# Nutritional Regulation of Gut Function: Weaning

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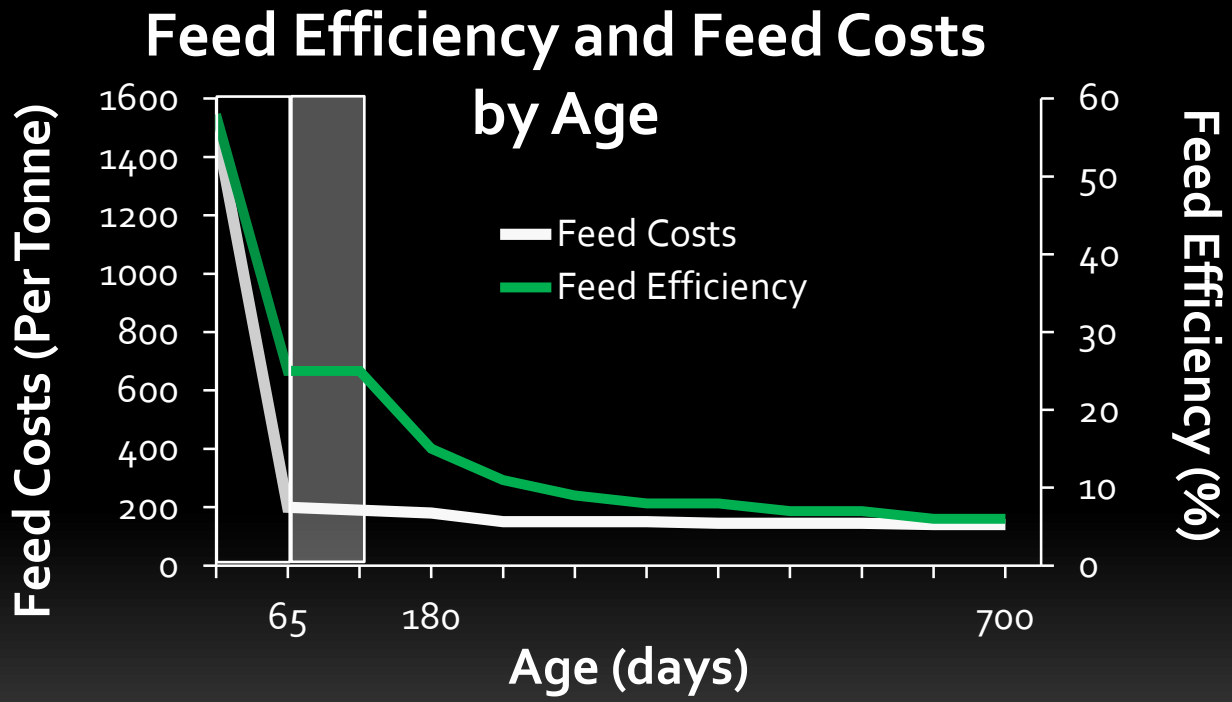
# Nutritional Regulation of Gut Function: Weaning

I. The biology of weaning
II. Factors impacting weaning
    - Plane of Milk
    - Age
    - Step-Down
III. Post-weaning

# The Investment of Raising Replacements

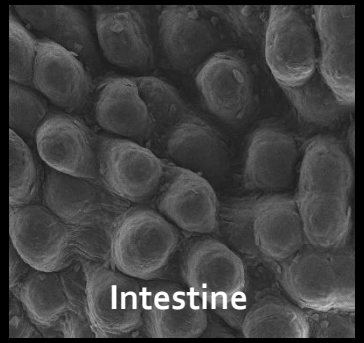


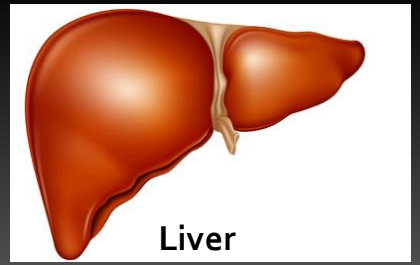

$2,000 investment

(Bach et al., 2013)

# Pre-Ruminant Absorption & Metabolism

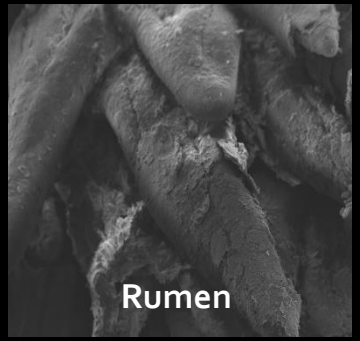
- Pre-ruminant calf is completely dependent on glucose absorbed from intestine
- Liver function
  - Primary site of ketone body synthesis
  - Not much glucose being synthesized



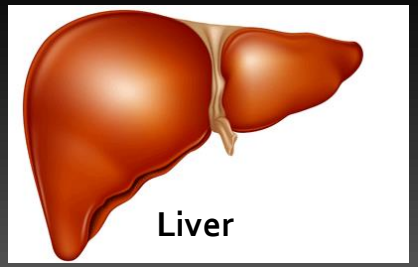



# Ruminant Absorption & Metabolism

- Ruminant calves produces and absorbs VFA which is the primary energy source

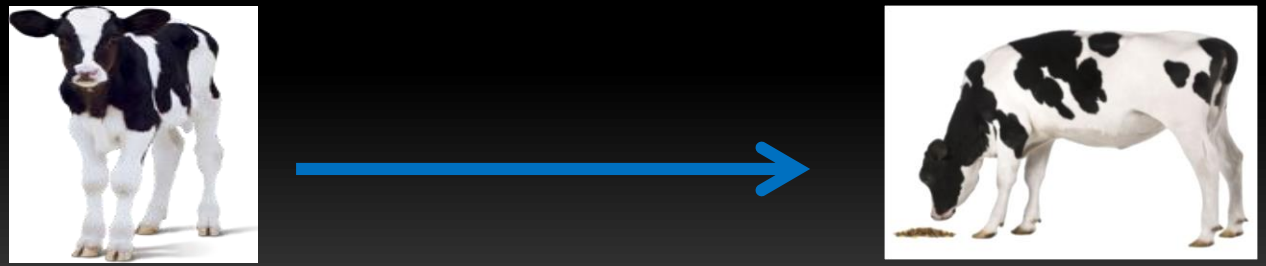



- Liver function
  - Glucose synthesis increases, predominately from propionate
  - Urea synthesis increases
  - Metabolic activity increases

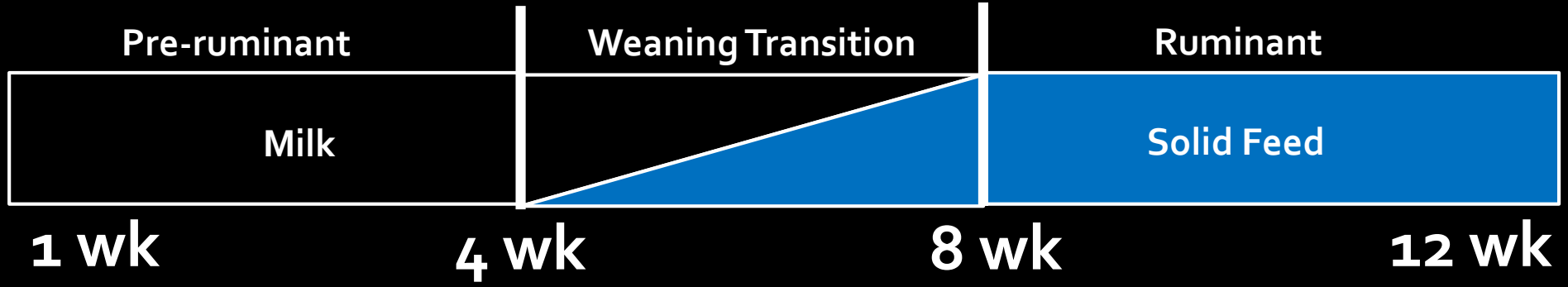


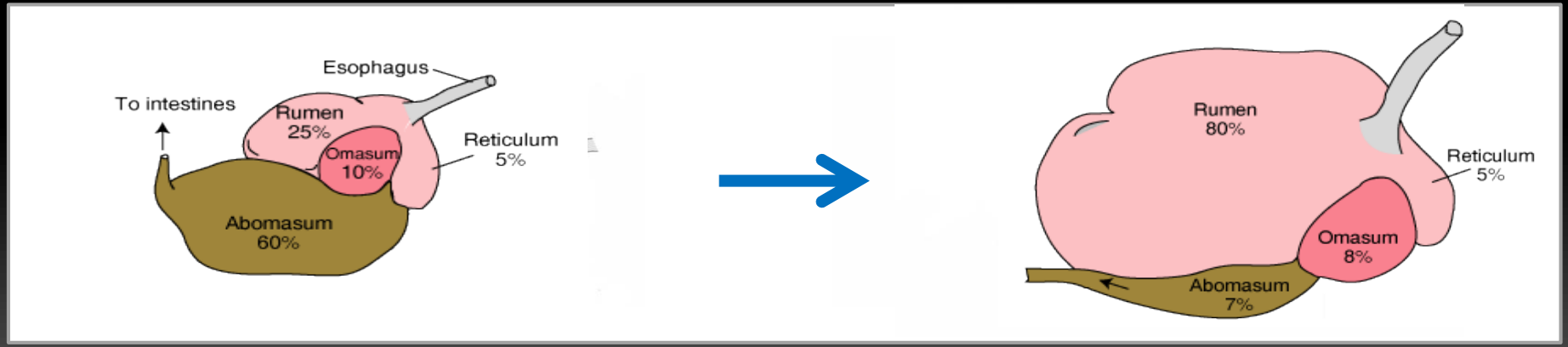
# Weaning Challenges

- A smooth transition from a monogastric to a ruminant
  - Decreases morbidity and mortality and increases gain (Khan et al., 2012)
  - Requires adequate size and function of the rumen (Baldwin, 2004)



# Pre and Post-Weaning



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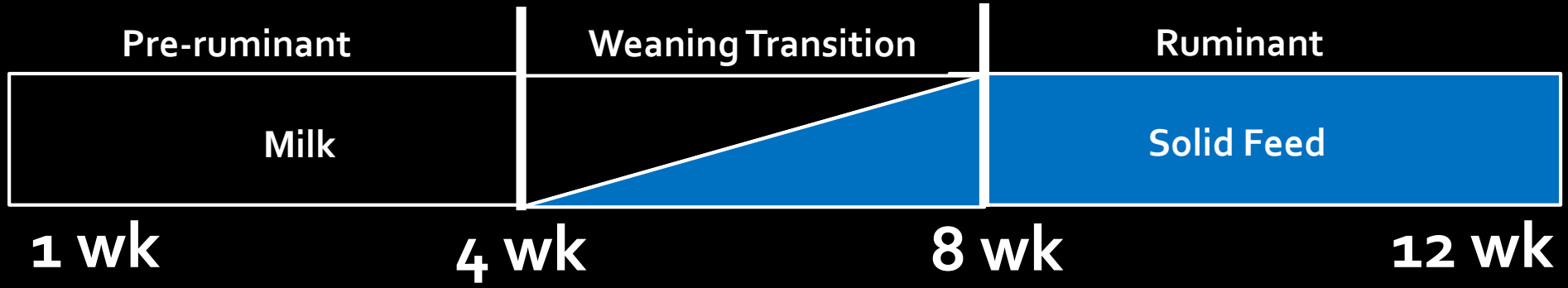
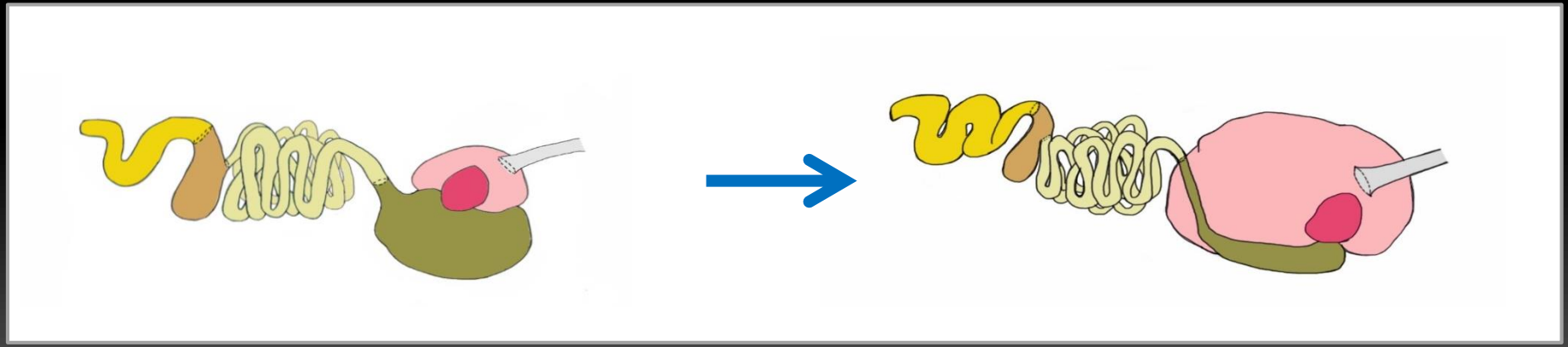
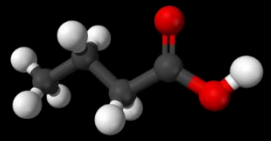


# Rumen Development

- Consumption of solid feed
  (Khan et al., 2011)

- Volatile fatty acids
  - Cellular growth
  - Blood flow
    - (Baldwin and McLeod, 2000)



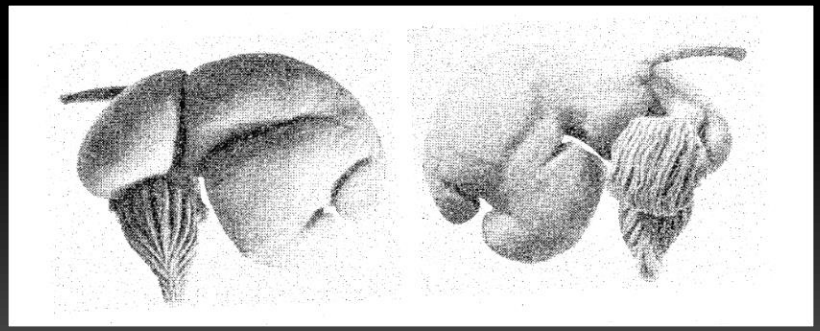
- The age of the calf (Lane et al., 2002)

# Rumen Development

- **The Machinery to Absorb VFA**
  - Rumen Epithelial Development
- **The Employees to Make VFA**
  - Rumen Microbial Development

# Prenatal Rumen Development

- Distinguishable areas of stomach compartments are present in the third week of embryonic development

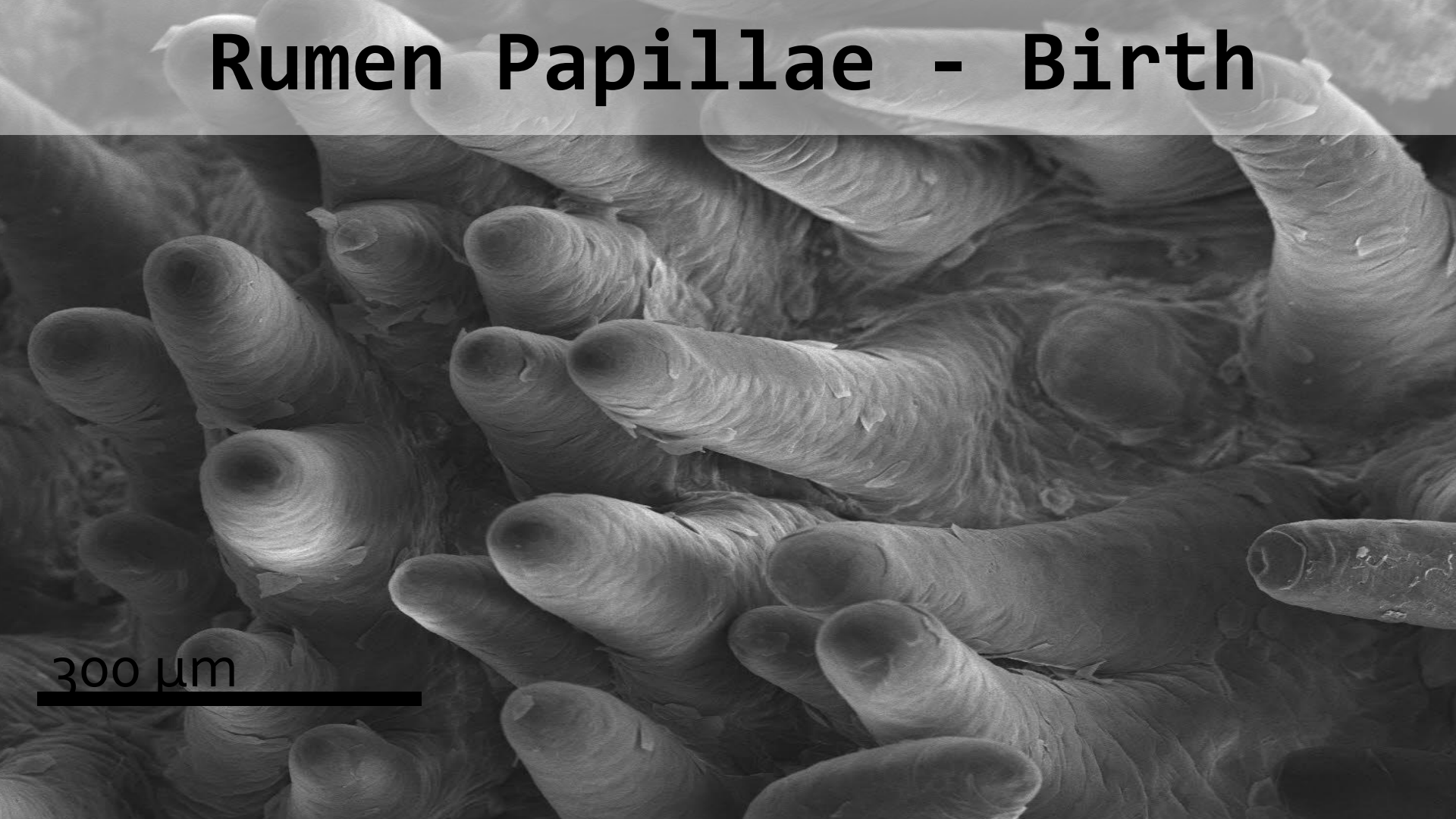


- All rumen compartments have been formed by the third month (Warner, 1958)

# Rumen at Birth

- No rumen papillae visible
- Very smooth surface
- Thin and transparent

# Rumen Papillae - Birth



# Rumen Papillae - Transition

# Papillae Protrude from Polyps

# Rumen Papillae - Transition

# Rumen Papillae - Ruminant

# Rumen Development

- **The Machinery to Absorb VFA**
  - Rumen Epithelial Development
- **The Employees to Make VFA**
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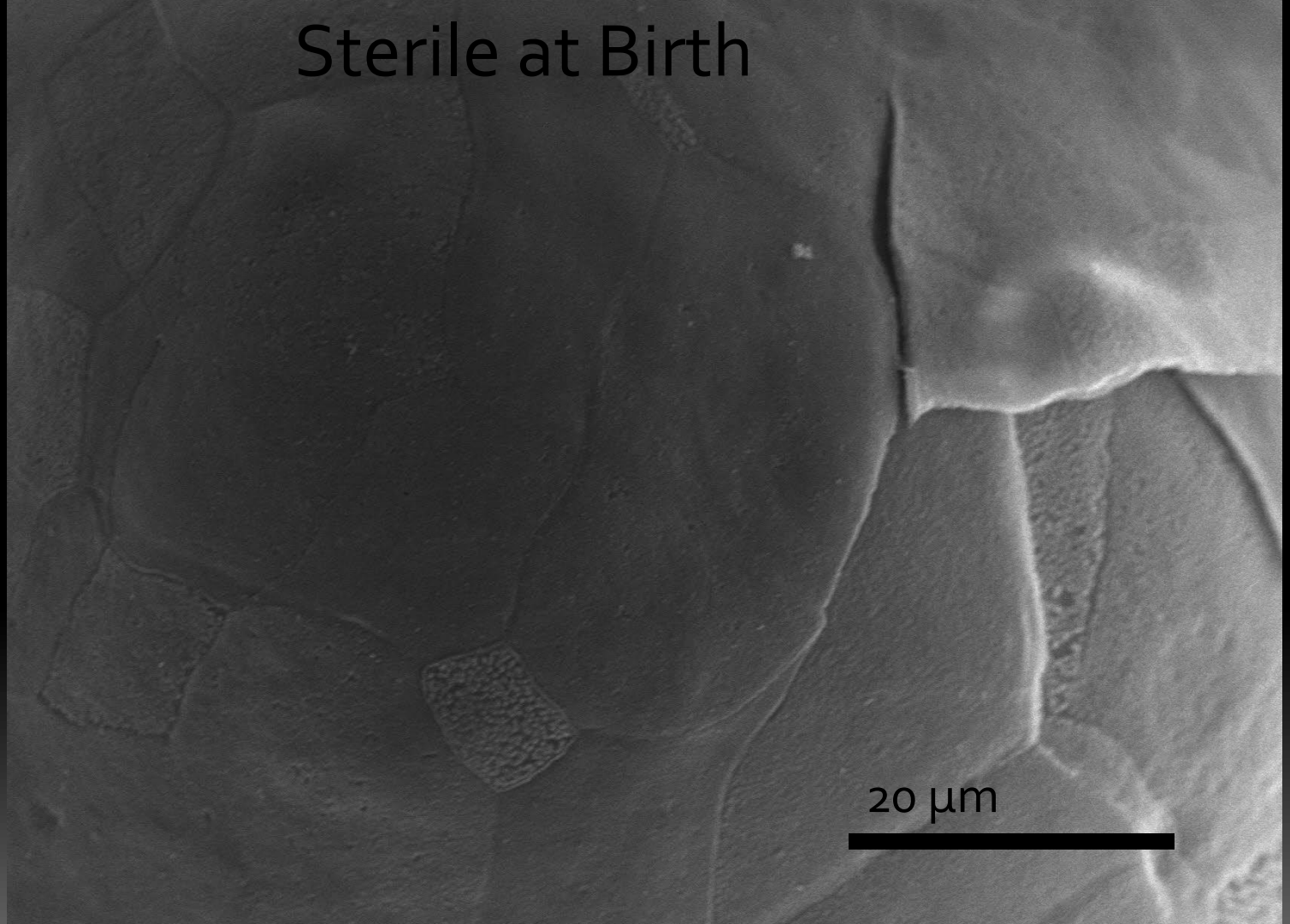
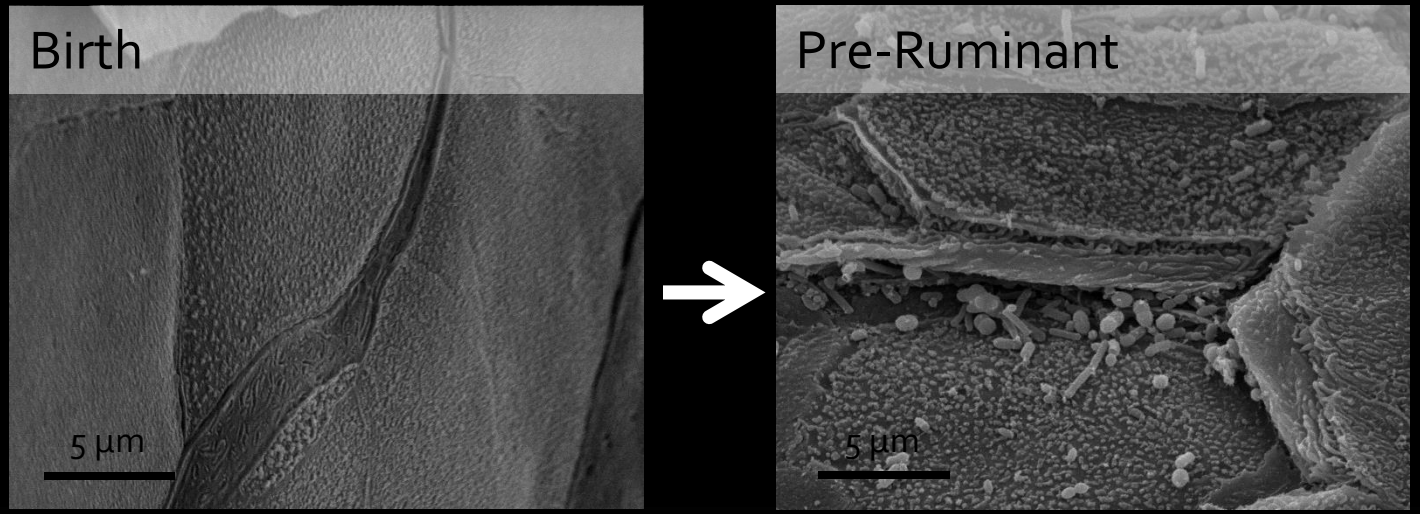
# Sterile at Birth



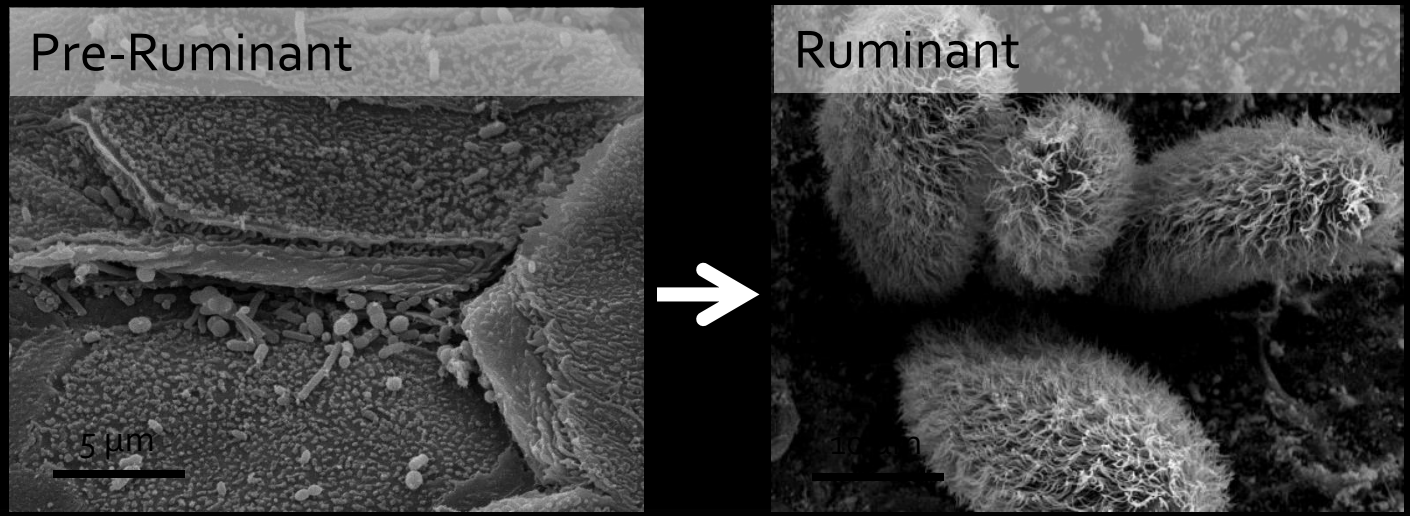
# Rumen Microbial Development




- After birth aerobic bacteria colonize
- Anaerobic bacteria soon predominate
  - Cellulolytic and methanogenic first

(Fonty et al., 1989)

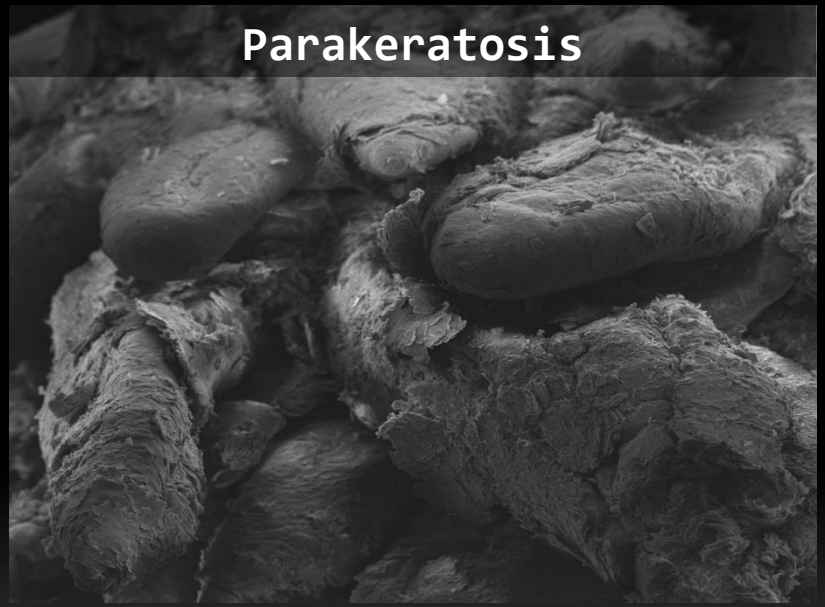
# Pre-ruminant to Ruminant




- Lactate-fermenting bacteria exceed adult values then decline
  - Protozoa are introduced via contact with mature ruminants

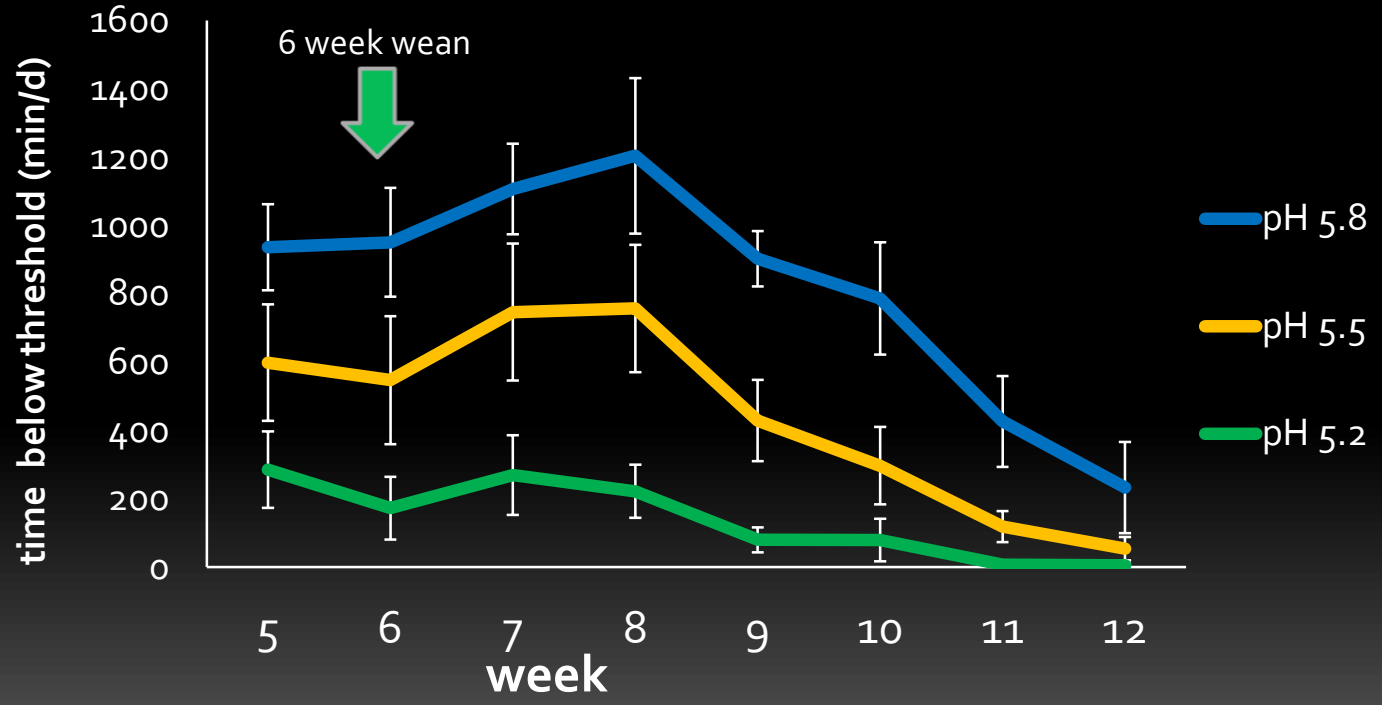
# Abnormal Gut Development

- Ruminal parakeratosis is common during weaning (Bush, 1965)




- Ruminal acidosis has been documented however to date, no research has linked it to impairment of gut health (Laarman et al., 2012)
- Is ruminal acidosis good or bad for the calf?

# Ruminal pH During Weaning




(Kohler et al., 2017)

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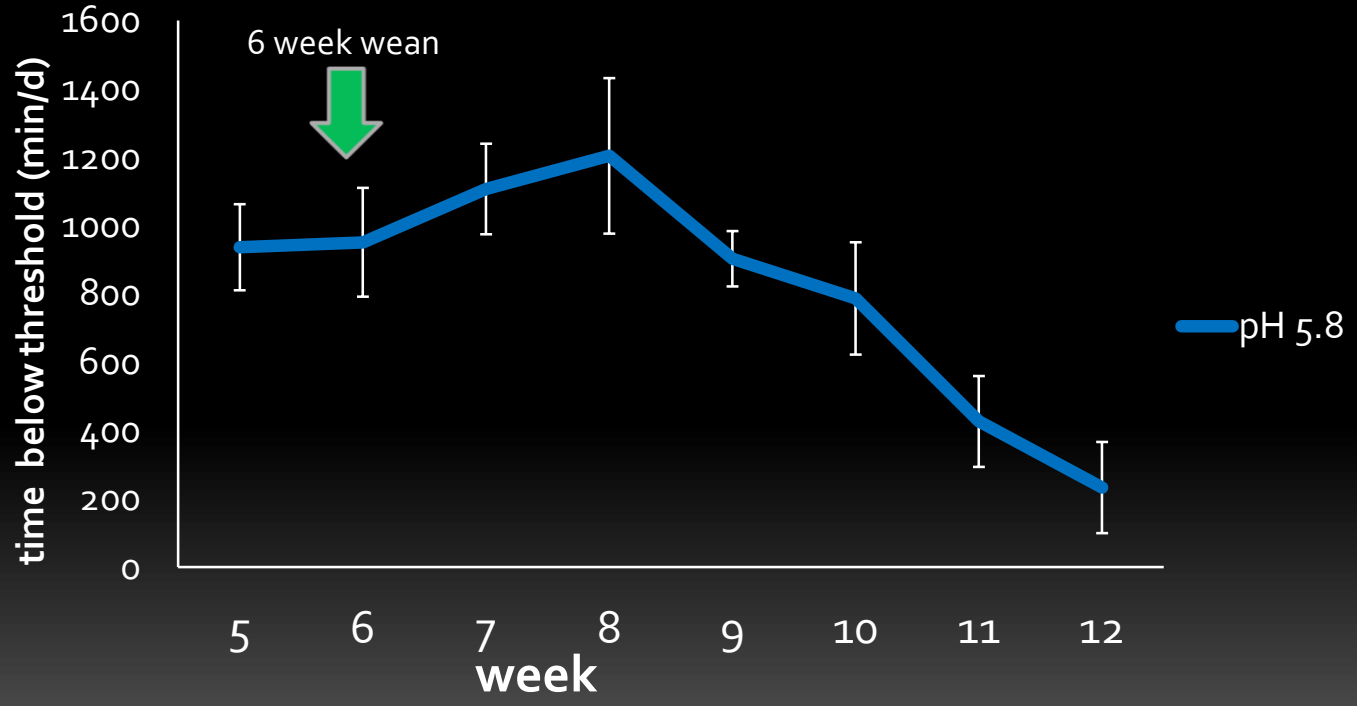
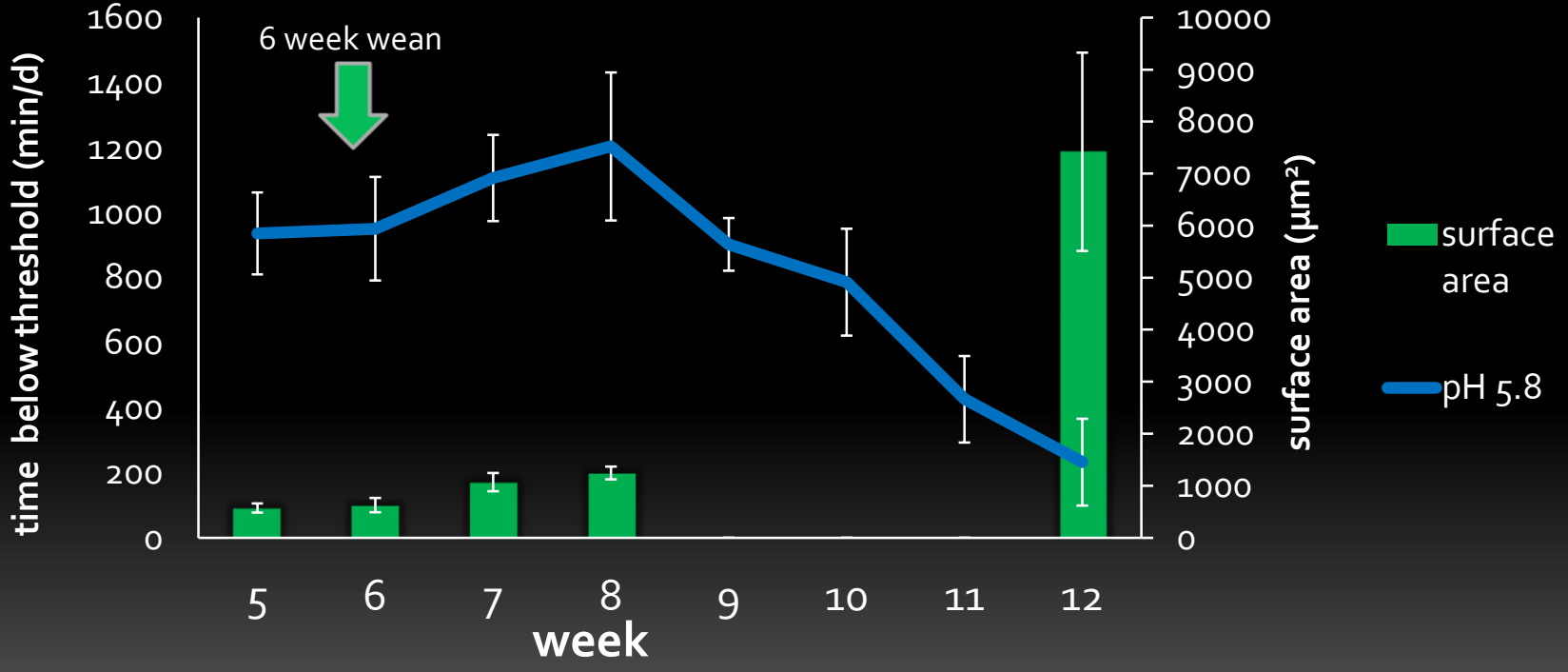


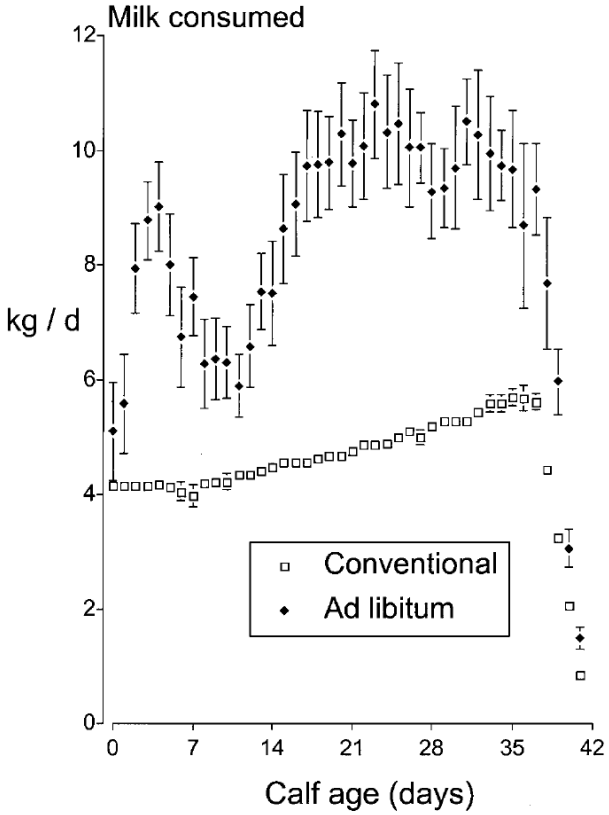

(Kohler et al., 2017)

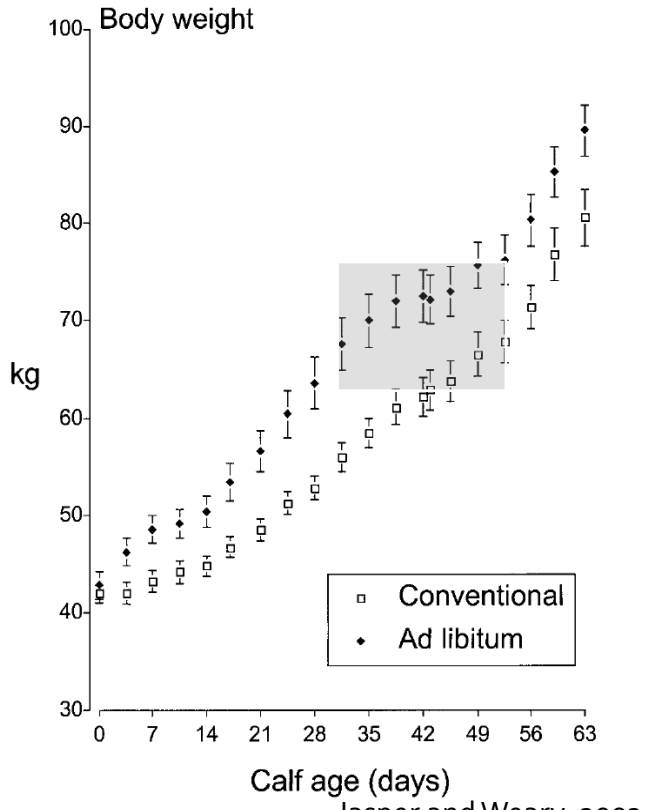
# Ruminal pH During Weaning




(Kohler et al., 2017)

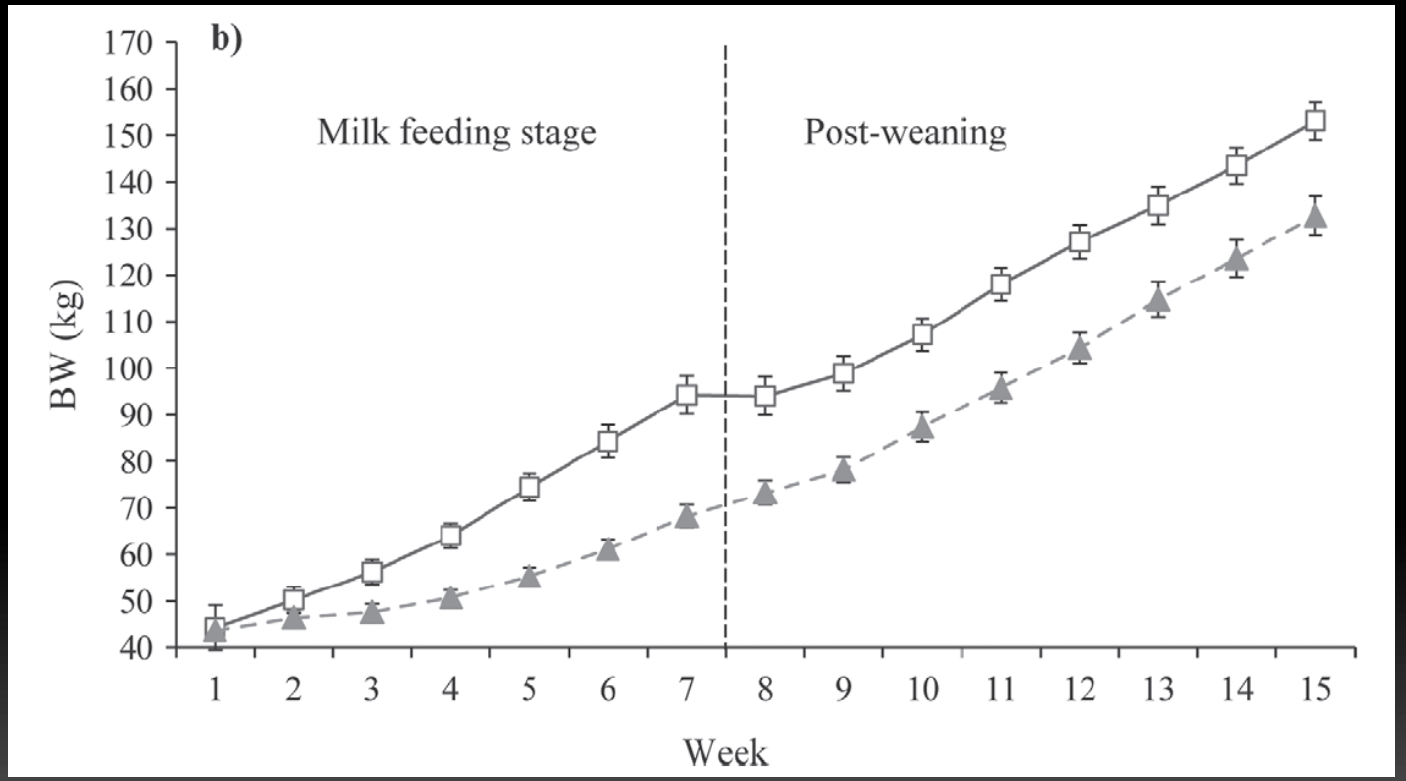
# Weaning Challenges – High Milk



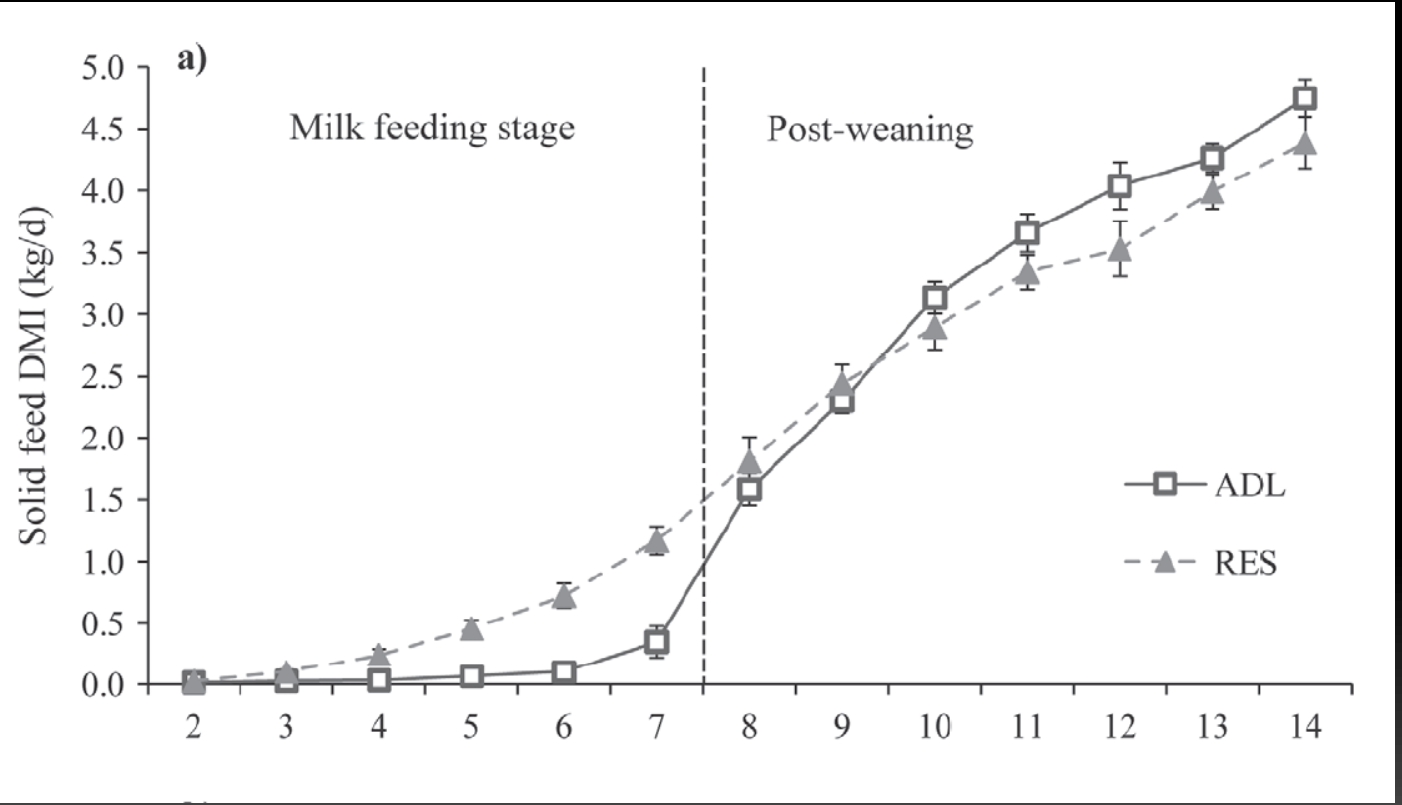

Jasper and Weary, 2002

# Weaning Challenges – High Milk



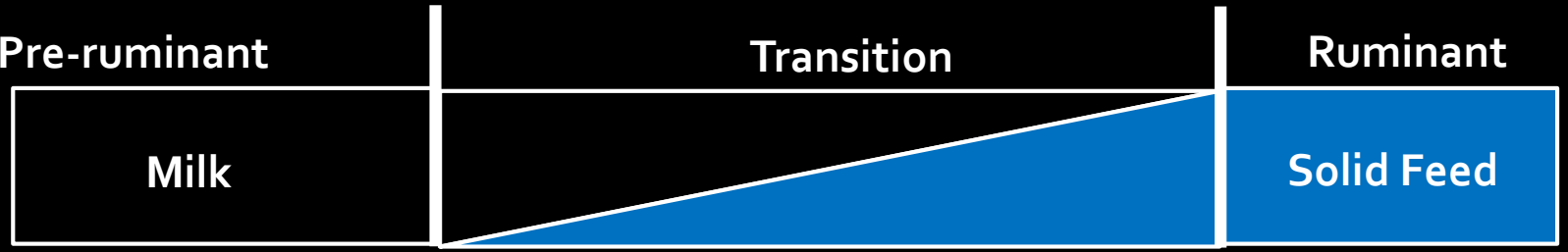

(Miller-Cushon et al, 2013)

# Weaning Challenges – High Milk

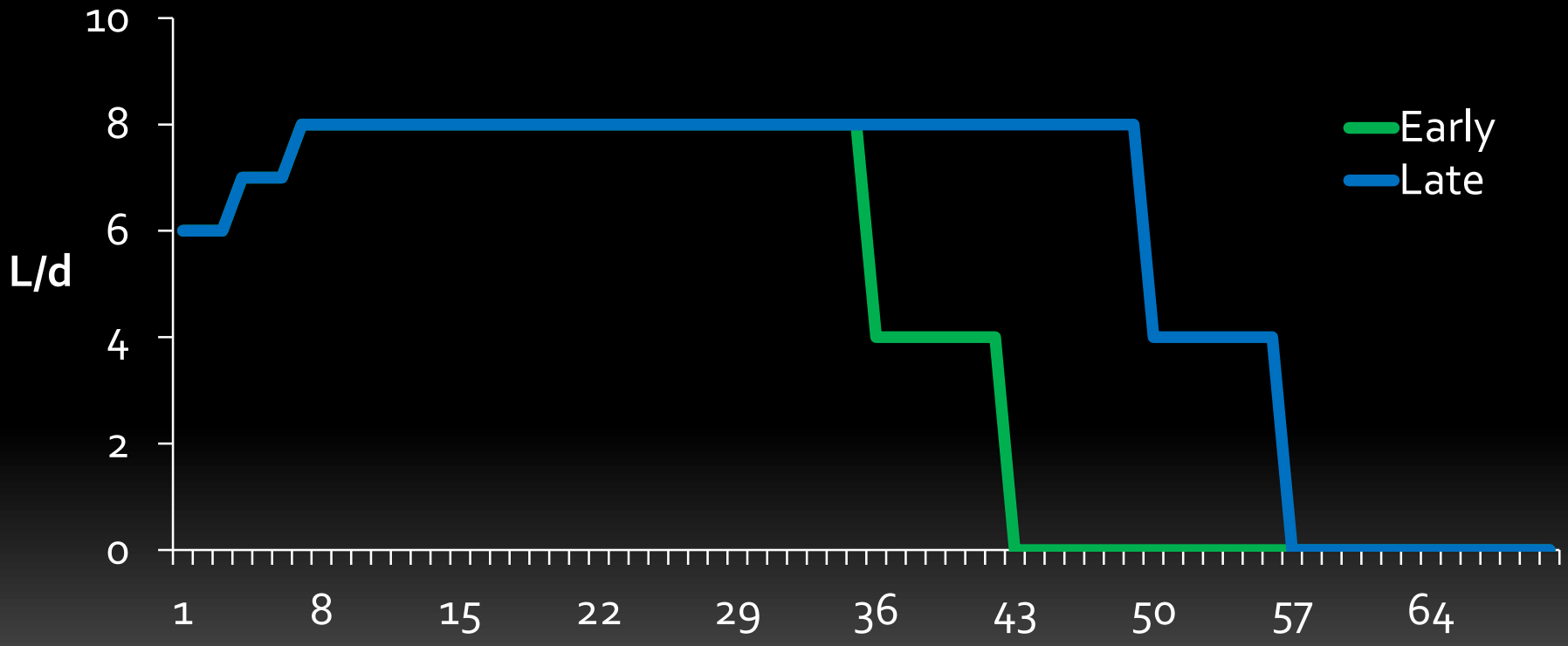



(DeVries et al., 2013)

# Early and Abrupt Weaning

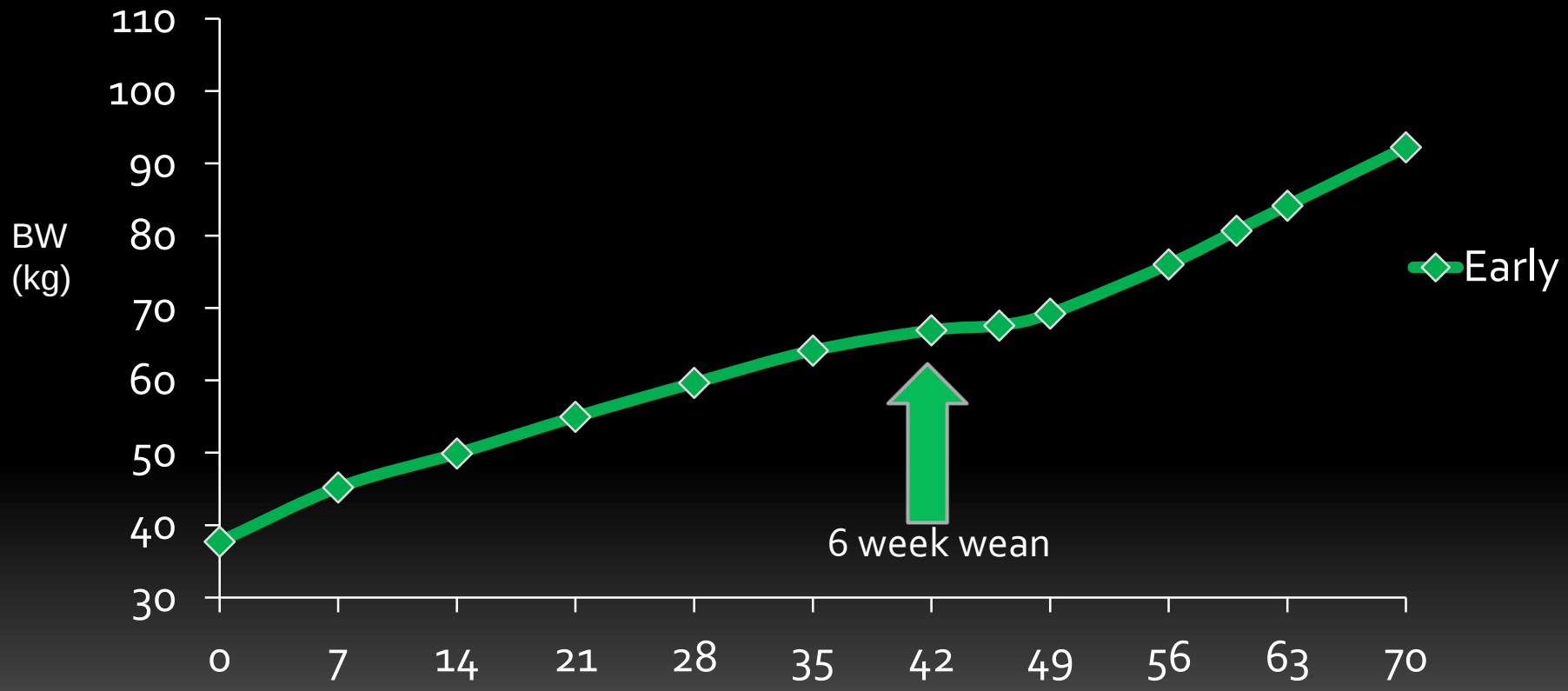



# Weaning Age




(Eckert et al., 2015)

# Weaning Age - Bodyweight




(Eckert et al., 2015)

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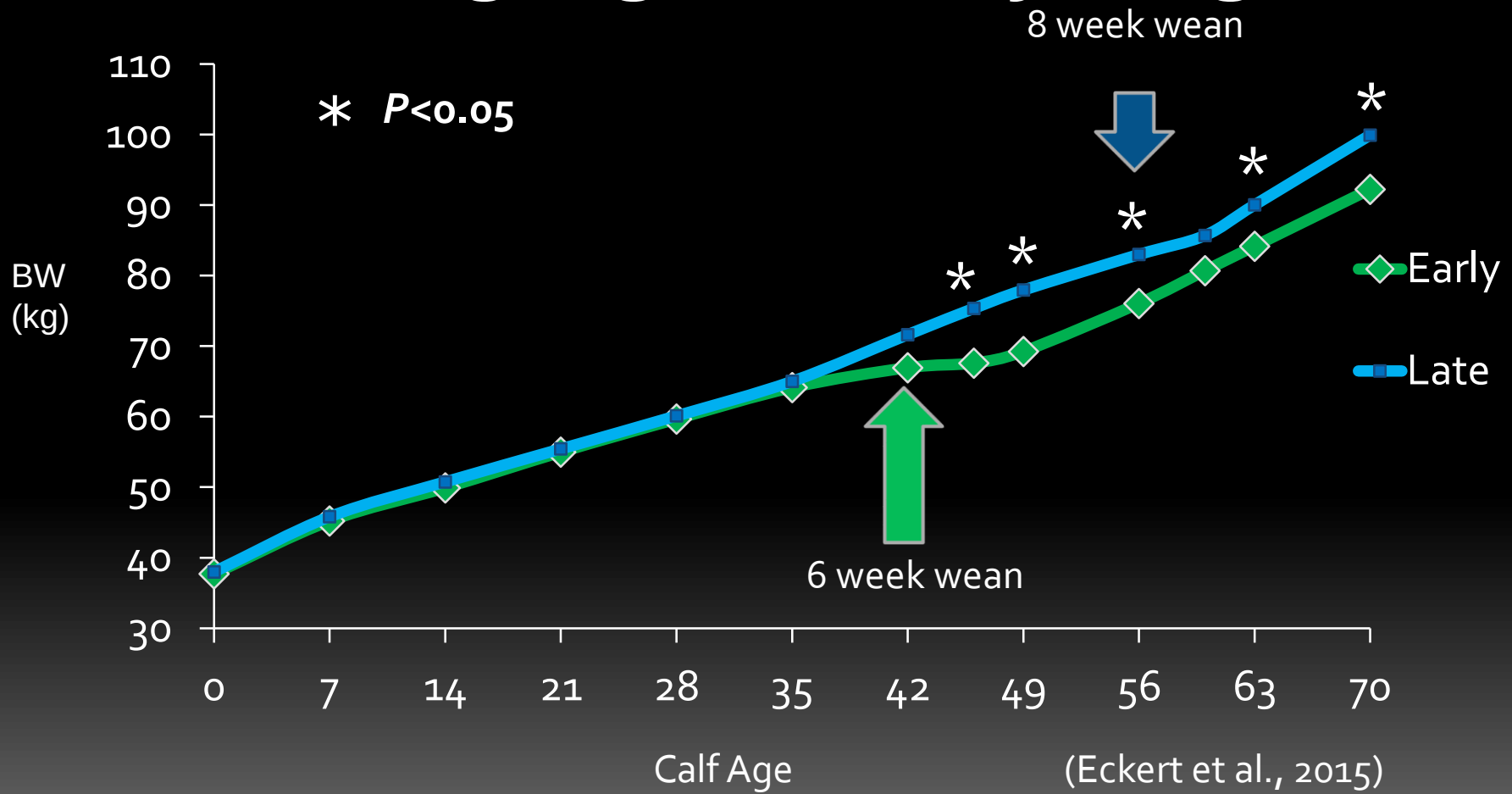
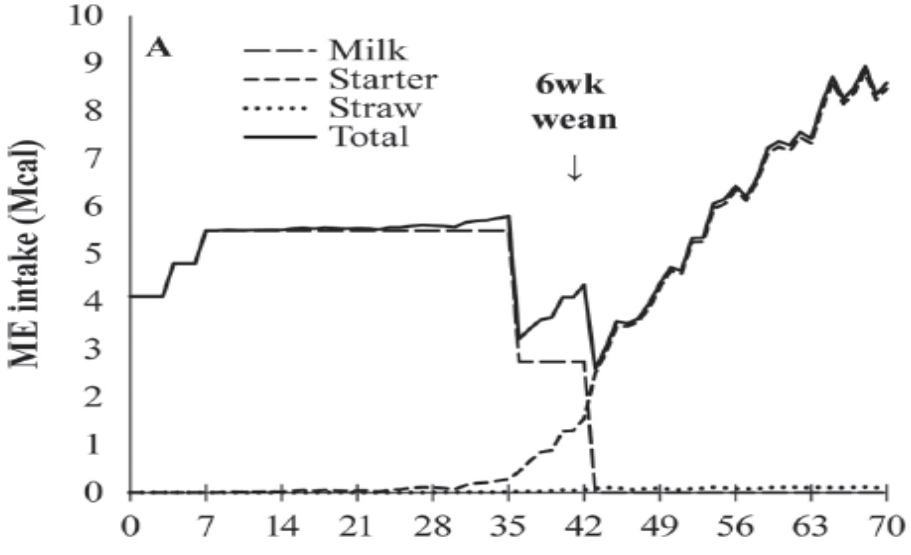
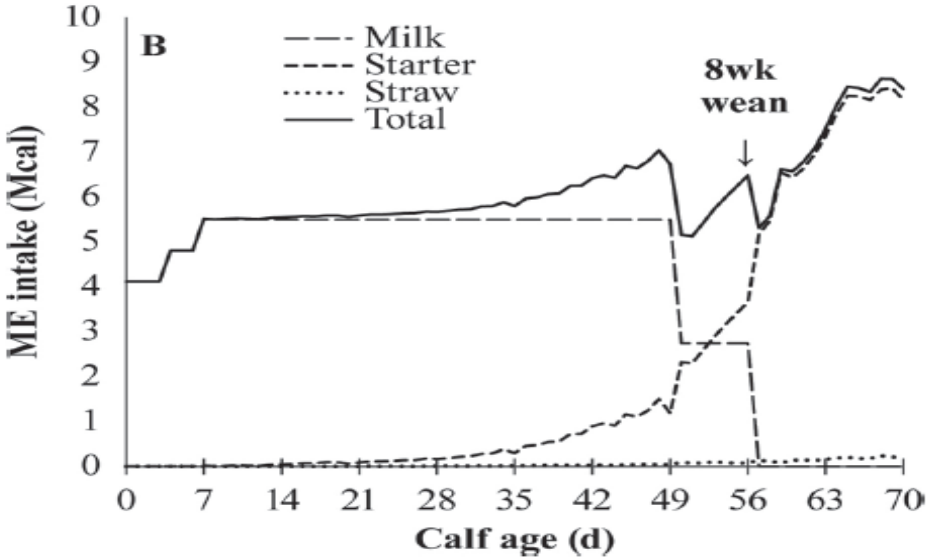



(Eckert et al., 2015)

# Weaning Age – ME Intake

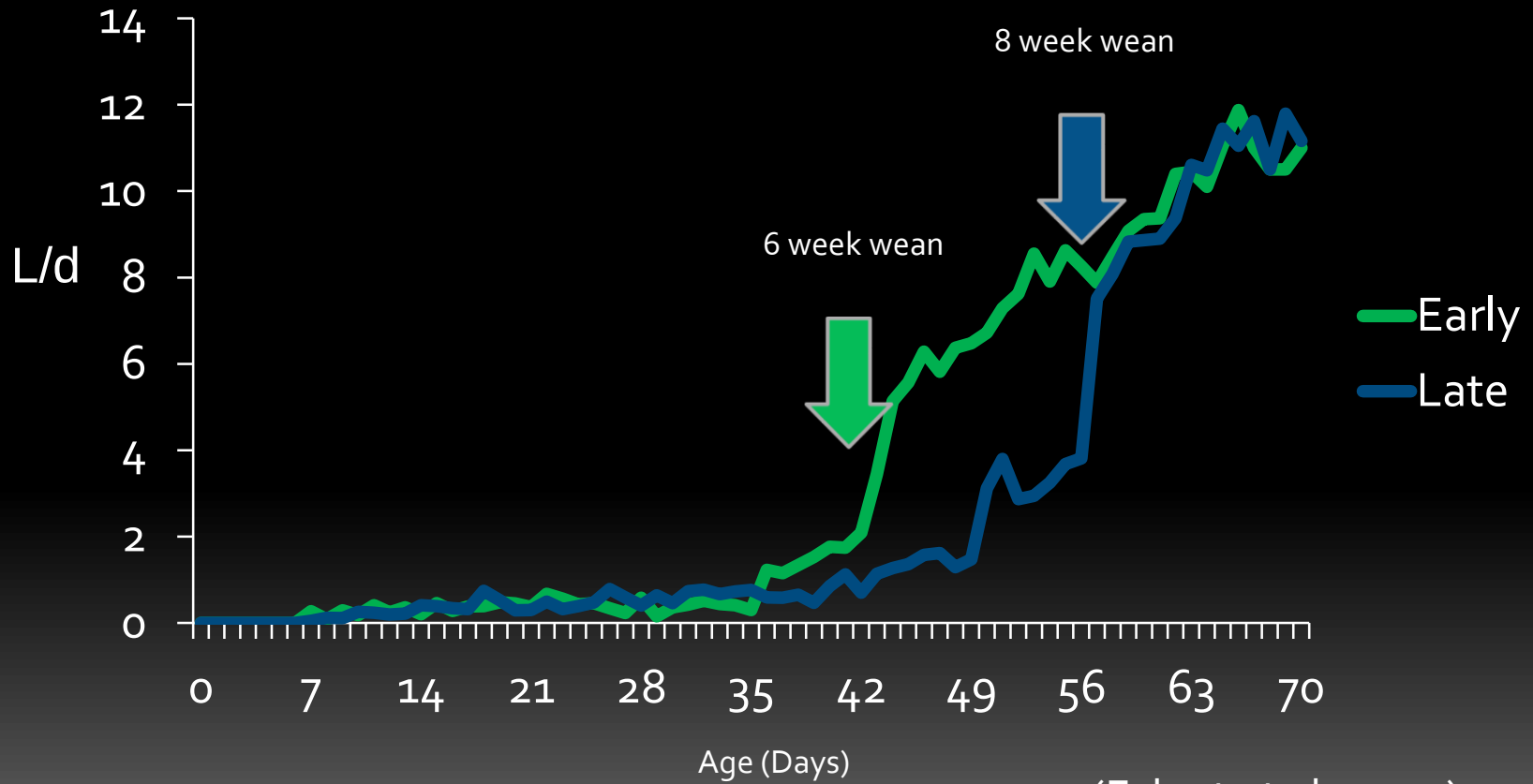



- In both treatments, weaning increased ($P$<0.01) ruminal SCFA, blood BHBA and fecal starch
- Yet, the differences between the week before and after weaning were greater ($P$<0.01) in calves weaned at six weeks

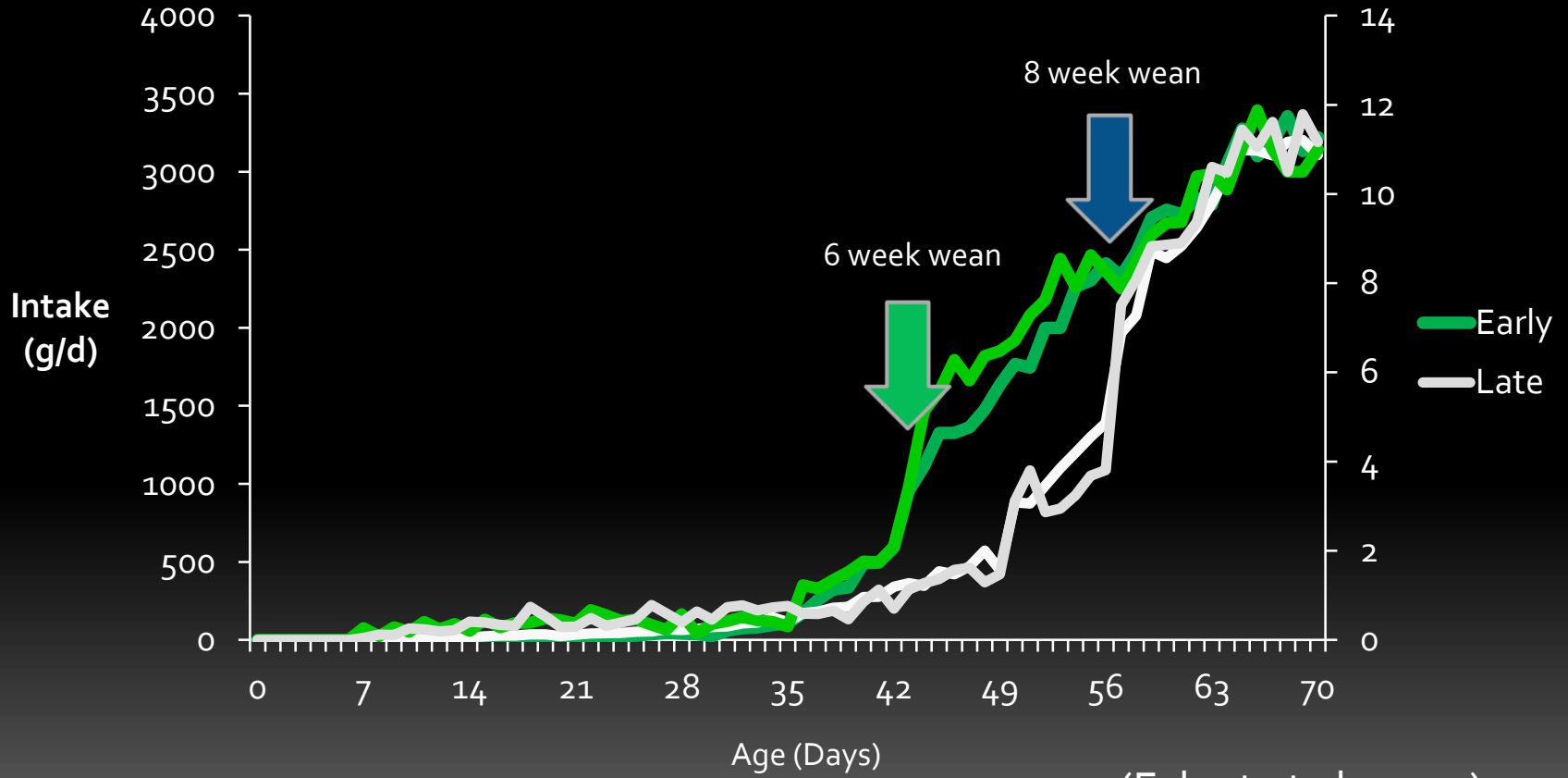
(Eckert et al., 2015)

# Water Intake



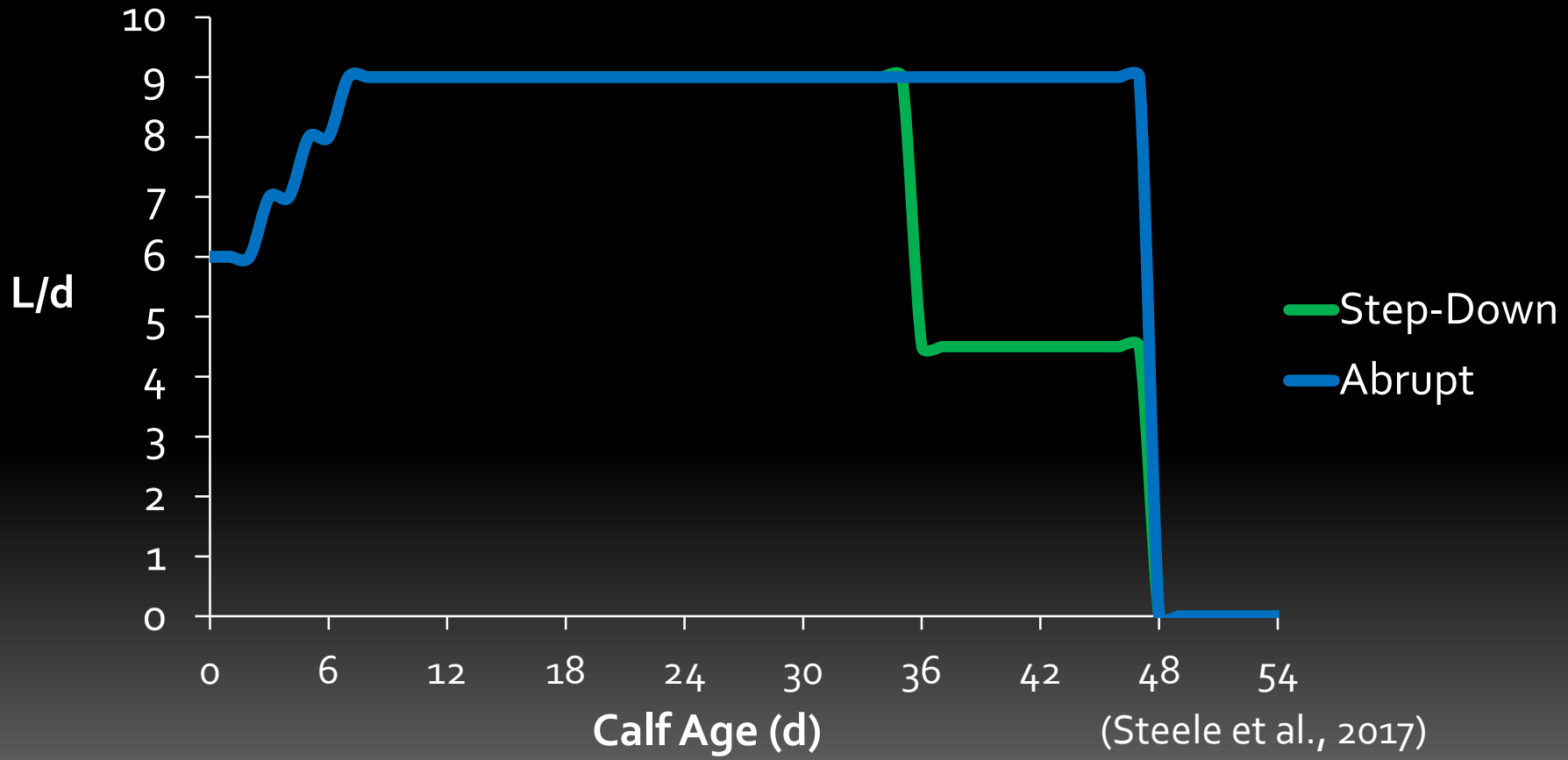

(Eckert et al., 2015)

# Water and Starter Intake



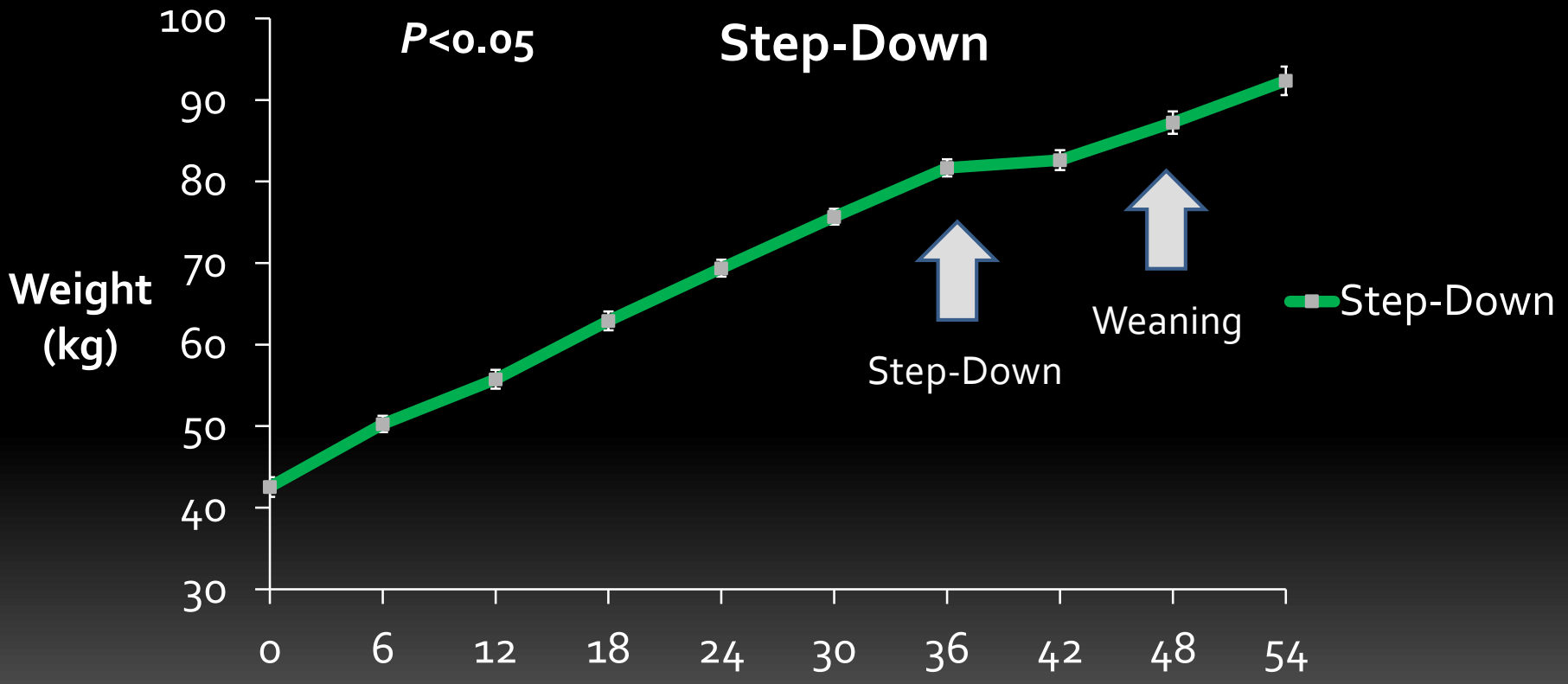

(Eckert et al., 2015)

# Step-Down Weaning




(Steele et al., 2017)

# Step-Down - Bodyweight

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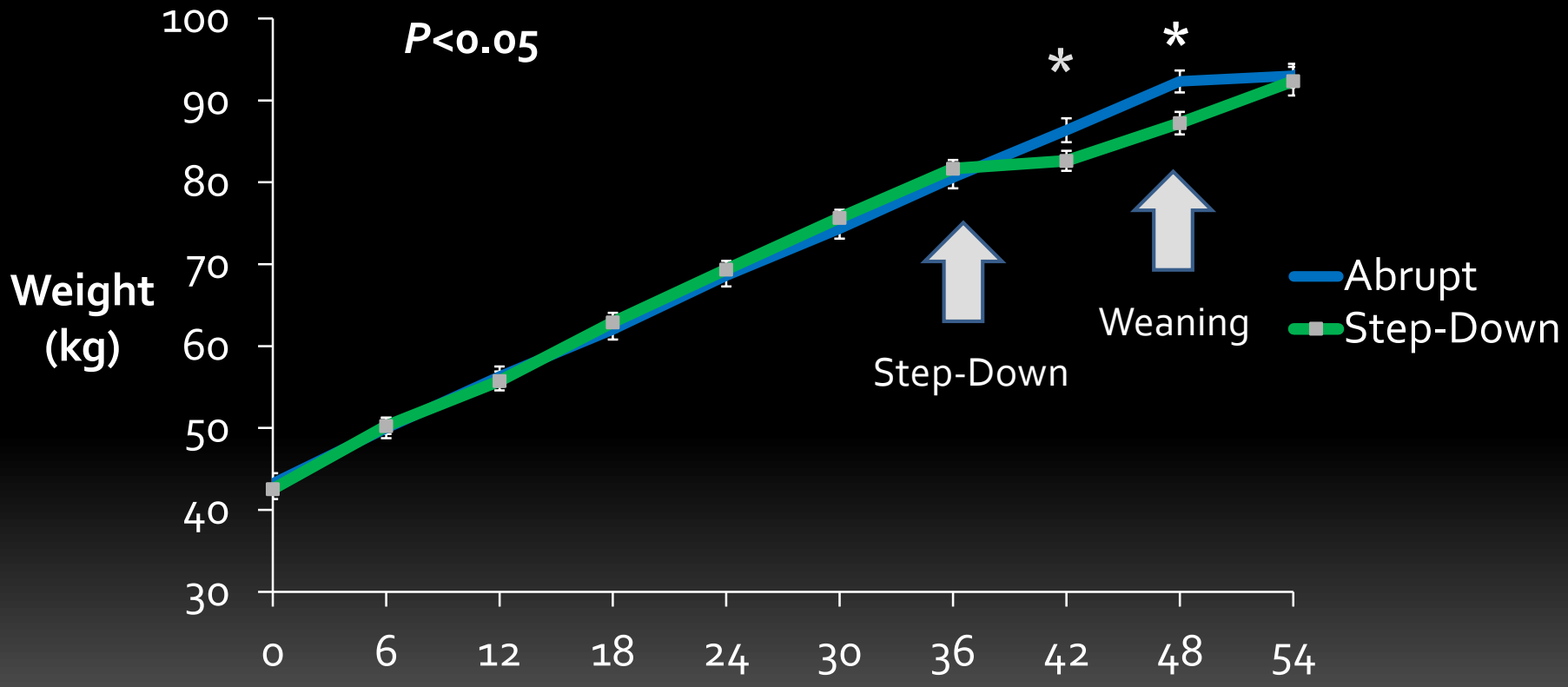
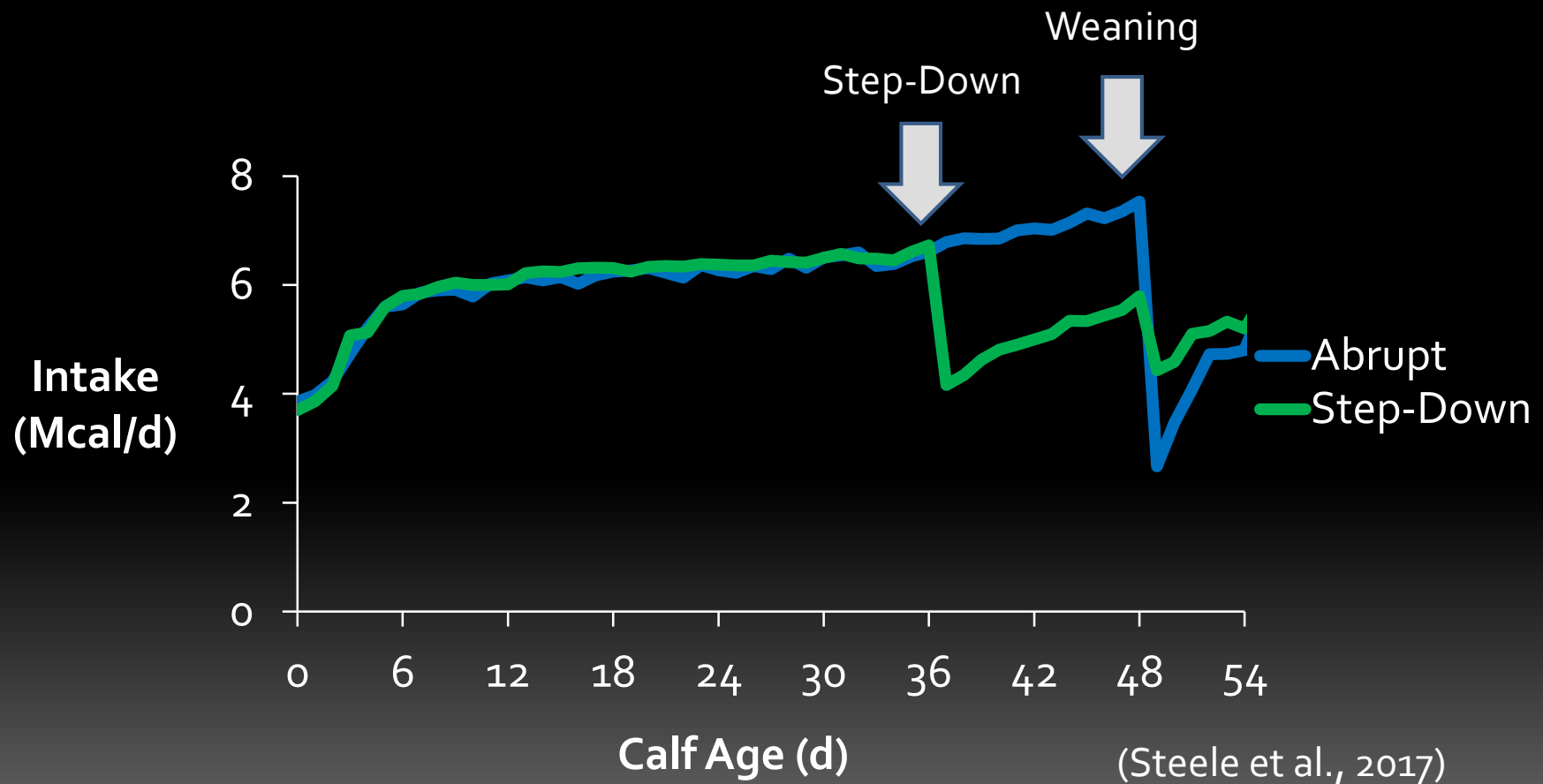



(Steele et al., 2017)

# Metabolizable Energy Intake




(Steele et al., 2017)

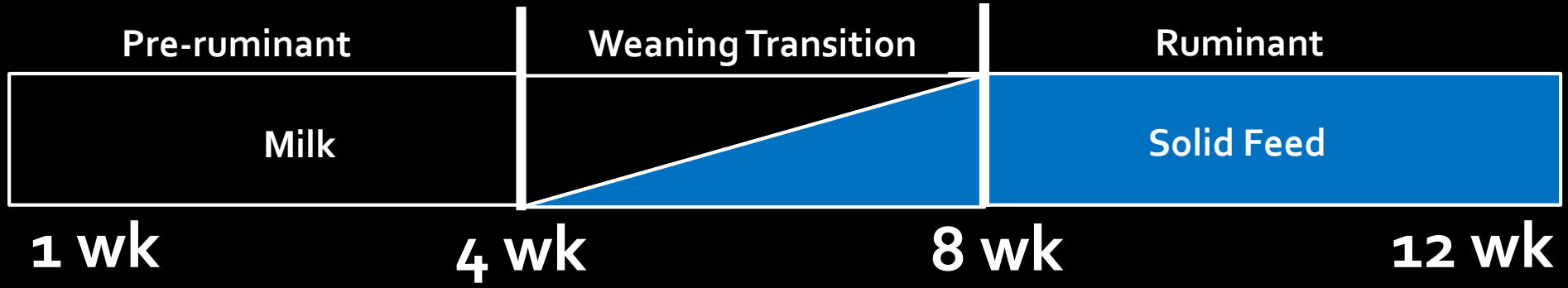
# Dissection Results

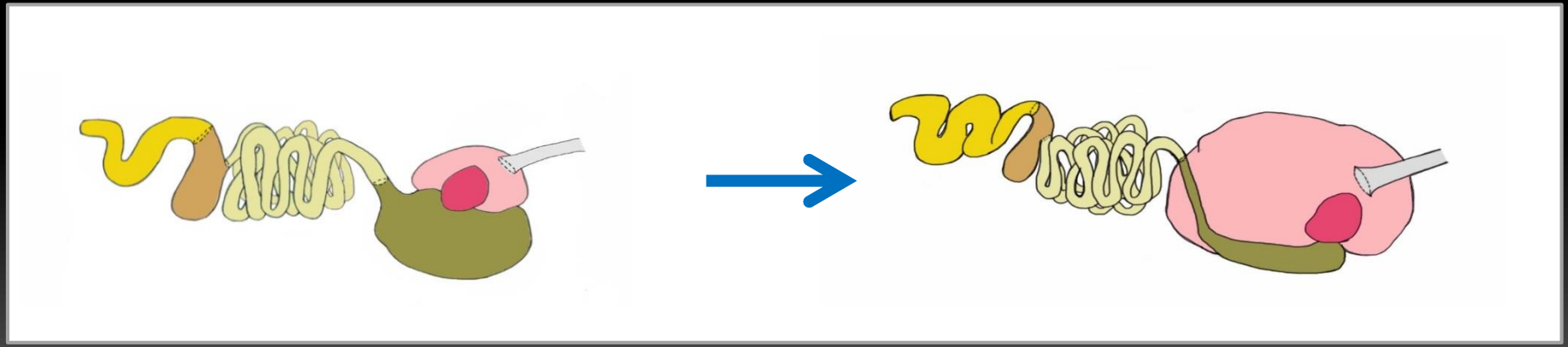
| | Step-Down | Abrupt | SE | P-Value |
|---|---|---|---|---|
| **Gross Anatomy (kg)** | | | | |
| BW | 94.1 | 94.8 | 2.3 | 0.85 |
| Forestomach | 11.0 | 9.7 | 0.6 | <0.01 |
| Lower Gut | 6.8 | 6.5 | 0.3 | 0.23 |
| Rumen Full | 8.2 | 7.0 | 0.4 | 0.03 |
| Rumen Empty | 1.7 | 1.5 | 0.1 | 0.07 |

- No differences in omasum, abomasum, small intestine, cecum or large intestine gross anatomy

(Steele et al., 2015)

# Pre and Post-Weaning

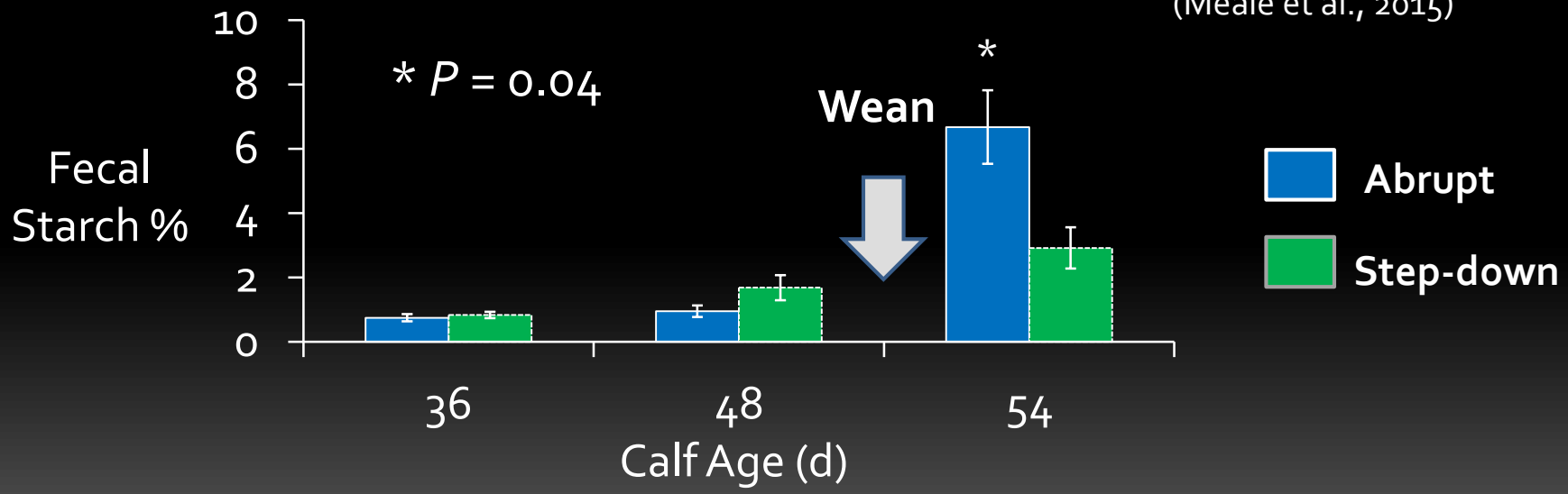


# Abrupt Weaning – Delayed Weaning Impact on Hindgut

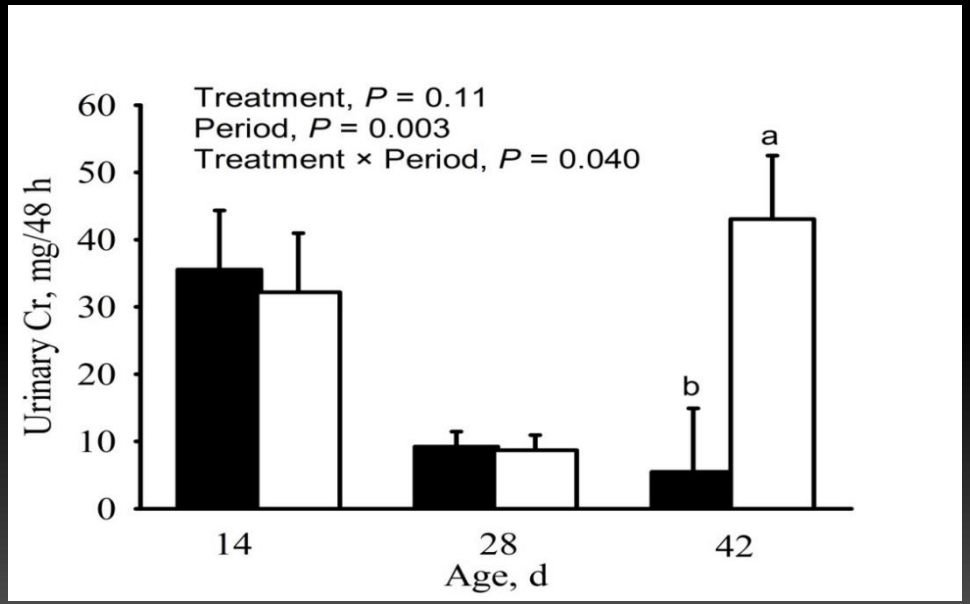
- Fecal microbiota displayed more diversity post-weaning

(Meale et al., 2015)



# Barrier Function at Weaning

- Starter feeding in calves decreased the expression of tight junctions (Malmuthuge et al., 2012)




Not Weaned

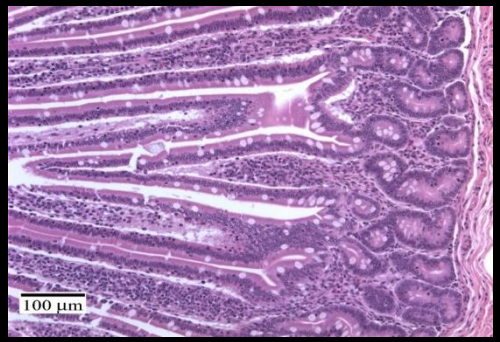
Weaned (d 40)

(Wood et al., 2015)

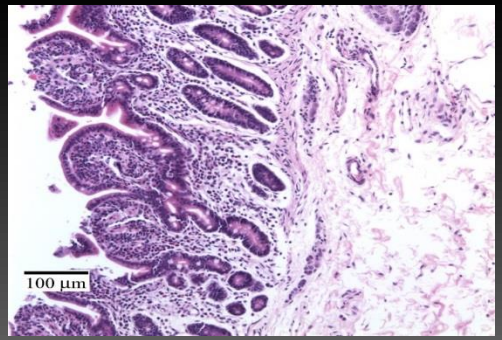
# Barrier Function at Weaning

- Weaning related changes of the gut epithelium (Pletts et al., 2016)

**Rumen** | **Duodenum**


**Not-Weaned, d 42**

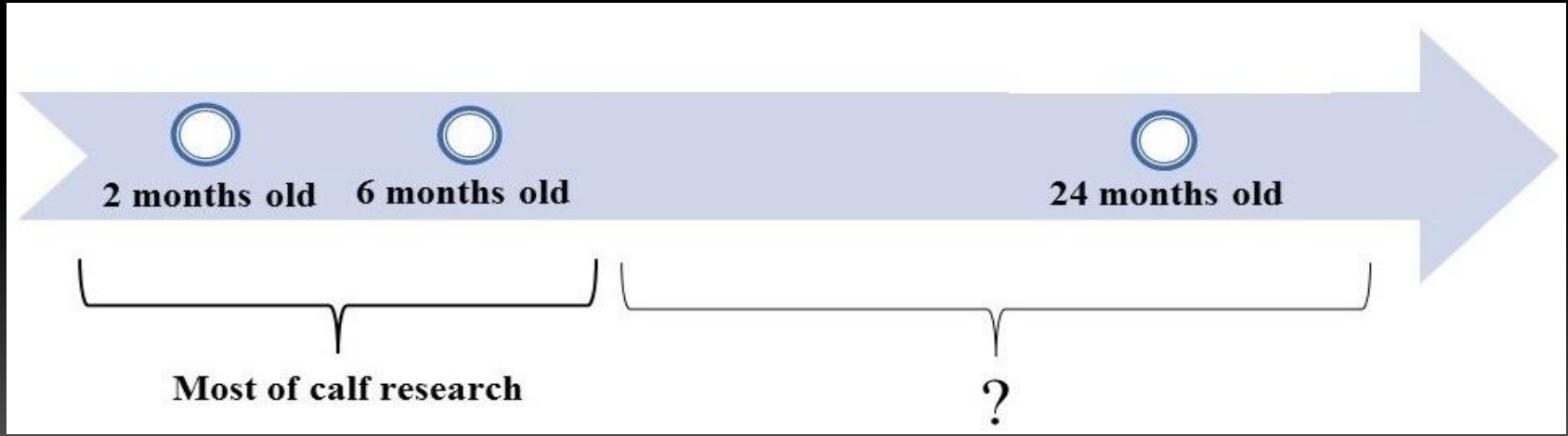




**Weaned, d 42**

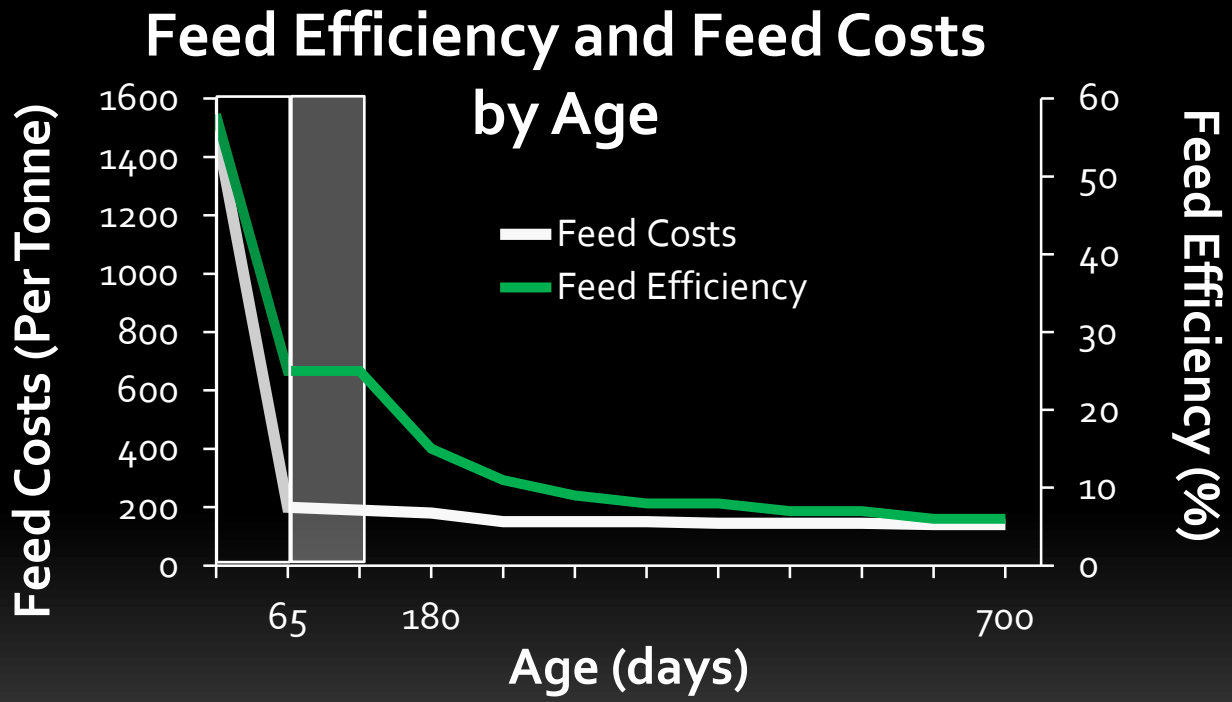
# Diversity in Fecal Scores

# Post-Weaning and Beyond

- An area that has not been studied
- Need to integrate pre and post weaning planes of nutrition with lifetime performance



# The Investment of Raising Replacements



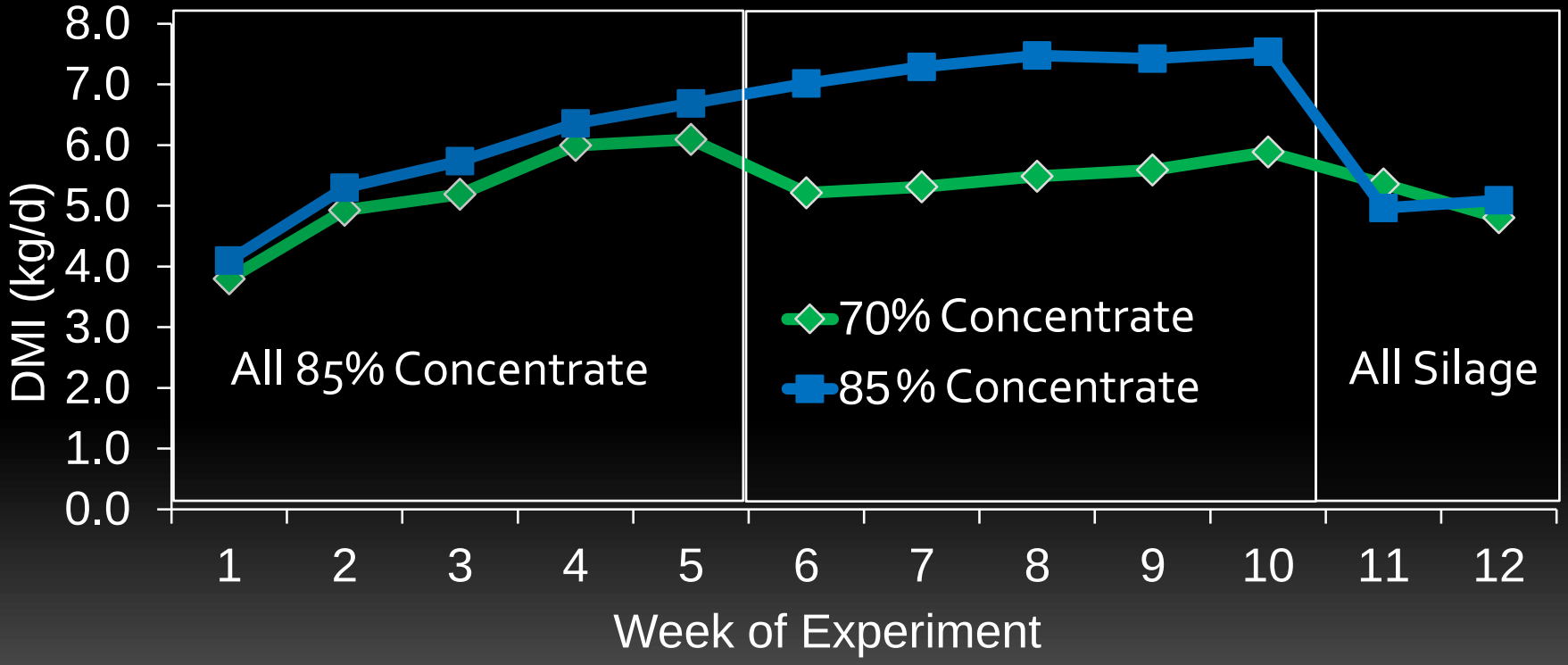

$2,500 investment

(Bach et al., 2013)


70% Concentrate
30% Straw

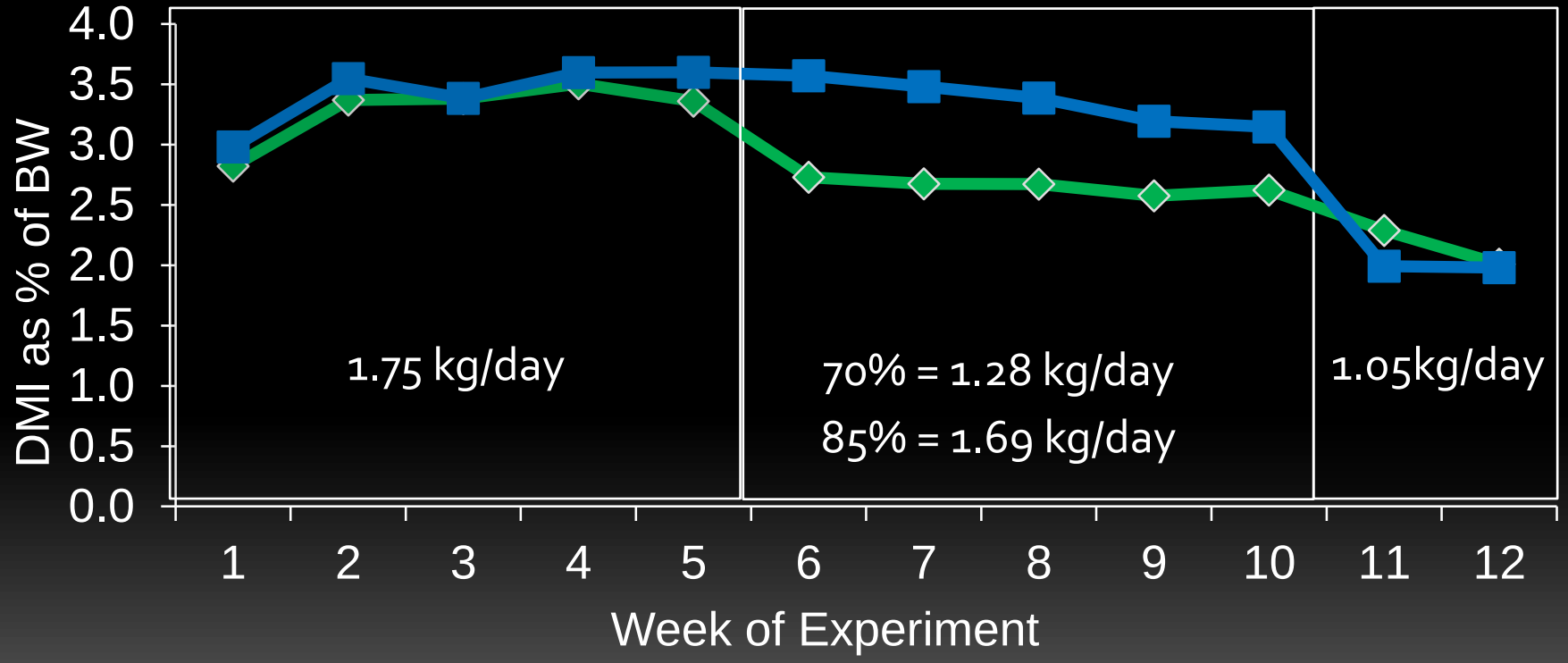

85% Concentrate
15% Straw

# Dry TMR - Dry Matter Intake




(Groen et al., 2015)

# Dry TMR – Average Daily Gain




(Groen et al., 2015)

# Take Home Messages

- Weaning in dairy calves is one of the largest transformations of the gut in nature
- Milk feeding level has a large impact on weaning stress
- Weaning age and abruptness impact performance on high planes of milk nutrition
- Weaning is also associated with gut health problems
- Post-weaning nutrition is another area left undiscovered in calf nutrition