IOWA STATE UNIVERSITY
Department of Animal Science
Swine Reproduction and Biotechnology

Efforts to better understand factors compromising sow livability

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Participating Farms

About 385,000 sows

104 sow farms

15 U.S. states

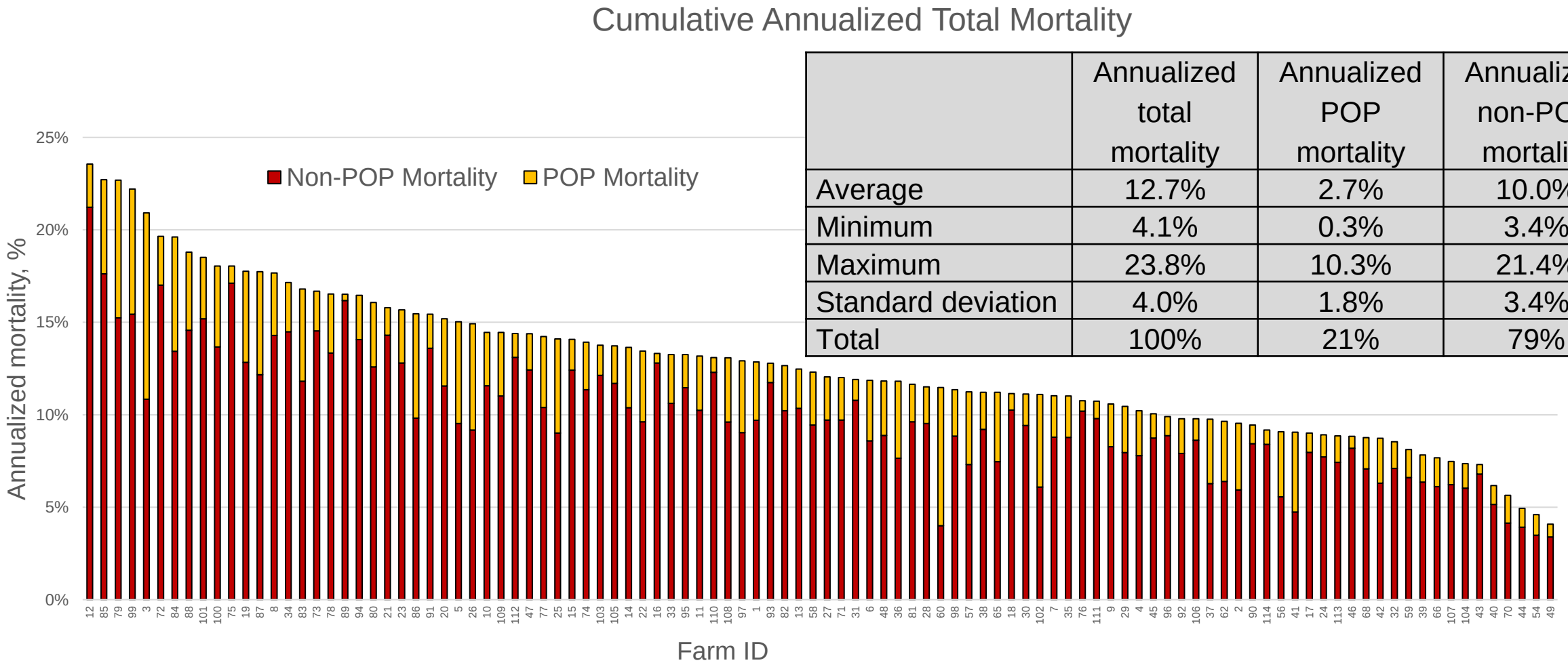
52 weeks of mortality data
62 site visits

Sow inventory
Ranging from 614 to 10,606

Larger production systems:
85 farms
Independent:
19 farms

	Average bred sow inventory
Average	3,713
Minimum	614
Maximum	10,606
Standard deviation	2,000
Total	386,166

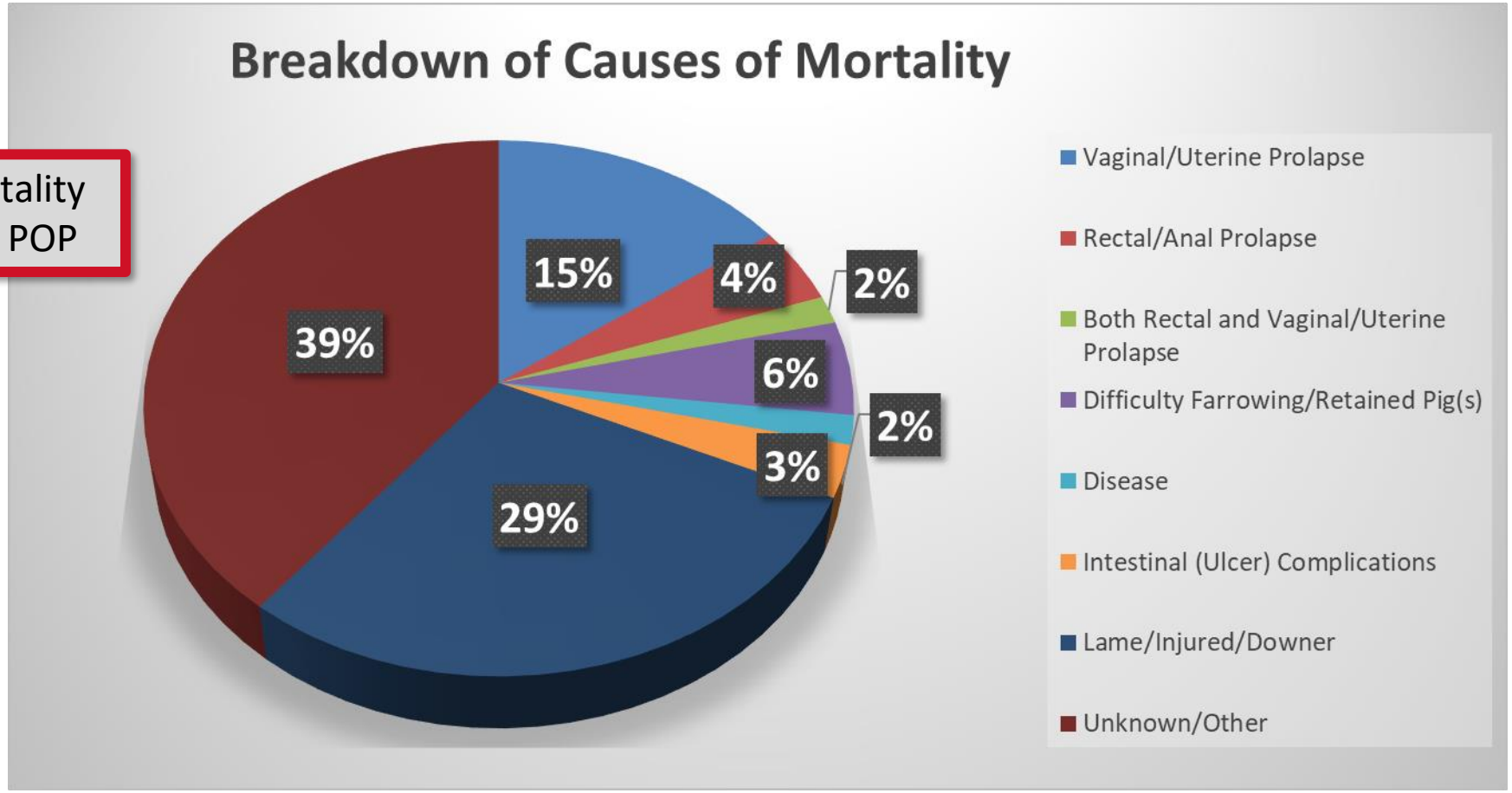
Average Mortality for 104 Farms



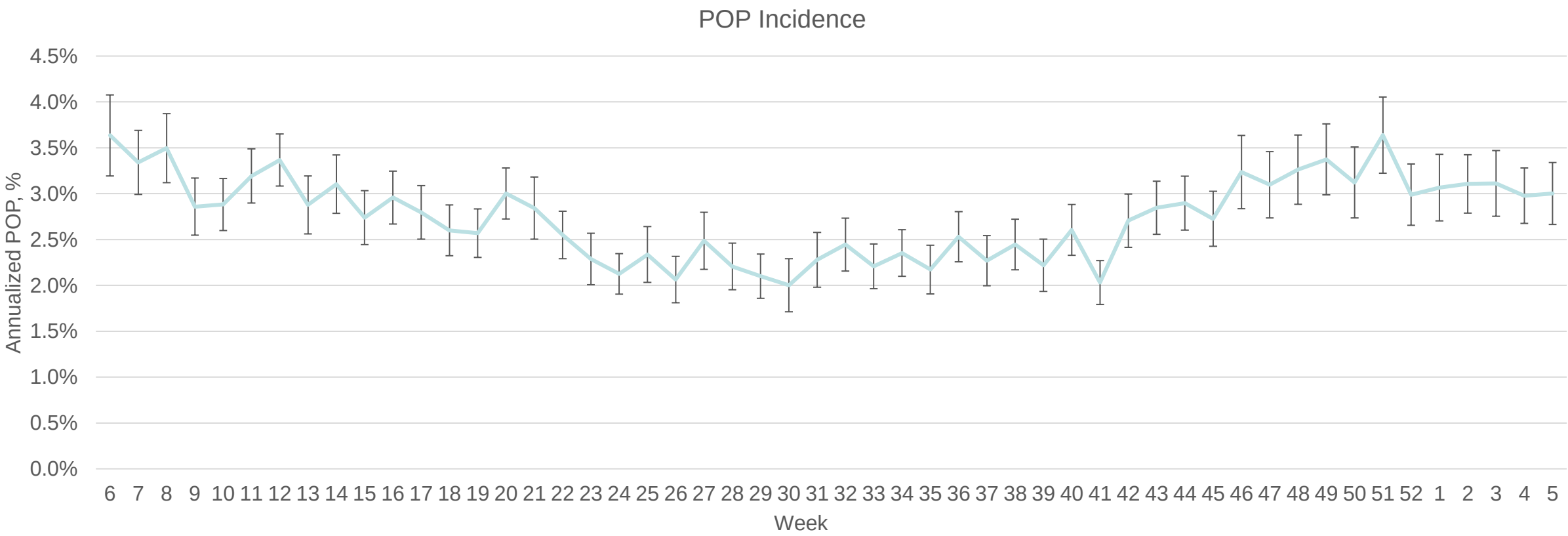
	Annualized total mortality	Annualized POP mortality	Annualized non-POP mortality
Average	12.7%	2.7%	10.0%
Minimum	4.1%	0.3%	3.4%
Maximum	23.8%	10.3%	21.4%
Standard deviation	4.0%	1.8%	3.4%
Total	100%	21%	79%

Causes of Mortality

21% of mortality was due to POP



Trends Over Time: POP



Herd size, induction protocol, sleeving protocol, tail length, hygiene, particle size

Geographical region, sow housing, laxatives, mycotoxins, health status and disease outbreaks, nutrition, genetics, antibiotic usage

Water quality, body condition, bump feeding strategy, perineal score

Perineal score evaluation

Score 1: Presumed ***"little to no" risk of prolapse.*** Has none of the following: Protrusion, vulva swelling and/or swelling of the perineal region.

Score 2: Presumed ***"moderate" risk of prolapse.*** Has evidence of some but not all of the following: Protrusion, moderate vulva swelling and/or swelling of the perineal region.

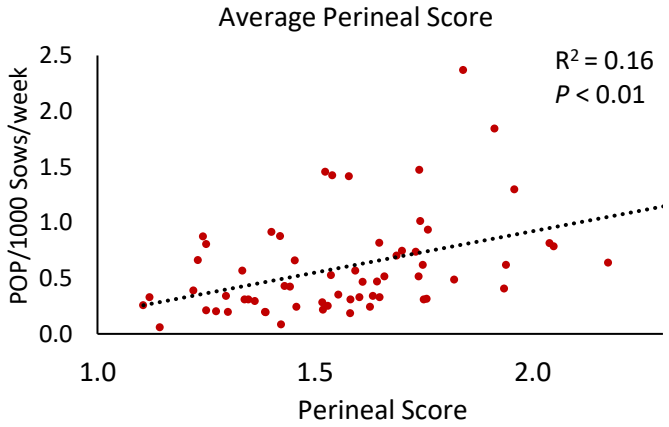
Score 3: Presumed ***"high" risk of prolapse.*** Has all of the following: Protrusion, moderate to severe vulva swelling, swelling of the perineal region and the possible beginning of a prolapse.

Why are perineal scores important?

Perineal scores are an indicator of prolapse risk

Something biologically is happening and causing a score 3

Now we can design experiments before a prolapse happens to further understand what is going on and why is it happening



Perineal Score 3

Research Project 2.2.a.
Determine physiological, endocrinological, nutritional, genetic, microbial, and management strategies, and their interactions that influence POP.

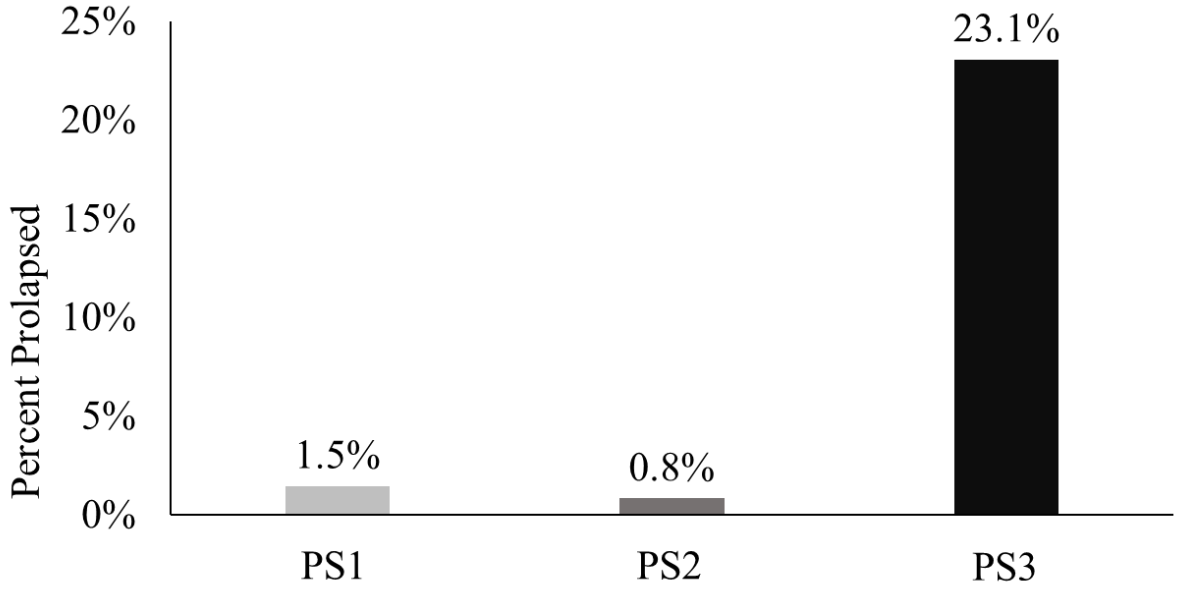
Dysbiosis Connected to Reproductive Dysfunction

- Dysbiosis: Imbalance or decrease in microbial diversity
- Humans
  - Pelvic inflammatory disease (PID)
  - Bacterial vaginosis (BV)
- Cattle
  - Endometriosis
  - Uterine disease
- Swine
  - Limited information
  - Little focus on relation to reproductive dysfunction

Study 1: Vaginal microbiome and serum metabolite differences in late-gestation commercial sows at risk for pelvic organ prolapse

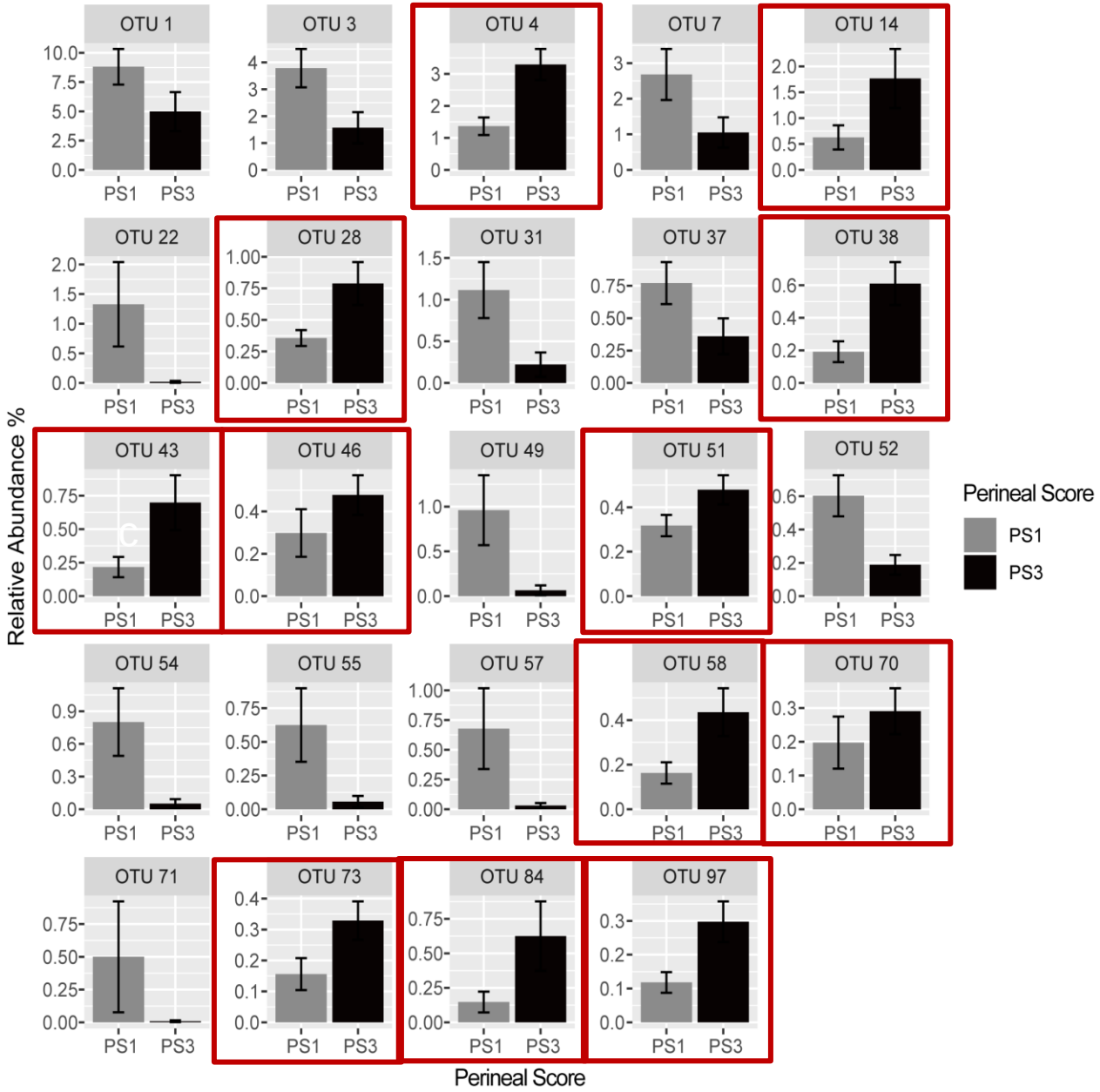
The objective of this study was to characterize the vaginal microbiome in late-gestation sows and identify any molecular features within the serum associated with risk of POP in sows.

- Two commercial sow farms
  - Different states and producers
- 213 late-gestation sows
  - Gestation days 105–117
  - PS assigned
  - Vaginal swabs and blood collected
    - PS3 sows' parity matched to PS1 sows



Study 1: OTUs different between sows differing in PS

- 1,711 total OTUs
- Evaluated 100 most abundant OTUs
  - 24 OTUs different
  - 12 increased in PS1
    - *Veillonella* (OTU 1)
    - *Anaerococcus* (OTU 31)
    - *Porphyromonas* (OTU 22, 49, 57)
  - 12 increased in PS3
    - *Streptococcus dysgalactiae* (OTU 84)
    - *Treponema* (OTU 38, 70, 73)
    - *Prevotella* (OTU 58)



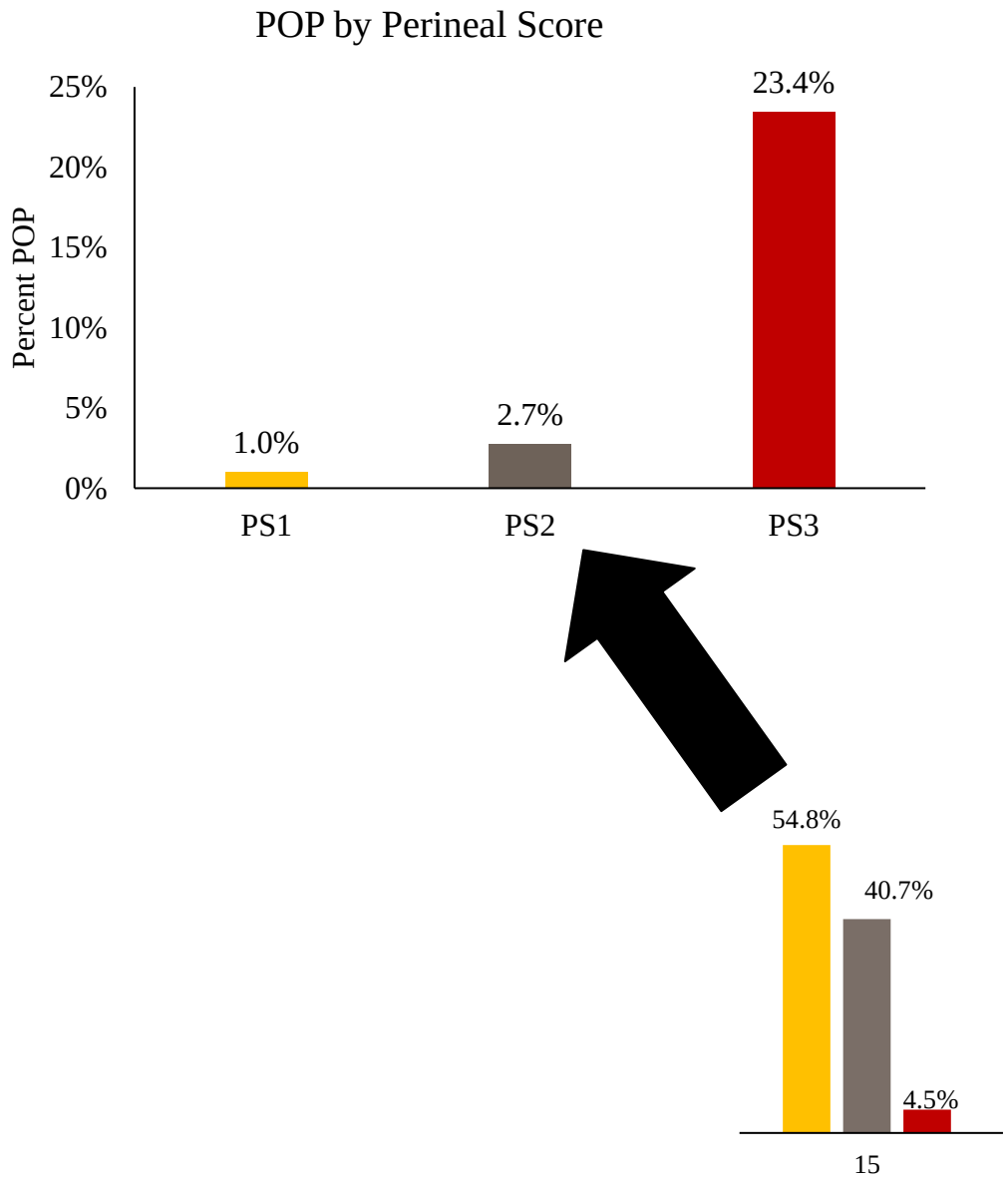
Study 2: Methods

Scored Animals

	Project Week 1	Project Week 2	Project Week 3	Project Week 4	Project Week 5	Project Week 6	Project Week 7
Gestation Week 12	200-300	200-300	200-300	200-300			
Gestation Week 13	200-300	200-300	200-300	200-300	200-300		
Gestation Week 14	200-300	200-300	200-300	200-300	200-300	200-300	
Gestation Week 15	200-300	200-300	200-300	200-300	200-300	200-300	200-300

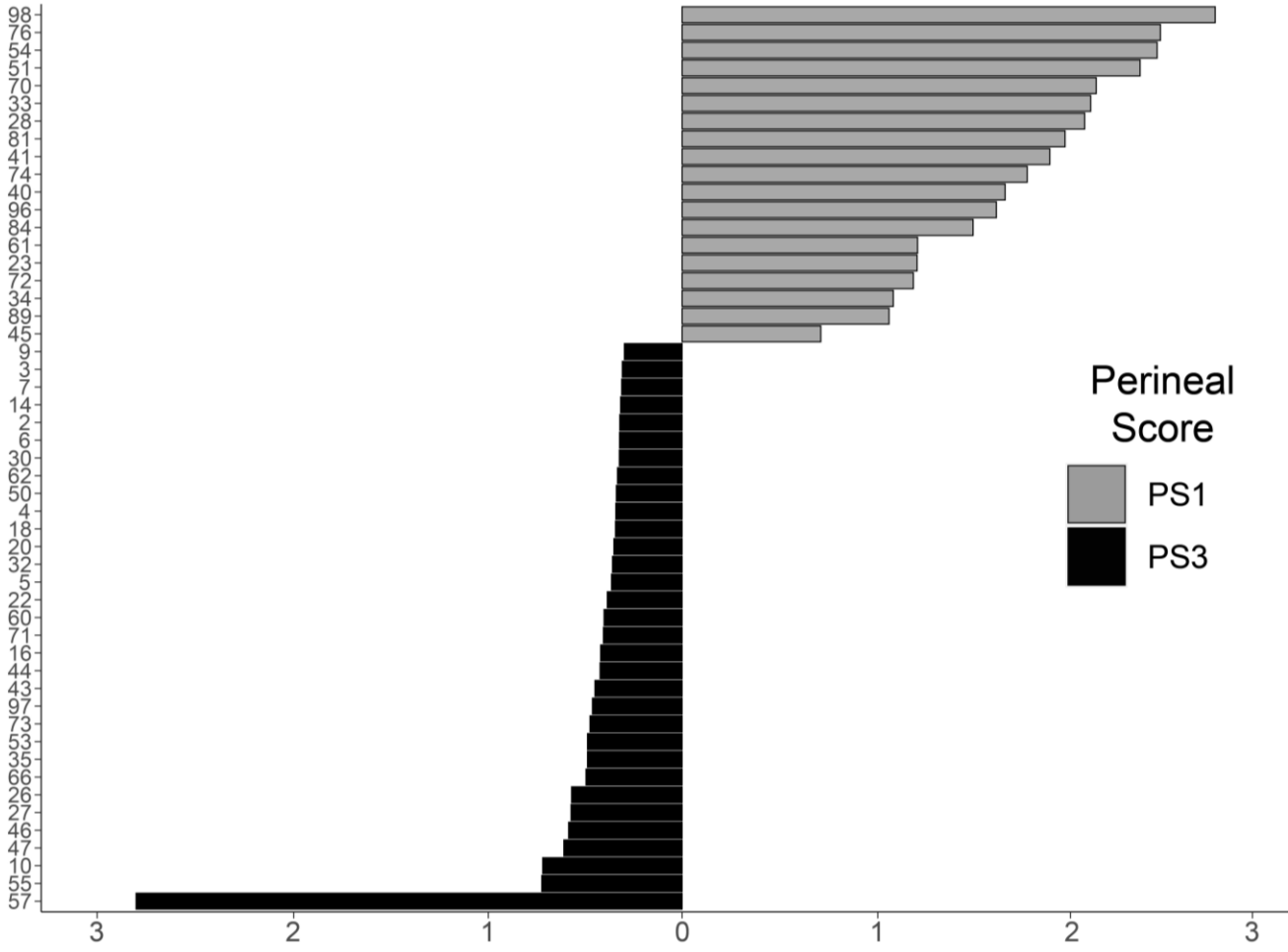
Collected samples

- Vaginal swabs



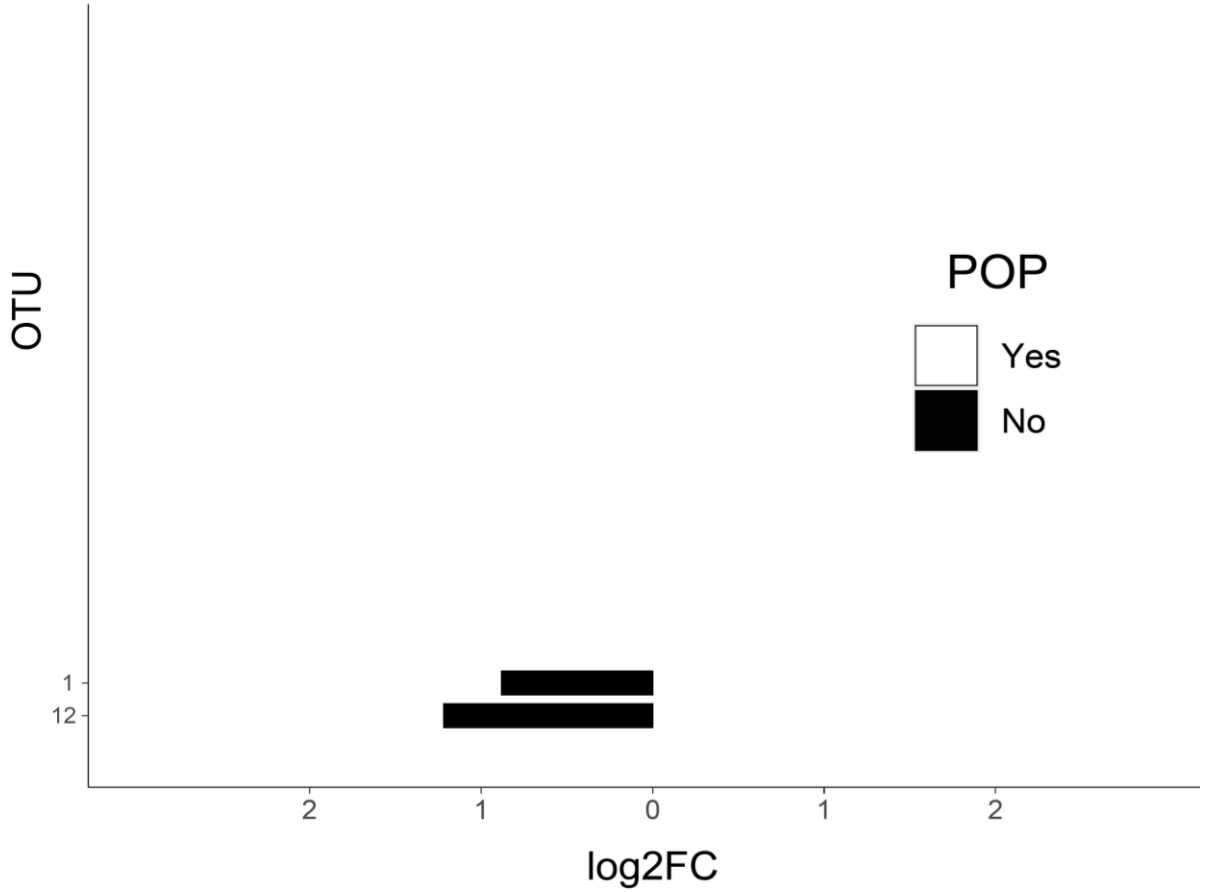
Study 2: OTUs different between sows differing in PS

- 18 OTUs more abundant in PS1
  - *Peptoniphilus* (OTU 41,45,96)
  - *Porphyromonas* (OTU 23,28,51,84)
  - *Anaerococcus* (OTU 34,54,61,70)
- 33 OTUs more abundant in PS3
  - *Corynebacterium* (OTU 10,26,35,46,53)
  - *Clostridium* (OTU 5,7,18,50)
  - *Duncaniella* (OTU 43)
  - *Streptococcus dysgalactiae* (OTU 4)
  - *Treponema* (OTU 47)
  - *Staphylococcus* (OTU 44,57)



Study 2: OTUs different between PS3 sows differing in POP outcome

- 2 significantly different OTUs
  - Both more abundant in non-POP sows
  - *Actinobacillus* and *Veillonella*



Study 3: Circulating biomarkers associated with pelvic organ prolapse risk in late-gestation sows

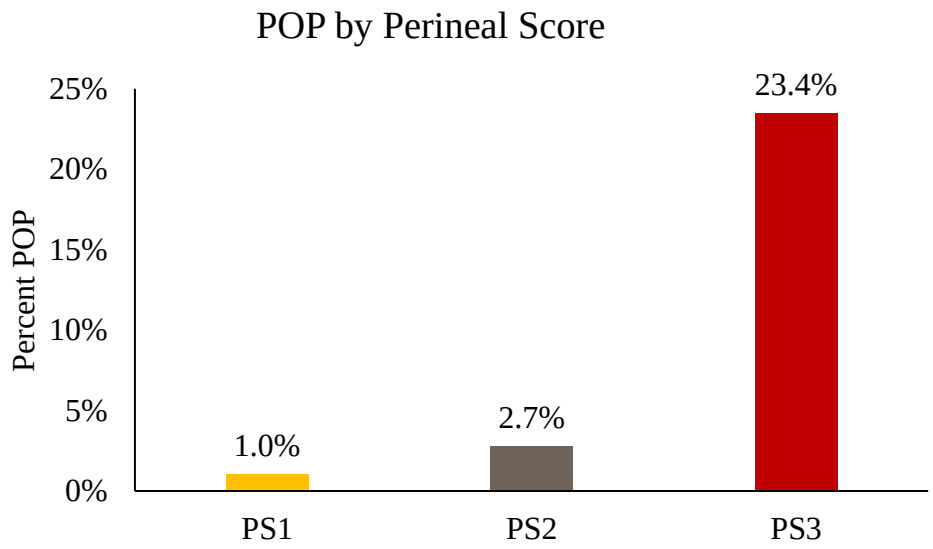
Scored animals

	Project Week 1	Project Week 2	Project Week 3	Project Week 4	Project Week 5	Project Week 6	Project Week 7
Gestation Week 12	200-300	200-300	200-300	200-300			
Gestation Week 13	200-300	200-300	200-300	200-300	200-300		
Gestation Week 14	200-300	200-300	200-300	200-300	200-300	200-300	
Gestation Week 15	200-300	200-300	200-300	200-300	200-300	200-300	200-300

Collected samples

Blood samples

- CBC
- Biomarkers
  - LPB
  - TNF-α
  - Haptoglobin
  - C-reactive protein
  - CK
- Steroid hormones

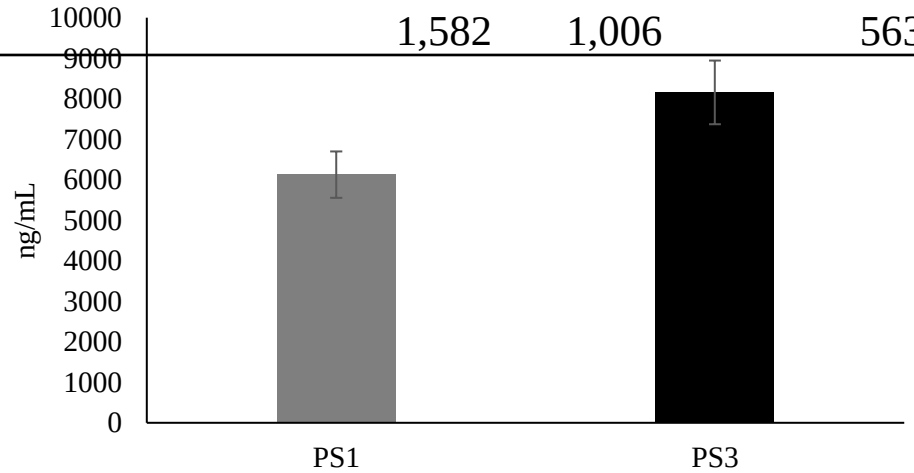


Decreases in Immune Cell Populations PS3 Sows

	Farm A		Farm B			P-value		
Parameter (units)	**PS1**	**PS3**	**PS1**	**PS3**	**SEM**	**Farm**	**PS**	**Farm*PS**
White blood cells, 10^3/µL	13.22	12.51	13.23	12.99	0.4	0.50	0.16	0.48
Red blood cells, 10^6/µL	5.20	5.12	5.24	5.17	0.09	0.61	0.27	0.93
Hemoglobin, gm/dL	10.8	10.7	10.8	10.7	0.1	0.89	0.45	0.85
Hematocrit, %	32.6	32.4	32.6	32.2	0.5	0.72	0.44	0.77
Mean corpuscular volume, fL	63.2	63.9	62.5	62.6	0.5	0.03	0.40	0.46
Mean corpuscular hemoglobin, pg	20.9	21.1	20.8	20.8	0.2	0.27	0.40	0.67
Mean corpuscular hemoglobin concentration, gm/dL	33.0	33.0	33.2	33.3	0.1	0.02	0.87	0.55
Red cell distribution width, %	16.4	16.1	16.5	16.7	0.2	0.11	0.84	0.12
Platelets, 10^3/µL	182	187	178	218	28	0.58	0.33	0.44
Mean platelet volume, fL	10.3	10.1	10.5	9.8	0.2	0.72	0.03	0.24
Neutrophils, 10^3/µL	6.50	6.37	6.08	6.24	0.33	0.38	0.96	0.60
Lymphocytes, 10^3/µL	5.13	4.88	5.55	5.12	0.21	0.10	0.05	0.60
Monocytes, 10^3/µL	0.52	0.46	0.51	0.50	0.02	0.42	0.04	0.14
Eosinophils, 10^3/µL	0.93	0.69	0.96	1.00	0.07	0.01	0.11	0.01
Basophils, 10^3/µL	0.05	0.04	0.04	0.04	< 0.01	0.36	0.24	0.08
Absolute large unstained cells, 10^3/µL	0.09	0.08	0.08	0.09	0.01	0.98	0.78	0.51

LPS Binding Protein Increased in PS3 Sows

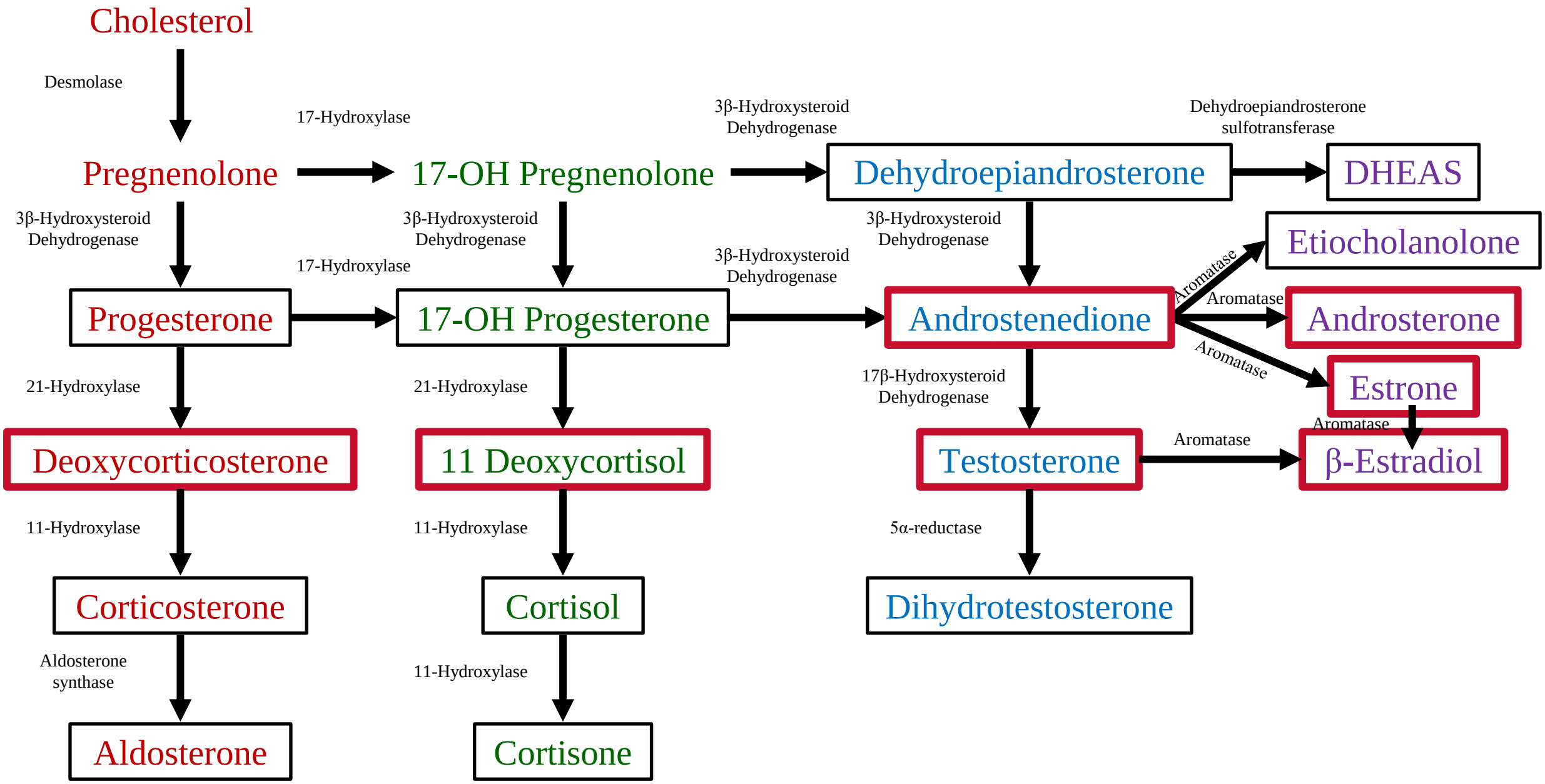
	Farm A		Farm B			*P*-value		
Parameter (units)	**PS1**	**PS3**	**PS1**	**PS3**	**SEM**	**Farm**	**PS**	**Farm*PS**
Lipopolysaccharide binding protein (ng/mL)	6,089	8,050	6,038	8,294	1,224	0.93	0.04	0.89
Tumor necrosis factor alpha (pg/mL)	58.0	61.1	62.7	74.6	24.5	0.60	0.64	0.78
C-reactive protein (µg/mL)	29.56	32.48	23.84	31.88	5.06	0.48	0.20	0.55
Haptoglobin (µg/mL)	847.9	888.7	786.5	791.9	139.1	0.28	0.51	0.54
Creatine kinase (pg/nm)	1,582	1,006	563	580	326	0.01	0.31	0.28



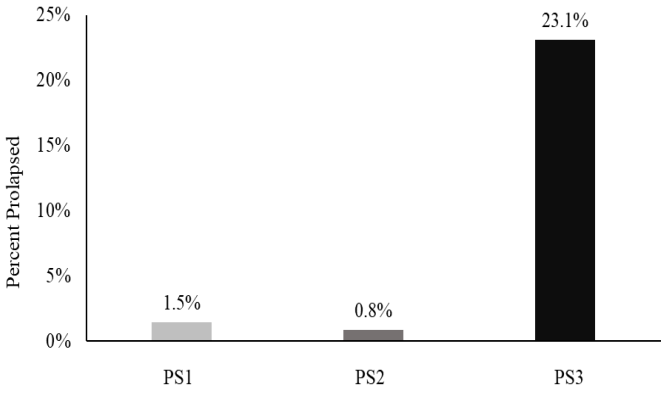
24.9% ↑ in PS3 sows

Increased Steroid Hormones in PS3 Sows

	Farm A		Farm B			*P-value*		
Steroid Hormone	**PS1**	**PS3**	**PS1**	**PS3**	**SEM**	**Farm**	**PS**	**Farm*PS**
Deoxycorticosterone, nM	0.23	0.26	0.29	0.34	0.04	0.06	0.18	0.80
Deoxycortisol, nM	0.41	0.48	0.51	0.63	0.13	0.23	0.33	0.82
Hydroxyprogesterone, nM	0.113	0.128	0.122	0.109	0.012	0.60	0.90	0.15
Aldosterone, nM	0.23	0.34	0.42	0.47	0.09	0.02	0.21	0.63
Androstenedione, nM	0.105	0.134	0.105	0.109	0.009	0.10	0.02	0.07
Androsterone, nM	0.060	0.074	0.056	0.068	0.006	0.40	0.02	0.95
Corticosterone, nM	0.61	0.53	0.72	0.75	0.12	0.09	0.74	0.52
Cortisol, nM	35	34	40	40	5	0.18	0.91	0.96
Cortisone, nM	10.7	12.1	11.7	11.3	0.8	0.89	0.37	0.15
Estrone, nM	8.4	12.4	8.6	10.2	0.8	0.15	< 0.01	0.09
β-Estradiol, nM	0.67	0.97	0.61	0.76	0.06	0.02	< 0.01	0.17
Progesterone, nM	26	23	24	24	1	0.61	0.11	0.45
Testosterone, nM	0.040	0.055	0.050	0.053	0.006	0.48	0.11	0.23


Cholesterol
Desmolase
Pregnenolone
17-Hydroxylase
17-OH Pregnenolone
3β-Hydroxysteroid Dehydrogenase
Dehydroepiandrosterone
Dehydroepiandrosterone sulfotransferase
DHEAS
3β-Hydroxysteroid Dehydrogenase
Progesterone
17-Hydroxylase
17-OH Progesterone
3β-Hydroxysteroid Dehydrogenase
Androstenedione
3β-Hydroxysteroid Dehydrogenase
Etiocholanolone
Aromatase
Androsterone
Aromatase
Estrone
Aromatase
21-Hydroxylase
Deoxycorticosterone
21-Hydroxylase
11 Deoxycortisol
17β-Hydroxysteroid Dehydrogenase
Testosterone
Aromatase
β-Estradiol
11-Hydroxylase
Corticosterone
11-Hydroxylase
Cortisol
5α-reductase
Dihydrotestosterone
Aldosterone synthase
Aldosterone
11-Hydroxylase
Cortisone

What is associated with a high risk of prolapse?



Biological changes

PS3 sows are at higher risk for POP

Changes in vaginal microbiota

Changes in serum metabolites

Decreased circulating immune cells in PS3 sows

- MPV
- Lymphocytes
- Monocytes

Increased circulating biomarkers in PS3 sows

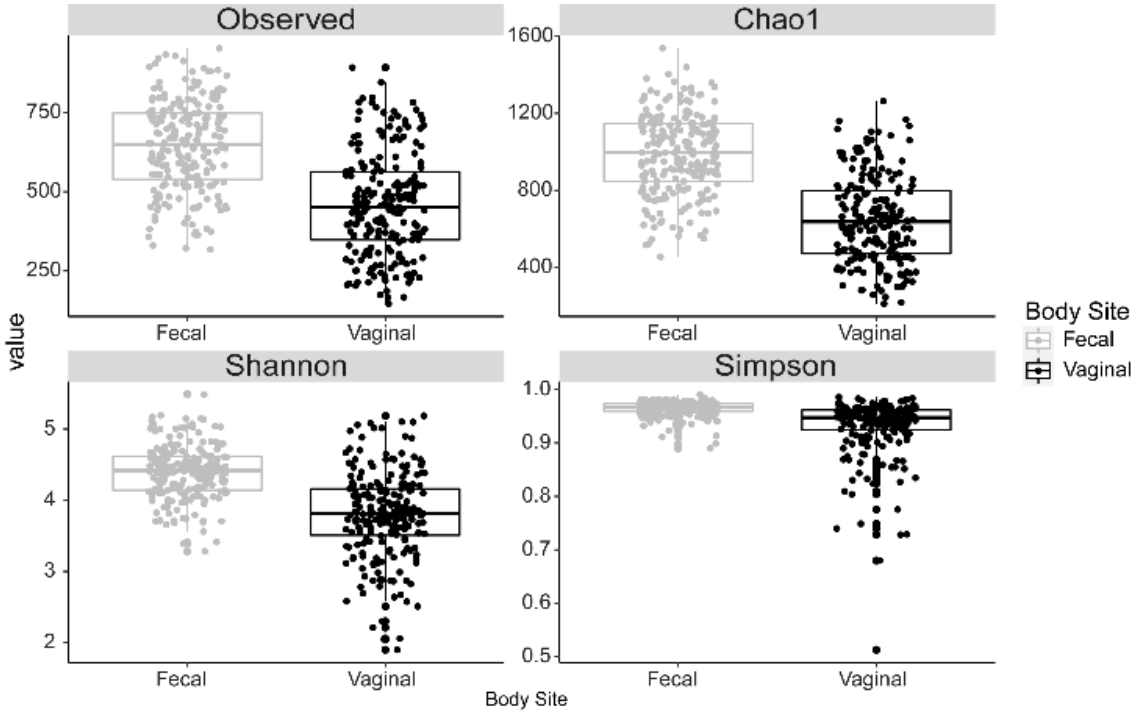
- Lipopolysaccharide binding protein

Increased circulating steroid hormones in PS3 sows

- Androstenedione
- Androsterone
- Estrone
- β-Estradiol

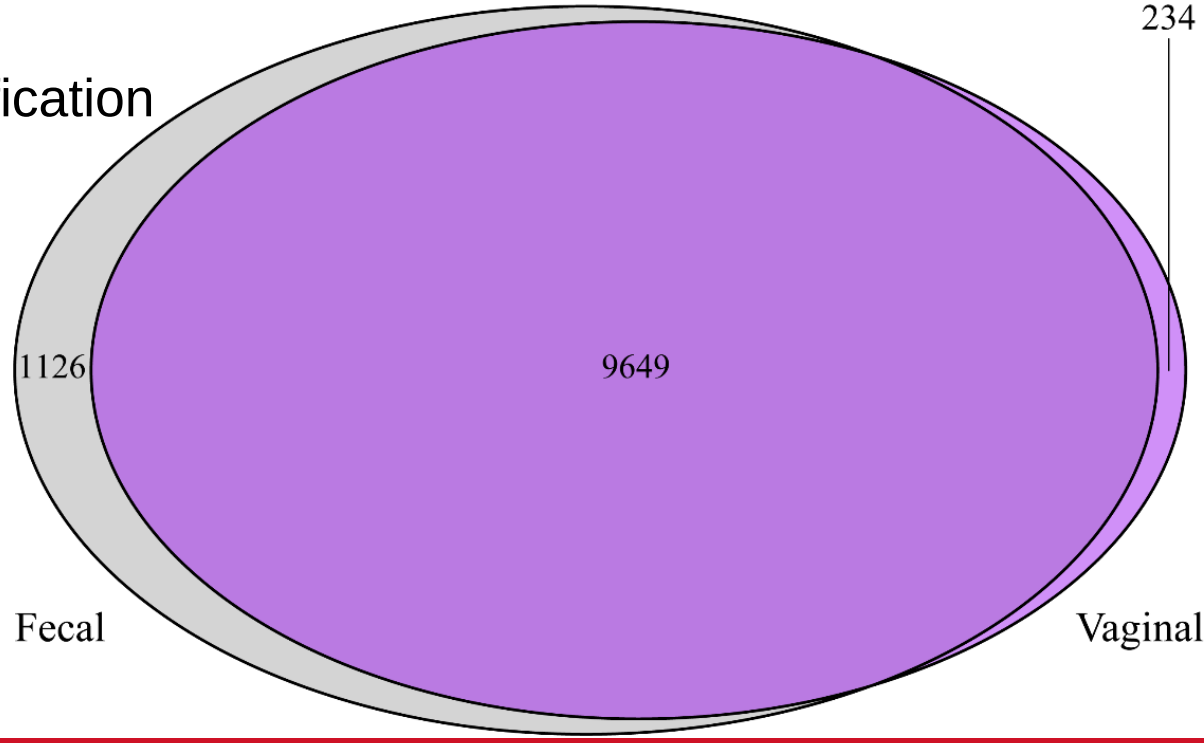
Study 4: Differences in Community Structure Between Vaginal and Fecal Microbiota Exist

- Differences ($P < 0.01$) in species evenness (Simpson), richness (Observed, Chao1), and diversity (Shannon) were observed between the vaginal and fecal microbiota.



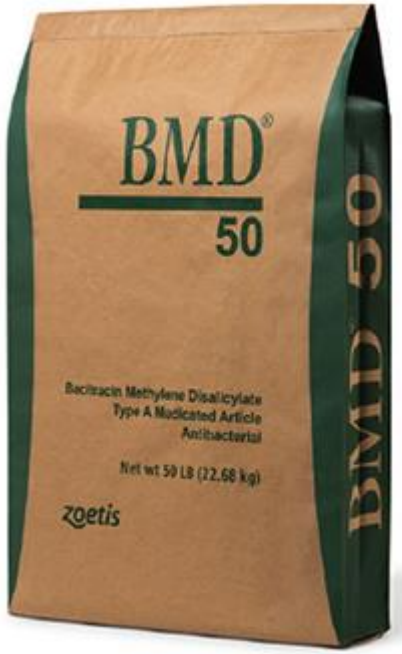
OTUs are Shared Across Body Site

- 9649 OTUs shared across body site
  - 12 OTUs identical within the top 50 most abundant
- 1126 unique to Fecal microbiota
- 234 unique to Vaginal microbiota
- Similar trends in abundance based on PS classification
  - *Clostridium*
  - *Treponema*
  - *Streptococcus*
  - *Veillonella*



Study 5: Evaluation of BMD during late gestation on pelvic organ prolapse incidence in sows

- Objective: The objective of this study was to determine if treatment with BMD® (bacitracin methylene disalicylate) for 2 weeks pre-farrow would reduce the prevalence of POP in late gestation sows.
- BMD is a narrow spectrum antibiotic used in sows for control of clostridial enteritis caused by *Clostridium perfringens* in suckling piglets.



Experimental design

Gestation week 14 sows allocated into treated (BMD) or non-treated (CON) groups

- Treatments assigned based on rows of gestation crates
- Sows received BMD for 2 weeks pre-farrow
- Conducted at 2 sow farms in same production system

Sows were assigned a perineal score before moving into farrowing

- Scorer was “blinded” to treatments
- Scored at one time point during gestation week 15
- Moved into farrowing at start of gestation week 16

Farm A: BMD in water

CON (n = 522)

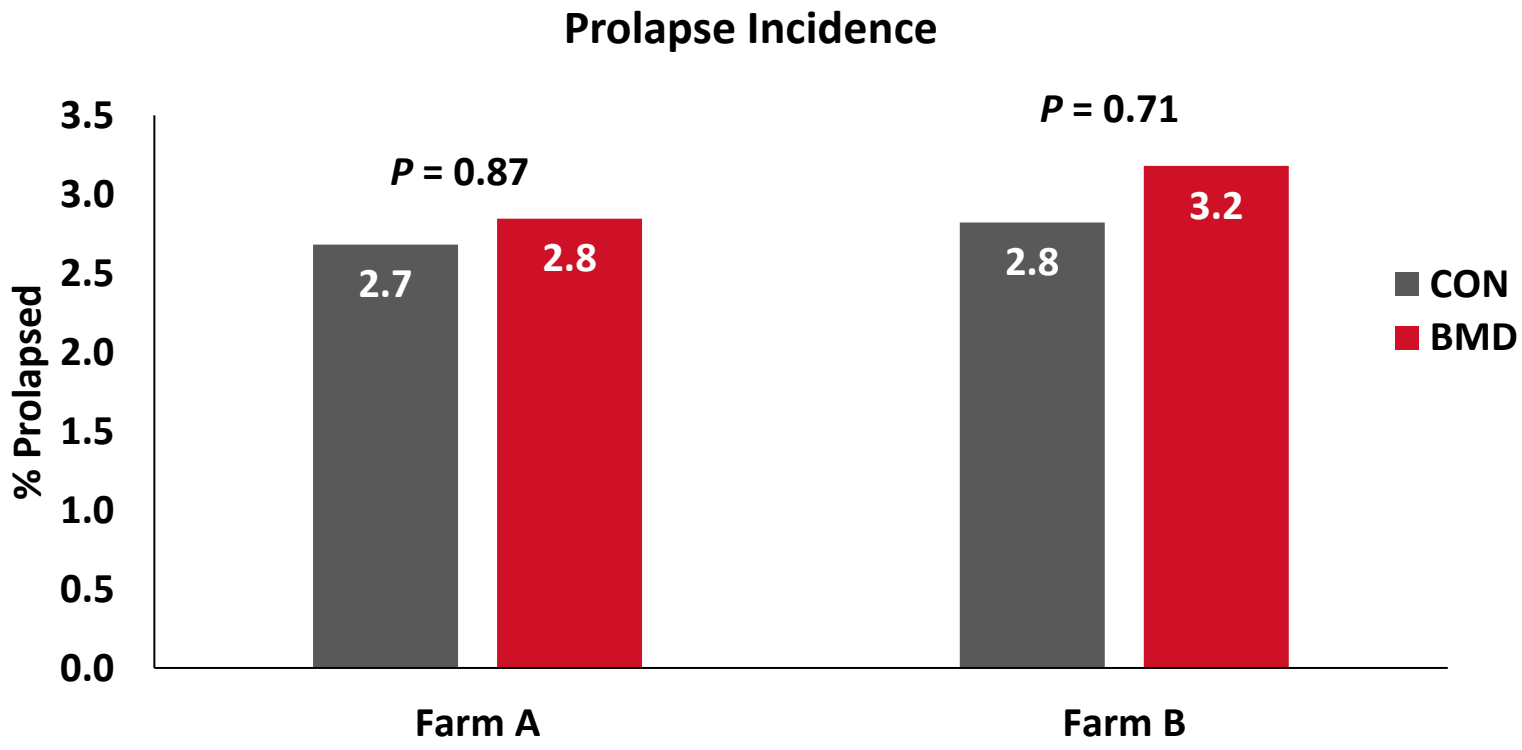
BMD (n = 492)

Farm B: BMD in feed

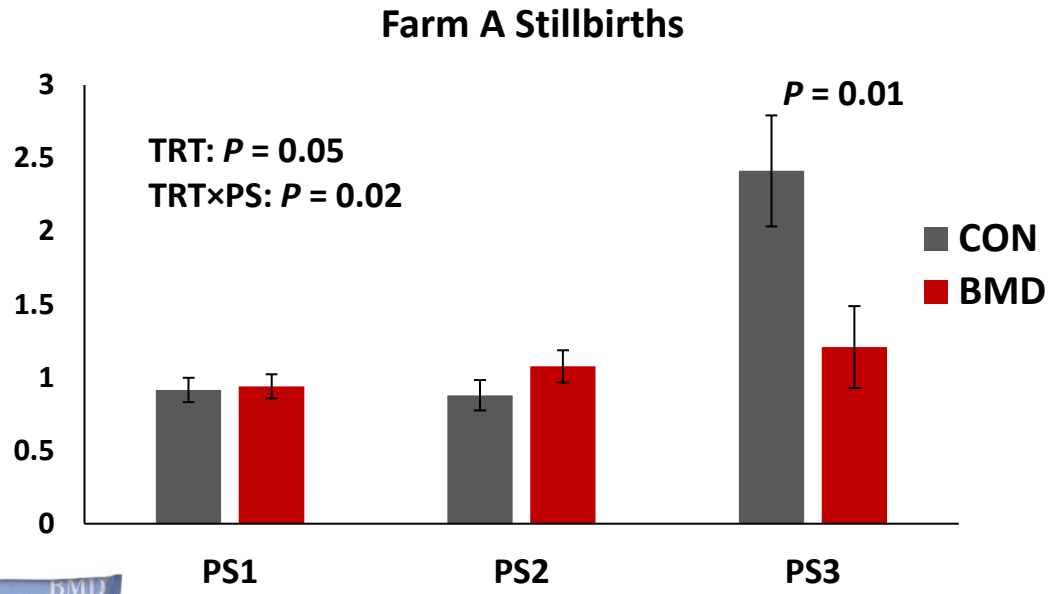
CON (n = 709)

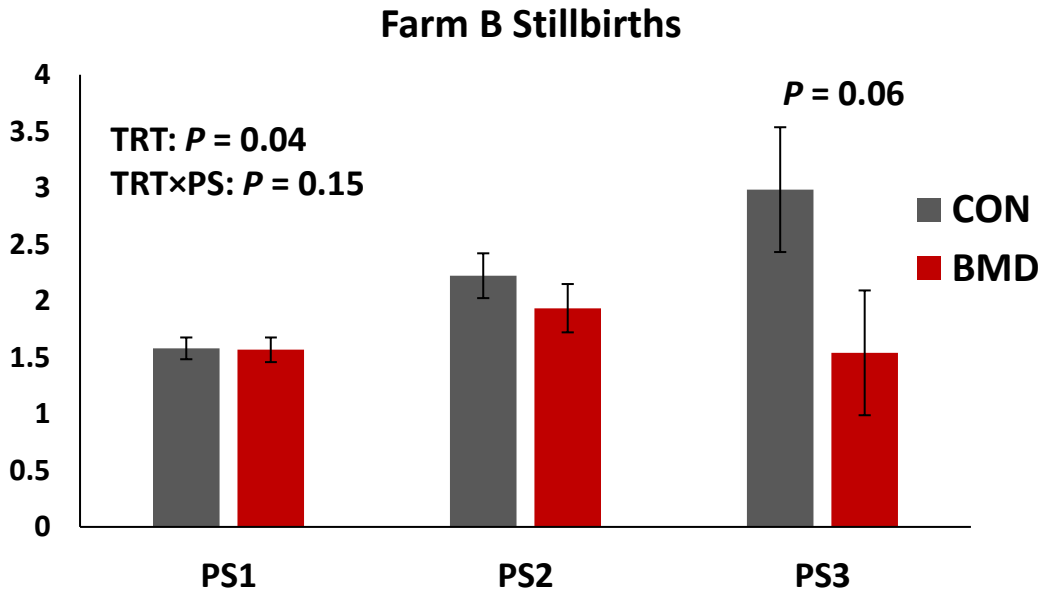
BMD (n = 566)

BMD treatment did not affect prolapse incidence at either farm



A decrease in number of stillborn piglets was observed in BMD treated sows compared to control at both farms





Study 6: Vaginal infusion of ampicillin during late gestation on pelvic organ prolapse incidence in sows

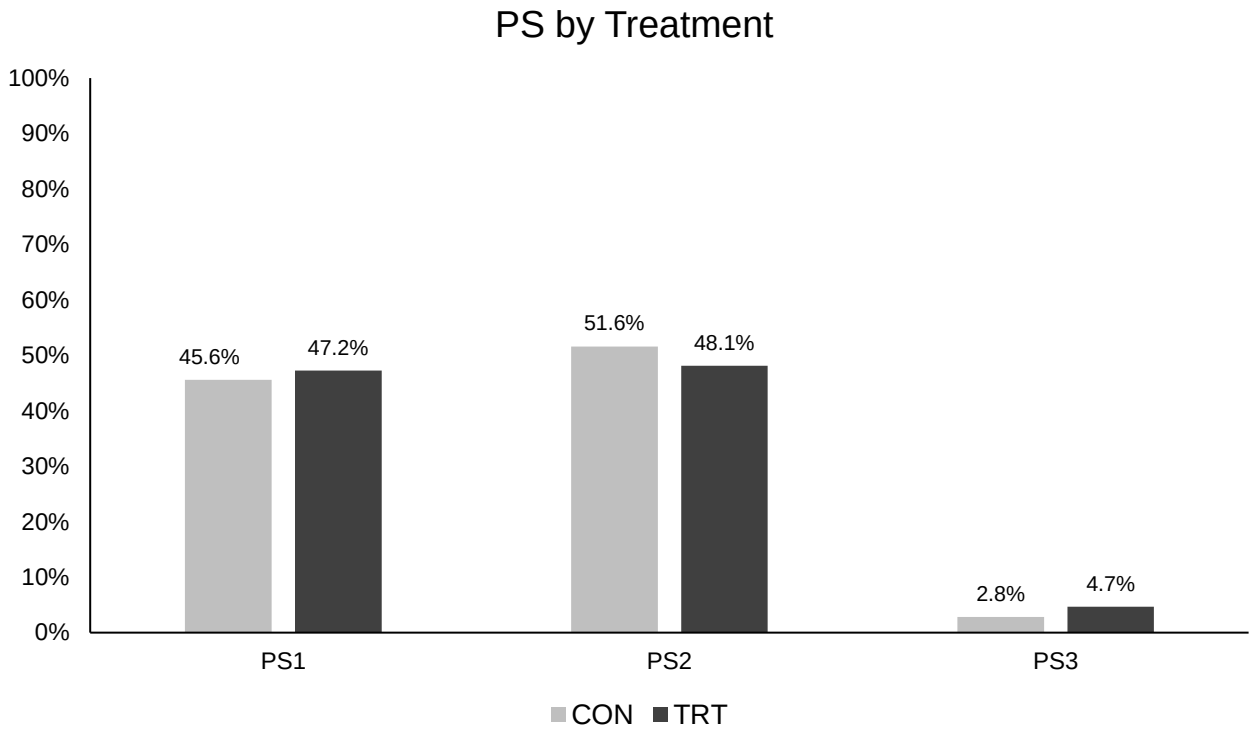
- Resuspended with 104.5mL of sterile water
  - 200mg active product per mL
- 10mL was infused intravaginally
  - ~3 weeks pre farrow
  - ~3 days pre farrow

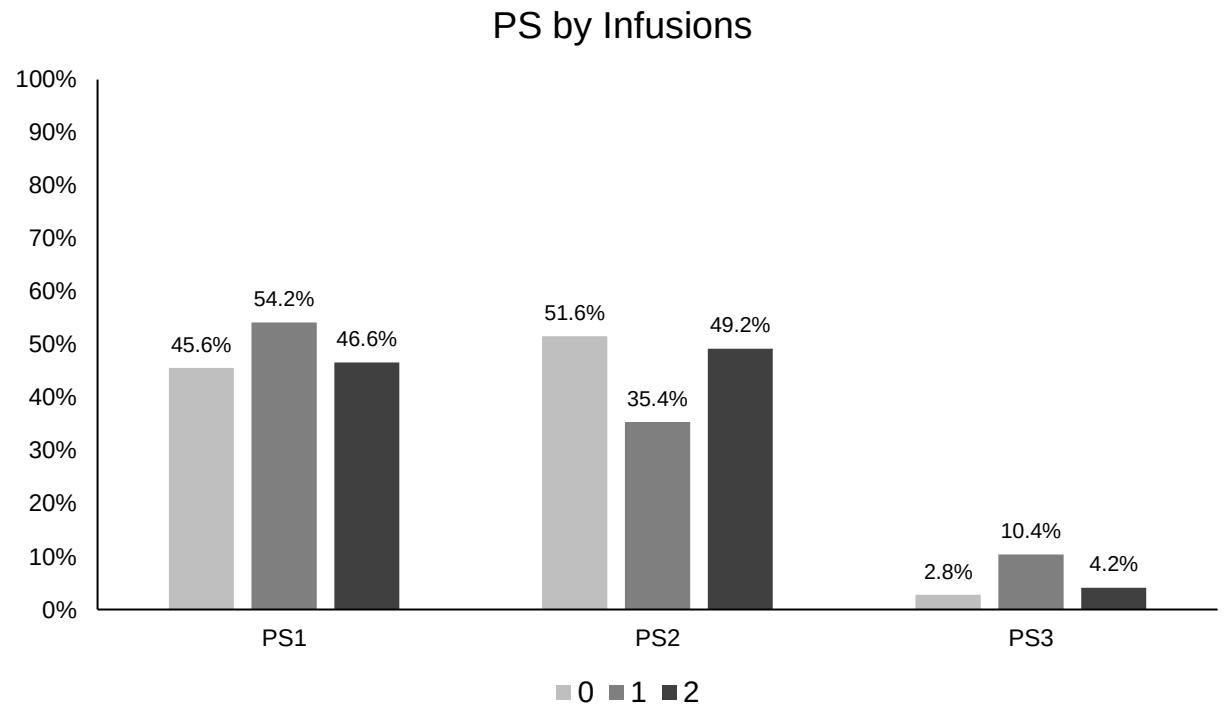
Animals and Treatments

- Utilized sows across 10 breed weeks
- 1,563 Sows
  - CON: 739
  - TRT: 824
    - 107 received only 1 infusion
    - 717 received 2 infusions
- Infusion 1 given gestation day 91-101
- Infusion 2 given gestation day 107-117

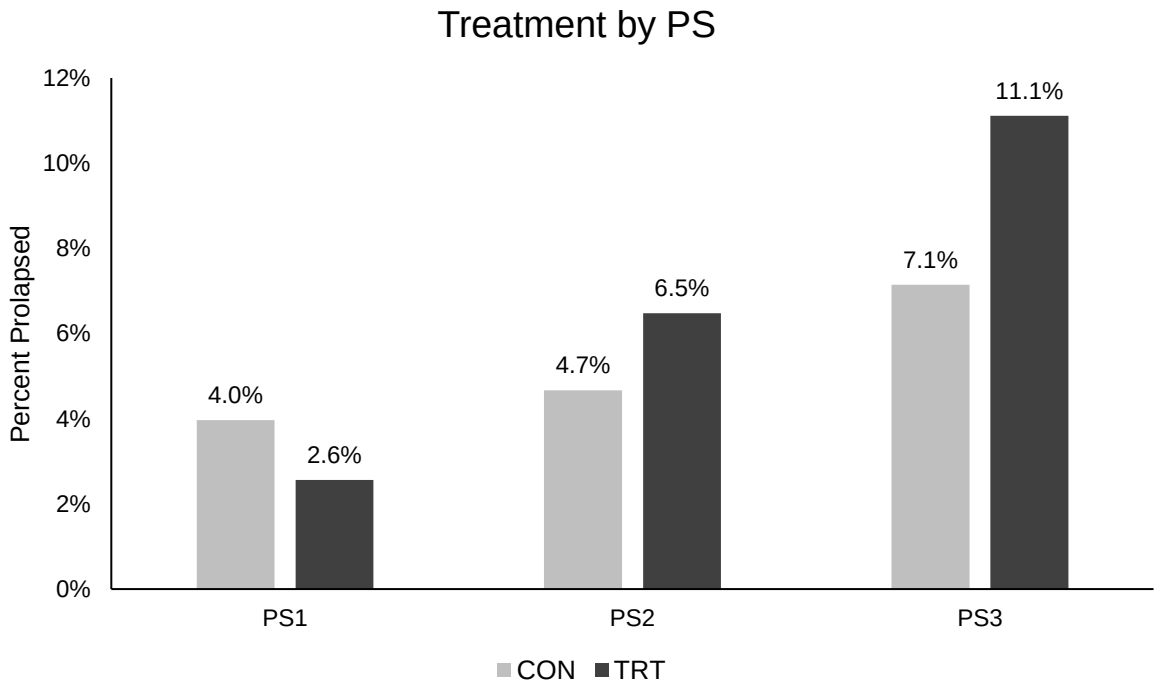
- Sows assigned a PS gestation day 107-116

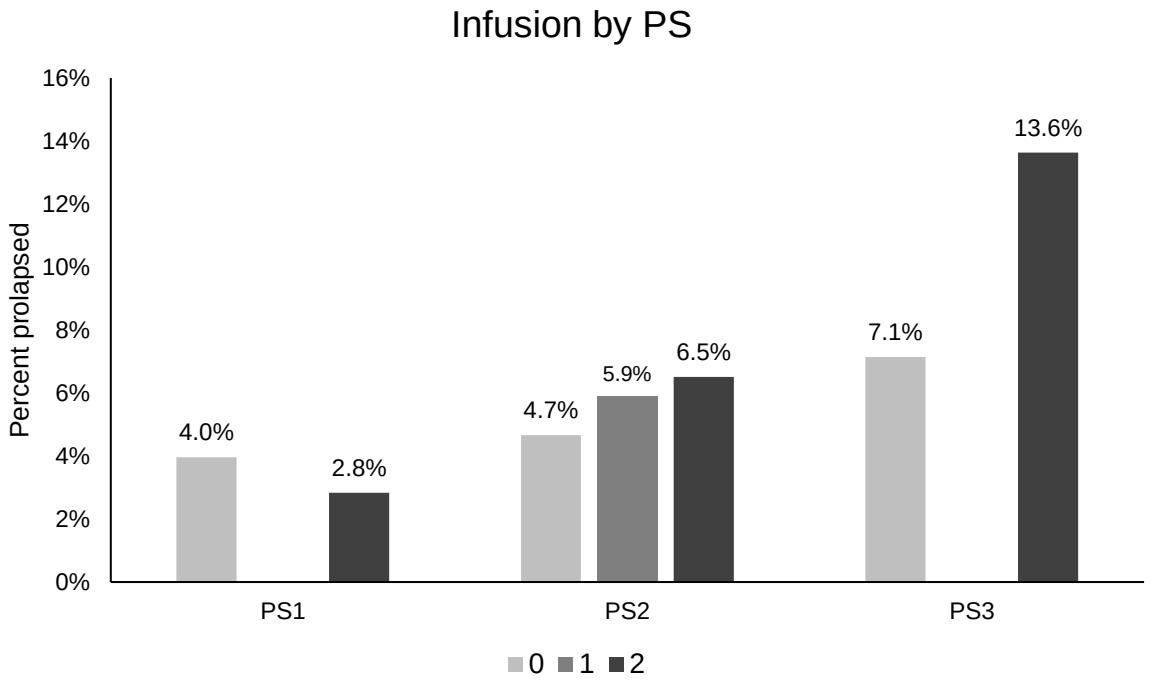
Treatment did not affect perineal score



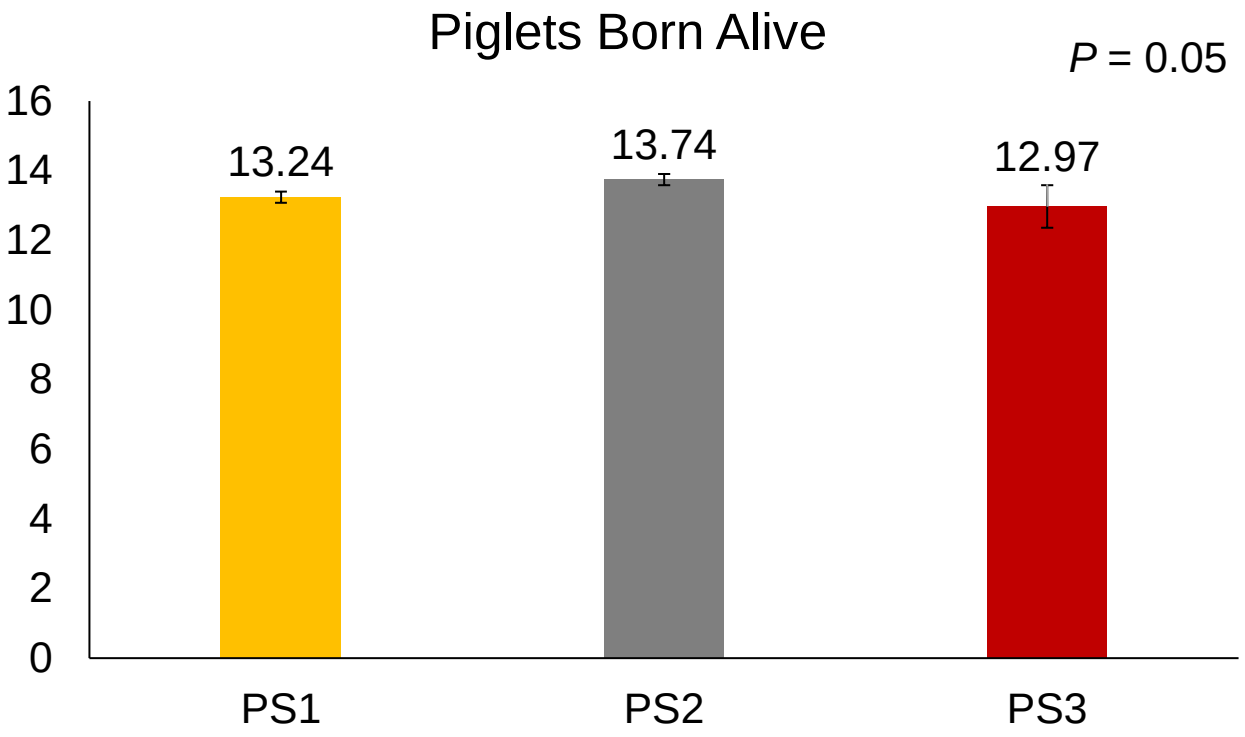


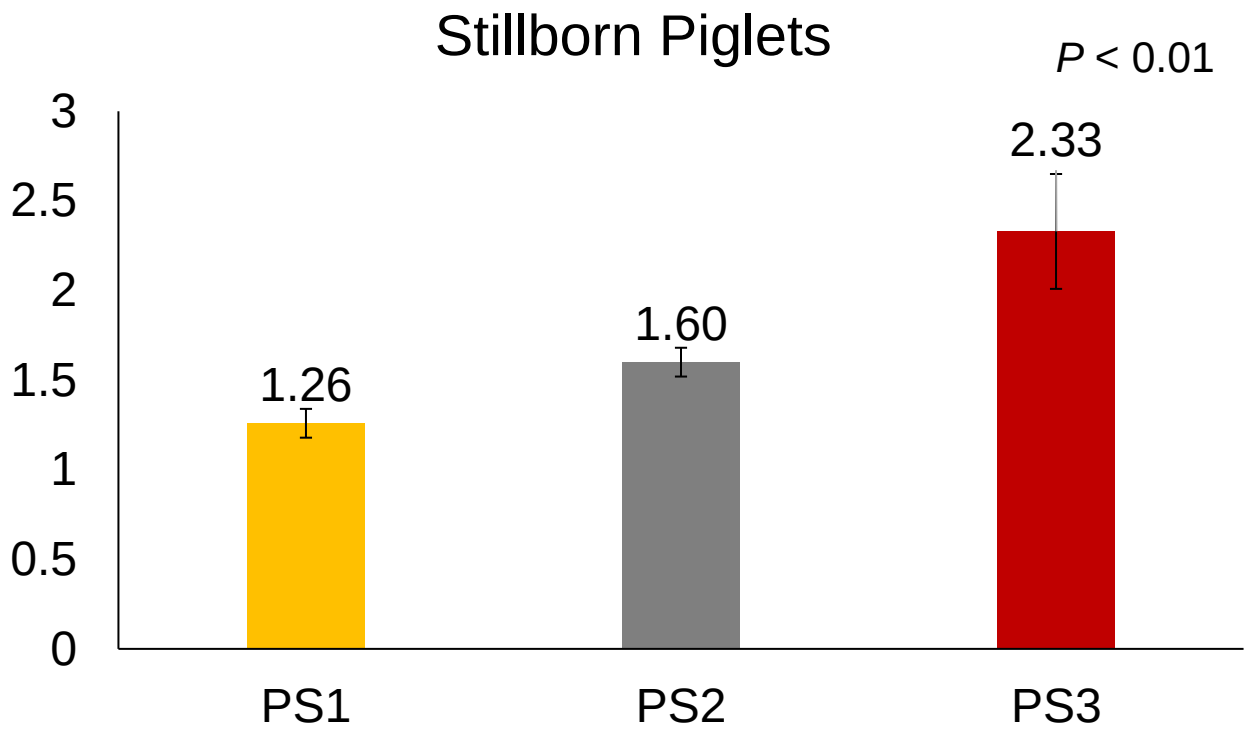
Treatment did not affect prolapse incidence





Decreased Born Alive and Increased Still Born Observed in PS3 Sows





Conclusions

- The vaginal and fecal microbiome differ based on risk of POP.
- On farm mixing of BMD did not influence POP incidence.
- Vaginal infusions with ampicillin had no effect on POP incidence or perineal score development.
- There is still work to do!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