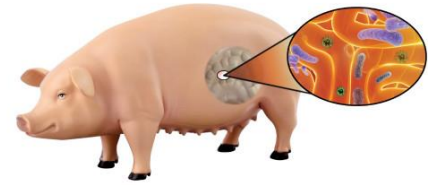


# Faecal microbiota transplantation in pregnant sows alters the growth and intestinal bacterial profile of pigs

U.M. McCormack, T. Curião, T. Wilkinson, B.U. Metzler-Zebeli, H. Reyer, J.A. Calderon-Diaz, T. Ryan, F. Crispie, P.D. Cotter, C.J. Creevey, GE. Gardiner, and P.G. Lawlor



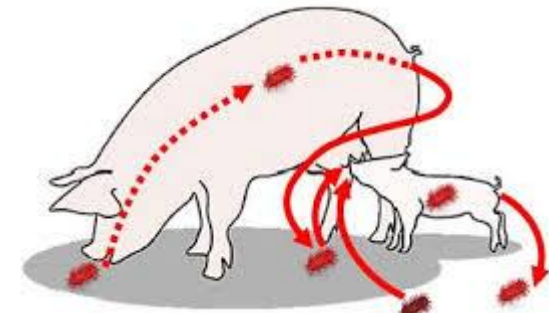
# Background



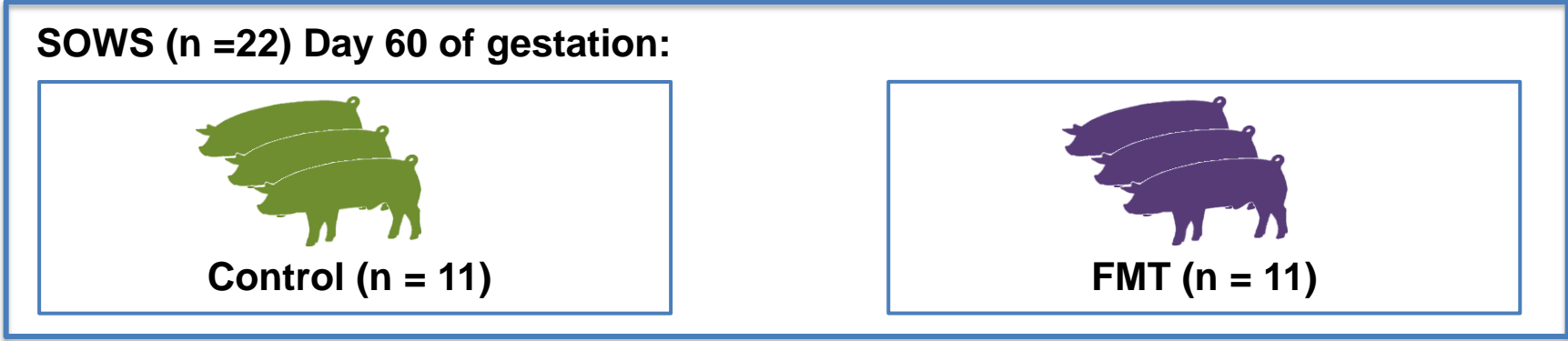
- Link between intestinal microbiota and feed efficiency (FE) in pigs
- Strategies to manipulate microbiota to improve FE?
  - Probiotics? Prebiotics?
  - Faecal microbiota transplantation (FMT)?
- Transfer of donor microbiota to recipient to establish more desirable microbiome
- Treatment of gastrointestinal disease in humans – mainly recurrent *C. difficile* (van Nood et al., 2013)
- Only one study on pig-to-pig microbiota transfer (Martin et al., 2015)
  - Prevented necrotising enterocolitis in neonatal preterm piglet model
  - BUT increased neonatal mortality

# Objective

- To determine if FMT from highly feed efficient donor pigs to pregnant sows can influence FE in offspring
- Donor faeces - 4 most feed efficient of 409 finisher pigs
- Greatest potential to influence intestinal microbiota early in life
- Maternal influence?
- Probiotics administered to sows:
  - Transferred to offspring (Buddington et al., 2010)
  - Modify offspring intestinal microbiota (Baker et al., 2014)
  - Improve offspring growth performance (Alexopoulos et al., 2000; Michiels et al., 2016; Taras et al., 2005; 2007)

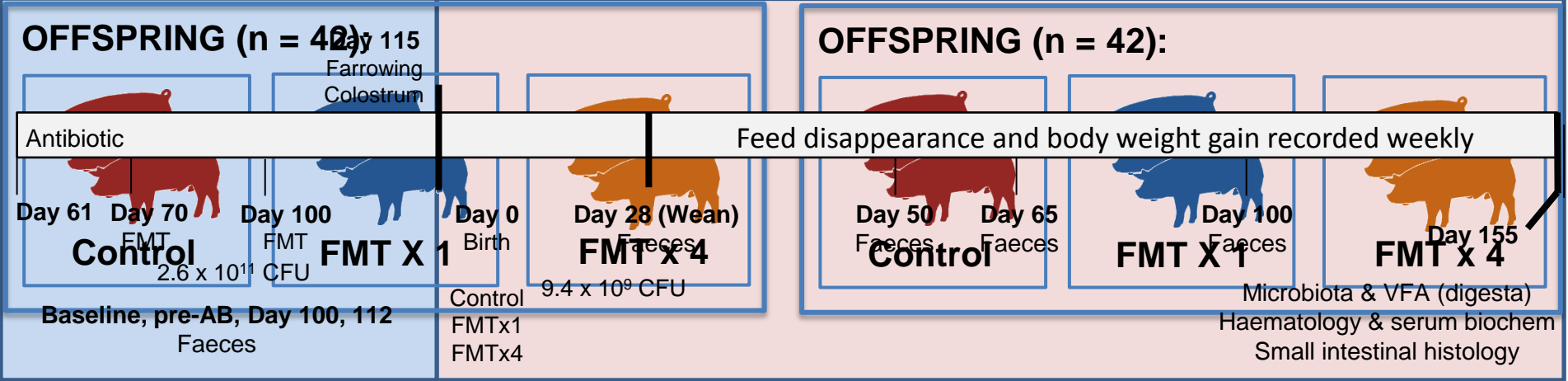


# Study design



**Sows – gestation** ↓

**Offspring subset (n = 36)** ↓

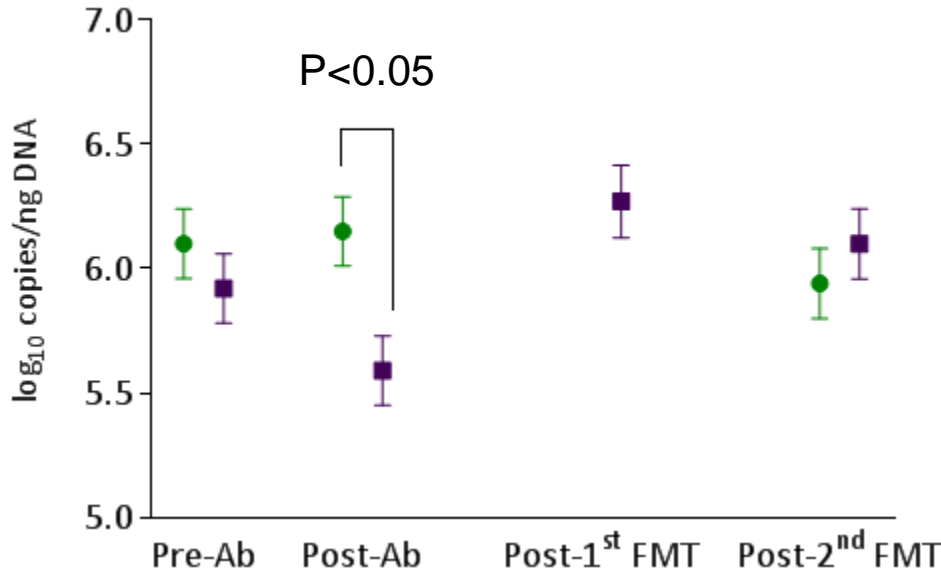


# Offspring growth performance

Parameter	Sow trt			
	Control	FMT	S.E.M	P
Weaning weight (Kg)	8.3	7.3	1.13	0.52
<b>Slaughter weight (Kg)</b>	<b>121.6</b>	<b>113.5</b>	<b>1.31</b>	<b>&lt;0.001</b>
<b>Carcass weight (Kg)</b>	<b>92.9</b>	<b>88.7</b>	<b>1.64</b>	<b>0.07</b>
ADFI (g/day)	1896	1830	38.6	0.25
ADG (g/day)	893	875	17.5	0.53
FCE (g/g)	2.06	2.05	0.037	0.72
RFI (g/day)	5.2	-6.4	12.35	0.51

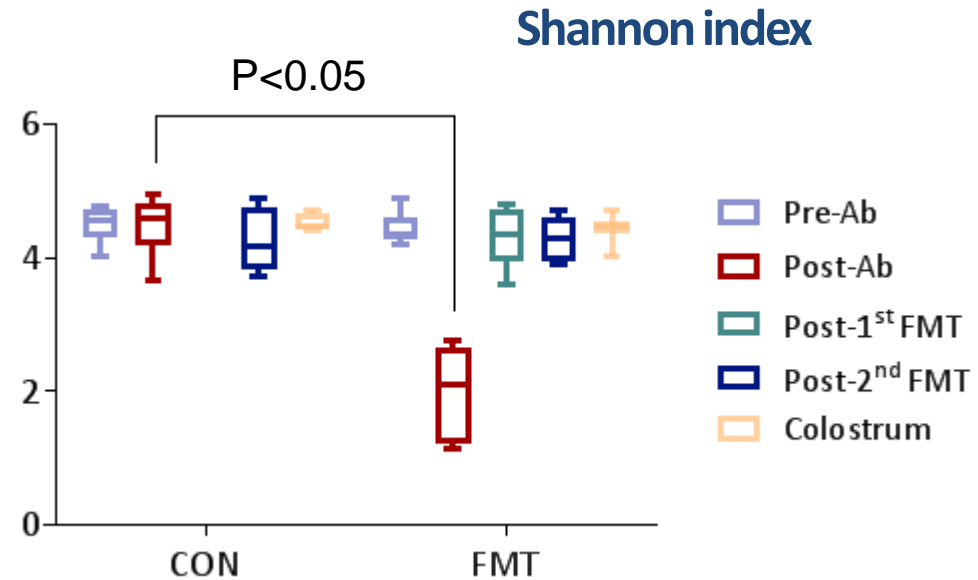
- Between weaning and slaughter (~155 days old):
  - FMT ↓ slaughter weight
  - FMT tended ↓ carcass weight

# Sow faecal bacterial load & diversity



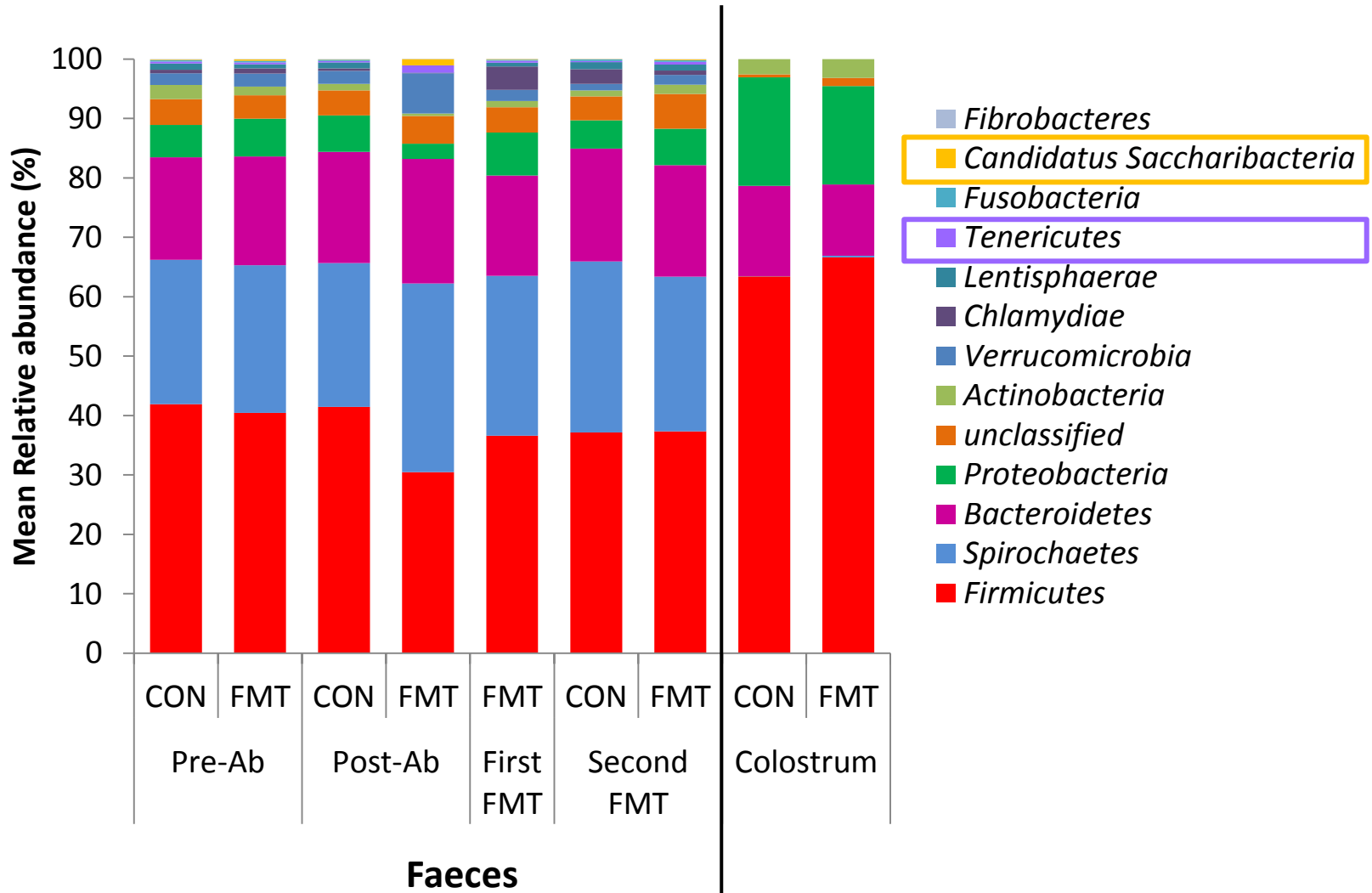
- Antibiotic ↓ bacterial load
- No effect of FMT

- Antibiotic ↓ bacterial diversity
- No effect of FMT



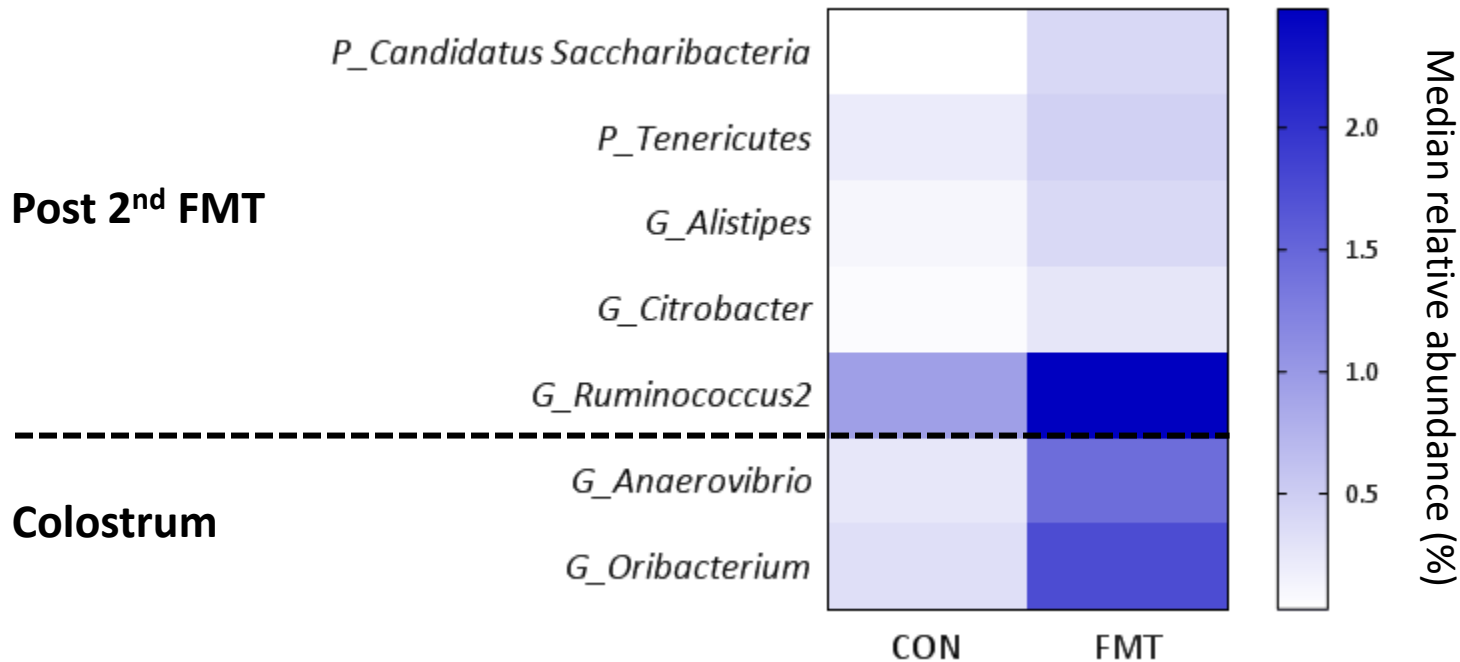
- FMT allowed recovery of bacterial load & diversity lost due to antibiotic

# Sow bacterial phyla



- Baseline: No phylum-level differences
- Post-antibiotic: 6 phyla & 22 genera affected
- Differences post 2<sup>nd</sup> FMT

# Sow bacterial phyla & genera



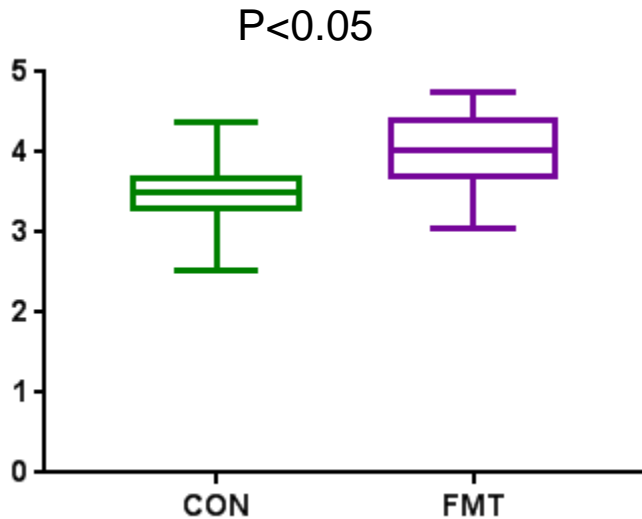
- *Alistipes* FE-enhancing in chickens (Torok et al., 2011)
- *Oribacterium* butyrate-producing
- *Ruminococcus2* - fermentation of complex carbohydrates
- ↑ *Citrobacter* undesirable? (some species human pathogens)



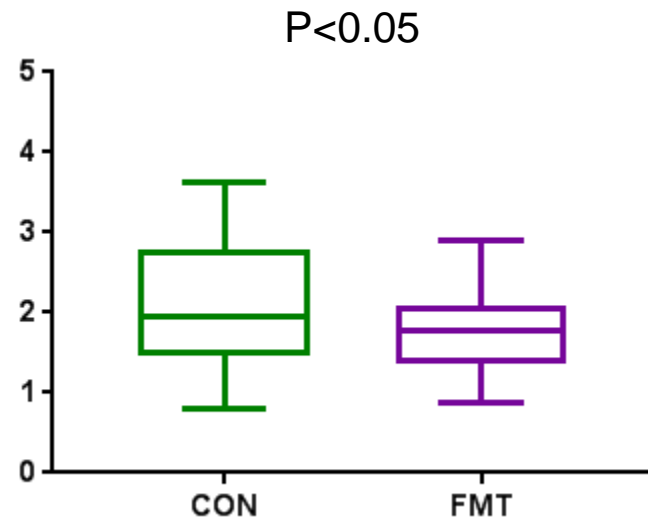
# Offspring bacterial diversity

## Shannon index

Faeces at ~50 days old

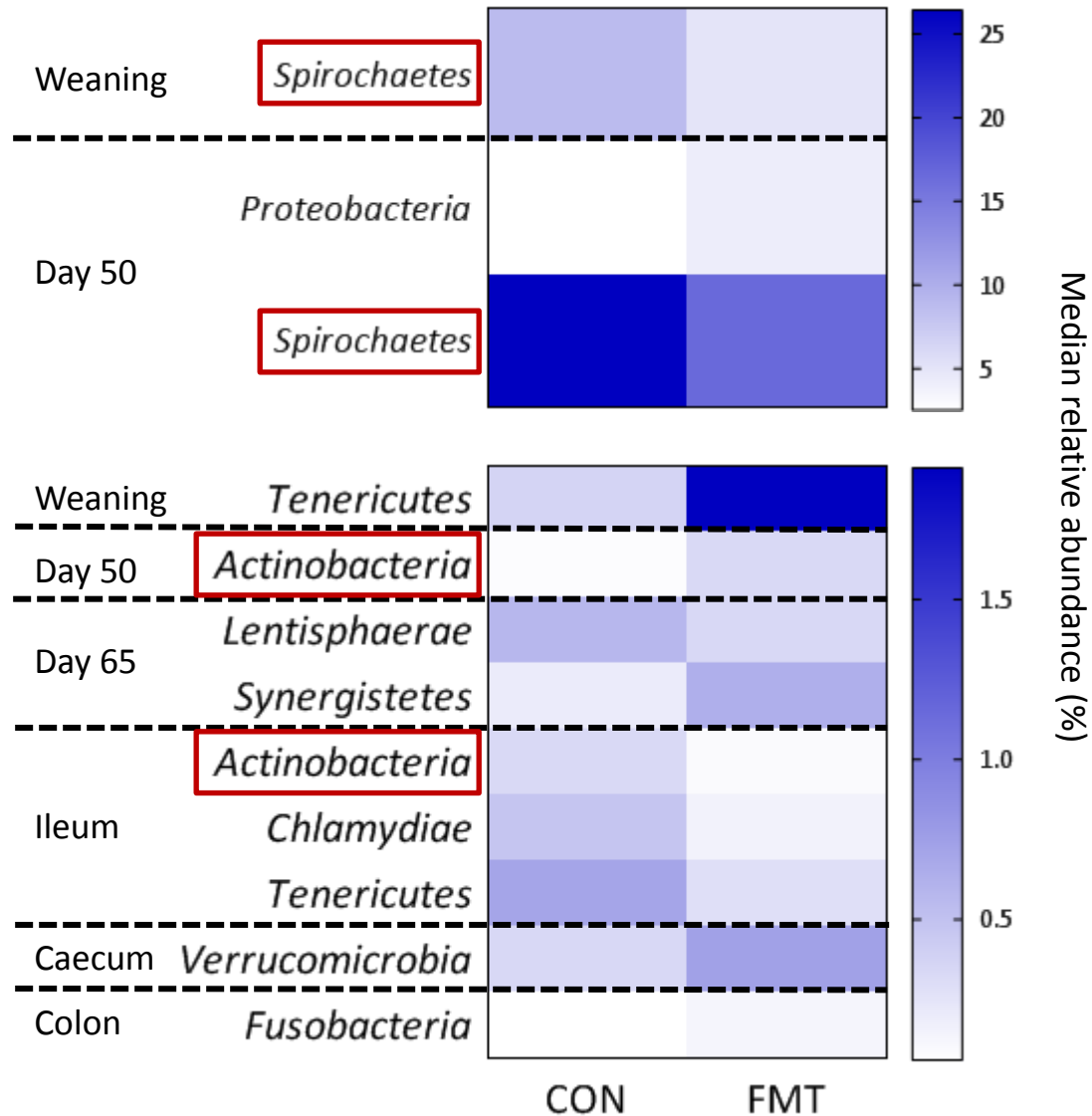


Ileal digesta at ~155 days old



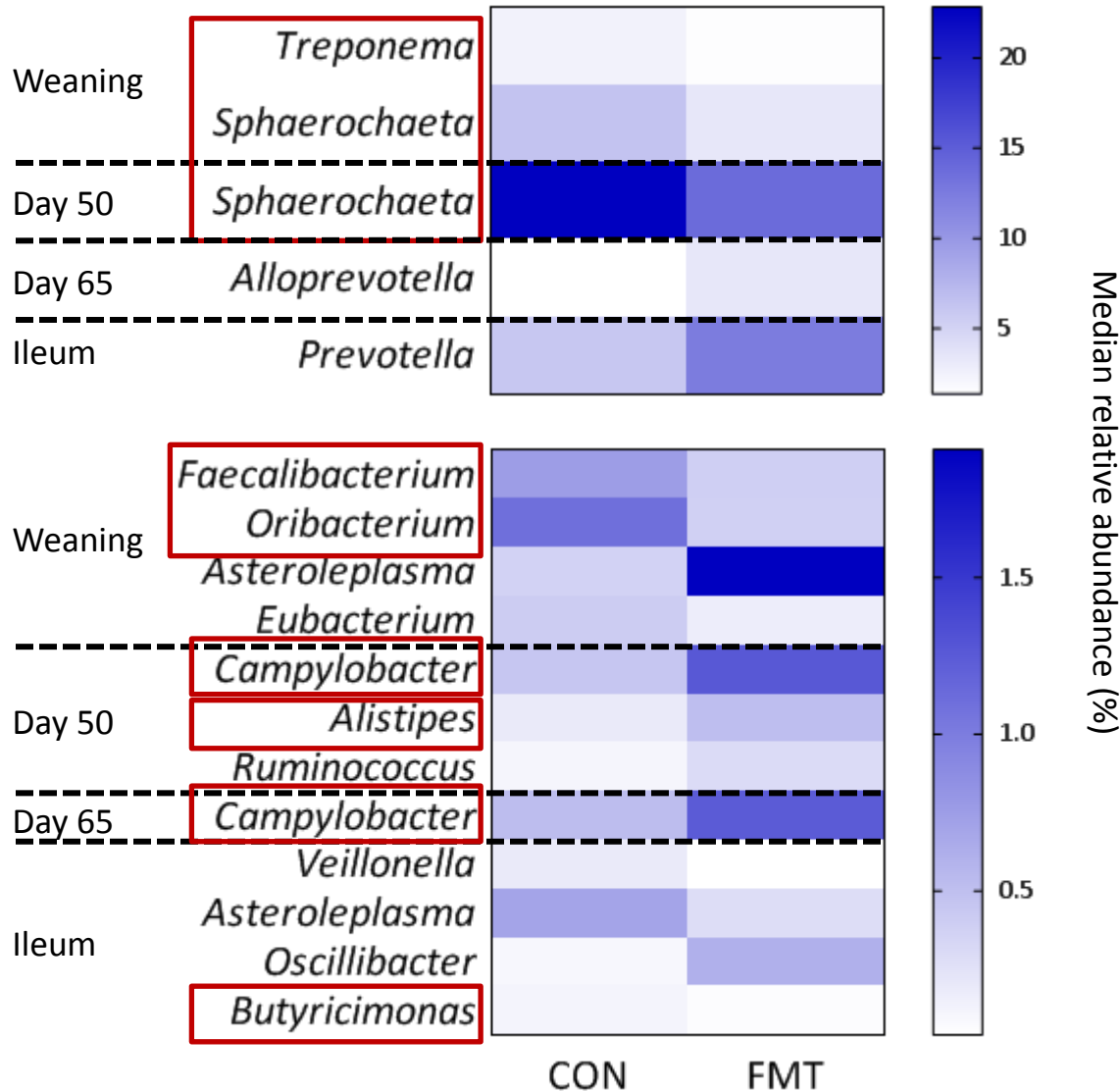
- FMT transiently ↑ faecal diversity
- But ↓ ileal diversity

# Offspring bacterial phyla



P < 0.05

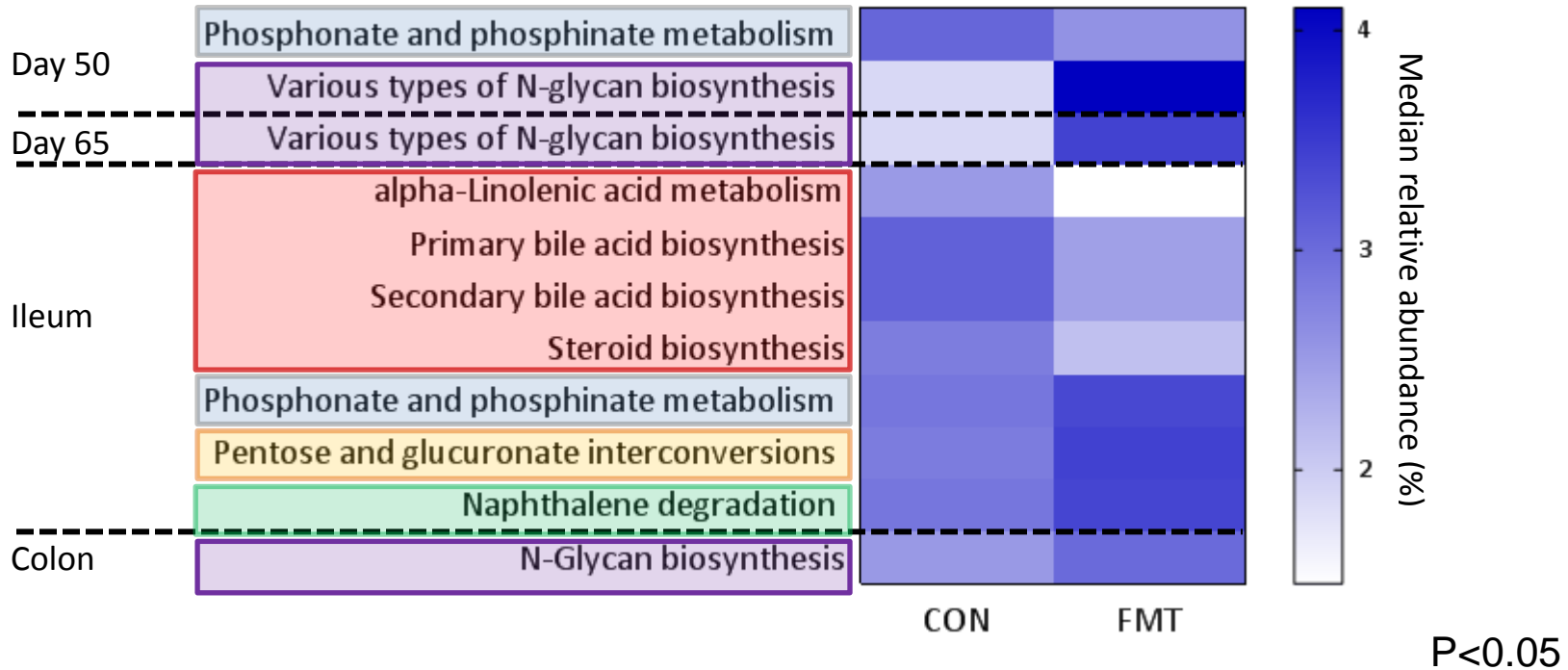
# Offspring bacterial genera



- ↓ *Treponema* - breaks down cellulose
- ↓ *Sphaerochaeta* - carbohydrate fermentation & metabolism
- ↓ *Faecalibacterium*, *Oribacterium*, *Butyricimonas* - butyrate producers (↑ *Oribacterium* in colostrum of FMT sows)
- ↑ *Campylobacter* - some spp. pathogenic to pigs
- ↑ *Alistipes* (↑ in FMT sows - enhanced FE in chickens)

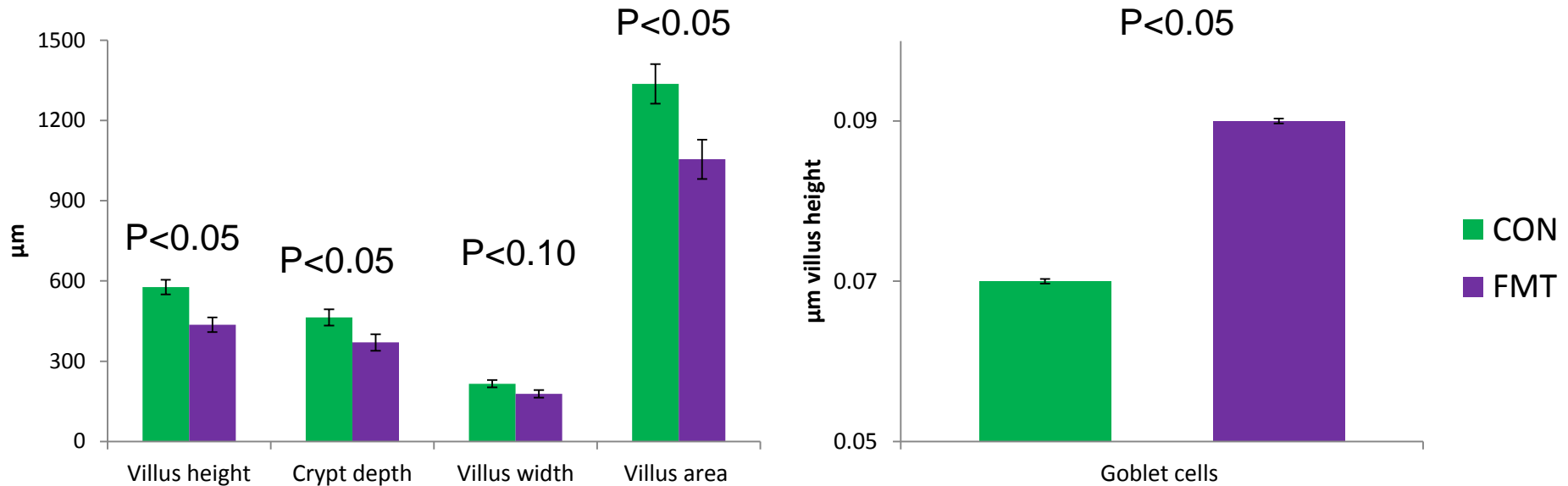
P < 0.05

# Offspring predicted bacterial functionality (PICRUSt)



- ↓ pathways related to lipid metabolism
- ↑ pathways related to N-glycan biosynthesis

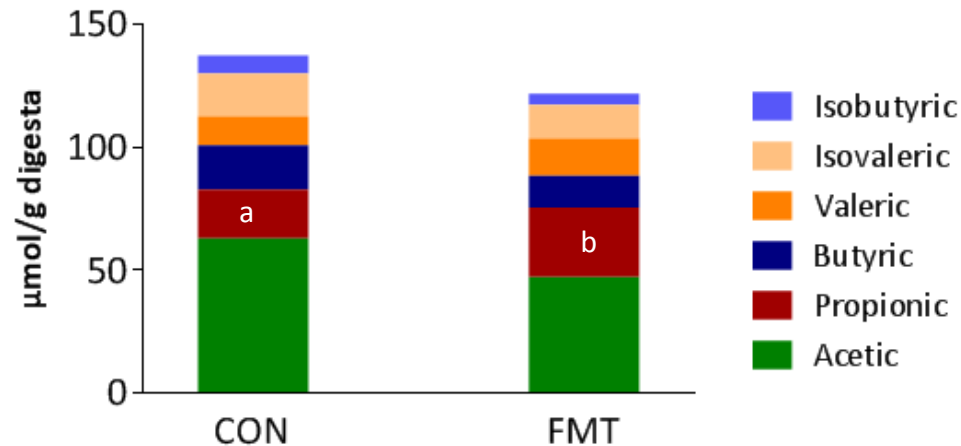
# Offspring ileal histology



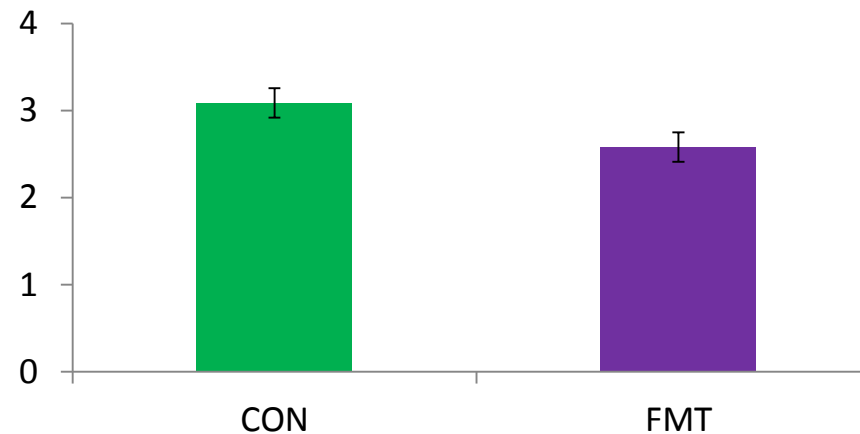
- FMT  $\downarrow$  villus height & area – reduced absorptive capacity?
- FMT  $\uparrow$  goblet cells -  $\uparrow$  mucin? – reduced absorptive capacity?

# Offspring volatile fatty acids & serum metabolites

Ileal digesta



Cholesterol (mmol/L)



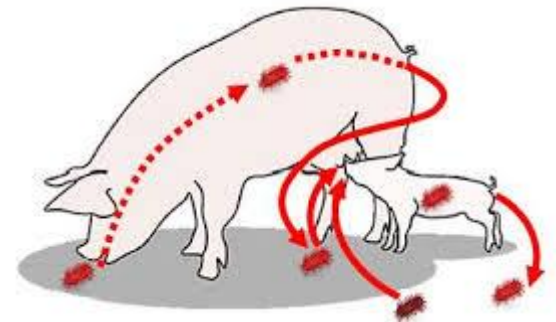
- FMT  $\uparrow$  propionic acid
- No differences in: total protein, blood urea nitrogen, glucose, triglycerides, cholesterol, creatinine, creatine kinase
- FMT  $\downarrow$  serum cholesterol

# Conclusions/Implications for FMT

- Detrimental effects on lifetime growth (↓ slaughter weight)
- FMT modified sow faecal and colostrum microbiota
- Carried over to offspring, but not all changes mirror those in sows
  - e.g. *Oribacterium* ↑ in sows but ↓ in offspring
  - But *Alistipes* ↑ in sow & offspring faeces
  - Transient ↑ faecal microbial diversity; ↓ ileum
  - ↓ beneficial microbes; ↑ potentially pathogenic microbes
  - Predicted functionality impacted
- Negative impact on ileal histology - reduced absorptive capacity?
- Early life intestinal microbiota impacts lifetime pig performance
- In utero? Via colostrum? Direct microbiota transfer from sow?

# Knowledge gaps/future work

- Is there a place for FMT in pig production?
- Optimum donor microbial profile - age of donor/recipient?
- Targeted vs. shotgun approach i.e. probiotics/prebiotics vs FMT?
- Taxa in control pigs - potential biomarkers/probiotics/targets for FE?





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