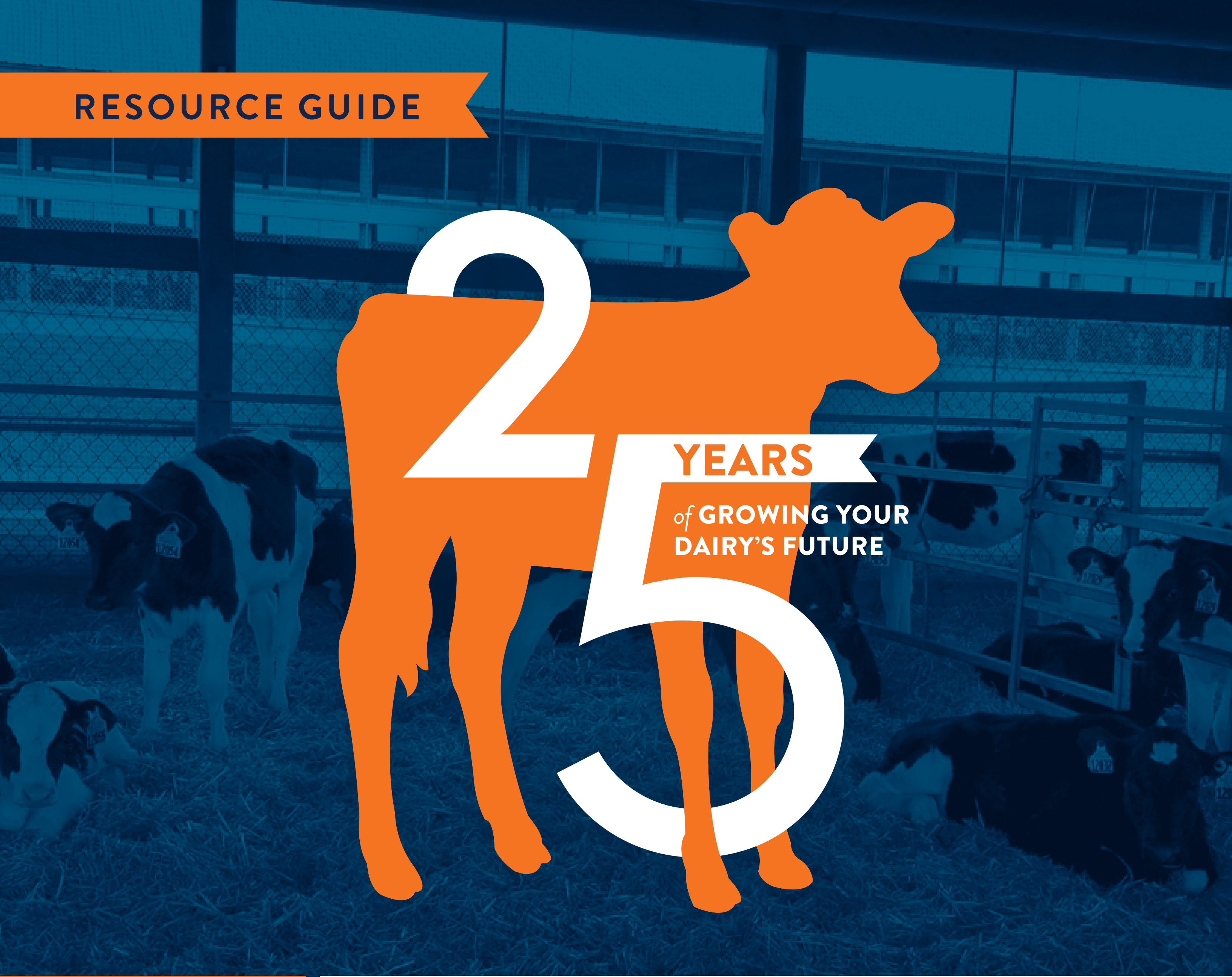
RESOURCE GUIDE



APRIL 6-8, 2021 APPLETON, WI

ANNUAL CONFERENCE & TRADE SHOW

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REGISTRATION

TUESDAY, APRIL 6
8:00 a.m.–4:30 p.m.

WEDNESDAY, APRIL 7
6:00 a.m.–3:00 p.m.

THURSDAY, APRIL 8
6:30 a.m.–12:00 p.m.

TRADE SHOW

The conference trade show will kick off with a reception Tuesday evening and remain open throughout the entire conference. Listed below are the specific trade show activities and breaks.

TUESDAY, APRIL 6
4:30 p.m.–6:00 p.m. Trade Show Reception

WEDNESDAY, APRIL 7
7:00 a.m.–8:00 a.m. Trade Show Open

12:30 p.m.–1:00 p.m. Trade Show Open

4:15 p.m.–5:45 p.m. Trade Show Reception

THURSDAY, APRIL 8
7:30 a.m.–8:30 a.m. Trade Show Open

12:30 p.m.–1:30 p.m. Trade Show Open


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CONFERENCE AGENDA

All times listed are Central time.

TUESDAY, APRIL 6

Registration opens
8:00 a.m.

Optional tour
9:15 a.m. | Shiloh Dairy, Brillion, WI
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Tour returns to hotel
1:15 p.m.

PRE-CONFERENCE SESSION

Colostrum deconstructed: Transforming our approach in an ever-changing world
2:00 p.m. | Salon B, C, D
Sponsored by: Zinpro and Milk Products

Impact of Saccharomyces cerevisiae fermentation products on the calf immune response and susceptibility to respiratory infection
3:15 p.m. | Salon B, C, D
Sponsored by: Diamond V

Reception in the Trade Show
4:30–6:00 p.m. | Salon A

WEDNESDAY, APRIL 7

Breakfast
6:30 a.m. | Salon B, C, D
Sponsored by: STgenetics

Trade Show open
7:00–8:00 a.m. | Salon A

GENERAL SESSION

Gold Standards overview
8:00 a.m. | Salon B, C, D
Terri Ollivett, University of Wisconsin-Madison and Sam Barringer, Gold Standards Committee member
Sponsored by: DBC Ag Products

TRACK OPTIONS — SELECT ONE

9:15 a.m.

Track A: Targeting the immune system to reduce and prevent bovine respiratory disease?
Salon B, C, D
Jodi McGill, Iowa State University
Sponsored by: Diamond V

Track B: Vaccinating calves and heifers: Why do we do what we do?
Rosewood/Linden
Amelia Woolums, Mississippi State University
Sponsored by: Elanco

Track C: Dairy data deep dive: Insights on the impact of early life on future performance
Great Hall
Jackie Boerman, Purdue University
Sponsored by: Cargill

Morning break
10:15 a.m.
Sponsored by: TechMix


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TRACK OPTIONS — SELECT ONE (REPEATED)

10:30 a.m.

Track A: Targeting the immune system to reduce and prevent bovine respiratory disease?

Salon B, C, D

Jodi McGill, Iowa State University

Sponsored by: Diamond V

Track B: Vaccinating calves and heifers: Why do we do what we do?

Rosewood/Linden

Amelia Woolums, Mississippi State University

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Track C: Dairy data deep dive: Insights on the impact of early life on future performance

Great Hall

Jackie Boerman, Purdue University

Sponsored by: Cargill

Lunch

11:30 a.m. | Salon B, C, D

Sponsored by: Agri-Plastics

Annual business meeting

12:15 p.m. | Salon B, C, D

Trade Show open

12:30 p.m.–1:00 p.m. | Salon A

TRACK OPTIONS — SELECT ONE

1:00 p.m.

Track A: Serum total protein: An accurate or deceiving test for monitoring passive transfer status

Great Hall

Mike Nagorske, SCCL

Sponsored by: SCCL

Track B: Healthy calves + Efficient operation = Sustainable business

Rosewood/Linden

Phillip Visser, Ecolab

Sponsored by: Ecolab

Track C: Producer panel: Developing relations with the people that are behind a healthy calf

Salon B, C, D

Moderated by Jorge Delgado, Alltech

Panelists: Emily De Benetti, Oxford Cattle Co., Clint Al-Ag, Blue Sky Farms, Sandy Larson, Larson Acres, and Sarah Daugherty, Paramount Calves

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TRACK OPTIONS — SELECT ONE (REPEATED)

2:00 p.m.

Track A: Serum total protein: An accurate or deceiving test for monitoring passive transfer status

Great Hall

Mike Nagorske, SCCL

Sponsored by: SCCL

Track B: Healthy calves + Efficient operation = Sustainable business

Rosewood/Linden

Phillip Visser, Ecolab

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Track C: Producer panel: Developing relations with the people that are behind a healthy calf

Salon B, C, D

Moderated by Jorge Delgado, Alltech

Panelists: Emily De Benetti, Oxford Cattle Co., Clint Al-Ag, Blue Sky Farms, Sandy Larson, Larson Acres, and Sarah Daugherty, Paramount Calves

Sponsored by: Alltech

Break

3:00 p.m.

Sponsored by: TechMix

GENERAL SESSION

Planting the seeds of greatness

3:15 p.m. | Salon B, C, D

Matt Rush, The Gooder Guy

Reception in the Trade Show

4:15–5:45 p.m. | Salon A

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THURSDAY, APRIL 8

Breakfast

7:00 a.m. | Salon B, C, D

Sponsored by: Denkavit, USA

Trade Show open

7:30–8:30 a.m. | Salon A

TRACK OPTIONS — SELECT ONE

8:30 a.m.

Track A: Key aspects of solid feed for calves from birth to post-weaning: Nutrients, physical forms and quantity

Great Hall

Alex Bach, ICREA

Track B: Nutritional strategies to support recovery of diarrheic calves

Rosewood/Linden

Juliette Wilms, Trouw Nutrition

Track C: Producer panel: Calf housing

Salon B, C, D

Moderated by Jeff Langemeier, SCCL

Panelists: Ben Chamberlain, New York, Chuck Stokke and Jon Robison, California, Jan Gawthrop, Indiana

Sponsored by: SCCL

Break

9:30 a.m.

Sponsored by: TechMix

TRACK OPTIONS — SELECT ONE (REPEATED)

9:45–10:45 a.m.

Track A: Key aspects of solid feed for calves from birth to post-weaning: Nutrients, physical forms and quantity

Great Hall

Alex Bach, ICREA

Track B: Nutritional strategies to support recovery of diarrheic calves

Rosewood/Linden

Juliette Wilms, Trouw Nutrition

Track C: Producer panel: Calf housing

Salon B, C, D

Moderated by Jeff Langemeier, SCCL

Panelists: Ben Chamberlain, New York, Chuck Stokke and Jon Robison, California, Jan Gawthrop, Indiana

Sponsored by: SCCL

GENERAL SESSION

There's a snake in my bumper

11:00 a.m. | Salon B, C, D

Matt Rush, The Gooder Guy

Lunch

12:00 p.m. | Salon B, C, D

Trade Show closes

1:30 p.m. | Salon A

POST-CONFERENCE SESSIONS

1:30–2:30 p.m.

Calf diseases and the judicial use of antibiotics, in English

Presented by: Matt Dodd, Diamond V

Great Hall

Calf diseases and the judicial use of antibiotics, in Spanish

Rosewood/Linden

Presented by: Julia Hamann, Diamond V

Schedule subject to change

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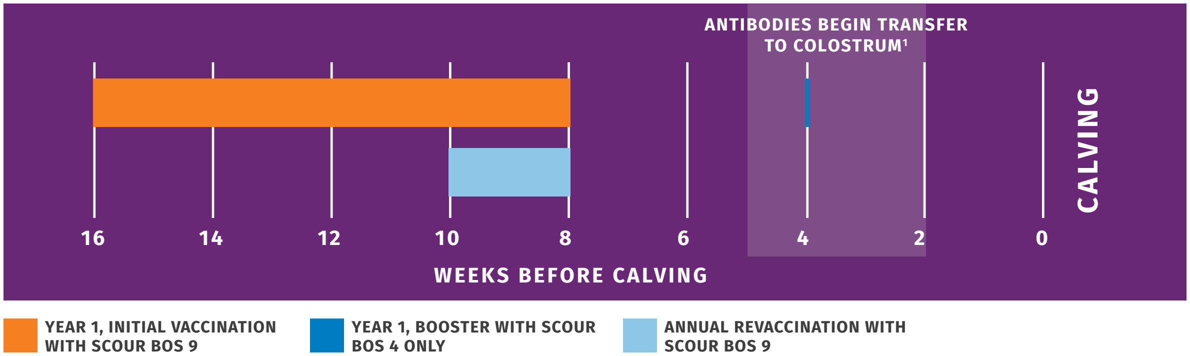

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[1]Herr M, Bostedt H, Failing K. IgG and IgM levels in dairy cows during the periparturient period. Theriogenology. 2011;75(2):377-85.

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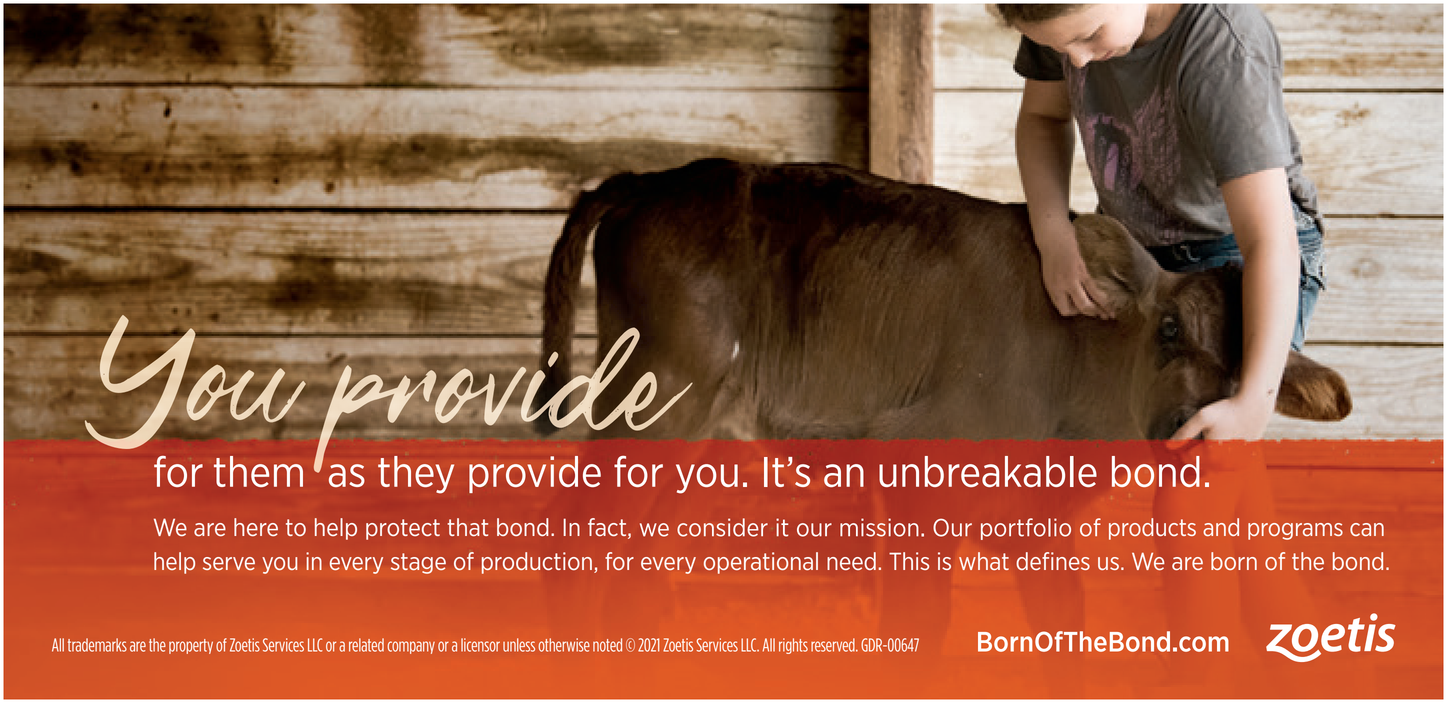

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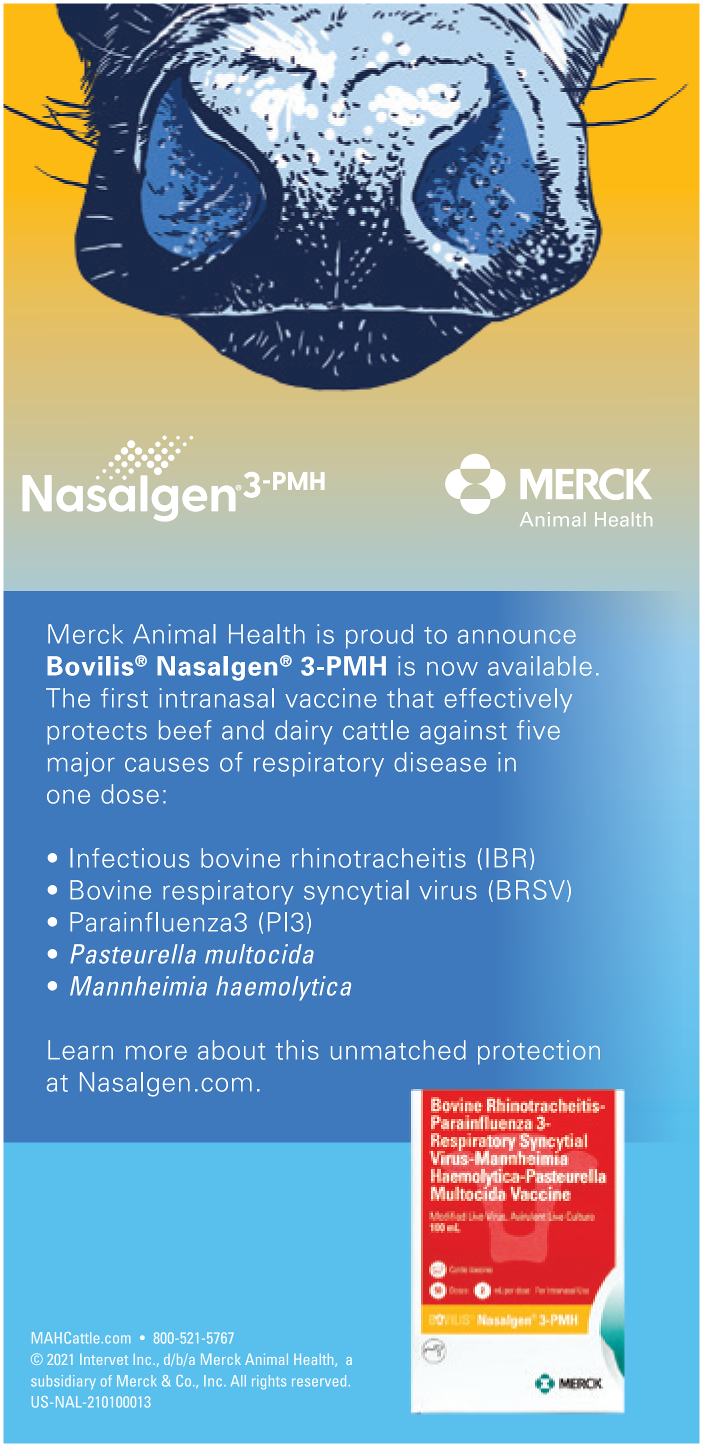
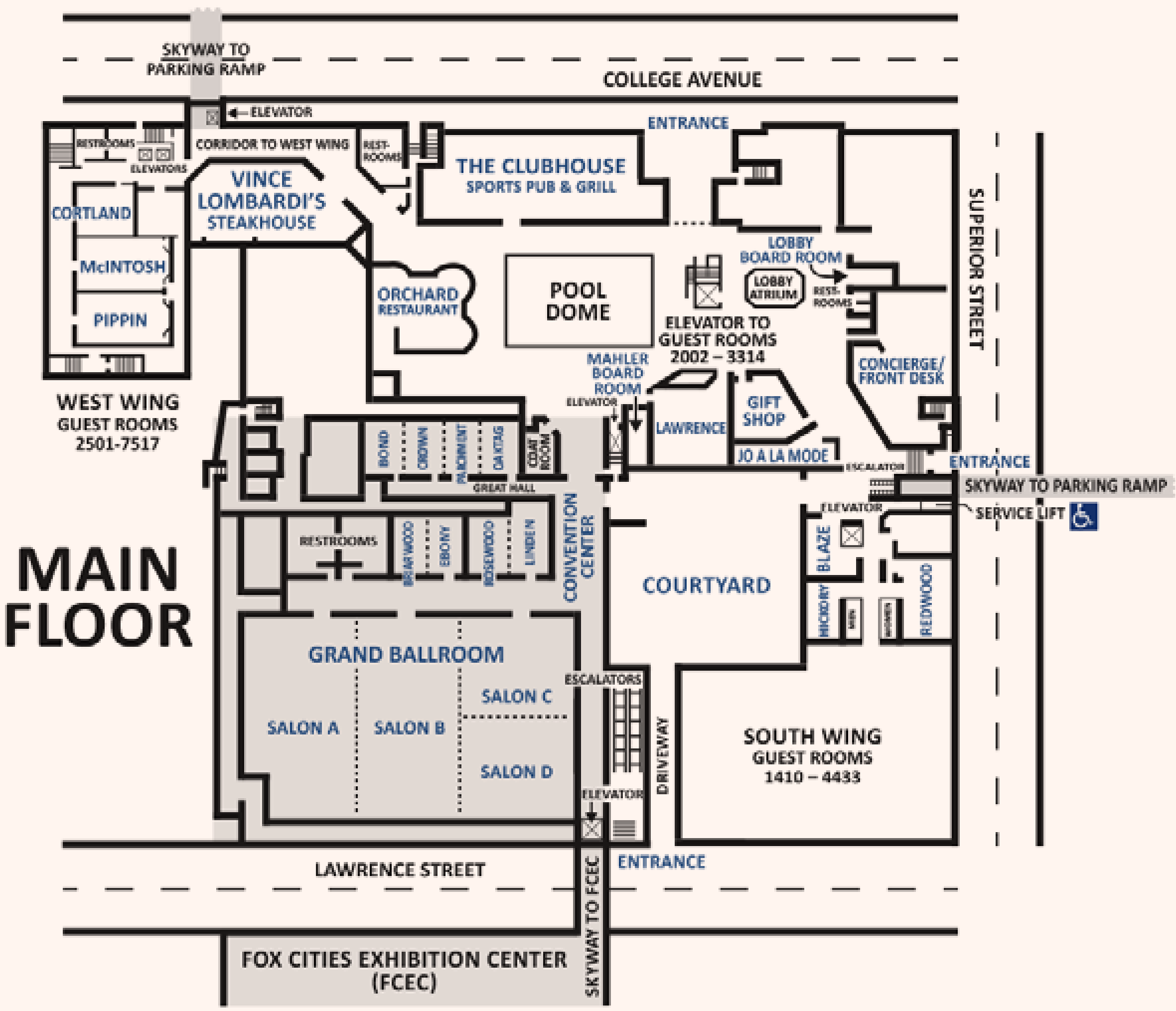
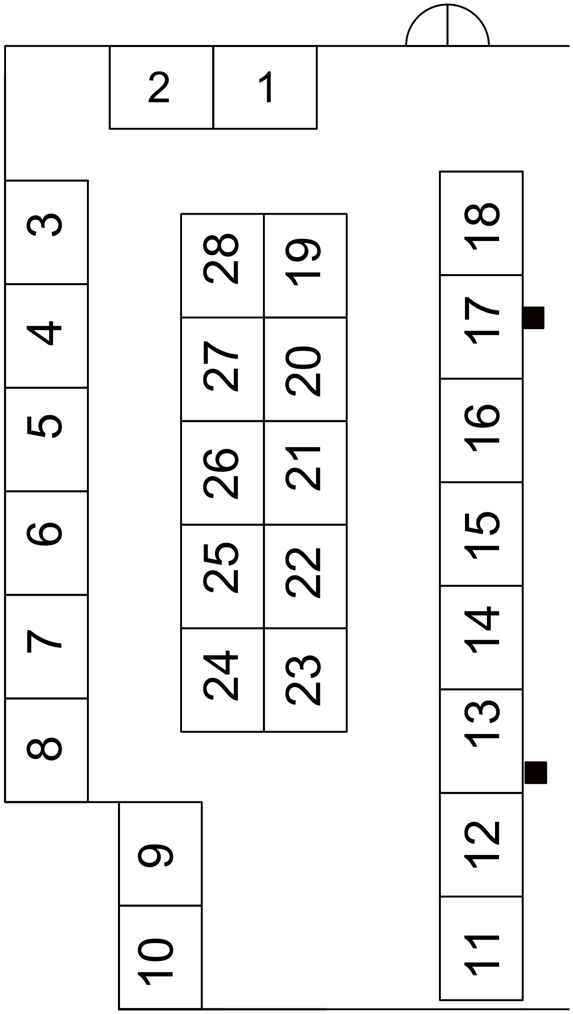


MEETING SPACE MAP



EXHIBITION HALL MAP



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Gold Standards overview

Theresa Ollivett, *University of Wisconsin School of Veterinary Medicine*

The Dairy Calf and Heifer Association (DCHA), in collaboration with DCHA leaders and advisors, has used published data and dairy industry expertise to develop the 3rd edition of its Gold Standards. This document broadly divides benchmarks and management practices into Performance Standards and Production Standards, when consistently applied, offer the best opportunity for raising successful dairy replacement animals in a broad array of operations.

Within the Gold Standards, the Performance Standards provide benchmarks on outcomes linked either directly, or indirectly, to the short-term welfare of the calf and the long-term welfare of the dairy operation. More specifically, these Standards relate to health status, survival rate, growth rate, and reproduction.

Pneumonia and scours, the two most common disease conditions and causes of death in young dairy cattle, serve as the outcomes of interest under Health Status within the Performance Standards (USDA, 2018). For these Standards, pneumonia is defined as a case of respiratory disease, which requires individual animal treatment. Scours is defined as a case of diarrhea that requires any intervention for more than 24 hours. For both pneumonia and scours, target morbidity depends on stage of life and is provided for preweaning, postweaning to 120 days, and 121- to 180-day-old calves. Similarly, targets for mortality, or the percentage of calves that die after living at least 24 hours, depend on life stage and are provided for 24 hours to 60 days, 61 to 180 days, 6 months to freshening, and 24 hours to freshening.

Early life growth, especially during the preweaning period, has been associated with greater milk production in the future (Soberon et al., 2012). In addition, the speed at which replacement animals grow typically determines how soon breeding, pregnancy, and lactation can be established. Given the long-term importance of adequate early life growth, target growth rates are specified within the Performance Standards for both gain in weight, as well as gain in height between 24 hours and weaning. Weaning age is set at 56 days within the Standards, which means that operations weaning earlier or later will need to adjust their targets accordingly.

The Performance Standards for growth rates after weaning are much more variable and depend heavily on the herd's breed, genetic goals, and mature size. Mature size is defined as the average weight of a third-lactation cow in mid-lactation. Target weights and approximate average daily gains, based on 1,000-, 1,400-, and 1,800-pound mature body weights, are provided for each stage of growth. These include birth to weaning at 56 days of age, weaning to first

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breeding, and first breeding to post-calving for first-lactation heifers. Additional assumptions that are outlined within the Standards are average birth weight, age at first breeding, and duration between first breeding and first calving.

The Performance Standards for reproduction include targets for age at first breeding and age at first calving, first-service conception rate, and pregnancy rate, based on semen type (conventional and sexed), as well as body weight and body condition score immediately after calving. Target age at first breeding, which is determined by body weight, is based on a percentage (55%) of mature size for the herd. Therefore, approximate age ranges, instead of specific ages, are provided to account for the variation in mature weights for Holstein and Jersey breeds.

The second component of the Gold Standards, the Production Standards, provide best management practices intended to help producers meet the outcomes outlined above in the Performance Standards discussion. These guidelines focus on newborn care, colostrum administration, nutrition and water, health management, housing and the environment, pregnant heifer management, handling and transportation, biosecurity, and euthanasia.

The first moments and days in the life of a newborn calf often determine how well they thrive during the preweaning period and beyond. Therefore, the newborn care component of the Production Standards provides best management practices for removal of calves from the maternity area, navel disinfection, pain management during dehorning, identification, measuring birth weight, and BVDV (bovine viral diarrhea virus) screening.

Given the significant impact of maternal transfer of immunity on calf performance, an entire section of the Production Standards is devoted specifically to colostrum management and administration. Specific recommendations are provided for the timing of harvest, as well as heat treatment, storage, delivery, and assessment of colostrum quality. Updated guidelines for assessing passive immunity in 2- to 7-day-old calves are also presented.

Following the colostrum administration component of the Production Standards, the nutrition and water section provide an extensive list of best management practices that will ensure calves receive the appropriate amount of high-quality milk, milk replacer, concentrate feeds, and water. These guidelines emphasize the need for meeting growth and energy demands through nutrition and highlight the importance of routine cleaning and sanitation protocols. Total ration protein targets, based on age, are also provided for weaned heifers.

Under health management, the basic principles of the veterinarian-client-patient relationship (VCPR) are described and specific guidance regarding vaccinations, dehorning, supernumerary teat removal, pain management, and parasite control are provided. Clinical disease prevention and management, and employee training recommendations are given. This section of the Standards lays out information for recording clinical illness, treating groups of animals at risk of disease, and working with your herd veterinarian.

General considerations for calf and heifer housing are provided in the housing and environment component of the Standards. In addition, specific housing and environmental standards are provided for newborn calves, preweaned calves, weaned heifers, and pregnant heifers. Resting space requirements and stall features are laid out based on facility design (bedded pack and freestall), approximate age, and body weight. The Production Standards component of the Gold Standards wraps up by providing best management practices regarding animal handling, fitness for transport, biosecurity, and penultimately, euthanasia.

References available upon request.

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Targeting the innate immune system to reduce and prevent bovine respiratory disease

Jodi L. McGill, *Iowa State University*

Take Home Messages

- Despite the wide availability and implementation of vaccines, bovine respiratory disease (BRD) continues to be a leading cause of morbidity and mortality in dairy calves and heifers.
- Vaccines target the adaptive immune system to produce antibodies and cells that defend against a specific pathogen. The adaptive immune system is very specific and develops long-lasting memory, but takes time to develop.
- The innate immune system is nonspecific and more broadly protective. It is the "first line of defense" against infection.
- Immunomodulation is a promising "alternative to antibiotics" approach, which engages or primes the host's own immune system to defend against infectious disease. While vaccines are effective at activating the adaptive immune system, immunomodulatory agents, instead, engage the innate arm of the immune system.
- Immunomodulatory agents may prime the innate immune system for a limited amount of time or may "train" the innate immune system to exist in a poised state for longer periods. Once primed, the innate immune system is able to respond to pathogens more quickly and vigorously to protect the host.
- There are a growing number of immunomodulators and feed supplements on the market that may have the ability to engage the innate immune system and improve calf resistance and resilience against BRD and other diseases.
- Immunomodulators are an active area of research. Expect new technologies in the coming years.

Bovine respiratory disease (BRD) is the second leading cause of preweaned heifer mortality and the leading cause of weaned heifer mortality. In the United States alone, BRD is estimated to cost beef and dairy producers in excess of $900 million (Peel, 2020). BRD incidence has remained static for the last several decades, despite the widespread availability of therapeutics and vaccines, underlining the need for improved intervention strategies (USDA, 2010, 2012). Metaphylactic use of antibiotics is generally effective against BRD and is an essential tool for controlling outbreaks. However, due to concerns regarding antimicrobial resistance, significant research efforts are currently aimed at designing new approaches for BRD prevention.

Innate immunity in the lungs

The innate immune system is the body's first line of defense against infection. The lungs and respiratory tract have many innate defenses that work together to prevent respiratory infections, including physical, chemical and cellular barriers. Cells lining the respiratory tract produce mucus, which works to trap dust and bacteria that enter the respiratory tract, and also contain many chemical components that kill or prevent bacterial growth. Cilia are small hairlike structures that line the inside of the respiratory tract from the nasal cavity all the way to the lower lungs. Cilia act like fingers to move mucus and debris up and out of the lungs. One study of healthy animals showed that <90% of aerosolized *Mannheimia haemolytica* could be eliminated from the lung within 4 hours of administration, primarily due to mucus and ciliary action (Lopez et al., 1982).

There are also innate immune cells that patrol the lung airways and tissues. These cells act as sentinels, positioned to constantly monitor for potential infections. If a sentinel cell senses a viral or bacterial pathogen that has entered the lung, it sounds the alarm bells, producing inflammatory mediators that "call the calvary" at the first sign of pathogen invasion. These inflammatory signals recruit cells, such as neutrophils, monocytes and macrophages, from the blood to the lungs and site of infection. Neutrophils are short lived and experts at engulfing and killing bacterial pathogens. Monocytes and macrophages also engulf and kill bacteria; however, they are longer lived and have an important role in activating adaptive immunity.

In concert, the innate immune system has the capacity to control the vast majority of pathogens that are encountered by the lung before they are able to establish and cause infection.

Risk factors for BRD

Known risk factors for BRD include stress due to weaning, transport, crowding and commingling with new animals. Several viral infections also predispose calves to the development of BRD, such as bovine respiratory syncytial virus (BRSV), parainfluenza virus (PIV), bovine corona virus and others. Stress and viral infection impair or suppress the innate immune system in the lungs. For example, viral pathogens, such as BRSV and PIV, cause ciliary dysfunction and necrosis (Ackermann et al., 2010, Caswell, 2014), which can lead to significant delays in the clearance of inhaled particles (Gershwin et al., 2008). Stress can inhibit inflammatory signaling and impair the recruitment of inflammatory cells to the lungs. Stress also causes changes in the respiratory tract that increases the ability of bacteria to attach to and invade lung tissue.

Immunomodulators to enhance the innate immune response

In a healthy animal, the innate immune system is able to prevent a majority of respiratory infections. The idea of counteracting the known effects of stress or viral infection to boost or enhance an animal's innate state of disease resistance is appealing. Such an approach could be particularly valuable for young animals or during well-defined periods of stress or immunosuppression, such as during weaning, shipping or comingling. Therefore, increasing attention has turned to the development of immunomodulators as a promising "alternative to antibiotics" approach. Immunomodulators engage or prime the host's own immune system to defend against infectious diseases. While vaccines are effective at activating the adaptive immune system, immunomodulatory agents, instead, engage the innate arm of the immune system.

The innate immune system is appealing as a target for novel therapeutic or preventative strategies. It is broadly specific and can therefore provide collateral protection against an array of invading bacteria and viruses. The innate immune system acts quickly, responding within minutes to hours, rather than the days required by the adaptive immune system. In very young calves, the adaptive immune system may not be fully mature. However, the innate immune system is active and poised for protection.

Until recently, the innate immune system was not thought to develop memory. It was believed that each time the body encountered a pathogen, the innate immune system would react with the same type and scale of response. However, the paradigm on innate memory has recently shifted, with substantial evidence indicating that innate immune cells can adapt after stimulation or microbial exposure. Primary exposure can leave the innate cell in a "poised" state or a state in which it is more ready to respond to a secondary insult. In a primed response, innate cells can react more rapidly and more vigorously, with increased production of effector molecules upon secondary exposure. In some cases, priming of the innate immune response may induce a poised effect that lasts for a short time (days). In certain cases, the innate immune system can be "trained" to exist in a primed state for weeks to months. This new understanding has created opportunities for the development of immunomodulators that can be used to boost the innate immune system when the calf needs it the most.

Several recent therapies have emerged with potential to prime or enhance the innate immune system during times of stress. One such DNA-based immunostimulant, marketed as the commercial product Zelnate™, can reduce the amount of lung damage in cattle experimentally challenged with *M. haemolytica* (Nickell et al., 2016) and significantly reduce mortality in high-risk cattle after feedlot placement (Rogers et al., 2016, Woolums et al., 2019). Product literature encourages the use of Zelnate immediately prior or within 24 hours of a perceived stressful event. Another immunomodulatory product, marketed as Amplimune™, is the cell wall fraction derived from the non-pathogenic *Mycobacterium phlei*. Amplimune™ nonspecifically activates the innate immune system and can significantly reduce the incidence and severity of K99 *Escherichia coli* infection in newborn calves (Radoslaw et al., 2017). It is currently marketed in the United States and Canada for this use. A recent study revealed that Amplimune™ also had significant beneficial effects in reducing the incidence and mortality associated with BRD in newly received, light-weight beef calves (Nosky et al., 2017). This example highlights the ability of the innate immune system to react broadly, demonstrating that a boost in innate immunity can potentially provide collateral protection against both respiratory and enteric diseases.

Certain immunomodulatory feed additives have also been shown to alter disease resistance in calves and cows. For example, supplementing with a *Saccharomyces cerevisiae* fermentation product (SCFP) improves outcome of experimental *Salmonella* or *Cryptosporidium* challenges in preweaned calves (Brewer et al., 2014, Vázquez Flores et al., 2016, Vélez et al., 2019). In a later field study, preweaned dairy calves receiving SCFP had improved fecal scores and overall reductions in morbidity and mortality during the first 70 days of life (Alugongo et al., 2017). More recently, in my own lab, we have observed that preweaned calves supplemented with SCFP are more resistant to respiratory disease caused by experimental BRSV infection (Mahmoud et al., 2020). Consequently, these calves also went on to develop fewer secondary bacterial infections. Beef calves receiving a yeast-based supplement in feed have a reduced incidence of BRD during the receiving period (Duff and Galyean, 2007, Finck et al., 2014). Beef heifers receiving a different live yeast product are more resistant to an experimental viral-bacterial infection (Kayser et al., 2019).

The mechanisms by which many of these immunomodulatory feed ingredients impact immune function in the calf or adult cow are not yet fully defined. In some cases, feeding certain ingredients has been shown to boost innate immune functions, such as increasing the ability of neutrophils to engulf and kill bacteria, or restoring proinflammatory immune responses to leukocytes from transition cows (Wang et al., 2009, Ryman et al., 2013, Nace et al., 2014, Alugongo et al., 2017, Wu et al., 2017, Knoblock et al., 2019). In our studies, calves receiving an SCFP had enhanced innate immune functions in the blood but less vigorous inflammatory responses in the lungs (Mahmoud et al., 2020). We speculate that dampening or maintaining less inflammation may be one critical aspect of keeping the lung healthy in calves with BRD.

Future directions

Given the need for proper antimicrobial stewardship, developing alternatives to antibiotics is an active area of research in calf health. In the coming years, expect new products to hit the market with the ability to give a short-term innate immune function boost in calves. These products could be useful during periods of high risk, such as weaning or comingling. In contrast to vaccines, these immunomodulatory products may have the ability to induce broad resistance against a wide array of pathogens. Therefore, such products could be useful for both respiratory and enteric diseases in young calves.

The past decade has led to a major shift in our understanding of innate immunity and its role in animal health. However, there is still a "black box" surrounding the mechanism by which many immunomodulatory therapies and feed ingredients influence disease resistance and immune function. Future studies will also be aimed at defining these mechanisms of action in order to further improve or refine their utility for calf and heifer health.

References available upon request.

NOTES

Vaccinating calves and heifers: Why do we do what we do?

Amelia R. Woolums, *Mississippi State University*

Immune response in the young calf

The calf's immune response can protect it from an amazing variety of viruses, bacteria, fungi, and parasites. Contrary to what some people think, the calf's immune system is completely functional at birth, but it is naïve and it cannot respond as strongly or as rapidly as it will when the calf becomes older. The calf immune response begins to function like an adult immune response between 5 to 8 months of age. Until then, antibodies, proteins that specifically attack infectious agents and which the calf first receives from colostrum, provide important protection. Colostrum also contains other factors that improve the calf's ability to resist infection. It has been proven repeatedly that calves that fail to get enough good quality colostrum are more likely to get sick, more likely to leave the herd early, and more likely to die, compared with calves that get enough good quality colostrum. Although U.S. dairy producers have improved colostrum management, a 2013 survey by the U.S. Department of Agriculture National Animal Health Monitoring System (NAHMS) found that 16% of calves tested had insufficient amounts of antibodies from colostrum and 76% of dairies had at least one calf with inadequate colostral antibodies (Urie et al., 2018). Thus, there is still room for improvement in colostrum management on U.S. dairies and vaccination cannot substitute for this.

What vaccines can do

Although the calf's immune response is naïve and immature for approximately the first 6 months of life, it can respond to vaccination during that time in ways that can help calves resist disease. Research has shown that healthy calves on a diet providing adequate protein, energy, vitamins, and minerals can respond to vaccination as early as the first day of life. U.S. dairy producers recognize this and many dairies vaccinate calves on the first day or two after birth, or in the first month of life. It is important to remember that early-life vaccination requires a booster (second dose of vaccine), which is also given within the first 6 months of life for reliable protection.

It is possible to vaccinate too much?

Some dairy producers follow vaccination programs that require the calf to receive a large number of vaccines in the first year of life. While the ideal number of vaccines that should be given, and the time when they should be given, depends on the operation, a vaccine given at the wrong time can make disease worse (Griffin et al., 2018). Also, if multiple different vaccines are given at the same time, a component in one vaccine could compete against a component in another, causing the calf to fail to respond adequately to the second vaccine (Cortese et al., 2011). When a single vaccine containing multiple viruses or bacteria is given (a "multivalent" vaccine), the manufacturer has been required to prove that an adequate immune response to all agents in the bottle will occur. However, very little research has tested the effects of giving different brands of multivalent vaccines at the same time. Thus, for most possible combinations, we just don't know whether a complete immune response will occur to all components in all vaccines that could be given at the same time. For this reason, it is likely best to avoid giving more vaccines than absolutely necessary at the same time. Giving multiple vaccines that contain Gram-negative bacteria (such as *E. coli, Salmonella* spp., *Mannheimia haemolytica, Pasteurella multocida, Histophilus somni, Moraxella bovis,* and/or *Moraxella bovoculi*) can be particularly problematic because these bacteria all contain endotoxin, which can cause adverse reactions or even death following vaccination.

What vaccines can't do

Some people have misconceptions about what vaccines can and can't do. It is important to remember that:

1. Vaccines cannot overcome poor management. Animals in a situation of heavy challenge by infectious agents due to a filthy environment, poor ventilation, crowding, or constant addition of new animals from outside sources will usually develop disease in spite of good vaccination.
2. Vaccines will not work well in animals with nutrient deficiencies. Supplementation of nutrients in excess of requirements does not always improve vaccine response, but it is clear that animals must be on a complete and balanced diet to respond properly to vaccination.
3. Vaccines don't work well if they are given too close to the time the calf is exposed to infection. The full response to a vaccine takes 14 to 28 days to occur. It is surprisingly common to find people vaccinating calves a day or two before or after they are moved to new housing, shipped, or mixed with new cattle. While research shows that some vaccines can provide some protection as soon as 3 to 5 days after administration (Fairbanks et al., 2004; Bittar et al., 2020), the full effects of the vaccine have not occurred at that time. Also, while some vaccines are labeled for single-dose use, research suggests calves less than 6 months of age respond best when they receive a priming (first) dose and a booster (second) dose (Ellis et al., 2018; Hill et al., 2019), with the booster generally given 3 to 8 weeks after the priming dose (though a longer period between priming dose and booster may still be effective [Hill et al., 2019]). Because it takes time for the immune response to be fully activated by the booster, the booster dose should be given a few days, and ideally 2 to 4 weeks, before challenge is expected. Anything less is setting up the vaccine for failure.
4. Modified live vaccines (MLV) cannot work if they have died before they are given. MLV should be used soon after they are reconstituted. Most manufacturers suggest that MLV should be used within an hour of reconstitution and MLV should certainly not be stored in the refrigerator and used a day or more after they are reconstituted. When vaccinating calves, keep the bottle of MLV in a cooler near but not on an ice pack, as placing a bottle of vaccine on an ice pack can freeze some of the

vaccine, leading to adverse reactions or vaccine failure. Keep the cooler lid closed, as ultraviolet light from the sun can also kill the vaccine.

5. A vaccine can't protect against viruses or bacteria that aren't in the vaccine. Vaccines work only for the viruses or bacteria that are in the vaccine. There are some viruses and bacteria, as well as parasites, that are not included in any licensed vaccines that can still cause disease in calves. This is why good management is necessary to keep calves healthy. Good management can help the calf's immune system resist disease against things you can't vaccinate against.

Work with your veterinarian to develop a calf vaccination plan

There is no single vaccine plan that works for all dairies. The selection of vaccines that should be given, and the time they should be given, needs to be tailored for your system. In many cases, the apparent failure of vaccines to protect calves can be traced to use of vaccines in ways that don't make sense, given what we know about what vaccines can do and what they can't do.

References available upon request.

NOTES

Dairy data deep dive: Insights on the impact of early life on future performance

Jackie Boerman, *Purdue University*

Investments in heifers, from birth to calving, represent up to 20% of the total costs of producing milk on a dairy farm. This cost in inflated by animals that fail to survive to first lactation or underperform based on genetic potential. Selecting animals more likely to be successful and profitable in a dairy herd earlier in the rearing process represents an area of opportunity to not only improve the quality of heifers but reduce the investment in animals that are less likely to succeed.

We partnered with a commercial farm that shared their automatic milk feeder, management software, and production records with us on a daily, individual animal basis. Several factors that were measured early in life were predictive of future growth, survivability, and milk production. The results lead us to believe that there are opportunities to alter management to impact those factors that have the largest impact on future performance, as well as making culling decisions about individual animals that are both phenotypically and genotypically less likely to be as successful. The following results are based off of the work done by T. Steckler Hurst as a master's degree student at Purdue University (Steckler and Boerman, 2019; Hurst et al., 2021).

Factors impacting growth

Data from an automatic milk feeder and dairy management software were collected for several years on a commercial dairy farm, representing more than 5,000 heifers. Bodyweights were measured at birth, weaning, and several time points prior to calving. As bodyweights were not measured on a consistent day of age, daily bodyweights were predicted for individual animals in order to make comparisons between animals on specific days of age. Average 60-day milk consumption for calves fed from the automated calf feeder was approximately 500 liters (528 quarts) per calf, with a range of 180 to 785 liters (190-830 quarts). Serum total protein, disease treatment records, and genomic predictions for body size composite score were collected from dairy farm management software.

We estimated growth up to 400 days of age and both feeder (n=8) and year (n=5) were factors that impacted bodyweight. While we were unable to control for both of these factors, it is important to note that the variance we observed among the bodyweights of animals fed through different feeders was not due to different feeding programs. From the data we used, animals that were on the feeder in the first years had higher bodyweights than animals that were fed in later years. This may be confounded by other management changes on the farm but may also be due to the importance of maintenance and cleanliness of equipment over time.

Milk consumption in the first 60 days of life significantly impacted predicted bodyweight of animals up to 400 days of age. This effect was both linear and quadratic, with milk consumption having less of an effect on bodyweight as calves consumed more milk. Birth weight significantly impacted bodyweight up to 400 days of age. Treatment for respiratory disease in the first 60 days of life resulted in reduced bodyweight up to 400 days of age, indicating respiratory disease long-term effects on future growth. Finally, genomic body size significantly impacted bodyweight at 400 days of age. Animals in the lowest 25% for genomic body size had a predicted bodyweight more than 21 kilograms (kg) (46 pounds) lighter than those animals in the top 25% of genomic body size. This result certainly has implications on breeding decisions based off of bodyweight in heifers based on differences in genomic potential for body size.

Factors impacting reproduction and survivability

We evaluated several factors that could potentially impact survivability to first lactation, which we defined as 850 days of age. There was no significant effect of treatment for pre-weaning respiratory disease on survivability. However, in the two months following weaning, animals that were treated for bovine respiratory disease were significantly less likely to survive to 850 days of age. Comparing animals that were not treated for respiratory disease to animals treated twice post-weaning had 20% greater risk of being culled. Additionally, heifers treated multiple times for respiratory disease had reduced likelihood of becoming pregnant than heifers that were not treated for respiratory disease post-weaning. Average daily gain (ADG) was a significant variable influencing conception age, with an interim ADG (from 0 to 400 days of age; approximately 1.1 kg [2.4 pounds]/day) resulting in the lowest conception age.

Factors impacting milk production

A subset of animals (n=1,324) that had production records through 280 days in milk were evaluated to determine which factors could be measured as a heifer that could impact future milk production. The genomic milk, season born, ADG, and heifer conception age all significantly impacted milk production. Genomic milk had the largest impact on 280-day milk yield, with every 1 kg (2.2 pounds) of genomic milk value resulting in a 1.42-kg (3.13-pound) increase in 280-day milk yield. Similarly, animals with higher ADG (from 0 to 400 days) resulted in higher milk production. However, this effect was modest, with 1 kg (2.2 pounds) of ADG resulting in approximately 1,300 kg (2,866 pounds) more milk in the first 280 days. In this data set, the older the heifer conception age, the more milk the cow produced in first lactation.

Lung consolidation vs. treatment records for respiratory disease

We performed lung ultrasound scans on a subset of calves (n=417) around weaning age. Animals with no lung consolidation had increased ADG pre-weaning compared with animals with lung consolidation on one or both sides of their lungs (0.14 kg [0.31 pound]/day difference in ADG). Interestingly, we observed animals that had lung consolidation were not always treated for respiratory disease and that a majority of animals that were treated for respiratory disease did not have lung consolidation. While many of our models above included respiratory disease treatment records, we believe that lung consolidation may also contribute to our understanding of growth and survivability.

Conclusions

As farm size and automation increase on dairy farms, the availability of data will also increase. This enables dairy farmers and those who support dairy farms to determine which calf and heifer factors impact growth, survivability, and production with their own data. We believe there are some unique factors on this farm due to genetics, management, and environment, which are not replicable. However, there are likely several significant factors that will translate to other farms. Of note, the negative long-term effects of respiratory disease early in life on growth, survivability, and reproduction represent a large potential for improvement.

References available upon request.

NOTES

Serum total protein: An accurate or deceiving test for monitoring passive transfer status

Alberto Lopez, Michael Steele and Dave Renaud, *University of Guelph, and*
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Failed transfer of passive immunity (FTPI) can be determined by measuring immunoglobulin G (IgG) concentrations, either by direct or indirect methods. The radial immunodiffusion assay (RID) is considered to be the gold standard for serum IgG measurement (Tyler et al., 1996; Wilm et al., 2018), since it is the only method that directly measures IgG (Gelsinger et al., 2015). When using RID, successful transfer of passive immunity is considered as serum IgG concentrations >10 mg/mL at 24 hours after birth (Weaver et al., 2000; Godden et al., 2008), whereas calves with serum IgG concentrations <10mg/mL are classified as having failed transfer of passive immunity. Despite being the gold standard test, this assay is time consuming, not applicable on farm, requires laboratory procedures and gives results in approximately 24 hours (Deleen et al., 2014; Renaud et al., 2018). However, it is not a totally inaccessible test. It should be used to troubleshoot passive transfer problems and for benchmarking and understanding individual differences in passive transfer status among calves.

Practical and simple indirect measures are often used to estimate levels of serum IgG or FTPI (Hernandez et al., 2016). The most common indirect method is serum total protein (STP) using refractometry (Deleen et al., 2014). Refractometers use the degree of refraction to estimate total proteins in solutions (Chavatte et al., 1998), which is valuable as immunoglobulins contribute to a proportion of protein in newborn serum (Calloway et al., 2002). It has been reported that STP is highly correlated with serum IgG. As such, it is commonly used to classify FTPI (McBeath et al., 1971; Deleen et al., 2014; Renaud et al., 2018).

A wide range of STP thresholds (4.0 to 8.0 g/dL; Buczinski et al., 2018) have been used to classify FTPI. Despite this variation, Buczinski et al. (2018) concluded that an STP threshold of <5.2 g/dL (sensitivity = 76.1%; specificity = 89%) was the most accurate for classifying FTPI in calves fed maternal colostrum. However, the authors did not include studies within the meta-analysis where colostrum replacer (CR) had been fed (Buczinski et al., 2018). As such, their STP threshold of <5.2 g/dL may not accurately represent FTPI in calves fed CR.

Similarly, an earlier study by Quigley et al. (2002) suggested that currently used STP thresholds were developed from calves fed maternal colostrum. As a result, the cutoff point to classify FTPI in calves fed CR is unclear.

CRs have been developed as an alternative for dairy producers who lack high-quality (IgG content), pathogen-free maternal colostrum or an adequate volume of maternal colostrum (Lopez et al., 2020). More producers are using CRs, with 19.1% of all U.S. operations using CRs (NAHMS, 2014). However, low STP readings in newborn calves are reportedly becoming more frequent, even when calves have serum IgG concentrations >10 mg/mL. In addition, Quigley et al. (2002), Lago et al. (2018) and Lopez et al. (2020) highlighted that when calves are fed CR, the STP threshold of ≤5.2 g/dL is inaccurate to predict FTPI. This threshold facilitates a misconception in which calves are falsely assumed to have FTPI (Donovan et al., 1998; Calloway et al., 2002; Priestley et al., 2013).

Thus, contained below is a study conducted by Lopez et al. (2020) in "Hot topic: Accuracy of refractometry as an indirect method to measure failed transfer of passive immunity in dairy calves fed colostrum replacer and maternal colostrum." The objective of this cross-sectional diagnostic accuracy study was to evaluate the ability of STP refractometry measures to estimate serum IgG and FTPI in calves fed maternal colostrum and CR. This study used pre- and post-colostrum STP, and serum IgG data (Saskatoon Colostrum Company Ltd.; SCCL; Saskatoon, SK, Canada) from calves fed maternal colostrum (n = 927) or SCCL colostrum-derived CR (n = 1,258). Data were collected on dairy farms located in North America from 2009 to 2017. Thirty-nine (4.20%) calves fed maternal colostrum had FTPI after colostrum feeding. STP for calves fed maternal colostrum was 5.80 ± 0.72 g/dL, whereas their mean serum IgG was 22.81 ± 10.14 mg/mL. Post-colostrum STP and serum IgG showed a strong, positive correlation, with STP explaining 81% of the variation in the serum IgG concentrations (R2 = 0.81; $P < 0.0001$) (Figure 1a). A total of 129 (10.25%) calves fed CR had FTPI after colostrum feeding. STP for calves fed CR was 5.14 ± 0.50 g/dL, whereas their mean serum IgG was 12.78 mg/mL ± 4.60 mg/mL. A weak correlation was found between STP and serum IgG, with STP only explaining 40% of the variation in the level of serum IgG (R2 = 0.40; $P < 0.0001$) (Figure 1b).

Figure 1a.

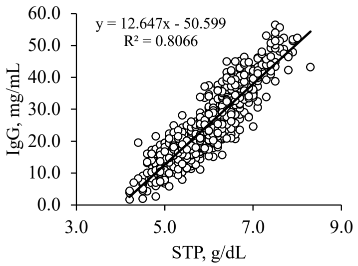
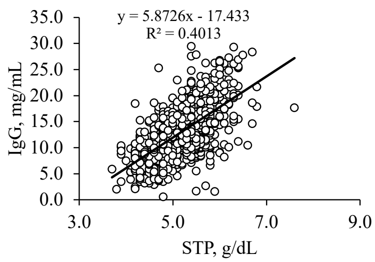


Figure 1b.



These results suggest that a lower STP cutoff point should be used to predict FTPI in calves fed SCCL colostrum-derived CR compared with calves fed maternal colostrum. However, even with a lower threshold, the low sensitivity and specificity of this threshold further compromises the use of STP as an indicator of FTPI for CR-fed calves, in general. The low sensitivity will result in a greater proportion of false negatives, with those classified as FTPI actually having successful passive transfer of immunity.

In addition to CR composition and manufacturing processes, refractometry readings can be affected by additional factors, such as dehydration (Buczinski et al., 2018). In dehydrated calves, blood components and protein contents become more concentrated and, as a result, their total STP is increased and might appear satisfactory (Buczinski et al., 2018). In consequence, calves could be mistakenly classified as having a successful transfer of passive immunity based on their elevated STP due to dehydration. Also, sick calves (i.e., septicemia or diarrhea) experience systemic inflammatory processes that could elevate their IgG levels, causing elevated serum IgG concentrations (Fecteau et al., 2013). Sick calves could also be wrongly classified as having a successful transfer of passive immunity because the serum refractance will be increased due to the higher presence of inflammatory markers (Fecteau et al., 2013).

There is good accuracy of STP with maternal-colostrum-fed calves. However, STP will be highly inaccurate for calves fed colostrum replacers. It is recommended to perform RID testing on colostrum replacer protocol calves to determine true passive transfer status.

A new set of guidelines established by Godden et al. (2019) is outlined in Figure 2. These guidelines would be good to follow for maternal-colostrum-fed calves, depending on the test–IgG via RID testing, total protein testing or Brix testing. If calves received CRs, again, it would be recommended to use the guidelines via RID testing. On a herd level, the proposed percentage of calves achieving each of the categories is outlined in the table.

Figure 2.

TPI category	Serum IgG categories (g/L)	Equivalent TP (g/dL)	Equivalent Brix %	Farm level % calves
Excellent	>25.0	>6.2	>9.4%	>40%
Good	18.0-24.9	5.8-6.1	8.9-9.3%	~30%
Fair	10.0-17.9	5.1-5.7	8.1-8.8%	~20%
Poor	<10.0	<5.1	<8.1%	<10%

References available upon request.

The role of hygiene in the prevention of cryptosporidiosis

Josephine Verhaeghe, *CID LINES NV – an Ecolab Company*

Cryptosporidiosis is a parasitic disease affecting calves age 5 to 35 days, and most frequently during the second week of life. Its severity depends on the calf's general resistance and the infection's intensity. The purpose of this article is to highlight the importance of the environment and hygiene on this pathology, as well as to propose practical recommendations to reduce risk factors.

The environment in which the calf is born and grows is critical, specifically when it comes to cryptosporidiosis. The ingested elements from the first feed bring millions of microorganisms into a sterile digestive tract. Hence, the importance of controlling the burden of pathogens through hygiene.

1. Environment management to prevent cryptosporidiosis

Environmental management aims to reduce the pressure of infection to a level low enough not to cause clinical signs in animals.

The oocysts of *Cryptosporidium parvum* are particularly resistant, as they are able to survive at temperatures ranging from -20 to +60 degrees C. (-4 to +140 degrees F.). The presence of feces and other organic matter helps them survive desiccation. The first critical point of environmental management is thus to eliminate as much organic matter as possible, as any area in contact with calves is likely to be a vector of contamination. Disinfect with a validated protocol (product * dose * adapted contact time).

Animal management is a key priority:

- In an environment with a proven prevalence of cryptosporidiosis, it is preferable to house calves <1 month old individually, without contact between them.
- It is recommended to empty, clean and disinfect calf boxes between each animal.
- Organize calves by age – not by animal size, because a weaker calf is a reservoir of parasites and other potential pathogens.

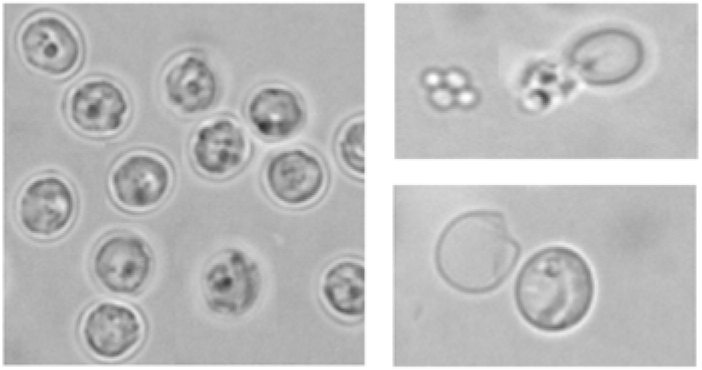
Minimize the risk of transmission via equipment and personnel:

- Maintain a logical order of animal management (e.g., feed the youngest calves first and move gradually to older calves)
- Make sure mobile equipment (buckets, milk bottles) are cleaned and sanitized between each use.

A study conducted in Canada showed that hygiene and management factors influenced the prevalence of *C. parvum* on the farm. Using a detergent to clean buckets and bottles is a parameter that can significantly reduce its prevalence. It is advisable to rinse drinking troughs, buckets and other materials containing water or calf feed. The prevalence is also further reduced when calves are raised on concrete floors, which has been validated through another study in Spain.

2. The use of effective products against cryptosporidiosis

Another peculiarity of *C. parvum* lies in its difficulty to be eliminated. It is not sensitive to conventional disinfectants that are effective against bacteria, viruses and fungi. Chlorine or glutaraldehyde, for instance, have no efficacy against *C. parvum*. An amine disinfectant, Keno®cox (2%, 2h), has proven its efficacy with a dilution of 2% and a contact time of 2 hours. Electronic microscopy images of Naciri et al. show the effect of Keno®cox on oocysts, because the disinfectant breaks the shell to destroy the sporozoites that are inside (see photos below).



3. Maintaining an environment below the critical threshold

Environmental management aims to reduce infection pressure to an acceptable level. Calves infected with a limited number of oocysts will not show symptoms and can develop immunity that makes them progressively less susceptible to parasites. This phenomenon is regularly observed when buildings are clean and empty at the beginning of the calving season. However, after several animals have been grown in the place, an accumulation of pathogens happens and diarrhea and other clinical signs can appear.

A study in Canada found that calves carrying oocysts were three times more likely to show signs of diarrhea than non-carrier calves. Beyond the threshold of 2.2 * 105 oocysts/gram of feces, calves are six times more likely to have diarrhea.

4. Reach the 3-week-old mark

The probability of being a carrier of oocysts increases during day 5 to 23, with a peak on day 14. Mother and colostrum can be vectors of oocysts. Scientific study concluded that the risk of diarrhea increases by 39% in case of contact with the mother after birth for more than one hour.

Similarly, a negative correlation was established between the amount of colostrum absorbed during the first day of life and the number of oocysts counted in calf feces. This must be interpreted in the specific context of farms with high prevalence of the pathogen. The more the calf absorbs colostrum, the more likely the calf will also ingest oocysts. In the same study, investigating farms where the presence of cryptosporidiosis had been validated, failure to transfer passive immunity was not identified as a significant factor associated with the risk of diarrhea. Passive immunity essentially influences calf morbidity and mortality. Passive immunity has not been shown to be important for parasite resistance. Naciri et al. showed that the antibody titer has no effect on the control of cryptosporidiosis. These elements confirm the need of environmental management to keep the number of oocysts that calves can absorb in the first days of life under control.

Conclusion

The environment and the associated microbial load is crucial for newborn calves. The digestive tract is sterile at birth. It is colonized by microorganisms in contact with the calf in the first days of life. Colostrum also plays an important role in helping the animal to defend itself before its immune system is fully operational. Essentially, passive immunity helps to fight against viruses and bacteria, but it has little effect on *C. parvum*. Therefore, it is even more important to optimize the hygiene conditions of the calving box, calf cages and all utensils used to feed animals. A regular and rigorous cleaning protocol, combined with a disinfectant with a proven efficacy against the parasite, are valuable assets to pass the critical course of the first 3 weeks of life.

References available upon request.

NOTES

Key aspects of solid feed for calves from birth to post-weaning: Nutrients, physical forms and quantity

Alex Bach, *ICREA*

Heifers represent a pivotal asset of dairy production as they sustain the renovation and improvement of the productive herd. But at the same time, dairy replacements represent an important economic investment and a great opportunity to improve the profitability of dairy herds. Bach et al. (2021) summarized data from 20,000 heifers along with cost of feed and group feed intake at different ages of development, between 2017 and 2020, reared in the largest contract heifer operation in Europe (Rancho Las Nieves, Mallén, Spain) to describe feed efficiency (FE) and economic returns throughout the rearing process. As depicted in Figure 1, FE and unitary feed costs progressively decrease with age; however, the combination of FE and unitary feed cost leads to a greater unit cost of growth after 400 days (d) of age than during the pre-weaning period, with the growth immediately following weaning being the most economically advantageous. Therefore, from an economic standpoint, fast growth pre-weaning, but especially right after weaning until breeding, should be a major objective in heifer rearing. Moreover, the return on the investment will be maximized when the produced heifer is not only inexpensive but also high producing and healthy. In other words, a growth rate that would effectively reduce rearing costs but would also increase the proportion of heifers that do not finish the first lactation would not be desirable.

Bach et al. (2021) used data from Figure 1 to describe the most effective growth curve for heifers to reach 1,360 pounds of body weight (BW) before calving at 670 d of life. The results are depicted in Figure 2. Under the assumed price scenario in Figures 1 and 2, heifer rearing costs would be minimized when average daily gain (ADG) during the pre-weaning period was 2.2 pounds/d and ADG post-weaning was 2.64 pounds/d. A simple sensitivity analysis showed that if ADG during the first 60 d was 1.76 pounds/d instead of 2.2 pounds/d, total cost of the heifer at 670 d with 1,360 pounds would only increase by $5. If ADG the first 60 d after weaning was 2.2 pounds/d instead of 2.64 pounds/d, then the cost of the heifer would increase about $9. Maximizing ADG right after weaning is more economically advantageous (and, perhaps, more feasible) than maximizing ADG the first 60 d of life. However, the potential impact of future milking performance and longevity of the growth curve during the rearing process should also be considered when designing a growth pattern.

Interestingly, rapid growth during the first 2 months of life has been positively associated with increased milking ability at adulthood (Bach, 2012; Soberon et al., 2012). Although a part of the industry is under the impression that the increased yield with ADG early in life is brought about by feeding more milk replacer (MR), what matters is total nutrient supply, regardless of origin (MR of starter feed). For instance, Gelsinger et al. (2016) concluded that ADG >1.1 pounds/d (obtained either from MR, from starter feed or both) was positively correlated with milk yield. Similarly, Chester-Jones et al. (2017) described a positive relationship between starter feed intake and milk yield, and Rauba et al. (2019) reported that crude protein (CP) and metabolizable energy (ME) intake from MR was not correlated with future milk yield, but CP and ME intake from starter feed alone or the combination of CP and ME intake from starter feed and MR was correlated with future milk

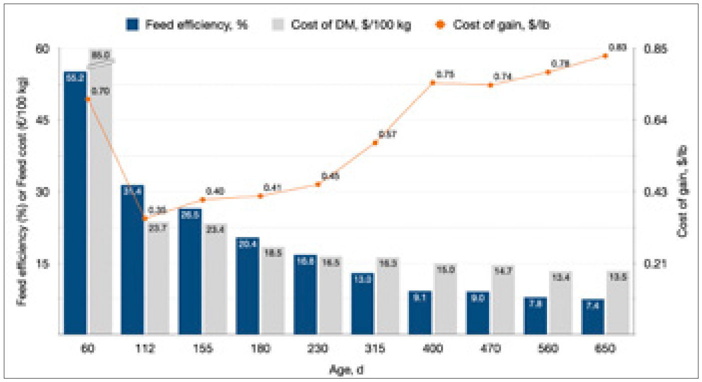


Figure 1. Feed efficiency, feed costs and cost of gain as affected by age of heifers (adapted from Bach et al., 2021)

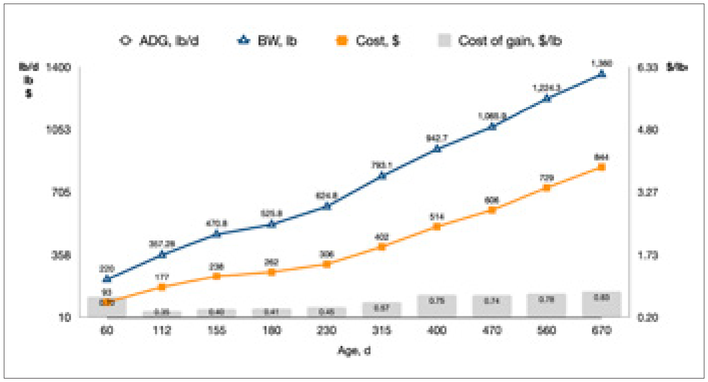


Figure 2. Optimum (least cost) growth curve of heifers to achieve 1,360 pounds of BW at 670 d of age (before calving), assuming different costs of gains during the animal's life (adapted from Bach et al., 2021)

yield. Furthermore, ADG between 60 and 200 d of life has been positively correlated with future milk production (Bach et al., 2021; Figure 3) and thus weaning strategies that set the stage for rapid ADG after weaning are attractive. One of the keys to collect these positive effects on future performance is to feed calves in a way that ADG can be maximized both before and after weaning, and that implies ensuring adequate solid feed intake.

Rate of calves between 70 and 120 d of life (adapted from Bach et al., 2021).

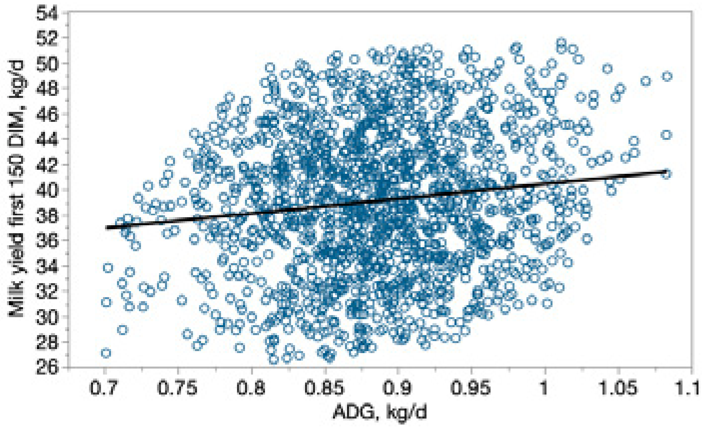


Figure 3. Average milk yield during the first 150 days in milk of the first lactation and growth

Nutrition and growth during the pre-weaning period

Growth during the pre-weaning phase is mostly affected by the amount of milk or MR and starter feed consumed by calves, and by the number of days that calves are fed milk or MR. Interestingly, ADG is not always improved with increasing supplies of MR. In some instances, with moderate provision of MR consumption and relatively long liquid feeding periods, solid feed consumption represents an important supply of nutrients toward the end of the weaning period leading to similar, or at times greater, total ADG than those obtained with increased amounts of milk or MR supply (Bach et al., 2013; Hu et al., 2019; van Niekerk et al., 2020). An ideal situation would be to offer relatively large volumes of milk (~2 pounds/d) but ensuring that intake of solid is as high as possible. At any given level of MR allowance, intake of solid feed is mainly determined by: 1) ingredient and nutrient composition of the starter, 2) physical form of the starter, 3) whether forage is made available to calves, and 4) social aspects.

Ingredient and nutrient composition of starter feeds

When feeding calves more generous MR volume (i.e. ~2 pounds/d), it may be advantageous to increase the CP content of the starter feed because calves will typically consume less dry matter (DM) (and thus every pound of feed has to provide more nutrients), and calves may benefit from additional CP. Stamey et al. (2012) reported increased solid feed intake around weaning (with ~0.7 pound/d difference) when comparing calves fed ~2 pounds/d of solids from a MR with 28.5% CP (and 15% fat, both in DM basis) and a starter feed containing 25.5% (DM basis), compared with one containing 20% CP (both on DM basis). Similarly, providing additional fat in the starter should be further explored. Fat inclusion in the starter feed has been generally discouraged, but results in the literature are inconsistent. Early publications (Kuehn et al., 1994) fed starter feeds containing 7-10% with no negative consequences on intake or growth before weaning, compared with starter feeds containing <4% fat; although Kuehn et al. (1994) found that calves on low-fat starter feeds grew more after weaning than those on high-fat starter feeds. More recent publications (Araujo et al., 2014; Hill et al., 2015; Berends et al., 2018; Doolatabad et al., 2020; Ghorbani et al., 2020) provide data about generous fat inclusion levels (~7%) in starter feeds, along with greater milk allowances (~ 2 pounds/d), and, overall, it seems that the supposed negative effect of fat in starter feeds may be related to the type of fat supplemented (soybean oil usually impairs performance) and milk replacer allowance. However, there is evidence that moderate fat content (~7%) in starter feeds seems to facilitate weaning (Araujo et al., 2014; Berends et al., 2018).

Physical form of starter feeds

It is generally accepted (Bateman et al., 2009; Nejad et al., 2012) that starter feeds with a large proportion of fines are consumed in lesser amounts than those pelleted or presented in coarser form (i.e., texturized starters). Less consistent differences exist between pelleted and texturized starter feeds, with most of the discrepancies being more likely driven by the ingredient and nutrient composition than by physical form. Finding straight comparisons between pellet and texturized starter feeds is difficult. In most occasions, the ingredients included in the two forms of stater differ. Nevertheless, results from studies allowing a direct comparison of pelleted or texturized starters with the same ingredient composition are inconclusive. Some studies (Bach et al., 2007; Terré et al., 2015) report no differences in ADG, but improvements in FE when feeding pelleted starter feeds compared with texturized starter feeds. Bateman et al. (2009) reported no differences in ADG but also no differences in FE (or intake). A more recent study (Moeini et al., 2016) reported greater intake and FE with texturized starter feeds, although the pelleted starter in this study had a large proportion of fines. Also, improvements in FE reported in some studies comparing pelleted vs. texturized starter feeds could be due to improved digestibility of pelleted starters (Du et al., 2021), potentially due to grinding of ingredients and heating of ingredients during the pelleting process. Differences among studies could be related to the ingredients used to manufacture the starter feeds and the strength (and amount of fines) in the final feeds, or also the level of appetence of the starter feeds. Calves have been shown to have preferences for specific ingredients, such as soybean meal (Montoro and Bach, 2012; Miller-Cushon et al., 2014). Furthermore, Miller-Cushon et al. (2014) evaluated the palatability of several energy and protein ingredients. They concluded that corn gluten feed and corn gluten meal should be avoided and wheat, sorghum, corn and soybean meal should be prioritized to increase palatability of starters. Oats, which are commonly included in starters, were found to have low palatability and thus their inclusion in starter formulation should not be forced. If possible, it should be avoided.

Forage supply and starter feed consumption

Provision of chopped hay increases ADG and DMI in young calves (Khan et al. 2011; Castells et al., 2012; Castells et al., 2013; Montoro et al., 2013). It has been shown that an effective method to foster solid feed intake of calves, contrary to what has been traditionally recommended, is to provide ad libitum access to poor-quality (nutritionally) chopped straw or chopped grass hay, which is seldom freely consumed at more than 10% of total solid feed intake. In the last century, it was believed that feeding a fiber source to young dairy calves was necessary because it improved rumen health and that if no forage was provided to calves, low fiber content of the complete starter should be avoided (Jahn et al., 1970; Thomas and Hinks, 1982). But, in the 1970s, the concept of textured starter was introduced (Warner et al., 1973). It was then assumed that with textured starters, no additional feeding of forage was needed. However, several authors (Kincaid, 1980; Thomas and Hinks, 1982; Phillips 2004; Suárez et al., 2007; Castells et al., 2012) have reported either an increase in starter intake or no effect on total feed consumption with the inclusion of dietary forage. Castells et al. (2012) offered an 18% neutral detergent fiber (NDF) and 19.5% CP pelleted starter in conjunction with different sources of chopped forage to young dairy calves. They reported that feeding chopped grass hay or straw improved total dry feed intake and rate of growth, without impairing nutrient digestibility and gain to feed ratio. It is important to note that, in the studies by Castells et al. (2012, 2013), when calves were fed ad libitum chopped alfalfa hay, forage intake was 14% of total solid feed intake, whereas when calves were offered chopped oats hay, forage consumption did not surpass 4% of total solid feed intake. Some nutritionists do not advocate for feeding forage and propose feeding texturized starter feeds instead, but their success may depend on the starter feed's scraping ability and more important the amount of solid feed consumed by the calf. If calves consume large amounts of starter feed, even a texturized starter feed may fail to provide sufficient scraping activity in the rumen and may actually end up limiting intake as calves age. Thus, from a practical point of view and to remove uncertainty, offering high-fiber (>60% NDF) chopped forage along with a starter feed (regardless of its physical form) is likely to result in optimum growing performance due to improved intake of solids. Lastly, an important consideration regarding feeding chopped forage to calves is that it needs to be well and consistently chopped at about 1 inch in length. Despite the fact that it must be high in fiber (>60% NDF), it must be of high quality (i.e., free of molds, mycotoxins and other impurities). Whether the forage is a legume or grass may matter. Grasses generally have greater fractions of potentially fermentable fiber and lower fermentation rates (Smith et al., 1972), tending to make them buoyant for a longer time and better at promoting rumen motility and rumination. However, they may also stay longer in the rumen and if consumed in large quantities may compromise intake. On the other hand, legumes tend to be more palatable than grasses and calves may consume excessive amounts, which may lead to reduced intake and performance.

Social aspects

Most dairy replacement calves are housed in individual hutches during the first weeks of life. The main purpose of housing calves individually is

to minimize spread of diseases and facilitate control of starter intake. The implementation of optimized management practices that reduce the spread of diseases or build calf immunity to fight pathogens when calves are grouped is especially important in contract heifer operations where animals from different origins are commingled. Reducing morbidity can be accomplished by reducing the amount of stress calves undergo (stress induces immune depression) and maintaining a high level of hygiene and a low microbial load in the environment. To minimize the stress associated with weaning, it is commonly recommended to keep calves individually housed for an additional 1 or 2 weeks following weaning. However, in recent years, several studies have reported important benefits of comingling calves early in life.

A University of Minnesota study (Ziegler et al., 2008) compared performance of calves that were weaned and immediately moved to groups of 10 animals with those weaned and kept in individual stalls for an additional 14 d. Researchers reported no differences in performance during the first 112 d following weaning. A subsequent study (Bach et al., 2010), involving 320 calves, reported that calves moved to groups immediately after weaning reached the target BW 6 d earlier and experienced a lower incidence of respiratory afflictions and had a greater ADG than those grouped 6 d after weaning. In a second experiment, Bach et al. (2010) used 240 female calves to assess the impact of grouping animals before weaning on ADG and health. Half of the calves were moved at 49 d of age (when MR was reduced from twice to once daily dose) to super-hutches holding eight calves with an elevated trough that was used to continue delivering MR until weaning. The other half remained individually housed for an additional week, after reducing the milk replacer offered from twice to once daily dose. Calves grouped at 49 d of age had a greater ADG and BW at 56 d of age as a result of a greater total solid feed consumption, compared with those grouped at 56 d of age. In addition, calves grouped at 49 d of age had a lower number of respiratory cases than those grouped at 56 d of age. More recently, Costa et al. (2015) have shown that social housing at 1 week of age supports greater intake and growth compared with calves grouped at 6 weeks of age; other studies also report similar results when providing social contact to calves before 3 weeks of age when feeding relatively large amounts (~2.2 pounds/d) of milk (Jensen et al., 2015; Overvest et al., 2018).

References available upon request.

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Nutritional interventions to support hydration and recovery of diarrheic calves

Juliette N. Wilms, Leonel N. Leal, and Javier Martín-Tereso, *Trouw Nutrition R&D*

Successful recovery from diarrhea relies on the implementation of appropriate nutritional interventions in the early stages of disease. Regardless of disease etiology, diarrheic calves experience extensive fecal losses of water and electrolytes, often resulting in dehydration, loss of acid-base balance and negative energy balance (Constable et al., 2001; Trefz et al., 2012). Severe intestinal epithelial damage reducing the nutrient absorptive capacity of the gut may also occur (Klein et al., 2008; Foster and Smith, 2009).

A common practice to avoid additional digestive disturbances associated with milk feeding is to withdraw milk up to 48 hours (h) or until diarrhea has stopped (Constable et al., 2001). However, research shows that withholding milk exacerbates weight loss and dehydration, and delays recovery from diarrhea (Garthwaite et al. 1994; Olivett et al., 2012). Besides sustaining milk feedings, oral rehydration solutions (ORS) should be offered to diarrheic calves in between milk meals to maximize daily fluid intake, and in this way, to mitigate dehydration (Rademacher et al., 2002).

Alternatively, mixing ORS directly into whole milk or milk replacer has been proposed to reduce labor associated with calf diarrhea (Bachman et al., 2012). However, this practice has nutritional implications worth consideration. Mixing ORS into milk or milk replacer increases the osmolality of the solution close to 600 mOsm/kg. High meal osmolality delays abomasal emptying (Sen et al., 2006; Hildebrandt et al., 2020), which is a risk factor for other gastrointestinal disorders, such as abomasal bloat (Burgstaller et al., 2017). Furthermore, if access to water is not available, something unfortunately common in very young calf management (USDA, 2016), the combined application of ORS and milk, can lead to hypernatremia (serum Na^+ >145 mmol/L) within 24 to 48 h (Wilms et al., 2020a). In such situations, plain water intake is insufficient to facilitate Na^+ and Cl^- renal excretion, which then accumulate in the extracellular space causing neurological complications in acute cases (Byers et al., 2014).

While the World Health Organization (WHO) recommends an ORS with an osmolality of 245 mOsm/kg, which include 75 mmol/L of Na^+ and 75 mmol/L of glucose for humans (UNICEF & WHO, 2016), ORS for calves often contain Na^+ and glucose concentrations greater than 100 mmol/L (Smith and Berchtold, 2014; Sayers et al., 2016). Consequently, ORS for diarrheic calves are often hypertonic and may reach osmolalities between 400 and 600 mOsm/kg (Smith and Berchtold, 2014). It is now generally accepted that diarrheic calves should continue receiving milk (Olivett et al., 2012) and therefore may not benefit from increased glucose concentrations in ORS (Wilms et al., 2020b). Recent work showed that low tonicity ORS (~300 mOsm/kg) with a similar Na^+ concentration as the WHO ORS are equally able to expand plasma volume when compared with hypertonic ORS or hypertonic milk-ORS mixtures with Na^+ concentrations greater than 100 mmol/L (Bachman et al, 2012; Wilms et al., 2020b).

Besides dehydration, metabolic acidosis is an additional consequence of excessive fecal mineral losses and lactic acids accumulation (Trefz et al., 2012). This is a common complication of severe diarrhea, particularly in calves and young small ruminants (Lorenz and Lorch, 2009). For this reason, ORS with high Na^+ concentrations and high strong ion differences (SID; >60 mEq/L) are used to prevent or mitigate the severity of metabolic acidosis (Trefz et al., 2012; Smith and Berchtold, 2014). However, our group has recently shown (Wilms et al., 2020b) that for a same SID of 74 mEq/L, low tonicity ORS (~300 mOsm/kg) are more effective at restoring and maintaining blood acid-base balance than hypertonic ORS (470 mOsm/kg) in diarrheic calves. This is because high osmolality ORS resulted in mineral retentions different than expected from the formulated SID. It can be concluded that moderate osmolality ORS (250 to 350 mOsm/kg) with high SID (>60 mEq/L) is a more effective intervention in diarrheic calves that continue to receive milk during rehydration treatment.

References available upon request.

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