Enhancing calf immunity through nutrition

Michael A. Ballou, Ph.D.
Department of Animal and Food Sciences
Texas Tech University, Lubbock, TX, USA
Michael.Ballou@ttu.edu
(806) 742-2805 x251
How much milk would a pre-weaned calf drink in a day if they were offered as much as they want?

A. ½ gallon
B. 1 gallon
C. 1.5 gallons
D. 2.0 gallons
E. 2.5 gallons
Outline

- Why do pre-weaned calves get sick?
- Nutrition and immunity of calves
  - 1st week(s) of life
  - Remaining pre-weaned period
- Implications and concluding thoughts
Pre-weaned calves get sick!

• Dairy calves in US
  • 7.8 to 10.8% pre-weaned heifers died
    • 57 to 61% of deaths associated with gastro-intestinal (GIT) disease
  • 1.8% post-weaned heifers died

• Dairy calves in England (1930’s and 40’s)
  • 5 to 6% pre-weaned heifers died

• Human neonates
  • 0.43% infants died from birth to 28 days of life
  • 0.24% infants died from 28 days to 1 year of life

Lovell and Hill, 1940; Withers, 1952; NAHMS, 1993; 1996; 2007 and CDC 2008
Why do calves get sick?

Disease Resistance

Microorganisms

Immune Responses
Why do calves get sick?

- Immune system recognizes “self” from “non-self”
Why do calves get sick?

• Risk of mortality greatly decreases after the first few weeks of life

• What has changed in the calf during this period?
Why do calves get sick?

• What has changed in the calf during this period?
  • Half-life of colostrum antibodies ~ 16 days
  • Many other immune cell responses have not changed or actually decreased
  • Other plasma bactericidal factors have increased?
  • Gastro-intestinal tract is more mature

Kampen et al., 2006; Ballou et al., 2009
Why do calves get sick?

- A competent GIT serves as the first barrier for potential pathogens
- The GIT of a new born calf is not yet mature
- Likely that nutritional and other bioactive factors in colostrum and milk influences the development of the GIT

Guilloteau et al., 2009
Strategies to improve immunity

• What role can milk nutrition play?
  • Quantity and frequency of feeding
  • Composition – Milk versus milk replacers
Strategies to improve immunity

- Prevent interaction of pathogens with calves
  - Prebiotics, Probiotics, and Hyper-immunized egg proteins
- Improve survival of severely sick calves
  - Prevent excessive inflammation
Prebiotics, probiotics, egg protein

• What are prebiotics, probiotics, and hyper-immununized egg protein?

• How can feeding these to calves prevent the interaction of pathogens with the GIT of calves?
Prebiotics, probiotics, egg protein

Antigens

Antigen-binding site

Antibody

Science 2011, 14:182
• **Prebiotics** – dietary components not digested by the calf but used by bacteria in the GIT

• **Probiotics** – all bacteria not all created equally. Some less dangerous and may prevent the more dangerous ones from causing disease

• **Hyper-immunized egg proteins** - laying hens vaccinated against the pathogens that commonly cause disease in calves
Effects of supplementing a blend of prebiotics, probiotics, and hyper-immunized egg protein on growth and incidence of scours in calves during the first 3 weeks of life (Ballou, 2011)

- Calves (N=90) either supplemented prophylactically with a commercial blend (C&E Agri-Products) or not given any supplement (Control)
- All calves fed ½ a gallon of a 20/20 milk replacer twice daily
- Fecal scores determined prior to each feeding by 2 independent, trained observers
Prebiotics, probiotics, egg protein

- Fecal scores determined before each feeding by 2 independent, trained observers
  - $1 = \text{firm, well-formed}$
  - $2 = \text{soft, pudding-like}$
  - $3 = \text{runny, pancake batter}$
  - $4 = \text{liquid, pulpy orange juice}$

- Scours classified as calf with consecutive fecal scores $\geq 3$
Results

- Mortality low (only 1 Control calf died)
- Supplemented calves refused less milk during the first 4 days of life (57 vs 149 grams of dry powder; \( P<0.01 \))
- Supplemented calves also had reduced incidence of scours over the first 21 days of life (25.0 vs 51.1%; \( P<0.01 \))
- No difference in calf starter intake or average daily gain
Prebiotics, probiotics, egg protein

- Conclusions
  - Ballou (2011) study reduced scours. Low mortality in study, even among Controls. More research needed on high-risk calves
  - Not all studies have reported improvements in GIT health, but no studies have reported adverse effects
Prevent excessive inflammation
Prevent excessive inflammation

- Excessive inflammation can cause so much damage to the calf’s body that death is inevitable.
- Identifying a severely-ill calf and intervening with anti-inflammatory drugs in time is difficult because the rapid onset.
- Preventing excessive inflammation prophylactically is likely a better solution.
Prevent excessive inflammation

- Effects of supplementing 0, 5, or 10% of the fatty acids in milk replacer those from fish oil (Ballou et al., 2008)

- After 23 days of supplementation calves were challenged with a high lipopolysaccharide to simulate excessive inflammation

  - A lot of measures of inflammation intensity measured after the challenge
Prevent excessive inflammation
Prevent excessive inflammation

Change in Serum Iron over Baseline, ppm

Time following challenge, hr
Prevent excessive inflammation

- Calves supplemented with fish oil had ($P < 0.05$)
  - Reduced sickness scores (depressed and lethargic)
  - Reduced catabolism of tissues
- Replacing either 5 or 10% of the fatty acids with those from fish oil reduced inflammation and the effect was linear with fish oil dose
- May reduce mortality in septicemic calves
Life after 2 weeks

• How do most people feed calves and why do they do that?
  • Quantity and frequency of feeding
Life after 2 weeks

- Conventional system
  - 1 to 1.5 lbs solids (1 to 1.5 gallons) per day in 2 meals
- Nature
  - 2.8 lbs solids (~2.5 gallons) per day in 12 to 17 meals
- Why limit feed?
  - Wean calves earlier
  - Perception that more expensive to raise a calf because 1 lb of milk powder is more expensive than 1 lb of calf starter

Hammell et al., 1988
Life after 2 weeks

- Unfortunately we do not have a good idea of the long-term impacts of restricting milk

- Recent meta-analysis suggests calves fed more fluid during the pre-weaned period have improved lactational performance

- Programs often called “Accelerated”, “Intensive”, or “Full Potential”

- Does plane of nutrition influence health?

Soberon and Van Amburgh, 2013
Life after 2 weeks

3 studies conducted at Texas Tech University
Life after 2 weeks

- **TTU#1 – Summer 2009**
  - 42 bull calves (n=20 Holstein and n=22 Jersey)
    - 2 ± 1 day old were studied in a 2x2 factorial
    - *Low* = 454 g / d of a 20/20 milk replacer (LOL)
    - *High plane Holstein* = 810 (wk 1) and 1,180 (wk 2-6) g / d of a 28/20 (LOL)
    - *High plane Jersey* = 568 (wk 1) and 680 (wk 2-6) g / d of a 28/25 (LOL)
  - Subcutaneous LPS challenge on d 7
  - On d 4, 42, and 77 *ex vivo* immune competence

Ballou, 2012
Life after 2 weeks

- Quantity of milk replacer
  - No effect of plane of nutrition x time following LPS challenge
  - On d 4 and 42 no differences in the neutrophil oxidative burst or whole blood killing of *E. coli*
  - High Plane Jersey’s improved neutrophil oxidative burst and whole blood killing on d 77

Ballou, 2012
Life after 2 weeks

Whole Blood Killing: Escherichia coli - 60 min Incubation

**P < 0.01

Ballou, 2012
Life after 2 weeks

- TTU#1 – Summer 2009
  - Jersey calves fed a more conventional plane of nutrition had reduced neutrophil and whole blood killing capacities during the post-weaned period
  - Does this influence susceptibility to disease?

Ballou, 2012
Life after 2 weeks

- **Follow-up study – Jersey Calves – TTU#2**
  - Summer 2011
  - 46 Jersey calves (3 ± 1 d old)
    - *Low Plane* – 409 g DM / d of a 20/20
    - *High Plane* – 610 and 735 g DM / d of a 28/25 wk 1 and 2-6, respectively
  - On d 7, 21, 42, and 77 ex vivo immune competence and biochemical analyses

Ballou et al., unpublished
Plasma Glucose Concentrations

**P < 0.01

# P < 0.10

Ballou et al., unpublished
Life after 2 weeks

- Follow-up study – Jersey Calves – TTU#2
  - On d 84 challenged with $10^7$ CFU of *Salmonella typhimurium*
    - 20 bull calves ($n=11$ Low plane; $n=9$ High plane)
    - Indwelling rectal temperature probes from -1 to +10 d
    - Peripheral blood sample taken daily
      - Glucose, urea nitrogen, and haptoglobin
      - Whole blood pro-inflammatory culture
      - Neutrophil oxidative burst to an *E. coli*

Ballou et al., unpublished
Life after 2 weeks

Neutrophil Oxidative Burst Intensity

Time relative to challenge, d
0 2 4 6 8 10
Neutrophil oxidative burst intensity, GMFI
80 100 120 140 160 180 200 220 240
Low Plane
High Plane

# P < 0.10

Ballou et al., unpublished
Life after 2 weeks

Plasma Haptoglobin Concentrations

- Low Plane
- High Plane

Time relative to challenge, d

Plasma haptoglobin, OD

Trt: P < 0.05

Ballou et al., unpublished
Life after 2 weeks

- Follow-up study – Jersey Calves – TTU#2
  - Jersey calves previously fed a higher plane of milk replacer had a more rapid up-regulation of the inflammatory and neutrophil responses with lower measures of disease

Ballou et al., unpublished
Life after 2 weeks

- Cornell Study – *Cryptosporidium parvum*
  - Holstein calves that were fed a higher plane of nutrition and challenged with *C. parvum* at 3 days of age:
    - Maintained better hydration and fecal scores improved faster
    - No difference in oocyst shedding

Ollivett et al., 2012
Life after 2 weeks

- Plane of fluid nutrition
  - This is an area of active research, but early reports are promising that feeding calves a higher plane of nutrition may improve disease resistance and the effects may persist past the pre-weaned period
Concluding thoughts

• Early life
  • Extremely susceptible to disease
    • *Reduce interaction of potential pathogens with the calf’s GIT*
  • High risk of mortality
    • *Supplementing omega-3 fatty acids may improve survival of severely-ill, septicemic calves*
  • More research is needed to understand how quantity, frequency of feeding, and composition of fluid influences GIT maturation and disease susceptibility
Concluding thoughts

• Life after 2 weeks
  • Risk of disease and death decreases
  • Early data report that plane of fluid nutrition during the pre-weaned period improves resistance to various infectious diseases
    • More data are needed in this exciting area of research
  • So should you feed your calves a higher plane of fluid?
    • Is it actually more expensive raise calves from birth to first parturition?
    • Are you weaning your calves early?
Calf Immunity – Clicker Question

How much milk would a pre-weaned calf drink in a day if they were offered as much as they want?

A. ½ gallon
B. 1 gallon
C. 1.5 gallons
D. 2.0 gallons
E. 2.5 gallons
Questions / Comments

Contact Information

Michael A. Ballou
Texas Tech University
Department of Animal and Food Sciences

michael.ballou@ttu.edu
(806) 742-2805 x251