Proceedings of the University of Guelph Swine Research Day 2017

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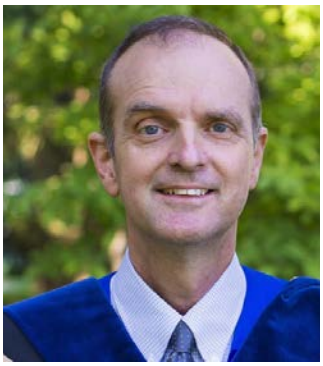

A truly outstanding scientist, colleague and mentor, Prof. Cornelis (Kees) F.M. de Lange was always thinking about the future and how to better the food animal agriculture industry through research. His legacy of excellence, originality and industry support is one that won't be forgotten by his colleagues, students and friends. Following his passing on August 1, 2016 and in honour of Dr. de Lange's accomplishments, an endowed graduate scholarship in swine nutrition will be created. This scholarship is fitting considering his contributions to the swine industry, his support of students and his significance to the University of Guelph community.

Kees was born in De Weere, the Netherlands, and grew up in this agricultural community where his family owned a feed company. He studied animal science at the University of Wageningen in the Netherlands, and moved to Canada in 1985 to conduct his Ph.D. studies at the University of Alberta. Following his graduate studies, he was employed in the Ontario feed industry and, subsequently, at the Prairie Swine Centre in Saskatoon, Saskatchewan.

In 1994, he joined the faculty of the University of Guelph in the area of swine nutrition where he had a very productive and well respected career. His peer-reviewed publications and presentations on swine nutrition exceed 150 and 130, respectively. He made outstanding and long-lasting contributions to the swine industry in Canada and internationally. As a result, he received the Canadian Society of Animal Science Excellence in Nutrition and Meat Quality award in 2010, the American Feed Industry Association Award in Nonruminant Nutrition Research from the American Society of Animal Science in 2012, and the 2013 Alumni Association Distinguished Extension Award from the Ontario Agricultural College. In addition to teaching undergraduate students, he supervised over 50 graduate students and postdoctoral fellows. Most of his students have gone on to leading positions in the swine industry, the animal feed industry, and faculty positions.

We invite you to join us in celebrating his life and achievements and extend his legacy through your support of this scholarship.

To support this scholarship please visit:
http://uofg.convio.net/keesdelange

The evolution of diet formulation: a look into the future

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Tribute to C.F.M. "Kees" de Lange (April 19, 1961 - August 1, 2016)

Dr. Kees de Lange was first appointed Assistant Professor in 1994, rising through the ranks until his promotion to Full Professor in 2003. Prior to the University of Guelph, he was a Research Scientist at the Prairie Swine Centre (1992-1994) and swine nutritionist with Ralston Purina Canada (1989-1992). Following early degrees earned from Wageningen Agricultural University, he received his Ph.D. from the University of Alberta in 1988. The stature and innovation of his Ph.D. dissertation would serve as an omen of the success Kees would achieve throughout his professional career.

He published over 150 refereed journal manuscripts, 3 books and 28 book chapters. His research has been cited more than 6,000 times. His publications generated an impressive H-index of 40 and an i10 index of 119. He supervised more than 50 graduate students and post-doctoral fellows. He received the top nutrition awards from the Canadian and American Societies of Animal Science, 3 Distinguished Faculty Awards from the University of Guelph and the (Ontario) Premier's Research Excellence Award. He was also selected to deliver the prestigious T.K. Cheung Lecture at the University of Manitoba; his title was: *A bright future for animal science: Perspective of an animal nutritionist*.

I suspect everyone in this room will have known Kees, and the tremendous contribution he has made to the field of nutrition, and specifically to the nutrition of the pig. He was definitely a global thought leader, making contributions in modelling, in energy and amino acid metabolism, in liquid feeding, and in ingredient evaluation. Indeed, the breadth of his contributions belie the depth of his research; generally someone who works in such broad areas sacrifices depth and understanding, but this was certainly not the situation with Kees. If anything, his breadth of investigation afforded him the opportunity to develop a level of knowledge of swine nutrition at the metabolic level that was without peer.

However, what really made Kees so special in his research was his relentless search for a better understanding. He was not satisfied with simply developing new knowledge; he wanted to achieve greater understanding as well. This drive for knowledge and understanding also made him an outstanding mentor of graduate students.

"Rate my professor" would by no means be considered an objective assessment of a professor's competence as a teacher. However, one student described Kees as follows: "Kees is a great prof and hard marker. Very funny and nice guy." Another said "Kees is a great prof, keen on the material and helpful to the students. Makes a great effort to stimulate interest in the topic of swine nutrition. Very knowledgeable." I suspect that a combination of those two comments would describe Kees as a teacher quite well: keen, helpful, great effort and knowledgeable. Oh, and yes, we could all guess he would appear to some to be a hard marker, although he never expected more of others than he expected of himself. It was this drive to continually achieve excellence in all that he did which made him the success that he was.

Following is a list of Kees' 5 most frequently cited first/senior author publications:

- de Lange, CFM, WC Sauer, R Mosenthin, WB Souffrant. 1989. The effect of feeding different protein-free diets on the recovery and amino acid composition of endogenous protein collected from the distal ileum and feces in pigs. Journal of Animal Science 67 (3), 746-754 (Cited 198 times)
- de Lange, CFM, WB Souffrant, WC Sauer. 1990. Real ileal protein and amino acid digestibilities in feedstuffs for growing pigs as determined with the 15N-isotope dilution technique. Journal of Animal Science 68 (2), 409-418 (Cited 180 times)
- de Lange, CFM, WC Sauer, W Souffrant. 1989. The effect of protein status of the pig on the recovery and amino acid composition of endogenous protein in digesta collected from the distal ileum. Journal of Animal Science 67 (3), 755-762 (Cited 154 times)
- Namkung, H, MLJ Gong, H Yu, M Cottrill, C de Lange. 2004. Impact of feeding blends of organic acids and herbal extracts on growth performance, gut microbiota and digestive function in newly weaned pigs. Canadian Journal of Animal Science 84 (4), 697-704 (Cited 147 times)
- CFM de Lange, J Pluske, J Gong, CM Nyachoti. 2010. Strategic use of feed ingredients and feed additives to stimulate gut health and development in young pigs. Livestock Science 134 (1), 124-134 (Cited 140 times)

While the above list represents his 5 most frequently cited papers, following is a list of papers which I liked the best, either because of their novelty and innovation or because of the impact they had on thinking in the swine nutrition community:

- Möhn, S, AM Gillis, PJ Moughan, CF de Lange. 2000. Influence of dietary lysine and energy intakes on body protein deposition and lysine utilization in the growing pig. Journal of Animal Science 78 (6), 1510-1519 (Cited 102 times)
- Birkett, S, K de Lange. 2001. Limitations of conventional models and a conceptual framework for a nutrient flow representation of energy utilization by animals. British Journal of Nutrition 86 (06), 647-659 (Cited 89 times)
- Möhn, S, CF de Lange. 1998. The effect of body weight on the upper limit to protein deposition in a defined population of growing gilts. Journal of Animal Science 76 (1), 124-133 (Cited 78 times)
- Birkett, S, K de Lange. 2001. A computational framework for a nutrient flow representation of energy utilization by growing monogastric animals. British Journal of Nutrition 86 (06), 661-674 Cited 60 times)
- S Birkett, K de Lange. 2001. Calibration of a nutrient flow model of energy utilization by growing pigs. British Journal of Nutrition 86 (06), 675-689 (Cited 41 times)
- Weis, RN, SH Birkett, PCH Morel, CFM de Lange. 2004. Effects of energy intake and body weight on physical and chemical body composition in growing entire male pigs. Journal of Animal Science 82 (1), 109-121 (Cited 35 times)

This very brief summary highlights a tremendously successful career, achieved in more recent times under the burden of a serious and progressive illness, as well as the distraction and time committed to his considerable administrative responsibilities. He contributed so much, but was taken from us far too soon.

Limitations of current feed formulation procedures

Before contemplating changes that might reasonably be expected to occur in future feed formulation, consideration should be given to limitations in current approaches. At the same time, credit must be given to the extraordinary progress achieved in feed formulation over the past 50 years, or since 1967. This seems like an appropriate time frame, given that 1967 was the year Canada celebrated 100 years as a nation, and this year, the still young nation celebrates its sesquicentennial.

Fifty years ago, feed formulation was obviously much less sophisticated than it is today. Using the NRC Nutrient Requirements of Swine series, supplemented with personal conversations with (retired) feed industry nutritionists, an intriguing evolution of our knowledge in swine nutrition, and thus feed formulation, emerges. In the 1960's, diets were formulated on the basis of TDN, crude protein, calcium, phosphorus and fiber. Some consideration was given to vitamins A, D and E.

NRC (1968) focused much of its attention on deficiency symptoms associated with an inadequate supply of an individual or mineral. Requirements were defined in terms of crude protein and digestible energy, although the latter was sometimes calculated from TDN rather than measured directly. There were also requirements for calcium, phosphorus, sodium, chloride and 9 vitamins. The requirement for some essential amino acids were presented, but they were expressed on a total basis, and many were absent for the finishing pig (35+ kg). There were also requirements for trace minerals, but the requirement was the same for all ages of pigs, including the breeding herd.

By 1979, DE was measured directly and not calculated from TDN. Metabolizable energy was added to the document, as was a more complete profile of amino acids (total basis). Vitamin and trace mineral requirements were specified according to age and phase of production (NRC, 1979). Requirements were also presented on the basis of both concentration and daily intake. More weight categories were added to improve precision of diet formulation; however, the concept of availability was very limited, so most nutrients were still expressed on a total as opposed to biologically available basis.

NRC (1988) revealed a higher level of sophistication, in that animal performance standards were presented as the basis for the associated requirements. However, this still reflected an empirical approach to defining nutrient requirements; the factorial approach would not arrive for another decade. Requirements were provided in much more detail for the breeding herd, including developing gilts and boars. Available phosphorus was added, representing a substantial step forward in recognizing the growing need for formulating on the basis of nutrient availability. The only new nutrient added in 1988 was linoleic acid, although one could argue that there was very little data to support any definition of its requirement.

The advent of modelling, the determination of nutrient requirements on the basis of performance, the inclusion of net energy and the adoption of true and apparent ileal digestible amino acids all arrived with the NRC (1998). These changes represented a major step forward in swine diet formulation. Perhaps the most significant change, however, was the inclusion of a growth model which could be utilized to estimate nutrient requirements in a much more sophisticated manner,

making adjustments for faster or slower growth as it might occur on-farm. This increasing sophistication was also revealed by the size of the document - 189 pages compared with 93 pages in the previous version.

The NRC (2012) represented yet another major step forward in swine nutrition and swine diet formulation. This document was written as a comprehensive reference not only on nutrients but also growth biology and other scientific disciplines which are fundamental to the understanding of nutrient requirements. Based on the depth of information in the various NRC documents, being an applied swine nutritionist got more difficult in 1998, and became even more challenging in 2012. The level of sophistication of the science of nutrition was surpassing the ability of the industry to implement it. It is therefore no wonder that the demand for nutritionists trained at the M.S. and Ph.D. level was exploding – along with their salaries.

Computerized least cost formulation using the principles of linear programming was a topic of growing research interest in the 1950s, it was gaining commercial application in the 1960s and was pretty universal among feed companies as the 1970s progressed. However, in Canada's centennial year, the ubiquitous Pearson Square was very much in common use. The capacity of least cost formulation rapidly expanded once it was broadly adopted; a major advancement occurred when it was adopted for use on personal computers, thus making the technology mobile with broader application.

Herein lies one major dilemma. Science has provided a much greater understanding of nutrition, as well as important associated disciplines like biochemistry and physiology. New tools in proteomics and transcriptomics, for example, support research on the genetic control of metabolism. At the same time, the pig industry has grown much more sophisticated in how ingredients are purchased and how diets are formulated. Students graduating today have never been better trained to take on the challenges of the future. Yet, at the level of feed manufacturing and delivery, the demands of mill throughput make it difficult to adopt some of the new technology in situation-specific feed formulation. Feed mill managers greatly prefer feed runs of 25 or 50 tonnes, rather than making diets specific to each individual client. Truckers prefer 20+ tonne loads transported to a single site, rather than smaller loads delivered to numerous locations. Structurally, our industry is moving in a direction that minimizes transportation and feed manufacturing costs, but limits our ability to implement the highest level of nutritional sophistication. There is a great opportunity for some smart people to develop a holistic approach to pork production that retains the ability to minimize these hard costs, but at the same time supports adoption of feeding programs that push the limits of our understanding of swine nutrition.

The ability to fit nutrition within the confines of high volume, low margin feed delivery represents perhaps one of the bigger logistical changes, but other scientific issues remain. There is also the challenge of appropriately expressing nutrient requirements. For example, amino acid requirements can be expressed on a concentration basis (eg. %, g/kg), on a daily intake basis (eg. g/day), per unit of protein accretion basis (eg. g/mg protein gain) or as a ratio to energy (eg. g/Mcal NE). Each expression has merits but also drawbacks.

Biological variation is a fact of life when dealing with animals and with plant products. Consider, for example, that the ME content of barley varies by ~15% and that of wheat by ~9%; corn is only slightly more uniform with a typical range in DE of ~8%. Ingredient variability is clearly a challenge for anyone involved in diet formulation, and can be addressed in a number of ways, including frequent analysis of source grains, more recently accomplished through the use of NIR. It can also be handled statistically; by defining the variation in the content of a given nutrient in each feedstuff, the specification for that nutrient can be defined. The final deviation in the nutrient specification from the mean in the final diet will be determined statistically according to the degree of variation within each ingredient and the number of ingredients used in the formulation. The statistical approach is of limited value in a simple corn-soybean meal diet, but fortunately they are also among the least variable ingredients.

Variation in the pig has to be handled in a different manner, and often is not addressed at all in current feed formulation. Typically, the average nutrient requirement is applied to large numbers of pigs, in part because it is difficult to be absolutely precise in defining nutrient requirements and because it is logistically very difficult to feed smaller groups of pigs according to their specific requirements. However, as one example, feed intake among farms varies by at least 30%, so this is not a trivial issue.

The other variation that nutritionists must deal with is market conditions. The spread between market prices and feed cost is constantly changing. Intuitively, the feeding program that maximizes net income when feed costs are high and market prices are low may not be optimal when feed costs are low and market prices are high. However, implementing an "optimal" feeding program that changes according to market conditions is very difficult because it must be implemented when pigs are placed, not adjusted during the course of their growth period. Forward contracting helps in this regard, but in any event, projecting market conditions 6 months out has always been an inexact science.

Three generations of nutritionists have been trained to develop diets that meet the nutrient requirements of the pig, according to its stage of production and anticipated level of performance. Their efforts have been further supported by the move to a more factorial approach to defining nutrient requirements, as opposed to the previously – and still far too popular - empirical approach. Meeting the pig's requirements for all known nutrients has served the industry well, but it is becoming increasingly apparent that the composition of the diet must also address the needs of the microbiome resident in the gastrointestinal tract. An increasing body of literature is revealing that non-nutritive characteristics of a diet can reduce or increase a pig's susceptibility to certain pathogens, primarily those of gastrointestinal origin. As pressure increases on the use of antibiotics in pig diets, this aspect of diet formulation will assume much greater importance.

In many scientific circles, the composition of the diet is characterized according to its soluble or insoluble fiber content. Soluble fiber appears to have prebiotic effects on the gut, while insoluble fiber may alter rate of passage or in some other way impair bacterial adhesion to epithelial cells. However, it is becoming increasingly clear that defining fiber solely in terms of solubility, or even fermentability, may be insufficient in predicting the impact on the microbiome, resistance

to disease or on pig overall performance. The changing relationship between protein production and the consumer, which currently is moving the industry towards elimination of antibiotics as growth promotants and restricted overall use in the feed, will also change the way we formulate diets.

Efforts to systemize the energy content of ingredients or the energy needs of the pig go back more than a century, and have evolved through TDN, then DE, then ME and then NE. Other energy systems are in use in select countries such as the Potential Physiological Energy (PPE) system in Denmark. While the NE system offers numerous advantages over DE or ME, problems remain in assigning an NE value to feedstuffs; this lack of confidence in ingredient NE values is impeding the adoption of NE in some circles. And while NE should theoretically be superior in predicting pig performance, it has not proven to be a quantum improvement over DE or ME. Following is a list of some of the problems associated with the use of any of the current energy systems:

1. Digestibility changes with age, so differing energy values are required for different ages of the pig
2. While amino acid, mineral and vitamin requirements are fulfilled by specific amino acids, minerals and vitamins, this is not the case with energy, which is supplied by simple or complex carbohydrates, protein and fat.
    - The efficiency with which different sources of energy are used by the pig depends on their metabolic fate, such as maintenance vs lipid deposition in the carcass
3. Heat increment (HE) is assumed to be waste in the NE system, but under certain environmental conditions, HE could be a valuable resource to help maintain thermal homeostasis and this spare energy for productive purposes
4. Measurements of energy digestibility ignore endogenous secretions. This is less of a problem with whole diets fed ad libitum, but can be consequential with constituents of ingredients, such as fat which is generally present in low concentrations
5. Like DE and ME, the concentration of NE in ingredients or diets can be determined using more than one methodology, but the resulting values are not interchangeable among methods

What does the future hold

The following thoughts on future developments are presented with the qualifier that nutritionists are not trained to be prognosticators! The following represents my best attempt to look at how formulation might evolve in the future, and in some cases how I feel it must evolve in the future to best serve the feed and animal industries.

The net energy system will continue to gain traction and become more prominent in diet formulation. For those individuals and organizations that have not yet converted, the biggest constraint is likely to be confidence in energy values assigned to ingredients. This problem will gradually sort itself out, and one would expect that the net energy system will supplant DE and ME. We have run numerous studies comparing NE and ME, and at no time did diets formulated using the former perform less well than those formulated using the latter. The clear benefit of the NE system is pricing of ingredients in a manner which more accurately reflects its energetic

value to the pig. Improved precision, resulting in greater predictability of performance, is a somewhat elusive expectation and in any event, will be only modestly better than ME or DE.

However, NE cannot address the fundamental challenges of any energy system as previously explained. In all likelihood, nutritionists will gravitate towards a more mechanistic modelling approach, which will address many of the limitations of energy systems. As everyone knows, Kees was a proponent of growth models and metabolic models, constrained only by the need for more mechanistic data to fill in some knowledge gaps.

At the present time, nutritionists consider gut health when formulating phase 1 and 2 starter diets. The inclusion of milk products, some blood products, novel proteins and processed vegetable products is a form of formulating to manage gut health. In the future, one can expect nutritionists to be more deliberative in this respect, and the scope of the practice will extend beyond the young pig.

The next generation of feed additives could be quite different from the present. Certainly, enzymes, direct-fed microbials (probiotics), prebiotics, yeast and yeast components, nucleotides and organic acids will continue to find purpose in the future. However, the next generation of such products will differ somewhat in their composition, structure and function. They are most likely to be even more specially designed to fill specific functions under specific health and environmental conditions.

While some feed additives justify their use through manipulation of the microbiota, the search for products with true antimicrobial impact will accelerate. By definition, these could be called antibiotics, and thus run of the risk of falling under the regulatory umbrella. However, they differ from what is currently considered “a drug.”

Enzyme use is certain to increase. The great success story of the past 2 decades has been phytase, which now enjoys almost universal application – and proves that the concept of exogenous enzyme use in feed to improve nutrient utilization is scientifically sound. In the future, enzyme blends will continue to supplant individual enzymes, increasing effectiveness.

There are many exciting new developments in feed processing. Included in this is support for in-line assay of ingredients using NIR to improve the precision – and the economics – of diet formulation. As this technology gains traction, nutritionists will be charged to take full advantage of this opportunity to reduce costs with no loss, and perhaps an improvement in animal performance.

Nonetheless, the quest to formulate diets more precisely according to pig performance under specific conditions will need to be balanced against maximizing feed mill throughput and minimizing feed delivery costs. This is not something that a nutritionist or team of nutritionists can attack on their own; it will require involving many layers of feed mill operation and management. Nonetheless, the reward for success will be substantial and could give a company considerable advantage in the marketplace.

The ability to develop and implement feeding programs according to economic conditions offers another opportunity to enhance the contribution of feed formulation to the financial success of pork production. Success in achieving this advancement will require partnering with other

participants in the production system, such as ingredient buyers, hog sellers and risk managers. Refining these inputs in a manner that strengthens future planning will allow nutritionists to develop feeding programs appropriate to specific economic conditions.

Similarly, feeding pigs according to their specific genotypic background and expected phenotypic outcomes also offers the opportunity for financial gains. At the present time, this is not possible in larger production systems, but certainly is possible on smaller individual family operations.

Summary

From centennial to sesquicentennial, the space of one generation of nutritionists, and ironically, the period of Kee's life, the process of feed formulation has changed dramatically. From Pearson's square to sophisticated, mobile linear programming, from TDN to NE, from crude protein to SID amino acids, from total phosphorus to STTD phosphorus, from no antibiotic growth promoters to their extensive and current decline. These and many other changes have been embraced by nutritionists to improve the science and application of their craft. The future holds many opportunities. Some changes will represent fine tuning, while others could be transformative. I hope the new generation of nutritionists retains an appreciation for the history of their chosen profession while at the same time embracing great enthusiasm for their future.

From production to demand medicine?

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University of Minnesota

It is stating the obvious that the North American swine industry has evolved a great deal in the years since I graduated from Ontario Veterinary College in 1984. Technical support services have also evolved. Though I am going to focus on my experience in veterinary services in this paper, many of the generalizations can be applied across all levels of technical support, both in the swine industry and across animal agriculture.

Way back in 1984 we had something called herd health, with the inherent assumption that any decrease in disease would add to the profitability of the farm. This evolved, with the aid of computer-based programs such as PigChamp, into something called production medicine, where the aim was to increase animal productivity, focusing on mechanisms that involve both infectious and noninfectious processes. Soon added to this was an emphasis on cost minimization, as cost estimates were readily available from profit and loss statements, and some efforts in maximization of productivity proved to be cost prohibitive.

The combination of focusing on both increasing animal productivity and cost control served the industry well for a number of years but it was also thought that some of the efforts resulted in did not improve the profitability of swine farms. The industry switched from financial accounting to management accounting, taking into account areas such as opportunity costs and capacity utilization. Over the past number of years we have not only seen improvements in productivity in areas such as pigs per sow per year and average daily gain, we have seen increased rates of productivity and quality of output of sow and growing pig capacity.

So what is next? It is an important question to ask as we train the next generation of people working in and for animal agriculture. I would argue that the great majority of short-term profit maximization tools are in place and the next steps should involve securing longer-term profitability, in other words, risk minimization. We have progressed to a certain extent in minimizing risks at the enterprise level, using methods such as biosecurity. The challenge is that most risks are actually aggregate risks, and to address those we need to reframe reward models for technical support. Some of this is already occurring, with veterinarians and others being involved in assuring compliance to generalized codes of practice, but aggregate strategies are, in many ways, in their infancy.

Let's take the example of porcine epidemic diarrhea virus. The enterprise-level effects were severe but the disease has been controlled with herd immunity and biosecurity. The control measures have fit well into an enterprise-level focus, and the support community has a compensation system to fit that enterprise level focus. However, the aggregate effects have been less of a focus. Frankly, it is not difficult to show a net economic benefit from the virus. The virus had little long-term effects, killing piglets that had a relatively low investment, and a herd immunity could be developed quite quickly. The disease occurred at an opportune time where, in the face of increasing productivity, demand had not kept up, and the disease had a real effect of increasing prices. The increased emphasis on biosecurity appears to have also reduced the spread of other diseases, particularly porcine reproductive and respiratory syndrome virus. Finally, this introduced disease resulted in neither significant trade restrictions nor consumer concerns,

allowing us the luxury to imagine what would happen to demand if either were true.

Conversely, this past winter we have seen as surprising amount of demand to match increasing supplies. Yet we have to ask whether we have supported strategies to increase levels of demand. This past season saw a demand not in loins but in bacon and butts. It was not the "other white meat" and it was not aligned with successes in increasing lean the deposition and in turn improving feed conversion rates. Not only is there a continuing revision of human nutritional recommendations, there is a growing emphasis on a differentiation between food and eating. In other words, we need to differentiate between nutrition and pleasure, to migrate from "we are what we eat" to "we eat what are". Some of this has been captured in branded products, but we have been slow in veterinary medicine to support new narratives that support demand for pork.

These concerns are recognized by commodity organizations and we have seen major changes in the focus of these organizations. However, the full innovative strength across the swine industry has not been harnessed. Though commodity organizations have contributed to the improvements in productivity that we have seen within the industry, it is the broad community that created the environment for uptake and refinement. We in the teaching enterprise have focused on entrepreneurship in productivity and enterprise economics while treating demand issues as topics about compliance, striking a more passive model for involvement.

A similar dichotomy exists in human health where issues of the aggregate are usually addressed within public health while individual issues are within medicine. Though there is an aggregate benefit of an investment in public health that outweighs an equal investment in individual medicine, the relative investment is biased towards individual medicine. For instance, there are occasions where the maximum benefit for an individual is to have everyone other than the individual be vaccinated. Likewise, in the case of individual farms, though biocontainment may be more efficient, biosecurity is the default.

The so-called technology treadmill has been used to describe a profit cycle led by early technology adoption. Those of us in the tech development and transfer business are beneficiaries of this competitive model, but are also involved in the increases in scale that it induces. An approach that changes and improves the aggregate is not only foreign to us, but demands a new economic and strategic model.

The first step is to create a public forum on a culture and capability of comparing and contrasting individual and aggregate benefits. The second step in this process is to define data that has an aggregate effect and then use it to not only create a strategy but a discipline. The third, and the most challenging, is to create a reward system for the aggregate strategy that exceeds the competitive outcome.

Competition is a great thing till it isn’t and we may be the last to see it.

Identification of genetic markers in Luman and LRF for stress-responsiveness in piglets

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Introduction: Stress negatively impacts swine immunity and health, affecting animal welfare and meat quality. Behavioral and neuroendocrine responses to stress are highly variable and can be attributed significantly to differences in genetic background and prior experiences. (1) Currently, the underlying genetic component for stress-responsiveness is unclear. Two stress regulatory genes, namely Luman and Luman recruitment factor (LRF), are of particular interest, having been shown to function as important regulators of the hypothalamic-pituitary-adrenal (HPA) axis and stress hormone signaling in mouse models. (2) Recently, we have found that Luman- and LRF-deficient mice are less susceptible to environmental stress. Based on these findings, investigation of these two stress-sensitivity regulatory genes represents a promising avenue for exploring potential applications in farm animals, including pigs. We propose that there are naturally occurring variations in the Luman and LRF genes in pigs that can be used as markers for stress-responsiveness.

Methods: A pilot study will be completed with 50 Yorkshire pigs, in comparison with Meishan pigs, which are known for their low stress and good temperament. Stress-responsiveness scores will be determined by measuring each piglet's behavioral response to four standardized stress tests and by measuring differences in stress hormone levels present in blood samples collected before and after exposure to various stressful events. Meat quality measurements will be taken at slaughter. DNA will be extracted from the blood samples, and the Luman and LRF loci will be sequenced and analyzed for the presence of genetic polymorphisms. The correlation between various genetic variations in Luman and LRF and stress-responsiveness scores in piglets will then be assessed.

Results: This pilot study is in progress. In our current study of the Luman loci in 20 pigs, we identified several naturally occurring polymorphisms including two known synonymous SNPs, one of which was present in 6 pigs, three known SNPs in the non-coding regions, and one previously undocumented missense SNP in 2 pigs. Interestingly, we found a SNP that exists predominantly in the Yorkshire breed (8 out of 9 animals).

Conclusions: Our preliminary analysis suggests that inter- and intra-breed genetic variation exists in the Luman and LRF loci of pigs. The data from this pilot study will: 1) provide us with critical information on the levels of genetic variations in pig populations; 2) enable us to standardize all experimental protocols, such as DNA extract, stress behavioral and stress hormone measurement. This small-scale study may also identify potential genetic markers which can be pursued and verified, or provide important guidance for the next-stage studies.

Industry Implications: Identified genetic markers can be added to an existing commercial genetic marker panel to enable the selection of low-stress pigs in breeding programs. Improving the adaptability of animals to their environment will improve animal well-being and general health, thereby reducing antibiotic use and management costs, while improving the quality of pork products and animal welfare. With increasing societal pressures and consumer awareness, improving animal welfare will also aid in the marketability of the pork product and overall sustainability of the pork industry.

Acknowledgements: Funding provided by OMAFRA. Support provided by CCSI (Canadian Centre for Swine Improvement) and AGC (Alliance Genetics Canada).

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A descriptive analysis of swine movements as a contributor to disease spread

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Introduction: The movement of animals between locations is a predominant area of concern when it comes to biosecurity efforts for any livestock animal production system. Within the swine industry, major efforts have been made to track animal movements to reduce the potential for disease spread or emergence between such locations. The objectives of this research was to use descriptive network measures to describe animal movements and to understand the potential for disease transmission within an Ontario swine production system.

Methods: A data set from an Ontario swine management company which encompassed 224 different production facilities was utilized. Swine shipments from January to December 2015 were recorded within this dataset and made up a total of 5398 unique animal movements. Yearly and weekly networks were then constructed. Subsequently, demographics along with descriptive network and node-level measures were analyzed. Node-level measures evaluated included: betweenness and in- and out-degree with subsequent count variables constructed from each. Poisson regression analysis was utilized on the betweenness count, and degree count variable for trends within a weekly time scale. Network measures included were: maximum weak and strong components and ingoing and outgoing contact chains (ICC and OCC). Within the yearly network only, community detection was conducted for facility association visualization.

Results: Communities were centred around nursery and finisher facilities. The maximum yearly weak component (WC) size and maximum weekly WC was 224 facilities, and 83 facilities, respectively. ICC results varied from a maximum of 173 nodes for the entire year, or a maximum of 53 nodes when calculated on a weekly basis. The OCC varied between a maximum of 79 and 6 different nodes when considered on a yearly and weekly basis, respectively. Regressions resulted in significant finisher facility betweenness and degree counts in a quadratic relationship with a weekly time frame, $\beta = -0.001$, p-value= 0.021 and $\beta = -0.001$, p-value= 0.017 respectively. However, nursery facilities did not result in significant quadratic relationships, although similar patterns to those of finisher facilities can be seen graphically.

Conclusion: Network descriptive measures have been used as disease transmission estimators (1). Although, depending on the time scale of interest these values can change drastically affecting interpretation and subsequently disease intervention efforts. Component size could be used as a potential estimator of the upper bound of an epidemic depending on an appropriate time scale and structure of the network (1). ICC and OCC can be used as a potential trace back or transmission infection chain in the event of an outbreak (2).

Industry Implications: The results from each network can aid in biosecurity efforts made within the swine industry. Weekly networks may be more useful for diseases with a short incubation period and with apparent clinical signs. Results based on the yearly networks could be more relevant for infectious agents that do not show obvious clinical signs and/or have a very long incubation period (3).

Acknowledgments: Funding provided by Ontario Ministry of Agriculture Food and Rural Affairs

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Compensatory body protein gain in newly weaned pigs

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Introduction: The concept of compensatory growth represents a means to improve nutrient utilization and decrease costs in pork production. While compensatory growth can occur following a period of amino acid intake restriction (1), there is limited work examining compensatory growth in newly weaned pigs. A serial slaughter study was conducted to determine effects of lysine (Lys) restriction immediately following weaning on growth performance and carcass composition.

Methods: 144 Duroc x Yorkshire x Landrace pigs (initial body weight (BW) of 6.9 $\pm$ 0.21 kg) were randomly allocated to 1 of 3 dietary treatments (6 pens/treatment with 8 pigs/pen; 4 barrows, 4 gilts). For 3 weeks (restriction phase), pigs were fed starter diets containing 110% (Control: 15.6 g/kg), 80% (Lys80: 11.3 g/kg), or 60% (Lys60: 8.5 g/kg) of NRC requirements for Lys (2). After the restriction phase, all pigs were fed a common grower diet containing 120% of NRC requirements for Lys (14.6 g/kg) for 6 weeks (recovery phase) (2). At week 3 and 9, 2 pigs per pen (1 barrow, 1 gilt) were slaughtered for body composition analysis.

Results: During the restriction phase, pig BW gain ($P < 0.01$; 411, 373, and 319 $\pm$ 7.5 g/d, respectively for Control, Lys80, Lys60) and G:F ($P < 0.01$; 0.807, 0.716, and 0.631 $\pm$ 0.0123, respectively) decreased linearly as the amount of dietary Lys decreased. At end of the restriction phase, there was a significant linear decrease in BW as the amount of dietary Lys decreased ($P < 0.01$; 15.5, 14.8, and 13.6 $\pm$ 0.37 kg, respectively). In addition, there was a linear decrease in carcass weight ($P < 0.01$; 11.6, 10.9, and 10.3 $\pm$ 0.30 kg, respectively) and carcass CP content ($P < 0.01$; 16.5, 16.1, and 15.3 $\pm$ 0.19 %, respectively) with decreasing dietary Lys levels in pigs slaughtered at the end of restriction phase. Following completion of the recovery phase there was a trend for a linear increase in BW gain ($P = 0.06$; 844, 862, and 905 $\pm$ 19.9 g/d, respectively) and a linear increase in G:F ($P < 0.01$; 0.529, 0.552, and 0.569 $\pm$ 0.0101, respectively) as the amount of dietary Lys decreased. Carcass weight ($P > 0.10$; 40.5, 40.3, and 39.6 $\pm$ 0.80 kg, respectively) and carcass CP content ($P > 0.10$; 16.8, 17.4, and 17.1 $\pm$ 0.18 %, respectively) were similar across dietary treatments in pigs slaughtered at end of recovery phase. At the end of the study, pig BW (average of 50.5 $\pm$ 0.63 kg) was similar ($P > 0.10$) across dietary treatments.

Conclusion: Newly weaned pigs previously fed a diet restricted in Lys for 3 weeks, achieved full compensatory growth after a 6 week recovery period.

Industry Implications: Compensatory growth may be an effective means to reduce diet costs during the nursery phase when feed costs are highly expensive without compromising growth performance and carcass composition.

Acknowledgments: Funding provided by NSERC, OMAFRA, Ontario Pork, Evonik, and Wallenstein Feed and Supply LTD.

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Antimicrobial use in Ontario swine production

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Introduction: Antimicrobial use (AMU) is an important driver of antimicrobial resistance (AMR), and the contribution of AMU in animal agriculture to AMR in human medicine is unclear. To obtain a better understanding of this issue, data on current AMU practices in animal agriculture is required. While the Public Health Agency of Canada's Canadian Integrated Program for Antimicrobial Resistance Surveillance Program (CIPARS) have collected data on AMU in grower-finisher swine since 2006[1], data on AMU in the earlier stages of production are lacking. The objectives of this research program are: 1) to describe AMU during 2017 in Ontario in the farrowing and nursery stages of swine production, 2) to determine if associations between AMU and AMR, biosecurity and herd health exist, 3) to compare AMU between stages of swine production, and 4) to describe AMU across the swine production cycle.

Methods: Swine veterinarians will enroll 25 farrowing operations and 25 nursery operations across Ontario and administer a questionnaire on herd demographics, biosecurity practices, herd health status and AMU in feed, water, by injection and by oral bolus. They will also collect a pooled fecal sample for analysis for antimicrobial-resistant organisms. Each operation will be visited once, and data collection will occur throughout the 2017 calendar year. A descriptive analysis of AMU in the farrowing and nursery stages of production will be conducted, and associations between AMU and biosecurity, herd health and antimicrobial resistance will be determined using modelling approaches.

Data from the farrowing and nursery stages of production will be combined with CIPARS Ontario grower-finisher data for 2017. A comparison of AMU between the earlier stages of swine production and the grower-finisher stage will be made and a descriptive analysis of use across the swine production cycle will be performed. Estimates of AMU will be obtained using several AMU metrics.

Results: Swine veterinarians in Ontario have agreed to participate, and data collection is currently underway.

Conclusion: It is anticipated that the collection of AMU data from the early stages of swine production will demonstrate the need for on-going surveillance in this sector. The study will likely highlight the value in a more comprehensive understanding of AMU in swine production and result in a better understanding of the relationships between use and bacterial resistance in this species.

Industry Implications: While information on AMU in the grower-finisher stage of swine production has been collected by CIPARS since 2006, quantitative data on AMU in the earlier stages of swine production has not been previously available in Ontario. This research project will fill this data gap, and provide information that can be used by the industry to inform AMU policies, stewardship and future research projects in AMU and AMR.

Acknowledgements: Funding provided by the Ontario Ministry of Agriculture, Food and Rural Affairs.

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Partitioning of dietary nutrients is facilitated by reduced insulin sensitivity in late gestating gilts

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Introduction: During gestation, the nutrient requirements of the developing conceptus are relatively low until the last third of pregnancy. In order to meet these increased nutrient demands in late gestation, maternal metabolism is modified to favour nutrient partitioning towards the conceptus. For example, a decrease in protein deposition (**Pd**; nitrogen (**N**) retention × 6.25) in maternal tissues occurs towards the end of gestation in gilts (1,2) and is suspected to relate to a progressive reduction in insulin sensitivity (3). The objective was to investigate the effect of pregnancy on Pd (whole body and maternal) and insulin sensitivity during late gestation in gilts.

Methods: Twenty-one pregnant (**P**) and 20 non-pregnant (**NP**) gilts were assigned to same experimental diet (3.34 Mcal ME/kg, 17.6 % CP, 0.78 % SID Lys) that met or exceeded ME and amino acid requirements of pregnant gilts (4), and given 2.16 kg/d from breeding to 112 d of gestation. Nitrogen balances were conducted at d 63 and 102 ± 0.2 of gestation (4-d in length). Frequently sampled intravenous glucose tolerance tests (**FSIGTT**) were conducted on d 75 ± 0.7 and 107 ± 0.4 by injecting 0.5 g glucose/ kg BW via ear vein catheter. Nitrogen retention was calculated as N intake – [fecal N + urinary N]. Pregnancy-associated Pd (fetus, mammary gland, uterus, and placenta and fluids) was calculated using litter size, average piglet birth weight, and the NRC (2012) model. Maternal Pd for P gilts was calculated as the difference between whole body Pd and pregnancy-associated Pd, and for NP gilts was assumed synonymous with whole body Pd. Area under the curve for glucose and insulin (**AUC_G** and **AUC_I**, respectively) above the fasting level were calculated using the trapezoidal rule. Parameters of glucose-insulin dynamics were estimated by fitting the minimal models of glucose disappearance and insulin kinetics described in the MINMOD computer program (5) to observed glucose and insulin concentrations.

Results: Whole body Pd was greater ($P < 0.001$) in P gilts at d 102 (similar at d 63) compared to NP gilts. Maternal Pd was lower ($P < 0.002$) in P gilts at d 63 and 102 compared to NP gilts. For the FSIGTT at d 75 and 107, AUC_I and AUC_G were greater ($P \leq 0.017$) in P compared to NP gilts. The insulin sensitivity (**S_I**) was lower ($P = 0.004$) in P compared to NP gilts during both FSIGTT, and the glucose effectiveness (**S_G**), first phase (**ϕ_1**) and second phase (**ϕ_2**) pancreatic responses were not different between P and NP gilts at either FSIGTT.

Conclusions: When fed identically, P gilts have greater whole body Pd in late gestation, which is reflected in the pregnancy-associated tissues and occurs at the expense of maternal Pd. Greater AUC_G and AUC_I in P gilts demonstrated that there is prolonged secretion of insulin and delayed clearance of glucose from circulation compared to NP gilts, characterizing insulin insensitivity. The similar ϕ_1 and ϕ_2 between P and NP gilts demonstrates that the pancreas is functioning normally. Lower S_I (but similar S_G) in P gilts demonstrates that the impairment is at the peripheral tissue level. Gilts were therefore insulin insensitive at d 75 and 107, which is in contrast to multiparous sows (3), where insulin sensitivity only changes after d 85 of gestation. This suggests that the degree or duration of insulin insensitivity is parity- (or maturity-) dependent and the competition for nutrients between maternal and fetal tissues is likely more pronounced in gestating gilts due to their relative immaturity and greater requirements for maternal growth.

Industry Implications: Evolutionary mechanisms to ensure sufficient nutrient supply to the developing fetus suggest that late gestating feeding strategies aimed to influence piglet birth weight (e.g. bump feeding) may not provide a benefit, assuming that sow nutrient requirements are already met with the current feeding program.

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A case control study on the early outbreak of porcine epidemic diarrhea (PED) in Canadian swine herds

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Introduction: On January 22nd 2014, the first case of porcine epidemic diarrhea (PED) was diagnosed in a swine herd in south-western Ontario.[1] An initial epidemiological investigation of the Ontario PED cases identified feed originating from a single feed company (FC) as the probable source of infection. The porcine plasma from FC was found to reproduce the infection under experimental conditions, however the complete feed containing the plasma could not.[2] In February 2014, FC voluntarily recalled nursery feed products containing porcine plasma. The objective of this study was to use a case-control epidemiological approach to evaluate the role of feed in the early phase of the PED outbreak, after controlling for potential confounders.

Methods: To capture the early phase of the PED outbreak in Canada, the study period of interest was from January 22nd and March 1st 2014. A total of 23 Canadian swine herds (n=9 case herds; n=14 control herds) were included in the study. A case control study was conducted. A case was defined as any swine herd with confirmed positive results for PED virus based on RT-PCR and with typical clinical signs at the herd level within the study period. Control herds were randomly selected and matched to cases based on herd size, herd type, and time of PED onset in case herds. A standardized questionnaire was created and administered to each producer from the case and control herds. A mixed multivariable logistic regression model, with the matched herds accounted for as a random effect, was created to assess the association between the number of pig/people movements onto and off farms, the number of feed deliveries received, whether a herd received any feed from FC, and herd biosecurity measures with the likelihood (odds) of a PED outbreak.

Results: More case herds received feed from FC (n=8/9) than control herds (n=3/14). Also, case herds had more pig/people movements onto and off farms with larger quantities of pigs delivered onto the farm compared to control herds. The odds of a PED outbreak was 24 times greater for herds receiving feed from FC (P=0.016) than herds not receiving feed. In contrast, no difference in the number of live pigs delivered onto sites, the biosecurity of the herd, semen deliveries, the frequency of deadstock pickup between the case and control herds could be detected.

Conclusions: This study supports the role of feed from FC as a significant risk factor for PED viral transmission during the early phase of the Canadian outbreak. Also, herd biosecurity and the number of pig/people movements onto and off farms were found not to be associated with the initial phase of the outbreak.

Industry Implications: The result to this epidemiological case control study is beneficial for the swine industry because it identifies the main risk factor on how the virus was transmitted in Canadian herds during the initial PED outbreak in 2014. This can help guide future recommendations and decisions surrounding the use of porcine plasma in feed and lead to possible prevention strategies for PED virus on farm.

Acknowledgments: Funding provided by OMAFRA, Ontario Pork, and NSERC- CRD

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Determining benchmark values of nursery pig performance on Ontario swine farms

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Introduction: The nursery phase of swine production presents many challenges (social, environmental, nutritional and physiological) to the newly weaned pig, often resulting in reduced performance (1). A frequent practice among producers is to compare current performance of their herds against some standard measures, a process commonly known as benchmarking (2). The objectives of this study are to establish benchmark values for Ontario swine nursery performance (gain, feed efficiency, mortality) and to determine what risk factors for reduced performance present challenges to Ontario swine nursery producers.

Methods: This study will collect data from 50 Ontario swine nurseries. A questionnaire will be administered to producers regarding farm management, barn layout and biosecurity protocols. Prospective and retrospective herd production records will be gathered. A subset of 20 pigs will be weighed on entry and exit from the nursery. Descriptive statistics will be examined to compare performance and variation within and across farms. Multilevel regression analysis will be performed to identify relevant risk factors for reduced performance.

Results: Data are still being collected. To date, 28 farms have been enrolled and 560 pigs sampled. Preliminary analyses show differences in performance at the farm-, batch-, and pig-level. Retrospective records indicate average daily gain, measured at the batch-level, ranging from 390 to 570 grams per day. Average daily gain at the pig-level ranges from 114 to 740 grams per day. Mortality rate was found to range from 0.1% to 7.5% and 0% to 5% at the batch-and pig-level, respectively. Volatility of the health situation was demonstrated by long periods of optimal mortality (<2%) and occasional spikes (>5%).

Conclusions: Further analysis of the data needs to be done, and more research into meaningful measures of performance and risk factors for poor performance need to be performed.

Industry Implications: Recording systems often require time and financial investments from producers, and it can be difficult to see the short-term benefit from these investments. Results from this study will demonstrate to producers the importance of record keeping by highlighting risk factors for poor performance and providing producers with strategies that target specific features of swine production in Ontario. Sharing of performance data among producers will allow creation of performance targets (benchmarks) specific to Ontario nurseries, aiding in decision-making about management strategies or interventions. Additionally, weighing pigs at the individual level will allow accurate assessment of variability within individual batches, information that is currently not widely available.

Acknowledgments: Funding provided OMAFRA UoG Research Partnership, Ontario Pork.

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Economic analysis of reducing antibiotic use on Canadian pig farms

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Introduction: Antibiotics are an essential tool for Canadian pig farmers in raising profitable and healthy pigs. They can serve four major functions including growth promotion, prophylaxis (disease prevention), metaphylaxis (disease prevention) and therapeutics (disease treatment). Canadian pig farmers incorporate antibiotics into their management practices in varying capacities based on personal discretion and the opinion of their veterinarian. Recent concern over antibiotic resistant bacteria has drawn significant attention to the use of antibiotics in raising animals for food. This concern has led to growing pressure from retailers, consumers, and the public to reduce antibiotic use on pig farms which presents both opportunities and risks to Canadian pig farmers. While the benefits of antibiotics are proven, an evaluation of antibiotic usage on Canadian pig farms may identify areas where it is more profitable to reduce antibiotic use or to adopt viable alternatives. The purpose of this study is to define antibiotic use on Canadian pig farms, outline the potential costs of reducing antibiotic use, and to propose economically viable alternatives to the use of antibiotics.

Methods: Surveying veterinarians across different provinces will provide sufficiently representative data about what antibiotics are being used on farms and how they are being used. This data will be incorporated into an empirical production simulation of a Canadian pig farm. This stochastic simulation will incorporate financial data so that a partial budget analysis can be performed. A partial budget method will be used to analyze the cost of reducing antibiotics on Canadian pig farms and the profitability of alternatives to using antibiotics. One major goal of this simulation is for it to be adjustable. This will allow farmers to use the simulation as a tool to evaluate their own farm's antibiotic program based on their own unique production parameters such as mortality, reproduction performance and growth.

Results: Despite historically providing substantial economic benefits (Zimmerman, 1986; Cromwell, 2002), more recent research suggests that the benefits of antibiotics in pig farming are less significant than in the past, in particular for their use for growth promotion (Drtiz et al., 2002; Key & McBride, 2014; Rojo-Gimeno et al., 2016). Significant improvements in management and housing have helped to drastically reduce many of the bacterial problems that once plagued the Canadian hog industry and needed to be controlled using antibiotics. Based on this trend, it is expected that the researchers will be able to uncover profitable alternatives to some of the antibiotic programs used on Canadian farms.

Industry Implications: The results of this research can be used by Canadian pig farmers to identify profitable means of reducing antibiotic use on their farms. Responding to public concern proactively can help to avoid arbitrary reduction measures mandated by regulation or retail. This approach to industry transition may increase the profitability of pig farming while reducing antibiotic use and improving the trust that consumers have in the products that Canadian hog farmers produce.

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Maternal dietary omega-3 supplementation in late gestation and effects on piglet health

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Introduction: Maternal stress, such as an infection, occurring in late gestation can predispose offspring to a variety of diseases later in life. Dietary supplementation during the last trimester of pregnancy with immune-modulating compounds may be a possible way of reducing maternal stress and limiting the damage it causes to the offspring. Omega-3 polyunsaturated fatty acids (n-3 PUFA) are well-known for their immunomodulatory and anti-inflammatory properties. These n-3 PUFAs are essential dietary nutrients because longer chain fatty acids such as docosahexanoic acid (DHA) cannot be readily synthesized in mammals. Until recently, fish have been considered a major source of n- PUFAs; this has put a great strain on the fishing industry. Algae meal (AM) produced from algae grown under strictly controlled conditions has therefore been suggested as an alternative source of n-3 PUFAs. AM is equally rich in DHA and may provide a more sustainable source of n-3 PUFA enrichment for gestating animal diets. The aim of this study was to compare a control diet to diets supplemented with AM or fish oil (FO), in addition to an immune stress challenge in sows during late gestation, to evaluate the effects of maternal n-3 supplementation on piglet growth, stress response and immune response.

Methods: Forty-eight sows were fed diets containing 3.12% Algae meal (AM), 3.1% fish oil (FM) or a control diet starting during late gestation (gestation day 75; gd75). On gestation day (gd) 112, half the sows in each treatment were immune stress challenged with bacterial LPS endotoxin at a dose of 10 ug/kg BW. After farrowing, the piglets were reared with their dams until 21 days of age, and then weaned onto diets containing high quality protein or low quality protein sources. One week after weaning, 4 piglets per sow were immune stress challenged with LPS. At the same time, 4 piglets per sow were vaccinated with novel antigens (OVA and CAA) at a dose of 1 mg/ml and received booster vaccinations two weeks later. Four weeks after the initial booster, a transdermal hypersensitivity immune challenge was performed using the same antigens. Blood samples were also taken to examine antibody response to both antigens over the course of the trial.

Results: PUFA enrichment in sow blood and piglet brain were detected after 40 days on feed. Results from piglet performance, piglet stress levels and fever response to LPS, and piglet immune response to vaccination were affected by maternal diet and maternal LPS status. Results also vary significantly between male and female offspring for parameters including basal cortisol levels, fever response, and skinfold thickness in response to OVA and CAA antigens. No differences were observed for piglets weaned onto high or low quality protein diets.

Conclusions: From these trials, one can conclude that AM supplementation in sows during late gestation is comparable to FO in terms of piglet growth performance and health in the face of an immune stressor.

Industry Implications: Results from this study suggest that AM and FO supplementation of maternal diets may increase piglet robustness and allow for the use of cheaper, lower quality nursery diets without compromising piglet health. AM may also be a more environmentally sustainable supplement than FO, and as further research is conducted in this area, AM may become a more economical choice.

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Replacing non-essential amino acids (NEAA) with ammonia nitrogen (N) does not alter amino acid (AA) profile of deposited protein in carcass of growing pigs fed a diet deficient in NEAA-N

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Introduction: Supplementing ammonia-nitrogen (N) in diets deficient in NEAA-N may alter the requirements for essential amino acids (EAA) as the amino acid (AA) profile of retained protein is the single main factor for determining AA requirements in growing animals (1). The objective of the present study was to determine the effect of supplementing dietary ammonia-N to pigs fed diets deficient in NEAA-N on the AA profile of retained body protein.

Methods: A total of 32 Yorkshire barrows, divided in two equal blocks (BW = 16.3 ± 1.0 kg, mean ± SD) were used. At the beginning of the study, 4 pigs per block were euthanized to estimate initial whole body protein mass and AA profile; the remaining pigs were assigned to 3 different dietary treatments. Pigs were housed individually and restricted fed at 3.0 x maintenance energy requirements. During 3 consecutive weeks, BW was monitored weekly. A basal diet containing casein and crystalline essential amino acids (EAA) as the only N sources was formulated. The basal diet exceeded requirements for all EAA (1), but was low in crude protein (CP = 8.01 %). Cornstarch (Control) and 2 different sources of N (di-ammonium citrate and a NEAA mix; tAmmonia and tNEAA, respectively) were added to the basal diet supplying 2.7% extra CP. The total amount of standardized ileal digestible (SID) NEAA in tNEAA was based on the NEAA profile of body protein (Mahan and Shields, 1998) to minimize the need for endogenous NEAA synthesis.
On the last day of the study, pigs were killed to determine final whole body protein mass and AA profile. For each pig, carcasses and pooled visceral organs were weighed and frozen. Frozen carcasses and visceral organs were ground, thoroughly mixed, and subsampled for subsequent analyses of dry matter, CP and AA contents. The protein AA profile was calculated as the proportion (%) of individual AA in carcass and viscera protein, respectively. The AA profile of retained protein in carcass + viscera was calculated as the ratio between the increment of total AA mass (i.e. AA retention) and the increment of total protein mass (i.e. protein retention) x 100%. For each EAA, utilization efficiency was calculated as whole body AA retention divided by SID AA intake x 100%. The minimum de novo synthesis of individual NEAA (g/d) was calculated as daily whole body AA retention minus daily SID AA intake.

Results: Crude protein content of whole carcass was lower for Control (37.2 ± 2.3 %; $P < 0.05$) compared to tAmmonia and tNEAA, while it was similar for tAmmonia and tNEAA (44.2 ± 2.1 %; $P > 0.05$). Whole body protein retention increased with adding either ammonia or NEAA compared to the control diet ($P < 0.05$), but it did not differ between tAmmonia and tNEAA ($P > 0.05$). The EAA contents in retained carcass protein were decreased for Leu, Lys, Met and Phe comparing Control vs. N-added diets ($P < 0.05$), but there were no differences between tAmmonia and tNEAA ($P > 0.05$). Total N and EAA utilization efficiency was increased with adding N to Control ($P < 0.05$), but it did not differ between tAmmonia and tNEAA ($P > 0.05$). The de novo synthesis of NEAA was increased for tAmmonia compared to tNEAA ($P < 0.05$).

Conclusions: Ammonia-N is as efficient as NEAA-N for decreasing catabolism of EAA when diets are limiting in NEAA-N. Supplementing ammonia-N does not affect AA profile of retained protein.

Industry Implications: When diets are highly supplemented with crystalline AA, ammonia could be used to provide extra N for the synthesis of NEAA decreasing catabolism of expensive EAA without affecting AA requirements.

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MicroRNA-574 suppresses oocyte maturation via targeting hyaluronan synthase 2 in porcine cumulus cells

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Introduction: MicroRNAs (miRNAs) have been established as important regulators of gene expression in the mammalian ovary (1). A previous screen of small RNA in the porcine ovary identified the down regulation of miR-574 during oocyte maturation, although its role during this process was not established.

Methods: Ovaries were collected from the Conestoga slaughterhouse and cumulus-oocyte-complexes (COCs) were isolated for in vitro maturation (IVM). Cumulus cell expansion and the numbers of oocyte were measured as previously described (2). Recombinant miR-574 lentivirus and anti-miRNA siRNA were used for gain-of-function and lost-of-function studies, respectively. Real-time quantitative PCR and Western blot approaches were performed to examine the influences caused by corresponding studies. Luciferase reporter gene assay was used to test whether miR-574 can interact with 3' untranslated region (UTR) of its target gene.

Results: Inhibiting this miR-574 during IVM increased HAS2 levels along with several markers of oocyte quality, and also increased oocyte meiotic progression. A 50% decrease in HAS2 expression and nearly 20% reduction in oocyte progression through meiosis were observed after over-expression of this microRNA by transducing miR-574-expressing lentivirus. To confirm the specific targeting of HAS2 by miR-574, we constructed several luciferase reporter vectors harboring the *HAS2* 3′ UTR. Co-transfection of the reporter construct and miR-574 attenuated luciferase activity. After mutating the putative miR-574 binding site, however, this effect was abolished and luciferase activity was retained.

Conclusions: Our results show that the direct targeting of *HAS2* by miR-574 negatively impacts oocyte quality during IVM and that inhibiting miR-574 derepresses HAS2 expression and subsequently improves oocyte maturation. Taken together, our work provides insights into a mechanism of post-transcriptional regulation by miR-574 in the mammalian ovary.

Industry Implications: The knowledge gained from this study will help to better understand the underling molecular mechanism for swine reproduction. Specifically it will have significant implications for infertility management and bring important benefits to swine breeding.

Acknowledgements: Funding provided the Natural Sciences and Engineering Research Council of Canada (NSERC), and Foshan University

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Bioavailability of ketoprofen when compounded with iron dextran for use in nursing piglets

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Introduction: Piglets undergo processing procedures including castration and tail docking early in life that have been shown to create both acute and ongoing pain (1,2). The Canadian Code of Practice for Care and Handling of Piglets was recently revised to state that it is a required for pigs to receive analgesia to control post-procedural pain as of July 2016 (3). Analgesia for swine is limited to non-steroidal anti-inflammatory drugs (NSAIDs) such as ketoprofen. Piglets receive iron dextran to combat anemia as a standard practice in North America. There is evidence that some producers are mixing (compounding) iron dextran with NSAIDs (in the same bottle) to be injected at the time of processing for ease of administration (4). This practice decreases piglet handling, amount of injections piglets receive, as well as labour. However, drug mixing can lead to pharmaceutical drug interactions and a potential alteration of drug bioavailability and pharmacokinetics (5). Previous work has shown the compounding of meloxicam (Metacam®, Boehringer Ingelheim Canada) and Flunixin Meglumine (Banamine®, Merck Animal Health) with iron dextran resulted in decreased drug bioavailability (6). The objective of this study is to assess the bioavailability of ketoprofen when compounded with iron dextran in piglets.

Methods: 18 piglets (9 male, 9 female) 3-4 days of age were selected from a commercial Ontario swine herd and individually housed, fed and monitored at the University of Guelph. Two separate batches of 9 trial piglets were used due to space allowance and logistics of managing surgical personnel. After a 2-day acclimation period, piglets were anesthetized and indwelling jugular catheters were placed surgically to enable serial blood sampling. Two days after surgical recovery, piglets were administered with one of 3 treatments via intramuscular injection; (1) ketoprofen (Anafen®, Merial Canada), (2) ketoprofen mixed with iron dextran (Dexafer 200®, Vetoquinol), or (3) iron dextran. Fifteen serial blood samples were taken from each piglet, and plasma isolated from these samples were submitted for analysis of ketoprofen levels by Mass Spectrometry at the Agriculture and Food Laboratory (University of Guelph). At 72 hours post-injection, piglets were humanely euthanized and tissue samples were collected from the injection sites; these were submitted to the University of Guelph Animal Health Laboratory for histological interpretation of injection site by a pathologist.

Results: A total of 15 blood samples from each piglet in treatment group 1 and 2 were collected, and 3 blood samples as control to ensure no NSAID drug presence from each piglet in treatment group 3. Mass spectrometry results were recently completed, and analysis of this data is currently pending.

Industry Implications: While there are benefits to compounding ketoprofen with iron dextran, if its practice is to continue, we require evidence that the drug remains bioavailable to the piglet. Altered drug bioavailability may result in a decreased control of inflammatory pain. If post-procedural pain is not efficaciously controlled, this results in reduced animal welfare, and deviation from the current recommended Code of Practice.

Acknowledgements: This project is supported by Ontario Pork, University of Guelph - OMAFRA Research Partnership, and the Ontario Veterinary College scholarship program.

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The effect of supplementing threonine or non-essential amino acids to a low glycine, low crude protein diet on growth performance and protein retention of growing pigs

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Introduction: Essential amino acid (EAA) requirements have been reasonable well defined in pigs (1). However, research determining requirements for nitrogen (N) and non-essential amino acids (NEAA) are scarce. The latter is in part because when feeding regular ingredients such as corn and soybean meal, dietary levels of N or NEAA are not limiting. Inclusion of crystalline amino acids (AA) allows the formulation of low crude protein (CP) diets that maintain EAA but decrease NEAA supply. In low CP diets, therefore, endogenous synthesis of specific NEAA may limit maximal growth if insufficient dietary amounts are provided. Among NEAA, Gly may appear to limit growth of pigs fed low-CP diets (2). Moreover, when dietary Gly supply is low, Thr catabolism may increase to produce extra Gly, through Thr-dehydrogenase (TDG), decreasing utilization efficiency of expensive EAA (3). The first objective of this experiment is to determine the effect of feeding growing pigs of 14 to 27 kg body weight (BW) low Gly, low CP diets as compared to a moderate Gly, low CP diet. The second objective is to determine the effect of supplementing Thr above requirements to compensate for low dietary Gly supplementation on growth performance and protein deposition in growing pigs.

Methodology: A total of 42 barrows (initial BW=14 kg) from Arkell swine research station (University of Guelph) will be used and housed individually. Eight pigs will be euthanized at the beginning of the experiment for determination of initial protein mass. The remaining pigs will be randomly distributed in 5 iso-nitrogenous diets and will be restricted fed at 2.8 x maintenance energy requirements for ME (191 kcal/kg $BW^{0.60}$; 3) in 3 equal meals per day for 3 weeks. The control diet is based on NRC (3) requirements for EAA. Total supplementation of NEAA will reach the optimum EAA-N to total N ratio of 0.48 (2). The other 4 experimental diets will have reduced Gly and Serine supplementation (60 and 20 % compared to the control) and supplemented with Thr or Glu-Ala at 2 levels each (Low and High) to maintain same CP levels. Glutamate and Alanine will be added to provide the same amount of N. Pigs will be weighed once weekly for determination of average daily gain (ADG). At the end of the experiment, pigs will be slaughtered and carcass and viscera samples will be frozen and analyzed for N content. Nitrogen retention will be calculated as the difference between final and initial N contents.

Anticipated Results: Pigs on Low and High Glu-Ala will have the poorest ADG showing that Gly synthesis is not enough to maintain ADG when pigs are fed low CP diets deficient in Gly. Pigs on Low and High Thr will increase ADG compared to Glu-Ala supplementation since excess threonine catabolism will spare Gly. However, for Low and High Thr, BW gain will decrease compared to control as Thr catabolism is not entirely through the TDG pathway. Nitrogen retention will follow similar responses.

Industry Implications: Under low dietary supply of Gly, Thr requirements may increase to compensate for increments in Thr catabolism through TDG. Better estimation for NEAA requirements are warranted for maximizing efficient utilization of dietary amino acids.

Acknowledgements: Financial support provided by Evonik Industries, OMAF, Ontario Pork, and Swine Innovation Porc.

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The impact of genetic variants in the innate immune system on *Salmonella* in swine

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Introduction: Foodborne salmonellosis is an important food safety issue in Canada, and pork products are a potential source of infection. It may be useful to control *Salmonella* at the farm level to lessen the spread of *Salmonella* through the food supply chain. Genetic variants in the porcine innate immune system have been associated with *Salmonella* shedding and colonization and may represent a focus for genetic selection of more robust animals. The objective of this study was to investigate the associations between genetic variants and *Salmonella* shedding and colonization.

Methods: Fourteen cohorts of pigs from 8 different farms (total of 809 pigs) were followed from birth to slaughter. Fecal samples were collected at birth and weaning, and at the end of the nursery, grower, and finisher stages, and tonsil and lymph node samples were collected at slaughter. All samples were cultured for *Salmonella.* Blood, tail or ear tissue was collected from each pig and genomic DNA was extracted using a QIAGEN DNEasy blood and tissue kit. Variants were identified using the Sequenom MALDI-TOF mass spectrometry system. A multilevel mixed-effects logistic regression modelling method was used to analyze the data.

Results: Over the course of the study 35% (284/809) of pigs shed *Salmonella* at least once, but 23% (134/583) of pigs tested positive for *Salmonella* at slaughter. A variant in the C-type lectin *MBL1* increased the risk of *Salmonella* shedding ($p<0.01$) while a variant in *NOD1* was associated with an increased risk of *Salmonella* isolation from tissues at slaughter ($p=0.02$).

Table: Single nucleotide variants associated with *Salmonella* in swine

	***Salmonella* shedding No (%) of pigs**	
MBL1	Positive	Negative
CC	233 (29)	415 (52)
Variant T	49 (6)	96 (12)
	***Salmonella* at slaughter**	
NOD1	Positive	Negative
GG	37 (6)	186 (32)
Variant A	96 (16)	262 (45)

Conclusion: The *MBL1* and *NOD1* genes encode pattern recognition receptors which detect foreign pathogens and coordinate an immune response, and the current findings are consistent with previous findings for these SNPs (1, 2). These variants may be an appealing target for further studies on *Salmonella* resistance in swine.

Industry Implications: This research demonstrates the potential value of these variants for genetic improvement programs towards breeding pigs with a more robust immune system against *Salmonella* and other pathogens. Future research is needed to investigate the effect of these variant alleles on other pathogens as well as on their impact on valuable production traits including carcass quality and reproduction.

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Measuring progress towards disease freedom: A descriptive study of Porcine Epidemic Diarrhea Virus (PEDV) and Porcine Delta CoronaVirus (PDCoV) in swine herds enrolled in a disease control program (DCP) in Ontario, Canada

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Introduction: Porcine Epidemic Diarrhea Virus (PEDV) and Porcine DeltaCoronaVirus (PDCoV) were first identified in Canada in 2014. Initial emergence of the two novel porcine coronaviruses, followed by their successful elimination from several initial case farms in Ontario, resulted in the current position of industry organizations that both infectious agents can and should be eliminated at the provincial level (OSHAB, 2017). Furthermore, an important component of any disease control program is measuring trends in incidence and prevalence, particularly when the disease of interest moves into the phase of possible elimination (Salman, 2003). Thus, the objective of this study was to estimate herd-level incidence and prevalence of PEDV and PDCoV in swine herds in Ontario (Canada) between January 2014 and December 2016, based on industry data.

Methods: PEDV and PDCoV data stored in an industry database - with unique identifiers, herd type, date of herd enrollment into the database, PEDV and PDCoV status of individual premises, and the date that individual premises changed their PEDV and PDCoV status - were imported into the R statistical programming environment and analyzed to produce yearly incidence and prevalence proportions between 2014 and 2016.

Results:

Table 1: Herd-level incidence risk of two novel porcine coronaviruses (PEDV and PDCoV) in Ontario swine herds between 2014 and 2016, and estimated prevalence of positive cases at the end of each year based on data provided in an industry database

Year	Cumulative n of new cases	Incidence (%)	95 % CI (%)	Number of cases at year-end	Prevalence (%)	95% CI (%)
Porcine Epidemic Diarrhea Virus						
2014	95	13.49	(11.06 - 16.24)	36	4.36	(3.07 – 5.99)
2015	29	2.97	(2.00 – 4.24)	27	2.25	(1.49 – 3.26)
2016	17	1.42	(0.83 – 2.26)	17	1.35	(0.79 – 2.16)
Porcine DeltaCoronaVirus						
2014	8	1.14	(0.49 – 2.23)	4	0.48	(0.13 – 1.24)
2015	3	0.30	(0.06 – 0.87)	2	0.17	(0.02 – 0.60)
2016	1	0.08	(0.00 – 0.45)	2	0.16	(0.02 – 0.57)

Conclusions: The data suggests that annual incidence and prevalence estimates have been steadily decreasing between 2014 and 2016 for PEDV and PDCoV. Current estimates of disease frequency support planning of disease elimination at the provincial level.

Industry Implications: This approach can be adapted for other diseases in swine and beyond. Ultimately, this research will lead to better utilization of swine health data to support optimal health, welfare and productivity of the Ontario swine herd.

Acknowledgments: Funding for this study was provided by the NSERC Discovery Grants Program. Authors are grateful to participating industry organizations and producers for providing access to data.

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The impact of epidermal growth factor (EGF) supernatant on pig performance and ileal microbiota

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Introduction: Early weaning of pigs can lead to low feed intake resulting in a lag in growth performance and intestine infection. Epidermal growth factor (EGF), the most abundant growth factor in milk, increased weaned pig body weight gain and feed efficiency in our previous work (1). It is believed that intestinal microbiota plays an important role in pig growth but data is limited on the impact of feed additives on intestinal microbiota.The objective of the study was to investigate if the positive influence on weight gain, and intestinal health with dietary EGF supplementation was related to differences in intestinal microbiota.

Methods: *Pichia pastoris* were engineered to secrete porcine EGF using codon-optimized sequence. To examine the efficacy of EGF, an animal trial was performed using 72 pigs (2 equal blocks of 36 pigs with 3 barrows and 3 gilts/pen). The animals were assigned to one of 2 dietary treatments at weaning (20 ± 2 d of age; n = 6 pens/treatment) balancing across treatment for litter, gender and initial BW. Supernatant with EGF at 120 µg/kg BW/d and without EGF (control) was added to the feed for 21d, followed by a common diet for 7d. Animal performance was monitored on a weekly basis and ileal digesta samples were collected for microbiome analysis after 21d of treatment.

Results: Pigs fed diets containing EGF fermentation supernatant had a greater (P = 0.01) overall daily gain which is consistent to our previous finding. No difference in alpha-diversity (Chao1, Shanon, and Simpson indices) and beta-diversity (weighted and unweighted UniFrac distances) of ileal digesta microbiota between EGF supplemented and control pigs were observed. The relative abundances of bacterial taxa did not differ among treatment groups at the phylum level; however, the abundances of *Corynebacterium* (0.0 vs 0.9%), *Blautia* (0.003 vs 0.26%), and *Coprococcus* (0.0 vs 0.05%) genera and *Rumminococcaceae* family (0.001 vs 0.08%) were decreased (P< 0.05) in EGF group compared to control, which might positively influence intestinal health.

Conclusions: EGF-supplemented pigs showed increased overall daily gain. There was no difference in alpha- and beta-diversity of ileal digesta microbiota between EGF supplemented and control pigs were observed. The relative abundances of bacterial taxa did not differ among treatment groups at the phylum level; however, the abundances of *Corynebacterium*, *Blautia*, and *Coprococcus* genera and *Rumminococcaceae* family were decreased (P< 0.05) in EGF group compared to control, which is considered to be beneficial for intestinal health.

Industry Implications: Pigs fed with EGF-supplemented diet improve daily BW gain and reduce some undesirable bacteria in the intestine, which may offer an alternative to antibiotic for early weaned pigs.

Acknowledgements: Funding supported by ABvista, NSERC, and OMAFRA, Swine Cluster

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An investigation into distribution of serotypes and antimicrobial resistance patterns of *Streptococcus suis* isolates from clinical cases and healthy carrier pigs

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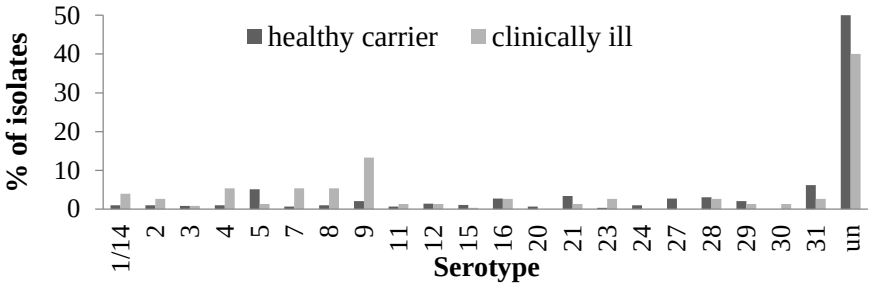
Introduction: *Streptococcus suis* causes a wide range of diseases in swine (1). Decreased performance and mortality resulting from *S. suis* infection have a significant economic impact on swine production. The objectives of this study were to investigate the serotype distribution of *Streptococcus suis* isolates recovered from healthy and diseased pigs using a multiplex PCR method and to determine antimicrobial resistance patterns.

Methods: Nasal, tonsillar, and vaginal swabs from healthy pigs, and tonsillar and meningeal swabs as well as tissue from tonsil and lymph nodes from clinically ill pigs were obtained from pigs on 31 farms. All samples were cultured, and the *S. suis* isolates were identified by MALDI-TOF or PCR. A disc diffusion method was used to test antimicrobial resistance to ampicillin, ceftiofur, florfenicol, tetracycline, tiamulin, spectinomycin, and trimethoprim/sulfa. A logistic regression method with farm as a random effect was used to compare the presence of *S. suis* and its serotypes in diseased and healthy pigs, and among pigs at different stages of production.

Results: Of 450 samples, 324 were collected from healthy and 126 from sick pigs. *S. suis* was more likely to be recovered from suckling and nursery piglets than from sows and finishers (P <0.001). *S. suis* was recovered more likely from healthy pigs as opposed to sick pigs (P <0.01). However, it is possible that some of the sick pigs had been treated with antibiotics before sample collection. Twenty-two serotypes were identified, with type 9 being the most common serotype found in sick pigs (Figure 1). Less than 1.0% of isolates had resistance against ampicillin, ceftiofur, and florfenicol, while resistance against tetracycline (84.2%), tiamulin (65.2%), and spectinomycin (40.4%), and trimethoprim/sulfa (13.2%) was detected more frequently.

Figure 1: *S. suis* serotypes isolated from healthy and clinically ill pigs



Conclusions: Multiple serotypes could be identified from a single pig; however, more clinical cases are needed to draw conclusions regarding the serotype distributions in sick pigs.

Industry Implications: This research will provide valuable information on distribution of *S. suis* serotypes in healthy carrier and sick pigs on Ontario swine farms. This knowledge can be used to ensure that the right strains are chosen for autogenous vaccines and to help in the design of appropriate management changes to reduce the prevalence of *S. suis* disease outbreaks. These findings are also useful when developing effective treatment strategies to prevent outbreaks in nursery pigs.

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Molecular characterization of porcine chromosomal abnormalities

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Introduction: Chromosome abnormalities such as reciprocal chromosome translocations are particularly prevalent in pigs. Translocation result from mis-matched DNA strand repair during meiosis, resulting in an exchange of genetic material between two chromosomes with no apparent loss (1). Though translocation carrier pigs are often phenotypically normal, they experience severe decreases in reproductive potential, which has major impacts on the economics of pork production (1, 2). In order to detect these abnormalities the King lab at the University of Guelph has initiated the largest cytogenetic screening program in Canada in order to screen carriers out of the population.

Methods: Blood samples are collected weekly, and cultured in a prepared media for a period of 72 hours. After which a solution is prepared using a standard cytogenetic procedure consisting of colcemid, a hypotonic solution, and three successive washes with a 3:1 methanol acetic acid mixture. This solution is dropped onto slides and left to age for a week, after which time a standard G-banding procedure is applied, yielding chromosomes distinguishable under light microscopy. Fifteen pictures are taken of high quality metaphases using a camera mounted microscope. Each pig is then karyotyped and visible abnormalities taken note of, including the chromosome involved, breakpoints, and polyploid cells. Genealogies are established for carriers to identify the origin and transmission of the abnormality.

Results: Since 2011 over 3,056 pigs have been screened. 36 distinct rearrangements have been found in 73 carriers. The prevalence of chromosome abnormalities in the Canadian swine population is 2.38%. The swine in this study on average experienced a 25.6% decline in fertility, resulting in an average loss of four pigs per litter. Additionally the translocation is transmitted to 46.5% of viable offspring. The rate of polyploid cells per hundred in carriers is 2.37, and 0.89 in normal pigs.

Conclusion: Chromosome translocations occur at a high rate in the Canadian swine population, and greatly impacts reproductive potential. The high prevalence within swine relative to other mammals has led us to speculate that these translocations are influenced by genetic factors. This has led us to begin both a comprehensive meta-analysis, and a genome-wide association study which began in 2017, in order to find genetic factors such as single nucleotide polymorphisms (SNP) and copy number variations (CNV) that may be linked to various genes and the formation of translocations. Using DNA samples derived from identified carriers and family members, we have applied SNP array genotyping to identify SNP and CNV in our carriers and relatives which we are currently in the process of analysing.

Industry Implications: A single translocation carrier may cause thousands of dollars in losses for individual farmers yearly. Extrapolated to Canada as a whole it is estimated that translocation carriers cost the swine industry millions of dollars a year. As such, effective screening practices to detect chromosome abnormalities are essential for efficient pork production.

Acknowledgements: Funding provided by, the Canada Research Chairs program, Ontario Swine Improvement, OMAFRA, and the Ontario Veterinary College.

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Efficacy of using a therapeutic high-tryptophan diet to reduce aggression and aberrant behaviour in growing pigs

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Introduction: In growing pigs, aggression and aberrant behaviours such as tail- and ear-biting can result in decreased growth, diminished health and welfare, increased morbidity and mortality and increased labour on the part of the producer. Tryptophan (TRP), an essential amino acid in the pig's diet, is known as a calming agent (1) through its role in the serotonergic system. The objectives of this study are to determine the effect of varying inclusion rates of dietary TRP on aggressive encounters and growth rate in grower pigs.

Methods: The first phase of this study will examine the effects of three feed treatments on a total of 90 grower pigs divided equally across the three trials in a completely randomized block design. Sex, weight and litter origin will be balanced across pens in each trial. There will be 10 pigs/pen and 3 pens/trial. This feeding trial will last a total of seven days, with feed and water being fed ad libitum. All pigs will be weighed on day zero (the day before the trial begins) and on day 8 (the day after the trial ends). A single diet will be formulated based on providing all nutrients at or above their estimated NRC requirements, and providing TRP at 100% of its standard ileal digestible (SID) requirement. Three amino acid mixtures will then be added to the base diet to provide: 1) Control diet, 2) TRP at 175% of its SID requirement, and 3) TRP at 250% of its SID requirement. This will result in an increase in the TRP:large neutral amino acid (LNAA) ratio, as the amount of LNAA in the three diets will remain constant, and only the TRP amount will increase. All pigs that are enrolled in this study will have continuous behaviour recordings done for 12 hours each day (06:00-18:00) beginning on day one of the study and ending on day seven. An ethogram will be used to examine eight mutually exclusive behaviours and to evaluate the severity and duration of aggressive interactions taking place, the number of bites and head-knocks, as well as the duration of time spent fighting, ear-biting and tail-biting will be recorded using all-instance sampling during 3 time periods of 30 minutes each day (08:00-08:30 h; 12:00-12:30 h; 16:0016:30 h). Plasma samples will be taken from half of the pigs in the study (5 pigs/pen, N=45) and the TRP and serotonin levels will be measured. The second phase of this study will be conducted at commercial swine farms (N=5) which have had continued issues with tail-biting outbreaks. After farms have been identified and enrolled in the study, live behaviour analysis will be done to confirm the outbreak. Half of all grower pens on each farm will be fed a therapeutic high tryptophan diet, while the remaining grower pigs will continue to be fed their regular commercial diet. All pigs will be weighed prior to the commencement of the study (day 0) and after the study is complete (day 8). Pigs will be individually marked, and their behaviour will be recorded for the seven days that the feeding trial is being conducted.

Results: This study has not yet commenced and so, at this time there are no results available.

Conclusions: There are currently no results available and so, at this time there are no conclusions available.

Industry Implications: The use of therapeutic TRP in pig diets could positively impact the entire pork industry. The producers will benefit from reduced labour costs, higher growth rates and better carcass quality; the industry will benefit from an improved public perception of how pigs are raised commercially; and the growing pigs will have increased health and welfare due to decreased levels of aggression.

Acknowledgements: Funding provided by OMAFRA.

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Generating a synthetic animal population structure: A geospatial database for Ontario swine farms

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Background: Infectious diseases in farmed animals have economic, social, and public health consequences (1). Foreign animal diseases (FADs) of swine are of significant concern (2). Mathematical models are often used to simulate FAD outbreaks and best practices for control (3). However, simulation outcomes are sensitive to the population structure used. Within Canada, access to individual swine farm population data with which to parameterize models is a challenge because of privacy concerns. The objective of this research was to develop a methodology to generate a synthetic population of swine farms in Ontario, Canada that could represent the existing population structure and improve the efficacy of simulation models.

Methods and Results: Multiple data processing steps were used to develop a synthetic swine farm population. Geographical information system data on factors such as facilities supporting farm infrastructure, land availability, zoning and local regulations, and natural geographic barriers that could affect swine farming in Ontario were identified. The relative importance of each of the factors were defined and an algorithm was generated to produce a combined likelihood score for swine farming. Probability scores were assigned to one square kilometer geospatial grids throughout the province and generated random farm locations on the probability surface. Assigned farm locations were proportional to the swine farm density described in the 2011 Canadian Census of Agriculture. Farms were then randomly assigned to farm types proportional to the existing swine herd types. Models were compared with a known database of swine farm locations in Ontario and the synthetic farm population demonstrated very high accuracy (AUC: 0.91, Standard deviation: 0.02) suggesting that our algorithm generated a reasonable approximation of swine farm locations at the county level.

Conclusion: In the absence of a full, identifiable population structure dataset, incorporating a synthetic population that captures key characteristics of the observed population structure while protecting privacy concerns is an important methodological advancement and will be useful for individuals interested in modeling the spread of pathogens between farms across a landscape and using models to evaluate disease control strategies.

Industry Implications: The development of a synthetic swine population recognizes the importance of protecting the privacy of individual farmers while capturing the key properties of the Ontario swine population that are vital for developing population-based disease transmission models. A synthetic farm population structure will be useful for individuals interested in understanding the risk of FAD introduction and modeling the spread of pathogens between farms, across a landscape and using these models to evaluate disease prevention and control strategies.

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Seroprevalence of *Salmonella* in nursery pigs

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Introduction: The prevalence of *Salmonella* has been reported to be the highest in the nursery stage[1] and may potentially have an impact on the growth performance of pigs[2]. Clinical signs during *Salmonella* infection may not be present and asymptomatic carrier pigs do not always continuously shed *Salmonella* making culturing methods unreliable in determining *Salmonella* status. Serological testing methods, to assess for antibody response to *Salmonella* infection, have shown to be an effective way in capturing the population of intermittent shedders[3]. The objective of this study was to determine the seroprevalence of *Salmonella* spp. in nursery pigs at point of entry and end of nursery stage.

Methods: Twenty nursery pigs between 3 and 4 weeks of age were selected from each of the thirty Ontario nursery barns. Blood samples were collected from pigs at entry and at the end of the nursery stage and tested by ELISA for presence of antibodies against *Salmonella*. Statistical analysis was conducted using STATA 14.

Results: Overall, 56% (132/235) of nursery pigs from 12 farms were *Salmonella* seropositive at entry and 32% (74/233) were positive at the end of the nursery stage (Table). The Wilcoxon signed-rank test revealed there were a larger number of pigs with increased titers at entry into the nursery stage than at the end ($z<0.001$). Furthermore, of the twelve farms so far tested, there was a decrease in the number of seropositive pigs during the nursery phase on most farms (11/12) indicating the disappearance of passive immunity but on one farm seropositivity increased indicating active infection in the majority of pigs in this nursery.

	Number (%) of pigs	
Salmonella	**Entry to nursery**	**End of nursery**
Positive	132 (56)	74 (32)
Negative	103 (44)	159 (68)
Total	235 (100)	233 (100)

Table: *Salmonella* seroprevalence in pigs at entry (n=235) and end (n=233) of nursery stage

Conclusions: The high level of seropositivity in herds (100%) and increased titres in pigs (>50%) at weaning demonstrates how widespread *Salmonella* is in the Ontario swine population. Furthermore, the herd that experienced an overall increase in number of seropositive pigs is indicative of pigs encountering *Salmonella* in the nursery after passive immunity has declined.

Industry Implications: This research will provide farmers, veterinarians and researchers with a better understanding of the prevalence of *Salmonella* and whether or not the nursery is a common stage of infection, and this information will be useful in planning *Salmonella* control strategies.

Acknowledgements: University of Guelph-OMAFRA research partnership, Swine Innovation Porc, Ontario Pork and the Disease Surveillance Plan, which is a joint federal-provincial Growing Forward 2 project.

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Experimental challenge study to investigate the effect of flavophospholipol on *Salmonella* infection in nursery pigs

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Introduction: On-farm control of *Salmonella* has proven difficult and there is need for a practical and inexpensive solution. Previous studies have suggested flavophospholipol, an antibiotic with non-transferable resistance, may alter the microflora in favour of beneficial bacteria, and lead to reduced *Salmonella* shedding and colonization.[1, 2]

Objectives: The objectives of this study were i) to compare *Salmonella* shedding and colonization as well as the antibody response to *Salmonella* in pigs receiving flavophospholipol compared to control pigs, ii) to determine time course of *Salmonella* shedding and antibody response in pigs challenged with *Salmonella* Typhimurium.

Materials and methods: Thirty-two weaned pigs were housed in 4 rooms in a level 2 biosafety isolation unit and fed either a diet containing 4 ppm flavophospholipol (Flavomycin®, Huvepharma) or the same feed without flavophospholipol (control). All pigs were challenged with *Salmonella* Typhimurium DT 104 on Days 7 and 8 of the trial. Feces and blood samples were collected several times over 36 days. Pigs were euthanized at the end of trial and tissue samples were collected. All fecal and tissue samples were cultured for *Salmonella* and CFU/g were determined. The level of antibody to *Salmonella* in serum samples was determined by ELISA. A mixed effects regression method was used to compare *Salmonella* shedding and antibody response among pigs in the 2 groups (treatment and control).

Results: *Salmonella* was recovered from all fecal samples collected at each post-challenge sampling, except on Days 14 and 28 when one pig in the treatment group tested negative. In the control group one pig developed septicemia and another pig died due to respiratory infection and tested positive for *Salmonella* in lung tissue. The number of *Salmonella* in feces collected from pigs receiving flavophospholipol was higher than in control pigs ($P<0.05$). There was no significant difference in antibody response among pigs in the 2 groups ($P>0.05$). Overall, 56%, 28%, and 87% of pigs were seropositive at Day 1 (28 days of age), Day 12 (40 days of age), and Day 36 (64 days of age), respectively.

Conclusions: The findings indicate that 4 ppm in-feed flavophospholipol did not reduce *Salmonella* shedding in nursery pigs. In fact, the pigs receiving flavophospholipol had a higher number of *Salmonella* in feces contradicting reports in the literature of a positive therapeutic effect. Although both premature deaths occurred in the control group, more trials are needed to evaluate the impact of flavophospholipol on *Salmonella*-related morbidity and mortality rates. Further, the seropositivity trend indicates that piglets entering the nursery stage may have maternal antibodies to *Salmonella* but this protection appears to wane over the next 2 weeks and acquired immunity begin to appear. Finally, the *Salmonella* infection model developed in this trial appeared to work well and can be used for future studies.

Industry Implications: Serum antibody trends can be used as an effective tool for monitoring exposure to *Salmonella* whereas bacterial culture is best suited for determining an ongoing infection. The use of 4 ppm in-feed flavophospholipol appears to be ineffective in reducing *Salmonella* shedding and colonization in nursery pigs.

Acknowledgments: Funding sources: Huvepharma, University of Guelph- Ontario Ministry of Agriculture, Food and Rural Affairs Research Partnership, and Swine Innovation Porc

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Examining the protective, anti-inflammatory effects of microbial fermentation supernatant on enhancing weaned animal performance

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Introduction: Early-weaning of piglets in the swine farming industry causes incomplete gastrointestinal tract development and abnormal intestinal function, which leads to a post-weaning growth lag and an increased susceptibility to intestinal infection (1). Additionally, the significant rise in antibiotic resistant bacteria in animals and humans, as well as the decision of the Canadian government to reduce in-feed growth-promoting antibiotic usage in animal production has prompted an urgent need for anti-infective alternative therapies to remedy these issues (2). We have previously found that recombinant protegrin-1 (PG-1) reduced the pathological effect of chemically induced colitis (inflammation) in mice, suggesting a potential interaction of PG-1 with intestinal epithelial cells to modulate inflammation and enhance tissue-repair. However, a high dosage of 10mg/kg body weight (BW) was used, which may limit its application in the production setting. Thus, the objectives of this study were to test if this potent pig-originated antimicrobial peptide PG-1 produced in yeast fermentation supernatant could rescue colitis in dextran sodium sulphate (DSS) induced mice, and determine the minimum dosage that effectively maintains immunoprotective potential.

Methods: PG-1 was expressed in the yeast *Pichia pastoris* and mass produced through fermentation. Harvested supernatant was then oral gavaged once daily for 7 days to 5-6-week-old female BALB/c mice supplied with 5% DSS in their drinking water. Treatment groups included 1, 5, and 10 mg/kg (BW) PG-1, along with a non-DSS control (healthy mice) and a blank-fermentation DSS-control. Clinical symptoms were scored using a Disease Activity Index (DAI) and BW changes were monitored and analyzed. After 7 days, mice were sacrificed and intestines harvested for examination. Using RT-PCR, gene expression analysis for mediators of intestinal differentiation and investigations into their underlying mechanisms are currently in progress.

Results: Experimental colitis was induced in mice, and significant weight loss and high DAI scores were apparent in DSS-treated groups in comparison to healthy mice (control). Treatment groups with DSS and PG-1 showed reduced weight loss in comparison to initial (Day 0) body weights, and lower DAI scores. The 1 and 10 mg/kg (BW) treatments followed similar trends to normal mice up until day 6, however the 5 mg/kg group mirrored that of the DSS-treatment group throughout the trial.

Conclusions: PG-1 demonstrated some protective effects in rescuing colitis in this preliminary study. Our next objectives are to further characterize the protective effects of PG-1, identify an effective concentration range that confers immunoprotection, and determine if PG-1 can effectively treat gastrointestinal infection in a bacteria-challenged mouse model while assessing for any potential side effects. Results will then be confirmed in piglets.

Industry Implications: Addition of PG-1 in feed may enhance animal intestinal tissue repair and infection resistance, act as an alternative to antibiotics in the animal industry and improve early-weaned piglet performance.

Acknowledgements: This project has been funded by NSERC and Ontario Pork.

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Growth performance and carcass quality in pigs fed low or high complexity nursery diets

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Introduction: Due to digestive limitations of the newly weaned pig, early nursery diets tend to contain highly digestible animal protein sources that are costly (1). A reduction in the complexity of diets fed to nursery pigs using plant (soybean meal) rather than animal (whey, blood plasma) protein sources could reduce the cost of feed during the nursery phase. Previous studies conducted in research settings identified that feeding low complexity (LC) nursery diets resulted in reduced growth performance during the nursery period, but through compensatory growth the pigs reached market at the same age, and carcass quality traits were not influenced (2). The effects of feeding LC nursery diets on overall growth and health performance have not been examined in commercial farm settings. Therefore, the objectives of this study were to investigate the impact of nursery diet complexity on lifelong growth performance, carcass traits at time of market and serum haptoglobin (as a general health biomarker), when fed on commercial farms.

Methods: A total of 774 pigs were enrolled during 13 cohorts across 7 commercial farms. Pigs were individually weighed 5 times over the study; within 2.8± 0.3 days after birth, at weaning (28.0± 0.6 days), at the end of the nursery period (67.0± 1.9 days), at the end of the grower period (108.1± 1.7 days) and at the end of the finisher period (154.0± 3.8 days). Individual blood samples were also collected at the time of weighing from weaning onwards in order to determine serum haptoglobin concentrations. During the nursery period, half of the enrolled pigs on each farm were assigned one of two dietary treatments, either high complexity (HC) or low complexity (LC). Both diets were fed in three phases over the 6 week nursery period. After the nursery period, all the pigs were fed the grower-finisher diets common to each farm. At a targeted live market weight (118 kg) a subset of pigs were processed, and individual carcass traits were collected.

Results: Overall, no difference was observed in average daily gain or pig bodyweight at any time point during the study due to nursery diet complexity ($P>0.05$). The cost of feed per pig during the nursery period was significantly reduced for the LC fed pigs by $2.82/pig ($P<0.001$). Carcass quality traits such as hot dress weight, loin eye depth, back fat depth and percent lean yield were not influenced by nursery diet complexity ($P>0.05$). Carcass value was similar for pigs fed HC and LC nursery diets ($P=0.98$). Serum haptoglobin concentrations were not influenced by nursery diet complexity at any of the sampling times ($P>0.05$).

Conclusions: Utilizing LC nursery diets on commercial farms appear to have no negative impact on lifetime growth performance, carcass traits at the time of marketing or serum haptoglobin at any measured time points.

Industry Implications: LC nursery diets in commercial settings may be a feasible way to reduce feed costs without negatively impacting lifetime pig growth and carcass value.

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Assessing the efficacy of ketoprofen and meloxicam when mixed with iron dextran on pain relief following castration in piglets

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Introduction: Piglets undergo processing procedures including castration and tail docking early in life that have been shown to create both acute and ongoing pain (1,2). The Canadian Code of Practice for Care and Handling of Piglets recently revised to state that as a requirement pigs are to receive analgesia to control post-procedural pain as of July 2016 (3). Analgesia for swine is limited to non-steroidal anti-inflammatory drugs (NSAIDs) such as meloxicam and ketoprofen. Piglets also receive iron dextran to prevent anemia as a standard practice in North America. There is interest in mixing iron dextran with NSAIDs at the time of processing (4), to decrease piglet handling, amount of injections the piglets receive, as well as labour and materials input. Mixing of drugs can lead to pharmaceutical drug interactions, and a potential alteration of drug bioavailability and pharmacokinetics (5). Previous work (O'Sullivan et al, unpublished and Reynolds et al, unpublished) drug pharmacokinetics and bioavailability will be built upon by aiming to determine if the efficacy of meloxicam and ketoprofen for controlling post-procedural pain in piglets is altered, when these NSAIDs are mixed with iron dextran.

Methods: 700 piglets from 100 litters will be observed and will be assigned to 1 of 7 treatment groups (each litter will contain one male piglet per treatment group): [1] ketoprofen (Anafen®, Merial Canada) injection prior to castration, [2] ketoprofen mixed with iron dextran (Dexafer 200®, Vetoquinol) prior to castration, [3] meloxicam (Metacam®, Boehringer Ingelheim Canada) prior to castration, [4] meloxicam mixed with iron dextran prior to castration, [5] iron dextran only prior to castration, [6] iron dextran injection and sham castration, and [7] sham castration with no injection given. All piglets will be administered their treatment 1 hour prior to castration in accordance with standard barn operating procedures by a trained stockperson. After castration, piglets will be observed in 1 of 2 groups. The first group (525 piglets) will be observed on site by a trained observer, using an ethogram developed by the research team. The second group (175 piglets) will, after castration, be observed for time to ambulate through a chute designed by previous research that has shown differences in travel time between piglets of suspected differing pain levels (6). Other measurements from a subset of piglets will include serum cortisol analysis, activated clotting time, and tissue drug depletion.

Results: Data collection for this study commenced in March 2017.

Industry Implications: If the practice of compounding NSAIDs with iron dextran reduces the efficacy of those drugs for the control of post-procedural pain, this research can guide recommendations regarding this reduction in efficacy to industry stakeholders. If drug efficacy is found not to be reduces, then this method of compounding NSAIDs with iron dextran may help to increase compliance with adherence to the recommended Code of Practice.

Acknowledgements: Funding provided by Ontario Pork, Ontario Ministry of Agriculture, Food and Rural Affairs, and the Ontario Veterinary College scholarship program.

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Comparison of single timed AI in gilts using OvuGel® or eCG/pLH to synchronize ovulation

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Introduction: Gilts make up a considerable part of the reproductive herd and in batch farrowing they are the most difficult group to control[1]. Controlling the estrus cycle of gilts will allow them to fit into the tight breeding schedule appropriately and reduce the number of non-productive days[1]. Single, fixed-time artificial insemination (FTAI) is made possible when estrus and ovulation become predictable[2]. FTAI protocols in weaned sows have been shown to result in reproductive performance that is comparable to the conventional two inseminations[2]. An OvuGel® FTAI treatment and a second FTAI protocol of equine chorionic gonadotrophin (eCG) followed by porcine luteinizing hormone (pLH) have both been shown to be successful, however, these protocols have not been compared in gilts[3,4,5]. The objective of this study is to determine whether the estrus and ovulation of gilts can be controlled such that a FTAI program can be employed and result in comparable reproductive performance as gilts bred using conventional methods.

Methods: Gilts were raised without boar contact until 6 months of age, at which time puberty was induced by boar exposure and an injection of 400IU of eCG and 200IU of hCG (PG600). Once gilts were observed in heat at least once, they were given an oral dose of altrenogest (Regu-mate®) for at least 14 days to stop cycling. Once Regu-mate® was withdrawn, the gilts were assigned to one of three treatment groups. Group 1 (controls): estrus detection was done by boar exposure once a day and if the gilt was found in standing heat she was inseminated and if in heat the next day insemination was repeated. Group 2: gilts were injected with eCG one day after Regu-mate® removal, followed by an injection of pLH 72 hours later. A single insemination was performed 36 hours after the pLH treatment. Group 3: gilts were given an intra-vaginal dose of OvuGel® on day 6 post-Regu-mate® and a single insemination 24 hours later. Time of ovulation was monitored by trans-abdominal ultrasonography (Honda HS-1600 scanner) to confirm time of ovulation in a subset of gilts.

Results: This project is still in the data collection phase, results still to come.

Conclusions: No conclusions without results.

Industry Implications: Implementation of a protocol that synchronizes ovulation in gilts would offer several advantages to producers such as reduced labour because heat detection is not required and only one insemination needs to be performed instead of two. Synchronizing gilt breeding will also reduce the variation in piglet age at weaning and enables precise scheduling of labour and resources[1].

Acknowledgments: Funding provided by Ontario Pork and the University of Guelph-OMAFRA Research Partnership. Staff of the Arkell Swine Research Centre provided much appreciated technical help.

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A study of *Salmonella* status in pigs from birth up to market using culture and serology

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Introduction: *Salmonella* is an important food safety concern and is often carried by apparently healthy pigs. Although culturing and serology methods have frequently been used to determine *Salmonella* status in pigs, the majority of studies have tested pigs at only one point in time. Additionally, diet may have an impact on *Salmonella* infection in pigs (1). This study aims to determine the association between *Salmonella* shedding and antibody response in pigs from birth up to market and to assess the impact of a low complexity nursery diet on pig antibody response to *Salmonella*.

Methods: Fourteen cohorts of pigs on 8 commercial farms were followed from birth up to market. Each cohort had ~60 piglets selected from 8-10 sows for a total of 832 pigs. During the nursery phase, pigs received either a high complexity (HC), standard commercial diet or a low complexity (LC), reduced animal protein diet with replacement by plant-based proteins including soybean meal. Fecal and blood samples were collected at weaning and the end of the nursery, grower and finisher stages. Fecal samples were cultured for *Salmonella* and sera were analyzed by ELISA for the presence of *Salmonella* antibody. A multilevel mixed-effects logistic regression model was used to analyze the data.

Results: *Salmonella* was recovered from 13% (433/3339) of fecal samples while 18% (473/2627) of serum samples tested positive by ELISA. *Salmonella* was isolated from 11% (82/784), 13% (94/747), 12% (90/730) and 20% (135/669) of pigs at weaning, and the end of the nursery, grower and finisher stages, respectively; however, 20% (143/703), 6% (41/712), 16% (106/665) and 37% (196/525) of pigs tested seropositive (in the same order). *Salmonella* shedding and seropositivity at different stages of production are shown in the Table. Preliminary data analysis indicated that pigs shedding *Salmonella* were more likely to be seropositive ($p<0.001$) and that pigs were more likely to become seropositive by the end of the finisher stage compared to earlier stages ($p<0.001$). Finally, diet complexity was not associated with pig *Salmonella* seropositivity ($p=0.88$).

Table: *Salmonella* shedding and antibody response at different stages of production.

Seropositive		*Salmonella* shedding (Number (%) of samples)									
		At weaning		End of nursery		End of grower		End of finisher		Total	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
	Yes	20 (27.4)	122 (19.6)	15 (16.9)	25 (4.1)	26 (31.3)	76 (13.6)	70 (66.0)	119 (30.0)	131 (37.3)	418 (18.2)
	No	53 (72.6)	501 (80.4)	74 (83.2)	579 (95.9)	57 (68.7)	481 (86.4)	36 (34.0)	278 (40.0)	220 (62.68)	1874 (81.8)

Conclusions: These findings suggest that serological detection may be an appropriate approach to screen pigs for *Salmonella*. It is also possible that pigs fed a low complexity diet could not mount a sufficient antibody response during *Salmonella* infection resulting in the increased risk of shedding seen in LC pigs.

Industry Implications: Screening swine farms for *Salmonella* may help to identify high risk herds and aid in determining where intervention strategies may be most effective.

Acknowledgements: Funding and support was provided by NSERC, Ontario Pork, OMAFRA, Swine Innovation Porc, the Canadian Center for Swine Improvement and Alliance Genetics Canada.

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Use of plant-based FaeG fed to newly weaned pigs to compete with F4+ *E. coli* for binding sites and prevent diarrhea

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Introduction: Enterotoxigenic *E. coli* (ETEC) post-weaning diarrhea (PWD) is a major economic concern on Ontario swine farms. When piglets are weaned around three weeks of age, they are forced to face many changes and challenges and thus, they are very susceptible to a variety of different pathogens and diseases. ETEC PWD is commonly seen within the first week of weaning. The bacteria replicate and colonize in the gastrointestinal tract (GIT) of the piglet through the binding of FaeG protein to genetically inherited receptors (1). Once the bacteria multiply, enterotoxin proteins are released causing an electrolyte and fluid imbalance in the small intestine. This imbalance results in scouring diarrhea in the piglets thus leading to high levels of morbidity and mortality (2). Although vaccines have been developed, the time frame that is required for active immunity to be stimulated is insufficient from when they were faced with the disease. Other methods of prevention include the use of in-feed antimicrobials to try and reduce the severity of diarrhea. A transgenic variant of tobacco has been modified to alter the DNA in the chloroplast of the plant leaf. This feeding trial will look at feeding the tobacco plant leaves to infected newly weaned piglets to determine whether oral delivery of the FaeG protein can compete with the ETEC bacteria to reduce the severity and outbreak of disease.

Methods: At nine days of age, piglets will be obtained from the Arkell Swine Research Farm. These animals will be selected by testing a whole blood sample to identify piglets that contain the F4 receptor. At weaning, these piglets will be transported to the OVC Isolation Facility. Piglets will then be randomly assigned to one of four treatment groups. On day three, all piglets will be challenged with the disease. Group one will consist of a control group where the piglets receive no plant-based protein. The subsequent three groups will receive two daily feedings of a low, moderate and high level of plant protein in a yogurt substance for palatability. Rectal swabs will be taken and cultured for ETEC, diarrhea scores and dehydration will be recorded. Observations will focus on whether a dose response is seen with each treatment. On day five, all piglets will be euthanized and a histology examination will be performed to see whether *E.coli* colonization has occurred. Three replications of this study will be performed.

Results: This trial is currently in the planning stage. At this point in time, there are no results to report.

Conclusions: This trial is currently in the planning stage. At this point in time, there are no conclusions to report.

Industry Implications: As the practices involved in animal welfare and husbandry continue to become an issue, consumers want pork products that are raised with less antibiotics and antimicrobials. If this trial is deemed successful there is a great potential for using this feeding strategy to reduce ETEC PWD. This will reduce the need for in-feed antibiotics and antimicrobials used in the nursery stage of production.

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Kinetic characterization of a porcine intestinal alkaline phosphatase isomer over-expressed in the *E. Coli* BL21 (λDE3)

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Introduction: Intestinal alkaline phosphatases (IAP), one group of the most abundant apical membrane-bound enzymes in the gut, play a pivotal role in dephosphorylation of endotoxin lipopolysaccharides (LPS) lipid moiety and other emblematic members of pathogen-associated-molecular patterns (PAMPs) such as ATP, therefore preventing gut dysbiosis and enteric diseases[1]. Nutritional and physiological factors are shown to affect IAP affinity[2]. There are 6 alkaline phosphatase genes identified in the porcine genome with possible 4 IAP and 1 tissue-non-specific alkaline phosphatase isomers likely expressed in the small intestine. The objective of this study was to elucidate roles of post-translational glycosylation on IAP isomer affinity by characterizing a porcine IAP isomer (protein product ID: XP_003133777.1-X1) over-expressed in the prokaryotic *E. Coli* BL21 (λDE3).

Methods: Both negative and X1-IAP over-expressed *E. coli* BL21 (λDE3) cell samples were sonicated to be homogenous and diluted for further enzyme kinetic analysis. The kinetic experiments were carried out by using the chromogenic synthetic substrate *p*-nitrophenyl phosphate (PNPP) with 16 gradient concentrations of PNPP, ranging 0 – 6 mM in incubation media in 4 replicates at pH 7.4 and 37^{0}C for 30 minutes.

Result: The kinetics (parameter estimates ± SE, $P < 0.05$, $R^2 = 0.91 – 0.94$, n = 64) of the X1-IAP-specific isomer and the intrinsic alkaline phosphatase of *E. coli* BL21 (λDE3) were obtained, including Vmax values of 11.59 ± 1.58 vs. 19.02 ± 3.39 nmol/(mg protein·min); and Km values of 4.72 ± 1.16 vs. 7.56 ± 2.09 mM. The X1-IAP isomer Km value measured at 4.72 ± 1.16 mM in this study is substantially higher than the range of weanling porcine IAP Km values (0.1 - 0.3 mM) determined under the same conditions (using PNPP at pH 7.4 and 37^{0}C) from our previous studies.

Conclusion: Our results showed that the porcine X1-IAP isomer over-expressed in the *E. coli* BL21 (λDE3) without glycosylation was associated with a very low enzyme affinity.

Industry Implications: This study results suggest that factors affecting post-translation glycosylation of the alkaline phosphatase isomers in the porcine gut would greatly influence their enzyme affinity towards detoxifying pathogenic bacterial LPS and other emblematic PAMPs members in the gut lumen for protecting gut health. Effective strategies need to be developed to increase IAP enzyme affinity to help young pigs cope with gut health challenges in commercial swine production.

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Beta defensin 3 plays a role in regulating ovarian follicular development

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Antimicrobial peptides (AMPs) are regarded as host defense peptides which processes bactericidal, and they have been also reported to have immunomodulatory function in many tissues. However, their role in the mammalian ovary is unknown. We have previously found that beta defensin 2 (BD2) and beta defensin 3 (BD3) are expressed in granulosa cells and cumulus cells during porcine ovarian follicular development and cumulus-oocyte-complex maturation. We hypothesized that these antimicrobial peptides are involved in the regulation of follicular development in ovaries. Granulosa cells were isolated from small (1-3 mm in diameter) and large (4-8 mm in diameter) porcine follicles and cultured in the absence and presence of 1, 10, and 50 μg/ml of BD2, and BD3. After 24 hours of treatment, cell numbers were counted using an automated cell counter. It was found that while BD2 appears to have no effect, BD3 stimulated granulosa cell proliferation in a dose dependent manner ($p < 0.05$). This effect is also dependent on the stage of follicular development, as it is effective on granulosa cell from small but not large follicles. In addition, transwell cell migration assay revealed that in the presence of BD3 (10 μg/ml), a 2.5 fold increase in cell migration was achieved. To further study the potential pathway involved in BD3 induced cell proliferation, Western blots were performed to determine the ratio of phosphorylated- and non-phosphorylated -ERK1/2. It was found that BD3 significantly increased the phosphorylated-ERK1/2 ratio. Moreover, U0126**,** the specific ERK1/2 phosphorylation inhibitor, suppressed BD3 induced ERK1/2 phosphorylation and proliferation, suggesting that BD3 may stimulate granulosa cell proliferation *via* activating the MAPK pathway. Our data suggests that antimicrobial peptides may play a physiological role, in addition to being the traditionally recognized immune-defense mechanism, in regulating ovarian follicular development.

Growth performance and nutrients digestibility in growing pigs when fed diets containing non-steeped or steeped DDGS supplemented with exogenous enzymes

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Introduction: Steeping fibrous feedstuffs such as DDGS with fiber degrading enzymes may improve feeding value in pigs. Diets containing DDGS treated with a blend of β-glucanase and xylanase (XB) with or without extended steeping were fed to growing pigs to investigate growth performance and apparent total tract digestibility (ATTD).

Methods: Three liquid treatments were 1) corn- soybean meal based diet with 30% DDGS (C), 2) C + XB without steeping (XBNS), and 3) C + XB with the DDGS steeped with XB (16% DM) for 10d at 40°C (XBS). The target activities for XB were 1,050 and 5,500 U/g of DDGS for β-glucanase and xylanase, respectively. All diets were formulated to meet nutrient requirements for growing pigs. A total of 144 pigs (23±3.5 kg BW) were randomly assigned to pens (3 barrows and 3 gilts) and allocated to the three treatments in a 2-phase feeding program (3-wk/phase). Diets were delivered by computer controlled liquid feeding system at a feed to water ratio of 1:4, four times per day. At the end of the experiment, 1 pig per pen was sacrificed for gastrointestinal measurements.

Results: Average daily growth (ADG) was higher in pigs fed XBNS ($P = 0.02$) than C in phase 1 and in phase 2. Overall XBNS pigs ($P < 0.05$) had higher ADG compared to XBS fed pigs. Pigs receiving C were similar to XBS pigs. There were no effects ($P > 0.05$) on ADFI however, pigs fed XBS had numerically lower ADFI in phase 1 (−4.0%) and phase 2 (−5.2%) relative than XBNS pigs. Pigs receiving XBNS (1.68) and XBS (1.69) had better feed:gain ($P = 0.001$) than C (1.78) during phase 1. There was no difference in empty gastrointestinal weight ($P > 0.05$). DM, OM, CP ATTD was highest in pigs fed XBS ($P>0.05$) followed by XBNS, and C being the lowest. NDF ATTD wasn't different among the three treatments, however numerically C (53.77) had the highest followed by XBS (51.01) and XBNS (49.86).

Conclusion: Treating DDGS with XB with or without steeping resulted in improved feed efficiency for the first 3 wk, which may be XB degrading dietary fibrous components that may limit nutrient utilization in younger pigs. Supplementation with XB improved ADG when DDGS were not steeped; however, steeping appeared to reduce feed intake, resulting in poorer ADG.

Key words: Liquid feeding, DDGS, Enzyme, β-glucanase, Xylanase, growth performance, Swine

Erratum: This abstract was inadvertently left out of the printed proceedings 2017, it should have been under *Additional Posters (Non-competition)* – our apologies to the author.