Development of gut microbiota through life in an Angus-Brahman multibreed herd

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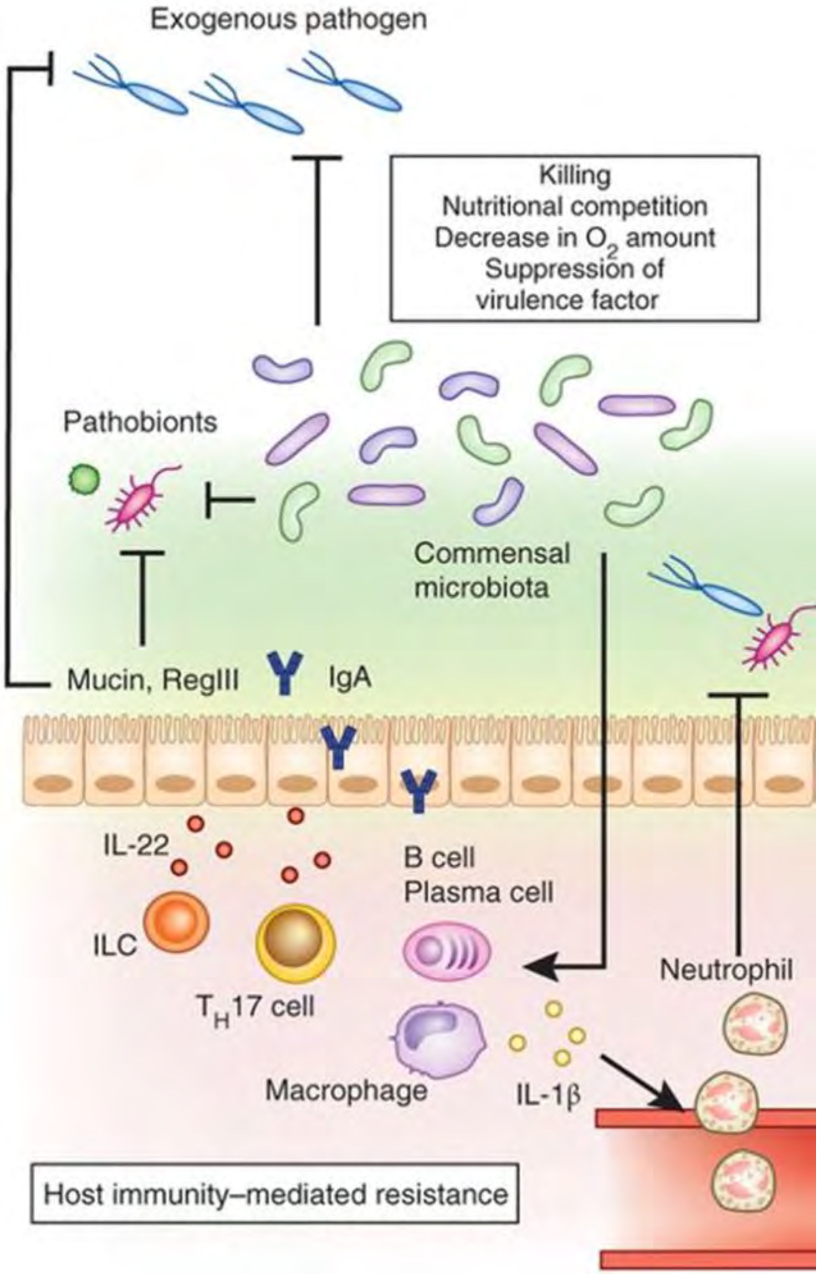
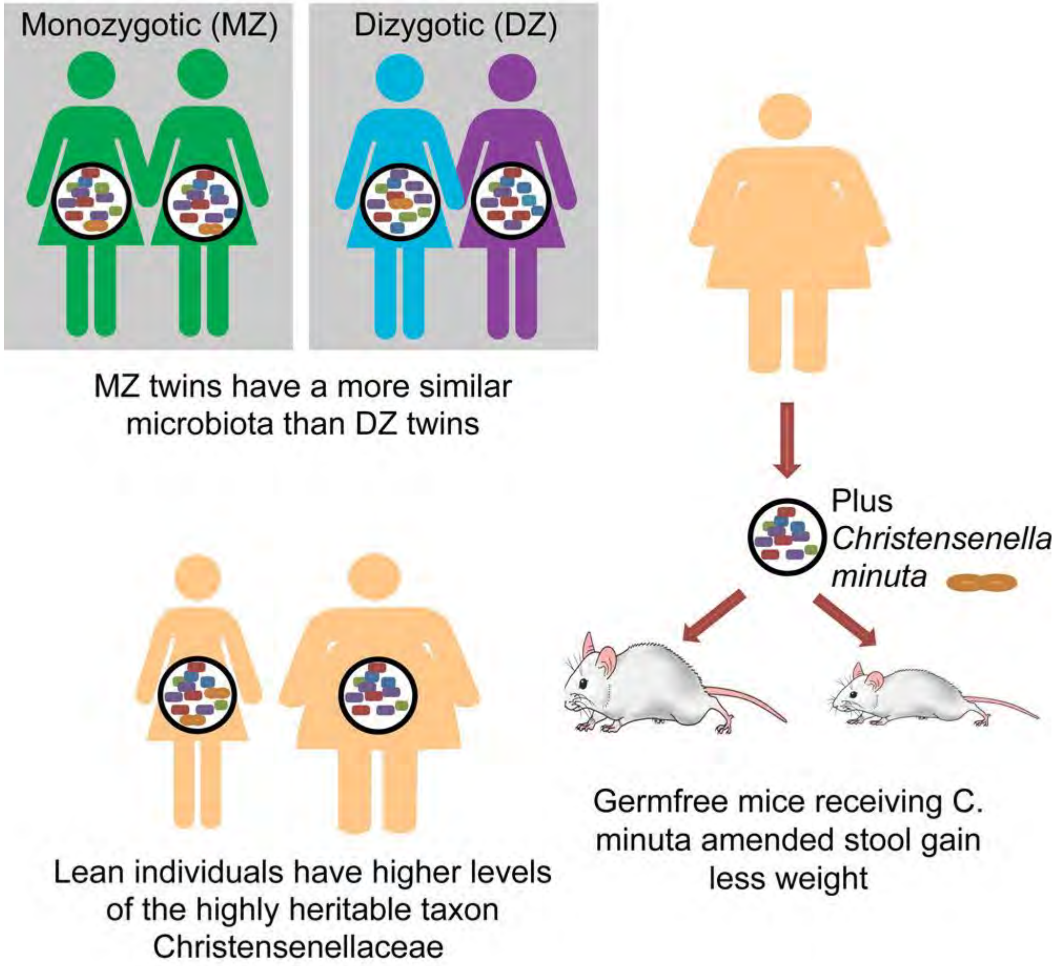
Gut microbiota



Commensal bacteria inhibit pathogen colonization

- ➢ Direct microbe-microbe interactions
  - ✓ Production of bacteriocins
  - ✓ Nutritional competition
- ➢ Indirect host-microbe interactions
  - ✓ Maintenance of intestinal barrier function
  - ✓ Regulation of innate and adaptive immunity

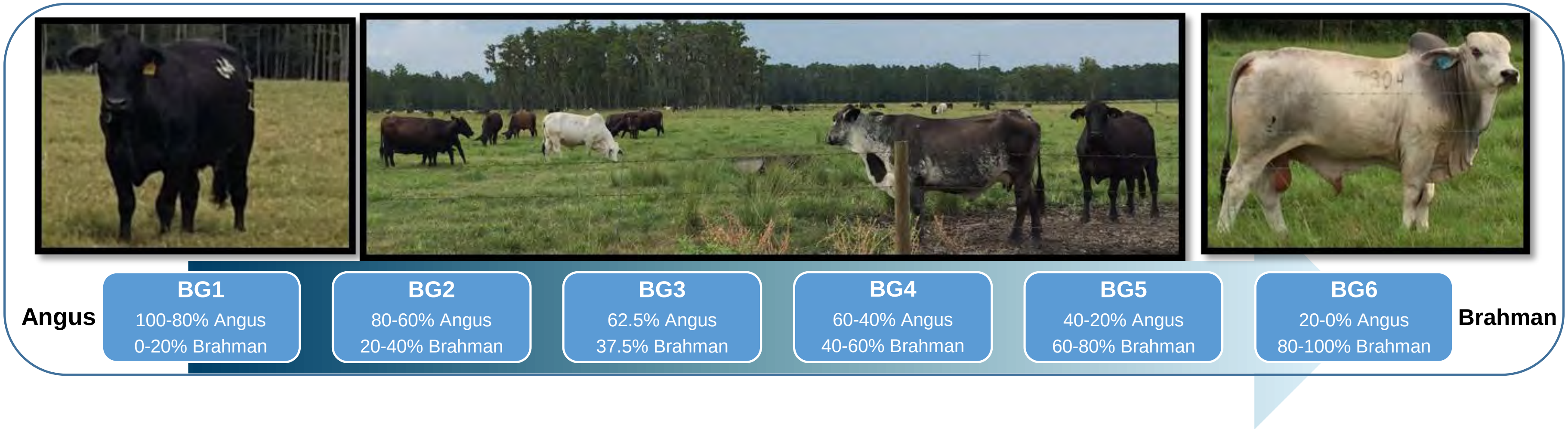
Kamada et al., *Nat Rev Immunol.* 2013



- Host genetics determine certain phenotypes by shaping the gut microbiota

Goodrich et al., *Cell* 2014

Angus-Brahman multibreed herd (MAB herd)

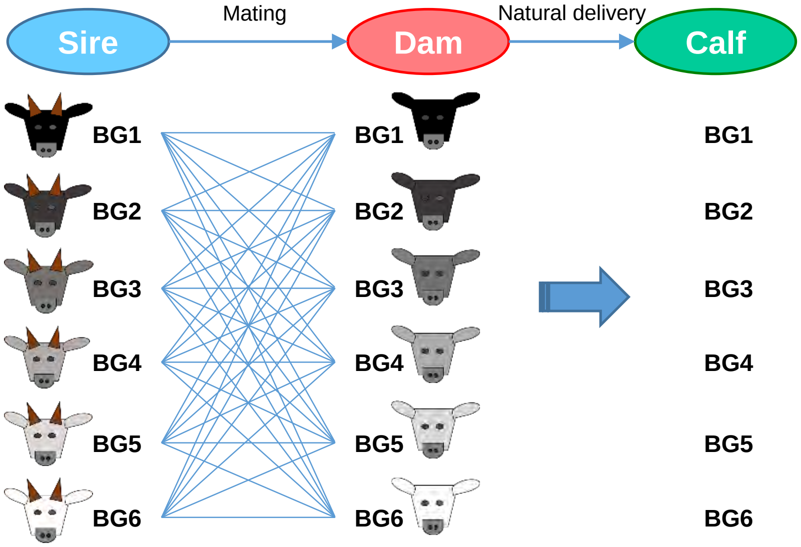


Angus

BG1	BG2	BG3	BG4	BG5	BG6
100-80% Angus 0-20% Brahman	80-60% Angus 20-40% Brahman	62.5% Angus 37.5% Brahman	60-40% Angus 40-60% Brahman	40-20% Angus 60-80% Brahman	20-0% Angus 80-100% Brahman

Brahman

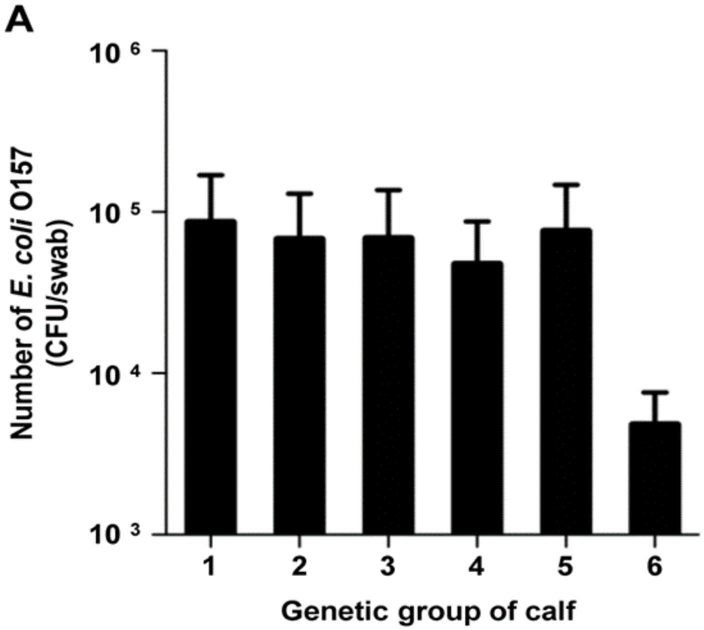
- ✓ The MAB herd was established in 1989 at University of Florida for long-term genetic studies in beef cattle
- ✓ Mating in the MAB herd followed a diallel design



Elzo, *J Anim Sci.* 1998

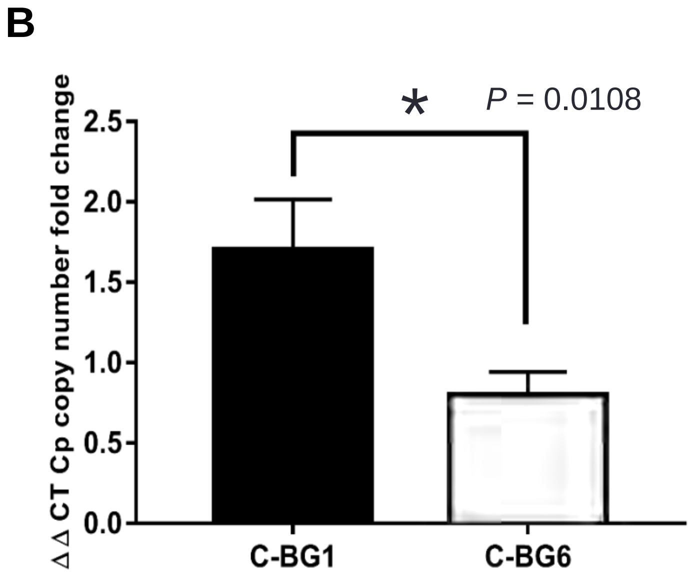
Host genetics & pathogen colonization

In MAB herd, postweaned calves in BG6 excreted lowest number of pathogenic *E. coli* O157



Jeon et al., PLoS One. 2013

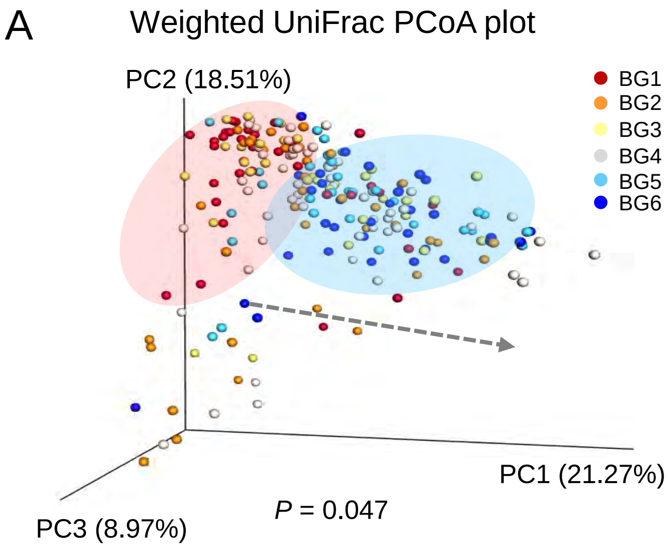
In MAB herd, preweaned calves in BG6 harbored less opportunistic pathogenic bacteria *Clostridium perfringens* compared to BG1



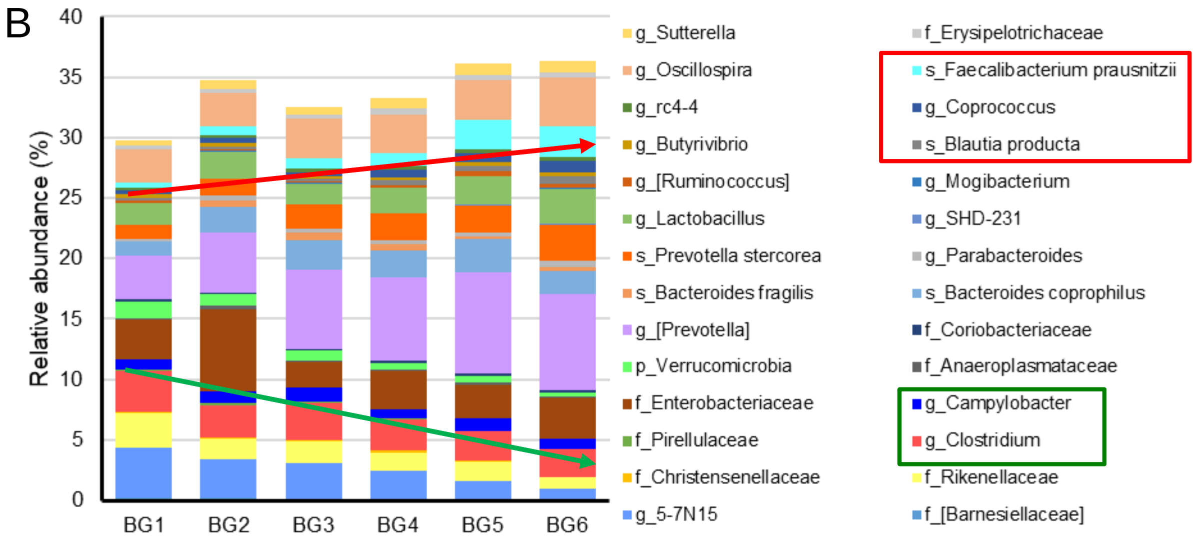
Cp: *Clostridium perfringens*

Fan et al., unpublished data

Host genetics & gut microbiota of MAB herd



- Gut microbiota structure of MAB preweaned calves was different among breed groups



- Breed composition linearly influenced at least 35% of core gut microbiota in preweaned MAB calves

Fan, unpublished data

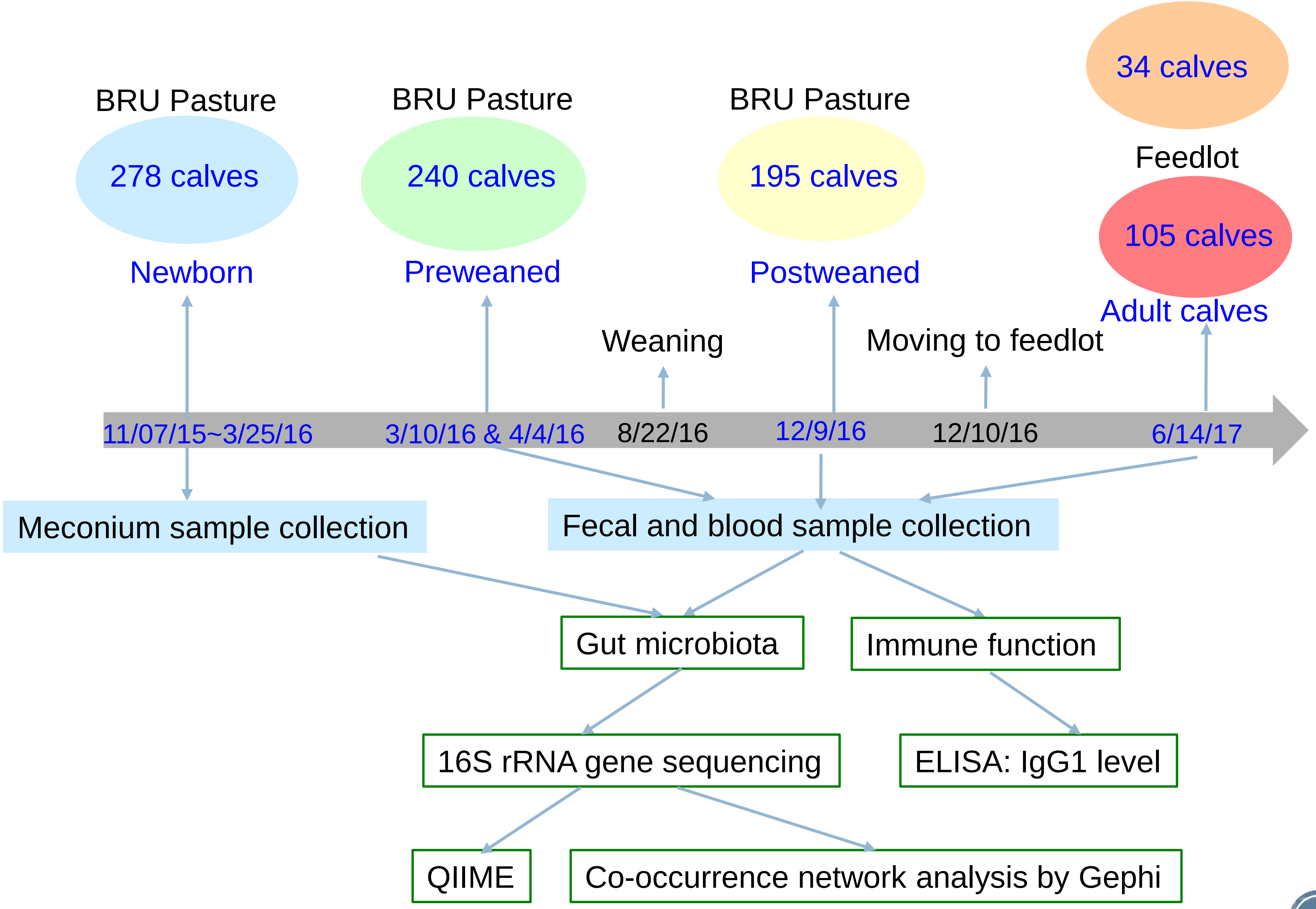
➢ Study question

- ✓ Does gut microbiota of calves with more Brahman proportion have advantages in prevention of pathogen colonization through life?

➢ Objectives

- ✓ Understand the development of gut microbiota of MAB calves through life
- ✓ Investigate effects of breed composition on gut microbiota during different growing stages

Materials & Methods



BRU Pasture

278 calves

Newborn

BRU Pasture

240 calves

Preweaned

Weaning

BRU Pasture

195 calves

Postweaned

Moving to feedlot

BRU Pasture

34 calves

Feedlot

105 calves

Adult calves

11/07/15~3/25/16

3/10/16 & 4/4/16

8/22/16

12/9/16

12/10/16

6/14/17

Meconium sample collection

Fecal and blood sample collection

Gut microbiota

Immune function

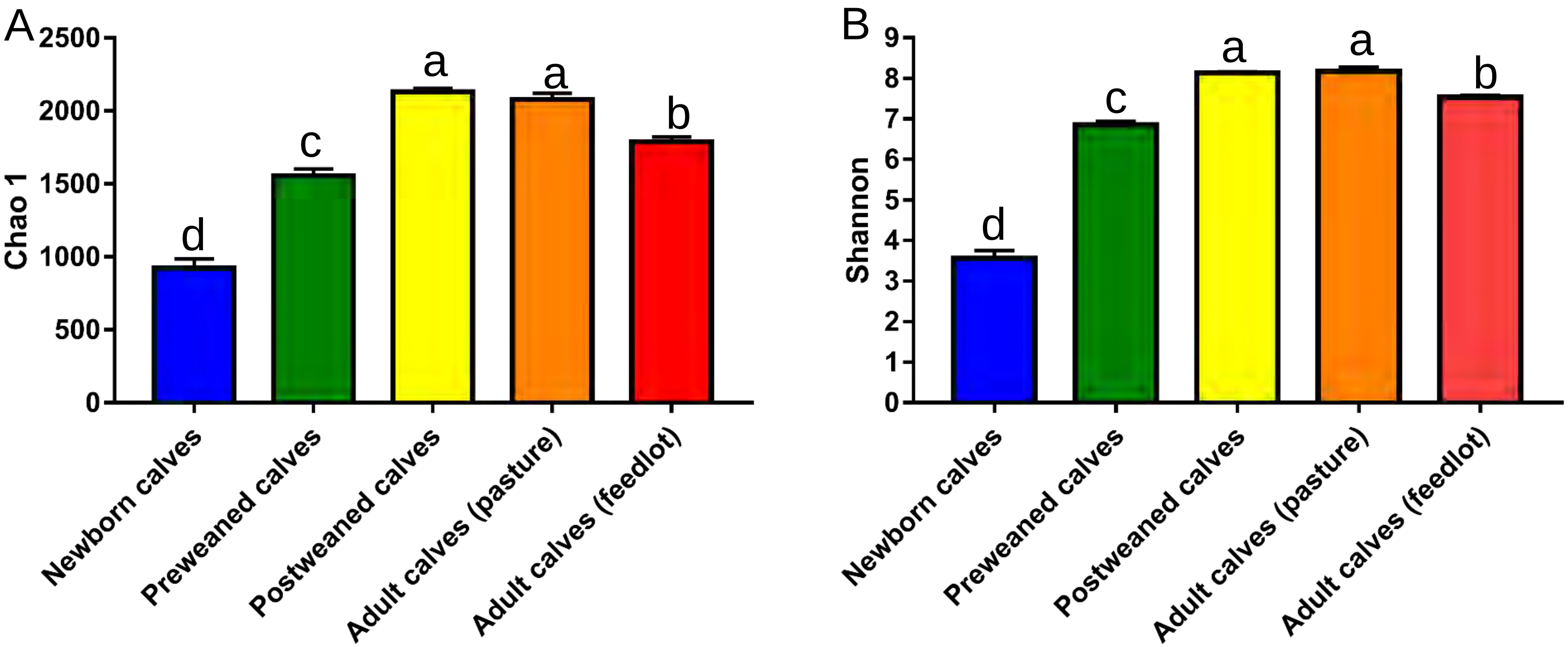
16S rRNA gene sequencing

ELISA: IgG1 level

QIIME

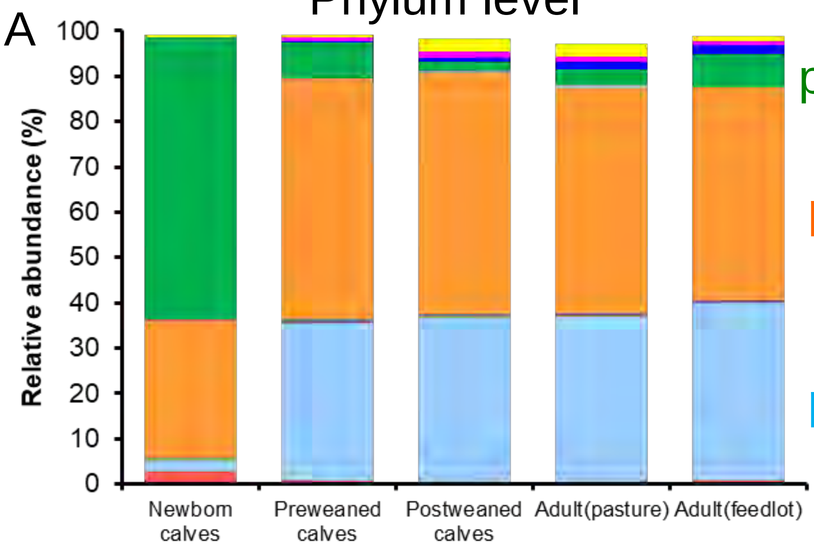
Co-occurrence network analysis by Gephi

How does gut microbiota develop after birth?



- ✓ Richness and diversity of gut microbiota gradually increased after birth and maintained stable after weaning when calves were kept on pasture
- ✓ Richness and diversity of gut microbiota significantly decreased when calves were moved to feedlot

What are dominant bacteria in different growing stages?

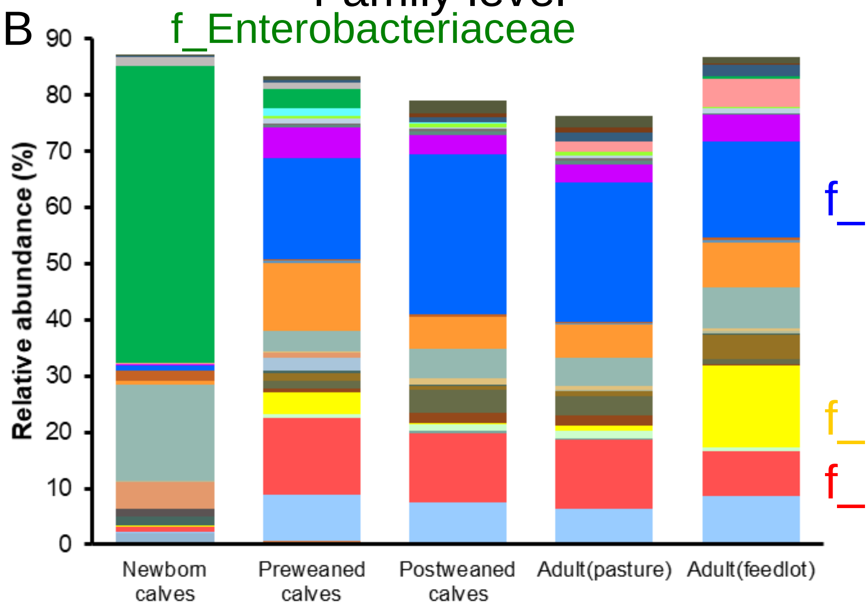


Phylum level

p_Proteobacteria

p_Firmicutes

p_Bacteroidetes



Family level

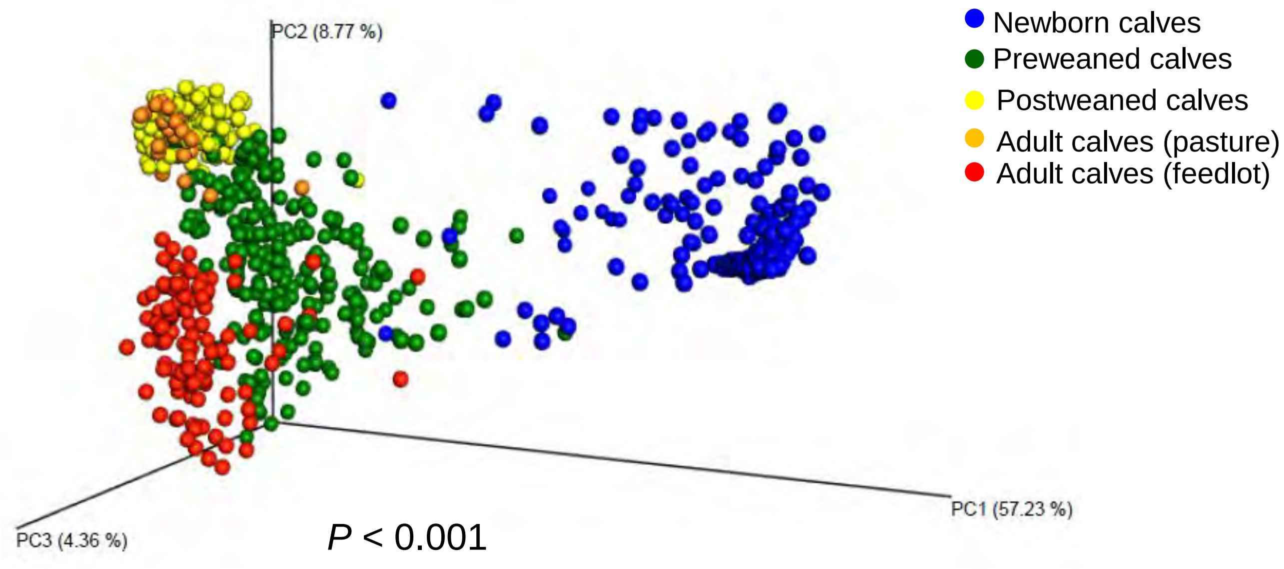
f_Enterobacteriaceae

f_Ruminococcaceae

f_Prevotellaceae

f_Bacteroidaceae

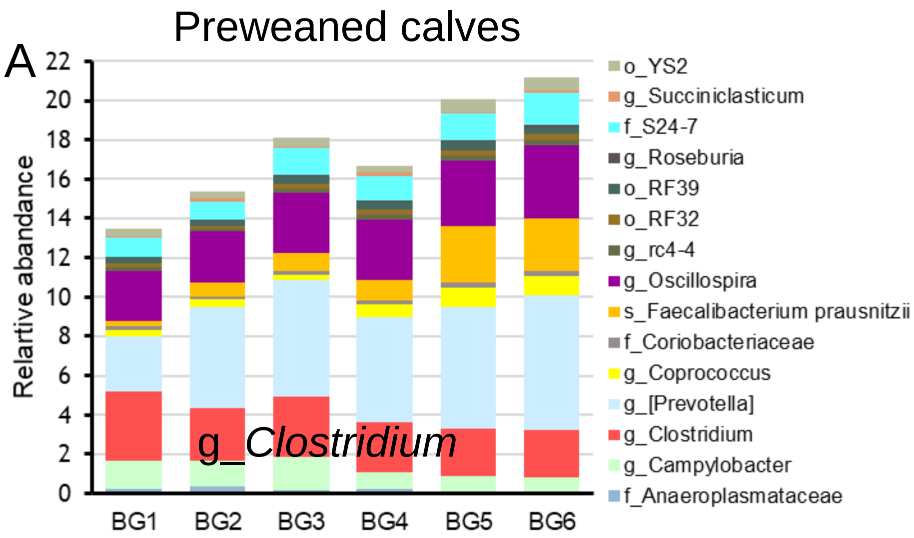
Weighted UniFrac PCoA plot

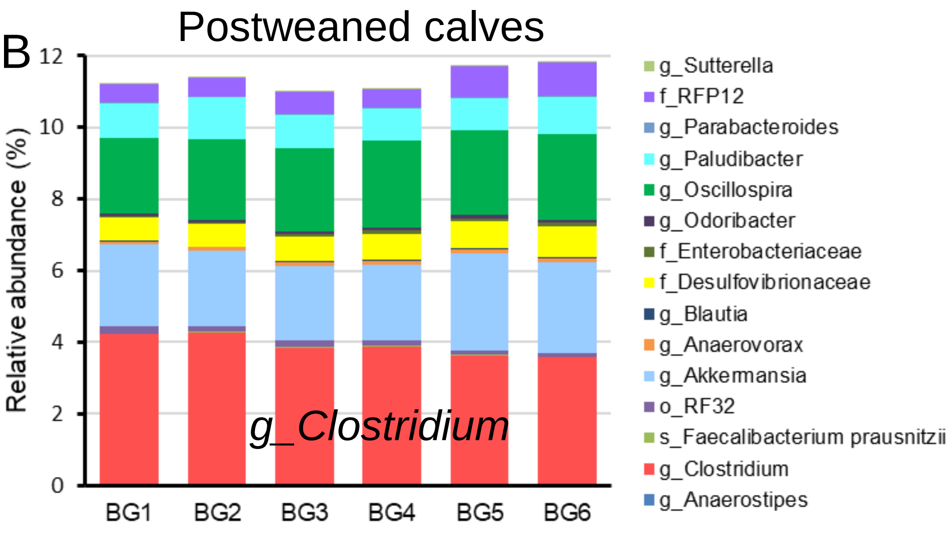


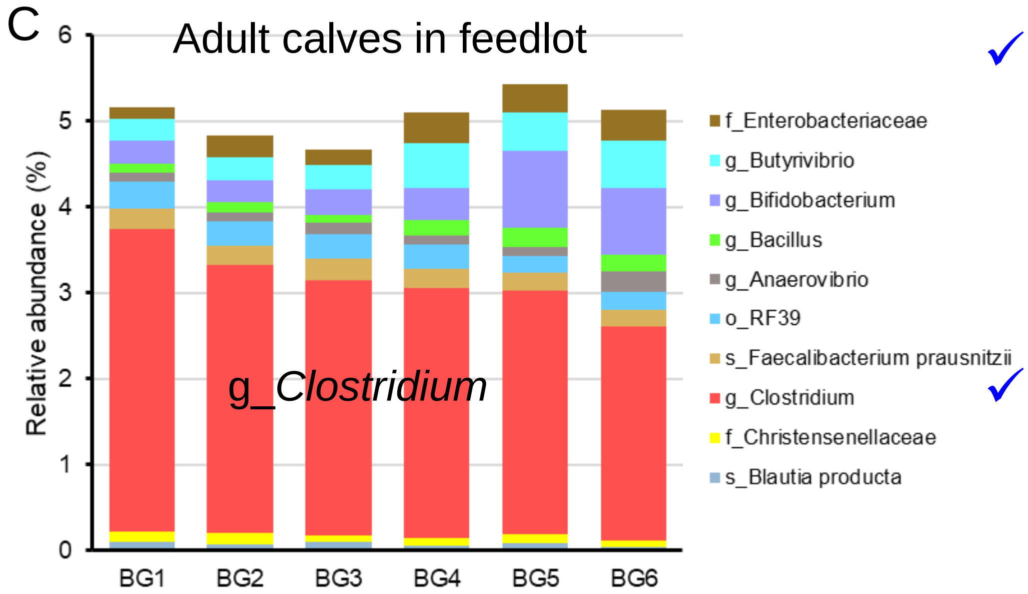
$P < 0.001$

The variation in gut microbiota structure among MAB calves decreased after weaning, but increased after calves were moved to feedlot

Does breed composition has consistent effects on gut microbiota of MAB calves at different growing stages?



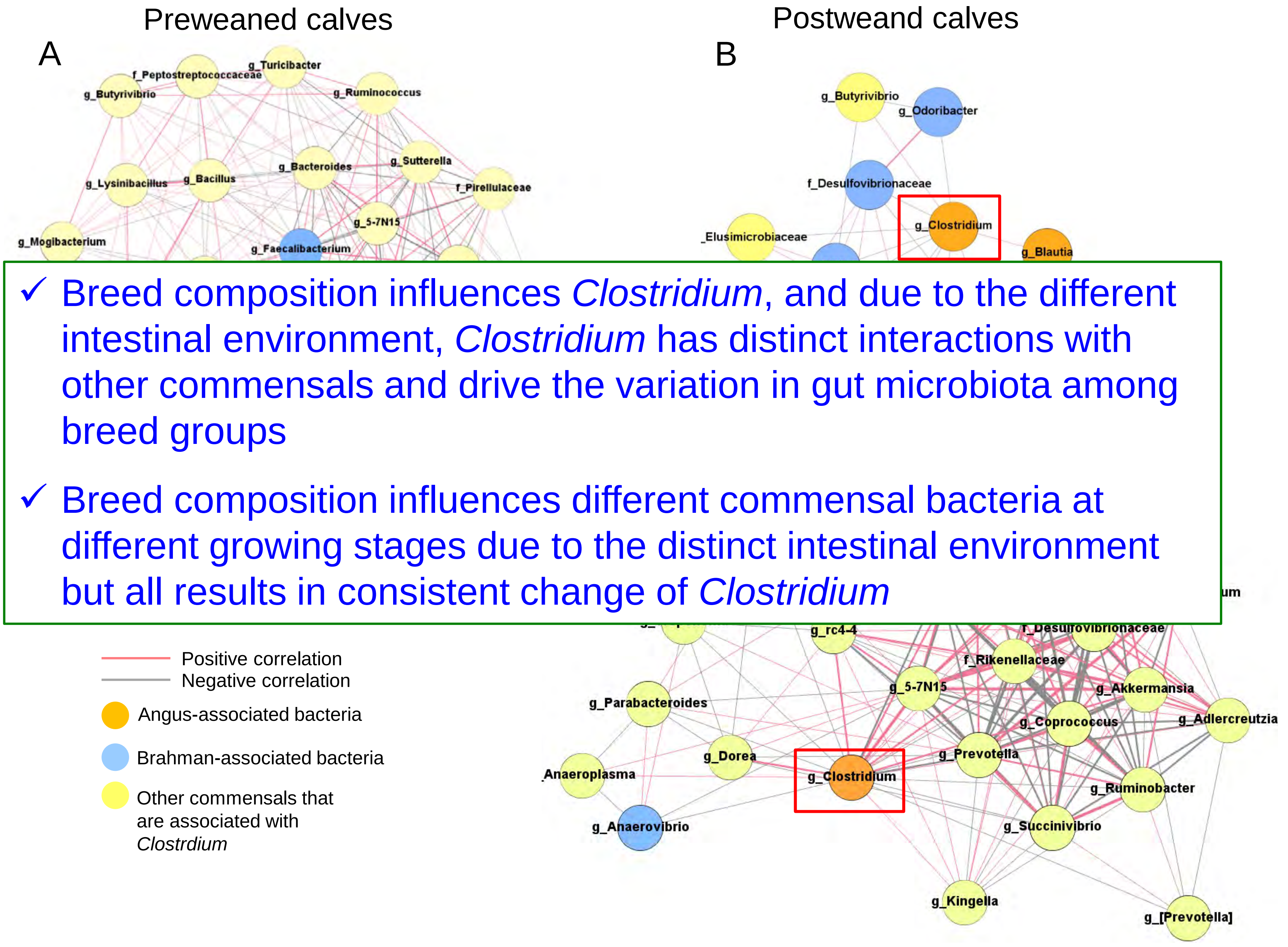




- ✓ Variation in gut microbiota caused by breed composition was more significant during preweaning and fattening stages compared to postweaning stage
- ✓ Breed composition had consistent effects on *Clostridium,* but not on other commensal bacteria

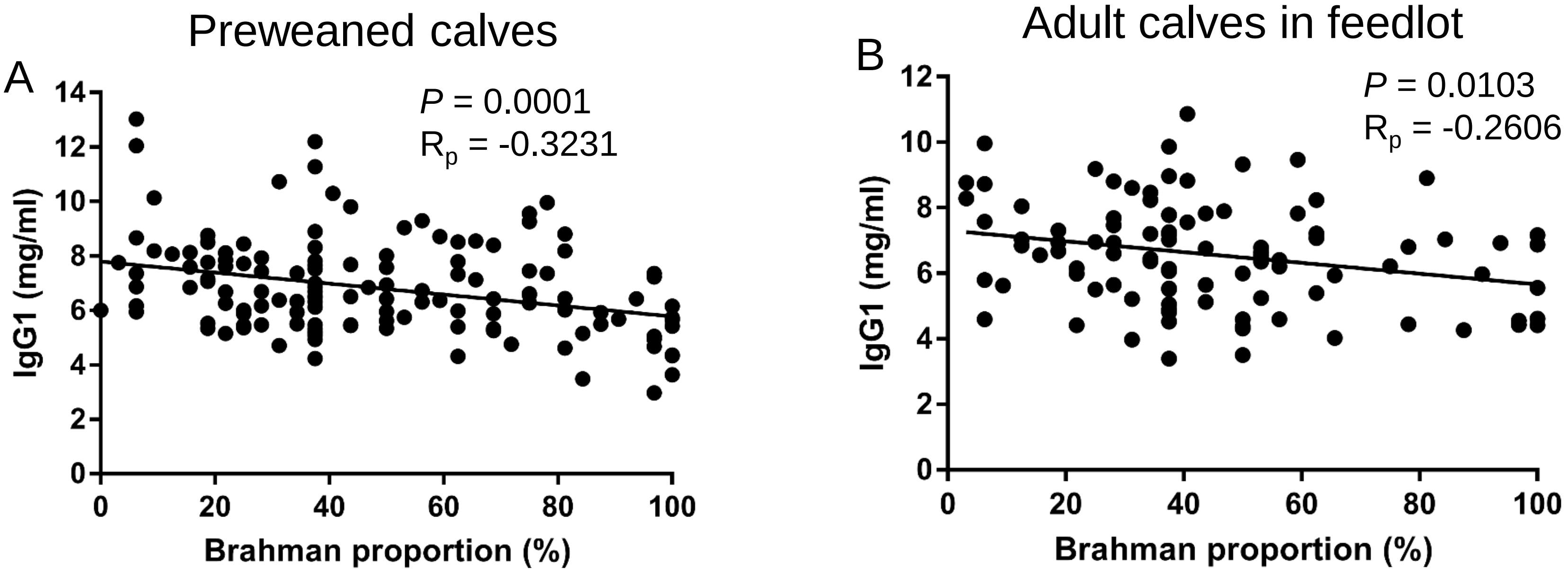
Generalized linear models (Glm) in R software:
Effects of Brahman proportion, age in days and the interaction of the two

Co-occurrence network



- ✓ Breed composition influences *Clostridium*, and due to the different intestinal environment, *Clostridium* has distinct interactions with other commensals and drive the variation in gut microbiota among breed groups
- ✓ Breed composition influences different commensal bacteria at different growing stages due to the distinct intestinal environment but all results in consistent change of *Clostridium*

Does breed composition has consistent effects on immune function of MAB calves?



Generalized linear models (Glm) model:
Effects of Brahman proportion, age in days and the interaction of the two

Humoral immunity of MAB calves is influenced by the breed composition

Conclusion

- Gut microbiota of MAB calves gradually developed after birth and maintained stable after weaning, but dramatically changed after calves were moved to feedlot
- Breed composition influenced the gut microbiota of MAB calves during different growing stages
    - It has more apparent effects on gut microbiota of MAB calves during preweaning stage and when calves were moved to feedlot compared to postweaning stage on pasture
    - Calves with more Brahman proportion harbored less *Clostridium* which bacterial genus includes several significant pathogens through life
- Humoral immunity of MAB calves was influenced by breed composition through life which may be associated with variation in gut microbiota

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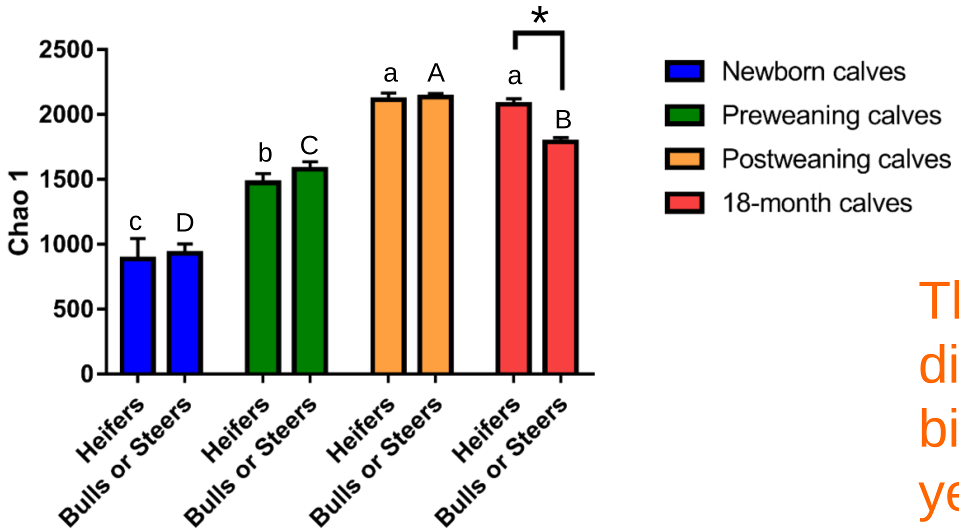
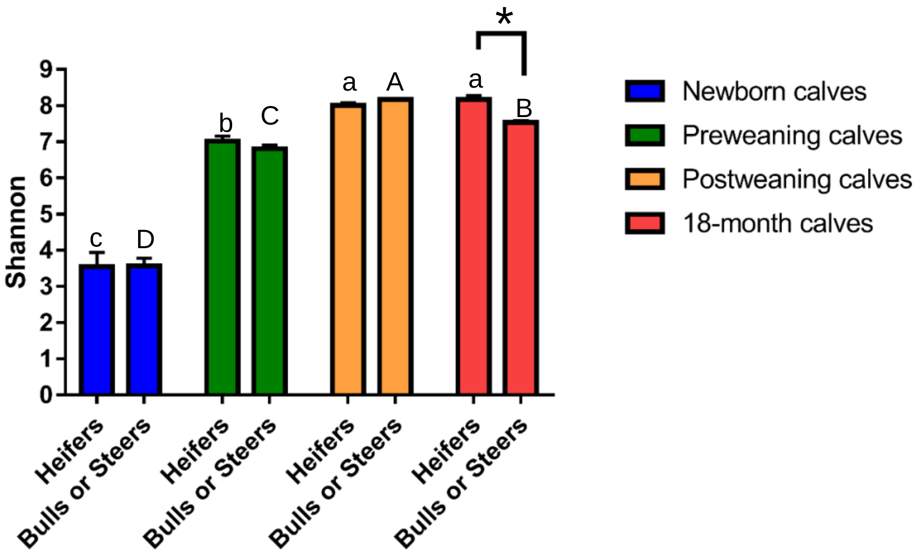
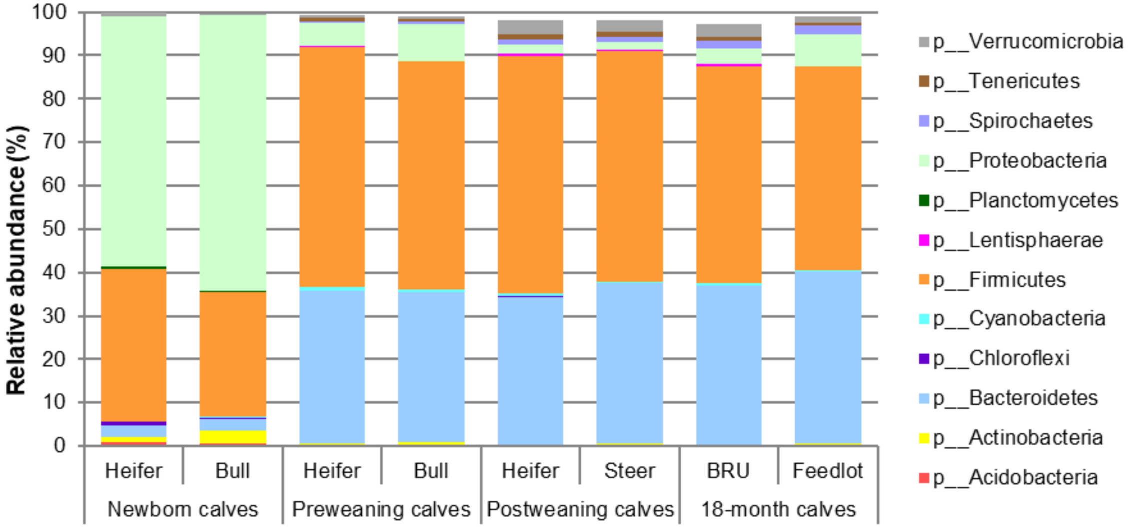
How does gut microbiota diversity change through life?





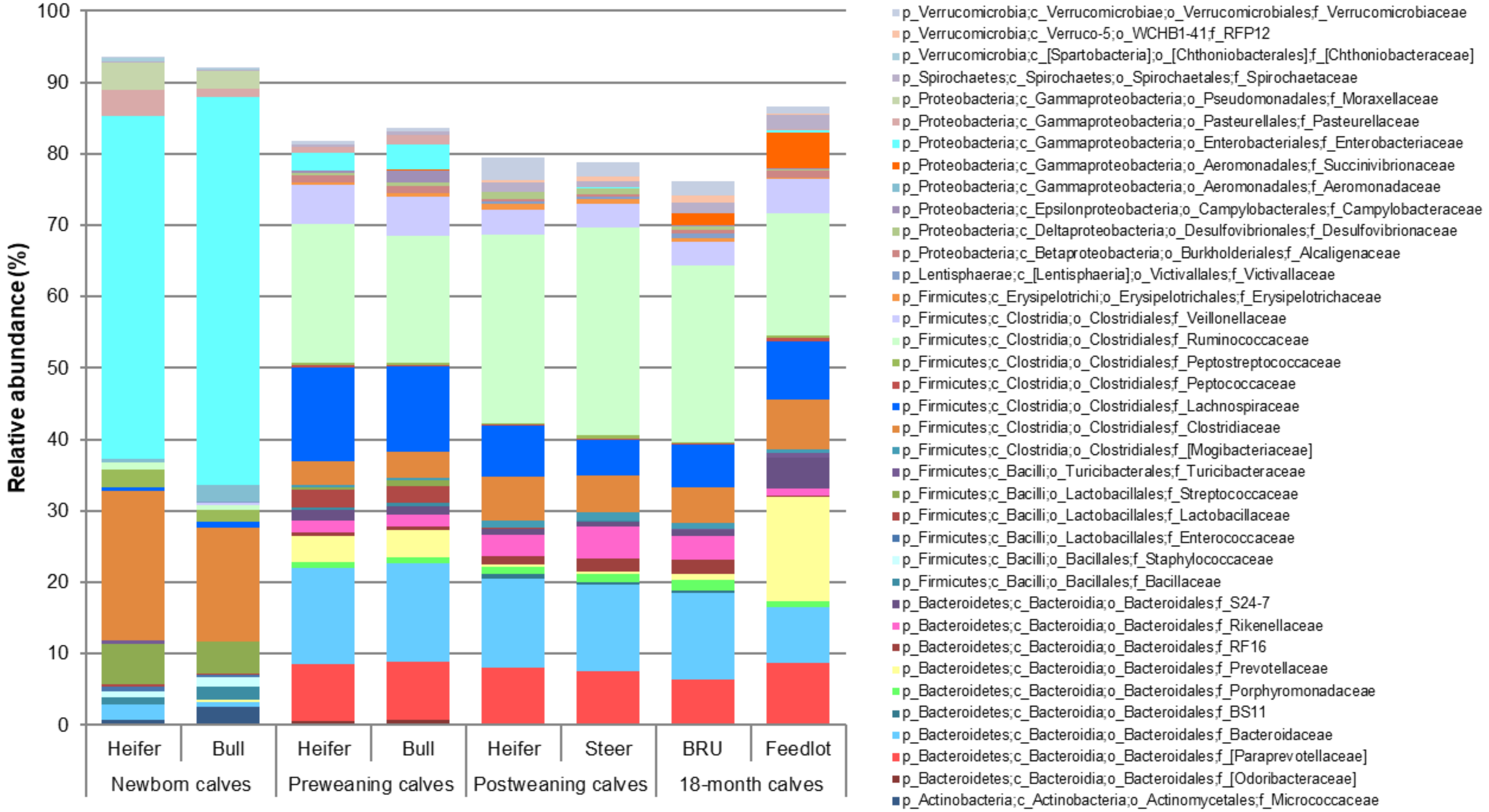
The gut microbiota richness and diversity gradually increased after birth and maintained stable after 1 year-old, but dramatically decreased after moving to feedlot

What are the dominant bacteria in different growing stage?



Note: Only phyla with relative abundance higher than 0.5% are included in the figure

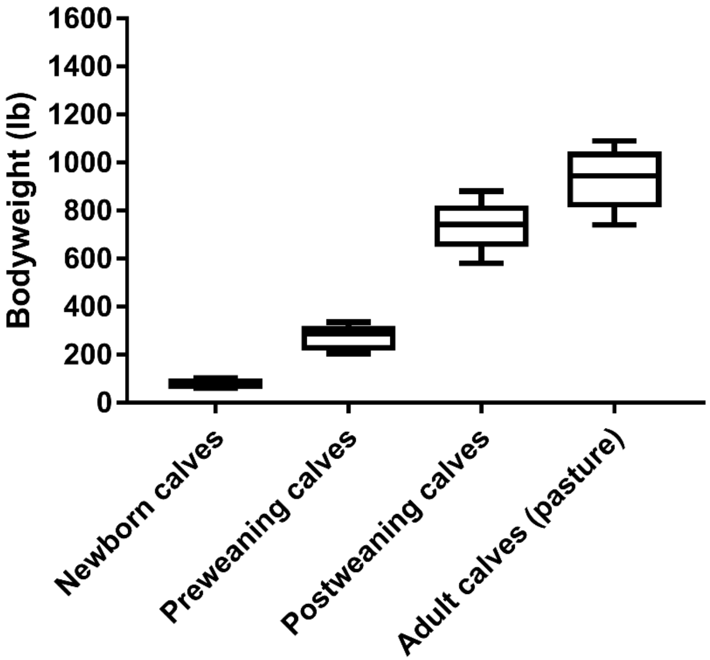
- ✓ Proteobacteria and Firmicutes are the dominant bacteria in meconium
- ✓ Firmicutes and Bacteroidetes become the dominant bacteria after birth

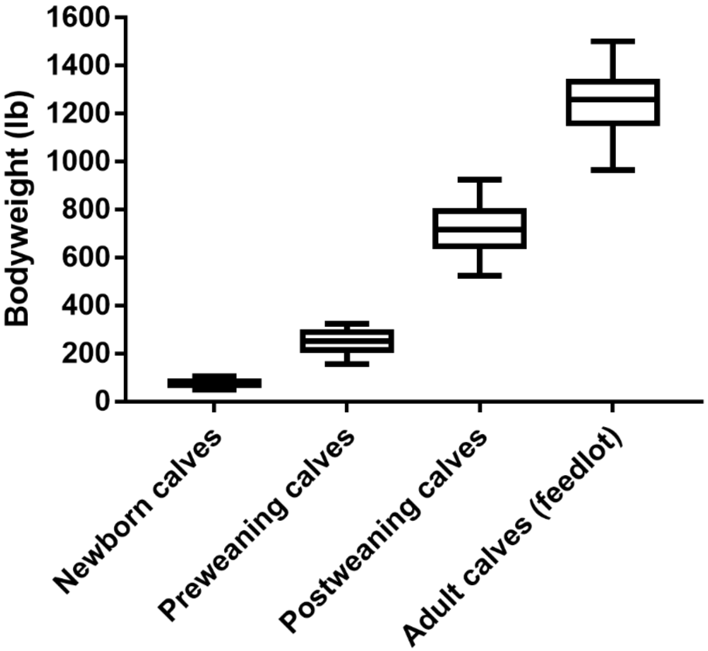


Note: Only familifies with relative abundance higher than 0.5% are included in the figure

- ✓ Enterobacteriaceae and Clostridaceae are the dominant bacterial families in meconium
- ✓ Ruminococcaceae, Lachnospiraceae and Bacteroidaceae become dominant bacterial families after birth
- ✓ The Prevotellaece decreased in postweaning calves but increased after moving to feedlot, while Rikenellaceae changed in an opposite direction

The animal weight steadily increased after birth and the growth rate was accelerated in feedlot





Postweaning

- ✓ **Diet:** The steers and heifers were fed differently. The steers were fed with more concentrate and higher level of copper

Oct 6~Nov 16: Steers---more Creep Hazen Feed
Nov 30~Dec 9: Steers---Gluten, Heifer---Cottonseed
Oct 21~Dec 9: Steers---UF Custom Range Mineral (copper: 2030 ppm)
Heifers---UF Custom Winter Mineral (copper: 2020 ppm)

Creep Hazen Feed

Crude Protein	Not less than 12.0%
Crude Fat	Not less than 2.0%
Crude Fiber	Not more than 14%
Vitamin A	4200/IU

Feedlot

Diet

Nutrient, DM Conc.	Unit
Moisture, %	36.23
Dry matter%	63.77
Crude Protein, %	12.94
NonProt N Prot Eqv, %	0.51
Fat, %	6.41
Rough NDF, %	4.71
Roughage, %	7.25
Calcium,%	0.77
Phosphorus, %	0.35
Potassium, %	0.6
Magnesium, %	0.18
Sulfur, %	0.16
Added Salt, %	0.21