Nutritional Strategies to Improve the Health & Performance of Dairy Calves

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Outline

- Why do pre-weaned calves get sick?
  - Development of gastrointestinal immunity
- Nutrition and immunity of calves
  - Reducing interaction of pathogens with calf
  - Plane of nutrition during pre-weaned period
  - Early life nutrition influence health later in life?

Why do so many calves get sick?

- Risk of mortality greatly decreases after the first few weeks of life
- What changed in the calf during this period?

Gastrointestinal Maturation

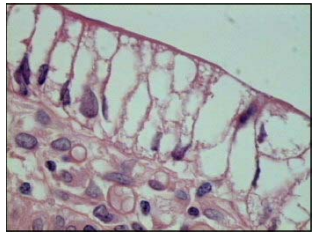
- Some components of the GI immune system develop after birth
- Catch-22 Situation
  - Passive absorption of macromolecules but increases risk for translocation of microorganisms
- Ideal situation
  - Absorb adequate antibodies
  - No absorption of microorganisms
  - Rapid maturation of the GI tract

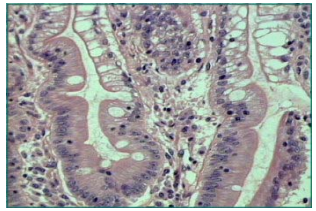
Gastrointestinal Maturation

- Many components to the GI immune system
  - Physical barrier
  - Chemical barrier
  - Immunological barrier
  - Microbial barrier

Gastrointestinal Maturation

- Physical
  - Vacuolated enterocytes
    - *Pinocytosis*
    - *Proximal to Distal*
    - *Crypt to Villus*
  - Reduced tight junctions
  - Goblet cells increase secretions
    - *Microbial exposure*

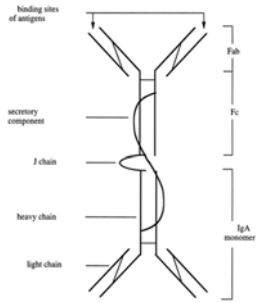




http://www.epathologies.com

Gastrointestinal Maturation

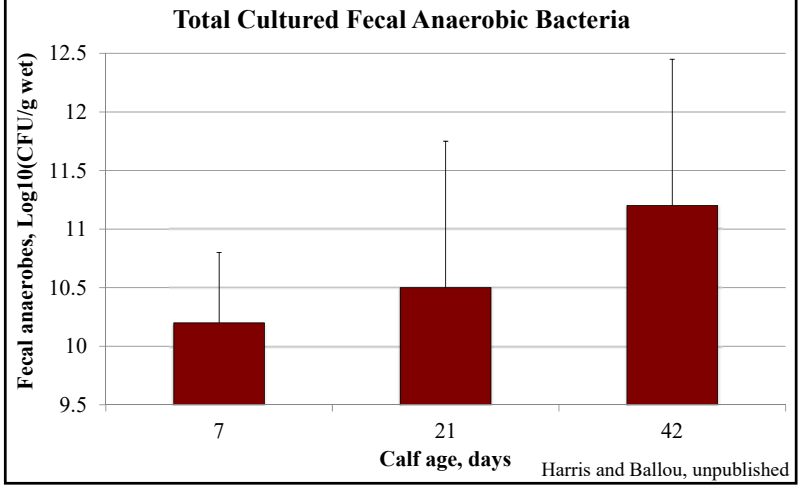
- Chemical and Immunological
  - Paneth cell numbers and secretions increase post-natal
  - Secretory IgA concentrations low
    - *Increase as calf develops own active immunity*
  - Recirculation of colostral antibodies
    - *Half-life only 1 – 2 weeks*



Gastrointestinal Maturation

- Microbial
  - 1,000,000,000,000 ± a lot microorganisms live in the gastrointestinal tract
  - Most of them are not a threat to the calf
  - In adults > 99% are strict anaerobes (ie: *bifidobacterium, lactobacilli*)
  - In neonates there is a progression from facultative anaerobes from the environment (ie*: enterobacteriaceae, streptococcus, and staphylocaccus*) to more strict anaerobes

Microbial Ecology



Why do so many calves get sick?

- Why do so many calves get sick and die during the first few weeks of life?
- **TAKE HOME: Many holes in GI immune system for the first few weeks**
  - ***Physical Barrier***
  - ***Chemical / Immunological Barrier***
  - ***Microbial Barrier***

Strategies to improve immunity

- What role can nutrition play in reducing enteric disease?

Colostrum

- What is the most important thing we can do on a farm to improve the health of calves?

- What is the goal of colostrum management?

Colostrum

- Most people - “Passive Transfer of Antibodies”
- There is more to colostrum than antibodies
  - Many compounds in colostrum and transition milk are involved in post-natal development of the gastrointestinal (GI) immune system
- Improve calf health if colostrum management is also focused on improving GI maturation

Colostrum

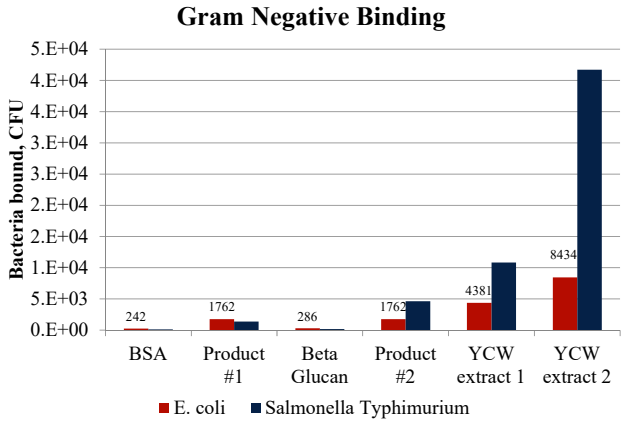
- What about colostrum cleanliness?
  - Ranged from 3,000 to 6,800,000 CFU/mL
  - 43% samples greater than 100,000 CFU/mL
  - 16.9% samples greater than 1,000,000 CFU/mL
- Pasteurize colostrum?
  - 60°C for 1 hour
  - Impacts on GI maturation?
- Bioactive additives?

Morrill et al., 2012, JDS

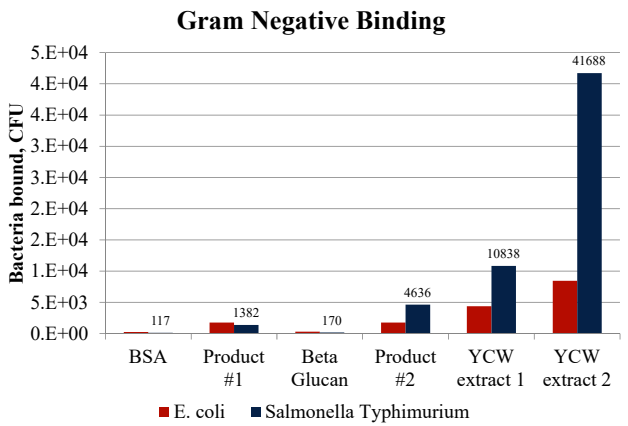
Strategies to improve immunity

- Prevent interaction of pathogens with calves
  - Prebiotics – not easily digestible carbohydrate
    - *Improve bacterial growth*
    - *Potential binding of gram negative*
  - Probiotics – strict anaerobic bacteria
  - Functional proteins
    - *Colostrum*
    - *Immunized egg*
    - *Plasma*

Strategies to improve immunity

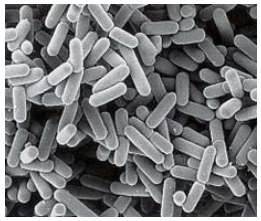


Strategies to improve immunity



Strategies to improve immunity

- Putative Probiotic - Mechanisms of Action
- Competitive inhibition – space and resources
- Antimicrobial factors
- Stimulate other mucosal immune defenses

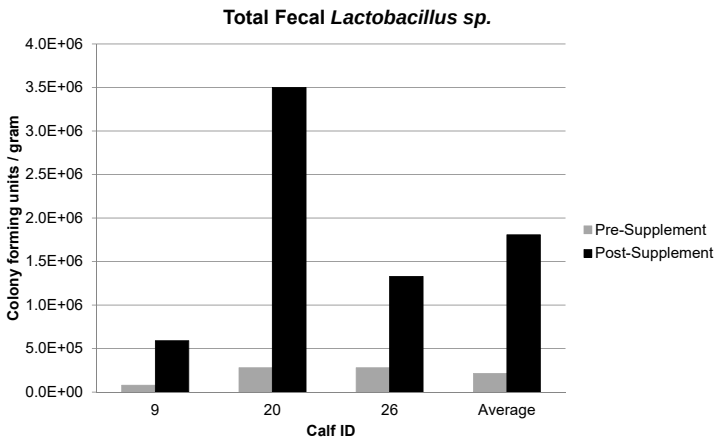


Direct fed microbials

Materials and Methods

- Anaerobic, lactic acid bacteria
- 3 Holstein heifers (7 d old)
- Supplemented for 3 d with 2 x 10^9 CFU of a combination of *Lactobacillus casei* and *Enterococcus faecium*
- Pre- and Post-supplementation fecal sample collected
- Total *Lactobacillus sp* present in fecal sample determined

Direct fed microbials



Direct fed microbials

- Ballou (2011) reported that calves (n=45) supplemented twice daily with a blend of prebiotics, probiotics, and hyper-immune egg protein from birth to 21 d of age
  - Less enteric morbidity (25% vs 51%)
  - Less milk refusal d 1 – 4 of life (57 vs 149 g DM)
  - No difference in plasma glucose, urea nitrogen, or haptoglobin
  - No in difference in ADG or efficiency
  - No difference in starter intake

Direct fed microbials

Materials and Methods

- 24 (1-d old) Jersey Bull Calves from a Calf Ranch
- Blocked by total serum protein and initial BW
  - **CONTROL –** Milk replacer only
  - **CONTROL + *Salmonella*** – Milk replacer only & challenged with *Salmonella enterica* on d 7
  - **Probiotic + *Salmonella* –** Milk replacer supplemented & challenged with *Salmonella* on d 7
    - **2 x 10^{10} CFU / d from d 1 to 3**
    - **2 x 10^{9} CFU / d from d 4 to 21**
- Calves were fed 500 g/d of a 22%CP and 20% fat milk replacer
- Ad libitum access to a 22%CP texturized calf starter

Liang et al. unpublished

Direct fed microbials

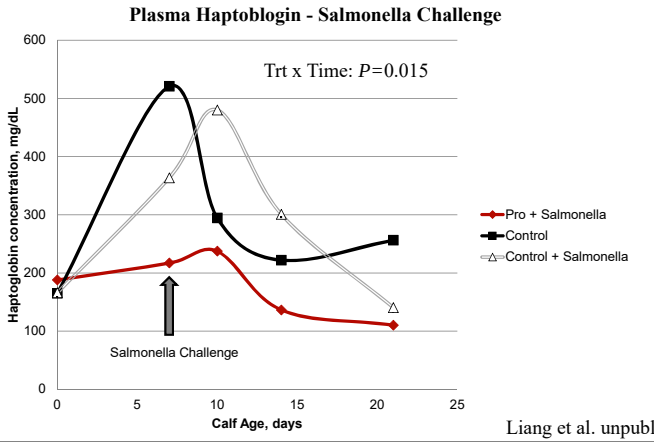
Materials and Methods

- Challenged with log-growth *Salmonella enterica* in morning milk replacer
- BW collected on d 0, 7, 14, and 21
- Blood collected on d 0, 7, 10, 14, and 21
- Histology d 21
  - *Duodenum and Ileum*

Liang et al. unpublished

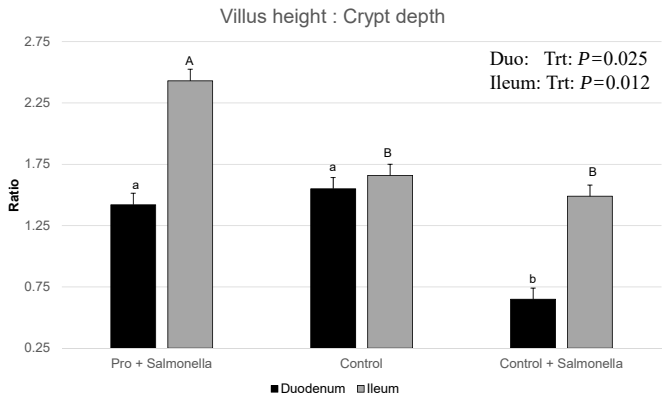
Direct fed microbials

Results



Liang et al. unpublished

Direct fed microbials



Liang et al. unpublished

Direct fed microbials

Conclusions

- Feeding certain strains of lactic acid producing bacteria can increase fecal excretion of those bacteria
- Reduce both measures of systemic inflammation and intestinal inflammation during an enteric disease challenge with *Salmonella*
- Impacts on other viral / protozoal infections remains to be determined

Liang et al. unpublished

High Risk Calves – Milk supplements

100 calves were enrolled within 24 hours of birth

- Transported from a calf ranch to the Texas Tech Calf facility
- Blocked by total serum protein and initial BW
- Study conducted in 2 consecutive periods
- Individual outdoor calf hutches
- Offered 700 g of a 22% CP / 20% fat milk replacer
  - *0700 and 1600*
- Ad libitum access to pelleted calf starter
- Weaned at 56 d and group housed in pens of 8 – 10 calves
  - *Preweaned – 1 to 56 days*
  - *Postweaned – 57 to 84 days*

Davis et al. unpublished

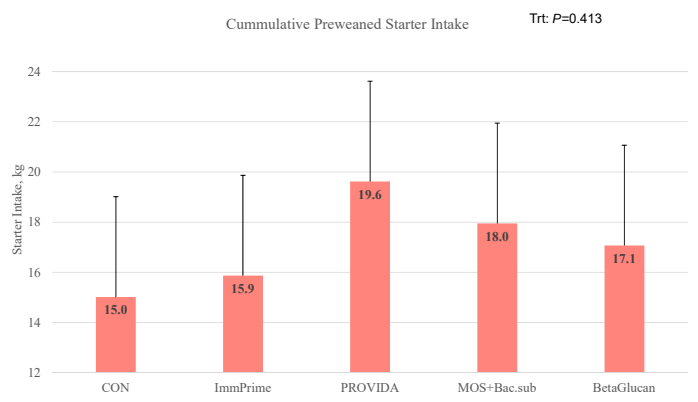
High Risk Calves – Milk supplements

Treatments Included:

- Beta-glucan from mushroom
  - *1 gram per day*
- ImmunePrime
  - *Per manufacturer recommendation – first 3 days only*
- PROVIDA Calf – 2 x 10^9 CFU / d
  - *Lactobacillus casei & Enterococcus faecium*
- MOS + *Bac. subtilus* – 3 g / d + 4 x 10^9 CFU / d

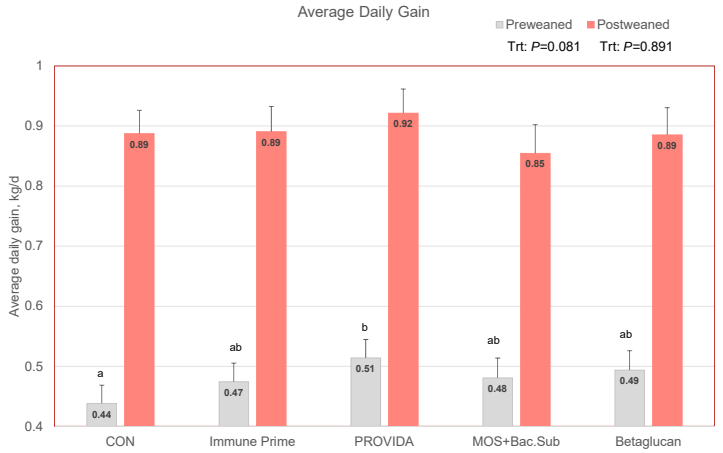
Davis et al. unpublished

High Risk Calves – Milk supplements



Davis et al. unpublished

High Risk Calves – Milk supplements



Davis et al. unpublished

High Risk Calves – Milk supplements

Implications

- Starter intake was variable
  - Numerically greater among the PROVIDA probiotics, MOS+*Bac. subtilis*, and Beta Glucan treatments
- All treatments numerically increased ADG during preweaned period
  - Supplementing the PROVIDA probiotics increased ADG during the preweaned period
  - No effect during postweaned period

Davis et al. unpublished

Strategies to improve immunity -

- **TAKE HOME** - Not all studies reported improvements
  - *Generally regarded as safe*
- Mechanistically speaking these products could reduce risk for enteric disease
- Generalization – possible effect size of 2 to 5 kg
- Reduce incidence or intensity / duration of disease

Quantity of milk solids

- "I'm not surprised so many calves die because we starve them"
  - Is this true?
  - It sure sounds good
- How much milk should I feed my calves?
  - Restricted (0.45 to 0.7 kg of solids / day)
  - Similar to nature (1 to 1.4 kg of solids / day)
- Why does the industry limit feed milk?
  - Wean earlier
  - Perception that it's more expensive to raise a calf because 1 kg of milk solids more expensive than 1 kg of calf starter

Quantity of milk solids

- Unfortunately we do not have a good idea of the long-term impacts of restricting milk
- Improved lactational performance
  - ~960 pounds of milk during lactation
- Does plane of nutrition influence health?

Soberon and Van Amburgh, 2013

Quantity of milk solids - Enteric

- Risk for Enteric Disease **High risk calves**
- Coronavirus challenge (Quigley et al., 2006)
  - Days with **scours increased by 53%** when fed the variable program
  - Days on **antibiotics** – **3.1 versus 1.9 d** for variable and conventional, respectively
- Colostrum deprived (Sharon et al., unpublished)
  - 2/18 calves died in both High and Low
  - More High calves bloated **(29.4 vs. 6.7%;** P=0.10)
  - More High calves scoured (**66.7 vs. 22.2%;** P=0.007)

Quantity of milk solids - Enteric

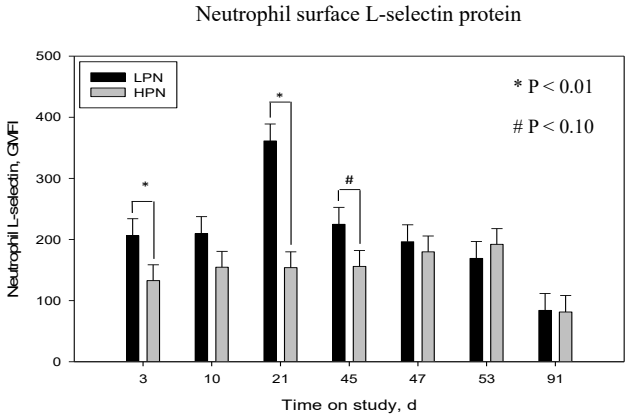
- Cornell Study – *Cryptosporidium parvum*
  - Challenged at 3 days of life
  - Holstein calves fed greater plane of nutrition:
    - *Maintained **better hydration** and **fecal scores improved faster***
    - ***No difference** in oocyst shedding*

Ollivett et al., 2012

Quantity of milk solids - Enteric

- Risk for Enteric Disease **<u>Leukocyte Responses</u>**
- Feeding higher milk solids
  - Greater inflammatory response potential (Ballou, 2012; Liang et al., unpublished)
  - Possibly more rapid upregulation of neutrophil responses upon infection (Ballou et al., 2015)
  - Reduced neutrophil activity during preweaned period (Obeidat et al., 2013; Ballou et al., 2014)

Holstein – Leukocyte function



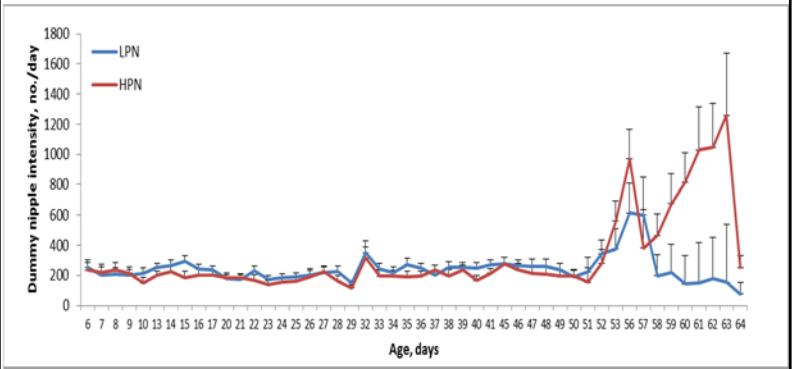
Obeidat et al., JDS 2013

Quantity of milk solids - Enteric

- Digestibility Study – **Healthy Cows**
  - 12 Jersey bull calves fed either a **LOW** or **HIGH** during the 1st week of life
  - Measured everything In minus Out
  - No difference
    - *Fecal DM **(31.9 vs 30.9%)**; despite fecal scores being greater among HPN calves **(1.52 vs 2.06**; P = 0.001)*
    - *Energy digested **(92.8 vs 92.7%)***
  - Protein digestion and retention greater among **HIGH**
    - *Digestible N **(83.7 vs 88.5%)** and N retention **(81.8 vs 86.6%)***

Liang et al., 2016, JDS

Quantity of milk solids - Enteric



Sharon et al., unpublished

Quantity of milk solids - Enteric

- **TAKE HOME** – Risks for Enteric Disease
- Fecal scores are not an appropriate measure of enteric health
- Healthy calves are able to digest and absorb nutrients well during the 1st week of life
- More active neutrophils among LPN calves may reflect less developed GI immune system or elevated microbial exposure (hypothesis)

Quantity of milk solids - Enteric

- **TAKE HOME** – Risks for Enteric Disease
- Complex
  - Pathogen:Calf interaction
  - Unique challenges to every strategy
  - Likely beneficial to feed greater than 2X per day

<u>Adding more milk solids to an existing problem will not solve your problem, vice versa</u>

Quantity of milk solids

- Does early life nutrition influence health later in life?
  - 30 Holstein bull calves fed either **LOW** or **HIGH** and weaned at 54 d of age
  - Challenged with 10^8 PFU/nostril with bovine herpesvirus-1 at 81 d of age
  - Challenged with 10^6,10^7, or 10^8 CFU *Mannheimia haemolytica* at 84 d
  - Observation period through 94 d
  - 4/15 Low calves died consistent with respiratory disease
    - *1, 2, and 1 challenged with 10^6, 10^7 & 10^8, respectively*
  - 0/15 High calves died

Sharon and Ballou, unpublished

Quantity of milk solids

Quantity of milk solids

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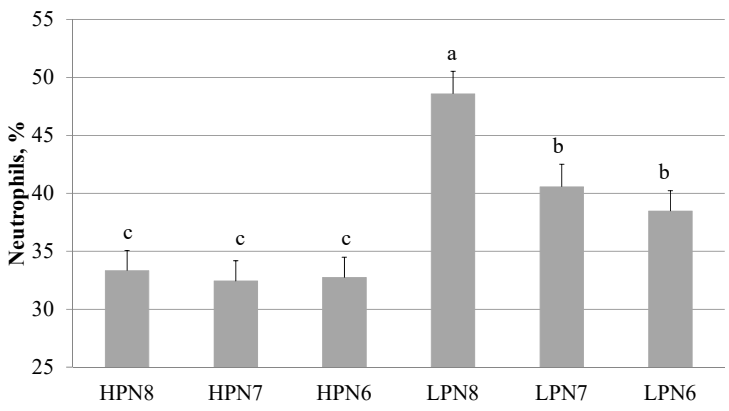
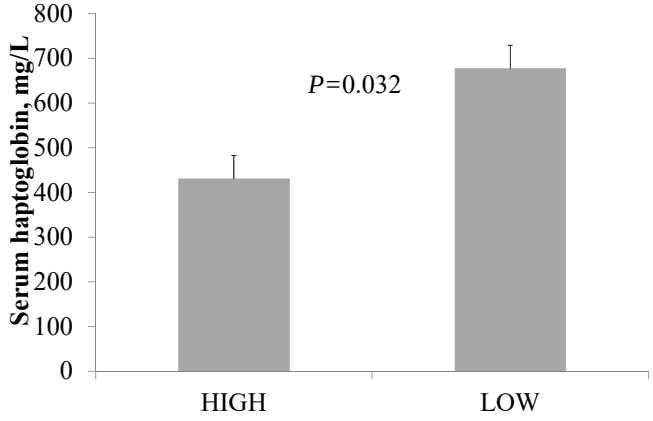


PON x MH Dose: *P*=0.041

Sharon and Ballou, unpublished

Quantity of milk solids



Sharon and Ballou, unpublished

Quantity of milk solids

- **TAKE HOME** – Risks for Disease Later in Life
- Data indicating that post-weaned health is improved among calves that were previously fed a higher plane of milk replacer
- Does this continue to persist later in life…?
- So how much milk solids should we feed calves?
  - Evaluate
    - *Body weight and structural growth at weaning*
    - *Health during both pre-weaning and post-weaning*

Questions / Comments

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