PRAIRIE SWINE CENTRE

2020 Annual Research Report

Sask Pork | Alberta Pork | Manitoba Pork | Ontario Pork | Saskatchewan Ministry of Agriculture | University of Saskatchewan

Our Mission

"We provide solutions through knowledge, ensuring a profitable and sustainable pork industry for our stakeholders and staff."

PRAIRIE SWINE CENTRE

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Report Highlights

Chairman's Report

Developing collaborations for a stronger Canadian pork industry

This past year has been a challenge for the Pork industry and also for the Prairie Swine Centre.

Navigating through a pandemic is not something any of us were prepared for. Under Murray's leadership the Prairie Swine Centre has however continued to provide research results to the industry as we move forward in solving the issues and opportunities that are in front of us.

Murray and his team have worked hard to implement the short and long term goals developed in the current strategic plan. The PSC board wants to recognize the effort and focus of these initiatives through the challenges of Covid-19. The Knowledge Transfer and Translation Program have adjusted the delivery of information and have remained very connected to the industry.

The Centre Board wants to recognize the production staff at the Centre as they continue to conduct and support world class research while achieving sow, nursery and finisher production numbers that benchmark amongst the best in Canada.

As we move into 2021 the Board and Senior Staff will work on integrating the valuable research by cooperating with other research centres in Canada and around the world.

The PSC deeply appreciates and values the financial support from the Province of Saskatchewan as well as the Pork Boards from Manitoba, Saskatchewan, Alberta, Ontario and Quebec. The PSC also wants to highlight the valuable relationship with the University of Saskatchewan and continue to help the University achieve its own research and teaching objectives.

On behalf of the board I want to thank the Prairie Swine Centre team for their hard work and commitment which has led to such a unique and successful research year. This annual research report is evidence of the passion and dedication of the entire team. I want to thank retiring Board members for their expertise and contributions, and welcome new Board members for 2020.

The PSC board looks forward to working with Murray Pettit and his highly skilled team during the coming year.

Don Down
Chairman of the Board

Left to right: *Javier Bahamon, Neil Ketilson, Zenon Forster, Rodelle Genoway, Andrew Van Kessel, Murray Pettitt, Fred Fast, Nicole Rozon, James Ressor, Don Down, Brad Marceniuk*

Missing: *John Harding, Robet Tyler, Nancy Johns, Vincent Cloutier*

President's Report

Creating our future - with a focus on yours.

In these times of unprecedented challenges to the Canadian swine industry, Prairie Swine Centre continues to provide information to assist the industry with the questions and challenges of today and the future.

The unexpected COVID-19 pandemic upset the pork supply chain, causing economic hardship for producers and other associated industries. Prairie Swine Centre remains focused on applied research that can contribute to the economic and environmental sustainability and social licence of the Canadian pork industry, especially during these turbulent times.

With the change in regulations eliminating the use of in-feed antibiotics, alternate management procedures need to be developed. This report contains updates on raised without antibiotics (RWA) pig production, development of alternative sanitization and disinfection measures that would be effective for control of potentially antibiotic-resistant pathogens, and the use of amino acid supplementation in the feed to enhance the health robustness of pigs.

Prairie Swine Centre is also focusing on biosecurity and pig welfare during transport through the development of a prototype trailer that improves the biosecurity and welfare of the pigs during transportation. This mechanically ventilated, filtered trailer is in the process of being modified based on our initial testing with the goal of developing a trailer that manufacturers can use as a guide for designing their next generation of biosecure- and welfare-friendly trailers.

Studies to develop safe feeding practices or processing techniques to mitigate the effects of grain contamination on the health of pigs are also included in this report. These and other articles included in this report address practical issues faced by swine producers throughout Canada.

The COVID-19 pandemic has eliminated in-person swine industry trade shows, meetings and conferences. Although we can no longer pass on our information at these events, we have adjusted our Knowledge Transfer and Translation Program to deliver information through electronic and video means. This will ensure we continue to serve our clients and you will continue to see regular updates from Prairie Swine Centre. I would also strongly encourage you to directly reach out to us when we can be of assistance.

I wish to thank all PSC staff and students for all of their contributions towards the work in this report, and for making the adjustments required due to COVID-19, to ensure we can continue to proudly serve the Canadian pork industry. Their dedication to excellence is reflected in this report.

Take care, be safe.

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Murray Pettitt
President

MANAGEMENT

Knowledge Transfer Report

Delivering timely, accurate and practical information has always been the goal of the KTT program at the Centre. The past eight months have been challenging in connecting with the pork industry in traditional ways. Meetings, conferences, trade shows and other in-person events have always been an important part of what has made the Centre successful. These events create a dynamic where an exchange of information is important to the producer and the scientists. We learn just as much from the industry in regards to challenges and opportunities producers face on a daily basis in their operations.

Finding new ways of delivering research results to the pork industry is not something new for the Centre. Over our history the KTT has evolved meeting the needs of an ever changing pork industry. While the pillars of personal, print and electronic communication remain the same over the years, the influence of each and how we communicate within each pillar has changed. Always keeping in mind the benefit to the producer and the pork value chain. We have added additional resources to the KTT program at the Centre. This ensures we will deliver the information and results required to make producers succeed. While we continue to adapt to challenges placed in front of us, we will all be stronger in the end as we make our way through these uncharted times.
Lets look back at an Ipsos-Reid survey of agricultural producers that identified print (72%) and websites (50%) as the two most commonly preferred ways of receiving information, while social media ranked very low comparatively (2%). It would be interesting to re-visit these survey results today, to see if challenges faced by producers and the pork value chain would require different types and frequency of communication. Today many web-conferencing services such as Zoom and Webex are common as we adapt to a new reality of reduced personal contact. It is important not to get lost in the shuffle of being Zoomed out – as most organizations have headed in this direction. Standing out can be a challenge, but one of the keys to success.

In the past year we have seen a roller coaster of emotion and profitability within the pork industry. The Ipsos-Reid survey also indicated that new technologies and products are typically the information that producers are looking for. Being an early adapter ensures producers they will remain competitive in the global market. However, when we are dealing poor margins in the short term, we can't lose sight of those things that have got the industry to where it is today. Successfully communicating and adapting research results and best management practices is key on helping the industry through these times.

Today approximately 40% of Canada's hog production is classified as vertically integrated, colonies represent approximately 25-30% of production with the balance of production being held in various sized operations. How we communicate with the industry is, and needs to be different than the way we have communicated in the past, especially throughout this past year. It seems reasonable that throughout 2020 more individuals and companies would rely on electronic communication. As such, the Centre has dedicated additional resources to ensure prairieswine.com has the latest and most pertinent information available to producers.

As we continue to adapt to these strange times we will continue to develop communication plans for each one of our target markets. The ultimate goal of Technology Transfer, is Technology Adoption. Ensuring the industry is implementing those recommendations produced by the research programs at the Centre will help to address profitability, competitiveness, and sustainability (welfare & environmental) in the industry.
We are always assessing the most effective way in driving research, and will continue developing new strategies in communicating with producers. The end goal always remains the same – a profitable and prosperous Canadian pork industry.

Ken Engele
Manager, Knowledge Transfer

Production Report

Each year the production team places a great deal of emphasis on addressing challenging areas in the barn, while continuously working towards improving sow productivity and managing research needs. This past fiscal year our focus was to improve sow body condition, increase productivity and reduce post wean mortality. Through regular observations of sow's behaviour, monthly feed calibrations/density checks and environmental adjustments, we were able to find that delicate balance of maintaining optimal body condition during gestation. We continue to use caliper as a guideline and currently 80 % of our herd falls under the ideal category. In the past six months, we have seen improvement in the post wean mortality. With nursery trials finished, we were able to resume regular production management of weaner pigs. Following recommendations from PIC, Dr. Harding and valuable information from the Pork Symposium, we made a few adjustments that made some positive impacts on the nursery pigs. Along with resuming creep feeding prior to weaning, sorting pigs by size at weaning, we also manage fewer pigs per pen in the nursery. Runt pens get extra matt feeding or wet feed for the first week in the nursery and replacements are moved away from the door and cold air drafts. Feeding program of newly weaned pigs has changed to multiple small meals throughout the day, for the first five days in the nursery. When possible, we hold back a nurse sow for smaller weaners. The number of treated pigs in the nursery has decreased in the past few months as well.

In reviewing rolling averages this fiscal year we are seeing overall improvement in all of the numbers. Our research clients require a consistent and large supply of pigs of all ages to be available to meet their needs.

Since July 2019, we had over twenty research projects started in grow finish, breeding, gestation, farrowing and nursery rooms (five Nutrition trials, six Ethology trials, three for Contract Research, six for VIDO and two for U of S research). We continue the balancing act between managing high productivity and meeting research needs.

Working closely with everyone, keeping communication lines open and having great staff that is willing to go the extra mile when needed makes all of this possible.

As of May 31st, we have sold 7,707 animals and by the end of this fiscal year, we should be over 8,240 animals sold. That is slightly above the target of animals sold for this year. The realities and challenges created by COVID-19 are taking a toll on the swine industry. Our customers and fellow researchers are facing challenges they have not faced before. The University shutting down and Penner Farms and Riverview Colony closing their door, for a few weeks, has contributed to fewer animals sold than expected in this fiscal year. Our efforts shifted to managing the risk to the work environment, safety and health of our personnel and their families as well as welfare of our animals. Centre entrance was limited to essential personnel only and to those whose activities were required in the barn. Staff are doing a great job in adapting and implementing new procedures and protocols.

Tatjana Ometlic
Assistant Manager, Operations

We developed a contingency plan in case there is a packing plant temporary closure. This should allow us not to ship for close to 4-6 weeks if the packing plant was to, temporarily, close.

In light of the effect of COVID -19 pandemic on the industry and the high degree of uncertainty, we revisited our breeding target and numbers of animals needed to fulfill our commitment to MLF and research. The decision was to remain at 14 animals bred per week. The current targets set will allow us to follow space requirements from the Canadian Code of Practice while sustaining a high productivity herd.

Table 1. Production targets for fiscal year 2019-2020

Category	Target/week	Rolling Average (Jan – May, 2020)
# Bred	14.0	14.1
# Sows farrowed	12.7	13.0
# Pigs born alive	178	182.2
Average born alive	14.0	14.1
# Piglets weaned	161.0	164.4
Pre-wean mortality	9.60%	10.36%
Post-wean mortality	3.0%	2.7%
Grow-finish mortality	2.0%	1.7%
# Sold/week	156.0	157.3

Table 2. Production parameters for calendar years 2017, 2018, 2019 and the first 21 weeks of 2020: (Pig Champ)

	2017	2018	2019	Jan-May 2020
Number of sows farrowed:	760	744	696	285
Conception rate %:	91.8	90.6	90.7	95.8
Farrowing rate %:	92.0	90.8	89.8	93.2
Average born alive/litter:	14.2	14.0	14.2	14.3
Farrowing index:	2.48	2.48	2.47	2.47
Number weaned/sow:	12.4	12.4	12.6	12.7
Pre-wean mortality %:	12.1	12.0	11.2	11.0
Pigs weaned/sow/year:	30.1	29.5	29.6	29.6

We had our yearly visit in November 2019 with PIC. Once again, Steffen Klenk was pleased with the barn appearance and condition of our herd. We reviewed our objectives from the last visit. Steffen noted that majority of the sows were in good condition and 20% of sows were a bit on the heavier side. The recommendation was to continue using caliper at breeding on days 30, 60 and 90 to help reassess the condition and adjust feed intake accordingly.

The quality of gilts at hand was very good. They had good leg and toe quality in particular. GDU is being managed well. Steffen recommended focusing on mating young, L03 gilts pure to minimize any genetic leg. At this time, Steffen decided that there is no need for new L03 females through a C – section project. We were to continue with the Gilt Dynamic pen in Gestation, once the Ethology trial was completed.

To help minimize any impact on farrowing rate, we agreed for gilts/sows not to be mixed before 30 days post breeding. We needed to shift a few activities in our weekly routines to accommodate this change, but were able to manage. We also agreed that it would be a good idea to do another ultrasound check at day 45-55 post breeding. Historically our herd has an average of 1 % abortions per year, but the number of NIP's is over 3%, on an average (based on the records since 2013). Despite our best efforts, prevention and management (mixing 30 days post breeding, gilt dynamic pen, second round of pregnancy checking, vaccination schedule 3-5 weeks before farrowing, environmental factors) we are still seeing a high number of abortions and NIP's. Multiple tissue samples were submitted to PDS for further investigation and to eliminate any underlining issues. Dr. Gauvreau did not find anything alarming in the findings from the PDS results.

Looking at the Performance Trend Analysis for the past 12 months, we can see periods where there is a decline in farrowing rate (89.9 %) due to the number of animals aborted or found NIP. Looking closely at the breeding weeks and dates, we can see that there was an issue with a couple of weeks' worth of semen in July 2019, ending with a significant number of open sows in gestation. We had 64 services in July and only 44 sows farrowed in November 2019. While performing regular semen checks staff noted that there was decreased semen motility and clumping at the time of semen collection for those breeding weeks in July. PIC was relocating their boar stud in June 2019 that could have contributed to the quality of semen collected from a new location in June 2019. Seasonal fertility could have contributed to some of the abortions/ NIP's, but certainly not in 5% of NIP's and 1.8% of abortions in 2019.

In May 2019, Canadian Council on Animal Care (CCAC) panel suggested that teeth clipping should be an exceptional procedure and used only in case of serious problems. We were committed to pulling away from teeth clipping, even though we were not successful with that in the past, as disadvantages would outnumber the benefits.

In November 2019, we discontinued teeth clipping. We have been scoring facial lesions to monitor closely and treat piglets with more severe facial injuries. The number of treatments has doubled since the non-teeth clipping procedure started.

In December 2019, we had our herd health visit with Dr. Cutts, as well as with Dr. Forster and Dr. Gray who were assessing our pigs after discontinuing teeth clipping in November 2019. In summary, Dr. Forster and Dr. Gray suggested that only most severe lesions would need antibiotic treatment. Less severe lesions could benefit from metacam and zinc oxide cream. Dr. Forster suggested that we are headed in the right direction and with proper management we could achieve the goal of eliminating prophylactic teeth clipping, pre-wean mortality and acceptable level of antibiotic treatment without compromising welfare of the piglets.

Our staff needed time to find the new balance in accepting that there will be more of face lesions and finding a level that will respond without antibiotic treatment. Having staff track lesions in litters helped in communicating better and working as a team.

These are challenging times and the information is changing from day to day. We are minimizing traffic to our main office and the barn. The PSC is an essential service and all measures will be taken to ensure that barn staff remain COVID -19 free. Only those staff, students and scientists required to be at the Centre to carry out research or production work would have access to facility. Therefore, all the upcoming visits (RWA audit, UACC facility inspection, Herd Health visit) have been postponed or will be held via teleconference or video conference, if possible.

I would like to acknowledge our staff at PSC, office and barn, whose efforts, hard work and enthusiasm are once again showing the strength of our organization. This unprecedented situation has impacted our lives in so many ways. Thank you all for doing your part to contain the spread of COVID -19 in our communities and our company.

I would like to commend our CEO for leading us through this difficult time by making sure that as a company, our top priority is to keep focused on doing what is right for our staff, and keeping the company healthy and operational while we navigate the COVID -19 virus pandemic. Staying connected with the barn staff, addressing issues and getting supplies are just a few of the things I am very thankful for. I look forward to the moment when we can all celebrate our achievements together.

Long-Term Feeding of Graded Levels of Deoxynivalenol in Grower-Finisher Pigs

D.A. Columbus[1,2], A.D. Beaulieu[1,2], N. Hogan[2] and R. Newkirk[2]

Summary

Mycotoxin-contaminated grains are commonly downgraded for use in livestock feed and, while the best strategy for livestock producers is to avoid feeding mycotoxin-contaminated grain altogether, with the increased incidence and level of contamination this is no longer a viable option. Therefore, strategies that allow the use of mycotoxin-contaminated grains in livestock feed are necessary.

Based on the preliminary results of this study, feeding 3 or 5 ppm DON resulted in reduced body weight and growth performance, however, evidence suggests pigs can adapt to DON-contaminated diets. In addition, DON may have less of an impact on younger animals. While older animals also have an ability to adapt to DON, the shorter time-period available for recovery may be insufficient. Results also indicate that the effects of DON-contamination on growth performance largely relates to a reduction in feed intake, as feed efficiency remained relatively constant across dietary treatments.

Introduction

The mycotoxin, deoxynivalanol (DON, also known as vomitoxin), is of significant importance to agriculture since it commonly contaminates corn, wheat, oats and barley and is one of the most prevalent mycotoxins in Canada. In the World Mycotoxin Survey conducted by BIOMIN, DON was reported to be the most prevalent mycotoxin in many ingredients of importance in swine, occurring in 77, 70, 46, and 48% of corn, barley, wheat and soybean samples tested, respectively. In North America, 58% of all grain samples analyzed contained DON, representing a 'severe risk' (Biomin, 2016). Data for wheat in Saskatchewan shows an increase in the incidence of fusarium, with 80-90% of wheat (CWRS and Durum) downgraded due to DON contamination.

Contaminated grains are commonly downgraded for use in livestock feed and, while the best strategy for livestock producers is to avoid feeding mycotoxin-contaminated grain altogether, with the increased incidence and level of contamination this is no longer a viable option. Therefore, many strategies typically include the elimination or reduction of the negative effect of mycotoxins in animal feeds. Most of these strategies focus on the deactivation of mycotoxins through binding of the mycotoxin using adsorbents, such as silicate clays and activated carbon, which can be included in feed as non-nutrient additives. In general, however, current feed additives are relatively ineffective in mitigating the negative effects of mycotoxins

Given the increasing incidence of DON-contamination there is an obvious economic impact of mycotoxin contamination for both the grain and pork sectors. Further information is required on long-term DON exposure in grower-finisher pigs that can be used to develop feeding programs which maximize inclusion of DON-contaminated grains while minimizing the impact on growth performance and profitability of both pork and grain producers.

Experimental Procedures

A total of 240 grower pigs (initial body weight of 35.9±1.1 kg) were housed in groups of six pigs/pen and randomly assigned to one of four dietary treatments over two blocks (n=10/trt). Dietary treatments (Tables 1) consisted of a control diet with no DON contamination (CON), or one of three DON-contaminated diets containing 1, 3, or 5 ppm DON (DON1, DON3, DON5). DON diets consisted of replacing clean wheat with naturally contaminated wheat and wheat screenings. Diets were isonitrogenous and isocaloric in order to meet or exceed nutrient requirements according to NRC (2012). Pigs were fed ad libitum for a total of 11 weeks (six weeks grower, five weeks finisher). Blood samples were obtained at 0, 2, 6, 8, and 11 weeks for liver and kidney blood chemistry panel (Prairie Diagnostic Services, Saskatoon, SK) as indicators liver and kidney function.

Results and Discussion

There was a significant decrease in body weight of DON3 and DON5 compared to CON-fed pigs by day 35, with no effect of DON1 (Table 2) to the end of the study. DON3 and DON5 reduced average daily gain in the grower phase and overall compared to CON-fed pigs. There was no DON effect on average daily gain in the finisher phase. There was a reduction in average daily feed intake during the first week of the study in DON3 and DON5-fed pigs compared to CON, with no effect of treatment in grower phase overall. Compared to CON, DON-fed pigs experienced a reduction in feed intake throughout the finisher phase and over the entire study, with no effects on feed efficiency.

Feed intake of DON-fed pigs was reduced compared to control fed pigs, while feed efficiency was only reduced in week one, suggesting that the capacity for growth is not affected in these pigs but feed intake is insufficient to support maximum growth. Based on these preliminary results, while feeding 3 or 5 ppm DON resulted in reduced body weight and growth performance, there is evidence that pigs can adapt to DON-contaminated diets. There was no impact of dietary treatment on any measures of kidney and liver health (data not shown).

Implications

Overall, it may be possible to feed diets containing higher levels of DON than currently recommended, however, adjustments would be needed in housing or feeding or in feed costs to account for reduced market weight.

Acknowledgements

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Table 1. Experimental diets used to determine effects of long-term mycotoxin exposure in finisher pigs

	CON	DON1	DON3	DON5
Ingredient (%, as-fed)				
Wheat (clean)	30.0	33.3	20.0	6.7
Wheat (8 ppm DON)[1]	-	4.9	14.8	24.7
Wheat screenings (35 ppm DON)[1]	-	1.7	5.2	8.6
Barley	39.2	39.2	39.2	39.2
Canola oil	3.7	3.7	3.7	3.7
Soybean meal	14.0	14.0	14.0	14.0
L-Lysine	0.463	0.463	0.463	0.463
DL-Methionine	0.075	0.075	0.075	0.075
L-Threonine	0.144	0.144	0.144	0.144
Limestone	1.00	1.00	1.00	1.00
Dicalcium phosphate	0.80	0.80	0.80	0.80
Salt	0.50	0.50	0.50	0.50
Vitamin/mineral premix[2]	0.20	0.20	0.20	0.20
Calculated nutrient content[3]				
DM (%)	86.4	86.4	86.4	86.5
ME (kcal/kg)	3291	3291	3291	3291
CP (%)	17.5	17.5	17.5	17.5
Lysine (%, SID)	0.98	0.98	0.98	0.98
DON (ppm)	0	1	3	5
Analyzed nutrient content[4]				
DM (%)	89.2	88.4	82.9	89.4
CP (%)	15.4	17.4	16.4	16.4
DON (ppm)	0.28	0.73	3.4	4.36

1 DON content of contaminated wheat and wheat screenings determined at Central Testing Laboratory (Winnipeg, MB)

2 Provided per kg of complete diet: vitamin A, 8000 IU; vitamin D, 1500 IU; vitamin E, 30 IU; menadione, 2.5 mg; vitamin B12, 0.025 mg; thiamine, 1.00 mg; biotin, 0.10 mg; niacin, 20 mg; riboflavin, 4 mg; pantothenate; 12 mg; folic acid, 0.50 mg; pyridoxine, 2.0 mg; Fe, 100 mg; Zn, 100 mg; Mg, 40 mg; Cu, 15 mg; Se, 0.30 mg; and I, 1mg

3 Nutrient content of diets calculated based on published nutrient requirements of ingredients according to NRC (2012) and INRA (2002)

4 DON content analyzed by Biomin.

Table 2. Growth performance of finisher pigs fed diets containing graded levels of DON for 6 weeks

	CON	DON1	DON3	DON5	SEM	P-value
Body weight (kg)						
Day 0	36	35.59	35.66	36.38	0.34	NS
Day 7	42.45	41.61	40.71	41.67	0.44	NS
Day 14	50.06[a]	49.81[a]	47.83[b]	49.20[ab]	0.49	0.01
Day 21	58.03[a]	57.70[a]	55.70[ab]	56.66[b]	0.60	0.04
Day 28	68.07	67.60	65.39	65.76	0.84	NS
Day 35	75.91[a]	74.47[ab]	72.73[b]	72.70[b]	0.86	0.03
Day 42	85.14[a]	83.73[ab]	81.98[b]	81.62[b]	0.91	0.005
Day 49	94.72[a]	93.09[ab]	90.94[bc]	89.83[c]	0.96	0.005
Day 56	102.66[a]	100.86[ab]	98.26[bc]	97.71[c]	1.00	0.004
Day 63	110.55[a]	108.64[ab]	106.32[bc]	105.02[c]	0.91	<0.001
Day 70	118.44[a]	116.22[ab]	114.59[bc]	112.92[c]	0.91	0.001
Day 77	124.92[a]	123.40[ab]	120.98[bc]	119.92[c]	0.91	0.002
Average daily gain (kg/d)						
Week 1	0.92[a]	0.86[a]	0.72[b]	0.76[b]	0.04	0.001
Week 2	1.09	1.17	1.02	1.08	0.04	NS
Week 3	1.14	1.13	1.12	1.06	0.03	NS
Week 4	1.44	1.42	1.38	1.3	0.06	NS
Week 5	1.15	1.12	1.14	1.11	0.04	NS
Week 6	1.32	1.32	1.32	1.27	0.04	NS
Grower Phase	1.17[a]	1.15[ab]	1.10[bc]	1.08[c]	0.02	<0.01
Week 7	1.37[a]	1.34[a]	1.28[a]	1.17[b]	0.04	<0.01
Week 8	1.13	1.11	1.05	1.13	0.06	NS
Week 9	1.13	1.11	1.15	1.04	0.05	NS
Week 10	1.13	1.08	1.18	1.13	0.04	NS
Week 11	0.93	1.03	0.91	1.00	0.06	NS
Finisher Phase	1.14	1.13	1.11	1.10	0.01	NS
Overall	1.15[a]	1.14[a]	1.11[b]	1.09[b]	0.01	<0.001
Average daily feed intake (kg/d)						
Week 1	1.59[a]	1.55[a]	1.40[b]	1.42[b]	0.04	0.002
Week 2	1.90	1.98	1.78	1.81	0.07	NS
Week 3	2.03	1.95	1.93	1.95	0.06	NS
Week 4	2.37[b]	2.58[a]	2.49[a]	2.49[a]	0.03	0.002
Week 5	2.79	2.77	2.67	2.60	0.05	NS
Week 6	3.17	3.07	3.09	2.95	0.08	NS
Grower Phase	2.29	2.27	2.20	2.18	0.03	NS
Week 7	3.17[a]	2.95[a]	2.96[a]	2.71[b]	0.08	0.004
Week 8	3.19[a]	3.06[ab]	2.99[b]	2.94[b]	0.06	0.01
Week 9	3.02	2.80	2.89	2.88	0.09	NS
Week 10	3.19	3.05	3.06	2.97	0.05	NS
Week 11	3.05	2.99	2.94	2.91	0.07	NS
Finisher Phase	3.12[a]	2.97[b]	2.96[b]	2.88[b]	0.05	<0.001
Overall	2.62[a]	2.55ab	2.47[b]	2.47[b]	0.03	0.003

[a,b,c] Means within a row without a common superscript differ significantly ($P < 0.05$)

Feed Processing to Reduce Ergot Toxicity

A.D. Beaulieu[1,2], E. Zeeman[2] and J. Panisson[1,2]

Summary

Wheat and rye screenings heavily contaminated with ergot (400 to 500 ppm) were subjected to either steam explosion (200 psi) or pelleting to evaluate the impact on toxicity. Total ergot content decreased 40 to 60% with processing, with a greater decrease associated with more drastic processing (steam explosion). Results also indicated that not all the ergot alkaloids are affected similarly by processing. However when these screenings were included in diets (0 to 4 ppm ergot) for weanling pigs growth and feed intake were linearly reduced in the first week with increasing ergot, but only when the ergot was unprocessed, indicating that the processing (steam explosion) did indeed reduce toxicity.

Introduction

Ergot alkaloids infect grasses and cereal crops such as rye, wheat, triticale and barley. Most commercial assays determine total alkaloid content and typically about 8 different alkaloids. There is some evidence that theses alkaloids vary in toxicity. Unlike other mycotoxins, ergot alkaloids are toxic to all livestock species, including ruminants. Symptoms of toxicity range from reduced feed intake to gangrene in the extremities. Synthesis or release of the hormone, prolactin, appears to be especially sensitive to ergot toxicity. The negative effect of ergot on prolactin is responsible for the decrease or complete cessation of milk production observed following ergot ingestion.

There is some limited evidence that suggests ergot toxicity can be reduced by processing such as pelleting. This project set out to utilize steam explosion as an example of extreme processing to determine potential effects on ergot toxicity, monitoring the alkaloid composition of contaminated material following steam explosion under different conditions. Feeding trials with piglets measured the change in toxicity. This information will be used to determine potential processing strategies to decrease ergot toxicity in growing pigs.

Experimental Procedures

Study 1

Rye and wheat screenings were subjected to steam explosion at 200 psi for two or five minutes with or without prior soaking for 40 minutes or “harsh” or “mild” pelleting with temperatures of approximately 75 or 85 °C, respectively. Samples of the processed or unprocessed screenings were assessed for ergot alkaloid content (HPLC/MS; Prairie Diagnostics Services, Saskatoon, SK)

Study 2

A total of 324 newly weaned piglets, housed four pigs per pen, were grouped by gender and weight and assigned to one of nine treatments. They received a phase 1 diet for 3 days, then the treatment diets for a 28 d growth trial.

1. Control (0 ppm ergot)
2. No processing 0.5 ppm ergot
3. No processing 1.0 ppm ergot
4. No processing 2.0 ppm ergot
5. No processing 4.0 ppm ergot
6. Steam exploded 0.5 ppm ergot
7. Steam exploded 1.0 ppm ergot
8. Steam exploded 2.0 ppm ergot
9. Steam exploded 4.0 ppm ergot

Heavily contaminated wheat screenings previously utilized in experiment one were steam exploded at 200 psi. The heavy contamination of these screenings allowed incorporation of only small amounts to achieve the desired ergot levels in the final diets.

Figure 1. The percentage change in ergot concentration when heavily contaminated rye screenings (~ 518 ppm) were subject to various processing methods

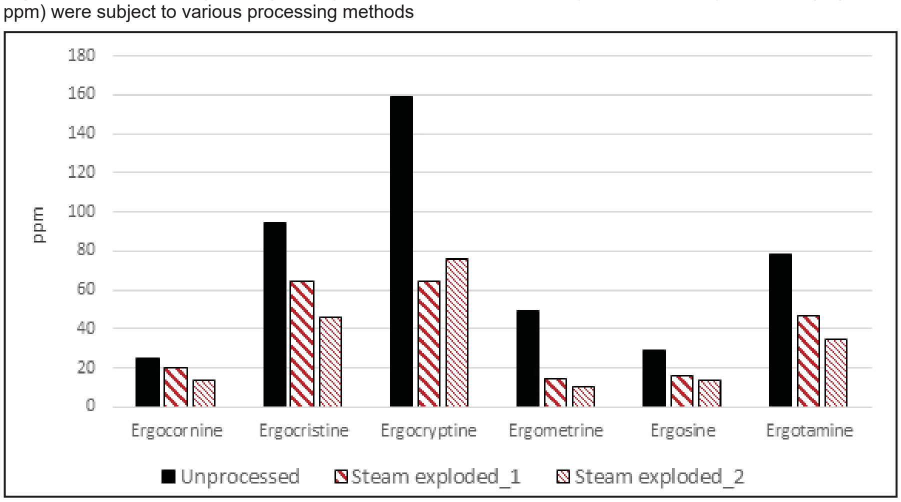

Figure 2. The effect of steam explosion (1) or steam explosion preceded by soaking for 40 minutes (2) on ergot alkaloid content (ppm) of heavily contaminated wheat screenings (approximately 434 ppm total ergot content)

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Results and Discussion

Pelleting reduced the ergot concentration of heavily contaminated rye to approximately 85% of the original concentrations, while steam explosion reduced it to approximately 60% of the original concentrations (Figure 1). Comparable results were observed with wheat screenings (Figure 2) as steam explosion (200 psi) resulted in a 55% reduction in total ergot alkaloid content, and steam explosion, preceded by soaking for 40 minutes reduced this by an additional 5%. As can be seen in Figure 2, the extent of the decrease in ergot content with processing varied among the various alkaloids tested. This is important as there is some evidence that toxicity of the alkaloids varies.

Study 2

Overall growth, feed intake and feed efficiency of piglets fed diets with 0 to 4 ppm ergot alkaloids for 28 days post-weaning was comparable among the ergot treatments (ergot P > 0.10). However, there was an ergot by processing interaction for the first week of the experiment (P < 0.01; Figure 3), as there was a linear reduction in growth rate when the piglets received the unprocessed screenings that was not observed when the screenings were processed. Unexpectedly, a comparable effect was not observed with feed intake (ergot by processing, day 0 to 7; P > 0.10) and thus there was an effect on feed efficiency (gain:feed ratio, ergot by processing interaction, day 0 to 7; P < 0.02). Piglets receiving the processed screenings, regardless of ergot levels exhibited increased growth rates, feed intakes and feed conversion throughout the entire experiment (processing, P < 0.01).

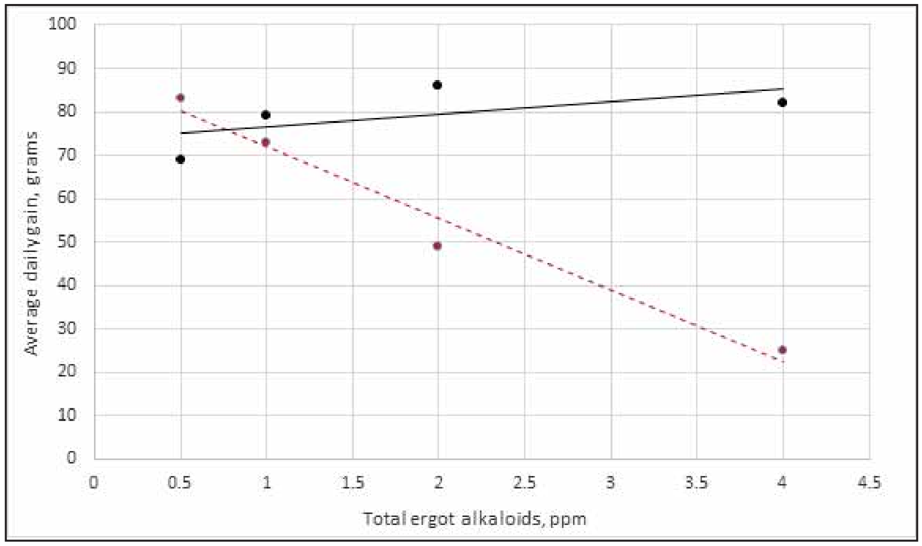

Figure 3. The effect of processing (steam explosion) heavily contaminated wheat screenings on the response of growing pigs, experimental day 0 to 71 post weaning, to 0.5 to 4 ppm ergot alkaloids in their diet (experimental d0 was 4 d post-weaning)

Implications

Extreme processing is a potential solution for reducing ergot contamination in cereal grains.

Acknowledgements

The authors acknowledge funding from the Saskatchewan Agricultural Development Fund under the Canadian Agricultural Partnership in support of this project. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we also wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

Modification of the Prototype Air-Filtered Trailer to Enhance Biosecurity and Welfare of Pigs During Transport

B. Predicala[1], A. Alvarado[1], J. Cabahug[1], M. Sapaden[1,2], and S. Kirychuk[3]

Summary

The development of a prototype trailer was aimed to address emerging biosecurity risks and enhance animal welfare during transport through the optimization of a current prototype trailer design. Trailer improvements were focused on enhancement of environmental control and data logging systems as well the addition or modification of necessary features such as drinkers, misters, and lighting in the animal compartment of the trailer.

Introduction

Airborne transmissible diseases have the potential to create significant economic losses due to loss in productivity, added costs of medication and eradication measures, and even loss of access to markets. A previous project examined the development of a new prototype trailer design aimed to protect the animals (such as high-value breeding stock) from airborne transmissible diseases during transport.

The design of the prototype trailer assembled in the previous project tried to integrate as many features as possible identified by stakeholders. The initial prototype was a first attempt at developing an entirely new platform for animal transport, however it still requires additional work before it can be widely adapted and commercialized. This project focused on the enhancement of trailer major components by integrating new desired characteristics in response to new and emerging concerns.

Experimental Procedures

The first phase of the project looked at implementing modifications to the existing prototype trailer to optimize its biosecurity and welfare properties for swine transport. Recommendations from previous work were re-examined to come up with a list of suggested modifications to the prototype air-filtered trailer, and supplemented by a search of information from various sources such as product brochures, feature articles, and promotional videos of various improved and modern livestock trailers. The search aimed to identify relevant, innovative and applicable features that can be part of the new trailer design. Further investigation also included the inspection of two existing state-of-the-art commercial pig trailers, manufactured in Europe, to gain first hand knowledge on available and promising new features.

Results and Discussion

Two aspects of trailer modification included: 1) modification of the instrumentation systems; and, 2) physical or structural modifications of the trailer. Table 1 presents a summary of modifications recommended for the prototype trailer.

Implications

A new and more versatile environmental control system was developed. The system has an independent and separate control for the top and bottom deck fans and will be governed by temperature, RH and CO_2 levels inside the trailer. The new system has more reliable data logging features that are capable of displaying data in real-time, allowing the driver to access to the data, or bypass the system, while in transit.

Acknowledgements

We would like to acknowledge the financial support for this research project from the Saskatchewan Agriculture Development Fund and the Canadian Agrisafety Applied Research Program funded by Agriculture and Agri-Food Canada. As well, Polar Pork Farms is acknowledged for the invitation to visit their modern hog trailer purchased from Europe. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we also wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

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Table 1. List of suggested modifications to the prototype trailer

Area of Modification	Description of Desired Modification / Reason for Modification
I. Instrumentation – Environmental Control and Datalogging System	
Ventilation system control	1. Independent and separate control for the top and bottom deck fans. The system is governed by: i. Temperature – primary ii. RH and CO_2 levels – could bypass temperature if RH and CO_2 levels are extremely high (exceed a set threshold level) while at minimum ventilation due to low temperatures. 2. Ability to log temperature, RH and CO_2 levels, as well as air flow inside the trailer at selected time intervals. Also, if possible, the % fan capacity at which each fan is running. This is to keep a log of ventilation flow rate for the entire journey. 3. Real-time display and access to above data while in transit, and capability to be bypassed by the truck driver if the need arises. 4. In-cabin controls and alarms.
Misting system	Ability to activate manually or automatically if certain temperature level is reached inside the trailer.
Portable heater	Ability to activate automatically or manually at certain temperature level in the trailer front compartment (i.e., close to air inlet, before the air filters)
Monitoring and data logging of the above parameters	1. Upgrade/replacement of sensors and stand-alone data loggers - shall be wired for permanent installation in the trailer, such that sensors (and its housing) can withstand washing and disinfection (including baking), or sensors can be easily removed/detached prior to washing and can be re-installed without technical complications. 2. Parameters to be monitored and logged: i. temperature ii. RH iii. CO_2 level iv. air speed/air flow v. trailer surface temperature – this parameter should be monitored real-time during baking to confirm when desired surface temperature is attained to achieve proper disinfection vi. GPS location monitoring
II. Physical / Structural Modifications	
Hydration control system	1. Water tank/s, water heater and water distribution system, with appropriate controller to activate the water tank heater at pre-set ambient temperature (i.e., European trailers have -10°C threshold, below which level the water system is not used). 2. Design safety for water distribution (e.g., avoid protrusions or pinch points) shall be considered.
Lighting	1. Interior lights will be permanently installed following welfare criteria on lighting, with manual or automatic control switches. 2. Installation of lights on rear exterior of animal compartment that can be activated together with hydraulic ramp control, for use during loading/unloading before dawn or after dusk.
Portable heater at front compartment	Heater/s shall be installed on the floor at the front compartment. This requires appropriate positioning and ducting to uniformly distribute the supplemental heat within the compartment, and then into both decks.
Space allotted for the front compartment	In the current prototype, the front compartment takes up much of the length of the trailer. For research, this may be convenient for conducting tests and data gathering, but for subsequent design, the front compartment space should be minimized to maximize the animal compartment capacity.
Access for inspection	This is required by regulation, especially at border crossing. This can be achieved by installing air-tight hatches along the side walls, which can be opened to carry out the inspection without compromising the biosecurity of the animals (i.e., prevent entry of unfiltered air into the compartment).
Wireless remote control of the hydraulic lift	The current wired controller for the operation of the hydraulic lift is quite inconvenient to use; a wireless option should be investigated.
Man-door or side access ladder	Walk-thru side door or a ladder on one side of the trailer at the rear part near the hydraulic lift should be installed for easy access to the hydraulic lift and into the animal compartment during loading/unloading.
Emergency unloading door for animals	In conjunction with the inspection hatch, this is needed in emergency situations when the hydraulic lift failed to operate.
Emergency plan in case of ventilation system failure/ malfunction	Also in conjunction with inspection hatch/unloading door, alternate openings for natural ventilation of the animal compartment should be installed in case of prolonged shutdown of the main ventilation system.
Water-proofing of sensor/ data loggers housing	Appropriate protective housing for electronic components should be installed. Alternatively, the sensors should be easily detachable prior to trailer washing and disinfection.
Generator exhaust pipe	Current exhaust pipe on the side of the trailer may allow the exhaust fumes to enter the air inlet of the front compartment. The exhaust pipe needs to be extended to vent the fumes at the top of the trailer.
Cleanability of animal compartment	Floor joists of the upper deck and support structures for trailer roof are exposed to which dirt can adhere. Currently, dirt accumulation is avoided by thorough power washing of these spots, but options to cover up the exposed structures should be explored to minimize washing time and to ensure better cleanability of the trailer.
Hydraulic lift side panels	Based on regulation, the required minimum height of the hydraulic lift side panels should be 90 cm. However, it has been noted during the tests of the prototype trailer that the current height of the existing hydraulic lift side panels is not sufficiently high for animal and handler safety. Options should be explored to increase the height of the side panels by adding detachable extension panels, without hindering the opening and closing of the hydraulic lift gate.

Investigation of Enhanced Sanitization and Disinfection Measures Applicable for Antibiotic-Free Pig Production System

B. Predicala[1], M. Baguindoc[1,2] and D. Korber[3]

Summary

This project aims to develop enhanced biosecurity measures that can eliminate or reduce the proliferation of disease-causing pathogens in antibiotic-free pig production as well as in conventional barns for all-inclusive disease prevention. Specifically, this will investigate alternative sanitization and disinfection measures that are effective for control of potentially antibiotic-resistant pathogens, and those measures that might prevent or reduce further development of antimicrobial resistance in the pig production environment.

A comprehensive literature review gathered information on existing and potential sanitization and disinfection technologies available in other jurisdictions, similar industries or applications requiring stringent pathogen control. Sanitization technologies identified from the initial literature search, including use of alternative chemical-based disinfectants, selected nanoparticles, thermal and irradiation technologies were subjected to screening to evaluate their potential applicability in Saskatchewan swine barns. Results will provide valuable tools for pathogen control not only to pig producers implementing antibiotic-free production but also for disease prevention in conventional livestock production in general.

Introduction

Overuse of antibiotics can contribute to the development of antimicrobial resistance to (medically important) antibiotics. In recent years, some pig producers have shifted to raising pigs without the use of any antibiotics, with processors offering premiums for pigs raised completely without antibiotics - as consumer demand for such products increased.

Producers developed strategies such as feeding prebiotics and enhanced vaccination programs to offset the reduced availability or the total absence of antibiotics in their operations. However past studies (Desrosiers, 2013) have shown high herd health also helps reduce the reliance on antibiotics. Therefore strong biosecurity and sanitization protocols are essential to ensure that exposure to pathogens is either eliminated or reduced significantly. Currently, the most commonly used method for controlling pathogens in pig production barns is the use of disinfectants such as quaternary ammonium compound (QAC) and peroxygen, which are more commonly known by their respective trade names. Repeated use of QAC-based disinfectants can lead to the disinfectant being no longer effective for gram-negative bacteria, especially to *Escherichia coli* (*E. coli*) and *Salmonella sp*. Therefore, there is a need for alternative sanitization and disinfection technologies that producers can reliably employ to control the growth and transmission of disease–causing microorganisms, particularly those that may have potentially acquired resistance to current conventional disinfectants and the antibiotics used in the farms.

Experimental Procedures

Phase 1: Evaluation of potential sanitization and disinfection techniques applicable to swine production in Saskatchewan

A comprehensive literature review was conducted compiling various sanitization and disinfection procedures and technologies that have been developed and applied in other industries and applications (such as water treatment facilities, hospitals, care home institutions, food processing and manufacturing facilities) to determine their possible application in swine barns. Potential measures include the application of technologies such as ultraviolet germicidal irradiation, non-thermal plasma, ozonation, thermo-assisted drying and decontamination, and the use of slightly acidic electrolyzed water, among others. Aside from the use of new technologies and equipment, the use of nanoparticles (zinc oxide, silver nanoparticle, and titanium dioxide) as potential antimicrobial agents was also considered, together with the use of various chemical-based disinfectants with different active ingredients (peracetic acid, hydrogen peroxide, chlorine dioxide, sodium hypochlorite).

Assessment criteria that considered cost, applicability, potential effectiveness against antimicrobial-resistant pathogenic strains, among others, was developed and then applied to identify the top three to four potential sanitization and disinfection alternatives for consideration in the next stage of evaluation.

Phase 2: In-barn testing of the selected most promising sanitization techniques

Efficacy of the top two potential sanitization and disinfection techniques identified in the previous phase for controlling the growth of disease-causing microorganisms will be evaluated in nursery and grower-finisher rooms at the Prairie Swine Centre (PSC) barn. After each room turn, selected rooms will be pressure-washed following standard cleaning practices, except the sanitizing/disinfecting step; this last step will be carried out as part of this experiment.

Phase 3: Feasibility analysis and development of recommendations and application guidelines

Following the in-barn experiments, a feasibility analysis will be conducted to determine the costs and requirements for the proper implementation of the top treatments in a typical swine production facility.

Results and Discussion

A preliminary evaluation of the various sanitization and disinfection measures can be seen in Table 1. To reinforce the screening process, an information survey is being conducted to supplement and verify the information gathered on each potential measure, by contacting additional information sources and experts such as swine veterinarians, animal scientists, health researchers, microbiologists, equipment and disinfectant suppliers, pig producers and livestock farmers with on-farm experience on the use of these measures, among others.

Initial results from the literature search also indicate that currently, the most common method for controlling pathogens in livestock facilities is the use of chemical disinfectants. The potential alternatives and experimental measures identified from the literature search included ultraviolet (UV) germicidal irradiation, ozonation, thermo-assisted drying, non-thermal plasma, and the use of slightly acidified water spray, among others, with varying degrees of efficacy in inactivating pathogens. The result of the preliminary assessment and ranking of the various potential measures shown in Table 2 allowed the initial identification of the most promising ones for the next phase of the study (testing under pig barn conditions).

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Table 1a. Evaluation of conventional disinfectants

Disinfectants	Cost	Applicability to Swine Barn	PROPERTIES				SAFETY	
			Antimicrobial Spectrum	Development of AMR	Effectiveness Against AMR	Reactivity	Health Aspect	Toxcity to Environment
A. LIQUID								
1. Alcohols	Moderate (requires high volume)	Applicable	Low	Low		Fast acting	Low	Low
2. Formaldehydes	Low	Applicable	High	Low	Low (selective)	Slow acting	Harmful	Intermediate
3. Glutaraldehyde	Moderate	Highly Applicable	High	Low	Low (selective)	Fast acting	Harmful	Intermediate
4. Iodine	Low	Applicable	Low	High risk (*S. suis, B. hyodysenteriae, ascaris suum* eggs)	Low (selective)	Fast acting	Low	Intermediate
5. Sodium hypochlorite	Low	Applicable	High	High Risk (Rotavirus and PCV virus) (*S. aureus*) (*S. enteritis*)	Moderate	Medium	Low	Low
6. Hydrogen peroxide	Moderate	Highly Applicable	High	Low (*S. suis, S. typhimurium* are resistant under high organic matter conditions)	Moderate	Fast acting	Low	Low
7. Peracetic acid	Moderate	Highly Applicable	High	Low (*S. suis, S. typhimurium* are resistant under high organic matter conditions)	High	Fast acting	Low	Low
8. Phenols and Phenolic derivatives	Low	Applicable	Low	Low Rish (rotavirus)	Moderate	Medium	Harmful	Harmful
9. Quaternary Ammonium Compound (QAC)	Moderate	Highly Applicable	Intermediate (Low)	High risk (*S. typhimurium, Salmonella* and *Bacillus sp.*)	High	Slow acting	Low	Low
B. POWDER								
1. Calcium Oxide	Low	Highly Applicable	Intermediate	Low	High	Slow acting	Intermediate	Intermediate
2. Sodium hydroxide	Low	Applicable	Intermediate	Low	Moderate	Slow acting	Harmful	Harmful
C. TECHNOLOGY								
1. Thermo-Assisted Drying and Decontamination	Extremely High	Applicable (material of construction should be considered)	High		Moderate	Slow acting	Harmful	Intermediate

Implications

Based on the initial screening and evaluation of identified sanitization and disinfection alternatives, the following measures i.e., use of peracetic acid, calcium oxide, slightly acidic electrolyzed water, and use of silver nanoparticles, were initially identified for consideration for testing and evaluation in subsequent phases of the project.

Acknowledgements

We would like to acknowledge the financial support for this research project from the Saskatchewan Agriculture Development Fund. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we also wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

Table 1b. Evaluation of non-conventional disinfectants.

DISINFECTANTS	COST	Applicability to Swine Barn	PROPERTIES				SAFETY	
			Antimicrobial Spectrum	Development of AMR	Effectiveness against AMR	Reactivity	Health Aspect	Toxicity to Environment
A. GAS								
1. Carbon dioxide contact cleaning	Extremely High	Not applicable (Inside access problematic)	Low		Low	Fast acting	Low	Intermediate
2. Chlorine dioxide	Extremely High	Applicable	High	High risk (*S. aureus*)	Moderate	Medium	Intermediate	Low
3. Slightly Acidic Electrolyzed Water	Extremely High	Highly applicable	Extremely high		High	Fast acting	Low	Low
4. Ozone	Extremely High	Highly applicable	Extremely high	Low risk	High	Fast acting	Harmful	Intermediate
B. NANOPARTICLES								
1. Silver Nanoparticles	High	Highly applicable	Extremely high	No risk	High	Fast acting	Low	Low
2. Titanium Oxide	Moderate	Applicable (limited, focuses on its photocatalytic property)	High		High	Medium	Intermediate	Low
3. Zinc Oxide	Moderate	Highly applicable	High	No risk	High	Medium	Low	Low
C. TECHNOLOGY								
1. HYDROVAC	Moderate	Not applicable (Not a sanitation procedure)	Low		Low	Slow acting	Low	Low
2. NON-THERMAL PLASMA	Extremely High	Applicable (mostly in vitro studies)	Extremely high	High Risk (*S. enterica, B. cereus, B.subtilis, G.* stearothermophilus, some yeast and molds)	High	Fast acting	Low	Low
3. Ultraviolet Germicidal Irradiation	Extremely High	Highly applicable	Extremely high	Low risk (for some fungi) (*E. coli* is resistant after 80 cycles)	High	Fast acting	Harmful	Intermediate
4. Steam wash	Moderate	Applicable (inside access problematic)	Low		Low	Slow acting	Low	Low
5. Soda Blast	Moderate	Not applicable (disinfection is still required)	Low		Low	Fast acting	Intermediate	Harmful (leaves high level of residue)

Table 2. Results of evaluated sanitation alternatives based on its efficiency.

Disinfectants	Applicability to Swine Barn (20%)	Properties (40%)			Safety (20%)			Total (low score; most preferred)	RANK
		Antimicrobial Spectrum (10%)	Development of *ARG (10%)	Effect on **ARB (10%)	Reactivity (10%)	Toxicity (20%)	Effect on Environment (20%)		
A. Conventional Disinfectants									
1. Alcohol	2	6	1	2	0	0	0	11	7
2. Formaldehyde	2	1	1	4	1	6	1	16	9.5
3. Glutaraldehyde	0	1	1	4	0	6	1	13	8
4. Iodine	2	6	4	4	0	0	1	17	11
5. Sodium hypochlorite	2	1	4	1	0.5	0	0	8.5	5
6. Hydrogen peroxide	0	1	1	1	0	0	0	3	2
7. Peracetic acid	0	1	1	0	0	0	0	2	1
8. Phenols and Phenolic derivatives	2	6	1	1	0.5	6	2	18.5	12
9. Quaternary Ammonium Compound	0	3	1	0	1	0	0	5	3
10. Calcium oxide	0	3	1	0	1	2	1	8	4
11. Sodium hydroxide	2	3	1	1	1	6	2	16	9.5
12. Thermo-assisted Drying and Decontamination	2	1	2	1	1	2	1	10	6
B. Non-conventional Disinfectants									
1. Carbon Dioxide contact cleaning	6	6	2	4	0	0	1	19	11
2. Chlorine dioxide	2	1	4	1	0.5	2	0	10.5	8
3. Slightly acidic electrolyzed water	0	0	2	0	0	0	0	2	3
4. Ozone	0	0	1	0	0	6	1	8	6.5
5. Silver Nanoparticles	0	0	0	0	0	0	0	0	1
6. Titanium dioxide	2	1	2	0	0.5	2	0	7.5	5
7. Zinc oxide	0	1	0	0	0.5	0	0	1.5	2
8. HYDROVAC	6	6	2	0	0	0	0	14	9
9. Non-thermal plasma	2	0	4	0	0	0	0	6	4
10. Ultraviolet germicidal irradiation	0	0	1	0	0	6	1	8	6.5
11. Steam wash	2	6	2	4	1	0	0	15	10
12. Soda Blast	12	4.8	0	3.6	0	1	1	22.4	12

Evaluation of Impact of Antibiotic-Use Reduction Measures on the Prevalence of Antimicrobial Resistance and Pathogen Abundance in Pig Production Barns

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Summary

The goal of this project is to compare the effect of the adoption of a RWA (raised without antibiotics) approach with non-RWA operations on the overall prevalence of antimicrobial resistance (AMR) and pathogen abundance in pig production facilities. We conducted surveillance of AMR and pathogens using whole genome sequencing (WGS), whereby primary data quantifying the resistome, virulome and bacterial diversity in the participating barns was obtained. Additionally, we developed a workflow methodology for metagenomics investigation of the effect of the RWA program on the resistome and virulome in conjunction with drug-use and animal health metadata collected from each type of barn.

Introduction

In response to the general concerns about the spread of antimicrobial resistance (AMR) along with increasing public apprehension regarding the use of antibiotics in livestock production, various measures such as the total ban on use of antibiotics in livestock feed and strict regulations on any antibiotic use for treatment of sick animals were implemented in Canada. Another strategy available to producers include adoption of raised without antibiotic (RWA) production practices, wherein appropriate steps are implemented to completely eliminate antibiotic exposure of the pig from gestation to market, without compromising animal welfare. In this work, we seek to answer the question on how effective are these alternative strategies in reducing the total on-farm use of antibiotics, the occurrence of pathogens, and the prevalence of antimicrobial resistance?

To answer these questions, this study conducted longitudinal surveillance monitoring of farms that implemented a RWA program as well as conventional farms using antibiotics as prescribed by a veterinarian (non-RWA). The monitoring strategy focused on three key areas: antibiotics usage, antibiotic resistance, and prevalence of pathogens. Based on the findings, recommendations for best management practices will be developed to help ensure the success of intervention measures such as RWA or other similar alternative production programs.

Experimental Procedures

For this study, we recruited two types of farms to participate: three (3) RWA farms and two (2) non-RWA farms. The overall workflow for the data collection and corresponding analysis to be conducted for this study is shown in Figure 1.

Activity 1 – Determining on-farm antibiotic usage patterns and total use

Each participating farm was requested to share their inventory of antibiotics in their barn, and their record of the use of any antibiotics for treatment, including type of drug, dosage, type and number of animal(s) treated and approximate age, treatment cause, location in the barn, and date and time. Typically, producers collect these information as part of the CQA/CPE program, and so we requested for copies of these records every 3 months. Based on these collected data, the total antibiotic use and usage patterns were determined for each participating farm.

Activity 2 – Surveillance monitoring of prevalence of antimicrobial resistance and pathogens

The second activity focused on monitoring the prevalence of antimicrobial resistance and pathogens in each of the participating farms. Representative fecal and manure samples were collected from each farm every 6 months from 6-week, 12-week and 20-week old pigs, and samples from the manure lagoon, and soil samples from the barn's immediate environment were also collected and analyzed. Sampling also included nasal swabs from 6-week old piglets, due to the potential for sequencing analyses to detect/identify subsets of respiratory viruses in addition to virulence factors along with other microorganism categories and their associated AMR.

Results and Discussion

Activity 1 – Determining on-farm antibiotic usage patterns and total use

Preliminary data obtained from the drug treatment records obtained from each participating barn from August 2018 to May 2020 indicate most antibiotics belong to four classes: Antifolates, β-lactams, Tetracyclines and Amphenicols. The most prevalent illnesses and treatment reasons recorded included: limping, scours, respiratory impairment and infection. Additional correlation analysis with resistome will determine if these illnesses/symptoms are related to antibiotic classes and whether it leads to any specific set or pattern of resistance genes.

Activity 2 – Surveillance monitoring of prevalence of antimicrobial resistance (AMR) and pathogens

Preliminary beta-diversity analysis of the resistome (statistical analysis between groups of samples) in 26 samples sequenced (three time-points from four barns and one time-point from an additional barn) showed two clusters of clearly-separate groups of type of samples – Fecal and Manure – with respect to the abundance of antimicrobial resistance genes (ARGs) (Figure 2). The Manure group had two close but distinct sub-groups that included the RWA and non-RWA data. Based on the first two time-points of this study, results demonstrate that comparative repeated measures of two ARGs readouts (abundance and frequency) significantly differentiate between RWA and non-RWA groups. For instance, we observed a significant decrease in the relative abundance of Tetracycline-ARGs and multi-drug resistant (MDR)-ARGs in manure samples from RWA barns. We also observed a significant decrease in the frequency of Tetracycline-ARGs in Fecal samples from RWA barns. On the other hand, a greater abundance of the Aminoglycoside-ARG class was observed in RWA barns. However, these observations remain to be confirmed in future sequencing time-points prior to correlation with drug usage trends.

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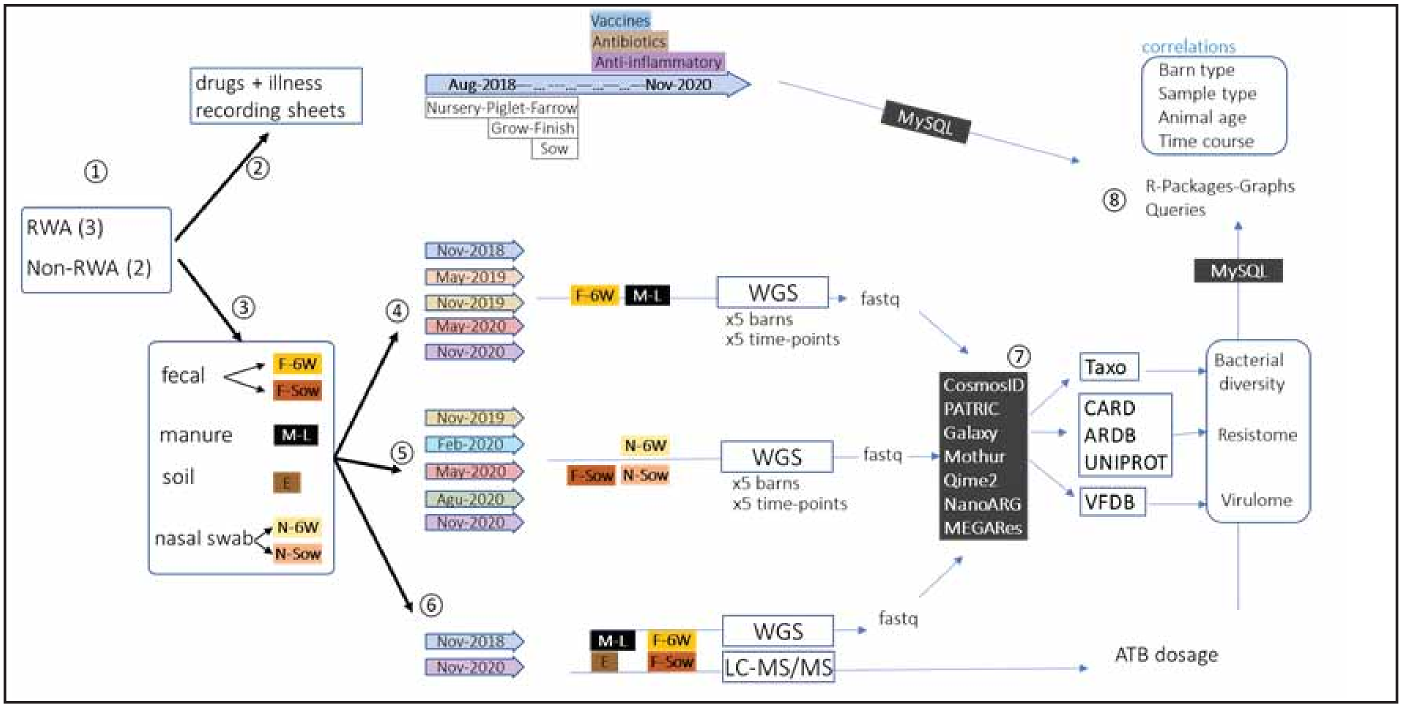

Figure 1. Diagram of workflow for longitudinal investigation of antibiotic resistance, pathogens and virulence factors associated with pig production. The diagram shows the steps in this project over a 2-year period of sampling and analyses: including sampling and whole-genome sequencing (WGS) strategy for Piglet (6-week-old) fecal material and manure every 6 months, sampling/WGS strategy for Piglet/Sow nasal swabs as well as Sow fecal samples every 3 months ((3,4,5), and first and last sampling time-points for WGS/LC-MS/MS strategy for Piglet/Sow fecal, manure and environmental samples (6). Raw shotgun data are analyzed comparatively through multiple platforms and with open source tools to generate 3 major classes of information: Bacterial Taxonomy, Resistome and Virulome (7).

Implications

Preliminary analyses demonstrated a substantial reduction in both MDR-ARGs and Tetracycline-ARGs in RWA barns as compared to non-RWA barns, suggesting that RWA measures can possibly contribute to mitigating the development of resistance to specific antibiotics used in pig production.

Acknowledgements

The authors gratefully acknowledge the financial support for this research project provided by the Saskatchewan Agriculture Development Fund and the Canada-Saskatchewan Growing Forward 2 Bi-lateral Agreement. As well, the support provided by the production staff and technicians in the participating barns is greatly appreciated. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund.

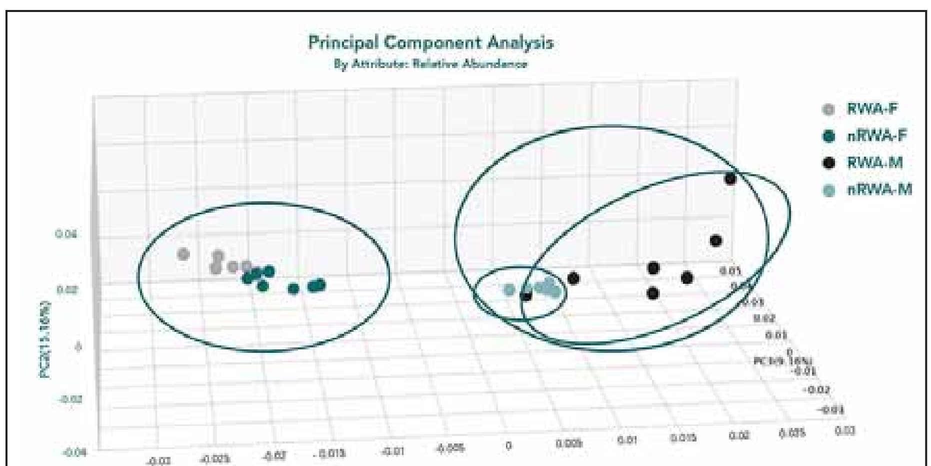

Figure 2. Statistical analysis of the resistome - beta diversity showing 2 distinct groups: the left ellipse represents the fecal group (containing a non-distinct subgroup of RWA (RWA-F) and non-RWA (nRWA-F)). The right large ellipse represents the Manure group containing 2 close but distinct subgroups of RWA (RWA-M) and non-RWA (nRWA-M).

Effects of Long Distance Transport on the Health and Welfare of Early Weaned Pigs

H. Golightly[1], T. O'Sullivan[1], Y. Seddon[2] and J.A. Brown[3,4]

Summary

During transport, piglets can experience numerous stressors, including feed and water deprivation, handling at loading and unloading, extreme temperatures, vibrations and noise. However, it is not known whether the combined impacts of weaning and transport overlap, are additive, or synergistic. The effects of long duration transports are of particular concern, but little research is available particularly under Canadian conditions. Research is needed on the effects of long transports, including food and water deprivation, on piglet welfare during and after transport. This research will aid greatly in identifying best practices for transport, provide a basis for transport policy, and direction for future study and improvement. Initial results on a study comparing long and short transport durations indicate there was no difference in mortality between the two groups.

Introduction

The North American swine industry relies heavily on the transport of weaned pigs. Approximately 120,000 iso-wean pigs born on Canadian farms are placed in US swine barns each week. The transport of weaned piglets across Canada, or into the US, involves travel durations ranging from one to 36 hours. The maximum acceptable transport time allowable for pigs without feed, water or rest in Canada is 28 hours (Canadian Health of Animals Regulation, C.R.C. 296) and was changed from the previous maximum of 36 hours in 2020. In the United States, the maximum limit is 28 hours (United States Department of Agriculture 49 U.S.C. 80502).

A greater understanding of the effects of long transports on weaned pigs is needed, including methods to mitigate any negative effects found. Weaning in itself is a stressful period for pigs due to separation from the sow, changes in diet, mixing with unfamiliar pigs, and introduction to a novel environment. Weaning even within a single site often results in piglets not consuming feed for >24 hours following weaning. Understanding how transport impacts the weaned pig and how this differs from weaning alone is important for improving animal welfare and economics of pork production.

Experimental Procedures

Experiment 1. Effects of long transport durations on weaner pigs

Piglets were transported under commercial conditions from two different locations in order to evaluate the effects of transport duration on their health and welfare. Transport treatments included short (~90 min) and long durations (~36 h) using a standard flat deck (short transport) and 4-deck pot-belly (long transport) trailers.

Various blood measures (cortisol, hematocrit, total protein, glucose and creatine kinase) were used as indicators of dehydration and stress before and after transport, in addition to recording body weight before, after and three days after transport. Pig behaviours (lying, standing, sitting and huddling) were recorded during transport by scan sampling using time-lapse photography inside trailer compartments. Trailer conditions including temperature, humidity and vibrations were monitored using iButton data loggers HOBO accelerometers. Piglet behaviour in the nursery was recorded following receipt using video cameras in daylight hours to observe aggression, postures, feeding and drinking behaviour. Piglet health including morbidity and mortality rates were monitored during the nursery period, up until the time of nursery exit (approx. 25 kg).

Experiment 2. Effects of providing electrolytes during transport on mitigating stress

Treatments for this phase of the study will include: 1) provision of water and electrolytes during transport; and 2) control pigs (no water or electrolytes). Data collection will take place in winter on short transports within Ontario using a flat deck trailer. Measures similar to experiment 1 will be taken, including piglet behavior monitoring, temperature and humidity measures inside the trailer. Body weight, lesions and lameness will be recorded at key time points and blood samples will be collected before and after transport. Following arrival, piglets will be kept in treatment groups within the nursery barn. Behaviour in the nursery will be monitored using live observations following receipt to observe aggression, postures, feeding and drinking. Growth performance will be recorded following arrival at the destination barn, and piglet morbidity and mortality will be monitored up until the time of nursery exit (approx. 25 kg).

Experiment 3. Evaluation of a hydraulic deck trailer design

This study will compare environmental conditions on a standard 4-deck pot-belly trailer to an alternative 4-deck hydraulic trailer, and measure their effects on piglets. Ten loads will be compared (five per trailer design) hauling weaners for a moderate duration (10 to 18 hrs) to a common nursery site.

Results and Discussion

Initial results indicate there was no difference in the risk of piglets being dead on arrival between short and long duration groups. Piglets undergoing short duration travel had higher odds of lameness observed at arrival compared to long. At arrival, piglets in the long duration group had biologically significant negative weight change from weight pre-transport. In this group, relatively heavy piglets lost more weight over the transport period than light piglets. No effect of duration was observed on net weight change from pre-transport to three days post-transport.

Implications

The results of Experiment 1 represent an essential component in understanding the effects of transport duration on piglet welfare and suggest that in these duration and temperature conditions, piglets were physiologically resilient to transport length. However, behavioural data collected during and following transit must be interpreted before final conclusions on welfare can be made.

Acknowledgements

Funding for this project is provided by Swine Innovation Porc through the Canadian Agricultural Partnership. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we also wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

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Identification of Risk Factors for Sow Mortality in Canadian Herds

C. Prade-Ramos[1,2], Y.M. Seddon[3], B. Sullivan[4], F. Fortin[5] and J.A. Brown[1,2]

Summary

Recent years have seen a trend towards increasing sow mortality figures around the world. In order to understand the underlying causes influencing sow mortality and culling on Canadian farms a project is under way to answer these questions using an integrated approach. Specifically by: 1) Surveying Canadian sow herds on sow losses and related management factors; 2) Visiting herds with high and low mortality levels to confirm survey results and gather additional information; 3) Reviewing the scientific literature and sow mortality data from other major pork producing countries; and 4) Developing recommendations on ways to improve and standardize recording procedures related to sow losses and best management practices to minimize sow losses.

The results of this work will provide a valuable benchmark for the Canadian sow herd and provide a comparison to other countries with similar production practices. In addition, it will identify risk factors for future evaluation and potential targets for genetic selection or improved management practices.

Introduction

Sow mortality is an important economic and animal welfare concern for pork producers. In addition, high sow mortality affects employee morale and is an important welfare indicator. While it is recognized that a sow must produce three or four litters to cover her replacement cost, the average productive life of sows is decreasing. Although sow mortality has been reportedly increasing, culling and mortality numbers are often combined or not recorded consistently, making it difficult to accurately determine these numbers.

Structural changes in the Canadian pork industry may also be influencing changes in sow mortality figures. The main changes relate to sow housing practices, which have been changing from stalls to group housing. Anecdotal reports suggest that levels of lameness may increase when sows are managed in groups. In parallel, genetic progress and reproductive technologies have led to larger litters and higher sow productivity, with possible negative consequences for sow longevity. Stricter enforcement of fitness for transport guidelines may be another factor influencing on-farm mortality, with more sows euthanised on-farm rather than being shipped as culls.

Recent reports from US herds indicate average sow mortality rates of 9%, with higher levels in larger herds and more productive herds. Furthermore, almost 50% of the reported death losses occurred in young animals (gilts to parity 2), indicating a significant cost to producers. Having comparable data for Canadian pig herds will benefit sow welfare and Canadian pork producers.

Experimental Procedures

Literature Review

An extensive literature review is being conducted, which will explore past and current research on factors affecting sow culling and mortality on pig farms with specific emphasis on environment, management, and genetic aspects influencing sow longevity. Part of the literature review will obtain and summarize production data related to sow mortality and culling from Canada and other major pork producing countries. In the US and in Europe, several regional and national databases exist with good coverage of pig farms, and large amounts of management data recorded.

Survey of producers

Over 100 farms across Canada with varying levels of sow mortality participated in this study. The data are undergoing analysis to determine factors related to sow mortality including: herd size, type of gestation, breeding and stall housing, feeding routine, genetics, floor type, average sow productivity figures, and culling reasons.

Data recording in Canadian pig farms

The aim of this study will be to collect data from up to 40 farms (20 farms with high and 20 low sow mortality rates) among farms surveyed in the previous activity. The data will identify significant risk factors associated with high mortality herds, and factors supportive of low mortality. Based on results from the literature review and information collected in the online survey, data recording standards will be developed to collect detailed information about sow mortality/culling information, as well as additional information such as sow body condition, feet and leg scoring, health issues, and injuries.

Results and Discussion

The project is currently ongoing. The pork producer survey was completed during the summer of 2020, while farms visits are on going. More information will be available at a later date.

Implications

The results of this work will provide a valuable benchmark for the Canadian sow herd on sow longevity and a comparison to commercial herds in other countries with similar production practices, as well as identifying the risk factors for future evaluation and potential targets for genetic selection and improved management practices. New approaches will emphasize improvements in gilt management to better prepare animals to enter the breeding herd.

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Funding for this project is provided by Swine Innovation Porc through the Canadian Agricultural Partnership. The authors would also like to acknowledge the strategic program funding provided by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we also wish to acknowledge the support of the production and research technicians at Prairie Swine Centre that make it possible to conduct this research.

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Motivated for Movement? Exercise and the Gestation Environment on Sow Performance and Welfare

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Summary

The Canadian Code of Practice for the Care and Handling of Pigs proposed that from July 1, 2024, all mated gilts and sows must be housed in groups, or individual pens, or stalls providing they are given the opportunity to turn around or exercise periodically, or other means that allow a greater freedom of movement. In order to understand what could constitute an acceptable greater freedom of movement, this research project evaluated the motivation of bred sows and gilts to leave their stall, and how periodic exercise influenced the welfare and performance of stall-housed gestating sows. Results identified sows and gilts have a moderate level of motivation to obtain time out of the stall, as measured by their highest price paid (number of times pressing a panel) to exit. However, sows have a greater level of motivation to access additional feed, and their motivation to exit the stall is reduced when high fibre feed is provided ad-libitum to sows. However, despite the provision of ad-libitum high fiber feed, a level of motivation to exit the stall remains, suggesting an intrinsic need for freedom of movement or possibly control over their environment.

In a gestation trial, comparing sows housed in stalls and provided with periodic exercise (E), compared to sows housed in groups (G) and sows housed in stalls with no exercise (S), providing 10-minutes of exercise to stall-housed gestating sows once per week has minimal effects on herd productivity; having an effect on older parity sows only, increasing the number of liveborn and reducing stillborn compared to sows housed in stalls and not provided with exercise. Group-housed sows displayed behaviours indicative of improved welfare; sitting 33% less, lying 27% more and in mid-gestation performing 33% fewer stereotypies than stall-housed (both E and C) sows. Piglets from stall-housed sows responded to a novel object test with 27% high activity than piglets from stall-housed and exercised or group-housed sows suggesting that continued confinement to a stall throughout gestation results in a more proactive coping response in offspring.

The results of this work indicate that sows show a level of motivation to exit their stall, but providing periodic exercise for 10 mins once per week has minor influences on herd productivity, and does not produce measurable benefits for sow welfare. The gestation housing treatments influenced the prenatal development of the piglets as measured through their behaviour. Understanding how the management of gestating sows influences the prenatal development of offspring should be researched further given the current conversion to group-housing will result in variations in gestation system.

Introduction

The Canadian Code of Practice for the Care and Handling of Pigs requires that from July 1, 2024, mated gilts and sows may also be housed in existing stall barns if they are provided with the opportunity to turn around or exercise periodically, or other means that allow a greater freedom of movement. However, what constitutes a greater freedom of movement and the suitable options to meet this Code requirement were to be clarified, by July 2019, as informed by scientific evidence.

At the time, there was a lack of scientific evidence on which to base a recommendation on when or how much exercise stall housed sows need to receive. Additionally, whether periodically providing stall housed sows with opportunities for a greater freedom of movement would benefit sow welfare was unknown. The present research was conducted to address key questions regarding the above-mentioned knowledge gaps. Results have contributed information to aid decision making during the Code of Practice five year review which took place in 2019.

Experimental Procedures

Experiment 1

Animals and housing: A total of 24 animals, n = 12 young (gilts) and n = 12 older sows (parity 2.75 ± 0.96, mean ± S.D.) were studied for their motivation to exit the gestation stall and gain access to the alleyway between stalls.

An operant panel was constructed on which two identical buttons were fixed (Fig. 1). Both buttons can be programed by a microcomputer to count the number of presses made to each. One button is designated as active button (AB), and push counts to this button result in a reward for the sow. The other is designated as a dummy button (DB), acting as a control measure, and press counts made to this button do not contribute to obtaining a reward for the sow.

In 50% of replicates animals were trained and tested for their motivation to exit the stall first, followed by retraining and testing for their motivation to access more feed, and in the remaining 50% of replicates animals were first trained and tested for their motivation to access more feed, and then retrained and tested for their motivation to exit the stall.

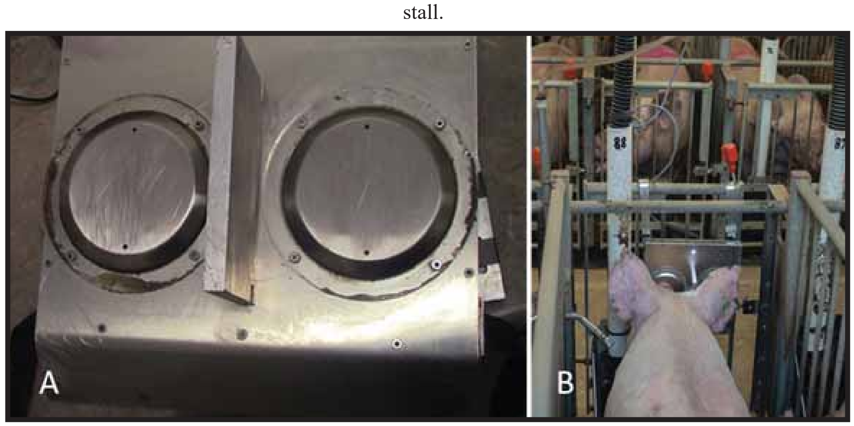

Figure 1. A) The operant panel containing two identical buttons, a central divider, and a light to indicate to the sow when the panel is active; B) Sow pressing the AB of the panel, in position hung over stall gate.

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When training and testing for access to exit the stall, sows were rewarded for pressing the active button with three minutes of time to freely move around within the alleyway between stalls. When sows were trained to press the operant panel for access to more feed, they were fed 70% of their standard gestation ration in the morning, to facilitate training for food as the reward. Thereafter, a handful of gestation feed (0.2kg) was provided as the reward, with the sow provided the remaining percentage of her feed ration over the course of testing. The position of the AB and DB was switched between training and testing for feed and access to time out of the stall.

Once trained, sows were tested on an ascending fixed ratio (FR) schedule, where the number of AB button presses required by the sow increased by 50% each day after starting at FR 9, up to a maximum FR of 365. This produced a testing schedule of FR 9, 14, 21, 32, 48, 72, 108, 162, 243, 365. The highest number of button presses a sow makes to the AB is known as the Highest Price Paid (HPP) and is a measure of her motivation.

Behaviour observations: A camera positioned at one end of the alleyway recorded the behaviour of sows once out of the stall. The frequency and duration of sows to seek social contact, to exercise and to seek feed (foraging) was recorded.

Experiment 2

A total of 42 sows (parity 2-3) were tested for their motivation to exit the stall when assigned to three treatments: i) Sows (n = 14) given ad-libitum access to a high fibre feed in addition to their standard gestation ration (Ad-libitum HF), ii) Sows (n = 14) given access to half of their ad-libitum high fibre feed intake once per day additional to their standard gestation ration (0.5 HF), three hours prior to motivation testing, and iii) Sows (n= 14) given no additional feed, and fed only their standard gestation ration (Control). Across all treatments, all sows were tested daily for motivation to leave the stall on an ascending FR scale as described for experiment 1.

Experiment 3

A total of 180 sows (parity 0-7) were studied to test the effects of low level periodic exercise on stall-housed gestating sows. Treatments included: i) Control (n=60) sows stall-housed throughout gestation (C), ii) Exercised (n=60) stall-housed sows that were walked around the gestation room for 10 minutes once per week (E), iii) Group (n=60) sows housed in groups from insemination to farrowing (G). Measures included sow behaviour (postures, activity, stereotypies) in early, mid and late gestation, cortisol measurement in hair as a chronic measure of stress over gestation, sow productivity, measures of placental characteristics and piglet viability, and piglet stress reactivity as a measure of prenatal stress.

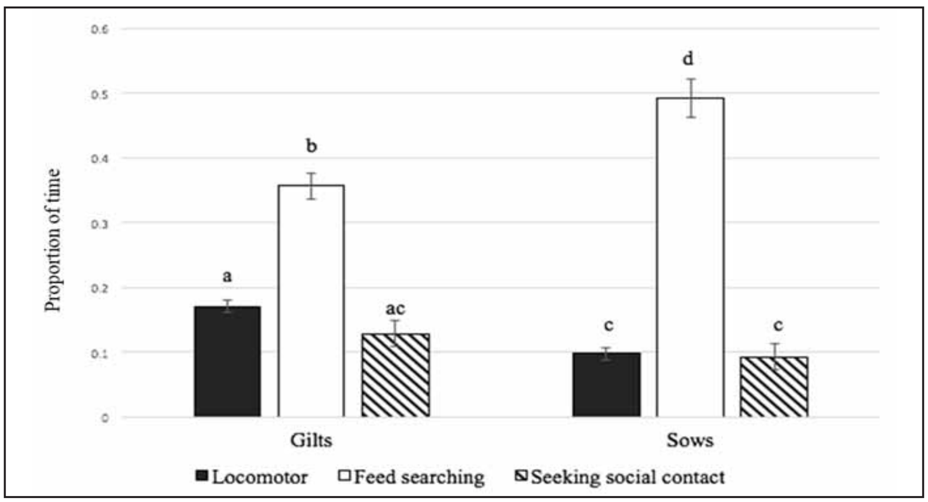

Figure 3. Proportion of time (mean±SEM, over all opportunities) for gilts (n=12) or sows (n=12), spent in locomotor behaviour, feed searching or seeking social contact when out of their stall. Where superscripts differ, P<0.05.

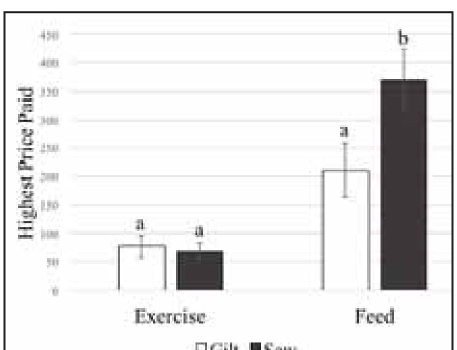

Figure 2. The highest price paid (mean ± SEM) for sows (n =12) or gilts (n = 12) to access time out of the stall, or a feed reward. Where superscripts differ, P<0.05.

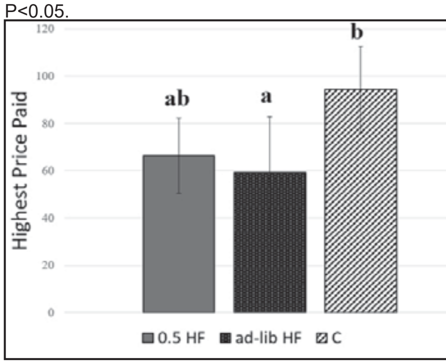

Figure 4. Highest price paid (HPP) for sows tested for their motivation to exit the stall for exercise when provided their standard gestation ration (Control, C, n = 14), provided with half of their ad-libitum daily high fibre feed intake in addition to their gestation ration (0.5 HF, n = 14) and provided ad-libitum access to a high fibre feed in addition to their gestation ration (ad-lib, n =14), (mean ± SEM). Where superscripts differ, P<0.05.

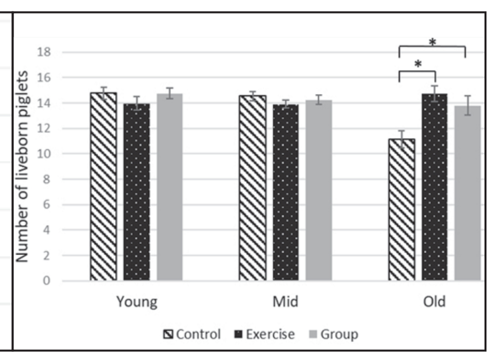

Figure 5. Number of liveborn piglets (mean ± SEM) for sows belonging to young (parity 0-1, n = 49), mid (parity 2-4, n = 95), and old (parity 5-7, n = 24) parity groups from control, exercise, and group treatments. Brackets connect treatments with significant differences,* P <0.05.

Results and Discussion

Experiment 1: Sows showed a significantly greater HPP for feed than movement, but for gilts it did not differ. Sows had a greater motivation to access feed than gilts. However, gilts and sows did not differ in their motivation to access movement, (Fig. 2).

Behaviour outside of the stall: Both gilts and sows spent a significantly greater proportion of the time out of the stall food searching, than in locomotion and seeking social contact. Neither gilts nor sows differed in their percentage of the time, spent in locomotion and seeking social contact. Gilts had significantly greater proportion of time, spent in locomotion and seeking social contact, than sows, and sows had a significantly greater proportion of time, spent in food searching, than gilts (Fig. 3).
Experiment 2: Sows that received only their standard gestation ration worked harder to exit the stall, as represented through a greater HPP than sows that were fed a high fibre feed at ad-libitum intake (Fig. 4). The HPP of sows that were fed a high fibre feed at 50% of their ad-libitum intake was intermediate, being no different to control sows or those fed high fibre feed at ad-libitum intake.

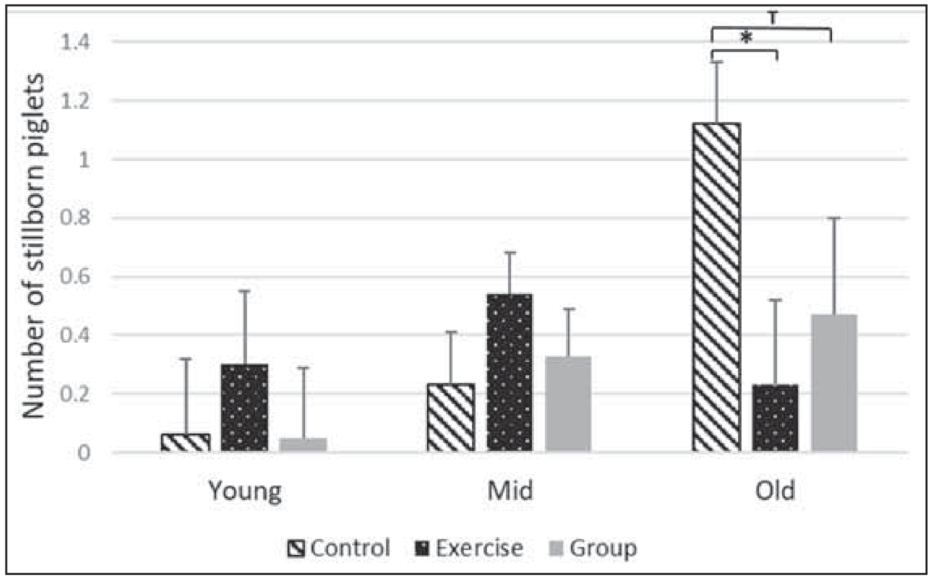

Figure 6. Number of stillborn piglets (mean ± SEM) for sows belonging to young (parity 0-1, n= 49), mid (parity 2-4, n = 95), and old (parity 5-7, n =24) parity groups from control, exercise, and group treatments. Brackets connect treatments with significant differences.* P <0.05; T: Tendency, P = 0.08.

Experiment 3: Sow reproductive performance and physiology: There was an interaction between gestation treatment and parity group on sow performance. Old parity sows that were housed in groups, or stall-housed with periodic exercised had a greater number of liveborn piglets compared to sows housed in stalls throughout gestation (Fig. 5). Additionally, old parity sows that were housed in stalls throughout gestation had a greater number of stillborn than exercised sows, and tended to have a greater number of stillborns than sows housed in groups throughout gestation (Fig. 6).

There was no effect of treatment on placental development, piglet birth weight, measures of piglet viability (latency to stand and suckle), and farrowing duration.

Sow Welfare: Gestation treatment influenced sow postures (Fig. 7). Group housed sows lay more and sat less than stall and exercised sows, which did not differ. In mid-gestation, group-housed sows performed oral stereotypies (sham chewing, tongue rolling) at a 33% lower frequency than exercised and stall-housed sows, whom did not differ. There was no difference in hair cortisol levels between treatment groups; an increase in cortisol towards in the third trimester of gestation may have blurred the ability to detect differences, contributing to large individual variation in levels. When exposed to a standardized stress test – the novel object test, female piglets from stall-housed sows visited significantly more squares of the test arena, than piglets from exercised and group-gestation sows, which did not differ, suggesting sows confined to stalls throughout gestation produce a piglets with a more proactive behavioural response to stressful situations.

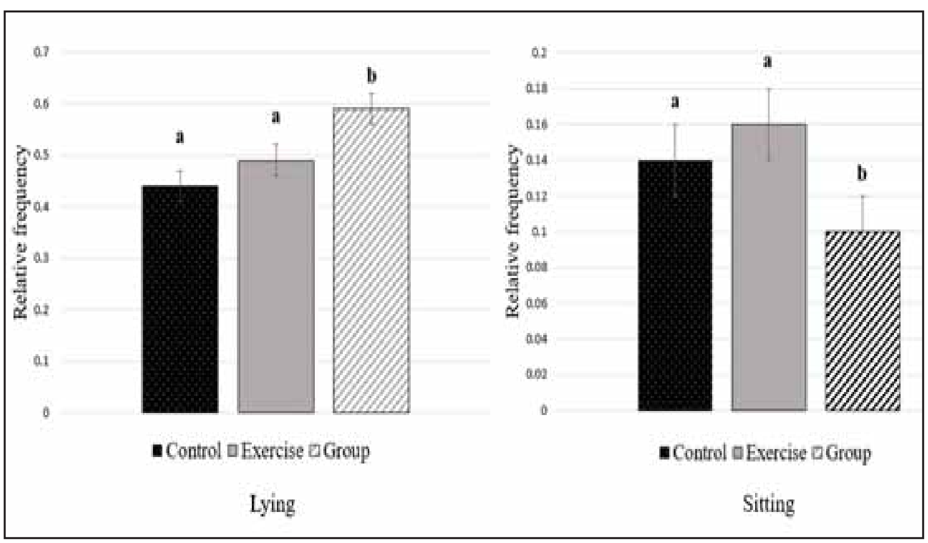

Figure 7. Relative frequency (mean ± SEM) of lying (left) and sitting (right) during the AM data collection period for sows stall-housed throughout the gestation (Control, n=53), stall-housed sows exercised for 10 minutes once per week (Exercise, n=56) and sows housed in groups from insemination to farrowing (Group, n=58). Where superscripts differ, P≤0.05.

Implications

The results from experiment 1 show that both sows and gilts show a level of motivation to exit the stall. However, for sows, the motivation was significantly greater to access feed than to exit the stall. This greater motivation for feed may be due to the fact that sows were recovering from lactation at the time of testing. Comparatively, the motivation to exit the stall was significantly lower for sows, with no difference in the motivation to exit the stall between sows and gilts. However, that the motivation level of gilts to receive feed was no different to their motivation to exit the stall, may indicate that gilts value opportunities for each reward equally. Experiment 2 identifies with consistent results to exp. 1 that sows have a level of motivation to exit the stall. However, this level of motivation is reduced when high fibre feed is provided to the sows. This implies that the motivation to exit the stall may be related to a motivation to seek additional feed. That sows fed a high fibre feed at 50% of ad-libitum, to full ad-libitum did still show a level of interaction with the operant panel may suggest that the provision of the panel provides an enrichment for exploration when presented in the stall. It may also suggest that there remains an intrinsic level of motivation for sows to access time out of the stall.

Results from experiment 3 reveal that providing 10 minute exercise per week to stall-housed gestating sows benefitted the performance of older parity sows only, increasing the number of liveborn and reducing the number of stillborn compared to stall-housed sows, and being similar to group-housed sows. This effect may be due to the fact that older parity sows benefit from the increased movement, and that younger sows are physiologically fitter, and therefore no effects of the exercise treatment were observed.

Results of sow behaviour suggest that sow welfare (as evaluated by postures and stereotypies) was improved in group-housing, and 10 minutes of exercise once per week was ineffective to improve sow comfort or reduce sow coping behaviours (stereotypies). However, the behavioural responses of piglets to a novel object test suggest that exercise did influence the coping response of piglets to a standardized stress test – with piglet behaviour being no different between exercised and group-housed sows, but stall-housed sows producing piglets with a more proactive coping response. Animals with a proactive coping response are identified as more behaviourally reactive to stress. This indicates that the freedom of movement provided by the gestation housing environment can influence offspring behavioural reactivity to novelty. As the Canadian industry undergoes a transition to group-housing, it warrants further investigation as to how different gestation housing systems will influence the physiology and behaviour of offspring. Providing 10 minutes of exercise once per week to stall-housed gestating sows did not have an effect on chronic stress, placental development and piglet viability measures. Chronic stress results are based on hair cortisol measurements, and our findings showed a high variability between sows which reflect large individual differences, and the need for a larger sample size in future studies. In the case of placenta characteristics and piglet viability, exercised sows did not differ from the other gestation treatments, and exercise did not affect the piglet latency to stand or reach the teat and the farrowing duration per piglet. Previous research has suggested that exercise has positive effects on fetoplacental growth resulting in faster placental development that improves the placental function (Clapp et al. 2000). However, with only an effect of gestation treatment on productivity observed in older parity sows, it may be that distribution of samples across parity groups has resulted in not a large enough sample size for differences to be observed in some of the other measures collected. This shall be reviewed as further analysis and interpretation of results takes place.

Conclusions

The results of this work indicate that sows show a level of motivation to exit their stall, but providing periodic exercise for 10 mins once per week has minor influences on herd productivity, and does not produce measurable benefits for sow welfare. The gestation housing treatments influenced the prenatal development of the piglets as measured through their behaviour. Understanding how the management of gestating sows influences the prenatal development of offspring should be researched further given the current conversion to group-housing will result in variations in gestation system.

Acknowledgements

We would like to acknowledge the financial support for this research project from the Saskatchewan Agriculture Development Fund, the Saskatchewan Pork Development Board, the Manitoba Pork Board and the Alberta Pork Board. The authors would also like to acknowledge the strategic program funding provided to the Prairie Swine Centre by Sask Pork, Alberta Pork, Ontario Pork, the Manitoba Pork Council and the Saskatchewan Agriculture Development Fund. In addition, we also wish to acknowledge the support of the production and research technicians at Prairie Swine Centre and the staff of the University of Saskatchewan engineering department that have made it possible to conduct this research.

Publications List

Agyekum, A., **D. Columbus**, and **D. Beaulieu.** (2019) Feeding straw to sows in late gestation. Benefits of processing? Pages 4-7 In: Centred on Swine (Volume 25, Number 2), Prairie Swine Centre, Saskatoon, SK.

Agyekum, A., **D. Columbus**, C. Farmer, and **D. Beaulieu.** (2019) Effects of supplementing processed straw during late gestation on sow physiology, lactation feed intake, and offspring body weight and carcass quality. J. Anim. Sci. 97:3958-3971. doi:10.1093/jas/skz242.

Agyekum, A., **D. Beaulieu,** and T. Gebreyohannes. 2019. High fibre diets. Potential for satiety in sows and offspring growth performance. PSC Annual Report 2019.

Agyekum, A., **D. Columbus**, C. Farmer and **D. Beaulieu**. 2019. Effect of supplementing processed straw during late gestation on sow physiology, lactation feed intake, and offspring body weight and carcass quality. J. Anim. Sci. 97: 3958-3971.

Agyekum, A., **D. Columbus**, C. Farmer and **D. Beaulieu**. 2019. Effects of supplementing processed straw during late gestation on sow physiology, lactation feed intake and offspring body weight and carcass quality. Journal of Animal Science. 97(9): 3958-3971.

Alvarado, A., and **B. Predicala.** 2019. Occupational exposure risk for swine workers in confined housing facilities. Journal of Agricultural Safety and Health. 25(1):37-50. (doi:10.13031/jash.12990).

Alvarado, A., and **B. Predicala.** 2020. Control of ammonia and respirable dust concentrations in swine barn facilities using engineering and management measures. Prepared for publication in International Journal of Environmental Health Research.

Alvarado, A., J. Cabahug, and **B. Predicala.** 2020. Comparison of ATP bioluminescence technique and traditional microbiological method for the assessment of cleanliness of swine transport trailers. Prepared for publication in International Journal of Hygiene and Environmental Health.

Barbosa, J., **L. Rodrigues**, **D. Columbus**, J.Aguirre, J. Harding, V. Cantarelli, and MdeO. Costa. (2020) Fecal calprotectin as a candidate non-invasive biomarker for infectious colitis in swine. 7th Le Porc Show. Submitted.

Beaulieu, D. (PI). 2019. Increasing sow milk yield and piglet growth via low-cost feeding and management strategies during gestation and/or lactation. Final Report. CSRDC (#1233). Swine Innovation Porc.

Beaulieu, D., A. Van Kessel, D. Sotto, E. Darambazar, and J. Wang. 2019. Pretreatment of feed ingredients to enhance value. PSC Annual Report 2019.

Bosompem, M., **M. Wellington**, **L. Rodrigues**, **J. Sands**, R. Petracek, and **D. Columbus.** (2020) Effect of long-term feeding of graded levels of deoxynivalenol on growth performance of grower-finisher pigs. J. Anim. Sci. In preparation.

Bosompem, M., **M. Wellington**, **L. Rodrigues**, **J. Sands**, R. Petracek, and **D. Columbus.** (2020) Effect of long-term feeding of graded levels of deoxynivalenol on growth performance of grower-finisher pigs. Advances in Pork Production. 31:237.

Bosompem, M., **M. Wellington**, **L. Rodrigues**, **J. Sands**, R. Petracek, and **D. Columbus.** (2019) Long-term feeding of graded levels of deoxynivalenol in grower-finisher pigs. Saskatchewan Pork Industry Symposium, November 14-15, Saskatoon, SK.

Bowling, H., **Y. Seddon**, G. Miguel-Pacheco, R. Nosach, G. Harmonic, M. Tucker, B. Ambros, D. Wilson, A. Pasternak, D. MacPhee, and J. Harding. (2020) Behavioural consequences of acute thyroidectomy-induced hypothyroidism in pigs. National Veterinary Scholars Symposium virtual meeting, 4-6th August 2020.

Burdett, S., **M. Wellington**, W. Mansilla, **D. Columbus**, R. Bergeron, and A. Shoveller. (2020) Variation in energy expenditure and macronutrient oxidation in female Yorkshire pigs. J. Anim. Sci. In preparation.

Bwala, H., **J. Brown**, T. O'Sullivan, and **Y. Seddon.** (2019) Risk factors for mortality of weaned piglets transported by road in Canada. In: Proceedings of the Pig Welfare Symposium, 13th - 15th November, Minneapolis, USA.

Bwala, H., **J. Brown**, T. O'Sullivan, and **Y. Seddon.** (2019) Risk factors for mortality of weaned piglets transported by road in Canada. Saskatchewan Pork Industry Symposium, 12th November, Saskatoon, Canada.

Bwala, H., **J. Brown**, T. O'Sullivan, and **Y. Seddon.** (2020) Transport associated risk factors for mortality in weaned piglets transported by road in Canada. In: Advances in Pork Production. Proceedings of the Banff Pork Seminar, Banff, AB, Canada, 7th-9th January, vol. 31, abstract #22.

Cargo-Froom, C., A. Shoveller, C. Marinangeli, E. Kiarie, R. Newkirk, Y. Ai, J. Smillie, and **D. Columbus.** (2020) The effects of common processing parameters on pulse ingredients and protein quality. Global Animal Nutrition Summit. Guelph, ON.

Cargo-Froom, C., A. Shoveller, C. Marinangeli, and **D. Columbus.** (2020) Invited review: Methods for processing of pulses to optimize nutritional functionality and maximize amino acid availability in foods and feeds. Cereal Foods World. In press.

Chekabab, S., J. Lawrence, **A. Alvarado**, **B. Predicala**, and D. Korber. 2020. A health metadata-based management approach for comparative analysis of high-throughput genetic sequences for quantifying antimicrobial resistance reduction in Canadian hog barns. Computational and Structural Biotechnology Journal. 18: 2629–2638. https://doi.org/10.1016/j.csbj.2020.09.012

Clark, J. (2020) How scientists use pigs to save lives. Pages 18-25 in Better Pork. Text interview.

Cochrane, B. (2019) Optimum nutrition and reduced stress at weaning maximizes lifetime productivity. Broadcast interview for FarmScape Online.

Columbus, D. (2019) What is the long-term impact of feeding DON to finisher pigs? Pages 1-3 In: Centred on Swine (Volume 26, Number 1), Prairie Swine Centre, Saskatoon, SK.

Columbus, D., and **M. Bosompem.** (Summer 2019) What is the long-term production and economic impact of feeding deoxynivalenol-contaminated feed to finisher pigs? Page 6-9 In: Canadian Hog Journal, Edmonton, AB.

Columbus, D., and **M. Wellington** (February 2019) Maintaining animal robustness: High-fibre diets and immune system stimulation increase growing pigs' threonine requirements. Pages 50-51 In: Better Pork, Guelph, ON.

Columbus, D., **M. Wellington**, A. Van Kessel, and J. Htoo. (2019) High-fiber diets: More threonine needed during immune challenge? National Hog Farmer, Minneapolis, MN. www.nationalhogfarmer.com

Columbus, D. (2019) Mycotoxins in Western Canadian diets. Red Deer Swine Technology Workshop. Red Deer, AB. Invited.

Columbus, D. (2020) Diet formulation to improve pig health and performance. 43rd Annual Saskatchewan Pork Industry Symposium. November 12, Saskatoon, SK. Invited.

Columbus, D. (2020) Feeding for health – can we adjust diets to create a more robust pig? Prairie Swine Centre Producer Meetings. Webinar.

Columbus, D. (2020) Fibre, protein, and amino acids – impact on gut health, immune function, and growth in pigs. 6th International Animal Intestinal Ecology and Health in China Summit Form. November 6-8, Zhengzhou, China. Invited.

Columbus, D. (2020) Functional amino acids to improve pig health. Symposium on Microbiome, Gut Health, and Piglet Nutrition, ASAS-CSAS Joint Annual Meeting, July 19-23, Madison, WI. Invited.

Columbus, D. (2020) Functional amino acids to improve pig robustness. ASAS-CSAS Joint Annual Meeting. Invited.

Columbus, D., and D. Ferguson. (2020) Can a swine model for low birth weight and neonatal undernutrition be used to benefit health care and agriculture? Michigan State University Canadian Partnership (MSUCP) Forum, Canadian Studies Center, International Studies and Programs, Michigan State University. Invited.

Darambazar, E., D. Damiran, and **D. Beaulieu.** 2019. Effect of hydrothermal, phytase, or organize acid pretreatments of canola meal on phytate level of the meal. Sustainable Agriculture Research. 8 (4): 35 – 47.

Darambazar, E., D. Damiran, and **D. Beaulieu.** 2020. Evaluation of diets with inclusion of hydrothermal, phytase, and organic acid pretreated canola meal on nutrient digestibility in swine. Sustainable Agriculture Research. 9 (2): 41 - 54.

El Karsh Z., J. Morton, M. Jarque, B. Patton, **L. Rodrigues**, K. Illing, A. Chicoine, **J. Sands**, A. Wellette-Hunsucker, D. Ferguson, **D. Columbus**, L. Weber, and T. Olver. (2020) Low birth weight pigs exhibit altered cerebral hemodynamics and vasomotor control. FASEB J. 34(S1):1.

Engele K., **M. Bosompem**, and **D. Columbus.** (2020) Pig performance and economics of long-term feeding of DON-contaminated diets. Centred on Swine (Volume 27, Number 3), Prairie Swine Centre, Saskatoon, SK. In press.

Everding, T., **Y. Seddon**, J. Perez-Palencia, and C. Levesque. (2020) Quantifying cortisol in the hair of sows in pen and stall gestation. South Dakota State University Swine Day virtual meeting, 3rd November.

Geddes, G. (2020) Science Taking Bite out of Feed Costs. Text interview for Swine Innovation Porc.

Golightly, H., **J. Brown**, R. Bergeron, J. Poljak, **R. Roy**, **Y. Seddon,** and T. O'Sullivan. (2020) The effects of transport duration on weaned piglets in Canada. In: Advances in Pork Production. Proceedings of the Banff Pork Seminar, Banff, AB, Canada, 7th-9th January, vol. 31, abstract #23.

Guide to Small Scale Pig Production for Saskatchewan farms. A Sask Pork Publication, Saskatoon, Canada. **Y. Seddon** contributed section: housing and management options and outdoor production.

Hernandez, G., V. Smith, M. Temple, D. Bennet, **D. Columbus**, M. Rice, K. Sprayberry, M. Edwards, D. Peterson, R. Fanter, C. Kitts, M. La Frano, D. Burrin, R. Manjarin, and M. Maj. (2019) A diet-induced pediatric model of non-alcoholic fatty liver disease using neonatal Iberian pigs. Curr. Dev. Nutr. 3(Suppl. 1):OR26-02-19.

Hernandez, G., V. Smith, M. Melnyk, **D. Columbus**, M. Burd, K. Sprayberry, M. Edwards, D. Peterson, D. Bennett, R. Fanter, J. Steibel, H. Glanz, T. Santiago-Rodrigues, C. Immoos, M. Rice, J. Blank, J. Vanderkelen, C. Kitts, B. Piccolo, M. La Frano, D. Burrin, M. Maj, and R. Manjarin. (2020) Dysregulated FXR-FGF19 signaling and choline metabolism is associated with gut dysbiosis and hyperplasia in a novel pig model of pediatric NASH. Am. J. Physiol. Gastrointest. Liver. Physiol. 318:G582-G609. doi:10.1152/ajpgi.00344.2019.

Jose, J., A. Agyekum, and **D. Beaulieu.** 2019. The effect of field pea and enzyme supplementation of swine diets on animal performance and nutrient Sask Pork Symposium 2019.

Jose, J., A. Kpogo, J. Panisson, J. Agnew, **B. Predicala,** and **D. Beaulieu.** 2019. The effect of field peas and enzyme supplementation on green-house gas emissions from grower pigs. Banff Pork Symposium 2020.

Khaledi, K. 2019. Evaluation of performance of magnetized activated carbon in removal of antibiotics from contaminated waters. Unpublished M.Sc. thesis. Saskatoon, SK: Department of Chemical and Biological Engineering, College of Engineering, University of Saskatchewan. (Co-supervised with Drs. Mehdi Nemati and Jafar Soltan)

Khaledi, K., G. Valdes Labrada, J. Soltan, **B. Predicala**, and M. Nemati. 2020. Adsorptive removal of antibiotics from contaminated waters using magnetized activated carbon. Prepared for publication in Water Research Journal.

Khaledi, K., H. Zanjani, G. Valdes Labrada, **B. Predicala**, T. Fonstad, and M. Nemati. 2020. Engineered permeable bio-barriers for protection of ground and surface waters from agricultural and livestock runoff. 70th Canadian Chemical Engineering Conference (CCEC 2020). Ottawa, Ontario. October 25–28, 2020.

Khaledi, K., J. Soltan, **B. Predicala**, and M. Nemati. 2020. Adsorptive removal of tetracycline and lincomycin from contaminated waters using magnetized activated carbon. 70th Canadian Chemical Engineering Conference (CCEC 2020). Ottawa, Ontario. October 25–28, 2020.

Khaledi, K., M. Nemati, J. Soltan, and **B. Predicala**. 2020. Evaluation of magnetized activated carbon for removal of antibiotics from contaminated waters. SustainTech 2020 Annual Conference. Saskatchewan Environmental Industry and Managers Association (SEIMA). March, 2020. Saskatoon, SK.

Kiros, T., A. Agyekum, J. Wang, R. D'Inca, **D. Beaulieu**, E. Auclair, and A. Van Kessel. 2019. Supplementation with live yeast increases rate and extent of in vitro fermentation of nondigested feed ingredients by fecal microbiota. Journal of Animal Science. 97(4): 1806-1818.

Kpogo, A., J. Jose, J. Panison, **B. Predicala**, **A. Alvarado**, J. Agnew, C. Sprenger, and **D. Beaulieu.** 2020. Greenhouse gas emissions and a partial life cycle assessment when the diet of growing pigs is supplemented with a multi carbohydrase enzyme. Submitted to Journal of Animal Science.

Kpogo, A., and **D. Beaulieu**. 2019 Performance of growing pigs fed wheat-based diets containing wheat millrun and a multi-carbohydrase enzyme. ASAS/CSAS annual meeting. 2019.

Kpogo, A., J. Jose, J. Panisson, J. Agnew, C. Sprenger, and **D. Beaulieu.** 2019. Greenhouse gases and swine. How are these values obtained? Sask. Pork Symposium 2019.

Kpogo, A., J. Jose, J. Panisson, **B. Predicala**, **A. Alvarado**, J. Agnew, and **D. Beaulieu**. 2019. Greenhouse gas emissions from growing pigs fed wheat millrun and a multi-carbohydrase enzyme. Banff Pork Symposium 2020.

Krone, J., A. Agyekum, M. ter Borgh, K. Hamonic, G. Penner, and **D. Columbus.** (2019) Characterization of urea transport mechanisms in the intestinal tract of growing pigs. Am. J. Physiol. Gastrointest. Liver. Physiol. 317:G839-G844. doi:10.1152/ajpgi.00220.2019.

Krone, J., M. ter Borgh, K. Burakowska, G. Gratton, K. Hamonic, A. Agyekum, G. Penner, and **D. Columbus.** (2019) Characterization of urea transport mechanisms in the intestinal tract of growing pigs. J. Anim. Sci. 97 (Suppl. 3):176.

Krone, J., M. ter Borgh, K. Burakowska, G. Gratton, K. Hamonic, A. Agyekum, G. Penner, and **D. Columbus.** (2019) Characterization of urea transport mechanisms in the intestinal tract of growing pigs. ASAS-CSAS Joint Annual Meeting, Austin, TX.

La Frano, M., G. Hernandez, V. Smith, **D. Columbus**, D. Peterson, R. Fanter, C. Kitts, D. Burrin, M. Maj, and R. Manjarin. (2019) Metabolomic characterization of a novel large animal model of non-alcoholic fatty liver disease. Curr. Dev. Nutr. 3(Suppl. 1):P08-131-19.

Mansilla, W., C. Marinangeli, S. Abood, **D. Columbus**, J. Larsen, K. Ekenstedt, L. Weber, and K. Shoveller. (2019) The association between pulse ingredients and canine dilated cardiomyopathy: addressing the knowledge gaps before establishing causation. J. Anim. Sci. 97:983-997. doi:10.1093/jas/sky488.

Mansilla, W., C. Marinangeli, **C. Cargo-Froom**, A. Franczyk, J. House, R. Elango, **D. Columbus**, E. Kiarie, M. Rogers, and A. Shoveller. (2020) Comparison of methodologies used to define the protein quality of human foods and support regulatory claims. Appl. Physiol. Nutr. Metab. 45:917-926. doi:10.1139/apnm-2019-0757.

Panisson, J., E. Zeeman, and **D. Beaulieu.** 2019. The effect of ergot and steam explosion processing on the performance of nursery pigs. Banff Pork Symposium 2020.

Patton, B. (2019) Heart health's potential link to early-life nutrition. Text interview for WCVM Today (wcvmtoday.usask.ca).

Patton, B. (2020) Heart health's potential link to early-life nutrition. Pages 9-11 in Centred on Swine (Volume 26, Number 2). Text interview.

Patton, B., **D. Columbus**, D. Olver, **L. Rodrigues**, J. **Sands**, and L. Weber. (2019) Low birth weight changes heart size while inadequate post-natal nutrition leads to ventricular stiffness in piglets. Western College of Veterinary Medicine Undergraduate Student Research Poster Day, Saskatoon, SK, September 4-5.

Pedersen-Macnab, M., **M. Tokareva,** and **Y. Seddon.** (2019) Progress made towards the Animal Welfare Research Priorities for Pigs: A review of research 2012 - 2019 for the Pig Code Technical Committee. Final submitted to Canadian Pork Council, November 2019.

Pedersen-Macnab, M., **Y. Seddon**, J. Harding, F. Fortin, G. Miguel-Pacheco, J. Dekkers, M. Dyck, G. Plastow, and PigGen Canada. (2020) The effect of environmental enrichment on measures of disease resilience in pigs. In: Advances in Pork Production. Proceedings of the Banff Pork Seminar, Banff, AB, Canada, 7th-9th January, vol. 31, abstract #15.

Petracek, R., M. ter Borgh, K. Bandaralage, J. Krone, and **D. Columbus.** (2019) Long-term feeding of DON-contaminated diets to finisher pigs. Advances in Pork Production. 30:223.

Petracek, R., M. ter Borgh, K. Bandaralage, J. Krone, and **D. Columbus.** (2019) Long-term feeding of DON-contaminated diets to finisher pigs. Saskatchewan Pork Industry Symposium, November 14-15, Saskatoon, SK.

Predicala, B. 2019. Can trailer design effectively reduce disease transmission? Centred on Swine. Prairie Swine Centre. Saskatoon, SK. Vol. 26. No. 1. pp. 4-5.

Predicala, B. 2020. Pigs consume more water when stressed. Centred on Swine. Prairie Swine Centre. Saskatoon, SK. Vol. 26. No. 2. pp. 2-4.

Predicala, B., **A. Alvarado**, J. Cabahug, and S. Kirychuk. 2020. Engineering a better ride. National Hog Farmer. Jan 10, 2020. https://www.nationalhogfarmer.com/animal-health/engineering-better-ride

Predicala, B., **A. Alvarado**, J. Cabahug, and S. Kirychuk. 2019. Evaluation of a prototype air-filtered trailer. 2019 PSC Annual Report. Prairie Swine Centre. Saskatoon, SK. pp. 15-17.

Predicala, B., **A. Alvarado**, and R. Baah. 2019. Technology provides extra eye on hogs. National Hog Farmer. January 9, 2019. https://www.nationalhogfarmer.com/animal-welfare/technology-provides-extra-eye-hogs

Predicala, B., J. Cabahug, **A. Alvarado**, and R. Baah. 2019. Mitigation of accelerated deterioration of pig buildings. Centred on Swine. Prairie Swine Centre. Saskatoon, SK. Vol. 25. No. 1. pp. 6-8.

Rodrigues, L., and **D. Columbus.** (2020) Functional amino acids can enhance the ability of pigs to cope with an enteric challenge. Pages 1-4 In: Centred on Swine (Volume 27, Number 1), Prairie Swine Centre, Saskatoon, SK.

Rodrigues, L., and **D. Columbus.** (April 2020) How to enhance pig robustness. Pages 35-38 In: Better Pork, Guelph, ON.

Rodrigues, L., and **D. Columbus.** (Spring 2020) Functional amino acids above requirements enhance the ability of pigs to cope with an enteric challenge. Pages 36-37 In: Canadian Hog Journal, Edmonton, AB.

Rodrigues, L., F. Ferreira, M. Costa, M. Meneguzz, **M. Wellington**, and **D. Columbus.** (2019) A multivariate analysis of the effect of disease challenge on the growth performance of pigs. Allen D. Leman Swine Conference Research Abstracts. 49.

Rodrigues, L., F. Ferreira, M. Costa, M. Meneguzzi, and **D. Columbus.** (2020) Performance level and sex impact the response to disease challenge in growing pigs. Advances in Pork Production. 31:252.

Rodrigues, L., **J. Sands**, P. Johnson, J. Krone, **M. Wellington**, and **D. Columbus.** (2020) The effect of birth weight and neonatal undernutrition on short- and long-term growth performance and organ development in pigs. Advances in Pork Production. 31:256.

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Rodrigues, L., **M. Wellington**, J. Gonzalez-Vega, J. Htoo, A. Van Kessel, and **D. Columbus.** (2020) Functional amino acid supplementation, regardless of dietary protein content, improves growth performance and attenuates the immune response in Salmonella-challenged weaned pigs. J. Anim. Sci. Submitted 10-02-2020, Manuscript ID: JAS-2020-4996.

Rodrigues, L., **M. Wellington**, J. Krone, J. Gonzalez-Vega, J. Htoo, A. Van Kessel, and **D. Columbus.** (2020) Functional amino acid supplementation, regardless of dietary protein content, improves growth performance, acute-phase response, and bacterial shedding in Salmonella-challenged pigs. ASAS-CSAS Joint Annual Meeting. Accepted.

Rodrigues, L., **M. Wellington**, J. Krone, J. Gonzalez-Vega, A. Van Kessel, and **D. Columbus.** (2019) The effects of functional amino acids and dietary protein content on growth performance and clinical score of growing pigs challenged with Salmonella typhimurium. Saskatchewan Pork Industry Symposium, November 14-15, Saskatoon, SK.

Rodrigues, L., **M. Wellington**, **J. Sands**, L. Weber, T. Olver, D. Ferguson, and **D. Columbus.** (2020) Characterization of a swine model of birth weight and neonatal nutrient restriction. Curr. Dev. Nutr. 4:nzaa116. doi:10.1093/cdn/nzaa116.

Rodrigues, L., **M. Wellington**, A. Van Kessel, and **D. Columbus.** (2020) Nutrition and Immunology in Swine. In: Sustainable Swine Nutrition, 2nd Ed. Chiba LI, editor. Wiley-Blackwell, Iowa, USA. In press.

Rudar, M., **D. Columbus**, J. Steinhoff-Wagner, A. Suryawan, H. Nguyen, R. Fleischmann, T. Davis, and M. Fiorotto. (2020) Leucine supplementation does not restore diminished skeletal muscle satellite cell abundance and myonuclear accretion when protein intake is limiting. J. Nutr. 150:22-30. doi:10.1093/jn/nxz216.

Sands, J., and **D. Columbus.** (2020) Does creep feed have any benefit? Centred on Swine (Volume 27, Number 3), Prairie Swine Centre, Saskatoon, SK. In press.

Seddon, Y. (2020) 'Economic evaluation of indoor farrowing systems,' in: I. Camerlink (ed.) Animal Welfare in Practice: Pigs, Sheffield, UK: 5M Publishing.

Si, Y., Y. Yang, M. Martel, B. Thompson, **B. Predicala**, H. Guo, L. Zhang, and S. Kirychuk. 2020. Microbial decontamination of metal surfaces by engineered water nano-structures produced by an electrospray. Submitted to Journal of Applied Microbiology. September 2020.

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Smith, V., G. Hernandez, C. Terkatz, I. Meyer, M. Rice, **D. Columbus**, M. Edwards, M. Burd, K. Sprayberry, J. VanderKelen, J. Steinhoff-Wagner, D. Peterson, R. Fanter, C. Kitts, M. La Frano, D. Burrin, M. Maj, and R. Manjarin. (2019) Western diet-induced dysbiosis is associated with intestinal hyperplasia and dysregulation of FXR-FGF19 gene expression in juvenile Iberian pigs. Curr. Dev. Nutr. 3(Suppl. 1):OR26-03-19.

Sotto, D., A. Van Kessel, and **D. Beaulieu**. 2019. The interaction of feeding acid-preserved high moisture wheat and particle size on weanling pig performance, nutrient digestibility and gut health. Banff Pork Symposium. 2019.

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Tokareva, M., **J. Brown**, D. MacPhee, G. Adams, and **Y. Seddon.** (2020) The impact of providing a greater freedom of movement through periodic exercise on sow performance. In: Advances in Pork Production. Proceedings of the Banff Pork Seminar, Banff, AB, Canada, 7th-9th January, vol. 31, abstract #26.

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Tokareva, M., **J. Brown**, A. Woodward, E. Pajor, and **Y. Seddon.** Movement or more food? A comparison of motivation for exercise and food in stall-housed sows and gilts. Applied Animal Behaviour Science. Submitted.

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Valdes Labrada, G., S. Kumar, R. Azar, B. **Predicala,** and M. Nemati. 2020. Simultaneous capture of NH3 and H2S using TiO2 and ZnO nanoparticles - laboratory evaluation and application in a livestock facility. Journal of Environmental Chemical Engineering. Vol. 8, Issue 1: Article 103615. https://doi.org/10.1016/j.jece.2019.103615

Wellington, M., A. Agyekum, K. Hamonic, J. Htoo, A. Van Kessel, and **D. Columbus.** (2019) Effect of supplemental threonine above requirement on growth performance of Salmonella typhimurium challenged pigs fed high fiber diets. J. Anim. Sci. 97:3636-3647. doi:10.1093/jas/skz225. (Featured Article – Amino Acid Supplementation and Performance)

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