



# Enhancing calf immunity through nutrition

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# 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.  $\frac{1}{2}$  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
  - 1<sup>st</sup> 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



# Why do calves get sick?

## *Disease Resistance*

*Microorganisms*

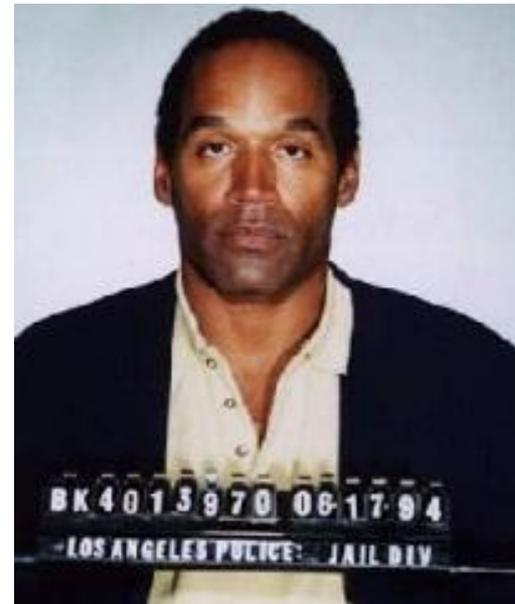


*Immune Responses*

# 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



# 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



# 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



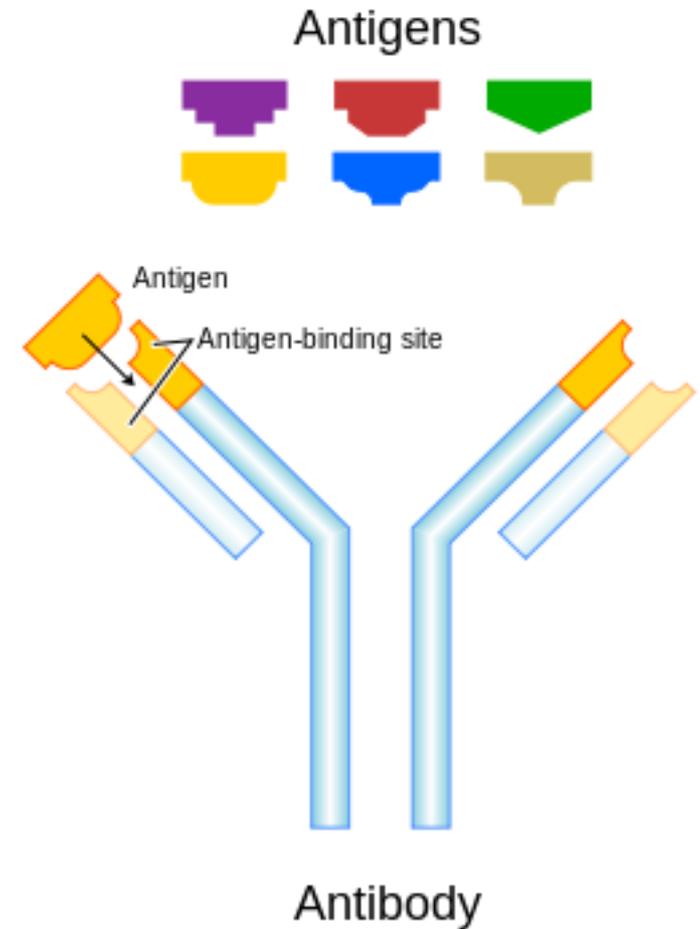
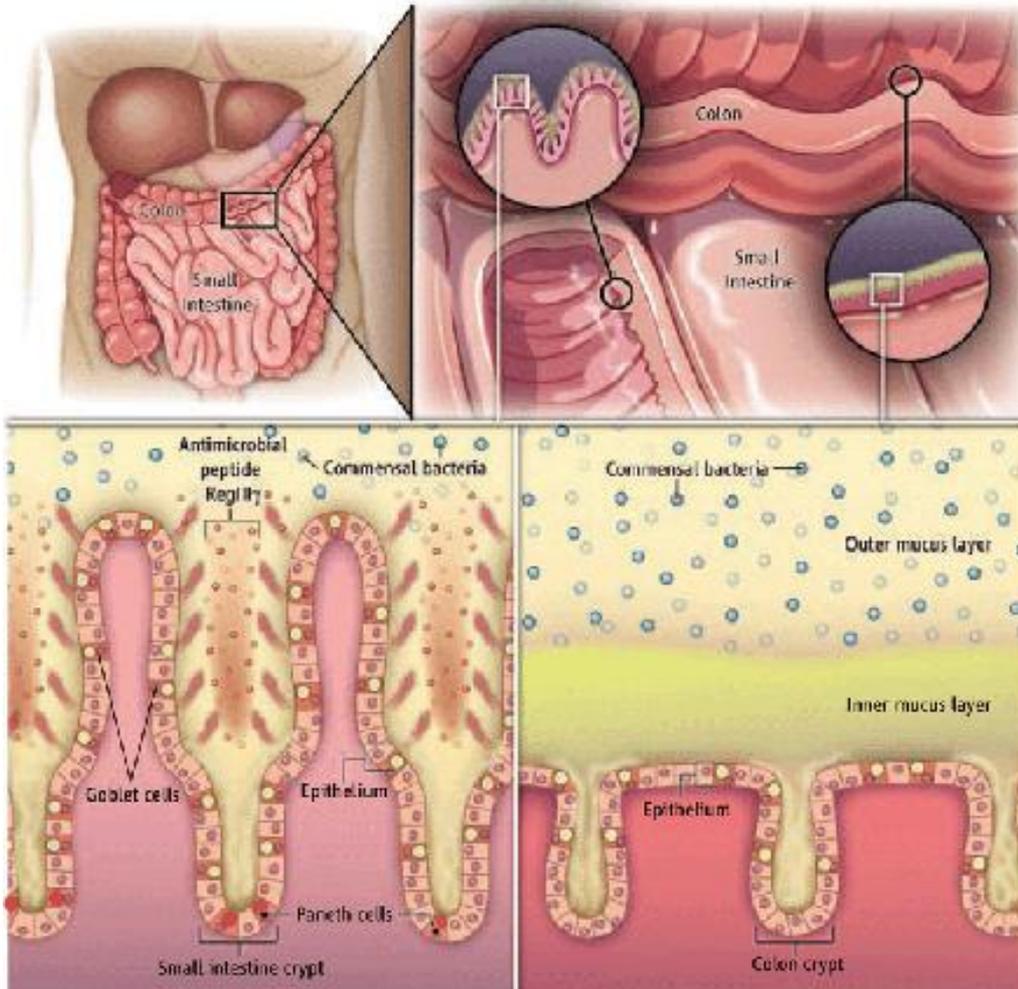
# Prebiotics, probiotics, egg protein



- What are prebiotics, probiotics, and hyper-immunized egg protein?
- How can feeding these to calves prevent the interaction of pathogens with the GIT of calves?



# Prebiotics, probiotics, egg protein



# Prebiotics, probiotics, egg protein



- **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

# Prebiotics, probiotics, egg protein



- 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  $\frac{1}{2}$  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 = firm, well-formed
  - 2 = soft, pudding-like
  - 3 = runny, pancake batter
  - 4 = liquid, pulpy orange juice
- Scours classified as calf with consecutive fecal scores  $\geq 3$

# Prebiotics, probiotics, egg protein



## ■ 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

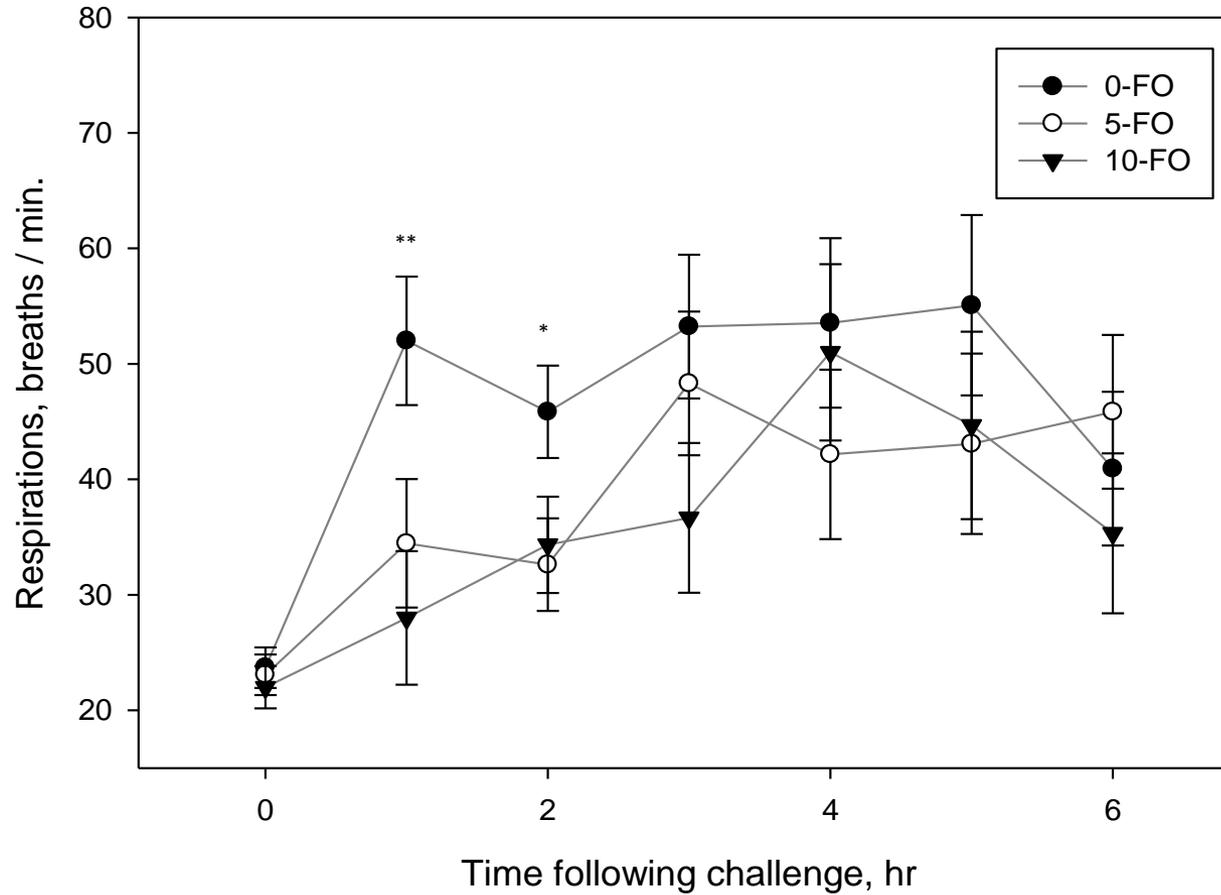


# Prevent excessive inflammation

- 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

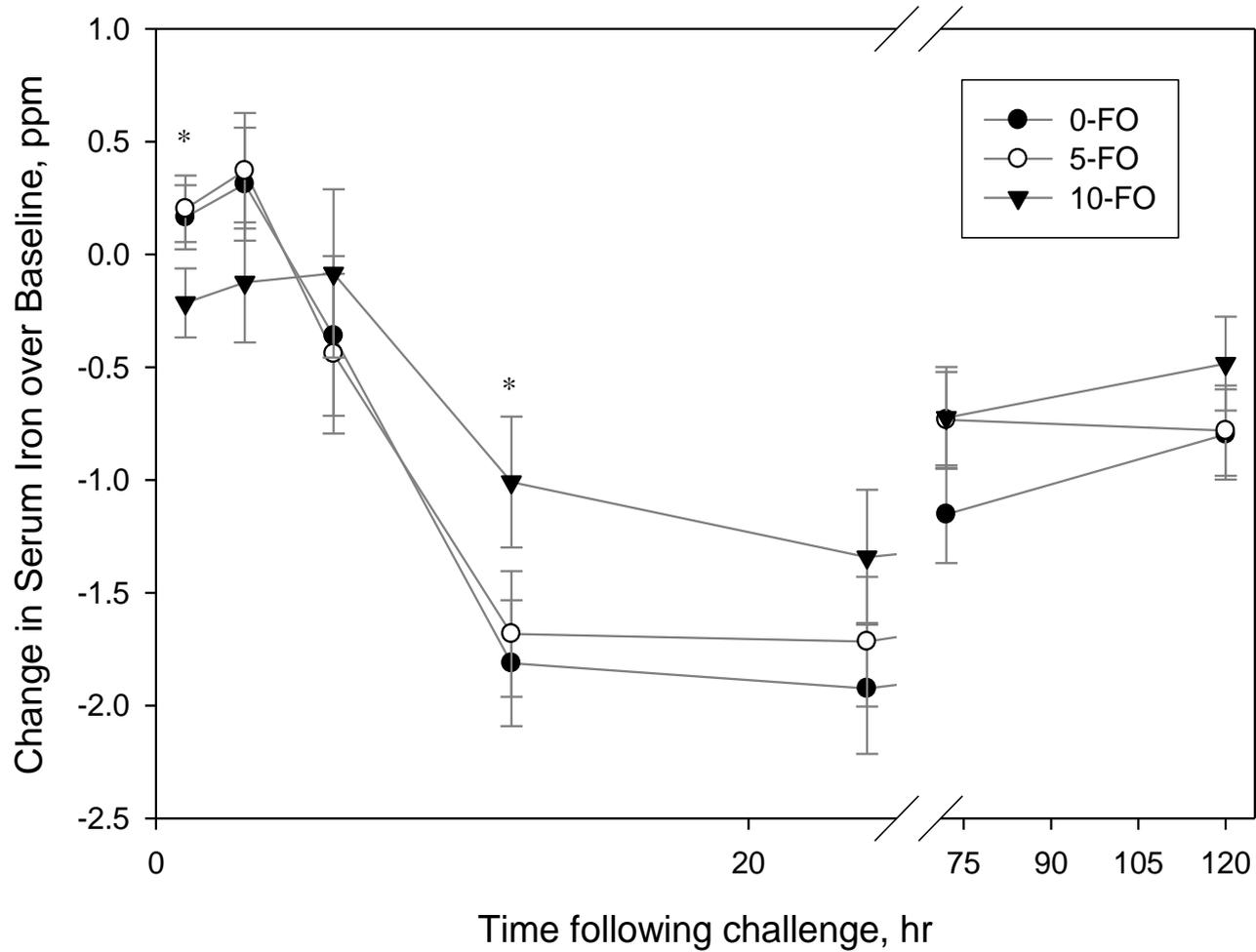


# Prevent excessive inflammation





# Prevent excessive inflammation





# Prevent excessive inflammation

- Calves supplemented 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



# 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?

# 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)
    - $2 \pm 1$  day old were studied in a 2x2 factorial
    - **Low** = 454 g / d of a 20/20 milk replacer (LOL)
    - **High plane Holstein** = 810 (wk1) and 1,180 (wk 2-6) g / d of a 28/20 (LOL)
    - **High plane Jersey** = 568 (wk1) 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



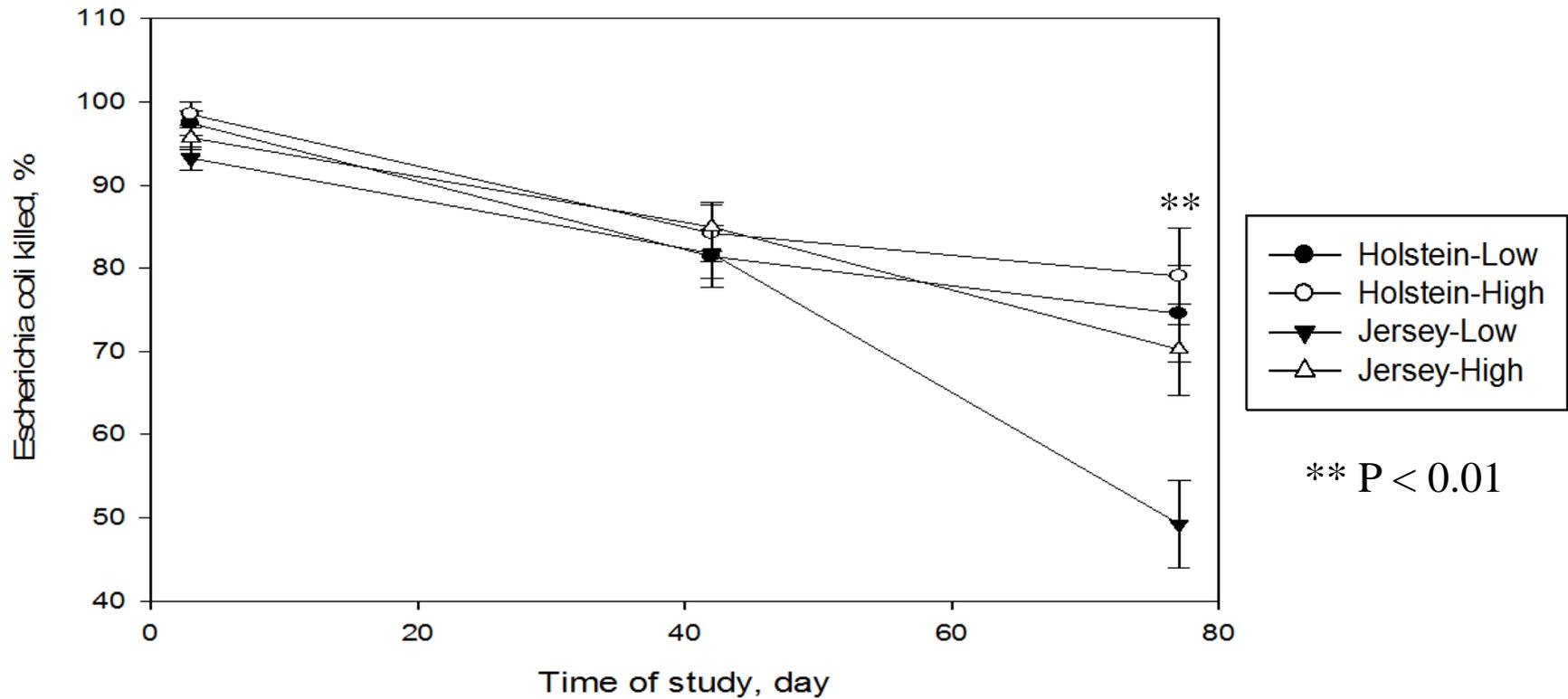
# Life after 2 weeks

- 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



# Life after 2 weeks

Whole Blood Killing: Escherichia coli - 60 min Incubation





# 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?



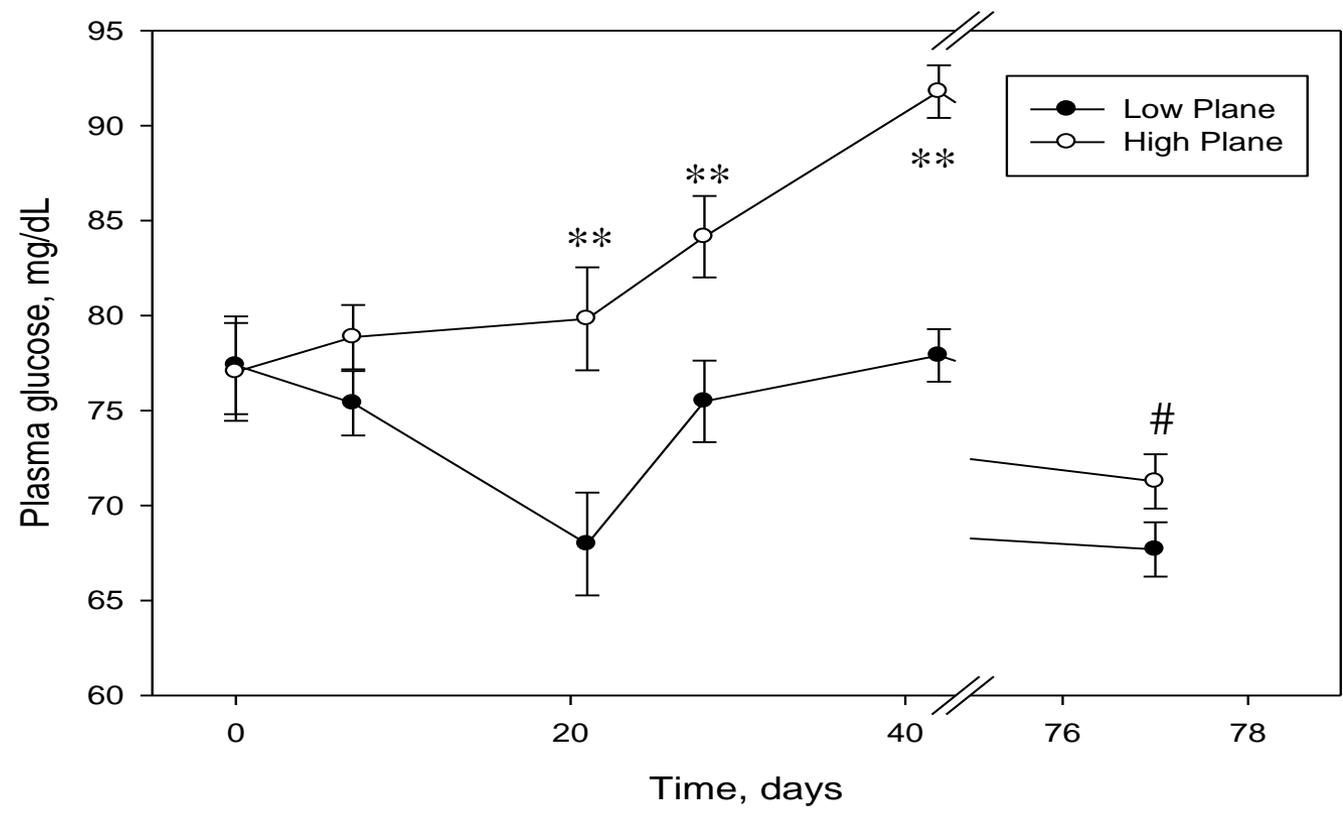
# Life after 2 weeks

- Follow-up study – Jersey Calves – TTU#2
  - Summer 2011
  - 46 Jersey calves ( $3 \pm 1$  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

# Life after 2 weeks



### Plasma Glucose Concentrations



\*\* P < 0.01

# P < 0.10



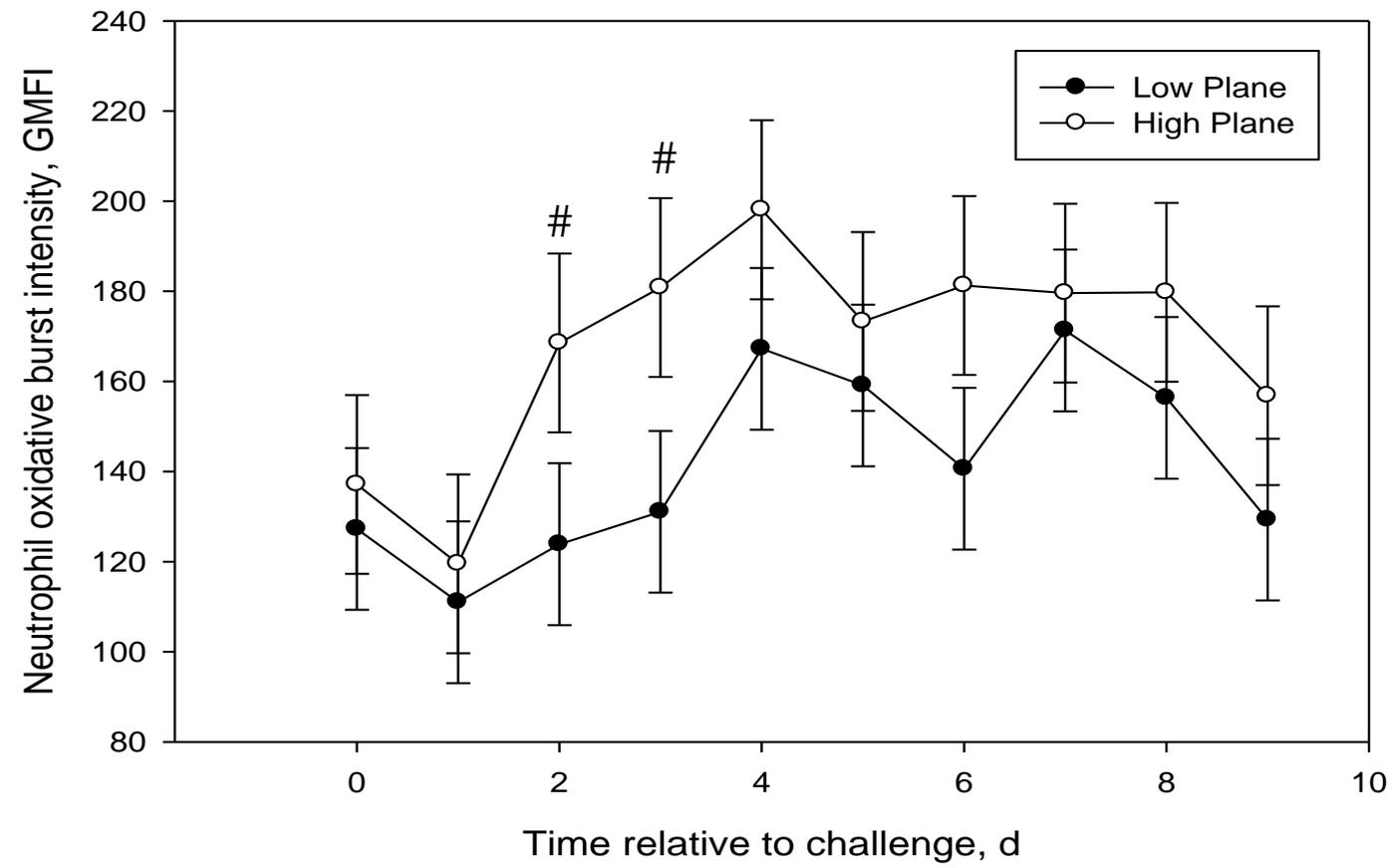
# Life after 2 weeks

- 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*

# Life after 2 weeks



### Neutrophil Oxidative Burst Intensity

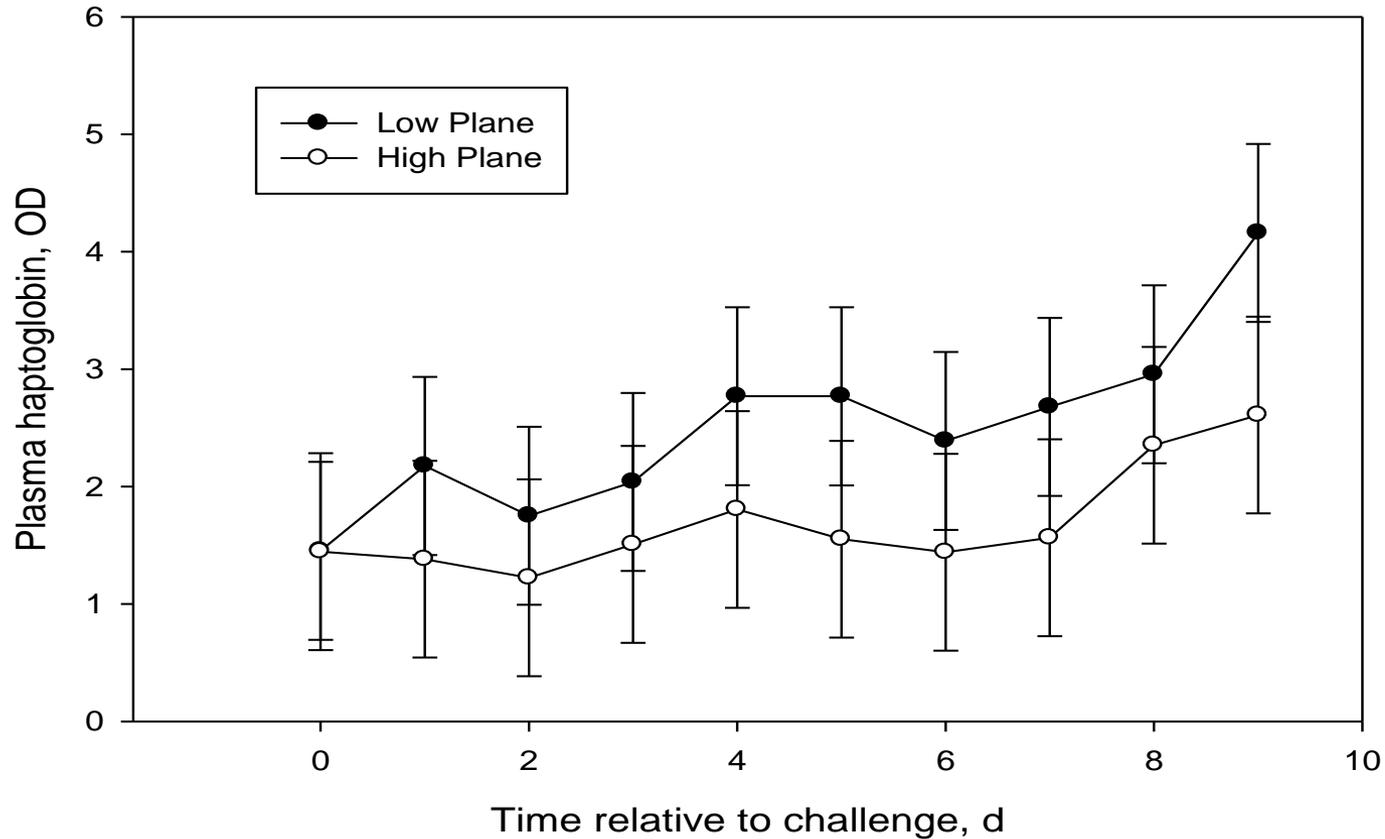


# P < 0.10

# Life after 2 weeks



## Plasma Haptoglobin Concentrations



Trt: P < 0.05

# 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



# 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



# 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?*

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# Questions / Comments



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