Tuberculosis among dairy workers in Texas

Anabel Rodriguez, PhD, MPH
Research Coordinator
University of Texas Health Science Center at Houston
School of Public Health in San Antonio, Texas
Department of Epidemiology, Human Genetics, and Environmental Sciences

BACKGROUND

One health hazard on a dairy farm is the potential exposure to *Mycobacterium tuberculosis* (TB).[1-6] Besides the human version, there is also a bovine (cattle) version of the disease called *Mycobacterium bovis* or bovine tuberculosis (bTB). Bovine TB is a zoonotic disease transmitted from cattle-to-cattle, cattle-to-person, and person-to-cattle and person-to-person via airborne droplets in close-proximity encounters, such as working on a dairy farm.[3] bTB can also be transmitted via the consumption of unpasteurized dairy products, a common practice in certain countries outside the U.S.[6] These infectious features of bTB make it particularly concerning among dairy workers who are routinely exposed to such risk factors.[2,3,6] In the U.S., *M. bovis* is *not* endemic. However, sporadic whole herd bTB infections have adverse economic, public health, and governmental implications.[7]

TB CASE STUDY

This study involved a secondary analysis of data that were collected by Texas State Department of Health Services (DSHS) Public Health Region 1 (PHR 1). A total of 140 dairy workers were tested using the T.SPOT.*TB* assay. Positive LTBI was found among 14/140 (10.0%) of the dairy workers tested. All LTBI cases were determined to be from Hispanic workers with 71.4% indicating having been vaccinated with the BCG vaccine in their country of birth and none indicated previously known exposure to TB.

TB KNOWLEDGE

A cross-sectional study design was used to collect 225 survey responses concerning knowledge of TB among dairy workers in Texas. A 17-item TB knowledge quiz measured: (1) TB characteristics, (2) TB transmission, (3) TB symptoms, (4) TB diagnosis, (5) TB treatment, and (6) bovine TB. Overall knowledge of quizzed measures was 41.8% (out of 100%) and basic awareness of TB as a disease was 37.3% among surveyed dairy workers.

TB EXPOSURE HISTORY & RISK FACTORS

A total of 4/225 individuals identified having been diagnosed with active TB in the past. However, only 2/4 reported seeking TB treatment which was successfully finished. About a third of workers reported consuming raw dairy products. Out of that third, 81.4% had consumed these raw dairy products in their non-U.S. home country and 18.6% while working on a U.S. dairy farm. Almost 6.0% of workers had worked with bTB infected cattle on U.S. dairy farms while 33.3% had heard of bTB outbreaks on other farms in their county.

FUTURE DIRECTIONS

Deficiencies in TB knowledge were identified at all quizzed measures. TB training on dairy farms should include all measures tested in this study and should be administered to all workers regardless of work experience on the farm. TB history among dairy workers remains vague. As a high risk population, dairy workers could be tested before their start date, tested if suspected of infection, and treated if positive for latent or active TB disease.

REFERENCES

1. Adesokan H, Jenkins A, van Soolingen D, Cadmus S. Mycobacterium bovis infection in livestock workers in Ibadan, Nigeria: evidence of occupational exposure. *International Journal of Tuberculosis Lung Disease.* 2012;16(10):1388-1392.

2. Bekele M, Mamo G, Mulat S, Ameni G, Beyene G, Tekeba E. Epidemiology of Bovine Tuberculosis and Its Public Health Significance In Debre-Zeit Intensive Dairy Farms, Ethiopia. *Journal of Biomedicine and Nursing.* 2016;2(2):8-18.

3. Hlavsa M, Moonan P, Cowan LN, TR Kammerer, JS, Morlock GC, JT LoBue, PA. Human tuberculosis due to Mycobacterium bovis in the United States, 1995-2005. *Clinical Infectious Diseases.* 2008;47(2):168-175.

4. RF K, Hamman S, Morgan K, et al. Knowledge of Bovine Tuberculosis, Cattle Husbandry and Dairy Practices among Pastoralists and Small-Scale Dairy Farms in Cameroon. *PLoS ONE.* 2016;11(1):1-20.

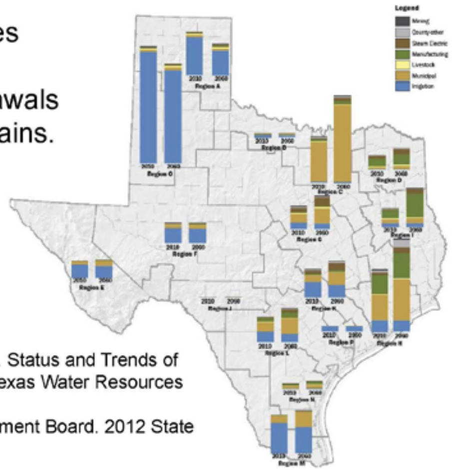
5. Thakur A, Sharma M, Katoch V, Dhar P, Katoch R. A study on the prevalence of Bovine Tuberculosis in farmed dairy cattle in Himachal Prades. *Veterinary World.* 2010;3(9):409-414.

6. Torres-Gonzalez P, Soberanis-Ramos O, Martinez-Gamboa A, et al. Prevalence of Latent and Active Tuberculosis among Dairy Farm Workers Exposed to Cattle Infected by Mycobacterium bovis. *PLOS Neglected Tropical Diseases.* 2013;7(7):1-8.

7. McCluskey B, Lombard J, Strunk S, et al. Mycobacterium bovis in California dairies: A case series of 2002-2013 outbreaks. *Preventative Veterinary Medicine.* 2014;115:205-216.

Agricultural Water Use in Texas

Agriculture comprises over 90% of total groundwater withdrawals in the Texas High Plains.



Source: Dr. Kevin Wagner. 2012. Status and Trends of Irrigated Agriculture in Texas. Texas Water Resources Institute.
Reference: Texas Water Development Board. 2012 State Water Plan.

Agricultural Water Use

Extending irrigated agriculture production in the region: considerations and complexities

Agricultural Water Use in the High Plains

Agricultural producers in the region have adopted highly efficient advanced irrigation technologies

- Low Pressure Center Pivot irrigation systems
  - LEPA, LESA, MESA, LPIC
- Subsurface Drip Irrigation

Agricultural Water Use and Conservation Strategies

Dana O. Porter, Ph.D., P.E.
Professor and Extension Agricultural Engineering Specialist – Irrigation and Water Management
Texas A&M AgriLife Research and Extension Service – Lubbock

Extension Program Leader and Associate Department Head
Department of Biological and Agricultural Engineering
Texas A&M University
E-mail: d-porter@tamu.edu

Agricultural producers in the region have adopted highly efficient advanced irrigation technologies

Further improvements to water use efficiency are possible with improved *management.*

- Irrigation scheduling tools
- Applied research programs in the region are addressing practical local issues.
- Collaboration among university research, extension, industry, groundwater conservation districts, USDA-ARS, USDA-NRCS and producers…can help identify and address issues; coordinate and facilitate technology transfer.

Regardless of the specific tools selected, optimizing crop water use depends upon:

- Managing and maintaining the irrigation system
- Applying knowledge of crop water requirements and soil-water-plant-atmosphere relationships
- Managing total crop water in the context of integrated crop management

Irrigation Management

Irrigation Scheduling

- Evapotranspiration
  - local weather data
  - public and private ET networks or on-farm ET weather stations

Need appropriate crop coefficients and training.
Siting and maintenance are very important.

Irrigation Management

Soil Moisture Monitoring

- Variety of sensors available commercially
- Each has advantages and limitations
- Data services and packaging promote adoption
- Soil moisture based irrigation controllers

Issues:

- Applicability / limitations
- Siting, installation
- Calibration
- Education / tech support

Irrigation Controllers and System Monitoring Technologies

Irrigation equipment manufacturers and other public/private sector groups offer packages to monitor and control irrigation equipment.

Available tools include:

- Internet-based dashboard visualization and control, smartphone apps, stand-alone systems...
- Variable Rate Irrigation, programmable controllers, sensor-based controllers.
- Remote system monitoring and/or control. Notifications of problems…

Recommended Resources

Irrigation topics and crop production guides:

Texas A&M AgriLife Extension Service
soilcrop.tamu.edu/extension/ and
itc.tamu.edu/irrigation-literature/by-topic/

Kansas State University Mobile Irrigation Lab
KanSched www.ksre.ksu.edu/mil

University of Nebraska-Lincoln water.unl.edu/

Crop production guides are available from Land Grant universities (Cooperative Extension), commodity organizations, seed companies, and irrigation equipment manufacturers.

Recommended Resources

Information on agricultural water conservation strategies and technologies are available at:

Texas Water Development Board
www.twdb.texas.gov/conservation/BMPs/Ag/index.asp

USDA-Natural Resources Conservation Service
www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/manage/irrigation/

Texas Water Resources Institute
Status and Trends of Irrigated Agriculture in Texas
http://twri.tamu.edu/docs/education/2012/em115.pdf

High Plains Underground Water Conservation District
http://www.hpwd.org/agricultural/

Optimizing Crop Water Management

Select appropriate efficient irrigation technologies and best management practices.
Management and maintenance are key.
One size does not fit all.

Apply knowledge of crop water demand.
Consider crop water use and critical growth stages.
Use available information resources.
(ET estimates, crop production guides, etc.)

Manage total water for high water use efficiency.
Optimize benefit from rainfall, stored soil moisture, and irrigation.

Manage water in the context of overall integrated crop management.
Consider limiting conditions and system constraints.

Forage Sorghum vs. Corn Silage: Effects of Water Stress on Silage Quality

Jourdan M. Bell
Texas A&M AgriLife Research and Extension Agronomist – Amarillo

2020 High Plains Dairy Conference

March 3, 2020

TEXAS A&M AGRILIFE RESEARCH

TEXAS A&M AGRILIFE EXTENSION

Considerations for Quality Silage

- Who is the end user?
  - Quality Concerns
- Herbicides
- Seed Costs
  - Fertility needs do not greatly differ between corn and sorghum silage
- Will you scout for Sugarcane Aphids? – do not forget about spider mites
- Planting Window
- Harvest Window
- Silage Pit Management
- <u>**How much water do you have?**</u>

Corn Silage: the Silage of Choice

- Corn Silage is high in energy.
  - Grain content AND stover digestibility affect energy level
- Higher Yield potential
  - 27 to 32 tons/ac
- Under water stress, corn silage quality is reduced
  - Corn silage quality is related the amount of grain produced

Corn for Silage

1. Corn Planted for Silage
2. Failed Corn
   - Hail Damage
   - Drought Stress

<u>Important to remember</u>:

POOR QUALITY FORAGE = POOR QUALITY SILAGE

Drought Damaged Corn Silage

- Poor ear development
- Decreased tonnage
- Increased shrinkage in the silage pit due to high DM
- Decreased starch and TDN
  - Normal corn TDN=90
  - Drought damaged corn TDN reduced by 60% (Mader et al.)

If there is a risk for drought damaged corn, consider forage sorghums.

High DM can create issues with fermentation losses and end-users who want quality silage because poor ear development results in reduced quality…

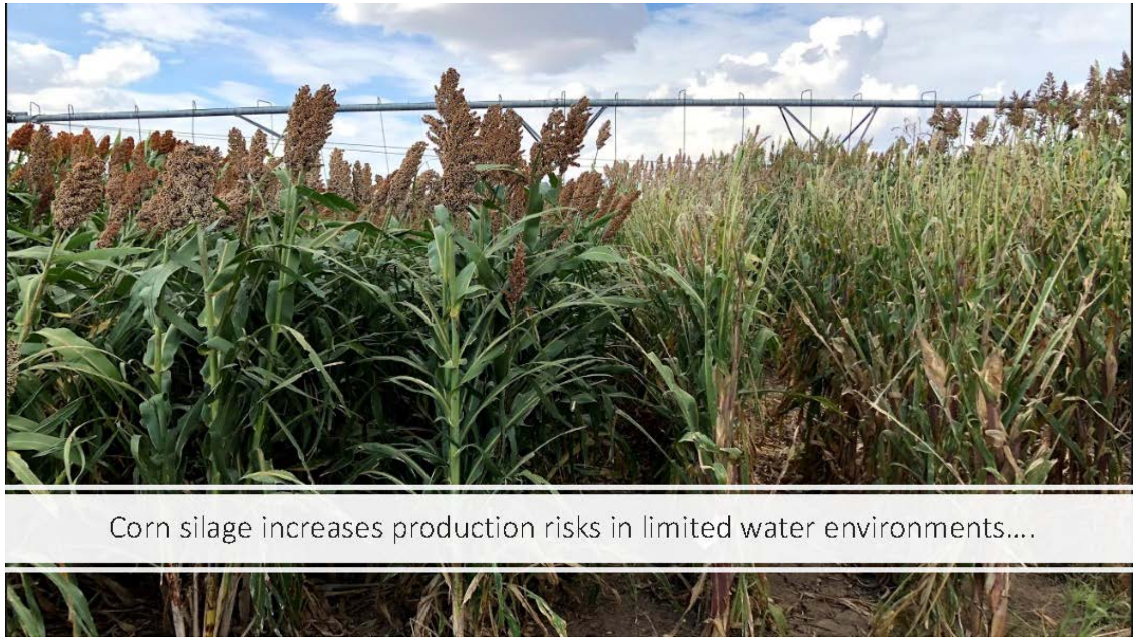
Improper DM and Shrink

- It is important for farmer to understand harvest timing and DM….
- Shrink is important because end-user does not want to run out of silage
- Or farmer gets blamed for shrink….
- Shrink results from fermentation and spoilage losses as well as scale and DM errors at delivery
- % Shrink = (lb delivered – lb fed)/ lb delivered

Example: 20,000 lb delivered and 16,000 lb fed

(20,000-16,000)/20,000 = 20% Shrink

End-user paid for pounds delivered not pounds fed!



Corn silage increases production risks in limited water environments….

Sorghum Type	Height at Harvest (in.)	% Lodging at Harvest	%Moisture at Harvest	Avg. Yield (tons/ac) 65% Moist.	%CP	%ADF	%aNDF	%Lignin	%Starch	%WSC
by Brown Midrib Trait										
BMR (39)	85	3.5	65.9	21.8	8.2	30.0	44.2	3.0	14.8	12.9
Non-BMR (50)	84	2.8	64.8	22.6	8.0	29.8	44.9	3.5	15.4	12.7
by Photoperiod Response										
Photoperiod Sensitive (6)	80	2.2	70.1	21.3	7.2	36.3	55.2	2.7	0.5	18.2
Non-Photoperiod Sensitive (83)	85	3.2	64.9	22.3	8.1	29.4	43.8	3.3	16.2	12.4
by Brachytic Trait										
Brachytic (21)	71	0.0	64.6	22.0	8.7	30.1	45.7	3.0	14.0	11.8
Non-Brachytic (68)	89	4.1	65.5	22.3	7.9	29.8	44.3	3.4	15.5	13.1
Test Average[†]	85	3.1	65.3	22.2	8.1	29.9	44.6	3.3	15.1	12.8
Grain Sorghum and Corn Checks										
Grain Sorghum including Checks (6)	57	1.1	63.6	18.9	10.1	27.1	39.3	3.8	26.6	5.7
Corn Checks (3)[‡]	84	0.0	60.7	17.7	9.5	22.1	38.9	3.2	27.3	9.2

Sorghum is a drought tolerant option…..

- Greater tonnage under limited irrigation
- In water limited environments, it is cheaper to make up the CP with another protein source.
- Energy: consider the carbohydrate sources – starch and WSC

Quality Forage Sorghum Silage Begins with Hybrid Selection

- Not all sorghum equal
- Evaluate variety trials from multiple locations
- Hybrid should match production system and end-user goals
- Later maturity class hybrids have greater yield potential, but do you have the water to meet the demand?
- Late season hybrids more prone to lodging under late season moisture and high fertility
- Choose hybrid based on hybrid specific characteristics not forage type

Quality forage sorghum silage is a function of:

1. Agronomic and harvest management
2. End-user management (Pit/Pile/Bag)

In addition to hybrid selection, management is necessary to optimize sorghum silage quality:

1. Harvest early targeting soft-dough stage
2. Target dry matter at ~30-35%
3. Swath if necessary, to obtain the correct moisture
4. Chop length about one-half inch.
5. Use a kernel processor
6. How is it ensiled?

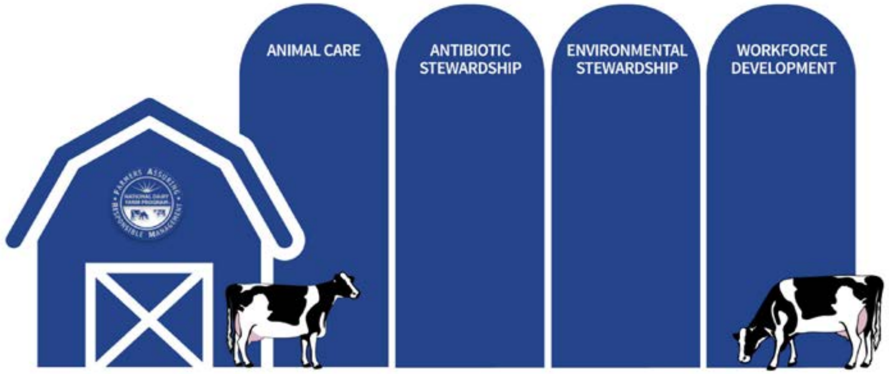
Questions?

jourdan.bell@ag.tamu.edu
806-677-5663

TEXAS A&M AGRILIFE RESEARCH | EXTENSION

Program Goal

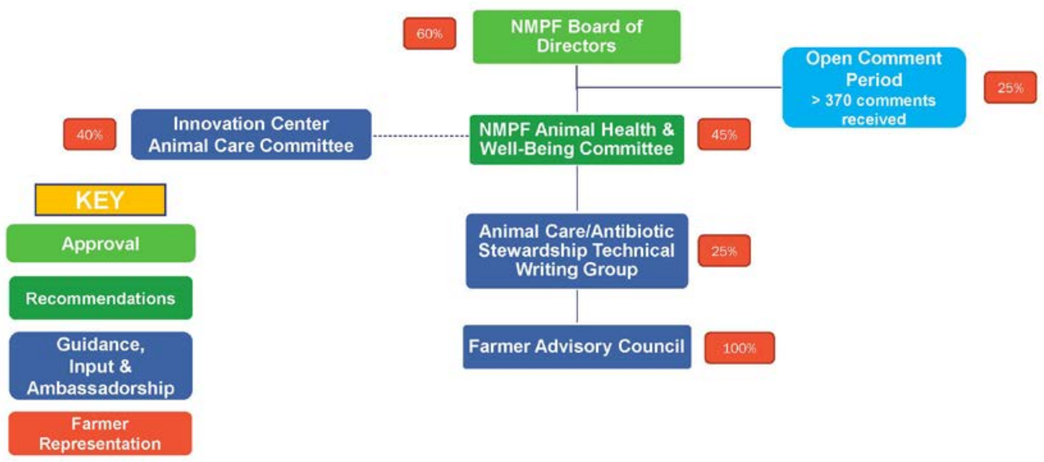
Assure Consumers & Customers that dairy farmers care for their animals, workforce and land in a humane and ethical manner



Animal Care Continuous Improvement

Version 1.0 (2009 – 2012)	Version 2.0 (2013 – 2016)	Version 3.0 (2017 – 2019)	Version 4.0 (2020-2022)
Voluntary Participation	Mandatory Participation	Greater accountability	Increased Accountability
	Voluntary Action Plans	Mandatory Corrective Action Plans: Training; VCPR; Tail Docking	Immediate Actions
	Tail-Docking Phase-Out 2022	Critical Control Points	Shorten Timelines
		Probation/ Suspension	Implementation Oversight

FARM Animal Care Governance



FARM Animal Care Scope

Does	Does Not
Framework and foundation for on-farm animal care	Ensure a culture
Create a culture of continuous improvement	Replace supervision & management of employees
Snapshot of farm management practices	Guarantee BMPs are followed
Requires producer monitoring, oversight and active on-farm participation	Eliminate threats to consumer trust

FARM Animal Care Version 4.0

Immediate Action

- Tail docking

Mandatory Corrective Actions

(within 9 months)

- Veterinarian review
  - VCPR
  - Herd health plan
- Pre-weaned calf practices & protocol
  - Disbudding prior to 8 weeks of age
- Non-ambulatory practices & protocol
- Euthanasia practices & protocol
- Fitness of transport protocol
- Feed & Water access
- Continuing ed for non-family employees

Continuous Improvement Plans

(within 3 years)

- Animal observations
  - Body condition score
  - Hock/Knee
  - Locomotion
  - Broken tails
- Pain management for disbudding
- Permanent (written/electronic) drug treatment records
- Continuing ed for family employees

Food Chain Customer Objective

Ensure leading food chain companies are aware of, connected with and supportive of U.S. Dairy's vital role and progress in a global and sustainable food system; nourishing people, communities and the planet.

U.S. Dairy STEWARDSHIP COMMITMENT
Innovation Center for U.S. Dairy

UNDENIABLY DAIRY™

Defining Success

- **Multiple-point relationships** with food chain customers focused on continuous engagement on IC priority areas.
- **Increased trust and support** of U.S. dairy's role in a global and sustainable food system.
- **Endorsement of U.S. dairy industry social responsibility initiatives**; where possible help communicate dairy's story.
- **Engagement opportunities** that foster **two-way dialogue** with food chain customers and the dairy industry.

8

Why Heifer Maturity Matters?

Gavin Staley,
DVM Diamond V

Introduction

How does one know when to breed virgin heifers? On many dairies the decision is entirely subjective. The heifers look "big" enough, or reach a certain age or the pen is getting crowded and they need to move on. But the critical question should be when are they mature? The following discussion will show that breeding immature heifers has a profoundly negative impact on the entire herd's future productivity. Heifer maturity, in this discussion, is the phenotypic characteristics (such as body weight) that allow full expression of milk production during subsequent lactations.

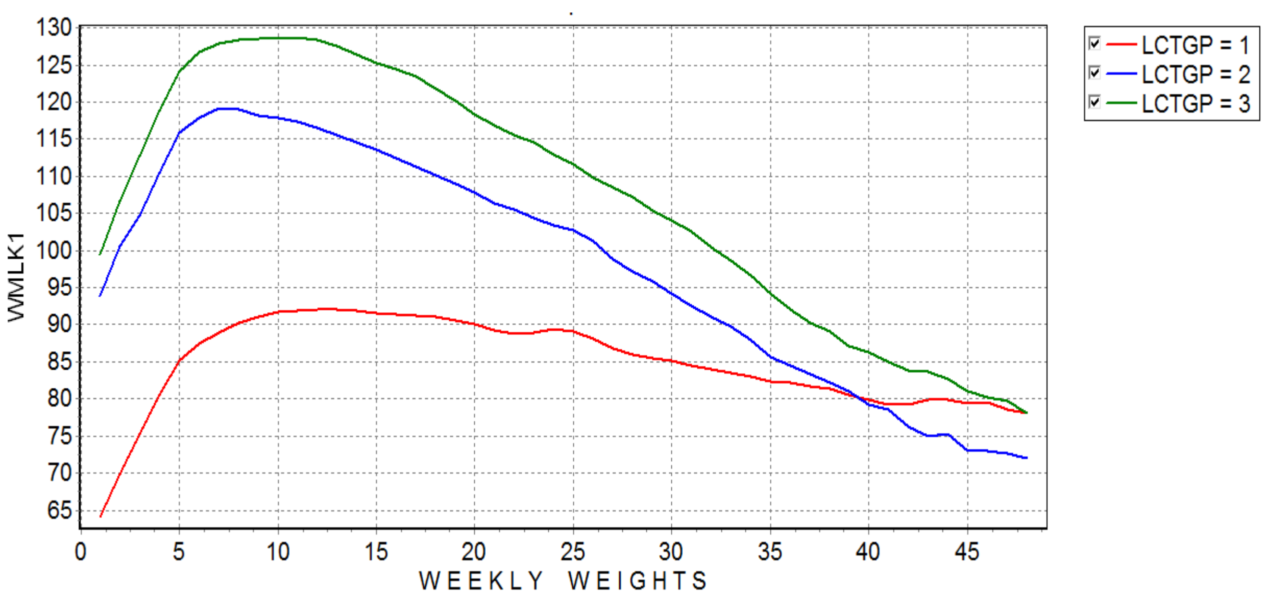
In recent years the potential financial benefits of calving heifers earlier were recognized and promoted, resulting in an industry wide trend to breed heifers earlier. Unfortunately, the necessary management changes to achieve the required maturity goals with earlier calving have been widely ignored. This has been due, in large part, to limited use of objective growth data to evaluate heifer raising.

The evaluation of DC305 dairy records from a large number of herds, primarily in the western US, resulted in the identification of significant patterns associated with heifer maturity, and the following observations were made.

Observation 1

The average annual milk production of a dairy approximates to the 10-week milk production of Lactation=1 animals (see Graph's 1 and 2 below). The percentage of Lactation=1 animals in the herd can influence this association. For example, at 38% Lactation=1 these numbers are very close. At lower % lactation=1 (e.g. 34%) the annual milk is 1-2 lbs higher than 10-week milk and at higher % Lactation=1 (e.g. 42%) the annual milk is 1-2 lbs lower, typically.

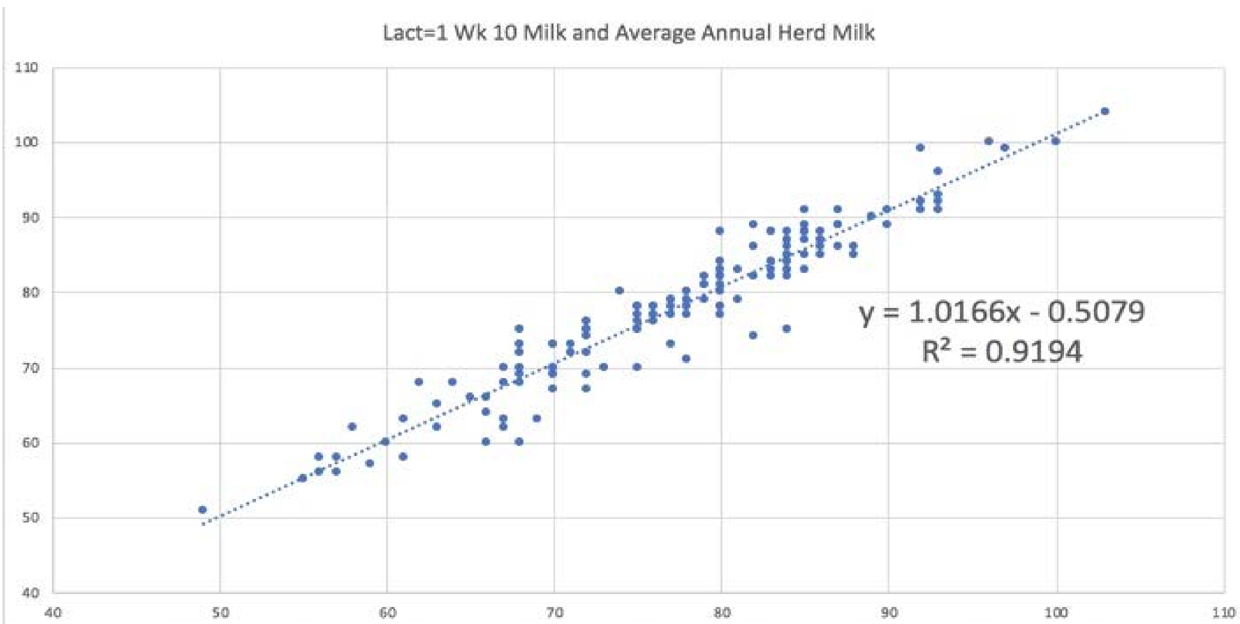
Graph 1: Lactation curves for Lactation Groups 1-3
Milk production (WMLK1) and DIM (Weekly Weights)



In the above 3X Holstein herd the average annual milk production (as recorded in Econ\ID, Reports) was 92 lbs. The 10-week milk of Lactation=1 is approx. 92 lbs. The above observation is important because it strongly suggests that the heifer milk production sets the "ceiling" for the entire herd. A herd cannot overcome the restrictions placed on it by under-performing heifers. It also goes without saying that high producing herds have high producing heifers.

To validate this observation DC305 data from 149 herds representing 401k cows was collated and the relationship determined (see Graph 2 below)

Graph 2: Average Annual Milk production and week 10 milk production of Lactation=1 (401k cows in 149 herds; no rBST supplemented herds included)

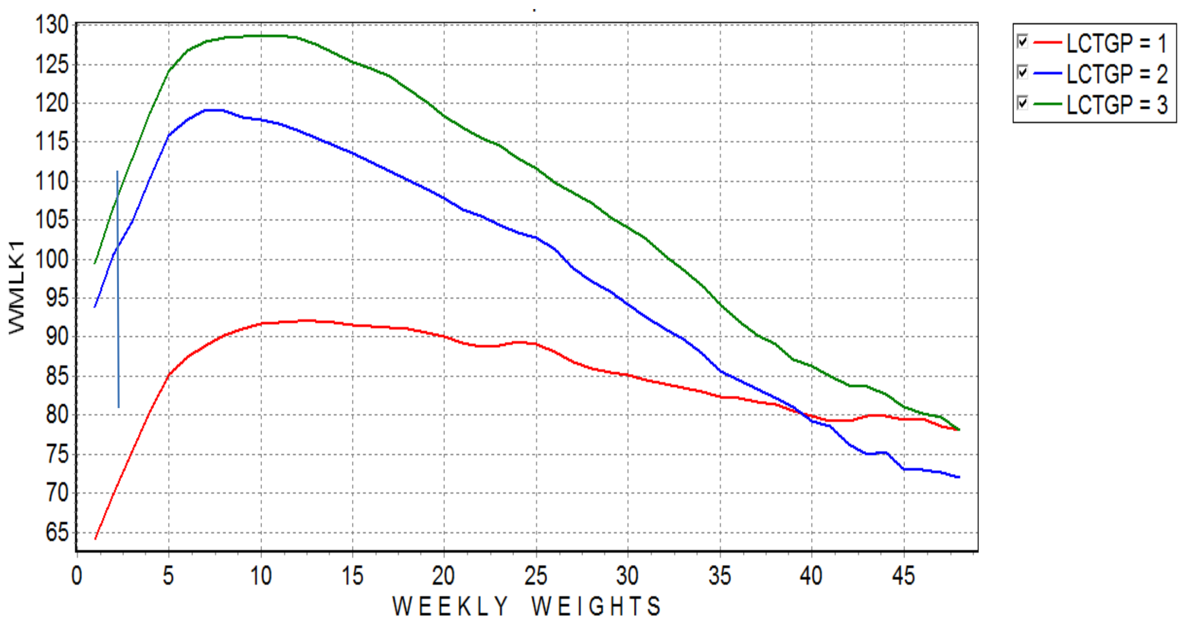


In the above graph average annual milk production is on the y-axis and week 10 milk for Lactation=1 is on the x-axis. The above graph shows the strong correlation (R squared=92%) between these two variables. Furthermore, the slope of the equation indicates that as 10-week milk increases by 1 unit (lb) so does the average annual milk (lb). An improvement of a pound of milk at 10 weeks of Lactation=1 will translate to an additional pound of milk for every cow, every day, as these Lactation=1 animals move on up into later lactations.

Observation 2

The production difference between Lactation=1 and 2 at 5 weeks of lactation is 30 lbs (13.6 kg) (Holstein)(Graph 3). Five-week milk production was chosen as a comparative time period to accommodate for the difference in peaks between lactation groups. This observation is consistent in "stable" herds. Stable herds in this discussion are herds where there is very little fluctuation in average annual milk production year to year and little intentional change to the heifer program over time. In other words, all animals in the herd have had a similar heifer raising experience. This observation is independent of milk production level.

Graph 3: Milk production by LCTGP (Holstein) (annual production)

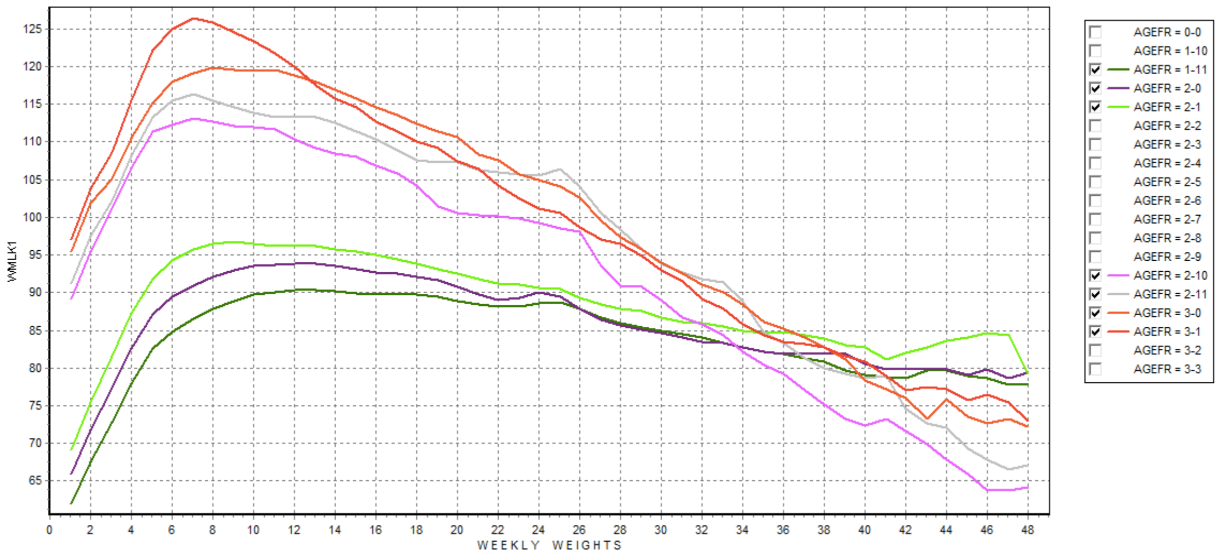


The above observation is important because it clearly demonstrates the predictable change in herd milk production resulting from a change in heifer management. For example, if the difference between Lactation=1 and 2 at 5weeks decreases by say 3lbs (ie is now 27 lbs) we can predict that the following year the difference between Lactation=1 and 2 will increase back to 30lbs and Lactation=2 production will have increased the incremental difference. Similarly a drop in Lactation=1 production will predictably drop milk production. Metaphorically, "all ships rise on a rising tide", suggesting improved heifer performance lifts production of all parities with time.

Observation 3

The age at calving (AGEFR) impacts milk production in both Lactation 1 and 2. This is best visualized in herds that breed by age and not size. In the example herd below, the age at calving is later (23-25 months) and yet a clear impact of age at calving on Lactation=1 production is still demonstrable. The impact of age at calving is especially obvious in herds that calve heifers at 20-21 months (personal observation).

Graph 4: Graph of milk production of Lactation 1 and 2 by age at calving (AGEFR)



In the above graph it is apparent that as heifers mature (ie grow) they produce more milk in lactation=1. This is not surprising. It is noteworthy that all these Lactation=1 animals are subject to the same management, reproductive programs, culling philosophies, transition, nutrition and facilities. The variable is age at calving (AGEFR). Also, the lactation curves reveal that the lactation curves differentiate almost immediately after calving, suggesting that culling of Lactation=1 animals is not a likely or significant reason for any variation in production. Furthermore, culling of virgin heifers is unlikely to influence subsequent Lactation=1 production curves since the two categories representing most culls in virgin heifers, namely deaths and open heifer culls are not represented at all.

At a growth rate (average daily gain) of approx. 2lb/day the breeding heifers will grow 60lbs/month and in this herd that will be approx. 2-3lbs more milk per cow per day for every month increase of AGEFR (from the logic of Observation 1). Since virgin heifers have a high conception rate (55% plus) it also means that in the above lactation=1 production curves there will be more 23m animals than the other two month cohorts. This is significant because it means that most of these Lactation=1 animals will under-perform relative to their cohorts.

Furthermore, the Lactation=2 lactation curves reveal a similar production and AGEFR pattern. Although these are not the same animals, almost all of the Lactation=2 animals that calved at 34 months would have calved at 23 months the year before. It is apparent that if a herd has excellent herd fertility and immature heifers these younger immature animals will be "locked" into lower Lactation=2 production. Since the average lactations of many herds in the US is low, e.g. 2.2 it follows that if immaturity negatively impacts both Lactation's 1 and 2 it will seriously impact the entire herd's production. It is not unreasonable to suggest that these herds effectively never reach full genetic potential. They never "grow up". They are experiencing the "Peter Pan Problem".

Recommendations

It is not good enough to rely on subjective criteria for breeding heifers. Objective criteria, such as body weight, wither or hip height and average daily gain (ADG) can greatly assist in determining the best time and size to breed heifers. While body condition score is not included in this conversation, the assumption is made that over-conditioning must be avoided. A suggested approach is laid out below.

1. Determine the mature body weight (MBW) of the herd. This is not the average of cull cows. This means weighing a cohort of cows in the 3rd and 4th lactation between 80-120 DIM;
2. Weigh either close-up (DCC>260) or fresh cows (DIM<7) to calculate the % of MBW of these animals. Close-ups should approximate 95% of MBW and fresh cows should be close to 85% MBW.
3. Determine the difference between desired and actual weights. This will be the increased body weight that must be made up by either delayed breeding of virgin heifers or increased ADG.
4. Determine the weight and age that virgin heifers need to achieve to be at 55% of MBW;
5. Implement the necessary changes and monitor the response by weighing heifers at convenient time periods to ensure a successful outcome.

Understanding Stress and Its Effect on Dairy Cattle

Jeff Carroll, Ph.D.
USDA-ARS Research Leader, Lubbock

Stress Regulation

The term "stress" was first introduced to the field of biology by Walter Cannon in 1915 as an animal's emergency reaction, fight or flight response, to a perceived harmful event, attack or threat to survival (Cannon, 1915). While his pioneering work into the physiological processes of the body in response to stressful stimuli was revolutionary, today we know that the stress response is a much more sophisticated and intricate series of biological events. Due to the complexity and multifaceted nature of the body's reaction to stress, the stress response may be more accurately described as "A choreographed series of biological reactions to a real and/or perceived psychological or somatic threat(s) regulated by neuroendocrine and endocrine processes to preserve life" that is precisely regulated by through activation of the hypothalamic-pituitary-adrenal (HPA) axis and activation of the sympathetic nervous system (SNS; Elenkov et al., 2000).

While the hormone cortisol is thought to be a primary indicator of the stress response, it also plays an important role in **gluconeogenesis,** the generation of glucose from other organic molecules like pyruvate, lactate, glycerol, and amino acids, during the "flight or fight" response. Cortisol increases blood glucose concentrations by stimulating the liver to convert fat and protein to these intermediate metabolites that are ultimately converted to glucose for energy. However, chronic exposure to high concentrations of cortisol can cause severe physiological and psychological problems such as excessive protein catabolism, hyperglycemia, immunosuppression, and depression. In domestic livestock, excessive concentrations of cortisol have been linked to reduced rates of reproduction, suboptimal growth, suppressed milk production, and suppression of immune function that could increase susceptibility to disease (Ono et al., 1984; Friend, 1991).

Stress in Dairy Cattle

Dairy cattle experience numerous environmental, managerial, and nutritional stressors throughout the production cycle that could potentially inhibit overall productivity and well-being due to neuroendocrine disruption and stress-induced immunosuppression. Generally, in the case of dairy cattle, stressors can be grouped into the following five broad categories: 1) Physical/Environmental; 2) Social; 3) Nutritional; 4) Psychological; and 5) Immunological. Examples of physical/environmental stressors would include injury, heat stress, cold stress, muddy conditions, and lameness/soreness. Social stress is typically encountered either by mixing unfamiliar animals together, isolating herd animals, or changes in the herd hierarchy. Nutritional stress can occur when animals are fed inadequate diets, contaminated diets, or feeding patterns are disrupted due to weather events or labor issues. Psychological stressors can be more difficult to discern and may be as subtle as moving cattle to a new pen, paddock, or pasture. Unfamiliar inanimate objects within the environment or the proximity of barking dogs, trains or vehicles can impose a psychological stress on cattle that may impact productivity and well-being.

Heat stress is dairy cattle costs producers millions of dollars each year just in milk production losses alone. However, the economic impact of heat stress in the dairy industry is not limited to losses in milk production, but also includes losses associated with acute health problems, rumen acidosis, reduced pregnancy rates, increased abortion rates, increased medicine costs, and increased mortality. While all of the biological pathways by which heat stress may reduce fertility and conception rates may not be fully elucidated, there is evidence of both direct and indirect effects of heat stress. Indirectly, heat stress could reduce fertility due to reduced feed intake observed in heat stressed cattle. Reduced feed intake can lead to a negative energy balance which in turn would result in decreased release of reproductive hormones causing reduced estrus expression and poor-quality oocytes (De Rensis and Scaramuzzi, 2003). In cultured cells obtained from dominant follicles collected at day 6 of the estrus cycle, Wolfenson and Roth (2019) reported significantly lesser concentrations of progesterone from cells collected during summer months compared to winter months. These authors also reported consistently lower first AI conception rates during the summer months as compared to winter months over a span of 18 years, with conception rates dropping more than 20% in years when the mean maximal August temperature exceeded 89.6 °F. Another indirect pathway by which heat stress could impact fertility is through the increased release of the stress hormone cortisol. Increased concentrations of cortisol have long been known to inhibit several aspects of the reproductive process. The direct effects of heat stress on fertility and reproductive performance are associated with alterations in the uterine environment. Changes in uterine pH and blood flow associated with heat stress would create a uterine environment that is not conducive to maintaining embryo development.

Losses in milk production due to heat stress are unfortunately a common occurrence in the dairy industry, and as milk production per cow continues to increase, so does the magnitude of the losses in milk production. In 2009 Rhoads and colleagues reported that in a 9-day controlled heat stress event, milk production was reduced by 10.6 kg/d/cow resulting in an economic loss of $36.96/cow (estimated value of $17.55/cwt) over the 9-day period. However, from 2009 until 2018, milk production per cow has increased 13% (USDA-NASS, 03-12-2019). As milk production increases, the heat increment also increases in the cow (Kadzere et al., 2002), thus increasing the heat load on the cows and making them less tolerant to elevated environmental temperatures. The temperature-humidity index for modern dairy cows has now shifted, and what was once considered the stress-threshold temperature-humidity index (THI) of 72 for dairy cattle has become a mild to moderate heat stress event, and the stress-threshold has decreased to a THI of 65-68.

Milk losses due to heat stress are not solely due to reductions in feed intake. While there is indeed a relationship between feed intake and milk production, prior studies have indicated that only 50% in the reduction in milk yield in heat-stressed dairy cows can be attributed to feed intake (Wheelock et al., 2010; Baumgard et al., 2011). The remaining losses in milk production may be associated with other factors such as increased incidences of acidosis, reduced blood flow to internal organs, slower gastrointestinal tract (GI) activity, shifts in the rumen microbiome, and altered nutrient metabolism. Increases in acidosis may occur due to changes in feeding behavior, reduced salvia production from decreased feed intake and rumination, and reduced salvia production due to panting may all impact the ability to neutralize rumen acid production. During heat stress events, cows also redirect blood flow from internal organs to peripheral tissues in an effort to cool themselves. This redirection of blood flow decreases nutrient uptake by the portal drained viscera. This along with the slower GI tract activity, results in a significant decrease in nutrient uptake. The shifts that occur in the microbial population of the GI tract can also impact digestion and nutrient uptake.

An additional aspect associated with heat stress is the energetic demand that it places on the cow. Prior research (McDowell et al., 1976) has reported that as ambient temperature increases from 68 °F to 104 °F, the maintenance energy requirement of the cow increases by 32% while dry matter intake decreases by 44%. Stress, regardless of the category, increases the energetic and nutrient requirements of the animal. During stressful events, typical biological responses that require energy include increases in heart and respiration rates, increases hormone production, increases in glucose utilization, increases in fat mobilization, and increases in protein degradation. Therefore, continual exposure to stressful events depletes nutrient and energy stores, resulting in periods of negative energy balance which contribute to both short-term and long-term health challenges.

Typical indicators that cattle are experiencing a heat stress include increased respiration rates, increased rectal temperatures, and decreased feed intake. With regard to respiration rate, it is recommended that if more than 2 out of 10 cows have respiration rates exceeding 100 breaths/minute, take immediate action to reduce heat stress (Fidler and Van Devender; http://www.uaex.edu). With regard to rectal temperature, cows with a rectal temperature of 102.2 °F in the afternoon are at risk for reduced milk yield and may experience fertility issues (Zimbelman et al., 2009). Other obvious signs of heat stress included increased standing time, crowding around shaded areas or cooler areas of the barn, crowding around water sources, and increased water intake.

Reducing stress and maintaining health cows requires proactive measures such as managing body condition of the cows, providing adequate housing, and the use of nutritional supplements to help neutralize reactive oxygen species, reduce stress, reduce inflammation and boost immunity. When evaluating body condition of the herd, don't rely on the mean body condition as it can be misleading. Instead, evaluate the number of cows that are outside the acceptable body condition range. Likewise, consider individual animal variations that exist within the herd. A cow's age, physical condition, health status, temperament, and social status can all have a significant impact on the magnitude of stress the cow is experiencing.

Literature Cited

Baumgard LH, Wheelock JB, Sanders SR, Moore CE, Green HB, Waldron MR, Rhoads RP. Postabsorptive carbohydrate adaptations to heat stress and monensin supplementation in lactating Holstein cows. J Dairy Sci. 2011; 94(11):5620-33.

Cannon, W.B. Bodily Changes in Pain, Hunger, Fear and Rage: An Account of Recent Researches into the Function of Emotional Excitement. Appleton-Century-Crofts 1915.

De Rensis, F. and Scaramuzzi, R.J. Heat Stress and Seasonal Effects on Reproduction in the Dairy Cow—A Review. Theriogenology, 2003;60:1139-1151.

Elenkov IJ, Wilder RL, Chrousos GP, Vizi ES. The sympathetic nerve - An integrative interface between two supersystems: The brain and the immune system. Pharmacological Rev 2000;52(4):595-638.

Fidler P.A., VanDevender K. Heat stress in dairy cattle. FSA 3040, University of Arkansas Cooperative Extension Service.

Friend TH. Behavioral aspects of stress. J Dairy Sci 1991;74(1):292-303.

Kadzere CT, MR Murphy, N Silanikove, E Maltz. Heat stress in lactating dairy cows: a review. Livestock Prod Sci 2002; 77:59-91.

Ono N, Lumpkin MD, Samson WK. Intrahypothalamic action of corticotrophin-releasing factor (CRF) to inhibit growth hormone and LH release in the rat. Life Sci 1984;35(10):1117-1123.

Rhoads ML, Rhoads RP, VanBaale MJ, Collier RJ, Sanders SR, Weber WJ, Crooker BA, Baumgard LH. Effects of heat stress and plane of nutrition on lactating Holstein cows: I. Production, metabolism, and aspects of circulating somatotropin. J Dairy Sci. 2009; 92(5):1986-97.

Wheelock JB, RP Rhoads, MJ VanBaale, SR Sanders, LH Baumgard. Effects of heat stress on energetic metabolism in lactating Holstein cows. J. Dairy Sci. 2010; 93:644-655.

Wolfenson D, Roth Z. Impact of heat stress on cow reproduction and fertility. Animal Frontiers 2019; 9(1):32-38.

Zimbelman RB, RP Rhoads, ML Rhoads, GC Duff, L H Baumgard, R J Collier. A Re-Evaluation of the Impact of

Feeding Dairy Cows the Best We Know: It Starts with the Rumen

Jeff Firkins, Ph.D.
The Ohio State University

Take-Home Message

Feeding the cow starts in the rumen. The rumen response helps explain the benefit of improving forage quality or grain processing for optimum carbohydrate digestibility and the ability to convert that fermentable energy into microbial cells that provide the majority of amino acids to the animal. Providing enough—but not too much—starch improves microbial protein synthesis and guards against erratic feed intakes, whereas excess starch fermentability depresses NDF digestibility and decreases the efficiency of microbial protein synthesis. Maximizing the supply of microbial protein improves the benefit of bypass amino acids from supplements or in the rumen-undegraded protein (RUP) fraction. Because models are imperfect, consideration of the rumen optimizes balancing rumen-degraded protein (RDP) and RUP properly to optimize diet costs, limit undesirable (and often unknown) side effects, and minimize environmental impact from urinary nitrogen excretion relative to milk production.

Introduction

Ruminal efficiency is a double-edged sword. Optimization of ruminal efficiency means implementing practices that should increase efficiency (front edge) while minimizing practices that could decrease efficiency (back edge). Because we don't always have good yardsticks to measure these issues in practice, I recommend relying on controlled research and then having some confidence in your expectation from that research while also testing the yard stick that is available (measured inputs or outputs on farms) when making dietary changes to improve profit or reduce costs. As a researcher, I look for grounded practices that centralize our expectations (including risk of being wrong in our decisions), whereas field nutritionists need to also deal with climate and economic issues that are relevant to their region and current growing year and often have limited controlled research on which to fall back. Even so, even regional differences can and should be considered with respect to physiological and nutritional principles. My goal is to emphasize important fundamental concepts that start in the rumen to have more confidence in your field decisions to feed the dairy cow the best you know.

Rumen Microbes

Often described colloquially as "bugs", we have learned much in the past decade about the rumen microbial community using DNA sequencing tools that have increased in throughput and decreased in cost. Remember the adage: "there are the 20% of people who do 80% of the work (or is it now 10 and 90%?)"? Similarly, there are 10 to 20% of so-called "keystone" bacteria that most effectively break down fiber (and resistant starch is like fiber) in the rumen…doing the most critical work for the entire rumen microbial community. They are key specialists. Obviously, we want to maintain or support those specialist populations because they improve fiber digestibility and support efficient growth of all microbes. There also are those microbes in the community that do important service such as biohydrogenating unsaturated fatty acids that would otherwise be toxic and those that convert urea to ammonia for others. Some of these colonize the rumen wall also help maintain a proper balance with the animal's immune system. On the other edge of the sword, there also are undesirable microbes. For example, a lactate producer might be desired in the silo but not in the rumen. Also, some microbes waste nutrients such as valuable RDP. Some of these microbes can be replaced by more desirable microbes that compete in the same niche.

Several studies are evaluating rumen microbial community members that are associated with desirable and undesirable rumen characteristics that are related to feed efficiency. We have heard a lot about methane in the past decade, and we need to remember that methanogens are on both edges of the sword; they do important service work, but they also probably contribute to inefficient energy usage. An analogy is that we need electricity to run a dairy farm. Much of the electricity is used in very important functions (e.g., to power pumps and cool milk), some electricity is used in general service such as providing light or airflow that is needed some of the time but not all of the time, and some can be wasted (e.g., stray voltage). The point is that methanogens help the keystone microbes do their job, and overly aggressive approaches to inhibit the methane-producing microbes (analogous to stray voltage) carries over to inhibit important keystone populations. Because lactic acid is a stronger acid than the volatile fatty acids, it has been implicated in problematic dietary situations. However, under the right situations, lactic acid production might actually be a benefit so long as it is further metabolized. Finding the “sweet spot” is key to preventing dietary manipulations from doing more harm than good.

Current research has highlighted some microbial populations are strong indicators of feed efficiency. A pen of animals might be fed the same diet, but some cows are more efficient at converting feed into milk than are others. Conversely, other microbes are indicators of worse feed efficiency among individual animals. They might not do anything bad themselves but pattern with undesirable outcomes. Some of these patterns appear random. However, current research is showing less randomness associated with chance and revealing more randomness associated with discovery of previously unknown factors that hopefully lend themselves to dietary manipulation. For example, many studies have shown that yeast and yeast products tend to support desirable populations of microbes (e.g., those that break down fiber), and ionophores do appear to control some of the undesirables (e.g., those that promote subacute rumen acidosis, SARA, or those that waste rumen-degraded protein, RDP). However, a properly balanced diet also provides a proper consortium of all the microbes, as I will discuss; some of the associations with “good” or “bad” microbes might depend on the base diet. Moreover, some research is showing that selective inoculation of calves, particularly during the transition period into weaning, might have lasting effects into their subsequent lactation.

Carbohydrates and Effective Fiber

Neutral detergent fiber (NDF) that stimulates rumination is termed “physically effective” (abbreviated as “pe”), whereas NDF that is not physically effective but reduces risk for SARA is often termed “chemically effective”. The peNDF gets a lot of attention, but unfortunately it typically is estimated rather than measured appropriately. The Penn State shaker box separates particles on an as fed basis (those sieve fractions typically are not dried before weighing). Thus, wet forages make up more of the large particles on an as fed basis than on a dry basis. NDF could be measured on whichever screen is used (probably 4 mm and higher) to assess peNDF rather than merely taking the as fed particle distribution and multiplying by the dietary NDF concentration (DM basis). However, my colleagues (Drs. Kononoff, Hall, and White) and I developed a procedure that is being converted into a mobile app; we call this “physically adjusted” NDF (paNDF) as distinguished from peNDF. This app estimates the particle length needed without multiplying the sieve fraction by dietary NDF. When relying on wet forages, we recommend the simple practice of drying sieved fractions with a Koster oven or microwave.

Of course, peNDF and manure sieving still have value in dairy nutrition compared with no information, but paNDF can also provide a different perspective. To explain this paNDF concept, we need to remember that cows need to consume enough particles of adequate length to form a good rumen mat. This mat "consistency" (i.e., firmness) has two edges to the sword. Cows need the mat to be consistent enough to stimulate rumination and to retain smaller fibrous particles; on the other hand, too many coarse particles can depress dry matter intake (DMI). I note here that whole cottonseed helps to firm up the mat about as well as long forage particles. Also, this optimum range (enough but not too much) of coarse particles probably moves up and down different types of diets depending on the amount of starch and perhaps other factors. Generally, the more starch in the diet, the more paNDF (or peNDF) is needed to stimulate rumination for salivation to buffer the fermentation acids. However, more coarse particles also limit the amount of TMR consumed per meal. In contrast, low starch diets can fit into some rations when fibrous byproducts are cheaper and more available. Even though starch is decreased, long particles still need to be adequate to help retain those small byproducts in the rumen. Without a firm mat, small particles slip through the rumen mat and are increased in the feces, limiting feed efficiency and wasting the opportunity to extract all the value out of that byproduct fiber. Moreover, some evidence suggests that even grains can pass more quickly from the rumen and wind up with higher starch in feces.

Dry Matter Intake and Feeding Behavior

We've all heard these types of adages: "when you feed the cow, you first feed the rumen" and the three most important words in dairy nutrition are "dry matter intake". I will condition DMI in that appropriately high DMI starts with forage quality, proper rations, cow comfort, and bunk management. Excessive rumen-degraded starch consumption typically increases propionate production, and resultant propionate metabolism as fuel in the liver (more than is needed for glucose synthesis) can limit DMI especially for those animals that would respond the most. However, high propionate is also a symptom of excessive carbohydrate availability to rumen microbes. Worse yet, energy from fermentable carbohydrate is not only in excess but also is intentionally metabolized to "spill" (intentionally waste) energy that could have been used to grow more microbial cells. The hidden result is that the cow would have lower microbial protein reaching her intestine relative to a computer model's predicted value.

Appropriately high intake of a properly balanced diet provides all the nutrients that microbes need to break down fiber and to grow microbial protein. That is, the three most important words in microbial protein synthesis also are "dry matter intake", assuming it is appropriately high DMI. Conversely, disproportionately high DMI relative to milk production could be from too high or too low intakes of peNDF, as explained above. The question is how do we predict and therefore model a proper balance of nutrients to optimize DMI? Results from synchronizing rumen-degraded starch with RDP have been mixed. When studied in the lab, the benefit of this synchrony is clearly established. However, in cow studies, we see less value because the cow eats multiple meals per day and spreads out the varying degradation rates; she self-synchronizes nutrients available in the rumen (the front edge of the synchrony sword is dull). That said, in controlled research, cows are not in competition with each other, and problem cows and other sources of variation are minimized. When group-fed, though, competition promotes cow sorting in which some cows get too much starch and some get too much forage. Probably the same goes with RDP; that is, more competition probably makes some cows consume excess RDP and some get insufficient RDP. Therefore, I think software that considers synchrony of carbohydrate and RDP decreases the risk associated with sorting and erratic feeding behavior in the field (the back edge might be sharp!).

Several studies now have documented that yeast or yeast extract can (but not always) stimulate cows to consume feed more consistently. That is, the average amount of DM or starch consumed per meal goes down while the average number of meals goes up. A few studies have shown the same kind of behavior with ionophores. A more even feeding pattern lessens the spikes in rumen acidity and increases periods in the feeding cycle when the concentration of growth factors such as RDP are available for microbes. That is, there is more self-synchronization of nutrients. With the more consistent feeding behavior by any single cow, there could be more consistent feeding of multiple cows within a pen. These patterns could result in either a greater milk production because DMI increased or, alternatively, yield the same milk production with slightly less DMI. Either way of improving feed efficiency should dilute fixed maintenance costs by cows and also improve income over feed costs.

Rumen-Degraded Protein and Isoacids

Numerous papers (including my own) have addressed RDP guidelines by dairy cows. Results are inconsistent, but adding RDP to a diet moderately deficient in RDP never has a negative response, whereas adding RDP sometimes has a positive response in microbial protein production or NDF digestibility in the rumen. The most consistent response associated with adequate RDP is its positive association with DMI. Whether the response is only in the rumen (as might be expected based for <u>rumen</u>-degraded protein) or has a post-absorptive role (RDP products absorbed into blood and influencing the brain's satiety center) is not fully clear. However, benefits of having adequate RDP start in the rumen. Moreover, numerous studies swapping soybean meal for some other bypass protein source on an equal protein basis have documented a depressed microbial protein flow (because RDP became deficient) that partially offset the benefit in post-ruminal supply of RUP. Because microbial protein is a well-balanced source of amino acids (perhaps with the exception of threonine) and is cheaper, RDP should not be limited. What constitutes "limiting" depends on several factors, including methods in papers. I think RDP should be 9 to 10%, with maybe some limiting returns in benefit up to 12%. However, the low fuel indicator should go off at 9% and never be lower than 8% of DM.

Why higher RDP? Lab studies have documented that many microbes benefit from preformed amino acids. Nearly all bacteria can use ammonia as their N source and make their own amino acids as would a growing plant. When energy is plentiful (as when rumen-degraded starch is moderate to high in the diet), a preformed supply of amino acids improves their efficiency of growth. An analogy could be like this: if a manager improved the flow of cows to and from a parlor, the parlor efficiency (milk per time) would improve. Preformed amino acids allows more efficient growth (more cells per time). The amino acids most beneficial appear to be phenylalanine followed by the branched chain amino acids and then potentially some others such as methionine. Because specific cellular proteins require specific amino acids, having a steady concentration of needed amino acids inside their cell maximizes the rate of protein synthesis. The aromatic and branched chain amino acids probably are more limiting intracellularly. Because microbial cells are over 50% protein, preformed amino acids in RDP improves the efficiency of microbial cells flowing to the intestine; on the other edge of the sword, less consistent amino acid availability promotes energy spilling and would limit microbial protein reaching the intestine.

Relying on non-protein nitrogen in the diet or blood urea transfer into the rumen (for conversion to ammonia) can save money and be a valuable resource in low protein diets. Grazing beef cattle and sheep have taken advantage of this phenomenon for centuries. However, providing adequate ammonia can increase the need for preformed amino acids and vice versa if the efficiency of microbial growth is increased up to its potential. In lactating dairy cows, ruminal passage rate would be increased dramatically compared with grazing beef cows, and those same microbes move from a dirt road to an autobahn. Models still are limited by (as yet) unexplained mechanisms and limitations in research. Databases lack representation by high producing cows, so even empirical (statistics-based) results have limitations. Hence, we need to go back to rely on what we know.

Using lab approaches, stable isotopes, and meta-analyses, my colleagues (especially Drs. Lee and Moraes) and I have been researching for the past few years whether or not isoacids (the carbon skeletons of branched chain amino acids) can replace RDP for proper bacterial activity. Although not always consistent, the combination of research results and known issues from the microbiology literature suggests an important role for isoacids in dairy diets with moderate RDP. First, we know that isoacids are important precursors either as the carbon skeletons needed to make the branched chain amino acids or else that can be elongated and incorporated into bacterial membranes. These isoacids can benefit all bacteria if the concentration in the rumen is increased below a certain threshold. However, we also have known for decades that certain critically important fiber-degrading keystone bacteria require one or more of these isoacids. If we limit these keystone degraders, then less effective fiber degraders probably trespass into that niche. From the microbiology literature, branched chain amino acids might be feedback indicators for cellular functions, so the corresponding isoacids appear more likely to consistently improve ruminal efficiency of microbial protein synthesis.

In the 1980’s a commercial product was developed to provide isoacids to successfully improve milk production albeit with some circumstances when these isoacids might not be needed or some other considerations associated with cost or palatability. Researchers from the 1980’s and 1990’s reckoned that the concentration in the rumen was sufficient for lactating cows. However, with steadily increasing DMI, the passage rate of rumen contents increases (as does washout of soluble nutrients such as isoacids), so bacterial efficiency and need for growth factors such as isoacids probably also increases accordingly. By analogy, if a manager had decreasing time available to do X functions for the day, that manager would need to streamline his or her ability to improve the efficiency of each of those X functions to get them all done or look for employment elsewhere. If someone partially prepares task needed for X rather than starting from scratch, the preformed information would improve efficiency. Even if isoacids could be derived by microbes from scratch, dietary supplementation appears to improve efficiency of using those isoacids. The second consideration is for isoacids to replace RDP to decrease cost or decrease the environmental impact or possible energy wasted from N excretion into urine.

Our on-going research is establishing the benefit of isoacids to replace a portion of the RDP in the diet. First, we have noted relatively consistent improvements in NDF digestibility in lab-based studies (and we are undergoing research to test these effects in lactating cows). Second, either improved substrate availability should increase the amount or else the efficiency of microbial protein synthesis. Third, a lactation study showed that isoacids improved feed efficiency (energy-corrected milk/DMI). Fourth, our survey of the literature supports a benefit to the branched-chain amino acid for milk production. Consequently, we are continuing to investigate if isoacids substitute for those amino acids more effectively to improve efficiency of milk production or if they can help substitute for RDP and therefore maintain milk production with lower protein diets. So far, results are encouraging.

Final Thoughts

The "best we know" starts with *what we know* and how to glean information to substitute for *what we do not know*. I've tried to explain the importance of feeding the rumen using analogies from applied dairy nutrition and management. For anyone looking at more scientific details, please see my paper in the 2015 Western Canadian Dairy Seminar https://wcds.ualberta.ca/2017/08/22/2015/

Transition Cow Management and Nutrition: *the latest producers need to know*

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

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

UNIVERSITY of FLORIDA

High Plains Dairy Conference

Timeline Management of Dairy Cows For Successful Transition

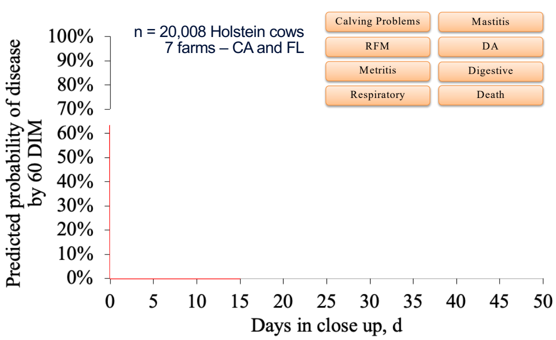
Provide Proper Comfort and Heat Abatement

1. **Dry off**
   - 230 days of gestation
   - Proper body condition
   - Control of mastitis
   - Routine hoof trimming
   - Vaccination program
   - Proper diet to avoid over and under consumption of nutrients
2. **Close up**
   - Move based on days pregnant - 255 days of gestation
   - Proper grouping
   - Vaccination program
   - Feed diets to minimize metabolic disorders in early lactation.
3. **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



Vieira-Neto et al. J. Dairy Sci. (2020) Abstr.

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

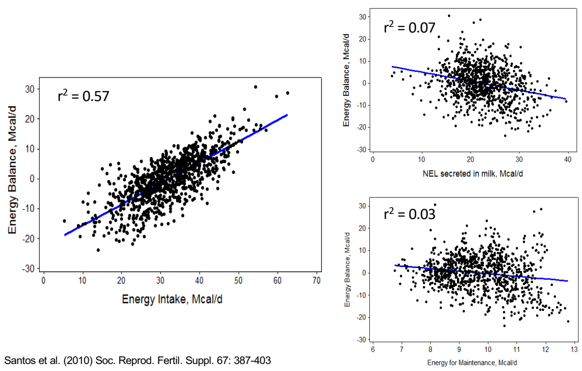
Santos et al. (2009) Anim. Reprod. Sci. 110: 207–221

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

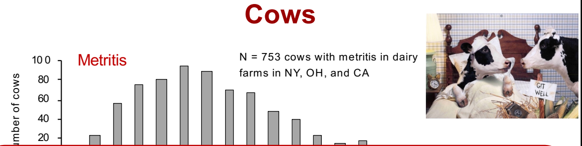
Important that cows and heifers do not calve overconditioned

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



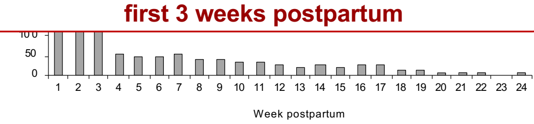
Santos et al. (2010) Soc. Reprod. Fertil. Suppl. 67: 387-403

Morbidity is a Problem of Early Lactation Cows



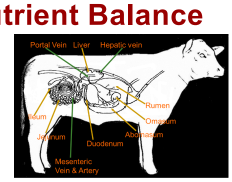
30 to 35% of cows are affected by disease in the first 3 weeks of lactation

78% the first disease diagnosis occurs within the first 3 weeks postpartum



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

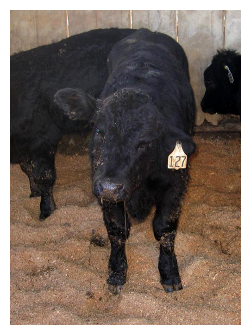
Disease Reduces Nutrient Balance



- ✓ 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)

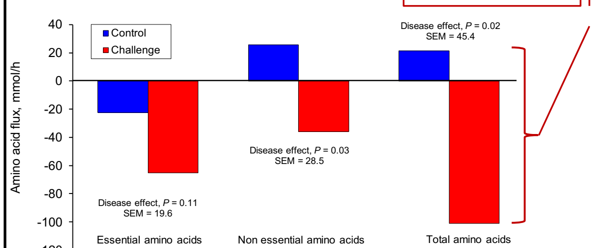
Two Conditions that Induce Systemic Inflammatory Responses



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

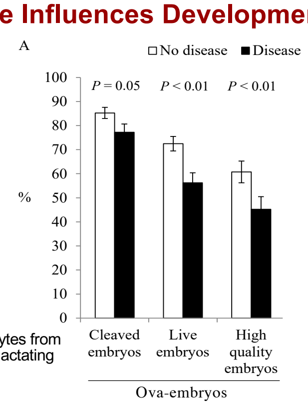
At 0.67 efficiency, this is equivalent to the true protein in 8 kg of milk (18 lbs)

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



Burciaga-Robles PhD Dissertation (2009)

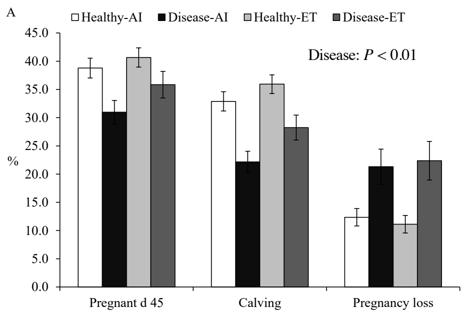
Disease Influences Development to Morula



419 embryo-oocytes from single ovulating lactating Holstein cows

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

Negative Impacts of Disease on Fertility Are Not Bypassed by Embryo Transfer (ET)



N = 4,206 cows

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

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

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

Prepartum Diet Formulation

Focus on 4 important aspects

✓Avoid excessive caloric intake (gain of adipose tissue or BCS)

✓Reduce fatty liver and ketosis

✓Prevent hypocalcemia

✓Supply adequate amount of metabolizable protein

Formulate Proper Diets for Prepartum Cows

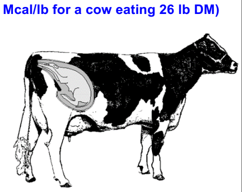
If you let them choose, *they can make bad choices*!

Prepartum diets should be simple!

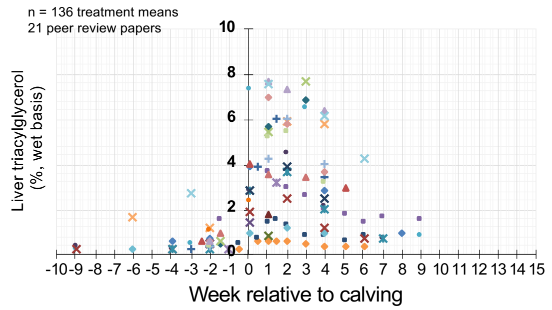
Caloric Needs of Prepartum Cows

- ✓ Last 3 weeks of gestation for a pregnant Holstein cow weighing 680 kg plus 40-50 kg of uterine/fetal weight
  - ✓ Cow needs ~11 Mcal/d of NE_L ($680^{0.75}$ x 0.08)
  - ✓ She needs another ~4 Mcal for fetal/uterine tissue accretion
  - ✓ To account for cow to cow variability and diet selection/competition, a total of 17 Mcal/d should be offered prepartum
  - ✓ This cow eats 11 to 13 kg of DM daily (23 to 28 lb;d); therefore, the diet should contain:
  - ✓ ~ 17 Mcal/12 kg = **1.42 to 1.45 Mcal/kg DM (0.65 Mcal/lb for a cow eating 26 lb DM)**

Typical diet
- ✓ Diet with 70 to 75% forage
- ✓ 45 to 50% NDF
- ✓ 15 to 18% starch
- ✓ 25 to 30% NFC
- ✓ 3% fatty acids

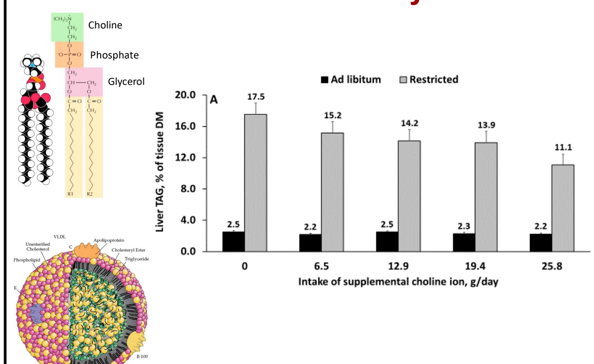


Hepatic Triacylglycerol Around Calving



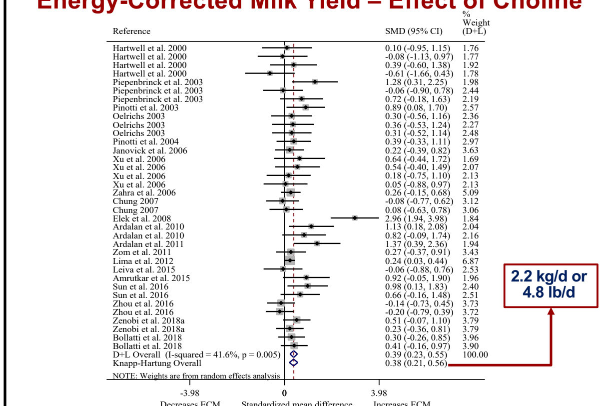
Summarized by M. Zenobi

Choline Reduces Fatty Liver



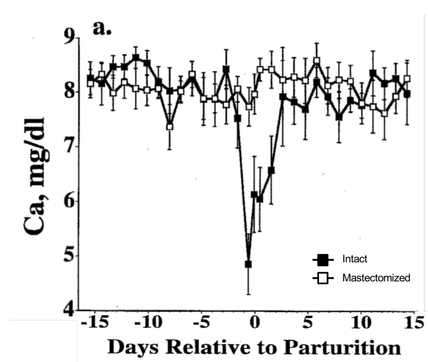
Zenobi et al. (2018) J. Dairy Sci. 101:5902–5923

Energy-Corrected Milk Yield – Effect of Choline



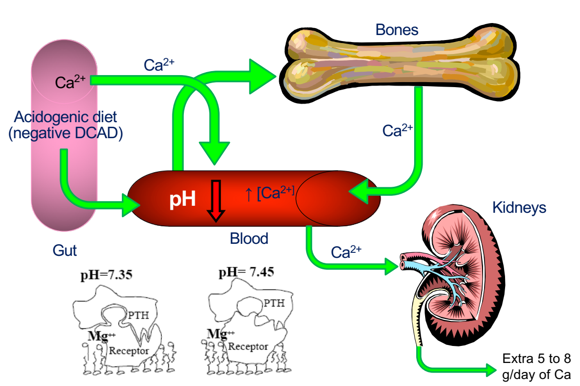
Usman et al. (2020) J. Dairy Sci. 103:282–300

Mastectomized Cow

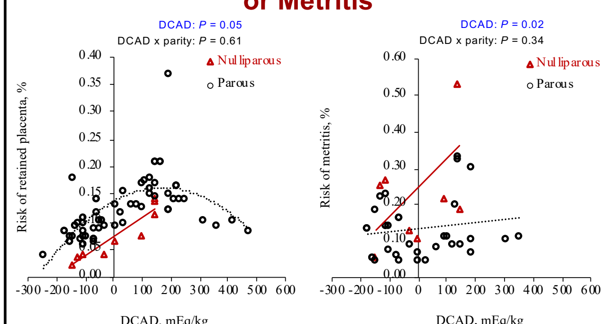


Goff et al. (2002) J. Dairy Sci. 85:1427-1436

Mechanisms of Acidogenic Diets

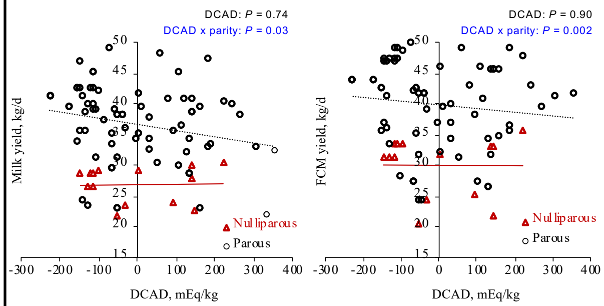


Effect of DCAD on Risk of Retained Placenta or Metritis



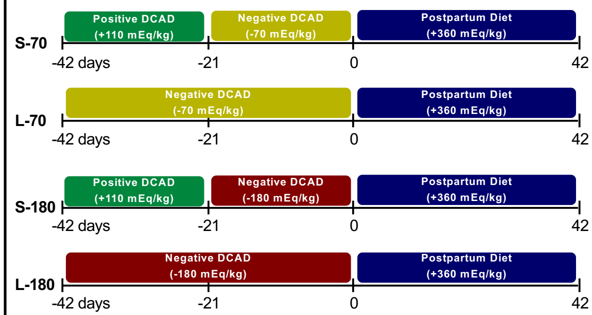
Santos et al. (2019) J. Dairy Sci. 102:2134–2154

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



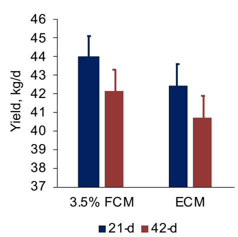
Santos et al. (2019) J. Dairy Sci. 102:2134–2154

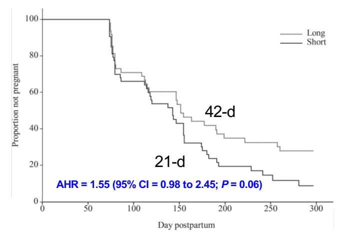
How Long Should We Feed Acidogenic Diets Prepartum



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

Feeding Acidogenic Diets During the Entire Dry Period

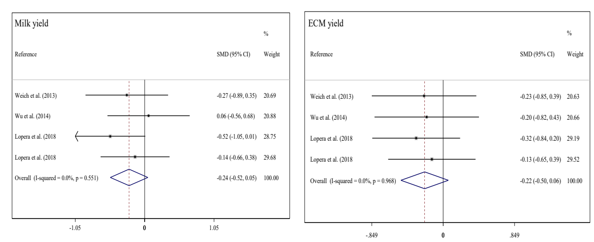




Lopera et al. (2018) J. Dairy Sci. 101:7907–7929

Feeding Acidogenic Diets During the Entire Dry Period

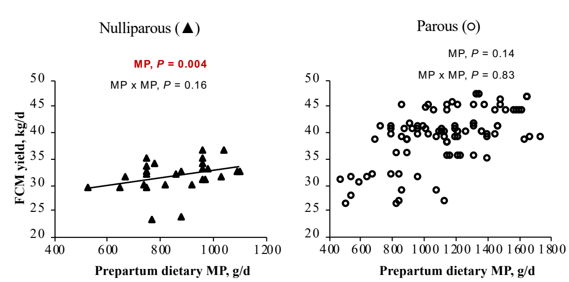
3 experiments show the same responsee



Protein Needs of Prepartum Cows

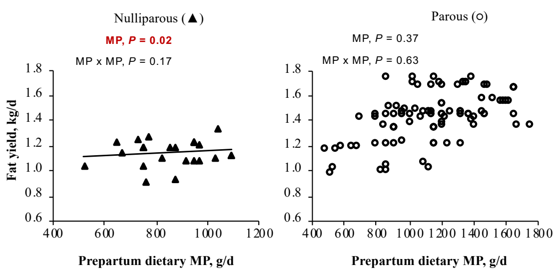
- Dry cows weighing 600 to 650 kg dry cow requires approximately 480 g/d of metabolizable protein for maintenance
- Metabolizable protein needed for gravid uterus accretion assuming calf birth weight of 43 kg
  - 270 d of gestation = 340 g/d
- Nulliparous are still growing and have requirements for lean tissue accretion
  - 250 g of MP for accretion of lean tissue
- Estimated requirements for MP
  - Parous cows = 820 g/d to meet maintenance and gravid uterus accretion (~ 2 lbs/d of digestible amino acids)
  - Nulliparous cows = 1,100 g/d to meet maintenance, gravid uterus accretion, and lean tissue accretion (~ 2.5 lbs/d of digestible amino acids)

Effect of Prepartum Supply of Metabolizable Protein on Yield of FCM



Husnain and Santos (2019) J. Dairy Sci. 102:9791–9813

Effect of Prepartum Supply of Metabolizable Protein on Milk Fat Yield



Husnain and Santos (2019) J. Dairy Sci. 102:9791–9813

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

Summary of Diet Manipulations

- ✓ 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
  - ✓ 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
- ✓ Supplement moderate amounts of FA to improve fertility (1 to 1.5% diet DM in early lactation)
- ✓ Prepartum diets should be simple and transition programs should be easy to implement

Thank you

Jepsantos@ufl.edu

Manipulating the Duration of the VWP to Optimize Herd Performance and Profitability

Julio Giordano, Ph.D.
Cornell University

TAKE HOME MESSAGES

- Extending the duration of the voluntary waiting period (VWP) from 50 or 60 DIM to 88 DIM can increase first service pregnancy per AI (P/AI) but delay overall time to pregnancy when either all timed AI (TAI) or combined (AI in estrus and TAI) programs are used for first service.
- The greatest effect of extending the VWP on first service P/AI may be observed in primiparous cows.
- Delaying first service from 60 to 88 DIM may result in greater profitability for primiparous but not for multiparous cows.
- Changes in VWP duration affected profitability primarily through differences in replacement cost and to a lesser extent by income over feed cost.
- In general, the effect of manipulating the duration of the VWP on herd performance and economics depends upon complex interactions between reproductive performance, herd exit dynamics, lactation performance, and economic conditions.

INTRODUCTION

Timing of pregnancy during lactation affects dairy herd profitability by defining the calving interval, milk production efficiency, and herd replacement dynamics. The insemination and conception risk after the end of the voluntary waiting period (**VWP**) are the two major determinants of time to pregnancy during lactation. Nonetheless, the duration of the VWP can also influence timing of pregnancy because it determines when cows become eligible for insemination.

Traditionally, dairy farms in the US began inseminating cows at ~40 to 50 DIM because sub-optimal estrous detection and fertility to AI required that cows received multiple services to conceive. In recent years, however, better cow health and reproductive management programs that ensure inseminating cows by a set DIM, led to increases in reproductive and productive performance of well-managed dairy herds. Improved detection of estrus and fertility reduces the number of inseminations needed to conceive and the variation in the timing required for cows to become pregnant. Thus, there is an opportunity to better control timing of pregnancy during lactation and thereby maximize profitability. In this regard, extending the VWP by a reasonable amount of time (20 to 30 d) may be a simple and inexpensive change with potential to impact the profitability of dairy herds.

In spite of the potential effect of manipulating the duration of the VWP on herd reproductive performance and profitability, very limited data is available about the reproductive performance and worse yet, on the profitability of dairy cows managed with different VWP duration. Indeed, in recent years many dairy farms have extended the VWP for their cows without a clear understanding of the implications to herd performance and profitability.

Potential Effects of VWP on Physiological Status of Cows before First Service

Extending the duration of the VWP may improve reproductive performance of cows through multiple mechanisms. For example, it may provide more time to recover uterine health (Gilbert et al., 2005; Sheldon et al., 2009) through improved immune status later in lactation, more time to resolve inflammation after calving, or both (LeBlanc et al., 2011;

2014). Likewise, a longer VWP may provide cows more time to resume ovarian cyclicity (Butler, 2003) allowing more estrous cycles before first service which, has been linked to fewer days to first service and greater pregnancies per AI (**P/AI**; Thatcher and Wilcox, 193;` Butler and Smith, 1989). Delaying first service beyond the period of negative energy balance nadir in early lactation may also improve reproductive performance by avoiding insemination during severe negative energy balance. ptimum` body condition score (**BCS**) at the time of insemination is strongly associated with high probability of pregnancy (Souza et al., 200;` 2008; Carvalho et al., 2014).

Previous Research on VWP Duration and Reproductive Performance

Despite the potential benefits of extended VWP on reproductive performance, the impact of this management strategy on overall herd performance has not been fully elucidated. Few randomized controlled experiments have evaluated the implications of VWP duration on the reproductive performance, herd exit dynamics, and economics of dairy cows. In an experiment with a limited number of second lactation cows (i.e., 54 cows per group), Van Amburgh et al. (199)` found no differences in P/AI at first service, heat detection efficiency, and services per conception when comparing VWPs of 60 versus 150 days. Similarly, Arbel et al. (2001) observed no effect of extending VWP by 60 d (from 90 to 150 in primiparous cows and from 60 to 120 in multiparous cows) on reproductive performance of dairy cows under Israeli conditions. In this experiment, only cows with above-average milk production that did not calve during summer were included. In contrast, in an experiment conducted in Germany using only cows with above- or below-average milk production, an increment of 13 and 20 percentage points in P/AI to first service was observed when VWP was extended from 77 to 98 or from 56 to 77 DIM for high- and low - producing cows respectively (Tenhagen et al., 2003).

More recently, Gobikrushanth et al. (2014) reported the results of a retrospective cohort study using data from a commercial farm in Florida that extended VWP duration during summer months only. Cows with the extended VWP had improved first service P/AI, more days open, and longer calving intervals. Nonetheless, results from this study might have been confounded by season of AI, as cows with short VWP (5 to 63 d)` received first service during summer and fall whereas cows with long VWP (64 to 121) received first service during fall only. Moreover, the reproductive program used to submit cows for first service resulted in overlapped DIM at first service for a substantial proportion of cows.

Collectively, the ambiguous results and multiple exclusion criteria of these previous studies did not allow decisive conclusion that extending the duration of the VWP is beneficial for the reproductive and lactation performance of dairy cows or determination of the potential effects of extending the VWP on the herd exit dynamics and economics of dairy herds.

RECENT RESEARCH ON DURATION OF THE VWP

Extending VWP from 60 to 88 DIM and Using All Timed AI for First Service

We recently conducted an experiment to evaluate the reproductive performance, herd exit dynamics, and economics of dairy cows managed with a VWP of 60 or 88 DIM in commercial dairy farms. We were also interested on evaluating the effect of longer VWP on markers of physiological and energy status before first service. Based on expected physiological benefits of delaying first service (i.e., improved uterine health, reduced rate of anovulation, improved BCS, and reduced systemic inflammation), we hypothesized that extending VWP duration from 60 to 88 DIM would increase P/AI to first service and improve overall reproductive performance (i.e., reduce overall time to pregnancy after calving).

Cows from three commercial farms in New York State were blocked by parity group (primiparous vs. multiparous) and within the multiparous group cows were stratified by total milk yield recorded for the previous lactation. Thereafter, cows were randomly assigned to a VWP of 60 [**VWP60**; n = 1,265] or 88 [**VWP88**; n = 1,260] DIM. For first service, all cows received the Double-Ovsynch (**DO**) protocol (GnRH-7 d-PGF-3 d-GnRH-7 d-GnRH-7 d-PGF-56 h-GnRH-16 to 20 h-TAI; Souza et al., 2008) for synchronization of ovulation. For second and greater AI services, cows were submitted for insemination after detection of estrus. In the three farms, cows not re-inseminated at detected estrus received TAI after resynchronization of ovulation with the Ovsynch protocol (GnRH-7 d-PGF-56 h-GnRH-16 to 20 h-TAI) initiated 32 ± 3 d after AI (**D32-Resynch**).

All farms housed cows in free-stall barns with four or six rows of stalls, milked cows thrice or twice daily (one farm), and cows were supplemented with recombinant bovine somatotropin (rbST; Sometribove zinc, Posilac, Elanco Animal Health, Indianapolis, IN).

Physiological Parameters before First Service

Our results for multiple markers of physiological status supported the hypothesis that a longer VWP would lead to an improved uterine environment, reduced anovulation, improved BCS, and reduced systemic inflammation before first service. The effect of extending VWP duration on uterine health was evident, as fewer cows were considered to have purulent vaginal discharge (**PVD**) and cytological endometritis (**CYTO**) at the beginning of DO and 10 d before TAI. The longer VWP also resulted in more cows with a BCS ≥ 2.75, which has been associated with greater first service P/AI. Assuming that most cows lost body reserves after calving, our data suggested that the longer interval from calving to first service for cows in the VWP88 treatment allowed recovery of more body reserves. Collectively, these observations for physiological markers and overall metabolic status suggested that providing cows more time to recover before first service was a feasible strategy to promote a physiological status more conducive to pregnancy.

A greater proportion of cyclic cows at the beginning of the DO protocol also reflected the effect of additional time for resumption of cyclicity, whereas the similar proportion of cyclic cows observed 10 d before TAI reflected the efficacy of the DO protocol to resolve anovulation. This was expected because previous studies have demonstrated that GnRH-based presynchronization protocols are effective for reducing the proportion of anovular cows before TAI (Souza et al., 2008; Herlihy et al., 2012).

Reproductive Outcomes

In support of our main hypothesis, extending the duration of the VWP from 60 to 88 DIM after synchronization of ovulation with the Double-Ovsynch protocol increased P/AI after first service in lactating dairy cows (Table 1). Nevertheless, most of the observed difference could be attributed to the greater P/AI of primiparous cows in the VWP88 treatment (no statistically significant difference for multiparous cows). The reason for the different response to treatments by parity is unclear at the moment because both groups presented a fairly similar physiological response to the extension of the VWP. Differences between parities in metabolic status, health, or both not captured by the parameters monitored in this experiment may explain such a discrepancy. As expected P/AI was greater ($P < 0.01$) for primiparous than multiparous cows (50.4 vs. 38.0%, respectively) and we also observed that cows with low (45.7%) and medium (46.7%) accumulated milk production up to 30 DIM had greater ($P = 0.02$) P/AI than cows with high

(39.9%) milk yield.

A lack of difference in pregnancy loss, proportion of cows inseminated after a detected estrus, and P/AI for second and greater services suggested that extending the duration of the VWP should not be expected to reduce pregnancy losses for cows pregnant after first service, improve the likelihood of re-insemination to estrus, or the fertility to second and greater AI services. Conversely, extending the VWP from 60 to 88 DIM, affected the total number of AI services up to 350 DIM because cows in the VWP60 treatment had more inseminations (P = 0.04) than cows in the VWP88 treatment (2.6 vs 2.4 services, respectively). This was the result of earlier opportunities for re-inseminations in cows not pregnant to previous AI services in the VWP60 group.

Our overall results for P/AI and re-insemination dynamics are in agreement with previous studies, which showed improved P/AI after extending the duration of the VWP (Tenhagen et al., 2003; Gobikrushanth et al., 2014). Nevertheless, direct comparisons between studies are difficult because of differences in experimental design and interactions between treatments and other confounders. Thus, in spite of substantial variation across studies, the collective results of the current experiment and others (Tenhagen et al., 2003; Gobikrushanth et al., 2014) conducted under conditions more similar to ours (i.e., using TAI and less difference in VWP duration) suggest that extending VWP duration increases P/AI to first service. The magnitude of the increment in P/AI, however, may be affected by parity, method of insemination, season, milk yield level, and the magnitude and timing of the extension of the VWP.

Because timing of pregnancy for lactating dairy cows is determined by the combined effect of all AI services rather than first service only, evaluating the pattern of pregnancy creation during the entire lactation is essential to truly determine the effect of VWP duration on reproductive performance. Rather than focusing on first service outcomes only, dairy managers should consider the potential effect of manipulating the duration of the VWP on pregnancy dynamics during the entire lactation and for all cows. In this regard, cows in the VWP60 treatment in our experiment became pregnant at a faster rate after calving than cows in the VWP88 treatment regardless of parity as evidenced by a greater hazard of pregnancy (i.e., an indication of the different speed at which cows become pregnant in two groups) after calving. As a result, median (days at which 50% of cows were pregnant) and mean days to pregnancy were 102 and 132 d for the VWP60 treatment and 128 and 154 d for the VWP88 treatment. The hazard of pregnancy was also affected by parity (P < 0.01) because primiparous cows became pregnant at a faster rate than multiparous cows (HR 1.48, 95% CI 1.36 to 1.62) and milk yield up to 30 DIM (P < 0.01) because cows with high milk yield up to 30 DIM became pregnant at slower rate (HR 0.84, 95% CI 0.76 to 0.94) than cows with medium milk yield (no difference between high and low milk yield). Essentially, the reduced P/AI to first service for cows in the VWP60 treatment was fully compensated by the creation of more pregnancies at earlier DIM due to more and earlier opportunities for re-insemination.

Interestingly, the faster rate of pregnancy creation did not result in a reduced proportion of nonpregnant cows at 350 DIM (P = 0.28; VWP60 7.3 vs. VWP88 8.6%) for cows that remained in the herd. These results suggest that the greatest consequence of longer VWP is shifting timing of pregnancy towards later lactation rather than generating a different proportion of pregnant cows during lactation. In agreement, two other studies reported the same patterns of pregnancy creation (Tenhagen et al., 2003; Gobikrushanth et al., 2014) than those observed in our experiment.

Herd Exit Dynamics

Cow parity and pregnancy status are

major determinants of the herd exit dynamics in dairy farms. Pregnant cows and younger cows (e.g., primiparous vs. multiparous) have reduced risk of removal from the herd (De Vries et al., 2010; Pinedo et al., 2010). Indeed, in our experiment, a smaller proportion of primiparous than multiparous cows left the herd and primiparous cows had a similar herd exit dynamics regardless of VWP treatment (HR 1.12, 95% CI 0.77 to 1.61). These results reflected the protective effect for culling of early pregnancy and younger age. Conversely, for multiparous cows a greater proportion of cows from the VWP88 treatment exited the herd as lactation progressed (P = 0.03; HR 1.21, 95% CI 1.02 to 1.44) reflecting the compounded effect of delayed pregnancy and greater culling pressure in older cows.

As expected, we also observed that cows in the low milk-yield group had a greater hazard of culling (P <0.01) than cows in the medium (HR 1.72, 95% CI 1.43 to 2.07) and high (HR 2.04, 95% CI 1.69 to 2.47) milk-yield groups. Therefore, milk yield level also played a role because non-pregnant cows with medium and high milk yield within each parity group had lower culling pressure than cows with low milk yield. These data suggest that through its effect on timing of pregnancy during lactation, manipulating the duration of the VWP can also affect the herd exit dynamics which may have important economic implications. As pregnancy is delayed cows are more likely to leave the herd, in particular multiparous cows.

Economic Outcomes

We monitored cows enrolled in our experiment for a total of 18 mo after calving to determine individual cow profitability based on income over feed cost (**IOFC**), replacement costs, reproductive programs costs, rbST supplementation cost, operating expenses, and value of calves born. Cash flow for an 18-mo period after calving for each cow enrolled in the experiment was calculated by addition of all these expenses and revenues. In order to better represent the reality of a dairy farm, we considered that every cow enrolled in the trial filled up a slot at the dairy and the slot had to remain occupied for the entire 18-mo period to maintain herd size constant. Therefore, every cow that left the herd due to sale or death was replaced by a randomly selected first lactation cow from the same experimental treatment. This cow contributed with expenses and revenues up to the end of the 18-mo period (i.e., filled up the original slot occupied by the cow it replaced). If the replacement cow left the herd before the end of the 18-mo period it was also replaced by another randomly choose first lactation. The method used for our economic analysis (i.e., fixed period of time including a significant portion of the lactation following application of the experimental treatments), was meant to better represent the effect of reproductive performance on herd profitability. Otherwise, the effect of timing of pregnancy on the current and subsequent lactation is not captured. It also important to note that due to substantial differences in performance and profitability between primiparous and multiparous cows, data was analyzed separately by parity group. Data for profitability by parity group is presented in Table 2.

For primiparous cows, cash flow per slot per 18-mo or per day was similar (P = 0.32) for the VWP60 and VWP88 treatment despite a $68 numerical difference in favor of the VWP88 group. Interestingly, most of the difference between treatments was due to greater replacement cost for the VWP60 treatment because the small differences observed for the rest of the parameters offset each other. The difference in replacement cost was primarily due to greater cost in the subsequent lactation because a slightly greater percentage of second lactation cows (i.e., first lactation during experimental lactation) left the herd before the end of the 18-mo period. Thus, when attempting to extrapolate the results of our experiment to other farms, it is important to recognize the dominance of replacement cost over total profitability because a different replacement cost dynamics (i.e., different culling pressure and different cash cost of culling) may be observed across herds and changing market conditions. Indeed, when we simulated the potential effect of changes in economic conditions (i.e., milk prices, reproductive cost, heifer replacement costs, calf values), replacement costs accounted for up to ~80% of the total variation in profitability.

Interestingly, the results for multiparous cows were opposite to those of primiparous cows. Although a statistically significant difference between treatments was not observed, cows in the VWP60 were more profitable by $85 per slot per 18-mo than cows in the VWP88 treatment. In this case, however, replacement cost was greater for the VWP88 reflecting increased culling pressure in non-pregnant cows in the VWP88 treatment in later lactation. Such contrast in results for overall cash flow likely reflected differences in milk production persistency (i.e., lactation curves are less persistent for multiparous than primiparous) and the interaction between parity and risk of leaving the herd as lactation progressed (i.e., only multiparous but not primiparous cows in the VWP88 were more likely to leave the herd). Although to a lesser extent than for primiparous cows, replacement cost explained a substantial proportion of the numerical economic differences for the results with fixed economics values or when we simulated varying economic conditions.

In summary, the economic outcomes for our experiment suggest that extending the VWP from 60 to 88 DIM when using all TAI to submit cows for first service may result in greater (numerical) profitability for primiparous cows, primarily through a reduction in replacement costs. Conversely, the same extension of the VWP duration for multiparous cows may lead to economic losses (numerical) primarily due to greater replacement cost and reduced IOFC which, cannot be offset by reduced reproductive program costs.

Results from our experiment should be interpreted with caution because in spite of the large number of cows in our experiment we did not detect statistically significant differences for overall cash flow, the fact that all cows received rbST, and the particular replacement dynamics of the herds involved in our research which, may have been affected by individual farm management decisions and the economic conditions during the trial. Of note, the method used to calculate cow profitability can also vary depending on whether profitability per unit of time and slot or, per cow regardless of time and herd size constraints are calculated.

Effect of Method of Submission for First Service and VWP Duration on Reproductive Performance

Dairy managers need to determine not only the duration of the VWP for their cows but also, the type of management strategy to submit cows for first service. In this regard, the effect of extending the VWP from 60 to 88 DIM on first service P/AI and subsequent reproductive performance in the experiment described above may have been specific to the use of all TAI with a GnRH-based fertility protocol (i.e., Double-Ovsynch). For example, using all TAI results in a narrow range of DIM to first service regardless of the ability of cows to display estrus behavior. This reduces variation of not only DIM to first service but also for second and greater AI services. By resolving anovulation, proper synchronization of ovulation, and optimization of the endocrine environment before insemination in a majority of cows (Souza et al., 2008; Herlihy et al., 2012; Giordano et al., 2013); GnRH-based protocols may also offset the detriment of shorter VWP on P/AI to a greater extent than programs not including synchronization of ovulation or synchronization of ovulation with PGF-based protocols. Thus, the method of submission to first service and the type of synchronization of ovulation protocol, if any is used, are important considerations at the time of defining the duration of the VWP. In this regard, many dairy farms continue to submit cows for first service through a combination of detection of estrus and TAI after the Presynch-Ovsynch protocol. Cows detected in estrus after Presynch (two PGF treatments 14 d apart) are inseminated, whereas the rest of the cows receive TAI after completion of the protocol. In this case many farms use a VWP of approximately 50 to 60 DIM. Therefore, a reasonable question is how programs that combine AI at detected estrus and TAI compare to all TAI programs at different VWP durations.

Effect of a Combined Approach versus All TAI and Different VWP on Reproductive Performance of Dairy Cows

As part of the experiment described above, in one of the participating farms we also included an additional treatment that consisted of a typical combined program with the Presynch-Ovsynch (**PSOv**) protocol. Cows in this treatment were allowed to be inseminated at detected estrus any time after 50 ± 3 DIM coincident with the second PGF treatment of Presynch. The other two treatments consisted of all TAI after the Double-Ovsynch protocol at 60 ± 3 (**DO60**) or 88 ± 3 (**DO88**) DIM, as described. Cows in the three treatments were managed equally for second and greater AI services.

Our most relevant findings were that cows managed for first service with the combined approach and VWP of 50 DIM had similar time to pregnancy during lactation than cows managed with all TAI and VWP of 60 DIM. In addition, both treatments with a shorter VWP had reduced time to pregnancy than the DO88 treatment group (Figure 2). As a result, median and mean days to pregnancy were 90 and 123 for DO60, 96 and 126 for PSOv, and 116 and 150 for DO88.

Although the overall effect of VWP duration on P/AI at first service followed the same trends (not the same differences were detected due to lack of statistical power) as for the larger experiment (presented above), the positive effect of longer VWP on this farm was not as dramatic favoring the groups with shorter VWP. This was particularly important for multiparous cows which had the exact same P/AI after all TAI at 60 or 88 DIM, and only ~4 percentage points lower overall P/AI for cows in the Presynch-Ovsynch treatment. Thus, we concluded that first service management programs that result in a similar range of DIM to first service regardless of being a combined approach or all TAI (e.g., AI at detected estrus and TAI with Presynch-Ovsynch with 50 d VWP and all TAI with Double-Ovsynch and 60 d VWP) can lead to similar time to pregnancy after calving. In addition, these programs with shorter VWP and similar range of DIM at first service can reduce time to pregnancy when compared to an all TAI program with an extended VWP (i.e., 88 DIM) which does not result in a substantial increment in first service P/AI. Our observations, are particularly important for herds that extend the duration of the VWP and do not observe a substantial increment in first service P/AI. Indeed, in our trial we estimated that to have the same proportion of pregnant cows at approximately 90 DIM, P/AI at first service for the program with extended VWP should have been 10 to 11 percentage points greater for primiparous and 7 to 12 percentage points greater for multiparous cows.

Because economic differences between reproductive management programs depend on multiple factors beyond timing of pregnancy during lactation, as clearly seen in our comparison of all TAI at 60 vs 88 DIM, it remains to be determined which one of the strategies was the most profitable in our experiment for programs using a combination of AI at detected estrus and TAI vs all TAI.

CONCLUSION

In conclusion, manipulating the duration of the VWP affects herd reproductive performance, exit dynamics (i.e., cow sales), and profitability. From a reproductive performance perspective the greatest effect of delaying the end of the VWP is greater P/AI to first service (in particular for primiparous cows) and an overall delay in time to pregnancy which, may increase the risk of leaving the herd (in particular for multiparous cows). Economically, extending the duration of the VWP as in our experiments may increase profitability of primiparous cows and reduce profitability of multiparous cows. Such effect would depend mostly on the herd replacement dynamics and milk production efficiency.

First-service management strategies that combine insemination of cows at detected estrus and TAI for first service (e.g., Presynch-Ovsynch) may result in similar days to pregnancy during lactation provided that average DIM at first service is similar than for all TAI programs and first service P/AI for the combined program is reasonable. Management programs that reduce DIM at first service through AI at detected estrus and TAI or all TAI can reduce time to pregnancy when compared with all TAI programs with longer VWP. In particular, when the extension of the VWP does not substantially increase first service P/AI.

Collectively, data from our recent research suggest that the effect of VWP duration and first service management strategies on dairy herd performance depends upon complex interactions between the pattern of insemination for first service, pregnancy per AI, and herd exit dynamics, all of which may vary for primiparous and multiparous cows. As a result, dairy managers should consider these complex interactions when defining VWP duration for their lactating dairy cows.

ACKNOWLEDGEMENT

This research was financially supported through a grant (AOR 13-006) from the New York Farm Viability Institute (Syracuse, NY) to J. O. Giordano. We thank our collaborators at Dairy Health and Management Services, LLC (especially Dr. Mark Thomas), the three commercial dairy farms that participated of this research, Merck Animal Health and Parnell Technologies Pty Ltd. for providing hormonal products, and Accelerated Genetics for providing part of the semen used in this experiment. Finally, we would like to thank Dr. Jim Ehrlich from DairySights LLC for his calculations of daily milk yield using the MilkBot model.

REFERENCES

Arbel, R., Y. Bigun, E. Ezra, H. Sturman, and D. Hojman. 2001. The effect of extended calving intervals in high lactating cows on milk production and profitability. J. Dairy Sci. 84:600-608.

Butler, W. and R. Smith. 1989. Interrelationships between energy balance and postpartum reproductive function in dairy cattle. J. Dairy Sci. 72:767-783.

Butler, W. R. 2003. Energy balance relationships with follicular development, ovulation and fertility in postpartum dairy cows. Livest. Prod. Sci. 83:211-218.

Carvalho, P., A. Souza, M. Amundson, K. Hackbart, M.Fuenzalida, M. Herlihy, H. Ayres, A. Dresch, L. Vieira, and J. Guenther. 2014. Relationships between fertility and postpartum changes in body condition and body weight in lactating dairy cows. J. Dairy Sci. 97:3666-3683.

De Vries, A. 2006. Economic value of pregnancy in dairy cattle. J. Dairy Sci. 89:3876-3885.

Gilbert, R. O., S. T. Shin, C. L. Guard, H. N. Erb, and M. Frajblat. 2005. Prevalence of endometritis and its effects on reproductive performance of dairy cows. Theriogenology 64:1879-1888.

Giordano, J. O., M. C. Wiltbank, P. M. Fricke, S. Bas, R.Pawlisch, J. N. Guenther, and A. B. Nascimento. 2013. Effect of increasing GnRH and PGF 2α dose during Double-Ovsynch on ovulatory response, luteal regression, and fertility of lactating dairy cows. Theriogenology 80:773-783.

Gobikrushanth, M., A. De Vries, J. Santos, C. Risco, and K. Galvão. 2014. Effect of delayed breeding during the summer on profitability of dairy cows. J. Dairy Sci. 97:4236-4246.

Herlihy, M., J. Giordano, A. Souza, H. Ayres, R. Ferreira,A. Keskin, A. Nascimento, J. Guenther, J. Gaska, and S. Kacuba. 2012. Presynchronization with Double-Ovsynch improves fertility at first postpartum artificial insemination in lactating dairy cows. J. Dairy Sci. 95:7003-7014.

LeBlanc, S. 2014. Reproductive tract inflammatory disease in postpartum dairy cows. Animal 8:54-63.

LeBlanc, S. J., T. Osawa, and J. Dubuc. 2011. Reproductive tract defense and disease in postpartum dairy cows. Theriogenology 76:1610-1618.

Pinedo, P., A. De Vries, and D. Webb. 2010. Dynamics of culling risk with disposal codes reported by Dairy Herd Improvement dairy herds. J. Dairy Sci. 93:2250-2261.

Sheldon, I. M., J. Cronin, L. Goetze, G. Donofrio, and H.-J. Schuberth. 2009. Defining Postpartum Uterine Disease and the Mechanisms of Infection and Immunity in the Female Reproductive Tract in Cattle. Biol. Reprod.81:1025-1032

Souza, A., H. Ayres, R. Ferreira, and M. Wiltbank. 2008.A new presynchronization system (Double-Ovsynch) increases fertility at first postpartum timed AI in lactating dairy cows. Theriogenology 70:208-215.

Souza, A., A. Gümen, E. Silva, A. Cunha, J. Guenther, C. Peto, D. Caraviello, and M. Wiltbank. 2007. Supplementation with estradiol-17β before the last gonadotropin-releasing hormone injection of the Ovsynch protocol in lactating dairy cows. J. Dairy Sci. 90:4623-4634

Tenhagen, B.-A.,C. Vogel, M. Drillich, G. Thiele, and W. Heuwieser. 2003. Influence of stage of lactation and milk production on conception rates after timed artificial insemination following Ovsynch. Theriogenology 60:1527-1537

Thatcher, W. and C. Wilcox.1973. Postpartum Estrus as an Indicator of Reproductive Status in the Dairy Cow. J. Dairy Sci. 56:608-610.

Van Amburgh, M.E., D.M. Galton, D.E. Bauman, and R.W. Everett. 1997. Management and economics of extended calving intervals with use of bovine somatotropin. Livest. Prod. Sci. 50:15-28.

Dairy Replacement Heifer Economics

Kevin Dhuyvetter, PhD
Michael Overton, DVM, MPVM

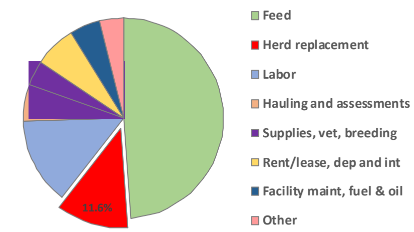
2020 High Plains Dairy Conference
March 3-4, 2020
Embassy Suites Downtown Amarillo
Amarillo, TX

EM-US-19-0204

Replacements are a major cost of milk production

Herd replacement is third largest of cost of milk production (feed and labor are top two costs)

Genske Mulder & Co, LLP -- Panhandle, 2016-18 Avg		
Expense	$/cow	% of total
Feed	$1,892	48.8%
Herd replacement	451	11.6%
Labor	548	14.1%
Hauling and assessments	225	5.8%
Supplies, vet, breeding	159	4.1%
Rent/lease, dep and int	261	6.7%
Facility maint, fuel & oil	189	4.9%
Other	150	3.9%
Total	$3,876	100.0%



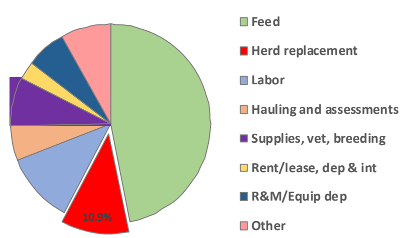
Personal communication with partner of Genske, Mulder and Co., LLP

EM-US-19-0204

Replacements are a major cost of milk production

Herd replacement is third largest of cost of milk production (feed and labor are top two costs)

Frazer, LLP -- Panhandle, 2016-18 Avg		
Expense	$/cow	% of total
Feed	$1,632	46.8%
Herd replacement	380	10.9%
Labor	397	11.4%
Hauling and assessments	196	5.6%
Supplies, vet, breeding	274	7.9%
Rent/lease, dep & int	101	2.9%
R&M/Equip dep	225	6.5%
Other	281	8.1%
Total	$3,487	100.0%



Frazer, LLP -- https://frazerllp.com/

EM-US-19-0204

Factors impacting heifer replacement decisions

1. Number of heifers needed annually
   - Herd replacement rate (static herd size)
   - Herd expansion plans (growth)
   - Heifer raising program (mortality, growth rates, etc.)
2. Number of heifers produced annually
   - Reproduction program (pregnancies, type of semen, etc.)
3. Costs of raising a heifer
   - Available alternatives (e.g., custom growers, purchase springers, etc.)
4. Heifer market prices
   - Current vs long-run, at various stages of growth (calf → springer)
5. Which heifers to sell, and which heifers to keep

EM-US-19-0204

Number of heifers needed annually

1. Number of heifers needed annually

Factors determining the number of heifers needed annually*

Metric		Example herd
A. Herd turnover, %		37.0%
B. Culled by 14 months, %		10.0%
C. Culled after 14 months, %		5.0%
D. Heifers that conceive, %	(1 - B - C)	85.0%
E. Pregnant heifers that calve, %		95.0%
F. Heifers entering program that calve, %	D x E	80.8%
G. DOA risk of heifers		5.7%
H. Heifer births needed per cow in herd	(A/F) / (1-G)	48.6%
I. Heifers calving as pct of heifer births	A / H	76.1%

* Based on static herd size.

EM-US-19-0204

Number of heifers needed annually

1. Number of heifers needed annually

Factors determining the number of heifers needed annually*

Metric		Example herd	47-hrd avg**
A. Herd turnover, %		37.0%	38.8%
B. Culled by 14 months, %		10.0%	9.9%
C. Culled after 14 months, %		5.0%	5.7%
D. Heifers that conceive, %	(1 - B - C)	85.0%	84.4%
E. Pregnant heifers that calve, %		95.0%	93.9%
F. Heifers entering program that calve, %	D x E	80.8%	79.2%
G. DOA risk of heifers		5.7%	5.7%
H. Heifer births needed per cow in herd	(A/F) / (1-G)	48.6%	52.3%
I. Heifers calving as pct of heifer births	A / H	76.1%	74.7%

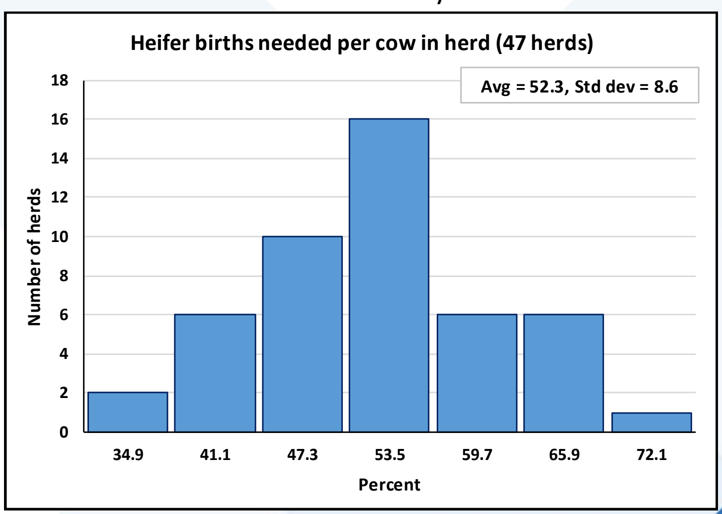
* Based on static herd size.

** Convenience sample of 47 herds on Elanco's DDAS for the year 2018.

EM-US-19-0204

Heifers needed varies considerably across dairies

1. Number of heifers needed annually

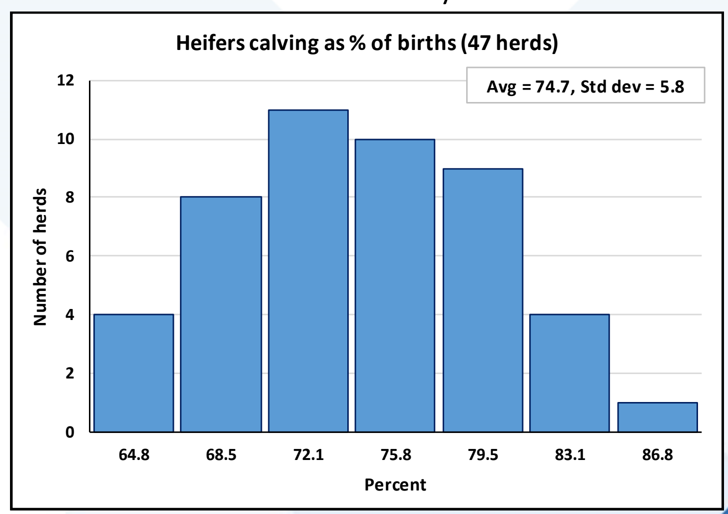


Based on data from a convenience sample of 47 herds on Elanco's DDAS for the year 2018.

EM-US-19-0204

Heifers needed varies considerably across dairies

1. Number of heifers needed annually



Based on data from a convenience sample of 47 herds on Elanco's DDAS for the year 2018.

EM-US-19-0204

Number of heifers needed – Example calculations

1. Number of heifers needed annually

Examples of the number of heifers needed annually

	Scenario A	Scenario B	Scenario C	Scenario D
Herd size (milking and dry), hd	1,000	1,000	1,000	1,000
Milking, hd	890	890	890	890
Fresh events per cow in herd	1.15	1.15	1.15	1.15
Fresh events per year	1,150	1,150	1,150	1,150
Herd turnover, %	37.0%	37.0%	37.0%	42.0%
Herd growth, %	0.0%	5.0%	0.0%	0.0%
Cows removed = Heifers need to calve, hd	370	420	370	420
Heifers that conceive, %	85.0%	85.0%	80.0%	85.0%
Pregnant heifers that calve, %	95.0%	95.0%	90.0%	95.0%
Heifers entering program that calve, %	80.8%	80.8%	72.0%	80.8%
Heifers needed to enter program, hd	458	520	514	520
DOA risk of heifers, %	5.7%	5.7%	6.0%	5.0%
Number of heifer births needed, hd	486	552	547	547
Heifers that freshen as pct of heifer births, %	76.1%	76.1%	67.7%	76.7%

A lot of different factors determine how many heifer calf births are ultimately needed on an annual basis.

Factors impacting heifer replacement decisions

1. Number of heifers needed annually
   - Herd replacement rate (static herd size)
   - Herd expansion plans (growth)
   - Heifer raising program (mortality, growth rates, etc.)
2. Number of heifers produced annually
   - Reproduction program (pregnancies, type of semen, etc.)

Number of heifers produced – Example calculations

2. Number of heifers produced annually

Examples of the number of heifers needed annually

	% female	Scenario A	Scenario B	Scenario C	Scenario D
Herd size (milking and dry), hd		1,000	1,000	1,000	1,000
Fresh events per year		1,150	1,150	1,150	1,150
Cows removed = Heifers need to calve, hd		370	420	370	420
Heifers entering program that calve, %		80.8%	80.8%	72.0%	80.8%
Heifers needed to enter program, hd		458	520	514	520
DOA risk of heifers, %		5.7%	5.7%	6.0%	5.0%
Number of heifer births needed, hd		486	552	547	547
Conception rate by semen type	% female	Percent	Percent	Percent	Percent
Conventional, %	48.0%	100%	65%	35%	0%
Sexed, %	88.0%	0%	20%	35%	55%
Beef, %	0.0%	0%	15%	30%	45%
Heifers from conventional semen		552	359	193	0
Heifers from sexed semen		0	202	354	557
Total number of heifers		552	561	547	557

There are many ways to achieve the required number of heifer calf births (or exceed it).

Factors impacting heifer replacement decisions

1. Number of heifers needed annually
   - Herd replacement rate (static herd size)
   - Herd expansion plans (growth)
   - Heifer raising program (mortality, growth rates, etc.)

Identifying the “best” strategy is complex, but knowing costs of raising a heifer by stage of production is an important starting point.

2. Number of heifers produced annually
   - Reproduction program (pregnancies, type of semen, etc.)

Strategies regarding number of heifers to produce

a) As many as possible, sell “excess” calves
b) As many as possible, sell “excess” heifers/springers
c) As many as possible, bring into herd (e.g., grow or replace cows)
d) Only as many as needed
e) None – purchase replacements
f) Combination of several of the above

Factors impacting heifer replacement decisions

1. Number of heifers needed annually
   - Herd replacement rate (static herd size)
   - Herd expansion plans (growth)
   - Heifer raising program (mortality, growth rates, etc.)
2. Number of heifers produced annually
   - Reproduction program (pregnancies, type of semen, etc.)
3. Costs of raising a heifer
   - Available alternatives (e.g., home raised, custom growers, etc.)

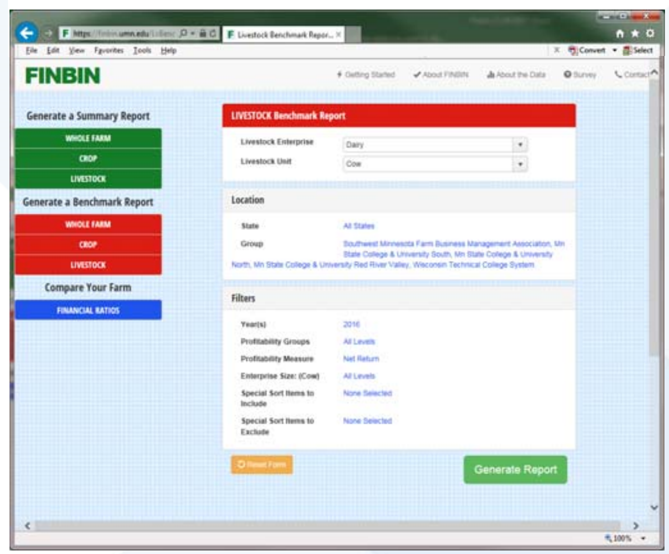
A few important economic concepts…

- Variable vs. fixed costs
  (economies of size (scale) is related to fixed cost)
- Short run vs. long run
- Cash vs. economic costs (P&I pmt vs depreciation)
- Price = cost (implies profit = $0)
  (on average, in the long run, in competitive industries)
- Marginal revenue > marginal cost
  (decision rule for profit maximization)
- Partial budget vs. whole-farm analysis
- Time value of money
- Comparative advantage, revealed preference, time & wealth

Economic concepts with actual data

Examples of historical dairy returns

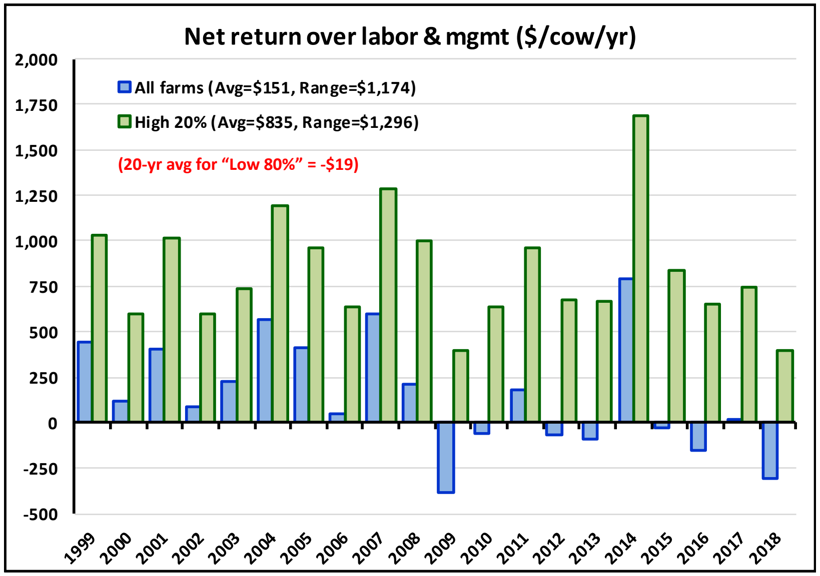
Historical returns to dairy operations



Benchmark reports for Dairy from 1999-2018 by profitability group.

High 20% vs All (by year)

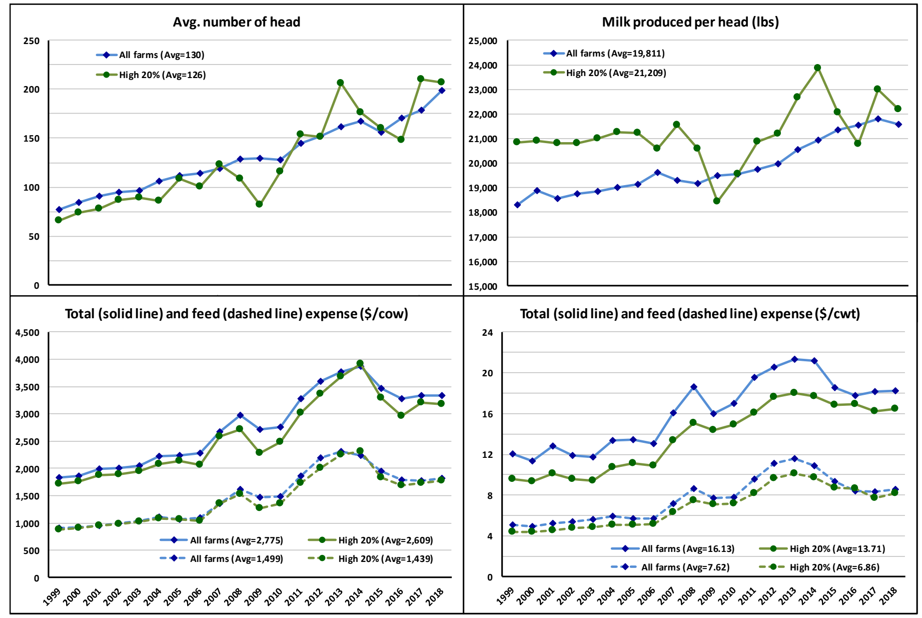
https://finbin.umn.edu/LvBenchOpts/LvBenchIndex



Source: FINBIN Livestock Benchmark Report for Dairy (Cow); MN and WI Groups, Years 1999-2018, Various Profitability Groups. https://finbin.umn.edu/LvBenchOpts/LvBenchIndex accessed 8/23/19.

EM-US-19-0204

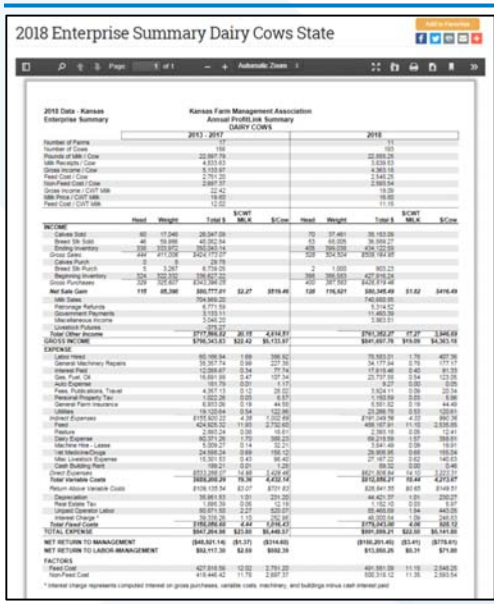
Dairies in Top 20% similar size, considerably more productive and have lower costs per cow and per/cwt



Source: FINBIN Livestock Benchmark Report for Dairy (Cow); MN and WI Groups, Years 2007-2016, Various Profitability Groups. https://finbin.umn.edu/LvBenchOpts/LvBenchIndex accessed 8/23/19.

EM-US-19-0204

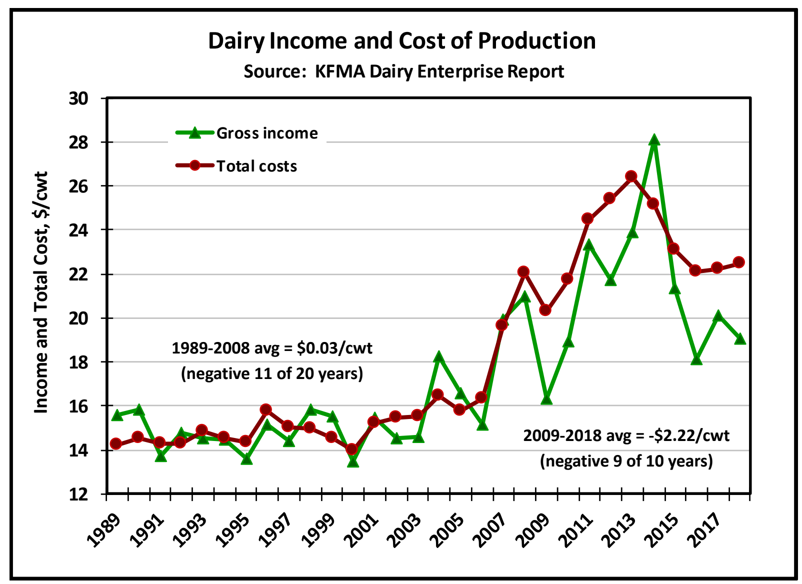
Historical returns to dairy operations



Annual Dairy Enterprise Reports covering years 1989-2018

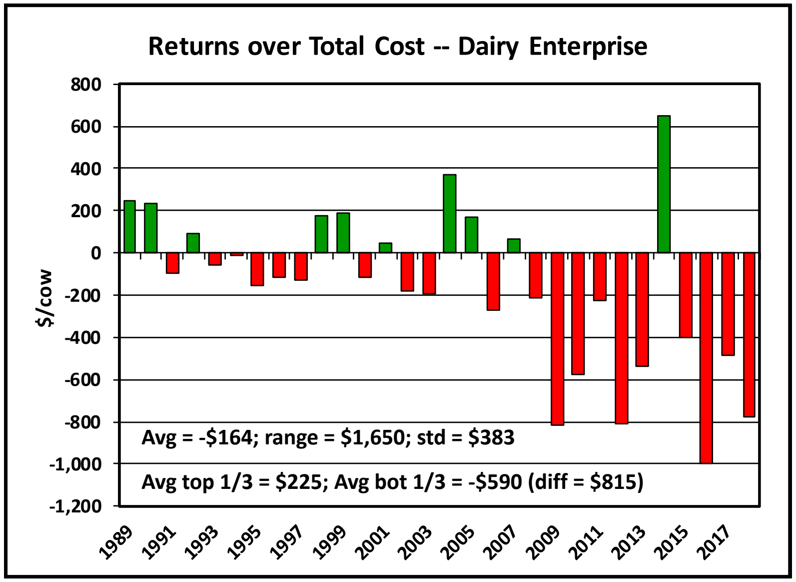
Reports from 1995-2018 available at https://agmanager.info/kfma

EM-US-19-0204



Kansas Farm Management Association (KFMA) Enterprise Summaries for years 1995-2018 available at http://agmanager.info/kfma. Accessed 6-18-2019.

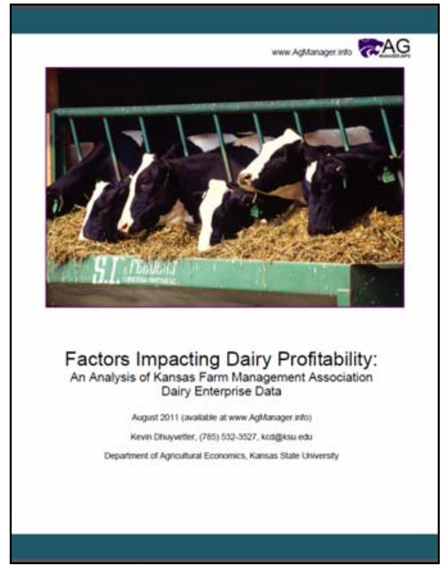
EM-US-19-0204



Source: Kansas Farm Management Association (KFMA) Enterprise Report (various years) available at http://agmanager.info/kfma. Accessed 6-18-2017.

EM-US-19-0204

Historical returns to dairy operations



Analysis of 2005-2010 Kansas Farm Management Association Enterprise Reports

Comparison by profit category based on individual farms multi-year average (high, mid, and low thirds)

Available at http://www.agmanager.info/node/7139. Accessed 28 Dec 2016

EM-US-19-0204

Dairy enterprise measures among high, medium, and low profit groups ($/cow)*

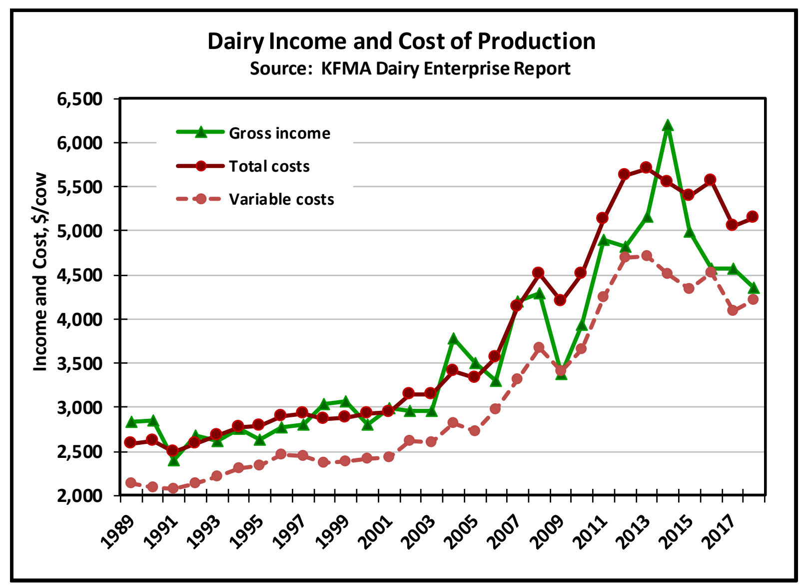
Item	All Farms	Profit Category High 1/3	Mid 1/3	Low 1/3	Diff. between High 1/3 & Low 1/3 Absolute	%
Number of Farms	38	13	12	13		
Number of Cows in Herd	114	133	120	90	44	49%
Cull rate, %	26.0	24.27	30.78	23.44	0.83	4%
Pounds of milk/cow	20,326	22,788	19,655	18,482	4,307	23%
Milk price, $/cwt	$16.29	$16.36	$16.39	$16.15	$0.21	1%
Milk sales, $/cow	3,292	3,720	3,206	2,944	776	26%
Other income, $/cow	321	400	285	277	123	44%
Gross Income	$3,613	$4,119	$3,491	$3,220	$899	28%
Feed	$1,888	$1,956	$1,839	$1,864	$92	5%
Labor	652	555	636	765	-210	-27%
Vet	110	129	93	108	20	19%
Dairy supplies	292	320	265	288	32	11%
Other	1,022	988	958	1,116	-128	-11%
Total Cost	$3,964	$3,948	$3,790	$4,142	-$194	-5%
Net Return to Management	-$351	$172	-$300	-$922	$1,094	

* Sorted by Net Return to Management (Returns over Total Costs) per Cow (min of 4 years of 2005-2010)

Compared to $815 between high/low years (82% income and 18% cost)

Dhuyvetter, K. 2011. Factors Impacting Dairy Profitability: An Analysis of Kansas Farm Management Association Dairy Enterprise Data." Kansas State Department of Agricultural Economics Report. August 2011

EM-US-19-0204



Kansas Farm Management Association (KFMA) Enterprise Summaries for years 1995-2018 available at http://agmanager.info/kfma. Accessed 6-18-2019.

EM-US-19-0204

Historical returns summary

- When examining information, it is important to understand how costs are defined
- If fixed costs are excluded from analysis, results will show less advantage to size of operation
- Non-cash costs (e.g., management, depreciation, etc.) are typically "fixed"
- Opportunity costs (e.g., market value of feed, labor, etc.) are important to consider when analyzing enterprises
- Excluding non-cash costs in the short run for decision making is okay, but remember this is not sustainable in the long run

EM-US-19-0204

Estimating the cost per heifer raised

Assumptions used in the model:

- Newborn heifer value, $/hd 100
- Birth weight, lb/hd 88
- Breeding weight, lb/hd 884
  (57% of mature weight & 51" WH)
- Labor, $/hr 15.00
- Interest, % 6.0
- AI cost, $/service 18.00
- Large dairy using hutches, 100% milk replacer, indoor housing, and TMR feeding
- Percent of heifers ultimately calving 86.2%
  (due to mortality of 7.3% and 6.5% repro culls)

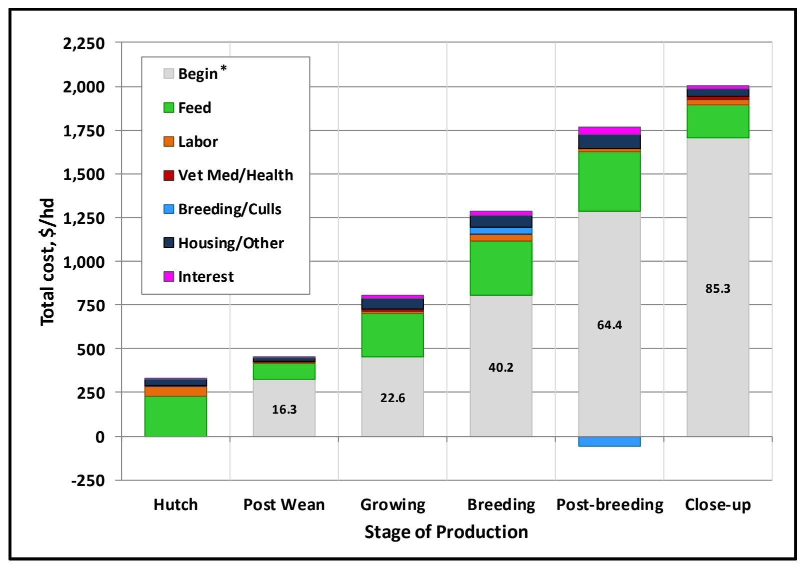
EM-US-19-0204

Cost of raising a heifer -- Baseline

	Baseline						
Stage of Production	Hutch	Post Wean	Growing	Breeding	Post-breeding	Close-up	Total
Age in months	Birth to 2	2 to 4	4 to 10	10.0-15.7	15.7-21.4	21.4-23.4	Birth - 23.4
Colostrum|Milk*	182.11						
Starter*	20.19						
Grain*		74.49					
Hay*		5.67					
Feed (TMR)*			231.01	287.74	338.43	185.37	
Total Feed*	$202.31	$80.16	$231.01	$287.74	$338.43	$185.37	**$1,402**
Labor*	47.92	10.49	12.29	33.43	14.43	31.12	**$160**
Vet Med/ Health*	10.22	2.36	8.03	2.89	2.65	16.15	**$45**
Breeding & Culls*	0.00	0.00	0.00	35.87	-57.90	0.00	**-$19**
Housing and Other*	29.31	18.26	56.09	61.12	79.55	44.30	**$304**
Interest*	1.39	3.47	16.68	26.28	39.42	17.12	**$109**
Total Cost*	**$291**	**$115**	**$324**	**$447**	**$417**	**$294**	**$2,001**
Cost/ Day*	**$4.85**	**$1.86**	**$1.77**	**$2.57**	**$2.43**	**$4.83**	**$2.81**
Entering Weight (lbs)	85	192	325	702	1,037	1,341	**85**
Exit Weight (lbs)	192	325	702	1,037	1,341	1,443	**1,443**
Average daily gain (lbs)	1.78	2.17	2.06	1.92	1.77	1.68	
Cumulative ADG (lbs)	1.78	1.97	2.03	1.99	1.93	1.91	**1.91**
Cumulative from birth							
Total Cost*	**$291**	**$411**	**$740**	**$1,191**	**$1,701**	**$2,001**	**$2,001**
Cost/ Day*	**$4.85**	**$3.38**	**$2.43**	**$2.49**	**$2.62**	**$2.81**	**$2.81**
Cost Including Wet Calf*	**$396**	**$519**	**$852**	**$1,307**	**$1,829**	**$2,131**	**$2,131**

EM-US-19-0204

Baseline cost of raising a heifer



* Values in gray bars represents the percent of total costs incurred up to that stage of production (e.g., 64.4% of the total cost of raising a heifer is incurred through breeding stage).

EM-US-19-0204

Sensitivity analysis of total cost of raising a heifer

Calf price, $/head	Feed Cost Adjustment: -25%	-10%	0%	10%	25%
$50	1,754	1,941	2,066	2,191	2,378
$75	1,786	1,974	2,098	2,223	2,411
$100	1,819	2,006	**2,131**	2,256	2,443
$150	1,884	2,071	2,196	2,321	2,508
$200	1,949	2,136	2,261	2,386	2,573

At a calf price of $100/head, total cost varies by $624/head as feed costs vary by +/- 25%.

How are home-raised feedstuffs valued?

Housing adjustment, %	Labor cost, $/hr: $9	$12	$15	$18	$21
25%	$1,805	$1,842	$1,878	$1,915	$1,952
50%	$1,881	$1,918	$1,954	$1,991	$2,028
75%	$1,965	$2,002	$2,039	$2,075	$2,112
100%	$2,058	$2,094	**$2,131**	$2,168	$2,204
125%	$2,158	$2,195	$2,232	$2,268	$2,305

At a labor cost of $15/hr, total cost varies by $353/head as housing cost assumption varies.

If fixed and/or non-cash costs are excluded, is this appropriate?

Facility Type	Housing Type: Drylot	Indoor housing	Pasture
Calf Ranch	$1,865	$2,095	$1,843
Large Dairy	$1,901	**$2,131**	$1,880
Small Dairy	$2,169	$2,399	$2,148

Cost varies by $556/head depending upon facility & housing type (and related assumptions).

How are fixed costs of facilities and equipment handled?

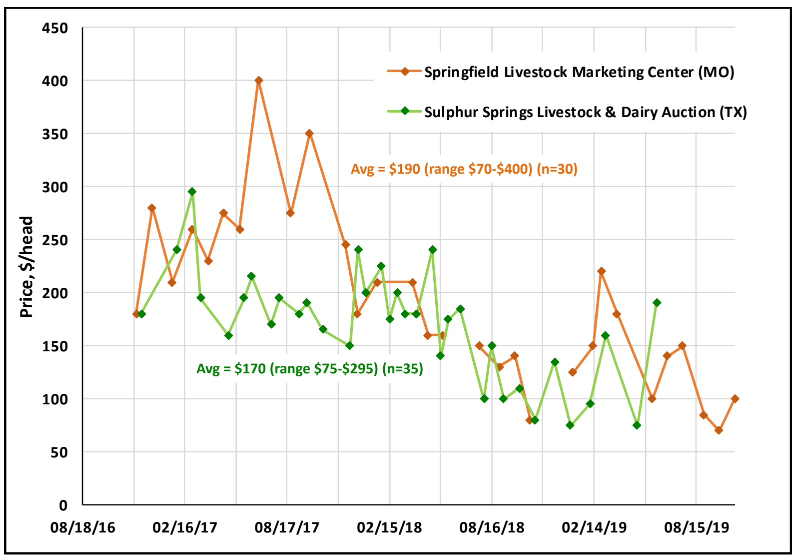
EM-US-19-0204

Factors impacting heifer replacement decisions

1. Number of heifers needed annually
   - Herd replacement rate (static herd size)
   - Herd expansion plans (growth)
   - Heifer raising program (mortality, growth rates, etc.)
2. Number of heifers produced annually
   - Reproduction program (pregnancies, type of semen, etc.)
3. Costs of raising a heifer
   - Available alternatives (e.g., custom growers, purchase springers, etc.)
4. Heifer market prices
   - Current vs long-run, at various stages of growth (calf → springer)

EM-US-19-0204

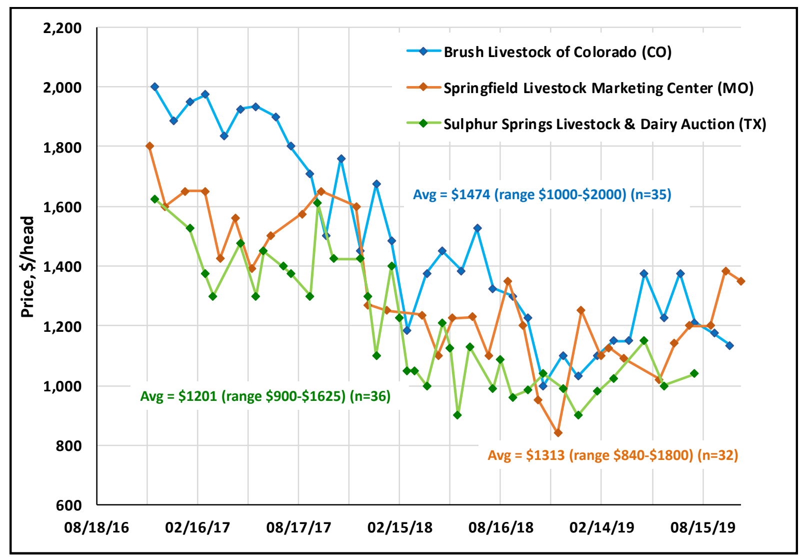
Price of heifer calves*



* Source: Complied from Progressive Dairy Market Watch (https://www.progressivedairy.com/magazine) last accessed on 12/10/19

EM-US-19-0204

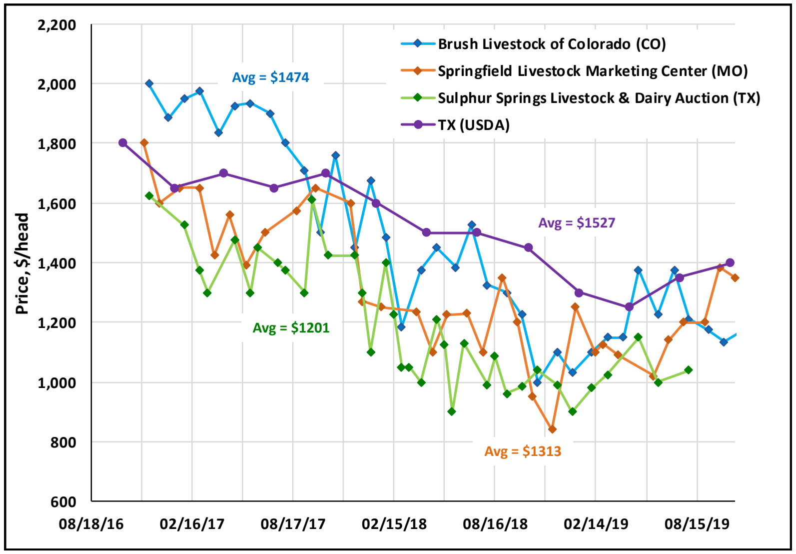
Price of top springers*



* Source: Complied from Progressive Dairy Market Watch (https://www.progressivedairy.com/magazine) last accessed on 12/10/19

EM-US-19-0204

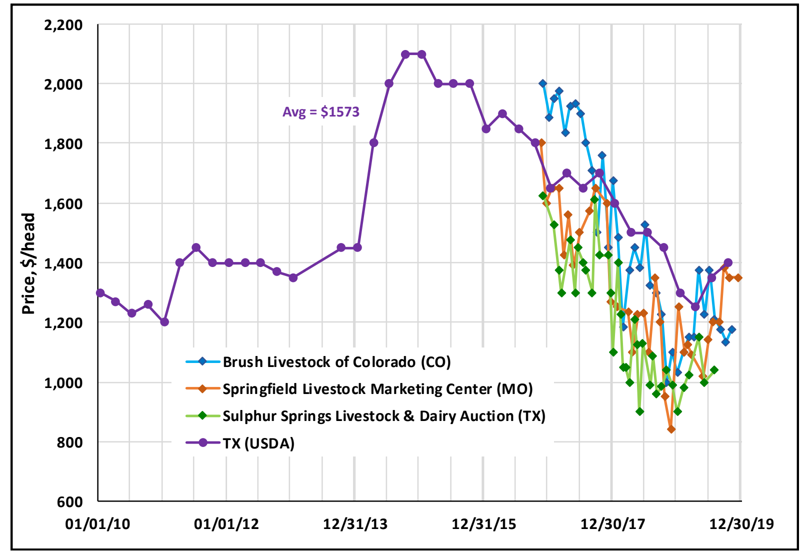
Price of top springers*



* Source: Complied from Progressive Dairy Market Watch (https://www.progressivedairy.com/magazine) and USDA Quick Stats (https://quickstats.nass.usda.gov/) last accessed on 2/17/20

EM-US-19-0204

Price of top springers*



* Source: Complied from Progressive Dairy Market Watch (https://www.progressivedairy.com/magazine) and USDA Quick Stats (https://quickstats.nass.usda.gov/) last accessed on 2/17/20

EM-US-19-0204

Factors impacting heifer replacement decisions

1. Number of heifers needed annually
   - Herd replacement rate (static herd size)
   - Herd expansion plans (growth)
   - Heifer raising program (mortality, growth rates, etc.)
2. Number of heifers produced annually
   - Reproduction program (pregnancies, type of semen, etc.)
3. Costs of raising a heifer
   - Available alternatives (e.g., custom growers, purchase springers, etc.)
4. Heifer market prices
   - Current vs long-run, at various stages of growth (calf → springer)

Based on heifer raising costs of ~$1800-2100/hd and historical average springer values, raising heifers to springers with intention of selling for a profit is questionable.

EM-US-19-0204

Factors impacting heifer replacement decisions

1. Number of heifers needed annually
   - Herd replacement rate (static herd size)
   - Herd expansion plans (growth)
   - Heifer raising program (mortality, growth rates, etc.)
2. Number of heifers produced annually
   - Reproduction program (pregnancies, type of semen, etc.)
3. Costs of raising a heifer
   - Available alternatives (e.g., custom growers, purchase springers, etc.)
4. Heifer market prices
   - Current vs long-run, at various stages of growth (calf → springer)
5. Which heifers to sell, and which heifers to keep

EM-US-19-0204

Factors impacting heifer replacement decisions

1. Number of heifers needed annually
2. Number of heifers produced annually
3. Costs of raising a heifer
4. Heifer market prices
5. Which heifers to sell, and which heifers to keep

Selectively culling heifers

a) Random?
b) Use genomic data?
c) Use performance data?
d) How does this impact costs of raising other heifers?
e) Is this economical?

Estimating the cost per heifer raised – Culling excess

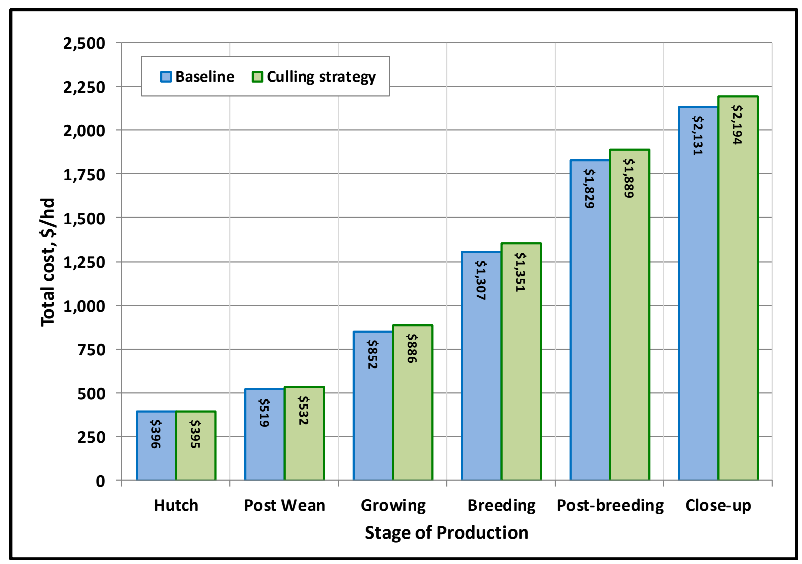
Assumptions used in the model:

- Same baseline assumptions as before
- Same mortality risk by stage
- Performance culls after weaning 5.0%
- Performance culls after grower 4.2%
- Percent of heifers ultimately calving 77.8%
  (due to mortality of 7.1%, 5.9% repro and 9.2% performance culls)
- Assumed labor costs had a fixed and variable component, but housing costs were completely fixed.
- Cull values based on projected body weight at time of culling and market values for Holstein heifers.

Cost of raising a heifer – Culling strategy

	Culling strategy						
Stage of Production	Hutch	Post Wean	Growing	Breeding	Post-breeding	Close-up	Total
Age in months	Birth to 2	2 to 4	4 to 10	10.0-15.7	15.7-21.4	21.4-23.4	Birth - 23.4
Colostrum|Milk*	182.11						
Starter*	20.19						
Grain*		75.43					
Hay*		5.75					
Feed (TMR)*			231.88	287.83	338.55	185.28	
Total Feed*	$202.31	$81.18	$231.88	$287.83	$338.55	$185.28	**$1,433**
Labor*	47.37	10.78	12.94	35.18	14.87	31.66	**$170**
Vet Med/ Health*	10.22	2.49	8.43	2.90	2.65	16.14	**$47**
Breeding & Culls*	0.00	-11.37	-14.58	35.89	-58.28	0.00	**-$49**
Housing and Other*	29.31	19.27	62.12	67.72	88.22	49.08	**$337**
Interest*	1.39	3.58	17.40	27.00	40.46	17.54	**$112**
Total Cost*	**$291**	**$106**	**$318**	**$457**	**$426**	**$300**	**$2,050**
Cost/ Day*	**$4.84**	**$1.72**	**$1.74**	**$2.62**	**$2.49**	**$4.92**	**$2.88**
Entering Weight (lbs)	85	192	325	702	1,037	1,341	**85**
Exit Weight (lbs)	192	325	702	1,037	1,341	1,443	**1,443**
Average daily gain (lbs)	1.78	2.17	2.06	1.92	1.77	1.68	
Cumulative ADG (lbs)	1.78	1.97	2.03	1.99	1.93	1.91	**1.91**
Cumulative from birth							
Total Cost*	**$291**	**$418**	**$762**	**$1,223**	**$1,746**	**$2,050**	**$2,050**
Cost/ Day*	**$4.84**	**$3.44**	**$2.50**	**$2.55**	**$2.69**	**$2.88**	**$2.88**
Cost Including Wet Calf*	**$395**	**$532**	**$886**	**$1,351**	**$1,889**	**$2,194**	**$2,194**

Cost of raising a heifer – Baseline vs Culling strategy



Factors impacting heifer replacement decisions

1. Number of heifers needed annually
2. Number of heifers produced annually
3. Costs of raising a heifer
4. Heifer market prices
5. Which heifers to sell, and which heifers to keep

Based on assumptions used, culling "extra" heifers results in cost of springer increasing (i.e., cull revenue was less than cost incurred up to point of culling and fixed costs diluted over fewer animals)

Based on an analysis of two herds, when culling was based on heifer growth (ADG) and genetics (PTAM), subsequent milk in first lactation was increased for remaining heifers. However, value of increased milk was not sufficient to offset the increased cost (data not shown).

Summary

- There is a wide range of profitability across dairies (variability across dairies at a point in time > than average across time)
- This wide variability likely exists with regards to cost of raising replacement heifers as well
- Many factors impact how many heifers are needed and produced annually (also varies considerably across dairies)
- Producing and raising more heifers than are needed as replacements on a given dairy, generally will not be profitable
- Identifying an "optimal replacement heifer strategy" is complex due to the many variable factors. However, having an accurate estimate of the cost of raising a heifer by stage of production is critical for making informed decisions.

Questions / Discussion

Thank You

Kevin Dhuyvetter, Ph.D.

(785) 410-3244

kdhuyvetter@elanco.com

Practical Pain Management on Dairies

Michael Kleinhenz, DVM, Ph.D.
Kansas State University

Introduction

Disbudding occurs on a large proportion of dairy farms. This practice has been associated with pain and activation of the neuroendocrine system. Both the AVMA and AABP recommend disbudding as early as possible in conjunction with pain mitigation drugs. New standards in the 4th Version of the FARM Animal Care Program have made these practices mandatory for participating dairies. Disbudding can be accomplished by either cautery methods (hot-irons); or the use of caustic pastes (eg. Dr. Naylor® Dehorning Paste). Both methods have been shown to cause pain, discomfort, and activation of the neuroendocrine system. Using a local anesthetic block combined with a non-steroidal anti-inflammatory drug (NSAID) provides optimum pain relief following the procedure.

Drugs for pain mitigation

****The listing of analgesic drug options presented here are by prescription only. Each individual facility will have to work with the veterinarian on record to obtain these medications; and to develop protocols for use as prescribed under their VCPR.****

Dehorning stress reduction

Disbudding has been shown to be a stressor to calves. Measures of the calf's immune system have shown that disbudding increases white blood cell numbers and lowers their reaction to inflammation. Providing analgesia in the forms of a local anesthetic block and NSAID attenuate these changes. Furthermore, it is recommended that disbudding not occur at times of stress such as transport and /or weaning as these stresses can be additive leading to increased risk of illness.

Local anesthetics

Local anesthetics function by blocking sodium channels within the nerve cells preventing the conduction and transmission of the pain signal. Blocking the nerve transmission to a region desensitizes the region, and prevents the pain sensation caused by heat or chemical burn of caustic pastes from being felt. Lidocaine is the most common local anesthetic used on farms, and will be the only medication discussed in this section. Lidocaine has a rapid onset of action and provides approximately 90 minutes of desensitization. Local anesthetic block using lidocaine is effective, inexpensive and safe. For cautery disbudding, allowing 5-10 minutes between lidocaine injection and the dehorning procedure will ensure the drug has had time to take effect. For producers that prefer caustic paste disbudding, lidocaine can be administered at the time of paste application. The use of lidocaine makes the task of disbudding easier for the calf and farm staff performing the procedure.

The cornual nerve provides innervation to the horn-bud region. The horn-bud and surrounding region can be desensitized by injecting 4-5 mL of lidocaine along the cornual nerve. Local anesthetic block of the cornual nerve can be easily performed using anatomic landmarks on the calf's head. The cornual nerve lies under the frontal ridge, which is a boney structure of the skull that travels between the eye and horn (**Fig. 1**). It can be readily palpated by passing a finger between the eye and horn. Placement of the lidocaine injection half-way between the eye and horn; and under the frontal ridge is the desired target for placement of a local anesthetic block. **Figure 2** provides step-by-step procedures to properly perform local anesthetic block of the cornual nerve for disbudding. It is recommended to work with your veterinarian for training on how to perform this quick, easy, and important technique.

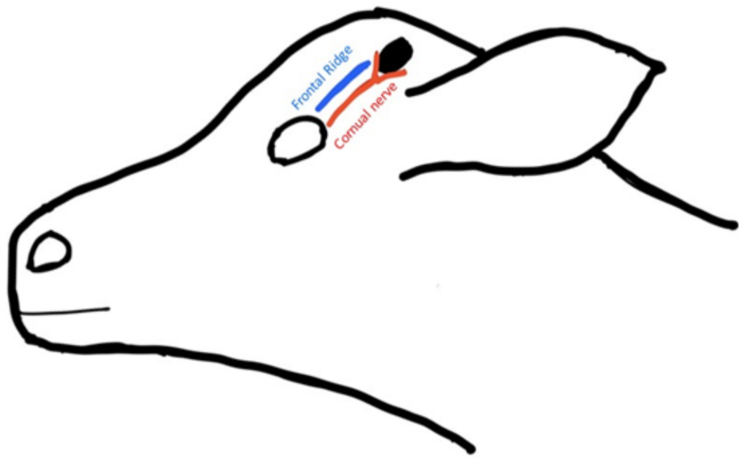


Figure 1. Anatomic location of the cornual nerve (red) and fontal ridge (blue)

Figure 2. Steps for providing local anesthetic for disbudding using a cornual nerve block. (A) Palpation of the temporal ridge and insertion of the needle below the ridge; (B) Inject 5 mL of lidocaine into the area.

Non-Steroidal Anti-inflammatory drugs

Non-steroidal anti-inflammatory drugs (NSAIDs) are an attractive option for pain management as they are relatively safe, have a relatively long duration of action, and do not cause sedation in calves. Currently, there are no FDA approved NSAIDs labelled for disbudding pain control. The use of NSAIDs for disbudding pain control are considered an extra-label drug use (ELDU), and can be used under AMDUCA with a valid VCPR (required by the FARM Program). Even though there are no approved NSAID options, there has been a large body of research work that supports their use for both cautery (hot-iron) and caustic paste disbudding. Additionally, NSAIDs and local anesthetic blocks work synergistically in providing analgesia to calves.

Flunixin and meloxicam are the only two NSAIDs that will be discussed for disbudding analgesia at this time. Both have a substantial body of research supporting their use along with information to comply with AMDUCA. The duration of action, ease of use, and costs associated with each drug differs.

Flunixin

Flunixin is a NSAID with FDA approval in the United States and is available in an injectable or transdermal formulation. The injectable formulation is labeled for intravenous injection only for treatment and control of pyrexia (fever) and endotoxemia. Giving injectable flunixin by intramuscular (IM) or subcutaneous (SQ) injection has been proven to be painful and cause significant tissue damage. Due to its short-lived analgesic effects and the need for intravenous injection, it is not recommended as a disbudding analgesic.

Transdermal flunixin is designed as a topical pour-on medication and is FDA approved for foot rot pain control. Transdermal flunixin is rapidly absorbed across the skin and has anti-inflammatory effects that last for 30-48 hours. Following cautery dehorning, transdermal flunixin lowered cortisol concentrations and improved central sensitization. Transdermal flunixin is recommended to be used at the label dose of 3 mL per 100 pounds, poured along the top-line.

Meloxicam

Meloxicam is a NSAID with approvals for pain control at disbudding in Canada and European Union. Under AMDUCA regulations oral meloxicam can be prescribed under a valid VCPR for pain control at disbudding. Human meloxicam tablets are typically prescribed as they are relatively inexpensive and can be administered orally. Meloxicam tablets are readily absorbed by cattle of all ages including pre-weaned calves. Research supports meloxicam use for disbudding analgesia. Meloxicam has been shown to increase mechanical nociception threshold measures when given at the time of dehorning indicating increased tolerance to painful stimuli. Meloxicam has also been shown to lower cortisol and substance P (a biomarker for pain) in calves following disbudding. The recommended dose for meloxicam is 1 mg/kg. This translates into using three 15 mg tablets of the human generic per 100 pounds body weight. It is advised to work with your veterinarian on dosing strategies. This will ensure proper dosing as well as employee compliance.

Take-Home Messages

- Disbud only healthy calves
- Avoid disbudding at the time of other stresses such as weaning or moving
- Implement the use of local anesthetic blocks and other pain relieving medications
- Work with you veterinarian to develop protocols and SOP’s to ensure every calf benefits from proper drug administration and timing
- Ensure employees are comfortable and trained in performing disbudding task.

A STATE VETERINARIAN'S EXPERIENCE WITH, AND PERSPECTIVE ON RECENT TB CASES

Ralph Zimmerman, DVM
New Mexico State Veterinarian
New Mexico Livestock Board

OBJECTIVES

1. Discuss the importance of zoonotic diseases
2. Determine the modes of transmission
3. Assess the risk of exposure
4. Discuss the importance of pasteurizing milk

IMPORTANCE OF ZOONOTIC DISEASES

- Zoonotic disease: an infection or disease that is transmissible between animals and humans. When transmitted to animals from humans, it may be called a reverse zoonosis, or anthroponosis.
- Extensive list of diseases
- A zoonotic agent may be bacterial, viral, parasitic or fungal
- According to the CDC, 6 of 10 known infectious diseases in people are spread from animals, and 3 out of every 4 new or emerging infectious diseases in people are spread from animals

MODES OF TRANSMISSION

Direct contact: Contact with saliva, blood, urine, nasal secretions, feces or other body fluids of an infected animal.

Indirect contact: Contact with areas where animals live and roam or objects/surfaces that have been contaminated with germs (e.g. aquarium tank water, pet habitats, coops, plants, soil, food and water dishes).

Vectorborne: Mosquito, tick, flea or other vector bite.

Foodborne: Ingestion of unpasteurized milk, undercooked meat and eggs or unwashed fruits and vegetables that are contaminated with feces from an infected animal

Affects mostly cattle, can be transmitted to other warm-blooded animals.
Agent: *Mycobacterium bovis*

Clinical signs in animals: difficult to diagnose on clinical signs alone.

- Early stage: no clinical signs
- Late stage: emaciation, lethargy, weakness, anorexia, low-grade fever, and pneumonia with a chronic, moist cough. Lymph nodes may be enlarged

Mode of Transmission:

- Through saliva of infected animals and spread through airborne particles from the respiratory tract.
- Feed or watering sites contaminated with saliva, urine, and manure
- Drinking raw, unpasteurized milk from infected animals.

Risk of exposure is greatest in enclosed areas, such as barns with poor ventilation and milking parlors.

BOVINE TB

TB can be introduced into a herd by infected animals or people. Such as:

- Purchase of or exposure to infected cattle
- Exposure to infected free-ranging wildlife
- Exposure to infected people

Clinical signs in humans:

- Active form: chronic cough, bloody sputum, fever, weight loss
- Latent form: no clinical signs

Risk: Approx. 33% of the world's population is infected with TB. New infections occur in about 1% of the population each year (WHO, 2002).

Human transmission: coughing, sneezing, speaking, singing or spitting. One sneeze releases up to 40,000 droplets. Each droplet may transmit the disease: the inhalation of less than 10 bacteria may cause an infection (Nikas et al. 2005).

BOVINE TB

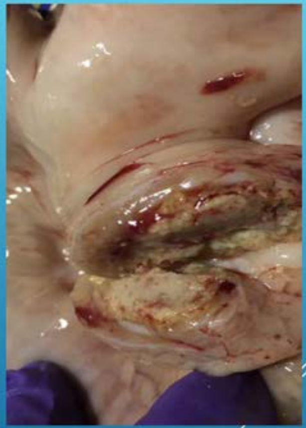
Minimize the Risk

- Keep a closed herd and raise replacement stock.
- Buy animals from an accredited TB-free herd.
- Test new animals prior to purchase, isolate them for 60 days and retest before commingling.
- Restrict/eliminate contact between your herd and other herds.
- Disinfect trailers or facilities that housed newly purchased animals or animals not originating from your herd.
- Keep on-farm visitors away from your herd.
- Keep fences in good condition to separate your herd from wildlife.
- Have a comprehensive new employee hiring protocol that includes TB testing.

BOVINE TB

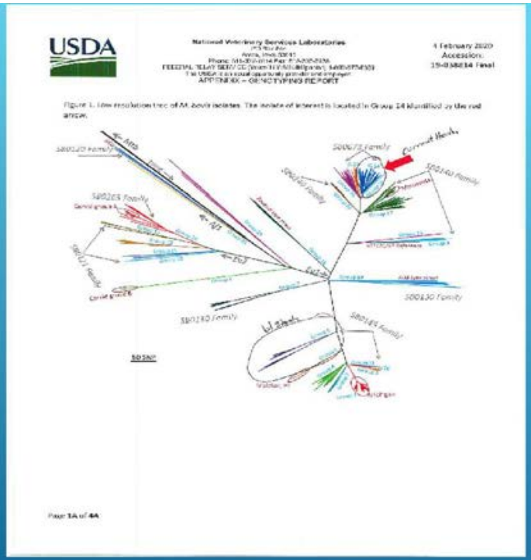
Young calf that ingested unpasteurized milk from an M. bovis positive cow. Intestinal lymph node with pyogranulomatous TB lesion.

115 head of young calves(+) caudal fold test. 12 calves thoracic lesions, 37 calves abdominal lesions,2 calves thoracic and abdominal lesions, 1 calf head and abdominal lesions, and 1 calf head and thoracic lesions.



BOVINE TB

THORACIC LYMPH NODE ON LEFT, ABDOMINAL ON RIGHT



- Take Home Messages!
- Educate yourself and your staff.
- Test all new employees for TB before they start. Test annually.
- Do not allow your employees to drink raw milk.

QUESTIONS?

Cosivi O., Meslin E-X., Daborn C.J. & Grange J.M. (1995). Epidemiology of Mycobacterium bovis infection in animal and humans, with particular references to Africa. *Rev. Sci. Tech. Off.int. Epiz.*, **14** (3), 733-746.

Dankner W.M. & Davis C.E. (2000). Mycobacterium bovis as a Significant Cause of Tuberculosis in Children Residing Along the United States-Mexico Border in the Baja California Region. *Pediatrics*, **105**, 79. doi:10.1542/peds.105.6.e79

Evans J.T., Smith G.E., Banerjee A., Smith R.M.M., Dale J., Innes J.A., Hunt D., Tweddell A., Wood A., Anderson C., Hewinson G.R., Smith N.H., Hawkey P.M. & Sonnenberg P. (2007). Cluster of human tuberculosis caused by Mycobacterium bovis: evidence for person-to-person transmission in the UK. *Lancet,* **369**, 1270-76. Retrieved from http://www.thelancet.com/

Olea-Popelka F., Muwonge A., Perera A., Dean A.S., Mumford E., Erlacher-Vindel E., Forcella S., Silk B.J., Ditiu L., Idrissi A.E., Raviglione M., Cosivi O., LoBue P. & Fujiwara P.I. (2017). Zoonotic tuberculosis in human beings caused by Mycobacterium bovis—a call for action. *Lancet Infect Dis,* **17,** e21-25. Retrieved from http://www.thelancet.com/infection/

Pugh, D.G. (2002). *Sheep & Goat Medicine* (1st ed.). Philadelphia, PA: W.B. Saunders Company.

Torres-Gonzalez P., Soberanis-Ramos O., Martinez-Gamboa A., Chavez-Mazari B., Barrios-Herrera M.T., Torres-Rojas M., Cruz-Hervert L.P., Garcia-Garcia L., Singh M., Gonzalez-Aguirre A., Ponce de Leon-Garduno A., Sifuentes-Osornio J. & Bobadilla-del-Valle M. (2013, April). Prevalence of Latent and Active Tuberculosis among Dairy Farm Workers Exposed to Cattle Infected by Mycobacterium Bovis. *PLOS Neglected Tropical Diseases,* **7**(4), e2177. Retrieved from http://www.plosntds.org/

REFERENCES

COMPEER FINANCIAL

NO COWS ARE SACRED, BUT ALL COWS HAVE A SACRED TIME

Steve Bodart
Sr Dairy Consultant
March 3, 2020

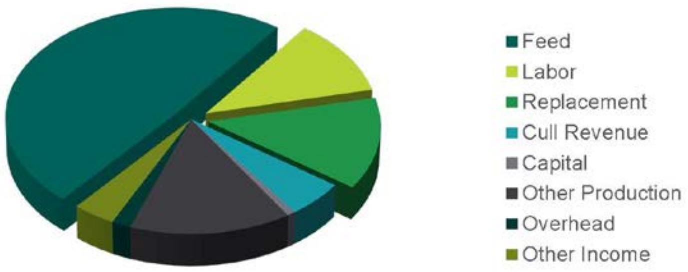
HISTORICAL MARGINS

NFI, $/cwt ECM (by accounting year)

- Net Farm Income Average: $0.84; Range ($6.34) - $8.39
- Farm and year accounted for 71% of variation in profit

SOME GOOD, SOME BAD YEARS; 2015 - 2018 WERE NOT PROFITABLE

COST OF PRODUCTION



Definition: The milk price necessary to cover all costs associated with the production of milk. It maintains the dollars of net worth of the business. Cost of production includes all operating costs, interest and management level depreciation minus non milk revenue. Cost of production does not include principal payments or capital purchases. The cost of production will be divided by the energy corrected milk production for that period to determine the cost of production/cwt.

SUCCESSFUL MANAGEMENT → OPPORTUNITY

- **Successful dairy management can create opportunities to manage heifer inventory more effectively**
- **Strong reproduction, calving and calf health programs can create excess heifer inventory**
- **How do we manage this inventory as efficiently as possible to ensure that retained replacements represent a wise investment in the herds future?**

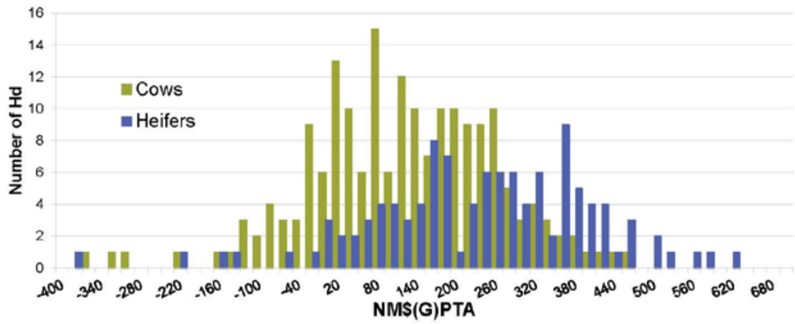
OPTIMAL INVENTORY MANAGEMENT

- Replacements coming in
  - Number
  - Quality
  - Development cost

» **Herd Removals**
- Number
- Timing
- Cull value
- Type
  - Voluntary
  - Involuntary
  - Size of heifer inventory

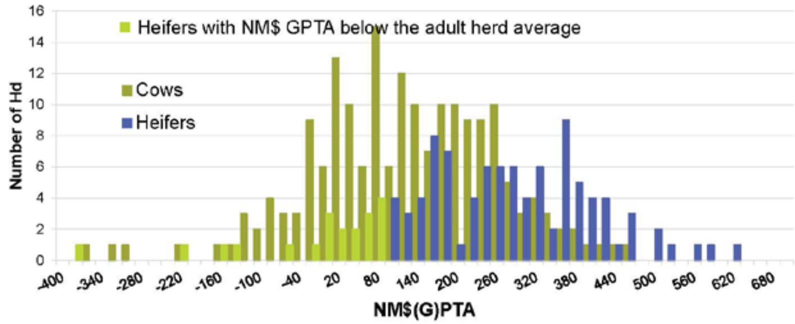
GENETIC PROGRESS AND HEIFER RETENTION

- On average, heifers should have greater genetic merit than cows in traits under selection, but not all heifers are better than the cows already in the herd



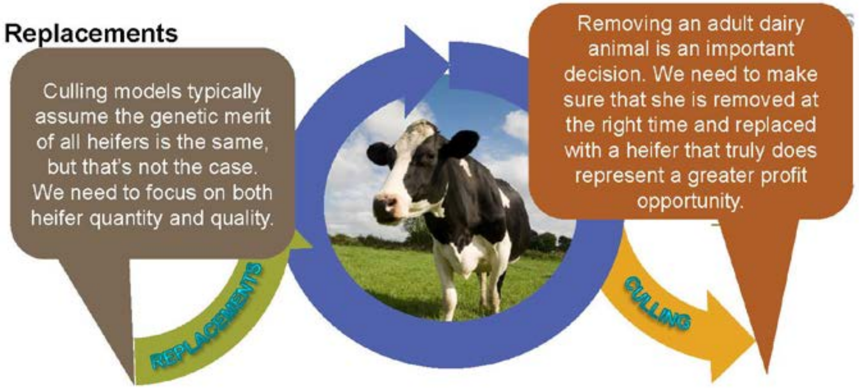
ATTENTION TO QUALITY

- On average, heifers should have greater genetic merit than cows in traits under selection, but not all heifers are better than the cows already in the herd



OPTIMAL INVENTORY MANAGEMENT

Replacements



HEIFER RAISING COST RECOVERY

Assumptions:

- **Average profit per mature cow is $500/year or $2.00/cwt of milk**

- **Average cull cow is worth $650**
  - (net of death loss)

- **Average offspring is valued at $100**
  - (bull at $75, heifer at $35, 8% DOA)

HEIFER RAISING COST RECOVERY

A cow must produce over 44,000 pounds before she has covered her raising costs and her ongoing cost of production and is adding to the profitability of the operation.

On average, this cow is in her 2nd lactation.

QUANTIFYING ECONOMICS OF TURNOVER DECISIONS

- **Historically replacement cost and cull revenue have been looked at as two independent factors when evaluating cost of production**
- **Problem: THERE ARE NO SACRED COWS**
  - Eventually every cow will be removed from the herd and needs to be replaced
  - To many assume that a low cull rate is good and a high cull rate is bad
  - High cull values seduce people to believe turnover is not expensive
  - To many base cull rate on available heifer inventory

- **Goal: Remove the right cow at the right time to minimize the negative impact that turnover has on the cost of production while maximizing the return on investment**
- **How do you quickly evaluate the cost of turnover in your herd?**

NET HERD TURNOVER COST

$$\frac{((\#\text{ of Animals Removed} \times \text{Balance Sheet Value}) - \text{Cull Cow Income})}{\text{cwt. of Energy Corrected Milk}}$$

Total Number of Animals Removed- this includes mortalities, involuntary and voluntary culls and dairy sales from the adult herd
Balance Sheet Value- this reflects the value of the adult animals in the herd and approximates the cost associated with raising heifers
Cull Cow Income- this is the salvage value received from culls and dairy sales; mortalities receive $0
Herd Milk Production- level of energy corrected milk production sold in cwt during period being evaluated

NET HERD TURNOVER COST

1000 cow herd scenario → 80 lb ECM average

Utilizing All Replacement Heifers		
43%	Turnover Rate	
8%	Death Loss	
$650	Average Cull Cow Income	
430	Total Number of Removals	
80	Dead Cows	
350	Cull Cows	
$227,500	Cull Cow Income	
$1,700	Balance Sheet Value	
$731,000	Herd Turnover Expense	
$503,500	Net Herd Turnover Cost	
$1.96	Net Herd Turnover Cost / cwt.	

COMPEER FINANCIAL

NET HERD TURNOVER COST

1000 cow herd scenario → 80 lb tank average

Utilizing All Replacement Heifers		Reduced Death Loss & Improved Cull Value
43%	Turnover Rate	43%
8%	Death Loss	6%
$650	Average Cull Cow Income	$700
430	Total Number of Removals	430
80	Dead Cows	60
350	Cull Cows	370
$227,500	Cull Cow Income	$259,000
$1,700	Balance Sheet Value	$1,700
$731,000	Herd Turnover Expense	$731,000
$503,500	Net Herd Turnover Cost	$472,000
$1.96	Net Herd Turnover Cost / cwt.	$1.84

COMPEER FINANCIAL

NET HERD TURNOVER COST

1000 cow herd scenario → improved tank average

Retain All Replacement Heifers		Reduced Turnover Rate & 1.5# Milk Production Increase
43%	Turnover Rate	34%
6%	Death Loss	6%
$700	Average Cull Cow Income	$700
430	Total Number of Removals	340
60	Dead Cows	60
370	Cull Cows	280
$259,000	Cull Cow Income	$196,000
$1,700	Balance Sheet Value	$1,700
$731,000	Herd Turnover Expense	$578,000
$472,000	Net Herd Turnover Cost	$382,000
$1.84	Net Herd Turnover Cost / cwt.	$1.46

COMPEER FINANCIAL

NET HERD TURNOVER COST

1000 cow herd scenario → Culling cows to late

Reduced Turnover Rate & 1.5# Milk Production Increase		Reduced Turnover Rate No Improvement in Management
34%	Turnover Rate	34%
6%	Death Loss	9%
$700	Average Cull Cow Income	$600
340	Total Number of Removals	340
60	Dead Cows	90
280	Cull Cows	250
$196,000	Cull Cow Income	$150,000
$1,700	Balance Sheet Value	$1,700
$578,000	Herd Turnover Expense	$578,000
$382,000	Net Herd Turnover Cost	$428,000
$1.46	Net Herd Turnover Cost / cwt.	$1.70

COMPEER FINANCIAL

RELATIONSHIPS BETWEEN NET HERD TURNOVER COSTS AND OTHER MEASURES

VARIABLE	CORRELATION w/ NHTC
Profitability (NFI, $/cwt ECM/day)	-0.33
ECM/cow/day, lb/day	-0.45
Cull + death rate, %	0.42
SCC x 1000	0.35

DIFFERENCE IN PROFIT BETWEEN HIGHEST 1/3 AND LOWEST 1/3 (BASED ON NHTC, $/cwt ECM)	$2.04/cwt (~$61 K/year*)

* Top third produced 315,189 cwt/year (86.0 lb/d); bottom third produced 285,098 cwt/year (76.0 lb/d)

NET HERD TURNOVER COST

- Goals
  - Holstein Herd <$1.35/cwt energy corrected milk
  - Jersey Herd <$1.85/cwt energy corrected milk

MANAGING TURNOVER RATE

- **Managing adult turnover is an art**
  - All cows will leave the herd at some point
  - Need to avoid getting rid of the cow to early or to late
  - Maximizing the value of the cow at the time she is removed
- **Minimizing involuntary culls**
  - Cow whisperer
  - Cow comfort

MANAGING TURNOVER RATE

- **Transition care**
  - <2.5% of fresh heifers leave within 60 days of calving
  - <4.5% of fresh cows leave within 60 days of calving
- **Selling marginal cows prior to dry off vs post fresh**
  - Cost of care for a dry cow between feed, labor and animal health can exceed $350/cow
  - Extended dry period cows

MANAGING TURNOVER RATE

- Targeted herd distribution
  - < 35% of adult herd is 1st lactation animals
  - > 40% of the adult herd is 3rd lactation animals

- Total milk production/day of life

1st lactation	24,000 lbs milk	24.4 lbs/day of life
2nd lactation	27,600 lbs milk	38.8 lbs/day of life
3rd lactation	30,800 lbs milk	47.5 lbs/day of life
4th lactation	30,800 lbs milk	53.7 lbs/day of life

NET HERD TURNOVER COST

- In summary understanding your herds NHTC allows you to
  - Make informed management decisions
    - + Make voluntary culling decisions at the appropriate time
    - + Match replacement heifer needs with desired turnover rate
  - Control your cost of production
  - Maximize your profit margin

WHAT IS YOUR NET HERD TURNOVER COST?

Number of Cows Culled	______	
Number of Cows Died	______	
Total Cull Cow Revenue Received	______	b
Pounds of Milk Sold	______	
Average Butterfat Test	______	
Average Protein Test	______	
Calculating Energy Corrected Milk		
(pounds milk X % butterfat X 12.82)	______	
+ (pounds milk X % protein X 7.13)	______	
+ (pounds milk X .323)	______	
= Total pounds energy corrected milk	______	c
Cows Culled + Cows Died X $1700/hd	______	a
Net Herd Turnover Cost (a – b)/c	______	

Goal: Holsteins <$1.35 Jerseys <$1.85

COMPEER FINANCIAL
WWW.COMPEER.COM
(844) 426-6733

STEVE BODART
STEVE.BODART@COMPEER.COM
(715) 688-6364
(715) 928-2946

What was My Net Herd Turnover Cost for 2019?

Number of Cows Culled __________
Number of Cows Died __________
Total Cull Cow Revenue Received __________ b
Pounds of Milk Sold __________
Average Butterfat Test __________
Average Protein Test __________

Calculating Energy Corrected Milk
(pounds milk X % butterfat X 12.82) __________

+ (pounds milk X % protein X 7.13) __________
+ (pounds milk X .323) __________
= Total pounds energy corrected milk __________ c

Cows Culled + Cows Died X $1700/hd __________ a

Net Herd Turnover Cost (a – b)/c __________

Goal: Holsteins <$1.35   Jerseys <$1.85

CoBank Dairy Outlook

Will Sawyer, MSc.
Lead Economist, Animal Protein, CoBank

The U.S. dairy sector remains in a state of transition. The first part of 2019 was marked by high dairy cow culling evidenced by significant YoY growth in dairy cow slaughter. For the year, national milk output increased only slightly YoY as cow numbers continued slipping through June. September and October were the first months to show the U.S. adding cows in response to higher milk prices. The national herd reached 9.327 million head, still 0.4% below a year ago. Dairy cow slaughter will end the year between 2% and 4% above a year ago.

Lower milk production in the first half of the year set the stage for increasingly higher prices. The national All Milk price began the year at $16.60 per cwt and will stretch to over $20 per cwt by the end of the year. However, while milk prices have posted a strong recovery, dairy producers are juggling higher feed costs.

Corn prices rose 7% over the 2018-2019 marketing year, while national soybean meal prices are estimated to have fallen by nearly 11%. Alfalfa supplies are still tight and prices remained similar to last year. The combination of rising milk prices and mixed feed prices resulted in better margins on an annual basis, although most of the gains were made in the second half of 2019.

Domestic demand for value-added products soared in 2019. Higher cheese prices were the main driver behind the All Milk prices received by producers reaching $20 per cwt. Block cheese prices rose to $2 per pound – the highest since 2014. Domestic disappearance of American-type cheeses (cheddar, Colby, Monterey, and Jack) through September averaged 4.5 million pounds per month higher than in 2018.

Exports for cheese through September were also stronger, up 3.2% YoY. The higher demand for Class III milk by cheese processors has tipped the Class III to Class IV price spread in Class III's favor. Class III is now $2.67 per cwt higher than Class IV. Although Class IV milk prices have not seen the gains that Class III had, it too posted gains in 2019. Class III milk price started the year at $13.96 per cwt and was $19.40 per cwt in mid-December. In contrast, Class IV started 2019 at $15.48 per cwt and in mid-December settled at $16.73 per cwt.

Export butter demand struggled in 2019 but domestic demand was very strong, with domestic disappearance averaging 1.3 million pounds higher than 2018 through the first nine months of the year. Although butter prices are still high by historical standards, the trend has been lower in 2019. The U.S. weekly average butter price reported by USDA-AMS reached as high as $2.41 per pound in July, but since that week has fallen sharply.

Mid-December wholesale butter prices were averaging below $1.95 per pound. Butter production is down 0.5% year-to-date in 2019, but cold storage inventories have climbed above the prior year since July. Although cold storage levels are not considered burdensome, the price impact on higher domestic demand appears to be primarily driven by smaller export figures.

Butter exports are down 42% so far this year. Mexico and Canada are the two primary markets for U.S. butter exports. Mexico this year is off 72% of last year's volume while Canada is down 42%. Together they account for more than 11,000 metric tons lost compared to last year in the January through September timeframe. U.S. butter prices have been notably higher than competitors'. Both Oceania and Western Europe are reporting FOB prices that calculate to less than $1.90 per pound in U.S. dollars since August. With the signing of TPP, Canada and Mexico consumers will have better access to Australian and New Zealand brands through larger quotas. The USMCA will finally see resolution with Congressional approval. However, even with this agreement, U.S. exporters could face steeper competition in these two key markets. The fourth quarter of 2019 is one of the highest consumption periods in the year for butter and cheese.

These holiday season trends support a further rise in milk prices to close out the year. However, with domestic consumption being the primary driver, milk prices are likely sensitive to slower macroeconomic activity.

The rapid rise in milk prices, gaining 10.9% YoY in October, will be a driving force to add more cows to the herd. The last two months have shown small gains, 5,000 head each, to the total U.S. sector. Dairy replacement prices are already climbing. After bottoming in 2019, the third quarter showed the highest dairy replacement price nationally in more than a year. The Jan. 1, 2020, cattle inventory report will provide a better indication for what to expect out of growing dairy cow numbers. Dairy heifers held for replacement were below a year ago in July. Expect dairy heifer supplies to tighten further as a result of the higher milk prices.

The increased use of sexed semen could help speed up heifer replacement growth, but in the near-term, dairy heifer replacement prices are expected to increase. The dairy industry is facing a new world with the signing of TPP, with the U.S. on the outside looking in. U.S. competitors now have improved access to the Pacific Rim. This year exports were largely mixed; butter and concentrates were down, as were whey and yogurt products. While the U.S.-Japan agreement provided similar access to the Japanese market for beef and pork, some dairy products were left on the sidelines, namely butter and skim milk powder. However, cheese, one of the largest U.S. dairy exports to Japan, will see the same benefits as TPP partners. The world dairy stage may see a bit of reshuffling over the next couple of years in the wake of new trade deals, a resolution with China, and new suppliers potentially emerging (India).

U. S. milk prices in 2020 are expected to be above a year ago, in part restrained by available heifer supply limiting rapid expansion in the short term. Domestic consumption is expected to continue to underpin the demand for dairy products, and is dependent on continued positive GDP growth. On the producer margin side, feed costs are expected to come down in 2020 with additional corn and soybean acres coming into production and normal yields continuing to support alfalfa availability and lower prices. The improved feed and milk price outlook will bolster dairy profit margins next year.