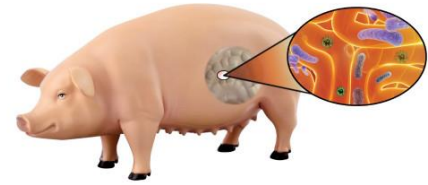


Faecal microbiota transplantation in pregnant sows alters the growth and intestinal bacterial profile of pigs

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



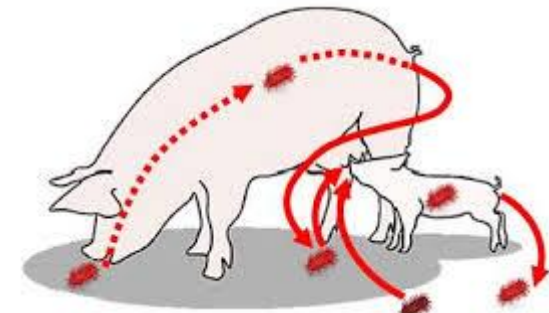
Background



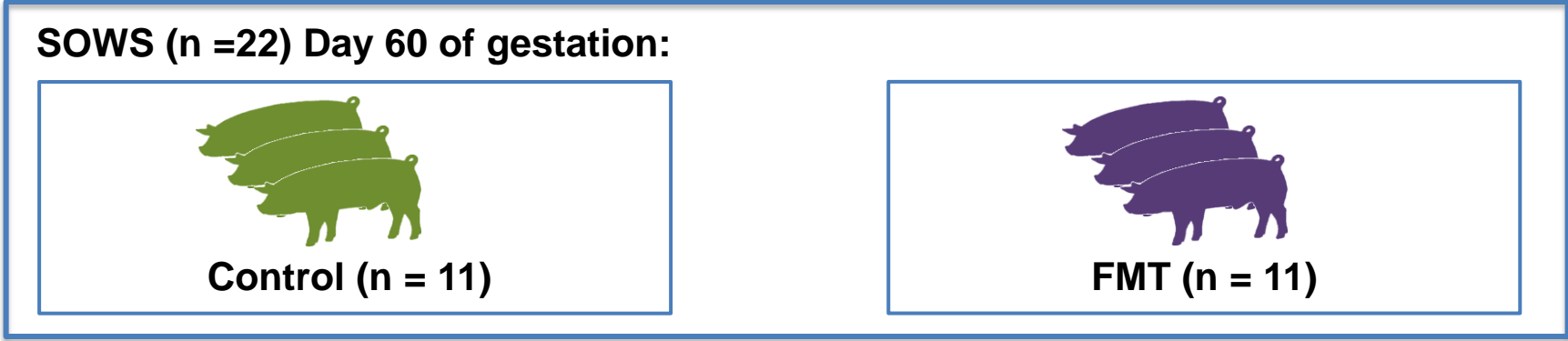
- Link between intestinal microbiota and feed efficiency (FE) in pigs
- Strategies to manipulate microbiota to improve FE?
 - Probiotics? Prebiotics?
 - Faecal microbiota transplantation (FMT)?
- Transfer of donor microbiota to recipient to establish more desirable microbiome
- Treatment of gastrointestinal 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)

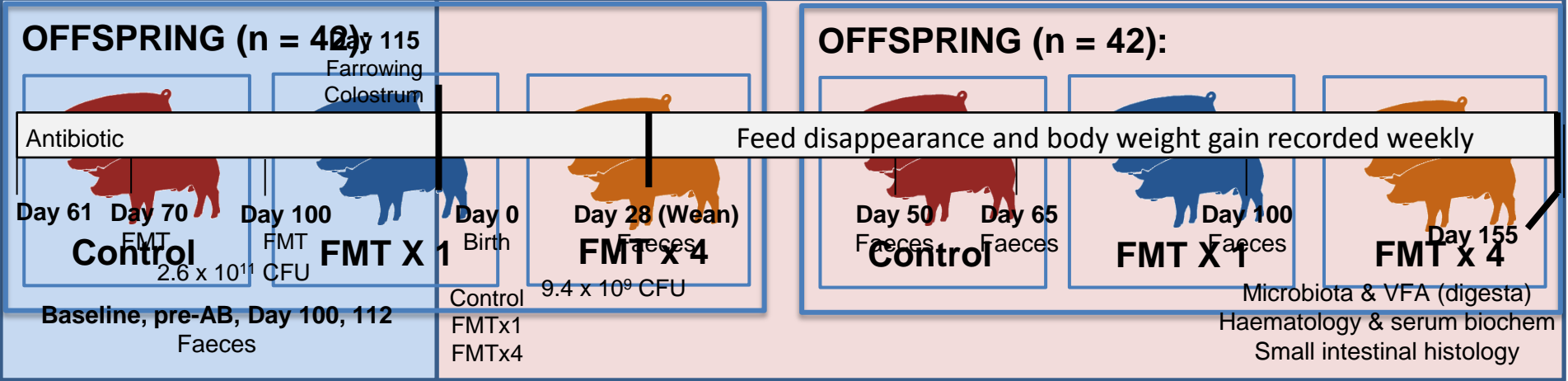


Study design



Sows – gestation

Offspring subset (n = 36)

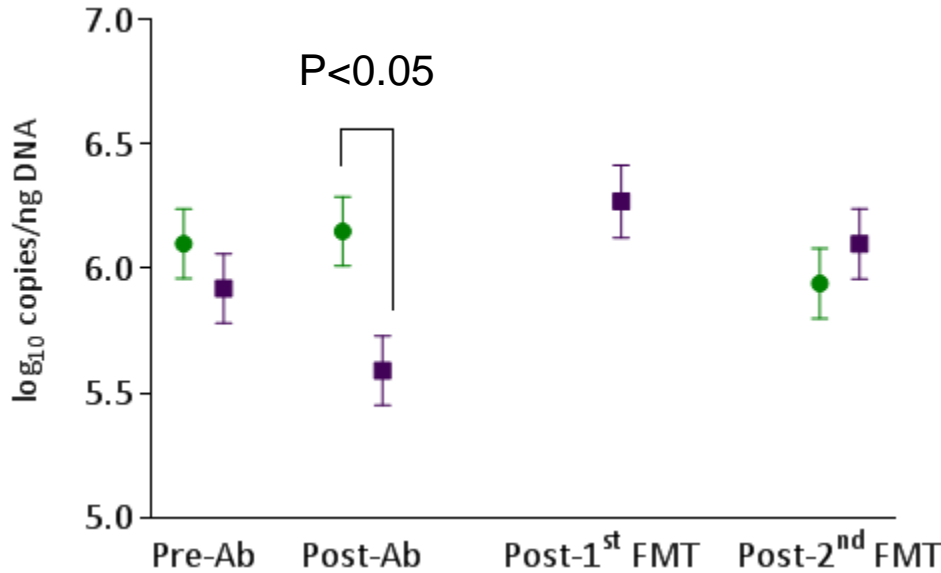


Offspring growth performance

Parameter	Sow trt			
	Control	FMT	S.E.M	P
Weaning weight (Kg)	8.3	7.3	1.13	0.52
Slaughter weight (Kg)	121.6	113.5	1.31	<0.001
Carcass weight (Kg)	92.9	88.7	1.64	0.07
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

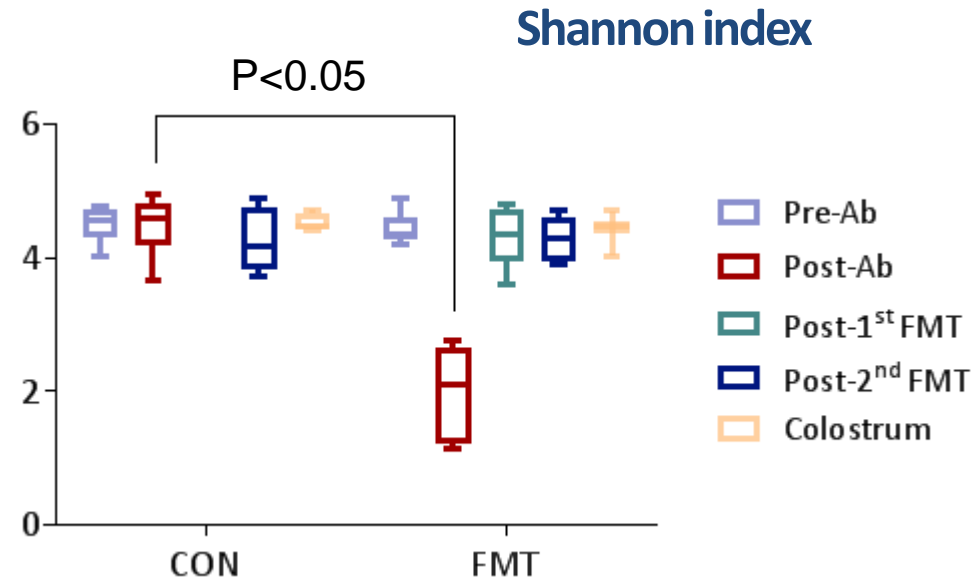
- Between weaning and slaughter (~155 days old):
 - FMT ↓ slaughter weight
 - FMT tended ↓ carcass weight

Sow faecal bacterial load & diversity



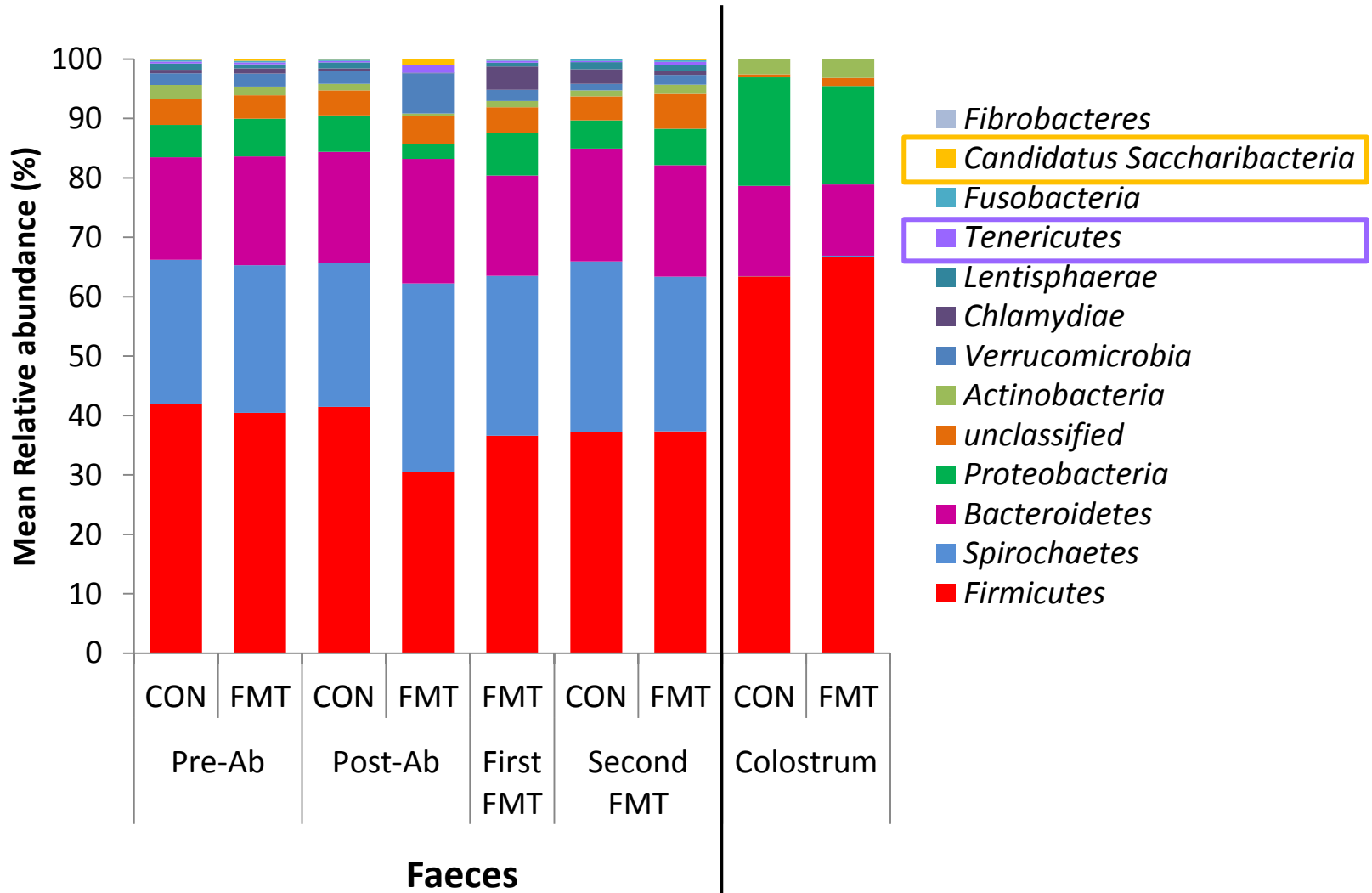
- Antibiotic \downarrow bacterial load
- No effect of FMT

- Antibiotic \downarrow bacterial diversity
- No effect of FMT



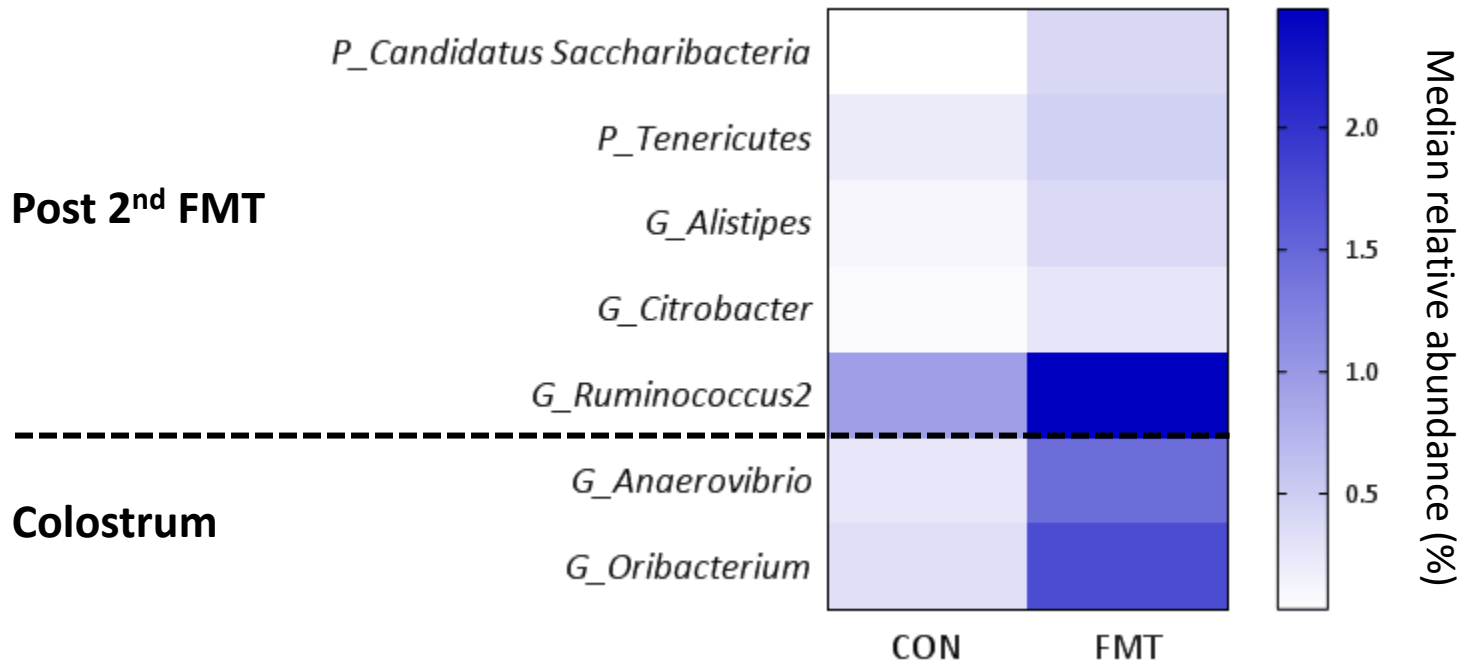
- FMT allowed recovery of bacterial load & diversity lost due to antibiotic

Sow bacterial phyla



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

Sow bacterial phyla & genera

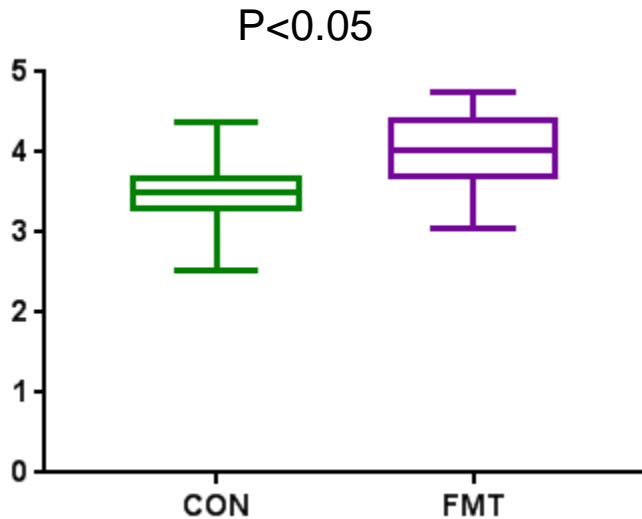


- *Alistipes* FE-enhancing in chickens (Torok et al., 2011)
- *Oribacterium* butyrate-producing
- *Ruminococcus2* - fermentation of complex carbohydrates
- ↑ *Citrobacter* undesirable? (some species human pathogens)

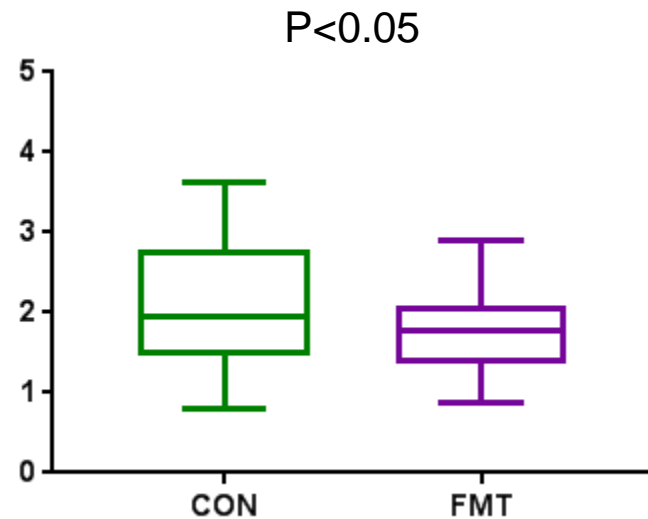
Offspring bacterial diversity

Shannon index

Faeces at ~50 days old

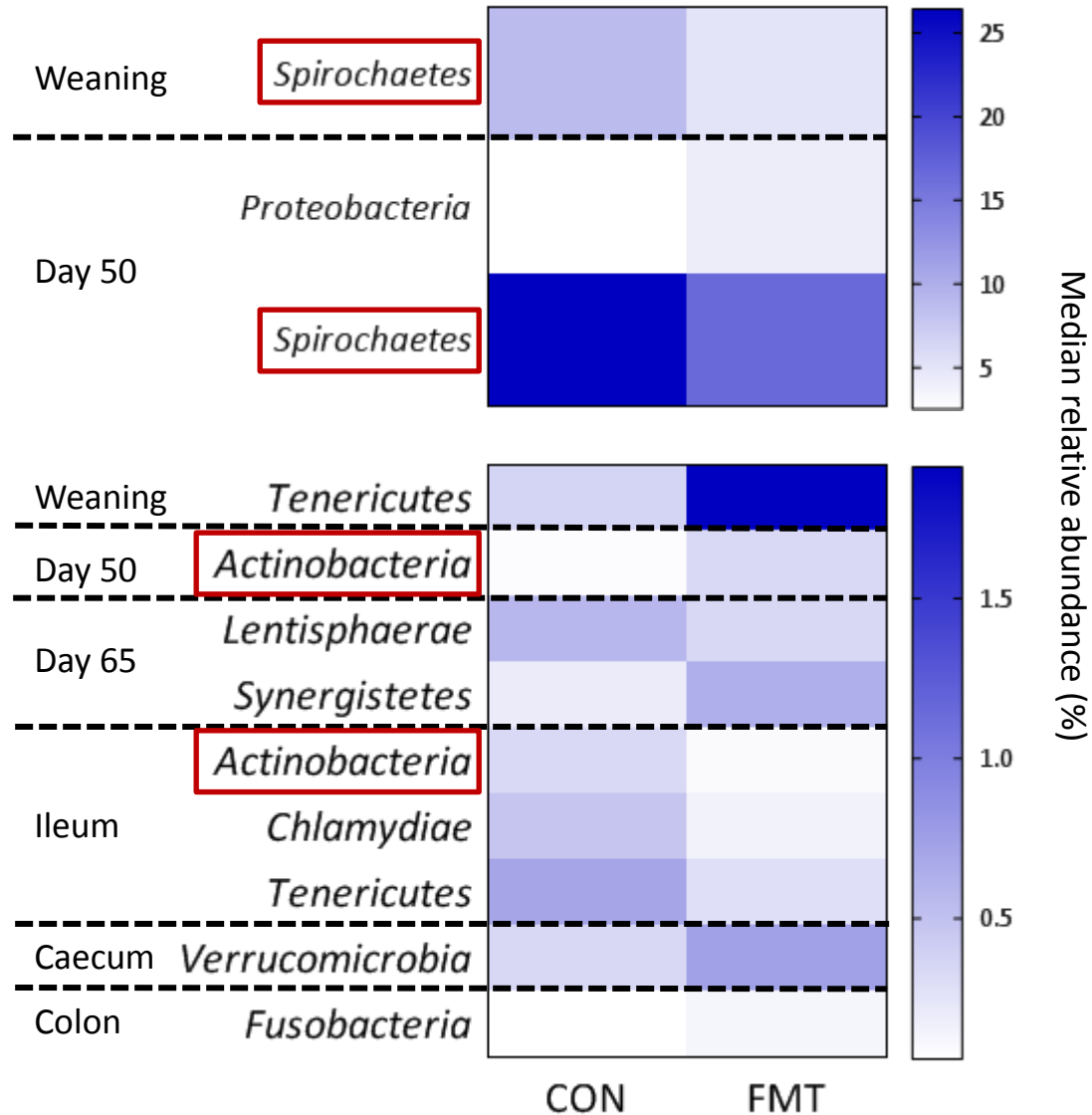


Ileal digesta at ~155 days old



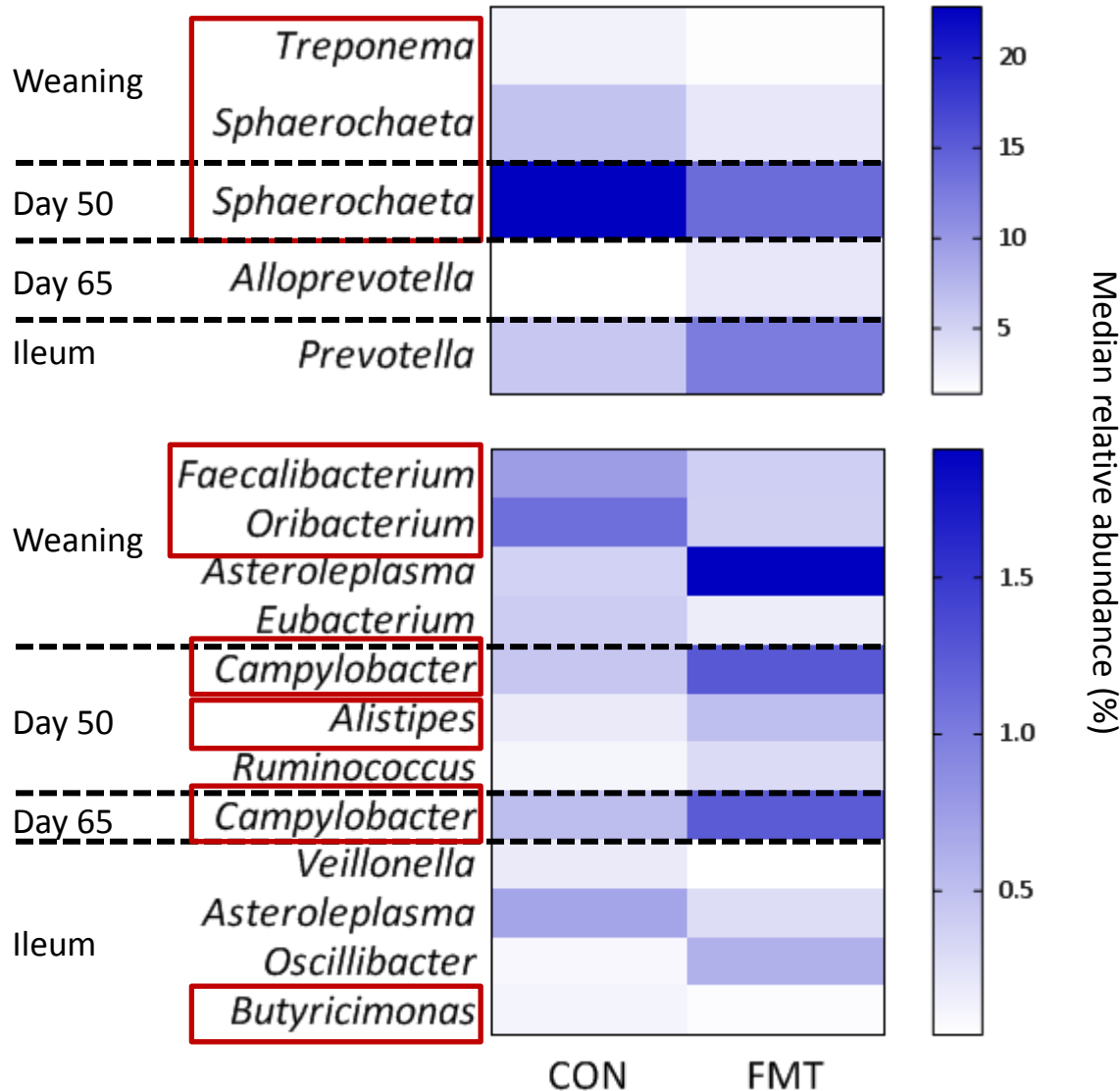
- FMT transiently \uparrow faecal diversity
- But \downarrow ileal diversity

Offspring bacterial phyla



P < 0.05

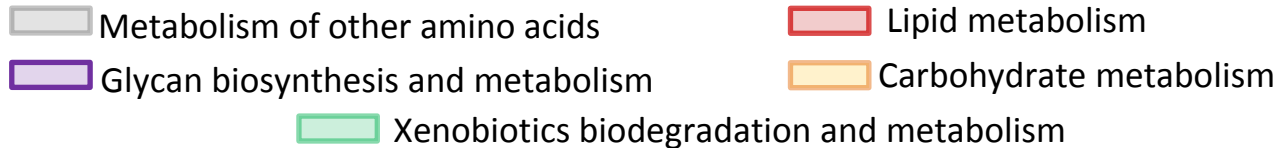
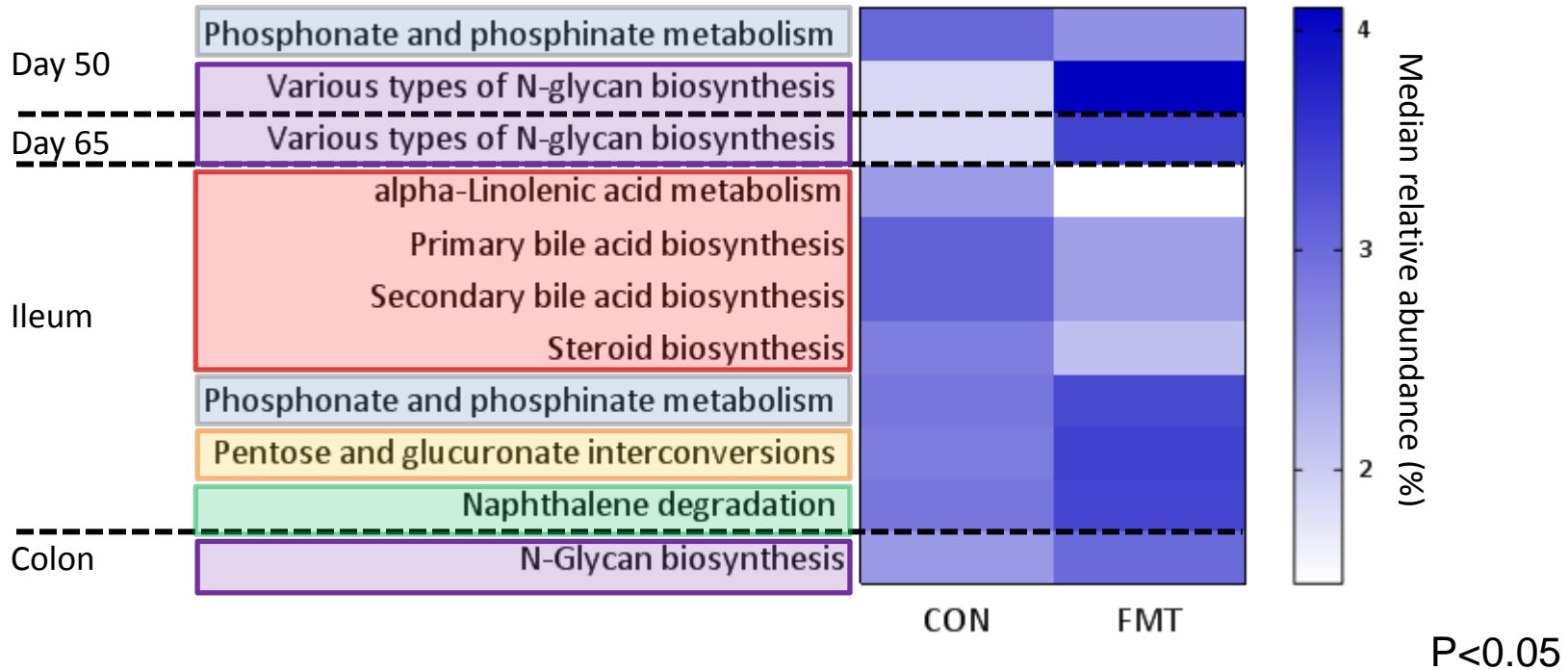
Offspring bacterial genera



- ↓ *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)

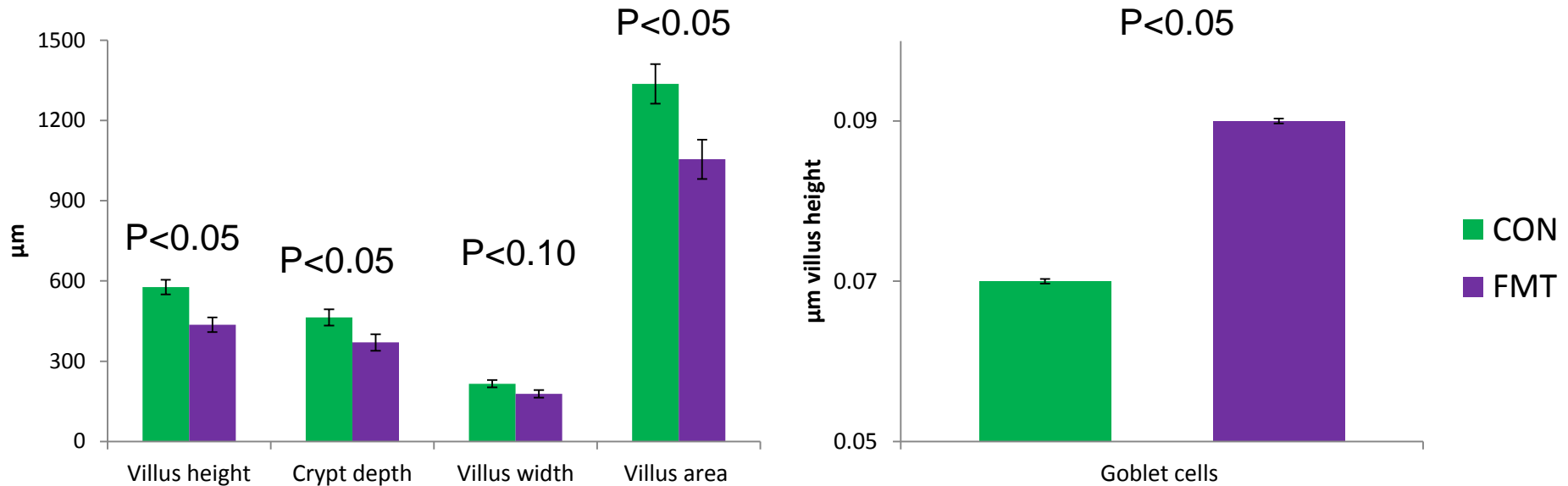
P<0.05

Offspring predicted bacterial functionality (PICRUSt)



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

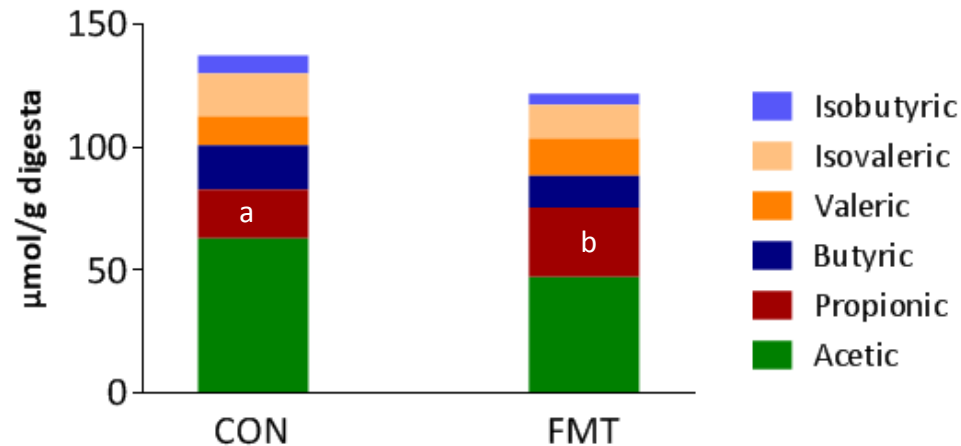
Offspring ileal histology



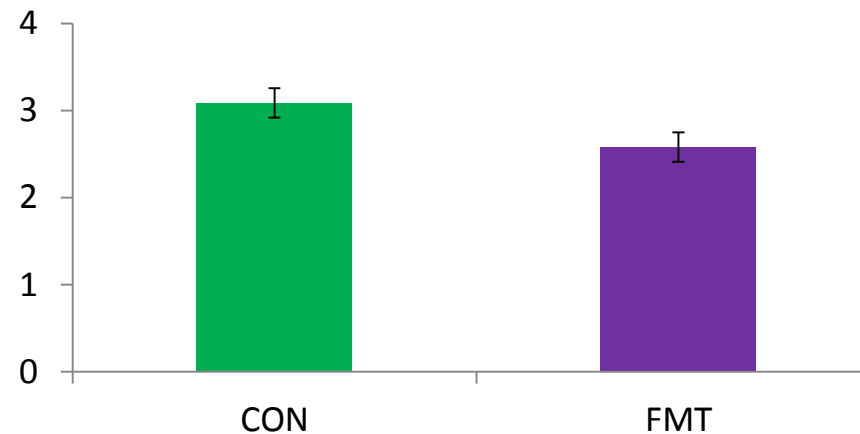
- FMT ↓ villus height & area – reduced absorptive capacity?
- FMT ↑ goblet cells - ↑ mucin? – reduced absorptive capacity?

Offspring volatile fatty acids & serum metabolites

Ileal digesta



Cholesterol (mmol/L)



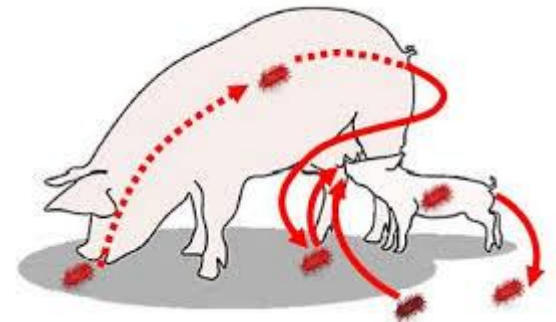
- FMT \uparrow propionic acid
- No differences in: total protein, blood urea nitrogen, glucose, triglycerides, cholesterol, creatinine, creatine kinase
- FMT \downarrow serum cholesterol

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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