Young Scholar Presentation

Effects of monoglycerides on intestinal morphology and immune responses of weanling pigs experimentally infected with a pathogenic *E. coli*

Sangwoo Park[1], Shuhan Sun[1], Kwangwook Kim[1], Adebayo O. Sokale[2], Adriana Barri[3], and Yanhong Liu[1]

[1]University of California, Davis, 95616

[2]BASF Corporation, Florham Park, 07932

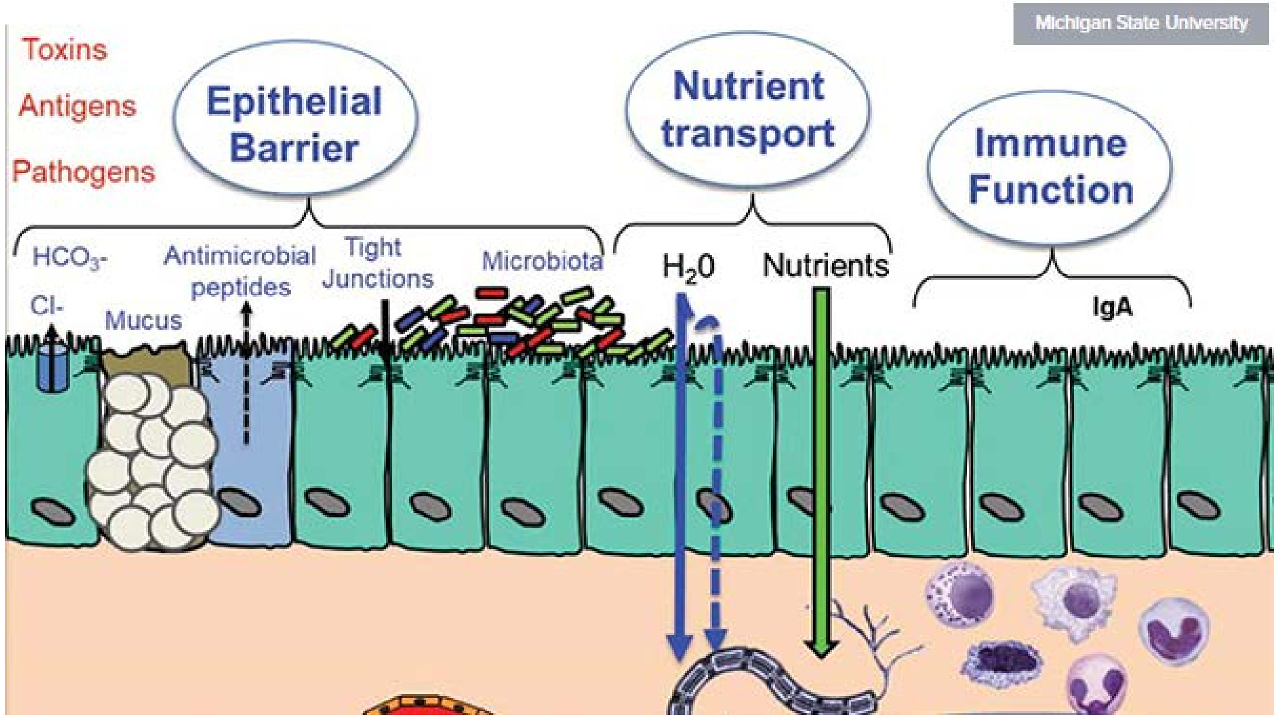
[3]BASF SE, Lampertheim, Germany

Outline

- Gut health and post-weaning diarrhea in pigs
- Monoglycerides
- Experimental design
- Results and conclusions

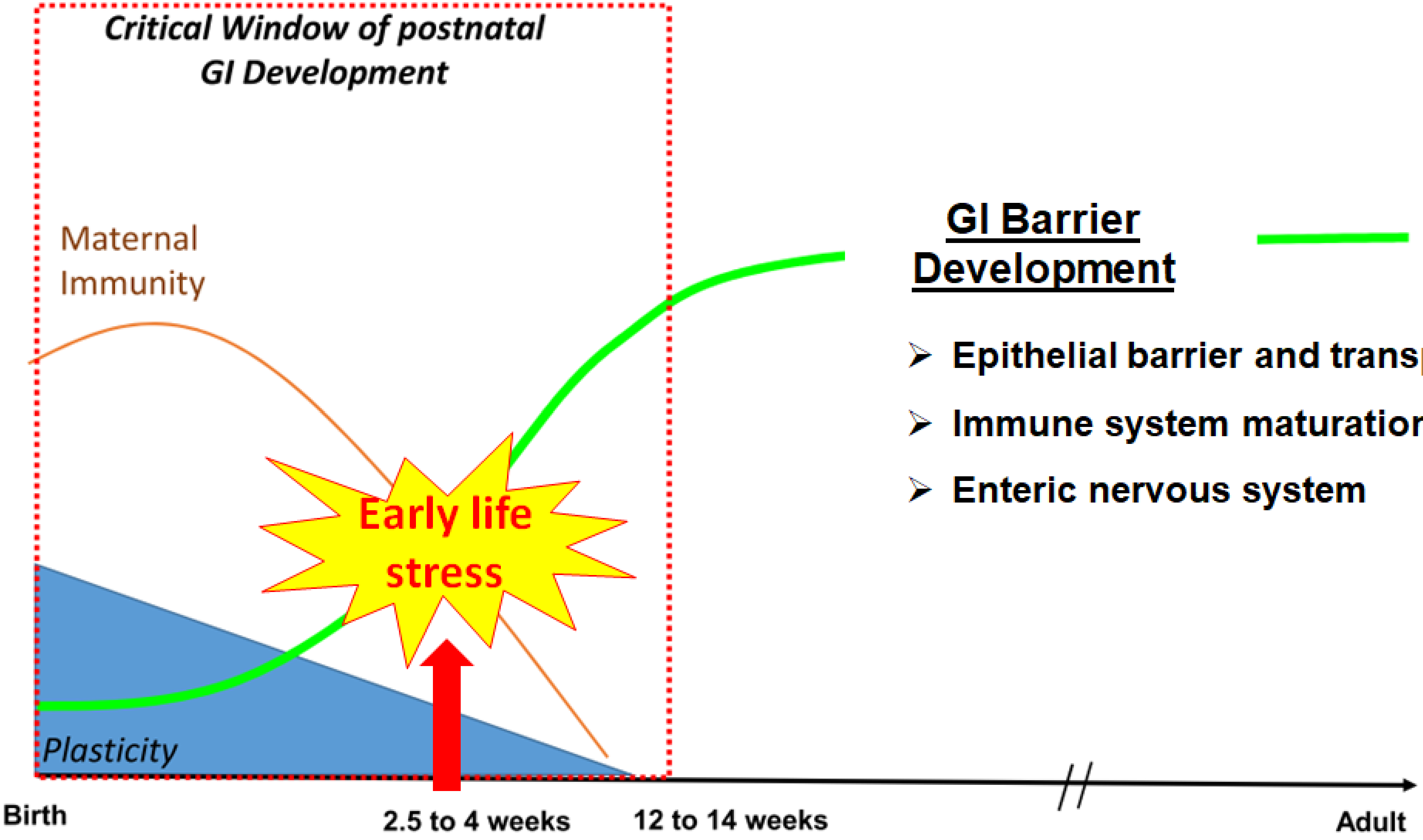
Gut health of weaning pigs

- ❖ Intestinal functions
  - ➢ Digest and absorb nutrients
  - ➢ Protect the host
- ❖ Growth and health of pigs
- ❖ Early-life stress
  - ➢ Harmful impacts on gut health



Moeser et al., 2018

Gastrointestinal (GI) function development in pig

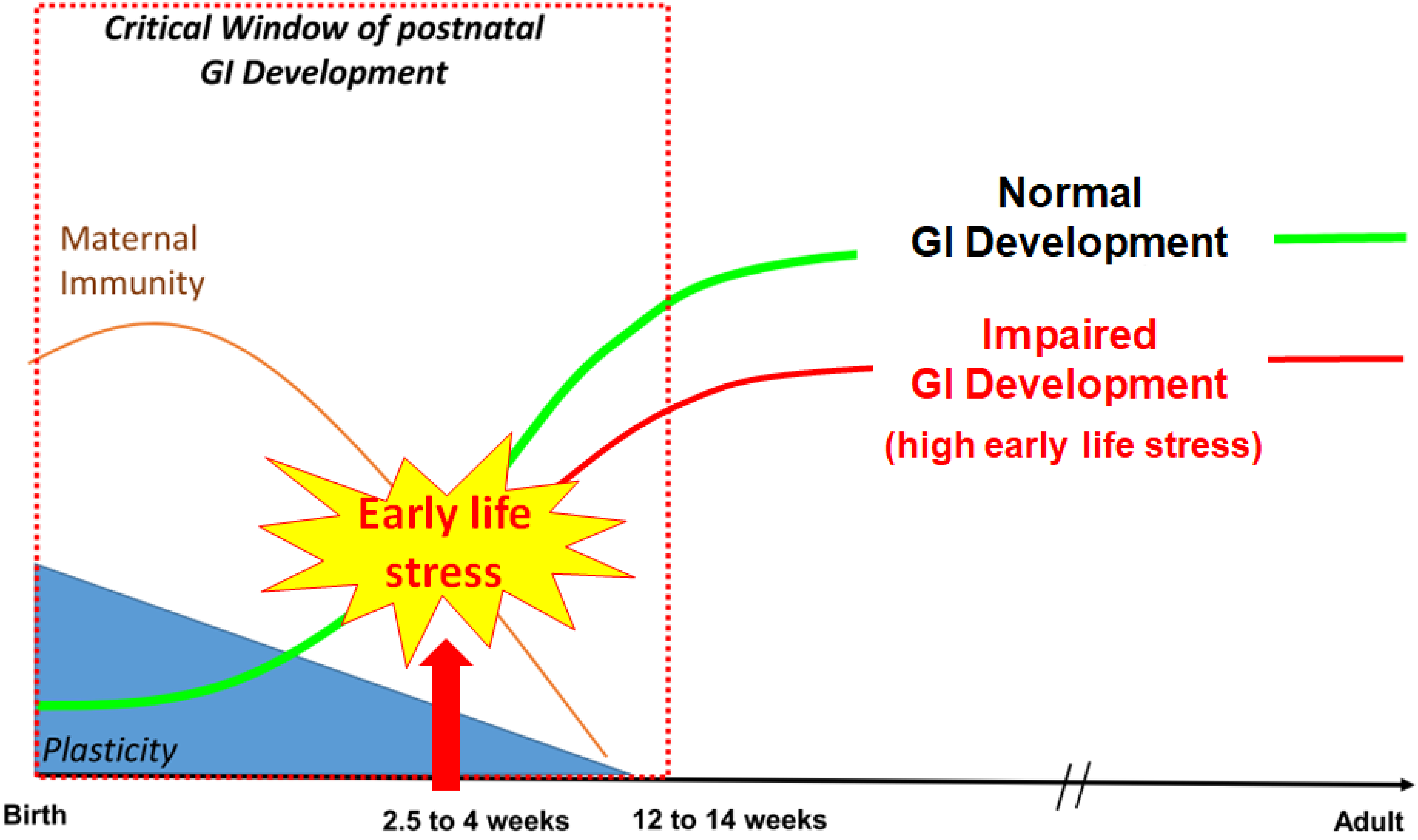


GI Barrier Development

- Epithelial barrier and transport functions
- Immune system maturation
- Enteric nervous system

Moeser et al., 2017

Gastrointestinal (GI) function development in pig



Moeser et al., 2018

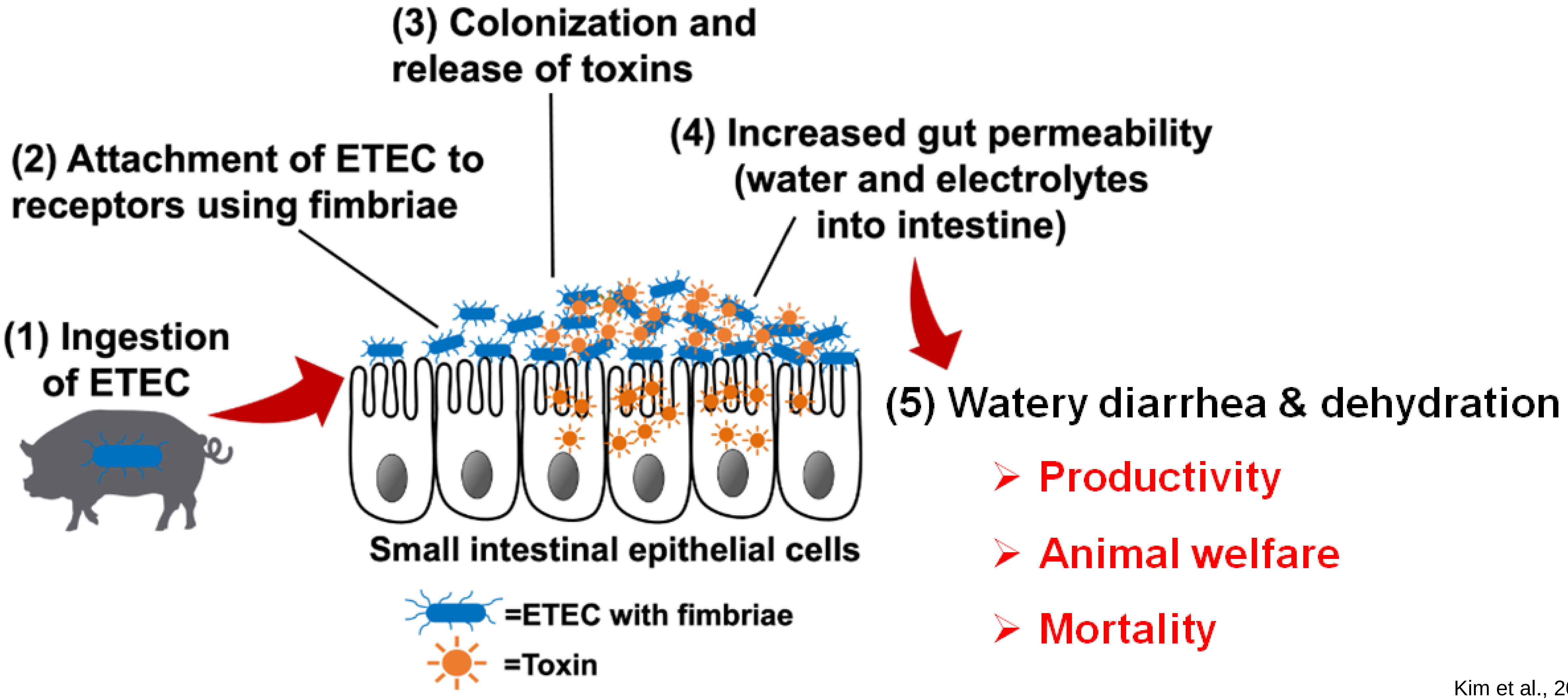
Weaning stress

- ❖ Multifactorial issue
  - ➢ Nutritional, physiological, and environmental challenges
- ❖ Stressor-induced changes
  - ➢ Reduced appetite
  - ➢ Induced intestinal dysfunctions
  - ➢ Increased exposure and risk to pathogens
  - ➢ **Post-weaning diarrhea (PWD)**

Post-weaning diarrhea (PWD)

- Gastrointestinal disease
  - Economic losses
- Enterotoxigenic *Escherichia coli* (ETEC)
  - F4 (K88) and F18 *E. coli*
  - Enterotoxins
    - ✓ Secretory diarrhea

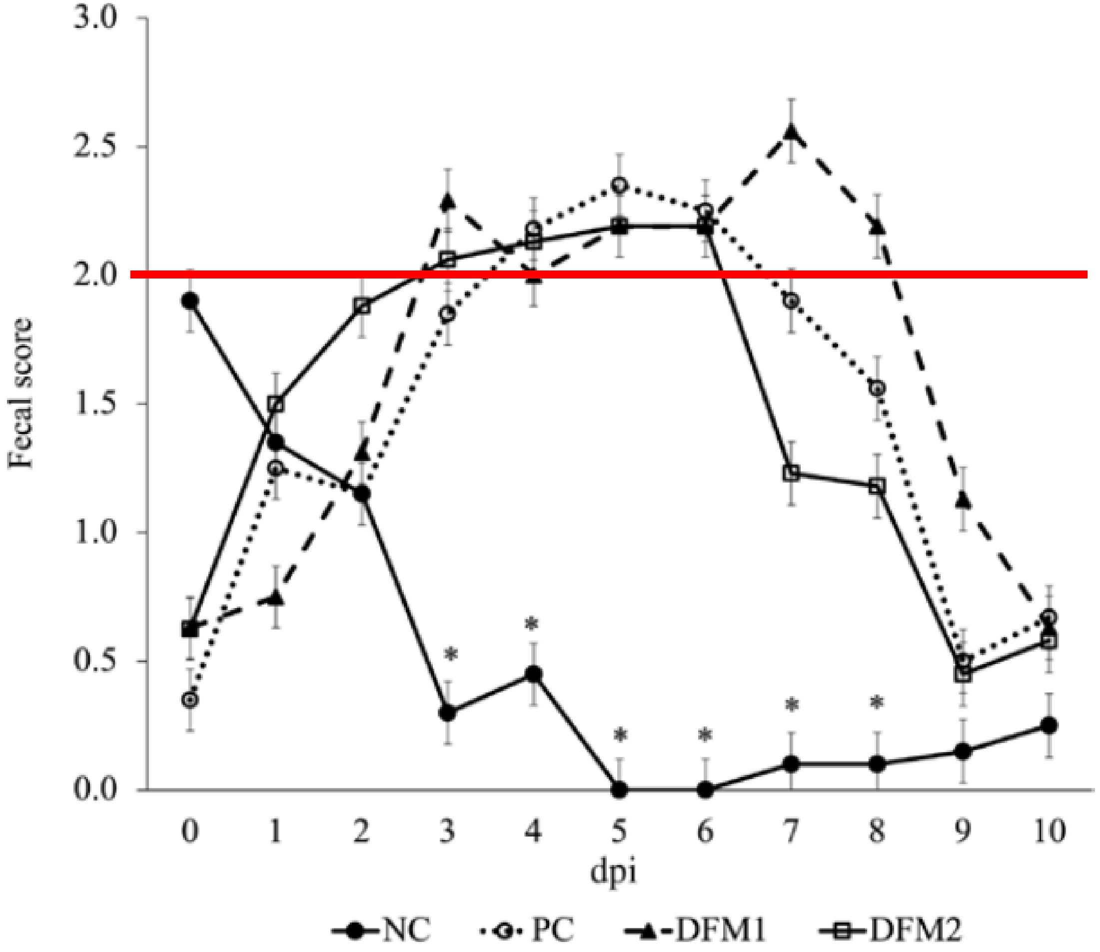
<u>Post-weaning *E. coli* diarrhea</u>



- Productivity
- Animal welfare
- Mortality

Kim et al., 2022

E. coli challenge and diarrhea



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Non Ruminant Nutrition

NON RUMINANT NUTRITION

Effects of an F18 enterotoxigenic *Escherichia coli* challenge on growth performance, immunological status, and gastrointestinal structure of weaned pigs and the potential protective effect of direct-fed microbial blends

Spenser L. Becker,[*] Qingyun Li,[*] Eric R. Burrough,[†] Danielle Kenne,[†] Orhan Sahin,[†] Stacie A. Gould,[*] and John F. Patience[*,1]

Figure 1. Effects of treatment on the daily fecal score of pigs challenged with F18 ETEC. NC (n = 10); PC (n = 9); DFM1 = PC + direct-fed microbial 1 (n = 8; three strains of *Bacillus amyloliquefaciens*; 7.5 × 10^5 cfu/g of feed); DFM2 = PC + direct-fed microbial 2 (n = 7; two strains of *B. amyloliquefaciens* and one strain of *Bacillus subtilis*; 1.5 × 10^5 cfu/g of feed). Supplementation rates were based on manufacturer's recommendations (Danisco Animal Nutrition). P (NC vs. PC; day postinoculation (dpi) 3) < 0.001, P (PC vs. DFM1, DFM2; dpi 3) > 0.10, P (all treatments; dpi 10) > 0.10.

*Fecal score: 0 = solid; 1 = semi-solid; 2 = semi-liquid; 3 = liquid
(≥ 2 was considered diarrhea)

E. coli challenge and performance

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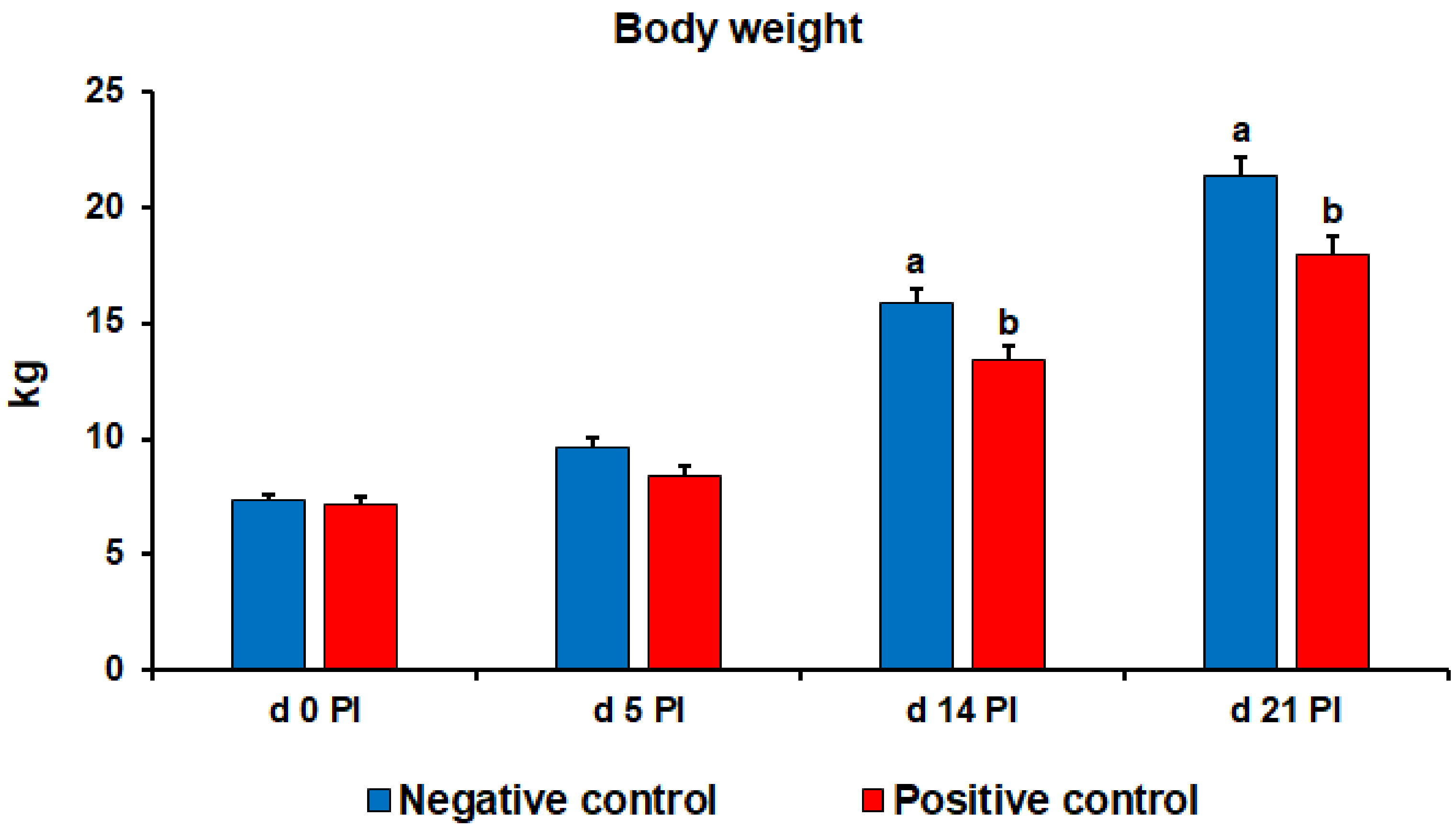
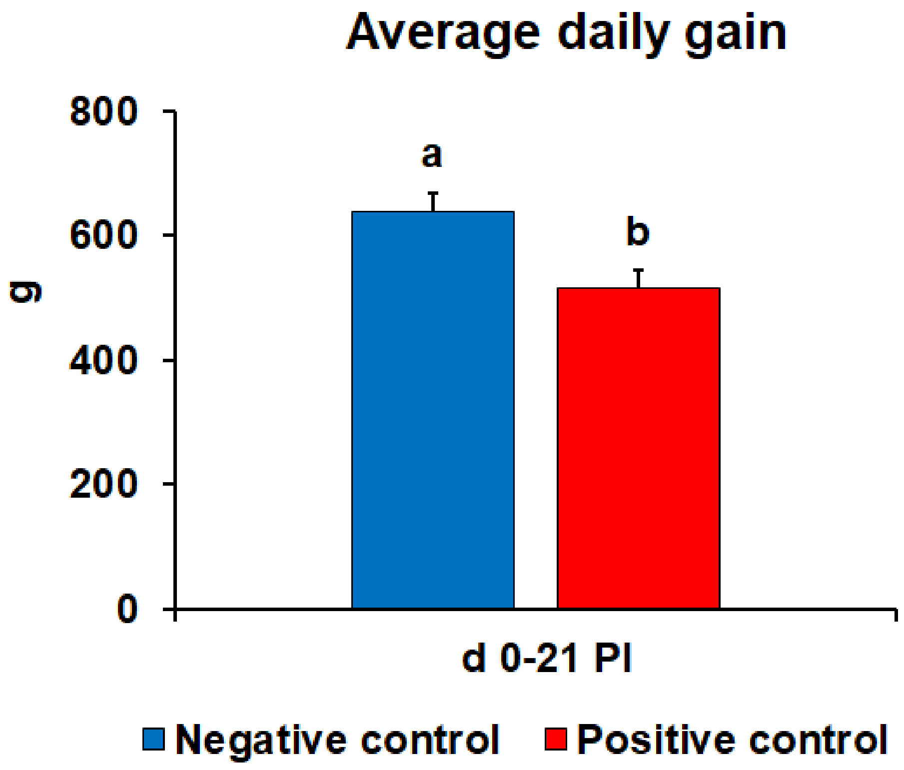
Advance access publication 22 October 2022
Non Ruminant Nutrition

Dietary supplementation of botanical blends enhanced performance and disease resistance of weaned pigs experimentally infected with enterotoxigenic *Escherichia coli* F18

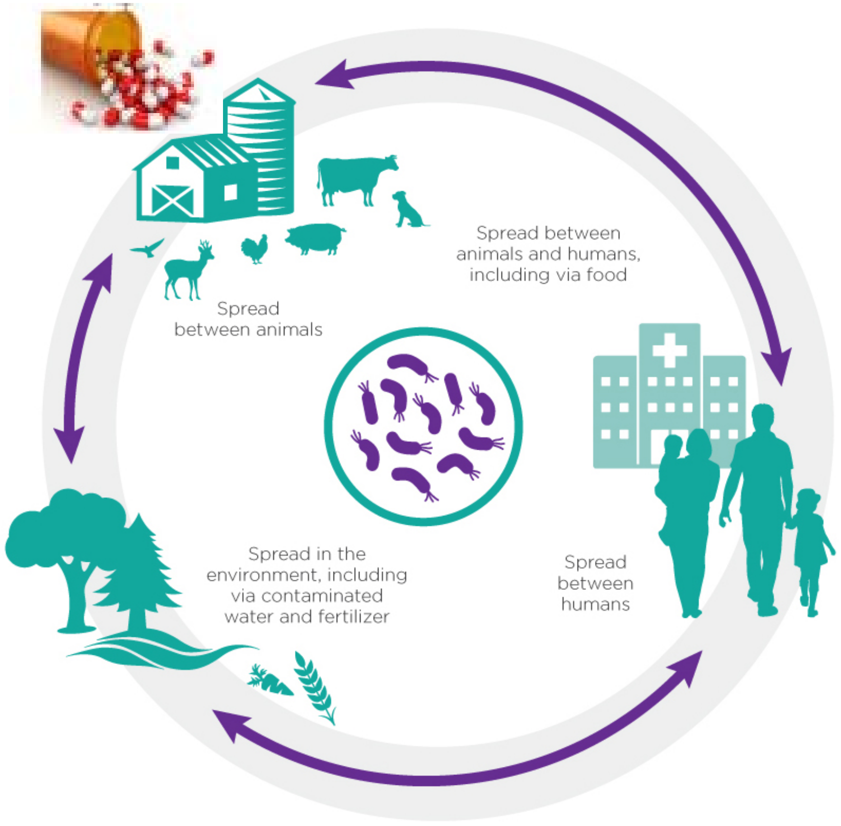
Braden T. Wong,[†] Sangwoo Park,[†,1] Lauren Kovanda,[†] Yijie He,[†] Kwangwook Kim,[†] Shiyu Xu,[†] Christopher Lingga,[†] Monika Hejna,[†,‡] Emma Wall,[||,2] Ravichandran Sripathy,[||] Xunde Li,[§] and Yanhong Liu[†,3]





Antibiotics and pharmacological dose ZnO

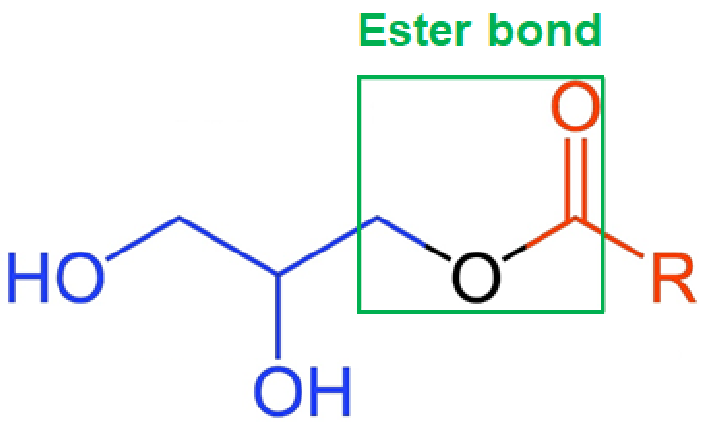
- Prevent and treat PWD
  - **Antimicrobial effects**
  - ⬆ **Nutrients availability**



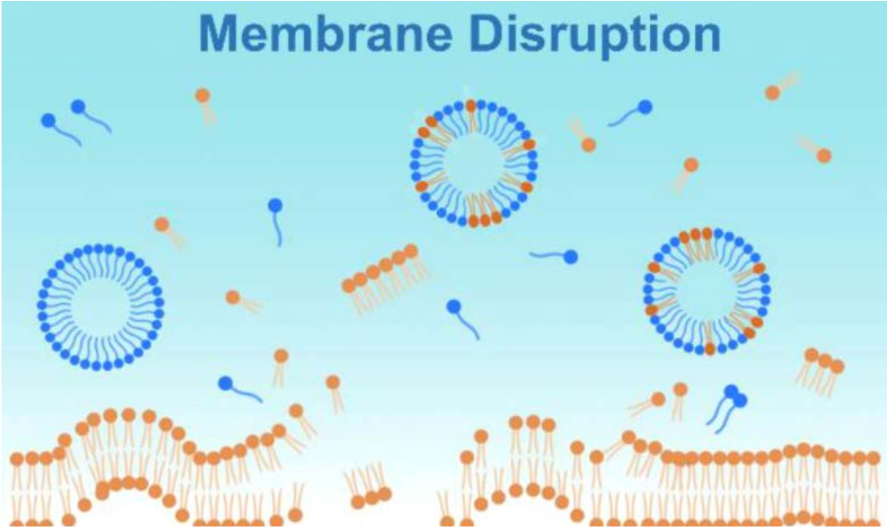
- Public health risk and concern
  - **Antimicrobial resistance**
  - **Environmental** transmission
    - Prohibition of AGPs (Jan 2017, FDA)
    - Prohibition of pharmacological dose ZnO (June 2022, EU)

Public Health Agency of Canada, 2017

Monoglycerides (MGs)



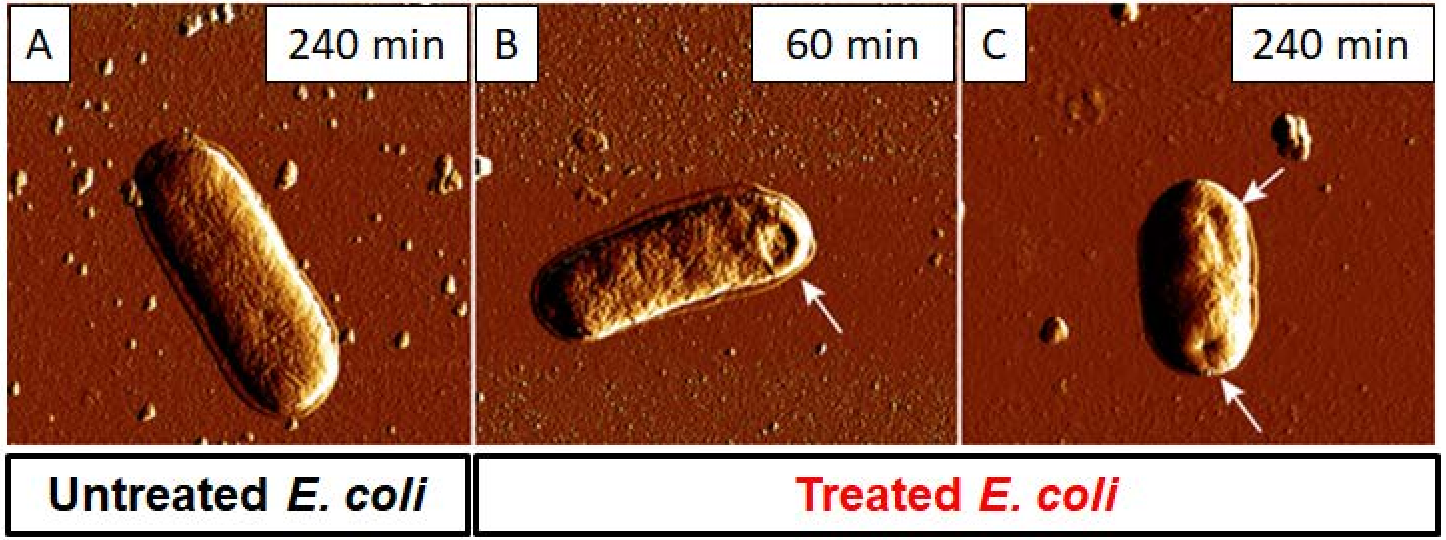
- **Glycerol** linked to **fatty acid** (esterification)
  - Short chain and medium chain fatty acids
- Natural compound
  - Used in food processing and production
- Amphiphilic nature
  - Hydrophobic & hydrophilic
  - **Antimicrobial activity**

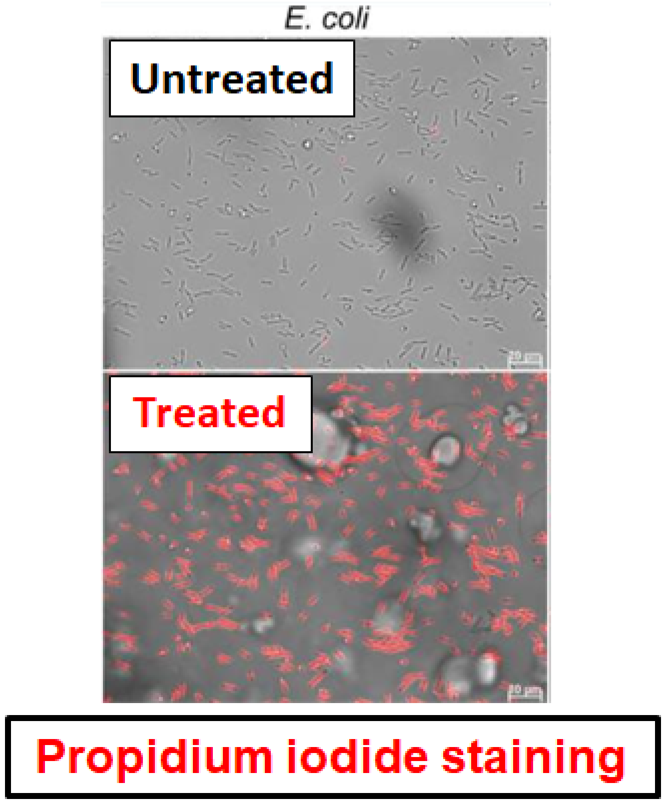


Jackman et al., 2022

Antimicrobial effects of MGs (*in vitro*)

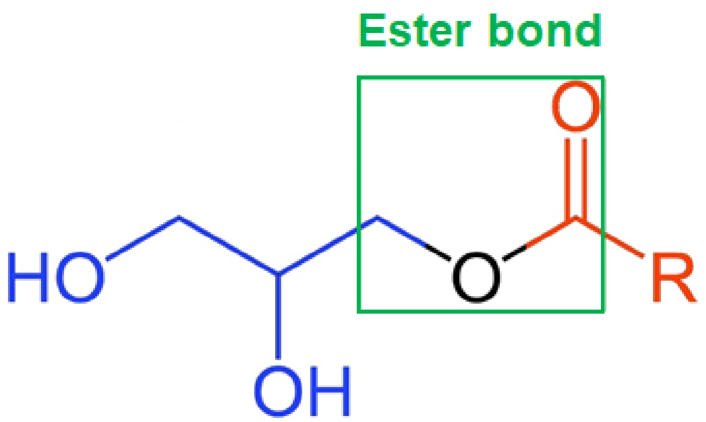
❖ Incorporate into the lipid membrane of microorganisms and **change the permeability**





Hyldgaard et al., 2012; Joshua et al., 2020

Additional benefits of MGs



- Strong covalent bond

	Organic acid	Monoglycerides
Antimicrobial	✓	✓
Non-corrosive	-	✓
Non-volatile	-	✓
Heat stable	-	✓
Neutral taste odor	-	✓
pH-independent	-	✓

- **Easy to handle and use**

FRAmelco, 2017

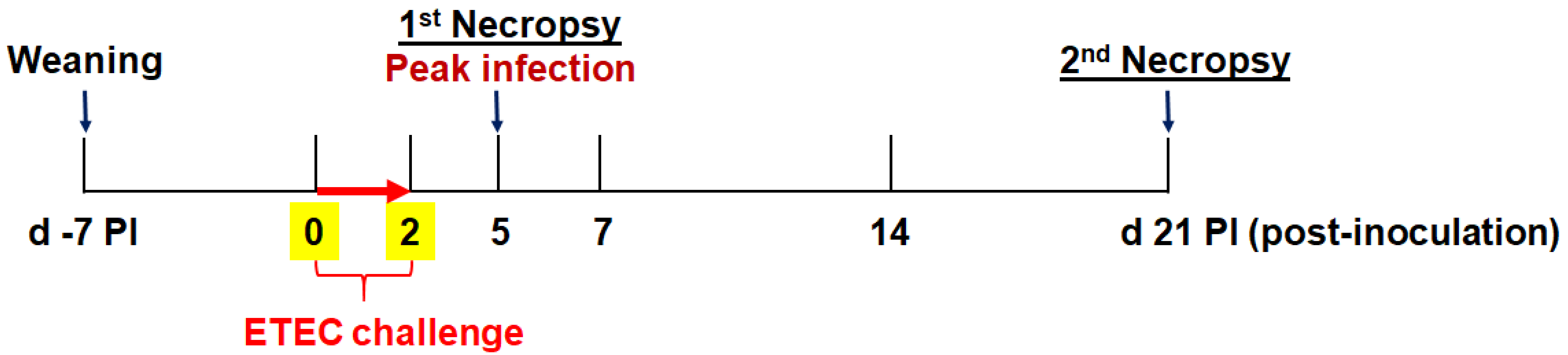
Objective

- Effects of **a mixture of monoglycerides** on weaned pigs experimentally infected with a pathogenic *Escherichia coli* (*E. coli*) F18
  - ✓ **Growth performance**
  - ✓ **Diarrhea**
  - ✓ **Intestinal health**
  - ✓ **Immune responses**

Animals & experimental design

- ❖ Animals
  - ➢ 60 weaned pigs (initial BW = 6.5 ± 0.74 kg; 21 d old)
    - ✓ Individual house (15 replications/treatment)
- ❖ 4 dietary treatments
  - ➢ Corn-soybean meal-based diet (**Control**)
  - ➢ Control + **0.3% monoglycerides**
  - ➢ Control + **3000 ppm zinc oxide (ZnO)**
  - ➢ Control + **50 mg/kg of antibiotic (carbadox)**
- ❖ 2-phase feeding (2 weeks/phase; overall 4 weeks)

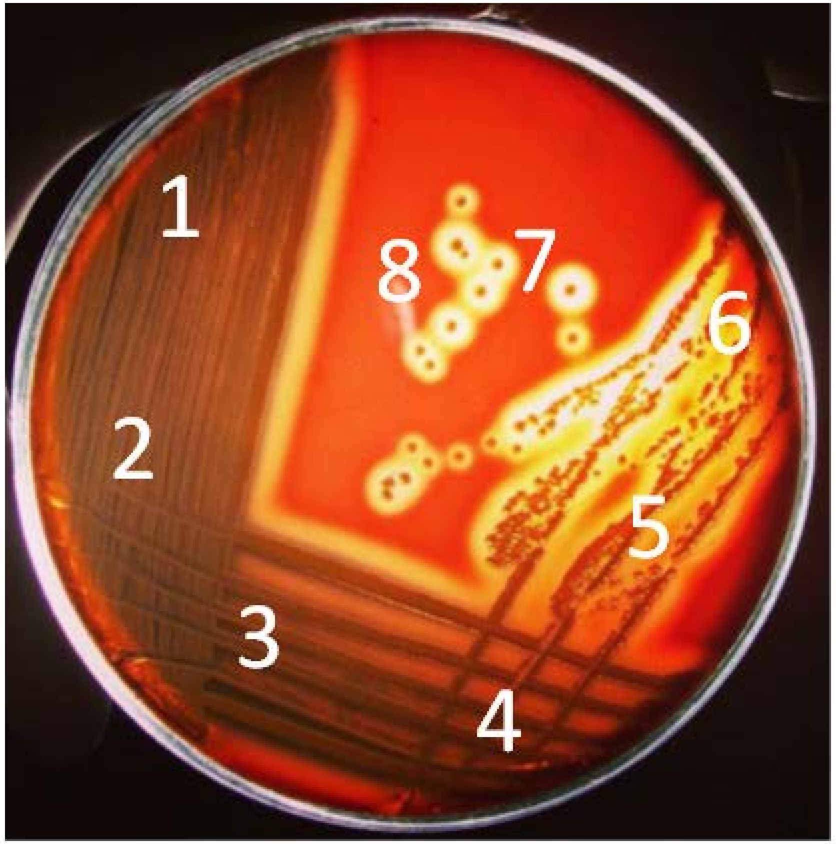
Timeline and data collection (I)



➢ All pigs were orally inoculated with pathogenic *E. coli* F18 (10^{10} CFU/dose)

- **Daily fecal scores**
  - Score 1 to 5 = firm feces to watery diarrhea
- Percentage of **β-hemolytic coliforms** in feces
- **Growth performance** (ADG, ADFI, and G:F)

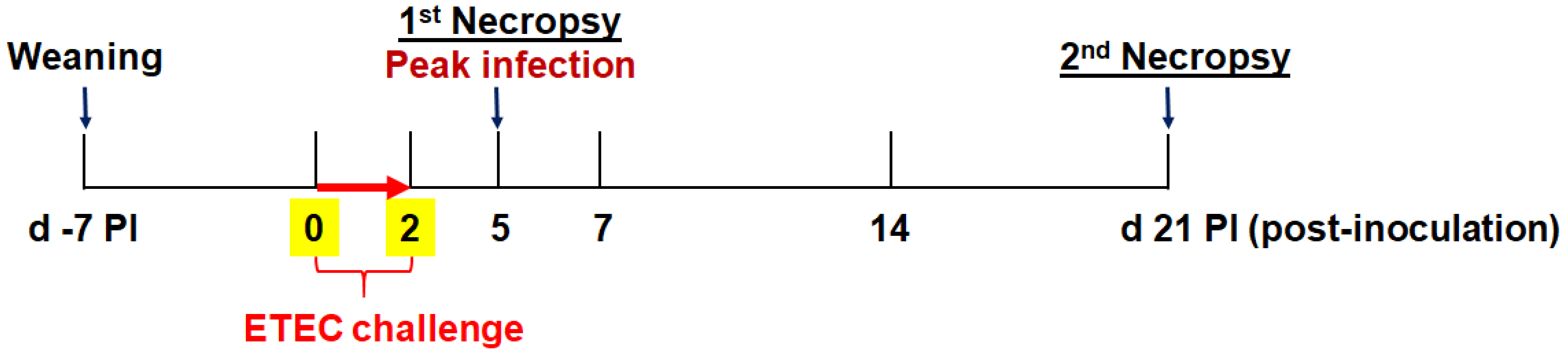
β-hemolytic coliforms
(feces)



Columbia blood agar
(β-hemolytic coliforms)

MacConkey agar
(Lactose-fermenting bacteria)

Timeline and data collection (II)



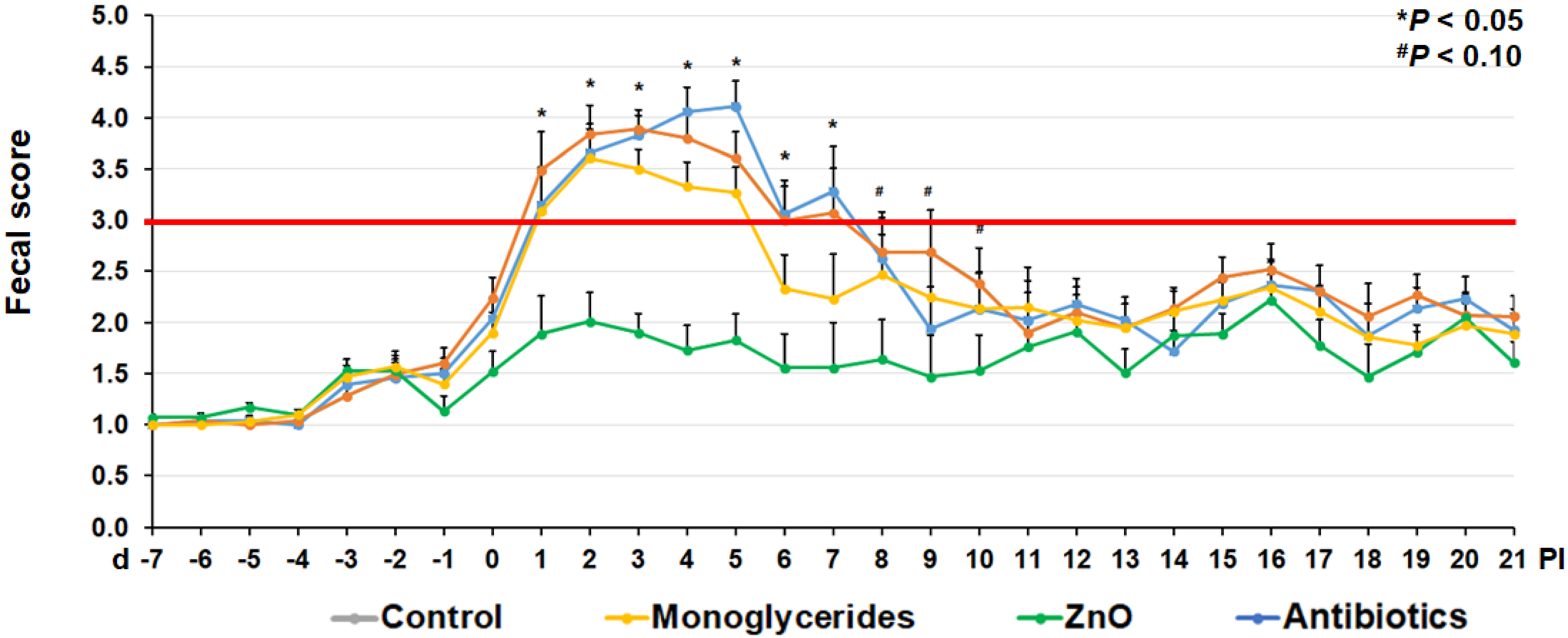
- All pigs were orally inoculated with pathogenic *E. coli* F18 (10^{10} CFU/dose)

- Serum **acute phase protein level** (d 0, 2, 5, and 21 PI)
  - C-reactive protein and haptoglobin
- Intestinal **morphology** and **immune-related gene expression**
  - d 5 PI (6 pigs/treatment) and d 21 PI (9 pigs/treatment)

Statistical analysis

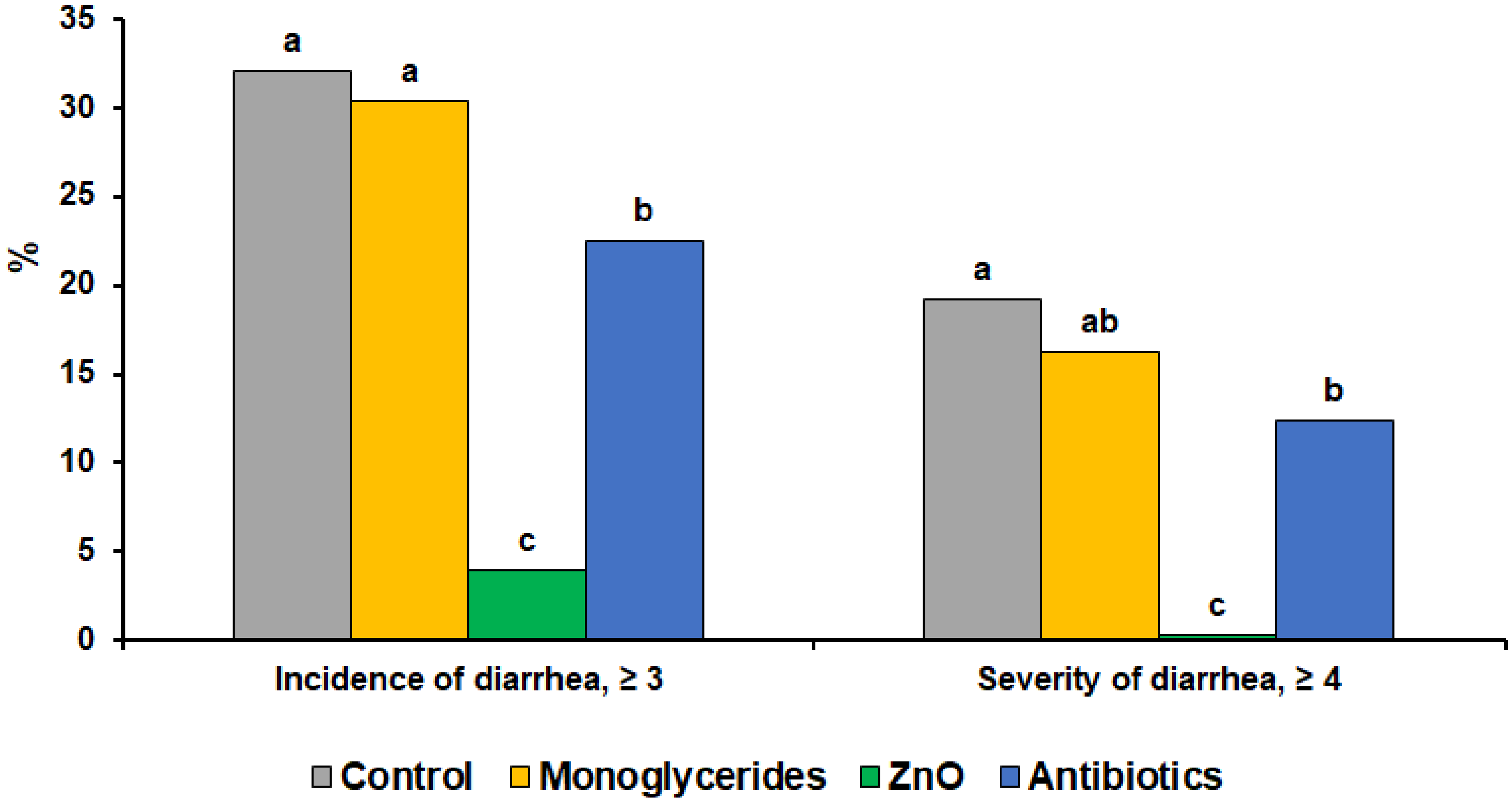
- PROC MIXED of SAS
  - Randomized complete block design (block: BW)
  - Experimental unit: pig
  - Fixed effect: dietary treatment
- Chi-square test
  - Frequency of diarrhea

Daily fecal score

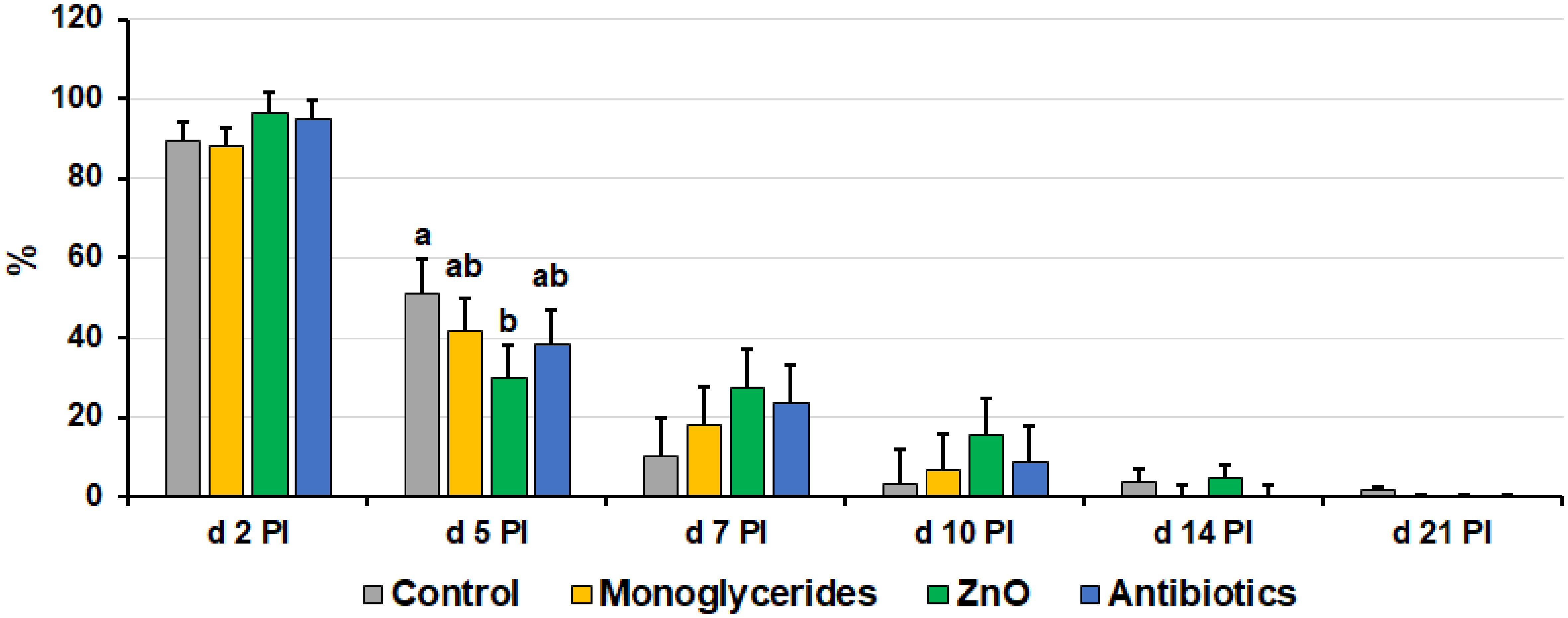


*Fecal score = 1, firm feces; 2, moist feces; 3, mild diarrhea; 4, severe diarrhea; 5, watery diarrhea

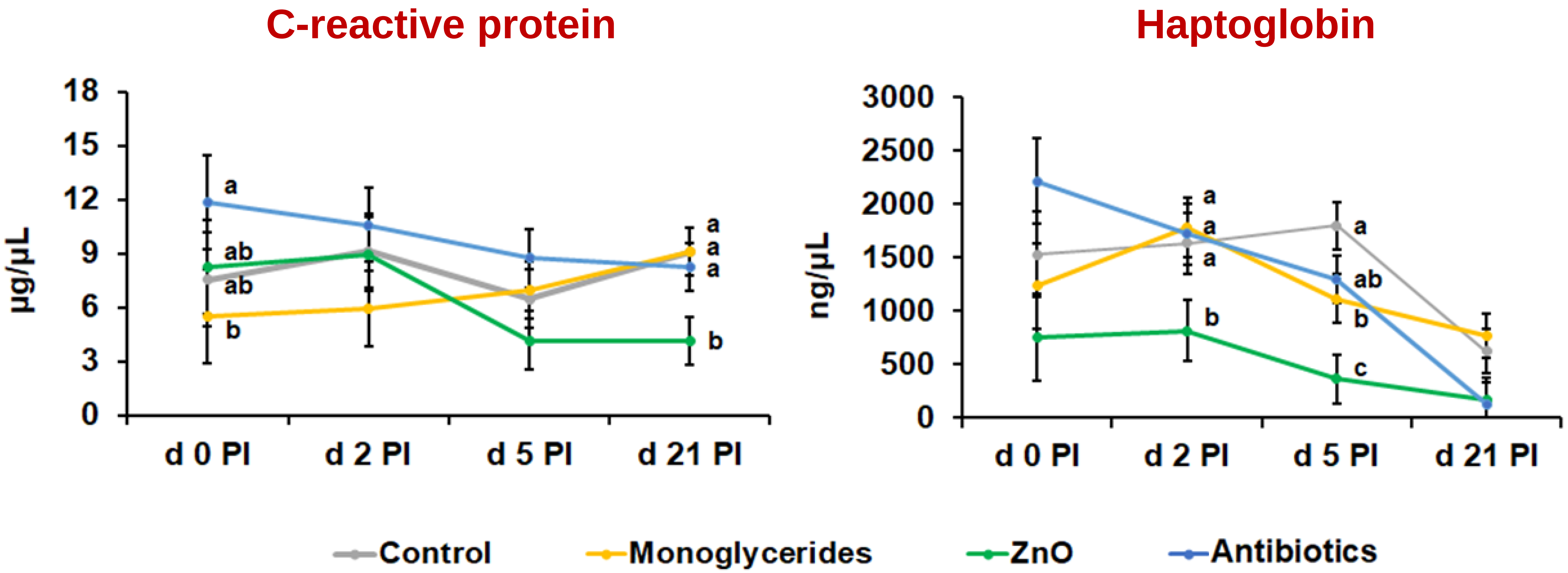
Frequency of diarrhea (overall)



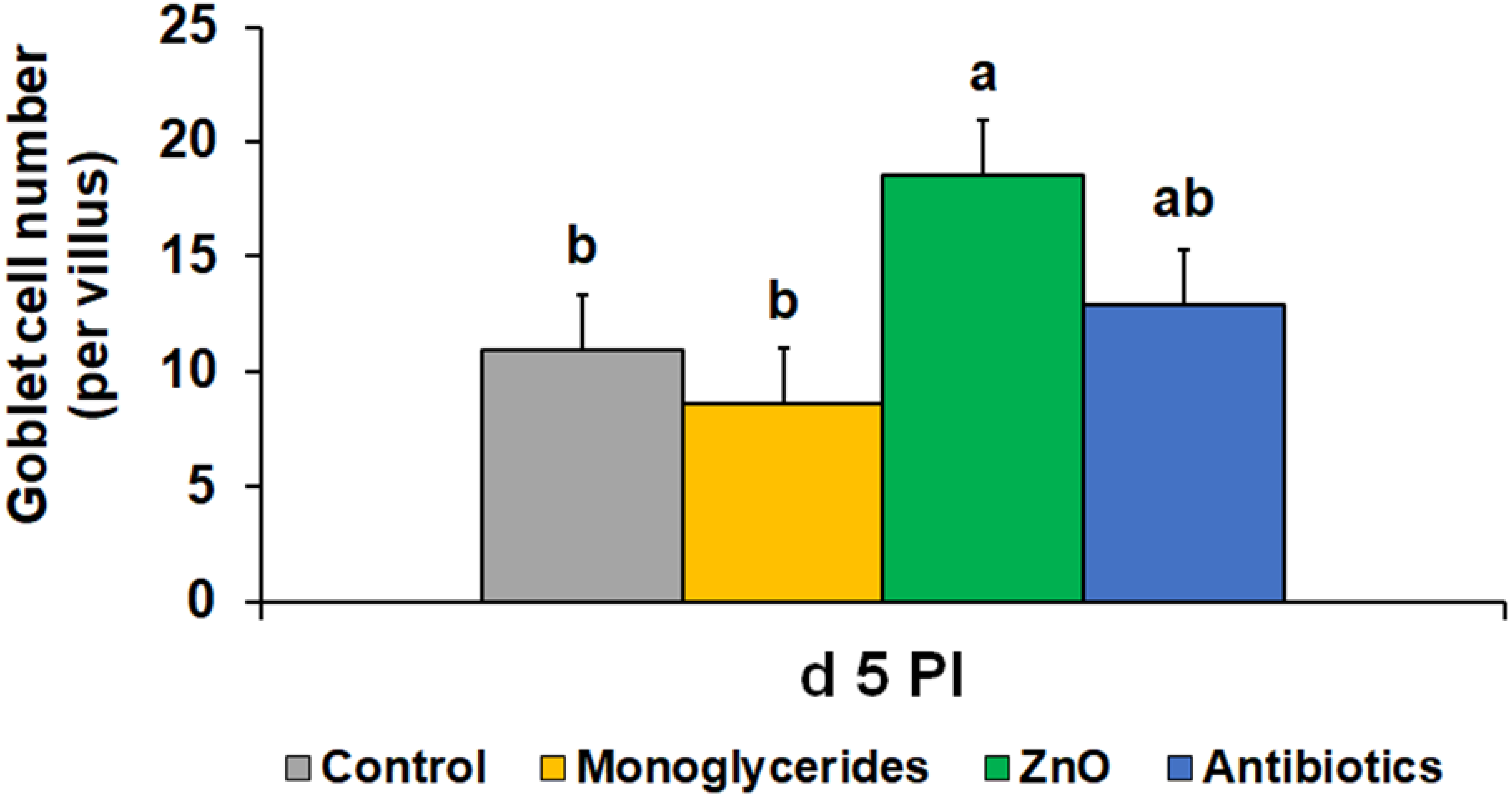
β-hemolytic coliforms (feces)



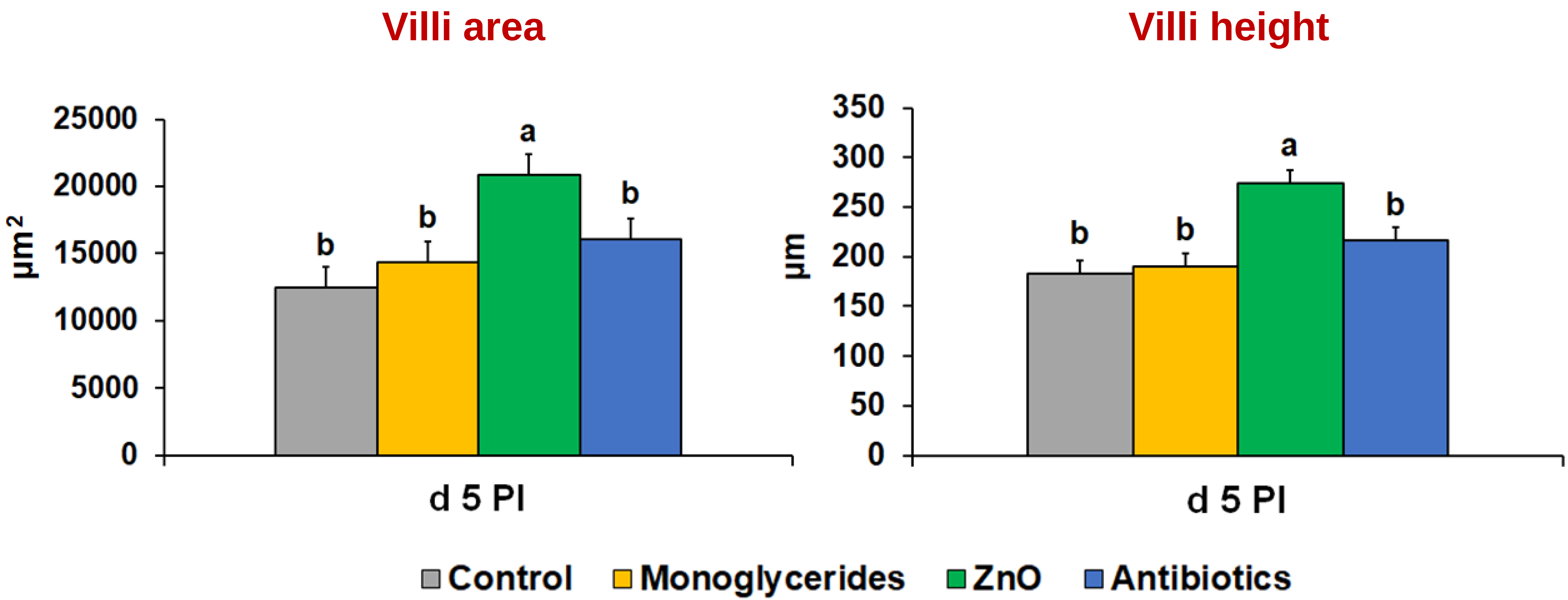
Acute phase proteins (serum)



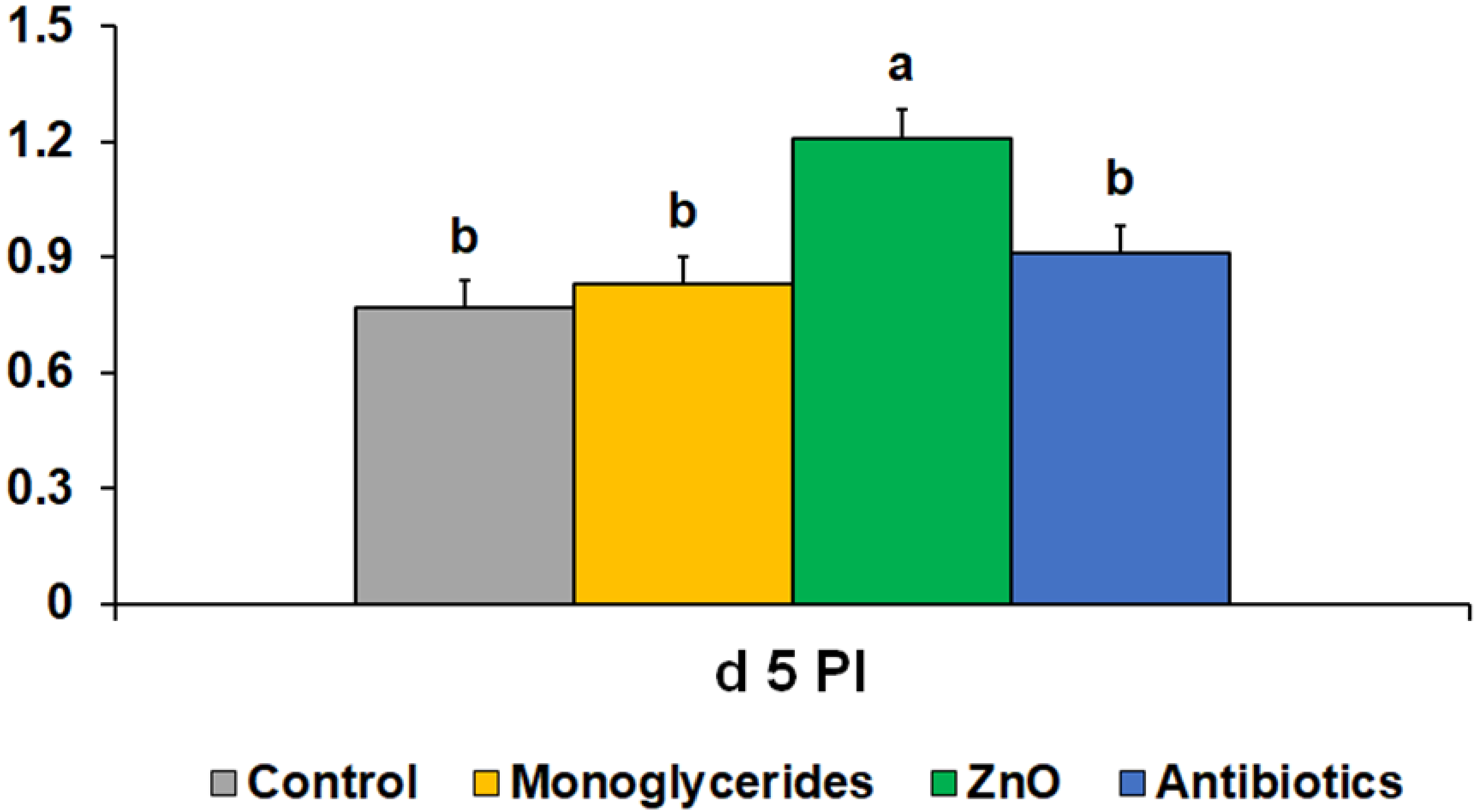
Duodenum goblet cell number



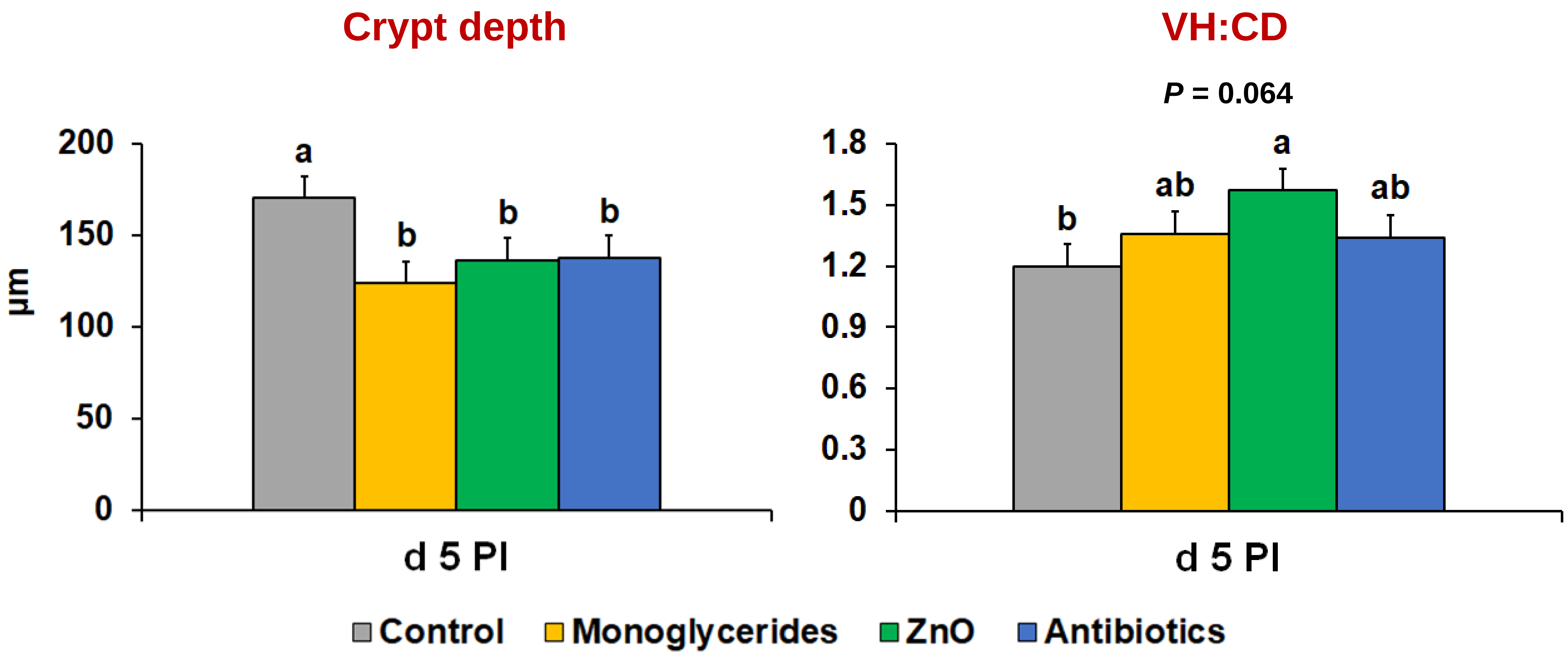
Duodenum villi area and height



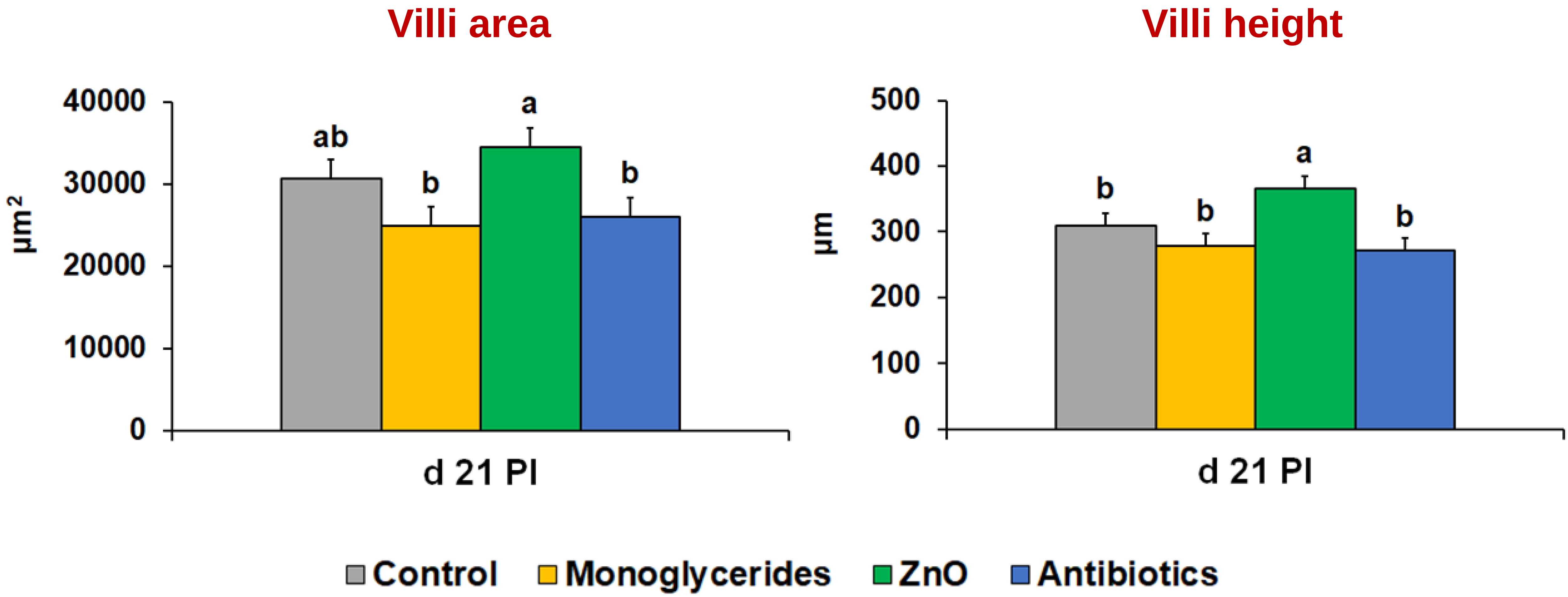
Duodenum VH:CD



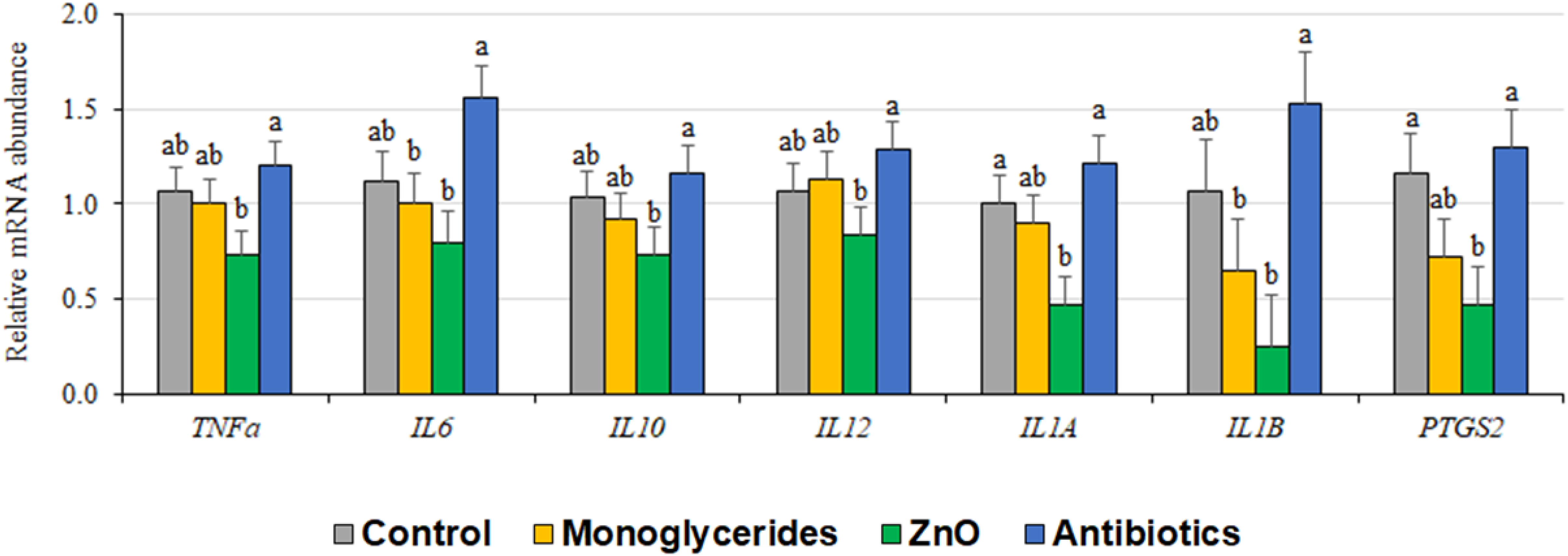
Ileum CD & VH:CD



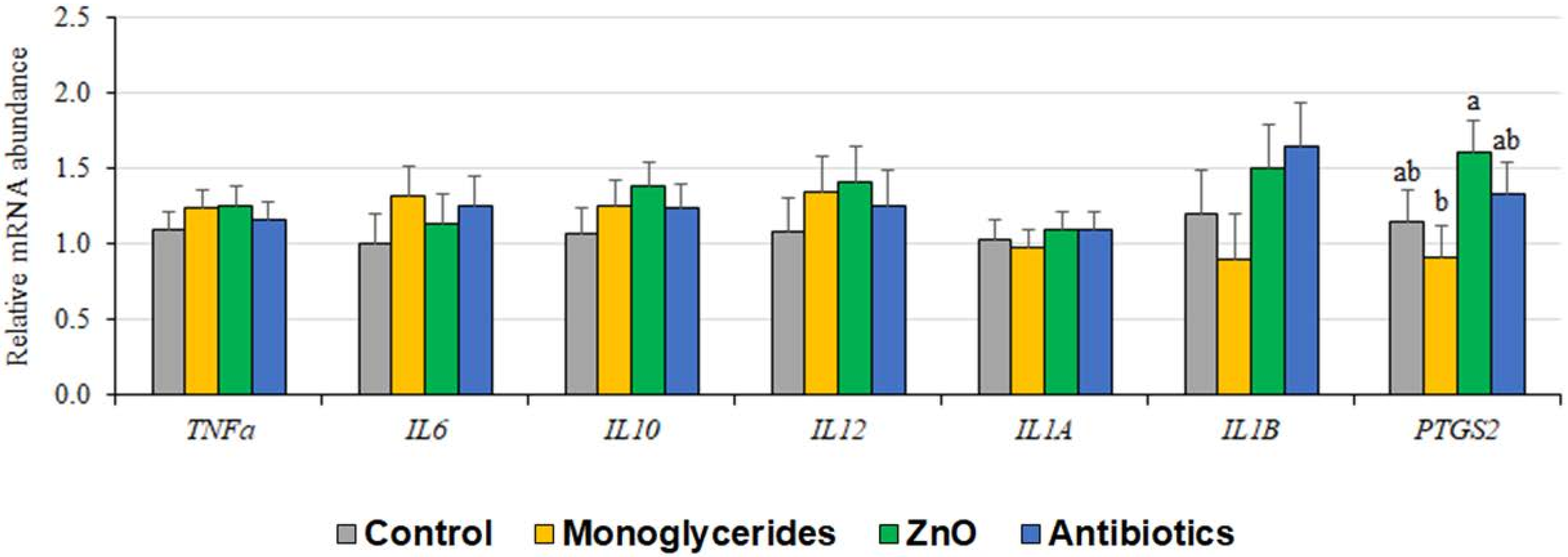
Duodenum villi area and height (d 21 PI)



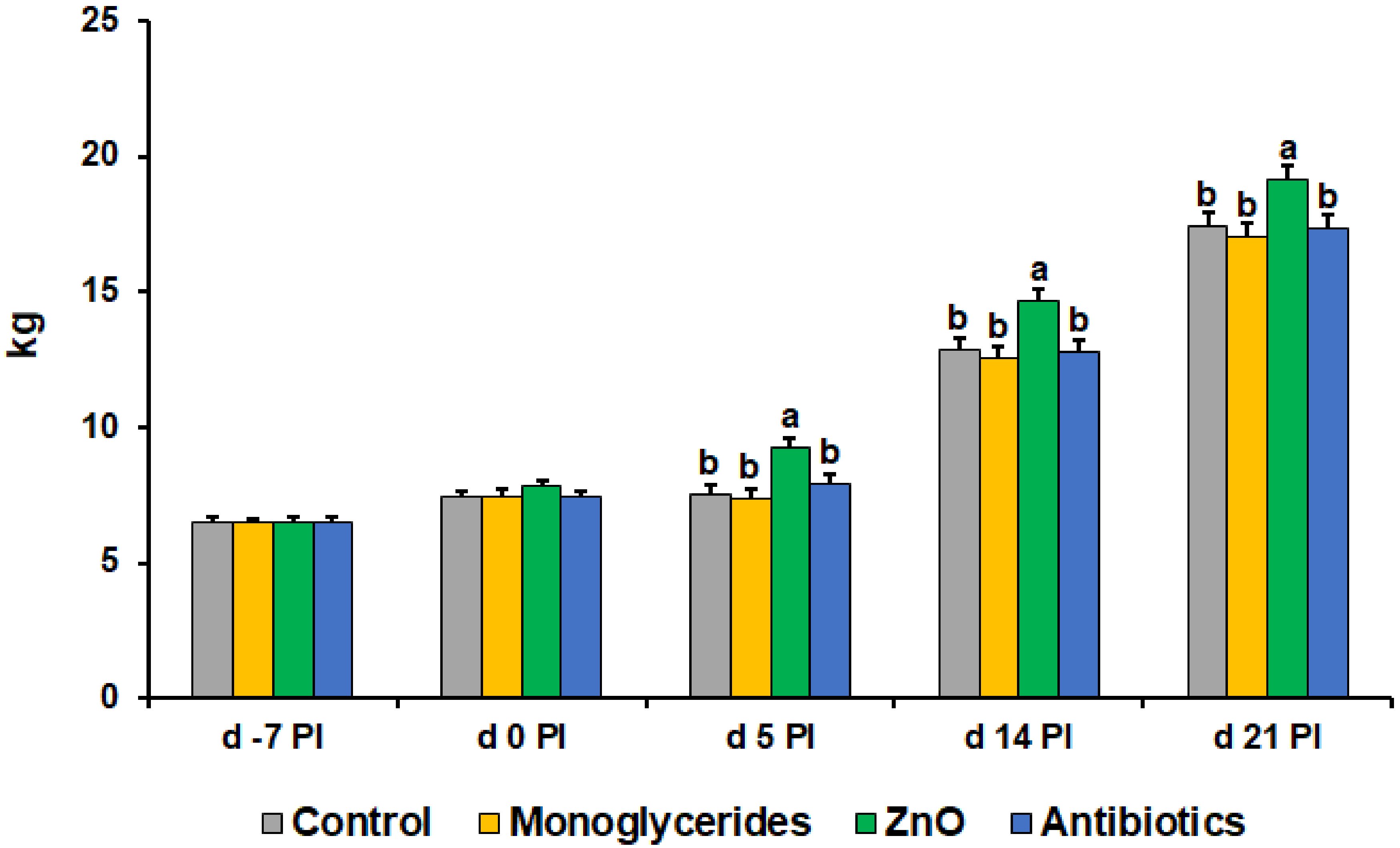
Ileum mucosa gene expression (d 5 PI)



Ileum mucosa gene expression (d 21 PI)

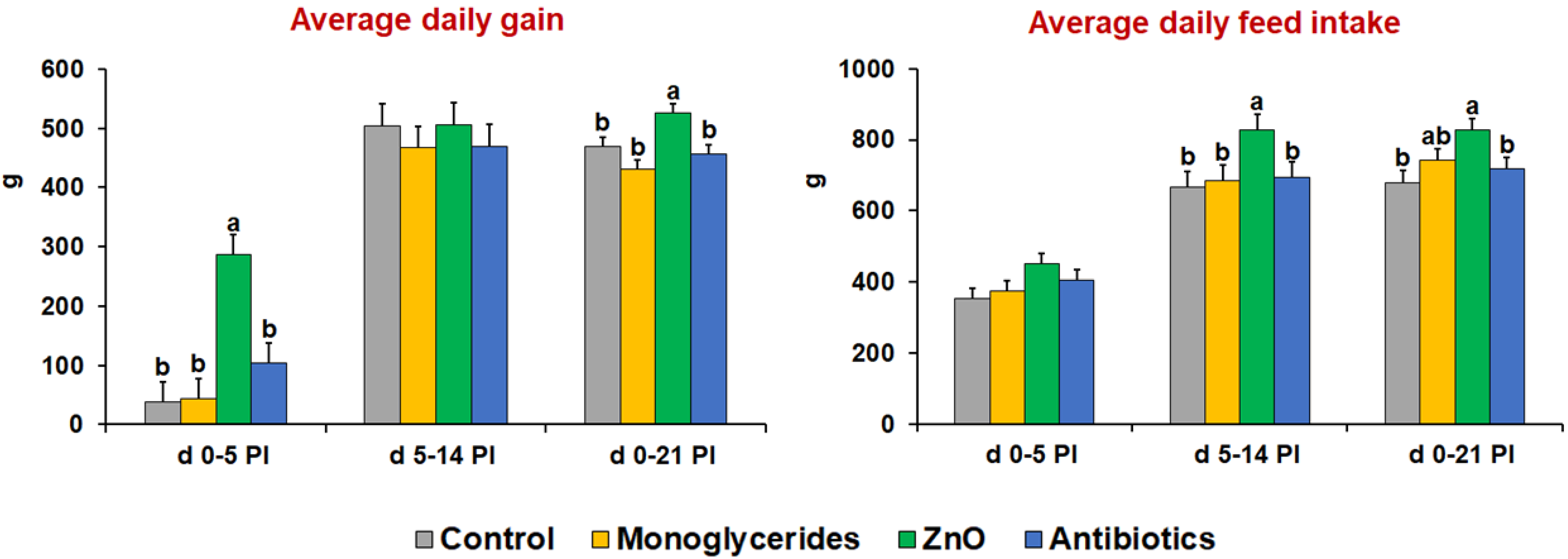


Body weight



25
20
15
10
5
0
kg
a
b b b
a
b b b
a
b b b
d -7 PI
d 0 PI
d 5 PI
d 14 PI
d 21 PI
Control
Monoglycerides
ZnO
Antibiotics

Growth performance



Conclusions

- **Monoglycerides** supplementation
  - Reduce the diarrhea severity
  - Have a positive effect on the intestinal morphology
  - Modify the intestinal and systemic inflammation

of weaned pigs infected with ETEC F18

Acknowledgements

- ❖ Comparative Animal Nutrition & Physiology Laboratory

- ❖ BASF Corporation

https://animalnutr-ansci.faculty.ucdavis.edu/

Greatly appreciate your attention!

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