calve cows at a lower BCS which in turn leads to more cows maintaining or gaining BCS after calving. Cows that maintain or gain BCS after calving have greater fertility than cows that lose BCS. The High Fertility Cycle coupled with the dramatic increases in reproductive performance due to the development and adoption of fertility programs is a new paradigm that we can now use to explain much of the variation in reproductive performance among herds. The goal of every farm should be to strive to get their cows into the high-fertility cycle and keep them there. The following are key considerations to achieve this: 1) implement BCS monitoring for transition cows 3 weeks before calving, at calving, 3 weeks after calving, and at AI; 2) use fertility programs to help get cows pregnant quickly after the end of the voluntary waiting period; 3) set a hard cutoff for the number times individual cows will be inseminated; and 4) consider nutritional strategies to prevent late lactation cows from gaining too much body condition.

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Using MUN to Manage Protein Feeding

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2020 4-State Dairy Nutrition and Management Conference Breakout Session

Using MUN to Manage Protein Feeding

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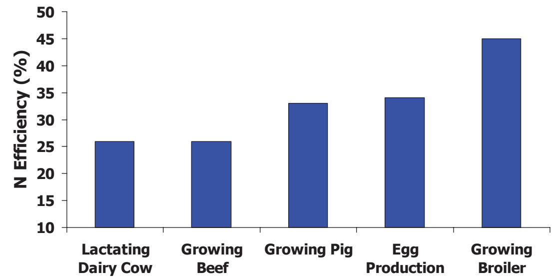
1

N Conversion Efficiencies for Different Production Systems



Bequette et al., 2003

2

Dairy Nutrient Values – 5-year Average

Nutrient values derived using Sesame
Buckeye Dairy News: Vol 22, Issue 2 (March, 2020)

Nutrient	Cost/Unit	Daily Supply*	Cost/cow/d
NEL (3X, NRC 2001) MCal	$0.08	35.4 Mcal	$2.83
Metabolizable Protein (NRC) Lbs	$0.43	5.44 lbs	$2.34
Effective NDF (forage NDF) Lbs	$0.14	10.4 lbs	$1.46
Non-effective NDF (Total NDF – Forage NDF) Lbs	-$0.02	7.3 lbs	-$0.15
Total Cost for Energy, Protein and Fiber			$6.48

* 1600 lb cow, 80 lbs milk/d, 3.0% protein, 3.5% fat

https://dairy.osu.edu/newsletter/buckeye-dairy-news/volume-22-issue-2/milk-prices-costs-nutrients-margins-and-comparison
Sesame can be licensed and used for local markets

3

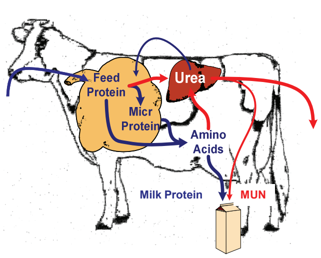
Environmental Impact of Waste N

Eutrophication

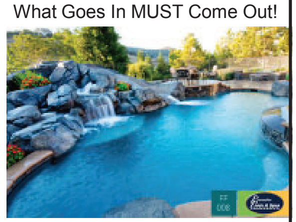
Air Quality and High N Rain

4

RDP/RUP and MUN



What Goes In MUST Come Out!

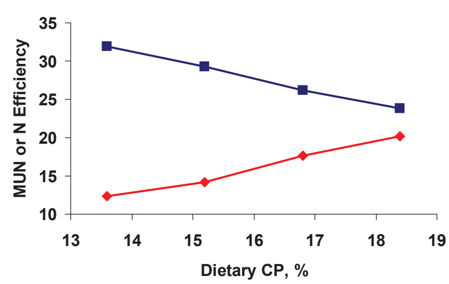


RDP = Ruminally Degraded Protein
RUP = Ruminally Undegraded Protein

CP = RDP + RUP
MP = Digestible (Microbial Protein + RUP)

5

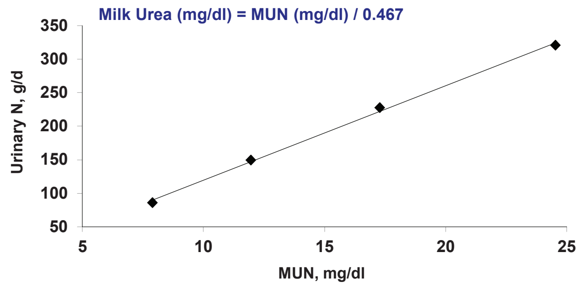
Effects of Dietary Protein (RDP) on MUN and N Efficiency



Cyriac et al., 2006

6

Relationship of MUN and Urinary N Output

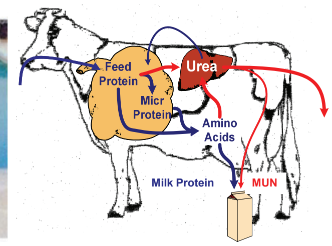


Burgos et al., 2007

7

MUN Responses to RDP/RUP

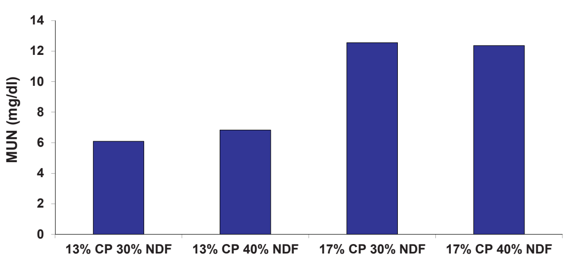
Does it Matter where the Water Enters the Pool?



Ruminally available CHO?

8

Effects of Protein and CHO on MUN



Kaufman and St-Pierre., 2001

9

High Salt Reduces MUN

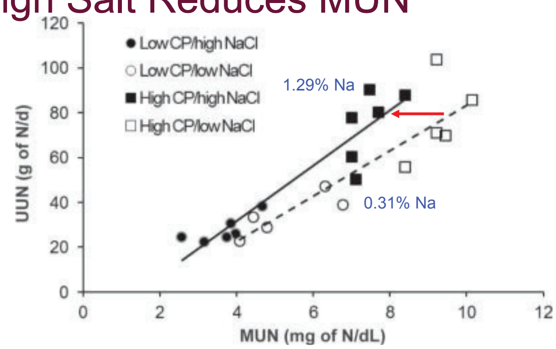


Figure 2. Relationship between MUN concentration (mg of N/dL) and urinary urea nitrogen excretion (UUN; g of N/d) for low NaCl (3.1 g of Na/kg of DM; dashed regression line) and high NaCl (12.9 g of Na/kg of DM; solid regression line) diets.

Spek et al., 2013

10

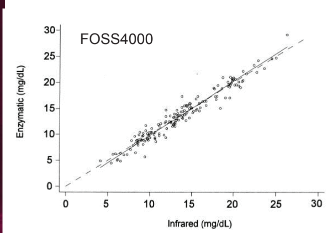
Genetics and MUN

Effect	Estimate	SE	*P*<
Intercept	-166	26	0.002
Dietary CP, % of DM	5.4	1.1	0.0001
Dietary NDF, % of DM	2.84	0.45	0.0001
Milk Yield, kg/d	0.66	0.12	0.0001
Milk Protein, %	37.7	7.3	0.0001
CP x NDF	-0.038	0.018	0.03
CP x Milk Yield	-0.0194	0.0057	0.001
CP x Milk Protein	-0.73	0.24	0.003
NDF x Days in Milk	-0.00005	0.00002	0.009
NDF x Milk Protein	-0.65	0.11	0.0001
Milk x Milk Protein	-0.073	0.023	0.002
Random Effects			
Herd	**1.6**		**0.08**
Cow(Herd)			**0.0001**

Aguilar et al., 2012

11

Are MUN Data Reliable?



Arunvipas et al., 2003 Can. J. Vet Res.

Table 1. Percent recovery of urea nitrogen among analytical methods.

Method	Recovery(%)[1]	SE(%)
Bentley	**92.1[a]**	**2.76**
CL-10	85.0[b]	2.76
Foss4000	47.1[c]	9.88
Foss6000	95.4[a]	10.1
Skalar	95.1[a]	7.61

[a,b,c]Means within a column with unlike superscripts differ ($P < 0.05$).
[1]Recovery = (Treated MUN - Control MUN)/4 mg/dL.

Peterson et al., 2004 JDS

United DHIA - Bentley
$0.25 / cow for full test
$10 for a single bulk tank sample

12

Monitor MUN to Achieve Optimum Return

1. Establish a baseline for your herd
   - Balance ration to NRC 2001 or equivalent
   - Feed ration for 2 weeks and Measure MUN (~11 mg/dl)
2. Systematically reduce RUP (0.25% units at a time)
   - For example, CP from 16.5% to 16.25% via RUP ($0.06/c/d)
   - Keep RDP and energy constant
   - Feed for 1 week; Monitor MUN and milk yield
   - MUN should ↓ by ~0.5 mg/dl
   - Any milk loss will be half of NRC predicted loss
   - Calculate Income/Feed Cost (IOFC)
   - If greater, retain reduction and lower another 0.25%
3. Reduce RDP by 0.5% of Diet DM while holding RUP constant
   - Same approach as for RUP, e.g. 16% to 15.5% ($0.02/c/d)
   - RDP ≥ 9% of DM is safe
   - ↓ DMI is first sign of deficiency
4. MUN at maximal IOFC is target for the herd
   - Can operate at 8 or below
   - May require RPAA → IOFC
   - High MUN = overfeeding protein
   - Low MUN = lost milk

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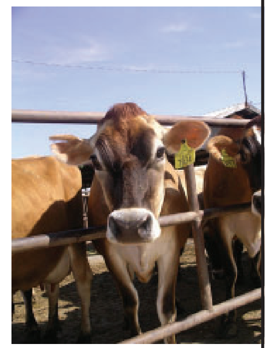
Summary

1. Excess N harms the environment and cost $
   - Environmental regulations are not going away!!!!!
2. Feed to requirements
   - 2001 RDP requirements are too high
   - MP Requirements → AA in 2021
3. Feeding Management is Critical
   - Monitor feeds for nutrient content
   - Balance to requirements
   - Monitor programs for feeding accuracy
   - Verify milk processor MUN accuracy
   - Monitor MUN as a process indicator



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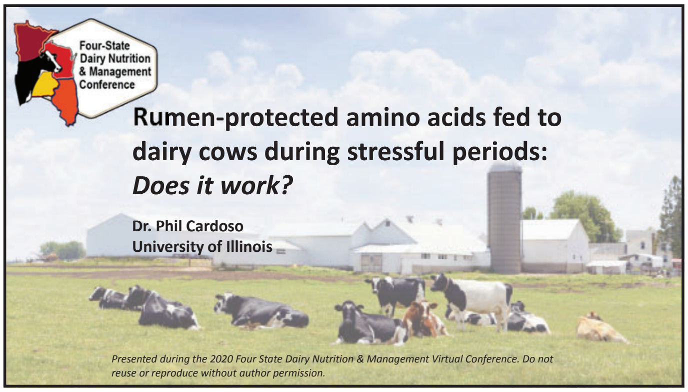
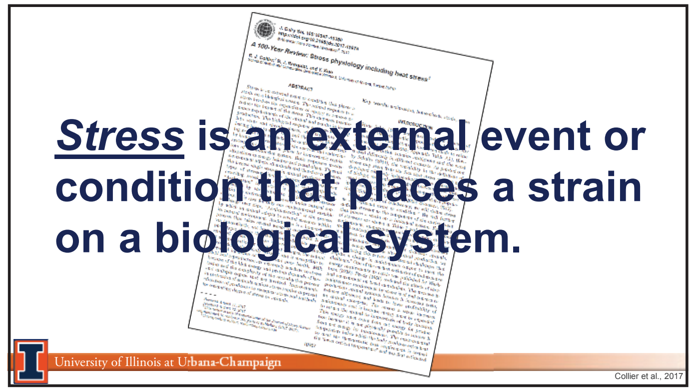
Rumen-Protected Amino Acids Fed to Dairy Cows During Stressful Periods: *Does it work?*

Dr. Phil Cardoso

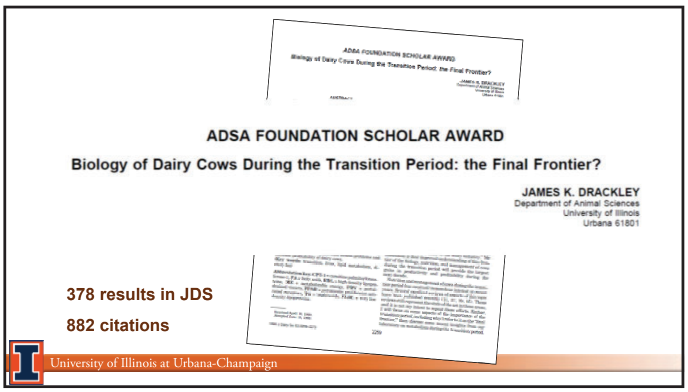
University of Illinois


Four-State Dairy Nutrition & Management Conference
Rumen-protected amino acids fed to dairy cows during stressful periods: *Does it work?*
Dr. Phil Cardoso
University of Illinois
Presented during the 2020 Four State Dairy Nutrition & Management Virtual Conference. Do not reuse or reproduce without author permission.

1


Stress is an external event or condition that places a strain on a biological system.
University of Illinois at Urbana-Champaign
Collier et al., 2017

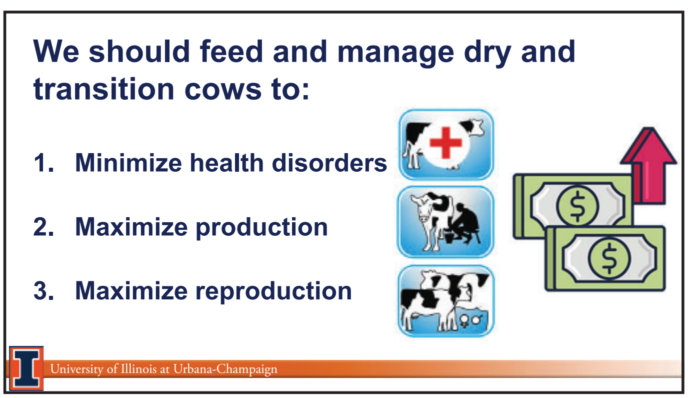
2


ADSA FOUNDATION SCHOLAR AWARD
Biology of Dairy Cows During the Transition Period: the Final Frontier?
JAMES K. DRACKLEY
Department of Animal Sciences
University of Illinois
Urbana 61801
378 results in JDS
882 citations
University of Illinois at Urbana-Champaign

3


So, What do we want from this cow?
University of Illinois at Urbana-Champaign

4

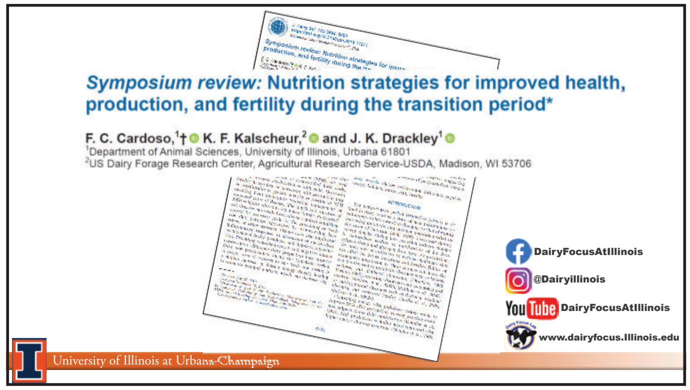

We should feed and manage dry and transition cows to:
1. Minimize health disorders
2. Maximize production
3. Maximize reproduction
University of Illinois at Urbana-Champaign

5


Rx

6

7



8

Dietary Recommendations for Dry Cows

- **NEL:** Control energy intake at 14 to 16 Mcal daily [diet ~ 1.32 Mcal/kg (0.60 Mcal/lb) DM] for mature cows
- **Crude protein:** 12 – 14% of DM
- **Metabolizable protein (MP):** > 1,200 g/d
- **Starch content:** 12 to 15% of DM (NFC < 26%)
- **NDF from forage:** 40 to 50% of total DM or 4.5 to 6 kg per head daily (~0.7 – 0.8% of BW). Target the high end of the range if more higher-energy fiber sources (like grass hay or low-quality alfalfa) are used, and the low end of the range if straw is used (2-5 kg)
- **Total ration DM content:** <50% (add water if necessary)
- **Minerals and vitamins:** follow guidelines (For close-ups, target values are 0.40% magnesium (minimum), 0.35 – 0.40% sulfur, potassium as low as possible (Mg:K = 1:4), a DCAD of near zero or negative, calcium without anionic supplementation: 0.9 to 1.2% (~125g) calcium with full anion supplementation: 1.5 to 2.0% (~200g), 0.35 – 0.42% phosphorus, at least 1,500 IU of vitamin E, and 25,000 – 30,000 IU of Vitamin D (cholecalciferol)

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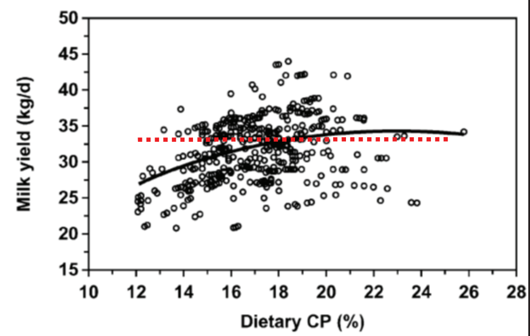
Relationship between milk yield and dietary CP (%) for lactating dairy cows



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Ipharraguerre and Clark, 2005

10

Dietary Recommendations for Dry Cows

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- **Crude protein:** 12 – 14% of DM
- **Metabolizable protein (MP):** > 1,200 g/d → Methionine, Lysine
- **Starch content:** 12 to 15% of DM (NFC < 26%)
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11

Effects of Rumen-Protected Methionine or Choline Supplementation on the First Dominant Follicle

- 72 Holstein cows entering 2nd or greater lactation
- Experimental design was a randomized block design
- Housed in tie stalls with sand bedding
- Milked 3x per day
- Fed same basal TMR to meet but not exceed 100% of the energy requirements as outlined by NRC, 2001
  - From -34 d to calving: prepartum diet
  - From 0 to 30 DIM: fresh cow diet
  - From 31 to 72 DIM: high cow diet
- Treatments were given as top-dress

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Acosta et al., 2016

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Effects of Rumen-Protected Methionine or Choline Supplementation on the First Dominant Follicle

1. Rumen-protected methionine (**MET**; n = 20, received 0.08% of the DM of the diet/d as methionine, Smartamine M®, Adisseo, Alpharetta, GA, USA, to a Lys:Met = 2.9:1)
2. Rumen-protected choline (**CHO**; n = 17, received 60 g/d choline, Reassure, Balchem Corporation, New Hampton, NY)
3. Both rumen protected methionine and choline (**MIX**; n = 19, received 0.08% of the DM of the diet/d as methionine to a Lys:Met = 2.9:1 and 60 g/d choline)
4. No supplementation to serve as control (**CON**; n = 16, fed TMR with a Lys:Met = 3.5:1)

Acosta et al., 2016

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Diets

Ingredients	Pre-Fresh -21 d to calving	Fresh Calving to 30 DIM	High 31 to 73 DIM
	% DM		
Alfalfa silage	8.35	5.07	6.12
Alfalfa hay	4.29	2.98	6.94
Corn silage	36.40	33.41	35.09
Wheat straw	15.63	2.98	---
Cottonseed	---	3.58	3.26
Wet brewers grain	4.29	9.09	8.16
Soy hulls	4.29	4.18	4.74
Concentrate mix	26.75	38.71	35.69

Acosta et al., 2016

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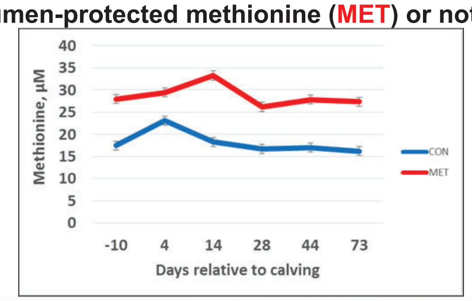
Serum Methionine Concentration from Cows Fed rumen-protected methionine (MET) or not (CON)



Control: n = 7; Methionine: n = 10

Stella et al., 2018

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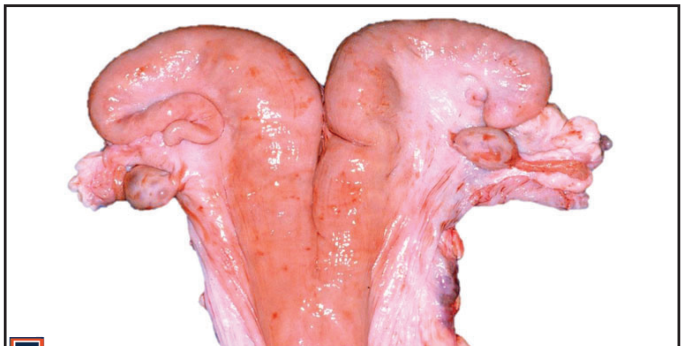

http://loribovinesection.blogspot.com/2013_07_01_archive.html

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Full Length Article

Effects of rumen-protected methionine and choline supplementation on vaginal discharge and uterine cytology of Holstein cows

Cassandra S. Skenandore [a,b], Diego A. Velasco Acosta [a,c,d], Zheng Zhou [a], Maria I. Rivelli [a], Márcio N. Corrêa [c], Daniel N. Luchini [e], Felipe C. Cardoso [a,*]

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[b] Department of Veterinary Physiology and Pharmacology, Texas A&M University, 4466 TAMU, College Station, TX 77843, USA
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[e] Adisseo NACA, 4400 North Point Parkway, Alpharetta, GA 30022, USA

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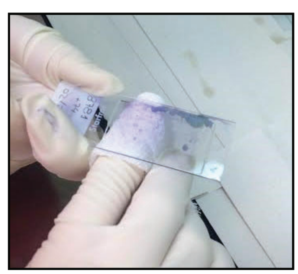
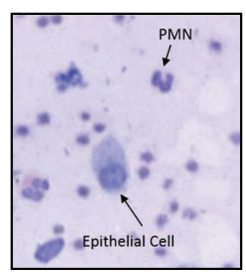
Uterine Cytology – Polymorphonuclear (PMN)





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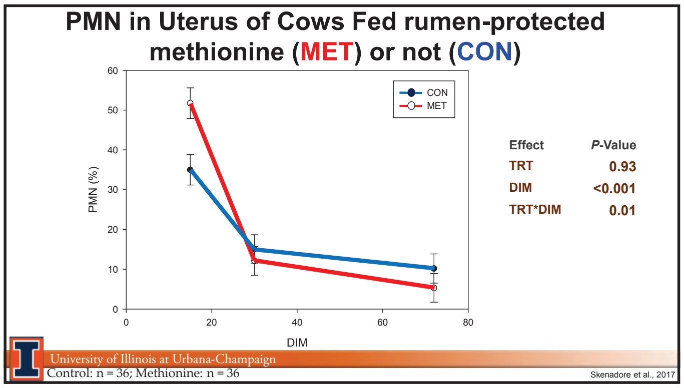

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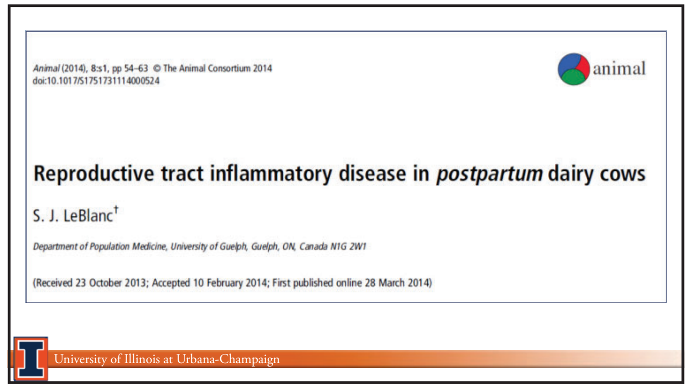

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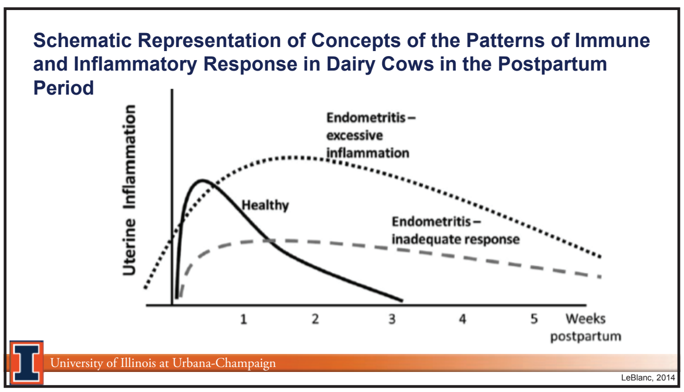

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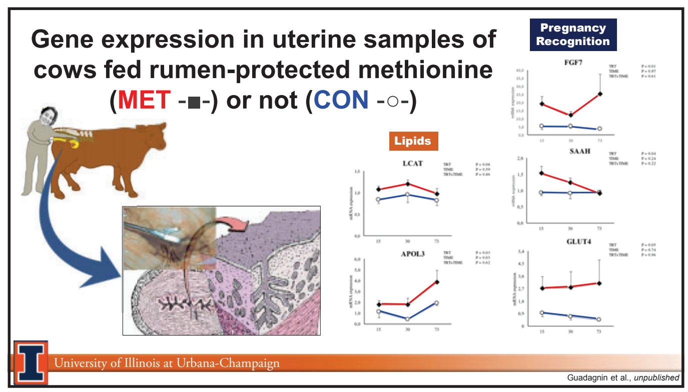

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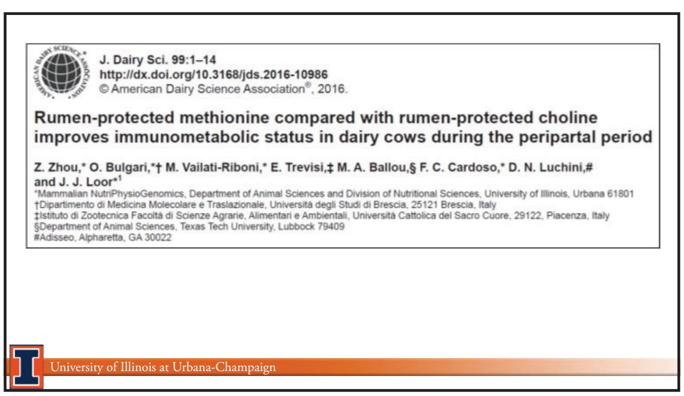

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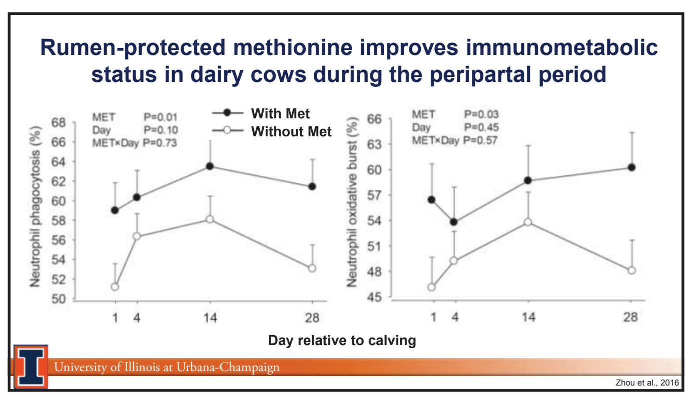

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J. Dairy Sci. 100:6720–6732
https://doi.org/10.3168/jds.2016-12299

Differences in liver functionality indexes in peripartal dairy cows fed rumen-protected methionine or choline are associated with performance, oxidative stress status, and plasma amino acid profiles

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Liver Functionality Index: LFI

Uses changes in plasma concentrations of several blood biomarkers (i.e., albumin, cholesterol, and bilirubin)

- Low LFI (**LLFI**) is indicative of a pronounced inflammatory response and less favorable circulating AA profile, which together suggest a more difficult transition from gestation to lactation
- High LFI (**HLFI**) is suggestive of a smooth transition

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Trevisi et al., 2012

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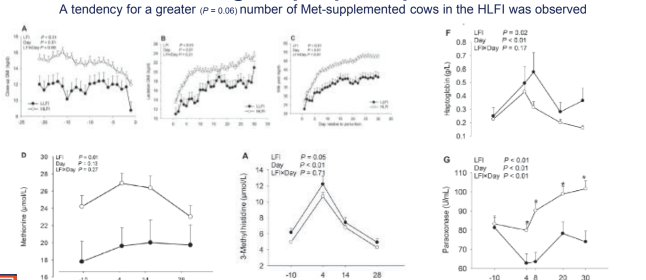
Rumen-protected methionine improves LFI in dairy cows during the peripartal period

A tendency for a greater ($P = 0.06$) number of Met-supplemented cows in the HLFI was observed



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Zhou et al., 2017

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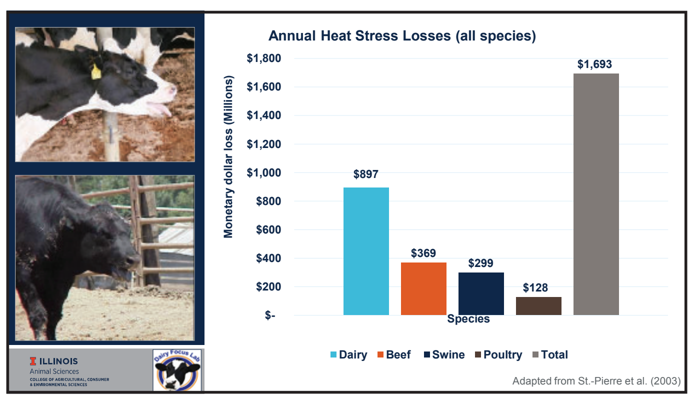

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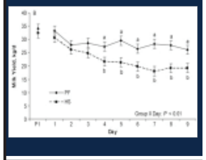

Heat Stress

Approximately $900 million lost annually

Physiological and production responses
- ↑ Respiration rate
- ↓ Dry matter intake
- ↓ Milk yield

Altered milk content and composition
- ↓ Milk fat %
- ↓ Milk protein %

Altered protein metabolism
- ↓ Total plasma AA concentration
  - ↓ Sulfur-AA (i.e. Methionine)

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Silanikove et al. (2000); Kadzere et al. (2002); St. Pierre et al (2003); Rhoads et al. (2009); Cowley et al. (2015); Gao et al. (2017)

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Heat Stress Challenge Experimental Objectives

- Evaluate the effects of commercially available rumen-protected methionine source (Smartamine M; Adisseo Inc.) fed at 0.105% of DMI on lactation performance and physiological responses of lactating, multiparous Holstein cows during heat stress

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Pate et al., 2020

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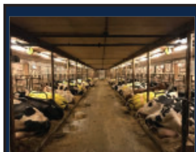

Materials and Methods

Crossover design
- September to December 2018

32 multiparous Holstein cows
- 184 ± 59 d in milk
- 2.8 ± 1.1 lactation number

2 dietary treatments
- **RPM –** 0.105% of DMI [~30g] as RPM*
- **CON –** No RPM*

2 environmental treatments
- **HS –**using electric heat blanket (EHB), ad libitum intake
- **PFTN –** thermoneutral conditions, pair-fed to HS counterparts

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Pate et al., 2020

* Mixed with 300 g molasses

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Environmental Treatment: **Electric Heat Blankets**

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Pate et al., 2020

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Environmental Treatment: **Pair-Fed Thermoneutral**

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Pate et al., 2020

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Split-Plot Crossover Design

		Period 1 (18 d)				Period 2 (18 d)	
Environmental Treatment (E)	Adaption (7 d)	Phase 1 – Baseline (9 d)	Phase 2 – Trial (9 d)	Wash-out period (14 d)	Adaption (7 d)	Phase 1 – Baseline (9 d)	Phase 2 – Trial (9 d)
Heat stress challenge	---	---	Group 1 (RPM and CON)		---		Group 2 (RPM and CON)
Thermal neutral and pair-fed	---	---	Group 2 (RPM and CON)	---	---		Group 1 (RPM and CON)
Thermal neutral and ad libitum	Group 1 (RPM and CON) Group 2 (RPM and CON)	Group 1 (RPM and CON) Group 2 (RPM and CON)	---	Group 1 Group 2	Group 1 (RPM and CON) Group 2 (RPM and CON)	Group 1 (RPM and CON) Group 2 (RPM and CON)	---

Sequence (S)

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Period Timeline

1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9

Phase 1 – Baseline Phase (No HS or PFTN) | Phase 2 – Trial Phase (HS or PFTN)

Physiological Measurements

- Vaginal Temperature (10 min)
- Rectal Temperature (3×/day)
- Respiration Rate (Daily)
- Heart Rate (Daily)

Performance Measurements

- Milk Yield (Daily)
- Dry Matter Intake (Daily)
- Milk Composition (3 d/phase)

✳ = Milk Sample (3×/d)

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Paired Difference Analysis

1 2 3 4 5 6 7 8 9 1 2 3 4 5 6 7 8 9

Phase 1 – Baseline Phase (No HS or PFTN) | Phase 2 – Trial Phase (HS or PFTN)

Average Phase 1 Baseline Mean — Individual Phase 2 Values

Milk yield:	30 kg/d	30 kg/d	25 kg/d	20 kg/d
Paired Difference Values:		0 kg/d	-5 kg/d	-10 kg/d

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Diet Formulation	
Ingredient	% of DM
Corn silage	40.9
Dry ground corn grain	17.7
Alfalfa silage	12.3
Corn gluten feed pellets	8.4
Alfalfa hay	6.3
Grain and mineral mix	6.7
Soybean meal RUP source	3.4
Molasses	3.3
Canola meal	1.7
Rumen protected lysine	0.4

Chemical Analysis*		
Item	Mean	SD
DM, %	47.0	1.0
CP, % of DM	15.6	0.2
ADF, % of DM	18.5	0.7
NDF, % of DM	29.0	0.6
Starch, % of DM	31.8	2.2
Crude fat, % of DM	5.1	0.2
Ash, % of DM	7.5	0.9

*Phase 1 and 2 from periods 1 and 2 (n = 4)

TMR Analysis

NRC (2001)

Pate et al., 2020

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Item	RPM	CON
CP	16.08	16.02
Met as % of MP	2.57	2.03
Lys as % of MP	7.01	7.05
Lys to Met Ratio	2.73	3.47

NRC (2001)

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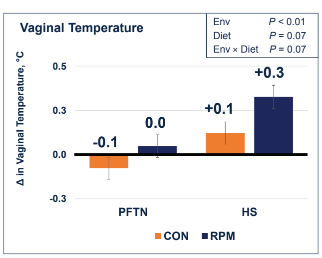
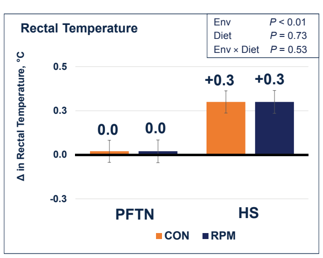
HS had greater increase in vaginal and rectal temperature than PFTN





Physiological Parameters

Pate et al., 2020

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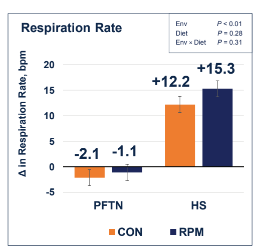
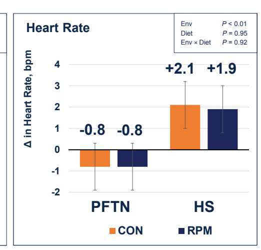
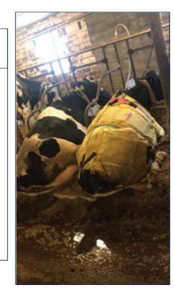
HS had greater increase in respiration rate and heart rate







Physiological Parameters

Pate et al., 2020

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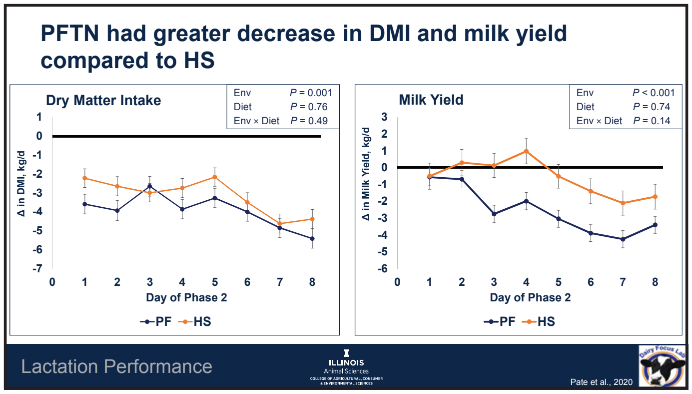

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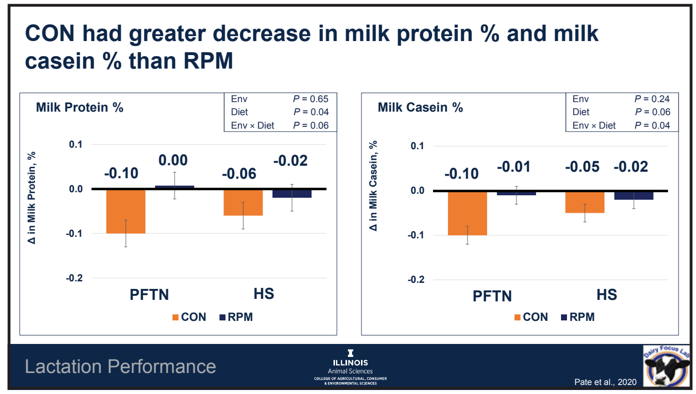

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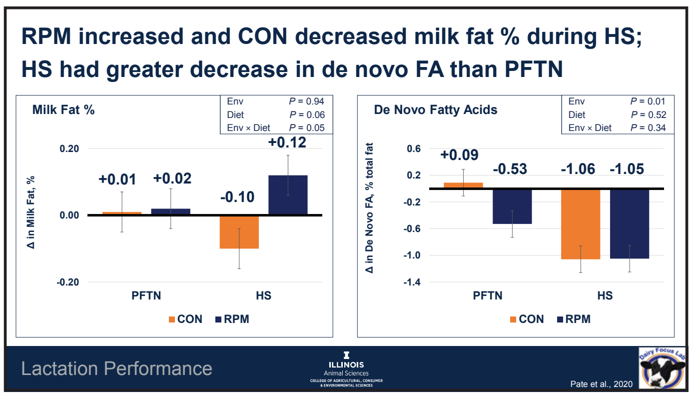

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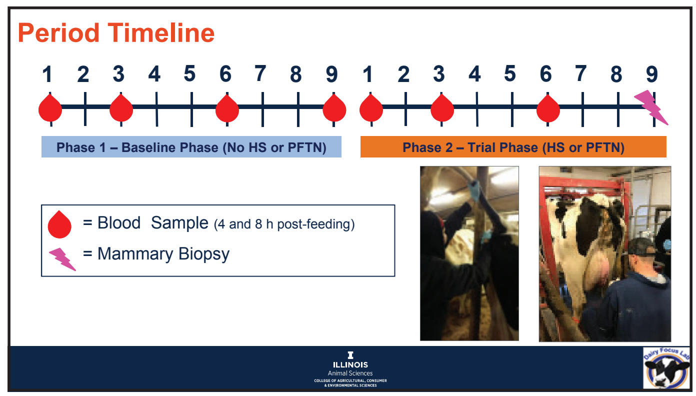

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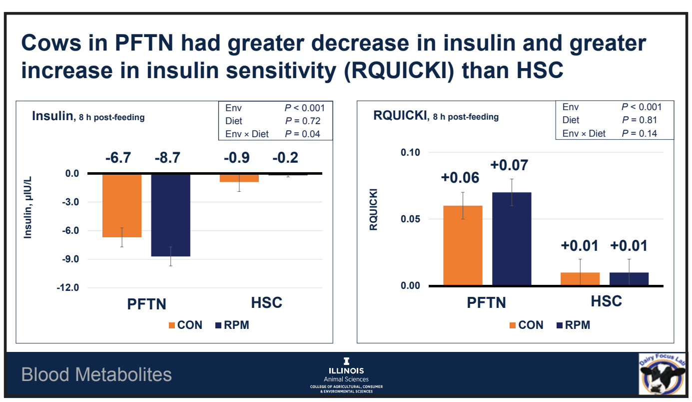

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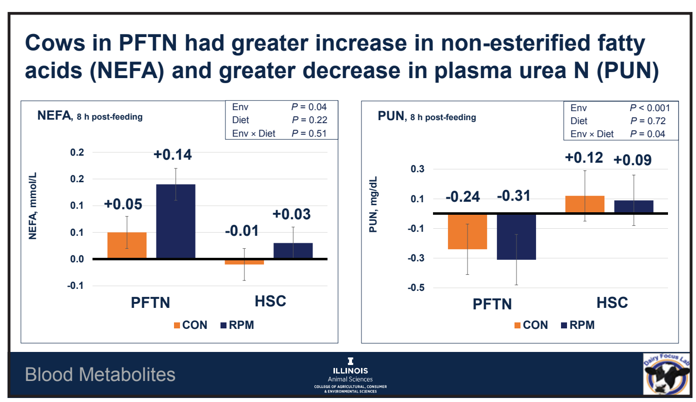

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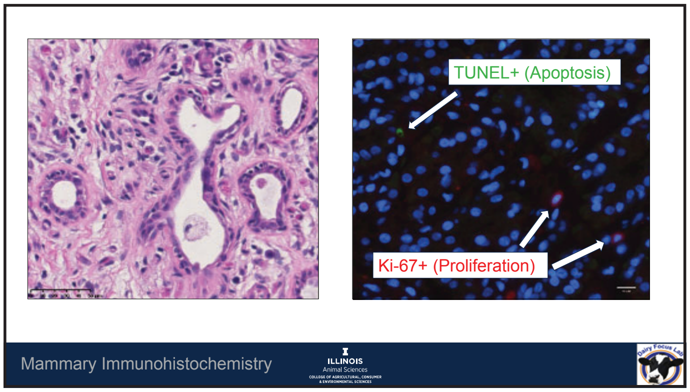

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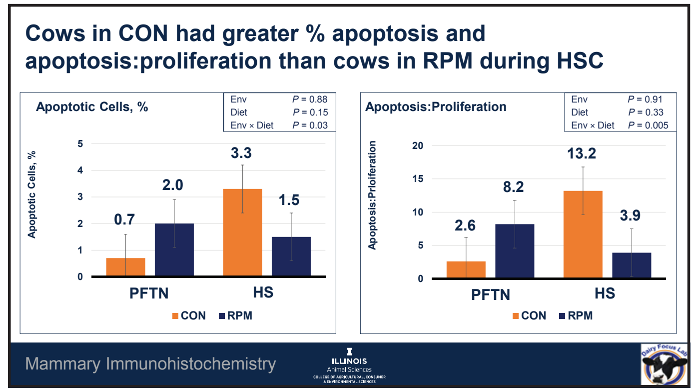

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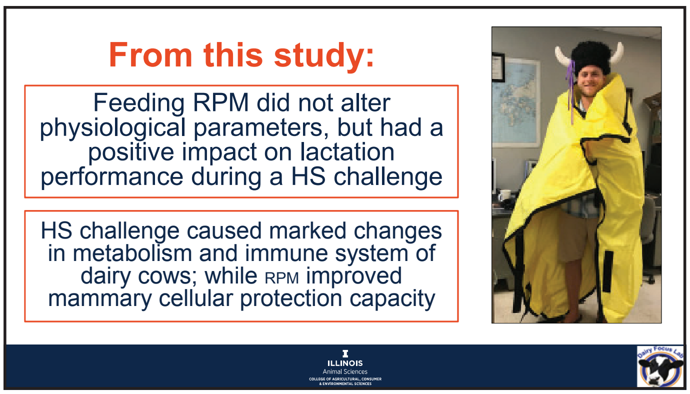

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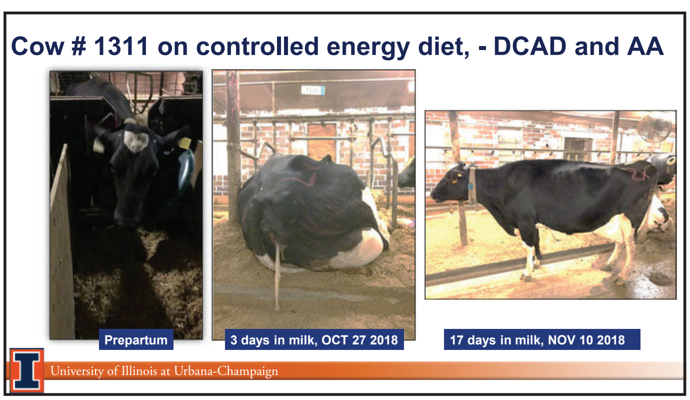

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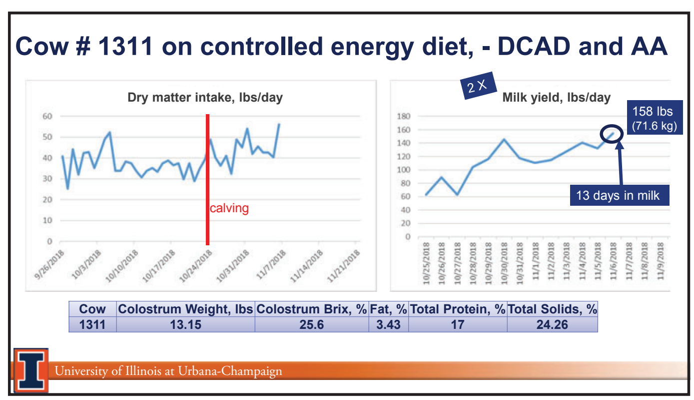

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Summary

Feeding rumen-protected methionine and lysine during the transition period and heat stress

– Impacted (+)
  – Dry matter intake
  – Milk Yield
  – Milk components
  – Uterine environment
  – Pregnancy recognition
  – Pregnancy loss
  – Oxidative burst
  – Phagocytosis
  – Liver Functionality Index

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Summary

- Manage dietary ingredients for
  - Manage for adequate CP (~13% Dry & 16% Lactation)
  - Metabolizable methionine in TMR (30 g/d Dry & 46 g/d Lactation)
    - ~ 15 g/d Dry & 20 g/d Lactation of rumen-protected methionine
  - Metabolizable lysine in TMR (84 g/d Dry & 129 g/d Lactation)
    - ~ 26 g/d Dry & 36 g/d Lactation rumen-protected lysine
    - Balanced for the ratios: Met 2.6% MP; Lys, 7.0% MP (8% PRE) (LYS:MET 2.7:1)
    - Methionine supply relative to energy is ~ 1.15 (no less than 1) – 1.19 g/Mcal ME
    - Lysine supply relative to energy is ~ 2.9 – 3.16 g/Mcal ME
  - Pregnancy rate > 20% (go for > 25%; conception rate at first AI > 40%)
  - Embryonic death < 15% (go for < 10%)

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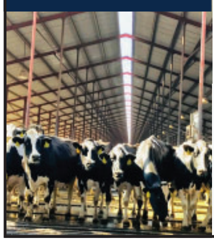

THANK YOU!

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Her Biology.
Our Technology.
Smart science brings us more than data and devices. It delivers the industry's most effective immune support product — NutriTek®.
Working naturally* with the cow's biology, NutriTek helps maintain immune strength for optimal health and more quality milk.
Healthy herd. Total dairy performance.
Life Stage Solutions®.
Only from Diamond V.
*natural as defined by AAFCO
NutriTek®
Diamond V®
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Animal Nutrition solutions
that help your customers succeed!
SQM
protected minerals
Organic Trace Minerals
ANEVIS
rumen-protected niacin
Rumen-protected products
• niacin
• lysine
• vitamin C
Feedbuds
Specialty Micronutrients
Custom Blends
Flavor Solutions
• Quality Products
• Superior Service
• Proven Results
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Lifetime
Performance®
ZINPRO
PERFORMANCE MINERALS
AVAILA
DAIRY
FEED INGREDIENT
Begin With Reproduction
From calf to cow, dairy cattle thrive when they receive optimal trace mineral nutrition throughout their life. It's what we call "Lifetime Performance®." In fact, research[1] shows that when dry and lactating cows were fed the complexed minerals in Availa®Dairy they experienced a 7% increase in pregnancy and 13 fewer days open.
Contact your Zinpro representative or visit Zinpro.com/lifetime-performance to learn more.
[1]Rabiee, A. R., I. J. Lean, M. A. Stevenson, and M. T. Socha. 2010. Effects of feeding organic trace minerals on milk production and reproductive performance in lactating dairy cows: A meta-analysis. J. Dairy Sci. 93:4239.
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