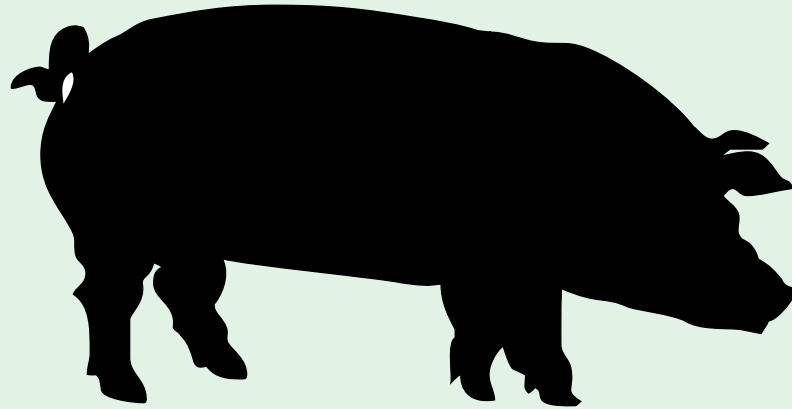


*29th Annual*



**CENTRALIA**

**SWINE**

**RESEARCH**

**UPDATE**

*January 27th, 2010*

**CentraliaSwineResearch.ca**

**CENTRALIA SWINE RESEARCH UPDATE**  
**Kirkton-Woodham Community Centre**  
**January 27, 2010**

9:00 a.m.	REGISTRATION and COFFEE	
9:50	Opening Remarks	
10:00	Pork Marbling.....	I-1
	Anita Ivanauskas, Ontario Pork	
10:15	Nutrition and Immune Function.....	I-3
	Anooshrokh Rakhshandeh, Department of Animal & Poultry Science, University of Guelph	
10:30	Metabolic Status of Sows in Late Gestation and Early Lactation.....	I-5
	Dr. Paul Luimes, Ridgetown Campus, University of Guelph	
10:45	Antimicrobial Resistance and Greasy Pig Disease.....	I-7
	Dr. Bob Friendship, Department of Population Medicine, University of Guelph	
11:00	Animal Health Act, 2009.....	I-9
	Dr. Deb Stark, Ontario Ministry of Agriculture Food and Rural Affairs	
11:15	Animal Welfare: Serving a Conflicted Public.....	I-11
	Dr. Terry Whiting, Manitoba Agriculture Food and Rural Initiatives	

**LUNCH**

1:30	Health Surveillance Data: What Does It Tell Us?.....	I-19
	Dr. Terri O'Sullivan, Department of Population Medicine, University of Guelph	
1:45	Spread of Common Viral Pathogens between Herds in Ontario: Current Knowledge and Future Work.....	I-21
	Dr. Zvonimir Poljak, Department of Population Medicine, University of Guelph	
2:00	Plant-to-Plant Differences in DDGS Nutrient Content and Availability.....	I-23
	Phil McEwen, Ridgetown Campus, University of Guelph	
2:15	Effects of Stage of Transport and Vehicle Design on Deep Core Body Temperature of Market Pigs.....	I-25
	Dr. Tina Widowski, Department of Animal & Poultry Science, University of Guelph	
2:30	Pain Relief in Pigs.....	I-27
	Dr. Derek Haley, Department of Population Medicine, University of Guelph	
2:45	National ID.....	I-29
	Clare Schlegel, Canadian Pork Council	
3:00	Clean Water Act/Source Protection Planning Process: Status Report .....	I-31
	Sam Bradshaw, Environmental Communications Specialist, Ontario Pork	

Adjourn

## WRITTEN-ONLY TOPICS

University of Guelph/OMAFRA Partnership Pork Research Program Projects.....	II-1
Bob Friendship, University of Guelph	
Update on U.S. Country-of-Origin Labelling (COOL) .....	II-5
Canadian Pork Council	
2009 Update on the Development of an Integrated Mycotoxin Management System in Ontario Corn .....	II-7
A.W. Schaafsma, V. Limay-Rios, University of Guelph, Ridgetown Campus	
Potential Application of Genomics for the Canadian Swine Industry .....	II-9
Mohsen Jafarikia, Laurence Maignel, Brian Sullivan, Stefanie Wyss, Canadian Centre for Swine Improvement	
Elimination of the Negative Effect of Feeding Vomitoxin (DON) Contaminated Corn on Pig Growth Performance by Microbial Detoxification .....	II-11
T. Zhou, X.Z. Li, J. Gong, H. Yu, J.C. Young, H. Zhu, Guelph Food Research Centre, Agriculture and Agri-Food Canada; C.F.M. de Lange, C.H. Zhu, Department of Animal and Poultry Science, University of Guelph; and W. Du, Ontario Ministry of Agriculture, Food and Rural Affairs	
Are We At a Stage Where We Know How to Handle a PRRS Break in a Sow Herd .....	II-13
Lori Moser, Managing Director, Ontario Pork Industry Council	
Update on Swine Liquid Feeding Research .....	II-15
C. de Lange, C.H. Zhu, D. Wey, J. Guimaras, D. Columbus and M. Or-Rashid, Department of Animal and Poultry Science, University of Guelph	
The Effects of Docked Tail Length and Nursery Space Allowance .....	II-17
K. Bovey, T. Widowski, Department of Animal and Poultry Science, University of Guelph; S. Torrey, Agriculture and Agri-Food Canada; C. Dewey, Population Medicine, University of Guelph	
Patterns of Condemnation Rates in Swine from a Federally Inspected Abattoir in Relation to Disease Outbreak Information in Ontario (2005-2007).....	II-21
Rocio Amezcua, David L. Pearl, Alejandro Martinez, Canadian Food Inspection Agency; Robert M. Friendship, Department of Population Medicine, Ontario Veterinary College, Guelph	
One Stone – Two Birds: Can Vaccination Against <i>Salmonella</i> Make Pork Safer and Improve Growth in Pigs? .....	II-23
A. Farzan and R. M. Friendship, Department of Population Medicine, University of Guelph	
Epinephrine-induced MMP Expression and its Relationship with AMPK signalling in Muscle Cells and Fibroblasts (Connective Tissue-forming Cells) .....	II-25
M.C. Cha and P.P. Purslow, Department of Food Science, University of Guelph	
Changes in Energy Metabolism During Gestation and Lactation in Sows.....	II-27
R.S. Samuel <sup>1</sup> , S. Moehn <sup>1</sup> , P.B. Pencharz <sup>2</sup> , and R.O. Ball <sup>1</sup>	
<sup>1</sup> Swine Research and Technology Centre, University of Alberta	
<sup>2</sup> Research Institute, Hospital for Sick Children, Toronto	

Dietary Lysine Requirement for Maintenance is 49 mg/kg0.75 in a Population of Modern, High Productivity Sows .....	II-29
R.S. Samuel <sup>1</sup> , S. Moehn <sup>1</sup> , P.B. Pencharz <sup>2</sup> , and R.O. Ball <sup>1</sup>	
<sup>1</sup> Swine Research and Technology Centre, University of Alberta	
<sup>2</sup> Research Institute, Hospital for Sick Children, Toronto	
Dietary Lysine Requirement is Greater in Late- than in Early-Gestation in Sows .....	II-31
R.S. Samuel <sup>1</sup> , S. Moehn <sup>1</sup> , P.B. Pencharz <sup>2</sup> , and R.O. Ball <sup>1</sup>	
<sup>1</sup> Swine Research and Technology Centre, University of Alberta,	
<sup>2</sup> Research Institute, Hospital for Sick Children, Toronto	
The Threonine Requirement in Early and Late Gestation and the Availability of Threonine in Common Feedstuffs in Sows .....	II-33
Crystal L. Levesque <sup>1</sup> , Soenke Moehn <sup>1</sup> , Paul B. Pencharz <sup>2</sup> , and Ronald O. Ball <sup>1</sup>	
<sup>1</sup> Swine Research and Technology Centre, University of Alberta	
<sup>2</sup> Research Institute, Hospital for Sick Children, Toronto	
Ractopamine, at 5 or 10 mg /kg, Increases Protein Deposition in the Carcass .....	II-35
K.A. Ross <sup>1,2</sup> , A.D. Beaulieu <sup>1</sup> , J. Merrill <sup>3</sup> , G. Vessie <sup>3</sup> and J. F. Patience <sup>1,4</sup>	
<sup>1</sup> Prairie Swine Centre Inc. Saskatoon	
<sup>2</sup> Dept. Animal and Poultry Science, University of Saskatchewan	
<sup>3</sup> Elanco Animal Health, Guelph, <sup>4</sup> Dept. of Animal Science, Iowa State University, Ames, IA	
Evaluating Energy Usage and Various Energy Conservation Strategies for Swine Barns.....	II-39
B. Predicala, E. Navia, Prairie Swine Centre Inc., Saskatoon	
Temperatures Within a Truck Transporting Pigs During Winter and Summer Months in Western Canada .....	II-42
Hayne, S. <sup>1</sup> , T. S. Samarakone <sup>1</sup> , T. Crowe <sup>2</sup> , S. Torrey <sup>3</sup> , R. Bergeron <sup>4</sup> , T. Widowski <sup>4</sup> , N. Lewis <sup>5</sup> , C. Dewey <sup>4</sup> , L. Faucitano <sup>3</sup> and H. W. Gonyou <sup>1,2</sup>	
<sup>1</sup> Prairie Swine Centre Inc., Saskatoon, <sup>2</sup> University of Saskatchewan, Saskatoon	
<sup>3</sup> Agriculture and Agri-Food Canada, Lennoxville, PQ, <sup>4</sup> University of Guelph, Guelph, ON,	
<sup>5</sup> University of Manitoba	

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Centralia Swine Research Update  
Box 37  
Exeter, Ontario  
N0M 1S6

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## **Pork Marbling**

Anita Ivanauskas  
 Ontario Pork  
 416-239-1929  
[saffron@sympatico.ca](mailto:saffron@sympatico.ca)

### **Background**

In 2007 a major Canadian retailer approached Ontario Pork, requesting that pork marbling grades be developed in an effort to establish consistent marbling standards across Canada. At that time, some retailers were starting to ask processors for marbling levels within the pork loin, based on the National Pork Producer Council (NPPC) marbling standards which range from 1 to 10, '1' being the lowest level of marbling and '10' being the highest level. Without standards however, it was impossible for retailers to source consistent product from multiple facilities. In addition, Canadian pork had been leaned down to extremely low levels and so higher levels of marbling were virtually non-existent on the market.

### **Research in 2008**

In response to this request, Ontario Pork applied for and received funding from The Agricultural Adaptation Council to carry out consumer research in 2008 and again in 2009, with a goal to establish and market pork with the marbling levels preferred by consumers. The original consumer research was managed by Bethany Uttaro of Lacombe Research Centre in Alberta. Not surprisingly, consumers preferred higher levels of marbling when evaluating cooked product (i.e. marbling scores of 3 to 6), but lower levels of marbling when visibly ranking raw cuts of pork (i.e. marbling levels of 1-3). Source: Pork Marbling Initiative: Consumer Product Testing of Pork Chops - An Initial Report, Jennifer Janz, February 2008

### **Research in 2008/2009**

In 2008 and 2009, Centre de développement du porc du Québec inc. (CDPQ) and the Canadian Centre for Swine Improvement (CCSI) were secured to determine the breed, feed and management practices required to attain the higher levels of marbling in pork identified as desirable by consumers. Higher levels of marbling were attained in the test using purebred Duroc and Yorkshire-Landrace cross, along with a high energy diet. NPPC scores measured through ultrasound ranged from 2 to 6 at 149 days, and by the slaughter date of 179 days, most loins measured marbling levels of 3 to 5. The animals however grew very rapidly and were thus substantially higher in weight than typical commercial hogs (142 kg vs the average 114 kg). Resulting sensory scores were relatively poor, with speculation that the size of the primals compromised the texture/tenderness of the product. The size of the primals would also be problematic at the processing level.

In 2009, Ontario Pork commissioned three Ontario producers to raise hogs according to the protocols set out by CDPQ, requesting that they target a slaughter weight of approximately 110-115 kg. These hogs will be processed at the end of January 2010 and sensory evaluation will be carried out on February 1, 2010.

### **In 2010**

Assuming that we are successful in identifying the protocols and in sourcing more highly marbled pork, Ontario Pork will work with producers, processors and customers to assist in the launch of this product. At this point, there are key foodservice and retail customers that are very interested in this initiative.





## **Nutrition and Immune Function**

A. Rakhshandeh and Dr. Kees de Lange  
Department of Animal & Poultry Science, University of Guelph

### **Introduction**

Economics and concerns about food safety and animal welfare shaped a new subdiscipline in nutritional science called nutritional immunology or immunonutrition. The primary goal of nutritional immunology is to use nutrition as a tool to reduce the negative impact of diseases on both animals and humans, and consequently reduce the need for (in-feed) antibiotics. Changes in animal physiology (e.g. cytokines, stress hormones and immune system activation) that accompany diseases disrupt normal nutrient metabolism and, consequently, reduce production in pigs. The objective of this paper is to briefly discuss the metabolism and utilization of energy, protein and amino acids during disease.

### **Nutrient digestibility**

Both enteric (gut) and systemic (non gut) disease can cause morphological and physiological changes in the gut of pigs, such as edema, change in gut motility, permeability, and microflora (Yamada, 1995). Enteric disease can affect nutrient digestion and absorption. For example, Morris and Marsh (1992) reported reduced nutrient digestibility in parasitic challenged pigs. However, systemic disease does not appear to affect nutrient digestibility. Zoric et al. (2003) reported no change in nutrient digestibility in pigs infected with *Actinobacillus Pleuropneumoniae*. In our laboratory, in two studies using bacterial lipopolysaccharide (LPS) injection to model systemic disease, we did not observe changes in apparent ileal digestibility of energy (control vs. challenged  $\pm$ SE;  $84.0 \pm 1.79$  vs.  $83.2 \pm 1.44$  %), protein ( $74.1 \pm 4.85$  vs.  $71.4 \pm 3.86$  %) or amino acids in growing pigs. Also, no effect of disease on apparent fecal digestibility of nutrients was observed (Rakhshandeh et al. 2009).

### **Energy metabolism**

During disease glucose becomes the major energy source for the immune system. Glucose can be derived from dietary starch and sugars, or derived from other nutrients such as protein via a process called gluconeogenesis (Tredget et al. 1988). With redirection of glucose toward the immune system, together with disease induced reductions in energy intake, fatty acids are used more extensively to supply energy for other metabolic activities. Increased fatty acid oxidation during disease has been repeatedly reported in literature (Tredget et al. 1988). One may think that increasing dietary energy density may improve pig growth performance during disease. However, van Heugten et al. (1996) reported that an increase in dietary energy density has no effect on performance of sick pigs regardless of the source of supplemental energy (i.e. carbohydrate or fat). This is likely because energy requirements for amplifying an immune response are lower than energy requirement for optimum growth.

### **Amino acid metabolism**

During disease amino acid metabolism is characterized by increased breakdown and reduced plasma levels of certain amino acids, which in extreme cases can result in a net loss of body protein. Loss of body protein occurs mainly in muscle (~70% of total body protein loss). Dietary amino acids and amino acids derived from muscle protein breakdown are utilized for energy supply and for processes activated as part of the defense mechanism, such as production of immune proteins, immune cells and related metabolites (Obled et al. 2002). The increased synthesis of immune proteins and metabolites during disease require additional intake of specific amino acids. It is well known now that the amino acids glutamine and arginine become conditionally essential during disease because of their unique

roles in the immune system. Beneficial effects of their dietary supplementation have been repeatedly reported (Obled et al. 2002). Special consideration should also be given to the amino acids tryptophan and cysteine. These two amino acids are known to play important roles in the immune system, and they are among the amino acids that may be limiting in practical pig diets that contain added crystalline amino acids, such as lysine HCL. In our laboratory we observed a 29% decrease in plasma tryptophan levels in sick gilts (Rakhshandeh et al.; unpublished). French researchers have also reported a 24% decrease in blood plasma tryptophan levels in sick pigs and have shown that the optimum dietary tryptophan to lysine ratio should be higher in sick pigs than in healthy pigs (Melchior et al. 2003). Cysteine requirements during disease increase due to its need for synthesis of glutathione and albumin. In studies in our laboratory we have observed a reduction in plasma cysteine levels and an increase in dietary methionine plus cysteine requirements for body maintenance functions in growing pigs (BW 21.5±3.5 kg) challenged with LPS (Rakhshandeh et al. 2009; and unpublished).

### **Implications**

Disease alters nutrient metabolism and utilization and, consequently, nutrient requirement of pigs. Reformulation of diets should be considered in order to reduce the negative impact of disease on pig performance and efficiency of nutrient utilization. In particular the dietary ratios of tryptophan and methionine plus cysteine to lysine may be increased during a disease challenge in pigs. This relatively new area of research will become more critical when the use of (in-feed) antibiotics will be further reduced.

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## Metabolic Status of Sows in Late Gestation and Early Lactation

P. Luimes\*, C. de Lange, R. Friendship, G. Simpson, S. Burlatschenko and G. Wideman

\*University of Guelph, Ridgetown Campus, Ridgetown, ON, N0P 2C0

519-674-1550 (p); 519-674-1555 (f); [pluimes@ridgetownc.uoguelph.ca](mailto:pluimes@ridgetownc.uoguelph.ca)

Sow productivity has increased dramatically in recent years. In the 6 years from 1998 to 2004 benchmarks have improved, for example, farrowing rate has increased by 12%, piglets weaned per sow per year has increased by 5% and weight of litter at weaning has increased by 4% (Ball et al. 2008). However, sow feed intake capacity, and thus nutrient intake, during lactation has not changing substantially. These changes occur at a nutrient and metabolic cost. Very little research has gone into nutrient requirements for sows in the last 20 years (Ball et al. 2008). As a consequence, modern sows have greater risk of nutrient deficiency and metabolic stress than their ancestors. As these trends continue, this will lead to increased incidences of metabolic disorders and compromised sow live-time productivity.

The metabolic stress modern, highly prolific sow can face during the periparturient period is significant. Already during late gestation sows can be in a negative energy balance and experience ketosis (Alsop et al. 1994), presumably due to the significant energy requirements of the late term growth of the piglets *in utero* and restrictions in feed intake. After farrowing, the metabolic demands of milk production are also significant. An average sow producing around 9.5 kg of milk per day will be secreting a similar amount of energy in her milk as an average dairy cow, on a metabolic body weight basis ( $BW^{0.75}$ ). There is no clear picture of what a lactation curve looks like for a sow but it appears peak milk production occurs between days 15 and 18 (Trottier and Johnston, 2001). When compared with a figure of frequency of decreases in average daily feed intake of sows over lactation (Koketsu et al. 1996), an interesting picture unfolds. The frequency of decreases in average daily feed intake increases dramatically around day 8 (the time noted by many producers as the critical day) and remains high until the reported peak around day 15 – 18 (Koketsu et al. 1996). Gaining an understanding of the metabolic status of a sow during the periparturient time will help nutritionists and herdsmen develop rations and feeding strategies that optimize performance by minimizing metabolic stress and disease.

### Experimental Procedure

Gestating sows were fed ~2 kg of a gestating sow ration daily until day 110. Sows were then moved to farrowing crates at day 110 of gestation. Upon entry into the farrowing facilities, sows were fed a lactating ration at restricted levels (2 kg/d) until farrowing when they were fed on an increasing scale up to *ad libitum*. Cross-fostering was done such that litters sizes of 7, 10 or 13 were achieved after initial colostrum intake was completed. The three treatments (the three litter sizes) were to have three levels of milk production, or metabolic stress, established by cross-fostering. All procedures conducted on animals were authorized by the University of Guelph Animal Care committee.

Sampling dates were established as follows: When the median sow in a group reaches day 109 of gestation (~ day -7 from farrowing) all the sows in that group will be blood sampled. This will provide a range of days around which ketosis may be significant during late gestation. A second sample was taken on half of the sows in the group on day 6 of lactation for the median sow. The other half of the sows had their second blood sample when the median sow reached day 8 of lactation. The reason for two days of sampling during the lactation period is to spread the work and stress level out, plus to get a wider range around the time when research shows sows are likely to go

off feed (and more ketosis may be expected). Serum samples were evaluated for blood concentrations of  $\beta$ -hydroxybutyrate by the AHL, using the Cobas 6000 c50.

## Results

As we are currently in the middle of the trial, I will only report raw averages for day relative to farrowing and for litter size (Table 1).

**Table 1.** Serum  $\beta$ -hydroxybutyrate concentration for day relative to farrowing and litter size.

	Serum $\beta$ -hydroxybutyrate concentration ( $\mu\text{mol/L}$ )*
Day relative to farrowing	
-7	13.0 (29)
6	7.5 (15)
8	22.0 (14)
Litter size	
7	10.2 (18)
10	17.4 (18)
13	13.5 (16)

\*number of samples (n) is in brackets

We have had very few animals “crash” during this trial so far but serum  $\beta$ -hydroxybutyrate levels of 133 and 290  $\mu\text{mol/L}$  were reached for two sows during their “crash” times.

## Discussion

It is difficult to make any clear conclusions from the data to date; however, there appear to be some small differences emerging, especially with respect to days relative to farrowing. Certainly, the sows that experienced a significant off-feed event showed much higher levels and are of greater interest to pursue. It will have to be decided how to pursue the investigation of these sows in a controlled experiment.

Thanks to Ontario Pork and OMAFRA for funding. Also thanks to barn staff: Dave Hogg, Bob Crow, Jessica Knoop, and students: Gavin Gardiner, Emily Jeffrey, Fanny Teselink and Bailey Trap for helping with blood sampling.

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## Antimicrobial Resistance and Greasy Pig Disease

Jeonghwa Park, Dr. Bob Friendship, Scott Weese, Cate Dewey and Zvonimir Poljak  
 Department of Population Medicine, University of Guelph  
 University of Guelph, Ph. 519 824-4120, ext 54022 ([rfriends@uoguelph.ca](mailto:rfriends@uoguelph.ca))

### What is “Greasy Pig Disease”?

Almost everyone involved in pig farming is familiar with greasy pig disease because it is very common. Piglets suffering from the mild form of the disease have small black scabs usually around the face. The disease is caused by infection of wounds by *Staphylococcus hyicus*, bacteria commonly found on the skin of pigs. In severe cases the infection can become generalized so that the skin over the whole body is damaged. The oozing of serum from the damaged skin makes the surface greasy and hence the name. In the case of extensive skin damage the mortality rate is quite high. Generally the disease is most severe in newborns and more likely to be limited to localized infection as the pig ages. The two periods when greasy pig is most likely to occur is in the first few days of life when pigs fight for teats and cut each other with needle teeth, and at weaning which is also a period of mixing and fighting.

### Why are we interested in this disease?

Outbreaks of the severe form of the disease results in high mortality and survivors are often poor-doing pigs that have to be culled. We think the prevalence of the disease is increasing, possibly because many herds are moving away from routinely clipping needle teeth. We have heard reports that the disease has become difficult to treat and we have wondered if that is related to antimicrobial resistance. We have previously looked into the presence of multi-drug resistant strains of another bacteria commonly present on pig skin, *Staphylococcus aureus*. While doing that work we inadvertently noticed isolates of *S. hyicus* with similar resistance patterns to *S. aureus*. The objective of our study was to determine if *S. hyicus* causing greasy pig disease has developed antibiotic resistance making this disease more difficult to treat.

### How are farmers currently treating greasy pig disease?

We have interviewed 49 farmers, and 44 reported that they presently have or have recently had cases of greasy pig disease in their herds. About 70% of respondents said that they routinely use topical treatments to control the disease, with mineral oil alone or in combination with an antibiotic such as novobiocin or they use an antiseptic such as iodine. More than half the respondents said they use an injectable antibiotic either alone or in conjunction with a topical treatment, and for most herdsmen the product of choice was penicillin. Thirty percent of those surveyed said they no longer clip needle teeth. Many expressed disappointment regarding response to treatment.

### What did we find when we sampled pigs?

So far we have the results from 17 farms. Generally 6 pigs were sampled, choosing animals showing clinical signs of greasy pig (if present at the time of the visit). Skin scrapings and skin swabs were collected from each pig. Recovery rate of *S. hyicus* was about the same using each technique (60% positive). We also cultured for *S. aureus* (40% positive).

Of the 66 *S. hyicus* isolates cultured from skin swabs, all showed resistance to penicillin and to ampicillin and about 70% of the isolates showed resistance to ceftiofur (Excenel®). These three antibiotics are members of the same family of drugs, the beta-lactams. The resistance pattern for *S. aureus* was similar. Additional molecular studies on some of the isolates show that some of the *S. hyicus* carry the *MecA* gene similar to methicillin-resistant *S. aureus*.

### **Why are these findings of importance?**

This study shows that greasy pig disease is unlikely to respond to injections of penicillin or any of the beta-lactam antibiotics and this is at least a partial explanation for treatment failure that was reported in the survey. This very widespread resistance would appear to have occurred recently and has spread rapidly. We can speculate that the gene that is associated with this resistance pattern also carries genetic material that provides some kind of survival advantage and there has been herd to herd spread and possibly spread from *S. aureus* to *S. hyicus* or vice versa. Whenever antimicrobial resistance is reported in the pig industry there is always a media storm and accusations of improper antibiotic use, particularly with respect to growth promotant levels in feed. We did not record drug use on these farms but it was noted that several of the herds were on a no-antibiotic program. Finding multi-drug resistant Staphylococci as the dominant strains on farms where antibiotics are not used strongly suggests that an industry-wide ban on antibiotic use will not in anyway solve this problem.

### **How should we treat greasy pig disease?**

This study shows that there is value in culturing the bacteria from cases and checking which antibiotics are most likely to work and this varies from farm to farm. There is a need to look at alternative approaches particularly in the area of topical treatments and vaccination strategies, but in general more research is needed to assess the value of these products.

Prevention needs to be emphasized and includes good sanitation, lowering humidity, minimizing wounds which might mean clipping needle teeth, eradicating mange, minimizing cross-fostering or non-essential mixing of pigs. Early application of antiseptics to wounds is also a good way to prevent infection and reduce the chance of greasy pig disease occurring.

### **Who is supporting this work?**

Ontario Pork, the Animal Health Strategic Initiative Fund , OMAFRA and the University of Guelph. In addition all culturing has been performed by the AHL bacteriology lab with input from Dr. Slavic. Molecular analysis of isolates is being carried out by Dr. Weese's lab. We are very appreciative of the farmers who have allowed us to sample pigs and who have answered our survey.

## **Animal Health Act, 2009**

Dr. Deb Stark, Chief Veterinarian  
Ontario Ministry of Agriculture Food and Rural Affairs

The Animal Health Act, 2009 passed third reading on December 8, 2009. When proclaimed, the act will provide measures for the Province to prevent, detect and respond to animal diseases and other potential animal health hazards. The act will help Ontario better protect its people, its animals and its economy.

### **KEY DEFINITIONS**

#### **Animals**

Because all animals have the potential to carry and transmit diseases that can pose risks to animal or human health, the act applies to all animals. Implementation will focus primarily on farmed animals (livestock and poultry).

#### **Hazards**

The act covers a broad range of issues that could affect the health of animals – not just diseases. The legislation refers to this larger group as “hazards”, and includes:

- Chemicals that could contaminate inputs, such as animal feed.
- Radiological hazards, such as nuclear contamination.
- Physical contaminants, such as metal shards in animal feed.

### **CHIEF VETERINARIAN FOR ONTARIO (CVO)**

While there has been a CVO within the ministry since 2005, the position now has legislated qualifications, functions and powers. The CVO must be a licensed veterinarian with a minimum of five years in veterinary practice. This person can appoint inspectors under the act, direct that inspections occur, and establish surveillance zones. The CVO is also responsible for reporting to the Chief Medical Officer of Health any matter that might pose a significant risk to public health.

### **INSPECTORS**

Working within ministry protocols and procedures, and under the guidance of the CVO, inspectors will work closely with industry partners to protect animal health in Ontario. If there is reason to believe a potentially significant animal health issue exists, or if the CVO is taking action to prevent an animal health issue, the act allows for inspectors to:

Inspect animals and/or related items, such as vehicles and premises.

Take samples and perform tests.

Issue compliance and quarantine orders

Perform other duties requested by the CVO.

### **RESPONDING TO ANIMAL HEALTH ISSUES**

Provisions in the act allow the government to take important steps to help reduce negative economic and public health impacts associated with animal health issues.

#### **Prevention**

The government will be able to take proactive steps to prevent diseases from affecting animals in Ontario, or to prevent its spread. For example, should a disease be found in an Ontario animal, or elsewhere in Canada, the ministry could establish control areas to keep it from entering Ontario, or to minimize its spread.



## **Detection**

Should there be reason to believe an animal health issue might exist, OMAFRA staff could sample or test at-risk animals, allowing more rapid detection of a potentially larger issue.

## **Response**

If a potentially significant animal health disease, or other issue, were found in Ontario, the act provides a range of tools to control or mitigate the effects. For example, the government might increase monitoring and testing in certain areas, or establish quarantines, surveillance zones or animal health control areas.

*Quarantine* – if an animal health hazard was identified at an individual premises, testing could be conducted, animals or related products could be held, or other measures could be ordered by the CVO to contain the situation.

*Surveillance zone* – if further monitoring for a hazard were required, a broader surveillance area could be set up, up to a maximum of 10 kilometres around quarantined premises.

*Control area* – this could involve movement restrictions within or to/from a certain area to prevent or control an issue that posed a significant risk to animal or human health in the province or part of it. Only the minister can establish a control area.

*Destruction order* – if necessary to control a situation, the CVO can order that animals, or related products, be destroyed.

## **COMPENSATION**

Should the CVO decide that an animal health issue require animals to be euthanized, the act allows the minister to compensate producers for the loss, based on the animal's market value. The Minister can also authorize compensation for the reasonable cost of cleaning and disinfection that might have been incurred while complying with an order made under the act.

## **FUTURE REGULATIONS AND CONSOLIDATION OF OTHER ACTS**

In the future, existing acts (Bees Act, Livestock Community Sales Act, and Livestock Medicines Act) and associated regulations may be modernized and consolidated under the Animal Health Act.

The ministry is committed to consulting with industry partners on regulations that are established under the act, including one around reportable diseases.

## **TRACEABILITY**

The act provides a framework for the minister to establish and oversee a provincial traceability system for animals and related products. Any traceability initiatives that might be developed provincially would align with national initiatives.

If traceability-related regulations were required under this act, they would be developed in consultation with industry partners.

## **For more information:**

Telephone: 1-877-424-1300

E-mail: [animalhealth@ontario.ca](mailto:animalhealth@ontario.ca)

[www.ontario.ca/omafra](http://www.ontario.ca/omafra)

## **Animal Welfare: Serving a Conflicted Public**

Dr. Terry Whiting  
Manitoba Agriculture Food and Rural Initiatives  
Winnipeg, Manitoba R3T 5S6  
[terry.whiting@gov.mb.ca](mailto:terry.whiting@gov.mb.ca) 1-204-945-6750

### **Introduction**

If big-P Politics is used to refer to the national political parties and the ongoing blustering one-up-man-ship game that has no bearing on our lives then; animal welfare concerns in North America, including food choice, is generally “small p” political. The essence of politics is grassroots activism, a shift in personal conviction that is broader and deeper than people carrying signs and burning giant puppets. In the briefest explanation, politics is about the lives of the ordinary people, and about the daily world they inhabit. This sort of politics isn't about looking good; it's about doing good. It's not about making pronouncements; it's about getting dirty and helping out. If Politics is talking the talk, politics is walking the walk.

There is an expanding political lexicon of descriptors related to food choice and dietary preference reflecting a continuing evolution of how society thinks about food, politically. As the primary purpose of the pig in western culture is to contribute to the human food chain this paper will review some of the current thought trends on “pig” as an animal and “pig” as bacon. When political ideas gain momentum they can become Political movements.

### **The Culture of the Human as Carnivore**

The eating of meat has strong cultural and emotional connotations. A typical or ceremonial meat dish often marks symbolic family gatherings and religious holiday meals. Most people see the slaughter of farm animals for human food as acceptable, although some small degree of animal suffering may be inherent in the process. If people had to kill the animal themselves however, most declare they would become vegetarian (Richardson et al., 1993).

Concerns over poor animal welfare are determined by people's perception of animal suffering. The boundary between acceptable and unacceptable production practices depends on the alternatives available, the cost of alternative methods, collateral impacts of methods (Dolphin friendly tuna) and the product produced.

There is however, a general reduction in meat consumption in western culture and an increase in vegetarian practices with the emergence of moral vegetarianism (Fox 2000; Fessler et al., 2003). Moral vegetarians view meat avoidance as a moral imperative and in contrast to health vegetarians are upset by others who participate in meat consumption (Rozin et al., 1997).

Even regular non-reflective consumers of animal products may feel or be made to feel “cognitive dissonance” associated with their consumption of a livestock product (Bennett 1995). The Dictionary of Psychology, Penguin Books, London, defines cognitive dissonance as “an emotional state set up when two simultaneously held attitudes or beliefs are inconsistent or when a conflict exists between exposed belief and overt behaviour”. The concept first used by psychologists, is also widely used in a marketing context in relation to consumer behaviour (Bennett 1995, Lee & Worsley 2002). Non-consumers of animal products may suffer from the knowledge that other members of society are engaged in production systems that they consider inhumane or environmentally damaging.

The fact that the perception that “purchase of this product does evil” may be the result of a poorly informed conviction does not change the reality of the perception or the injury (Bennett 1995). Non-profit organizations such as the Humane Society of the United States (HSUS) have been successful in lobbying for the prohibition of specific farming practices at the state level in the recent past. The HSUS, based in Washington, D.C., is the largest animal advocacy organization in the world. In 2007, it had 10.6 million members, and a budget of US\$120 million. The organization pursues many causes simultaneously and a case can be made that the HSUS is not interested in improving farm animal welfare put, is pursuing vegetarianism and veganism agenda, and a goal to eliminate animals for use as food (Smith 2006).

### **Killing Animals for Meat**

The practice of livestock farming is consistent with a belief that humane killing of animals does not harm them. There is no evil done when a 36 day old broiler chicken goes to slaughter. The same farm people would likely agree that the pig as an animal is sentient and that pigs have the ability to feel and try to avoid pain. For much of the evolution of animal welfare law in Anglo-American tradition has been based on the Jeremy Bentham circa 1832 paradigm “the question is not, Can they reason? nor, Can they talk? but, Can they suffer?”.

The general belief that painless animal killing is not an evil, some individuals however, believe that the death of an animal is in itself a loss (Yeates 2009) and the companion animal shelter movement, the backbone of most SPCA organizations is based on the popularity of saving of animal life. Western society has taken great effort to separate how we think about food animals from the social space we give to companion animals.

Vialles (1988) went to great effort to describe why the French love to eat organ meat. A question no doubt we have all asked. He describes two categories of meat eater; the ‘sarcophages’ and the ‘zoophages’. Sarcophages (muscle-eaters) he defined as those that seek to ‘forget’ or obscure the obvious relationship between meat and animal. For Sarcophages in Western urbanised society, only the most anonymous parts of the animal are edible. These anonymous bits are required to be effectively ‘de-animalised’ not only through processing and butchering but also through their nomenclature. They become, as Vialles puts it, ‘substances’ which are “defined by their culinary destination” and not by their animalian origin, a definition explicitly adopted by British – and other - food retailers.

*“We are no longer in the business of selling pieces of carcass meat. We must make our customers think forward to what they eat rather than backwards to the animal in the field”* (British Meat, 1987, quoted in Fiddes, 1991, p. 96).

An excellent Canadian example of applied Sarcophagia is in the “I am an egg farmer” television campaign recently running. In this series of television commercials, there are images of blue skies, red barns, honest and hard working farmers and usually an egg; however, no chickens. There is a clear separation between the chicken and the egg. The housing of layer chickens is currently a hotly debated subject in the farm animal welfare ranks and a primary HSUS “industrial farming” target.

The second category, the ‘zoophages’ (animal eaters) are fundamentally different. These are the unrepentant carnivores, who, recognise and, to a certain degree, embrace the animality of their food. For them, farm animals are there to be eaten and images of living animals in no way detract from this for their ‘destiny’ is unequivocal and unambiguous.

For many 'zoophages', the consumption of offal thereby represents the high point in the animality/food linkage; eat the heart of the hart! The Japanese restaurant, where the live fish is chosen from the tank and served still gasping to the customer is a pinnacle of zoophagia.

France as a whole might be characterised by the relative importance of the zoophage position. Germany on the other hand maintains of the former: One disguises the meat in the form of sausages and meat balls; that is the behavioural culinary manifestation of the 'sarcophage' attitude.

### **The Sociology of Animals**

The Merriam-Webster dictionary describes postmodern as "of, relating to, or being a theory that involves a radical reappraisal of modern assumptions about culture, identity, history, or language". Bauman in Postmodern Ethics describes postmodern reality as a manifestation of urban living and the compulsion of individuality.

Compulsory individuality is very difficult way to live, especially the stress that results from every individual being responsible to develop their own coherent set of moral convictions in isolation from any fixed community. Bauman discusses the largely urban inter-personal practices, the way people in highly concentrated urban populations treat each other, which organise and underpin different 'social spaces', cognitive, aesthetic and moral. In his discussion of cognitive urban space he looks at sociological accounts of how people relate to 'strangers'.

Bauman describes what he calls 'the arcane art of mismeeting'. This refers to 'a set of techniques for living with strangers' which involves relegating them to the background or context of interaction, treating them as 'non-admitted existence' and allocating them to 'the sphere of disattention'. In this constructed realm of non-engagement, there is no emotional cost and the space is ethically empty.

Social techniques are used to 'evict' others from one's social space, leaving them without recognition of their subjectivity and placed outside the rules of engagement and interaction operating in that space. For example panhandlers are recognized and placed in this realm of non-engagement. A key technique is avoidance of eye contact. Winnipeg has a by-law<sup>1</sup> forbidding panhandling within the vicinity of "captive" audiences: bus stops, banks and ATMs, parking lots and parked cars, indoor public walkways, elevators and outdoor patios. This by-law enforces the intent of urban public space to not be social space.

Bauman associate 'mismatching' strongly with urban human interaction but the idea also extends to account of how people deal with food animals (Tovey 2002). We might say that pets are met [have a name and are recognized as within society], wild animals are unmet [are respected, but are outside the common law], but vermin, pests and possibly food animals and laboratory animals are mismatched [have no or limited standing within society].

Sociological texts on animals and society emphasise simultaneously the distancing between humans and livestock animals and the increasing human affinity for companion animals both which is thought to have intensified during modernity as a result of urbanisation, the replacement of animal by machine power and the industrial concentration of livestock production.

Bauman/Tovey theory offers us a way of understanding food animals as creatures that have been re-incorporated into society but under conditions which render them ignored by it or "outside of society".

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<sup>1</sup> City of Winnipeg's Obstructive Solicitation By-law No. 7700/2000,

### **Ethical Consumerism**

Modernity requires that every individual is responsible to identify the good life for themselves and to bear the burden of their individualized moral convictions. In a consumer society we are what we own, and we manifest our beliefs by our purchases. Thus the importance of ethical consumerism to many companies worldwide has increased dramatically in recent years. Ethical consumerism encompasses the importance of non-traditional and social components of a company's products and business process to strategic success – such as environmental protectionism and child labour practices. Individuals can express their individual moral convictions through their purchasing decisions and shared moral convictions via political activities.

The number of large organized protests directed at international organizations like the WTO and at global companies like Nike has increased dramatically in recent years. Demonstrators have often become the main focus of news reports during large-scale meetings such as the WTO, G7 and the World Bank; and the number of groups focusing their attention on the social behaviours of companies also seems to have increased. For example, anti-sweatshop organizations abound with more than 40 in the US alone (Elliott & Freeman, 2001) and in areas such as environmental protectionism, human rights, and animal rights with large and well-established organizations like PeTA, HSUS, Greenpeace, Amnesty International and the World Wildlife Fund.

However in support of Wal-Mart 'price competition as the only concern of consumers' one study indicated that 39% of shoppers indicated they had no ethical concerns whatsoever related to method or place of production (Roberts 1996). Also, to a large extent consumers' ethical convictions do not translate into willingness to pay more for food products (Schroder & McEachern 2004). In the case of pesticide use in food production consumers will not pay more for pesticide free products but they will support regulatory control of pesticide use; consumer behaviour is not a good predictor of voter behaviour (Hamilton et al. 2003).

### **Moral Agent - Action as Consumer and as a Citizen**

Others have argued that the Consumer is in fact unable to make a free choice at the checkout counter when the decision in individual purchase is confounded by simultaneous competing concerns (Bennett 1995, 1996). Individuals can hold two views on animal welfare. On the one hand, they may think as "citizens" influencing societal standards, and on the other, act as "consumers" at the point of purchase. As citizens, they support the notion of animals being entitled to a good life; as meat consumers, they avoid the cognitive connection with the live animal and buy on price (Schroder & McEachren 2004).

Vegans are voting citizens but, are powerless in the food marketplace as they are non-consumers. They are unable to participate in policies that are limited to the marketplace.

Previous studies of consumer behaviour have used the contingent valuation method (CVM) and choice tests around willingness to pay (WTP). These are research techniques to try and guess how much demand would there be for a product that is not yet on the market. In application to animal welfare labelling research, consumers consistently overstate their WTP when compared with actual purchase behaviour (Taylor & Signal 2009).

In the voting box, when the consumer is acting as a citizen they will often support compulsory group action, to support social issues they themselves would shirk if acting independently. When asked about future theoretical behaviour people give "politically correct" answers but actual behaviour varies significantly from promised behaviour. Because of this, legislation has been the main and increasingly popular policy approach for protecting the welfare of farm animals. The use of legislation raises issues

such as whose preferences the legislation reflects and whether the preferences of some people in society should constrain the food consumption choices of others.

### **Food Animal Welfare a Societal Choice**

There are several ways that people can demonstrate they have opinions on farm animal welfare. Consumers can communicate directly with production chains by boycotting product or preferentially paying for speciality certified product. Citizens who are not consumers (Vegan-vegetation) can not communicate by purchase patterns. Citizen concerns are communicated by voting patterns and sometimes by participation or support of political agendas and non-profit political organizations.

Consumers, who won't voluntarily pay more for specific production practices as an individual, will often vote with non-consumers to make everyone pay more as demonstrated in recent political campaigns in the United States (Table 1) (Tonsor et al. 2009). In addition governments are often willing to constrain economic development in agriculture if supported by citizen concerns (Auger et al. 2003, Bill 17 Manitoba 2008).

**Table 1 Recent legislative initiatives in the USA , Limit or Protect Livestock Production**

State	Proponent -Target	Initiative	Law	Force (lag Y)
Florida <sup>1</sup>	HSUS – Sow Stalls	2002 Amendment 10	Fla. Const. art. 10, § 21	Dec 2008 (6)
Arizona <sup>2</sup>	HSUS – Sow Crate Veal Calf	2006 Proposition 204	Ariz. Rev. Stat. §§ 13- 2910.07 to 13-2910.08	Dec 2012 (6)
Oregon	Legislature – Sow Crates	2007 SB 694,	Or. Rev. Stat. §600.150	Jan 2012 (5)
Colorado	HSUS – Sow Crate Veal Calf	2008 SB 201	Colo. Rev. Stat. §§ 35- 50.5-101 to 103	Jan. 2012 calves (4) and Jan. 2018 sows (10)
California	HSUS – Veal, egg production, foie gras	2008 Proposition 2	Cal. Health & Safety Code, Division 20, Chapter 13.8	Jan 2015 (6)
Maine	HSUS – Veal, Gestation Stalls	2009 LD 1021	Me. Rev. Stat. Ann. tit. 7 §4020 17 §1039	Jan 2011 (3)
Michigan	HSUS – Veal, egg Gestation Stalls	2009 House bills 5127 and 5128	MI Rev. Stat. §287.746	Oct 2012, Calves (3) Oct 2019 hens & sows. (10)
Ohio	Farm Coalition	2009 Issue 2 <sup>3</sup>	Ohio Const. art XIV, § 1(A)	Livestock Care Standards Board
OK, SC, GA	Legislature	Prohibition on regulation of farm production by local governments	Various	Limit Municipalities

<sup>1</sup> This law affected exactly 2 farms

<sup>2</sup> The Arizona law affected 1 (one) hog farm and no veal operations were in existence

<sup>3</sup> prevents the introduction of State ballot initiatives to pass anti-cruelty measures in Ohio for farm animals

<http://www.nationalaglawcenter.org/assets/farmanimal/index.html>

The animal production industry has been working diligently to do more to educate the public on scientific issues of modern livestock production and the advantages and benefits to the animals of modern production practices. However, a recent study by Lusk and Norwood (2008) in the USA suggested that people's philosophic views on animal welfare are not likely to be strongly influenced by education campaigns; especially if those views are based in existing moral and ethical conviction. The results imply that science based animal production industry extension programs are unlikely to change public opinion about perceived welfare issues.

### **Can Agriculture Afford More Animal Friendly Systems?**

Nineteen cents of every dollar spent on U.S.-grown food goes to the farmer for the raw food inputs, while the other 81 cents covers the cost of transforming these inputs into food products, promoting them and getting them to our grocery shelves and lunch counters (ERS 2004). Relatively expensive changes to methods of production on farm have small incremental costs in final product. Bornett et al. (2003) estimated that moving from slatted floors to deep straw feeder pig production would increase the cost of production about 30% (farmer bankrupt if unilaterally implemented) but increase the cost of pork only 4%. Increasing the floor space of feeder pigs, (partially slatted floor system) from 7.5 ft<sup>2</sup> to 8.6 ft<sup>2</sup> increased full chain cost of production 1% (in Holland) but reduced on farm profitability by 45% (den Ouden, 1997).

Within the supply chain from farmer to consumer, the cost of shelf segregation of product by label greatly exceeds the cost of on farm implementation of significant improvements in animal welfare. From a holistic utilitarian perspective, using labels to segregate product based on method of production is a very inefficient tool to improve the welfare of the average production pig.

### **Conflicting Thinking within the Livestock Industry**

The big social concerns triggering intervention in livestock production in the 1990's have been environmental cost, food safety and animal welfare. Industry and government approach in food safety has been to seduce farmers to implement food safety and traceability programs on farm. This has been accompanied by the conceptual/semantic conversion of farmers from livestock producers to food producers; the "I am a beef producer" campaign. The "Beef Producer" identity has had very poor uptake in the beef cattle industry especially cow calf production where the farmers remain self-identifying as "cattle producers". This phenomenon has also been documented in Europe (Skarstad et al. 2007).

Conversion from the zoophage language "cattle producer" to the sarchophage language "beef producer" is a powerful tool to commodify the production chain. Commodify: to turn into or treat as a commodity; make commercial; is consistent with the food safety dogma. In animal welfare evangelistic credo, commodification of livestock is associated with innate corruption and industrialization of livestock production.

So on the food safety perspective; commodification of livestock production is the salvation of mankind and our hope for the future while from the moral obligation to animal perspective; it is the original sin.

### **Conclusion**

In a democratic society, the public expects to have its opinion count. The public in considering the complex processes in agriculture and food processing are likely to become engaged in the political questions posed.

Two questions likely to affect livestock production in North America in the next 20 years will be: 1) How do consumers and producers define good farm animal welfare? and  
2) How do consumers and producers view the role of animal welfare regulations and labelling?

The future is quite uncertain because (1) production practices could also be altered voluntarily by industry, (wait and see option); (2) voters intensely concerned about animal welfare are not necessarily large consumers of animal products, (Shanghaied by the vigilantes risk); and (3) an improved understanding of citizen desires for additional legislation is sorely needed (incapacitated by ignorance reality).

Over time consumers likely will conclude that some forms of livestock production are unnecessary or not reflective of societal values and will support regulatory intervention to address those concerns. As regulatory bodies currently claim a sound science base for decision making, more discussion is needed on how society will make decisions in the face of scientific uncertainty in food production or in the case of animal welfare, in the face of moral conviction. In highly contentious issues there will be some science on both sides of any specific argument and the final policy decision will be based on ethics/public opinion (Weaver and Morris, 2004).

It is probably impossible to expect the free market and information transparency to address the farm animal welfare concerns of society, especially, as the non-consumer is excluded from participating. The regulatory oversight of farm animal production is going to increase in the near future, similar to the regulatory oversight of manure management has increased in the recent past.

If the rule of law (regulations) is the tool chosen, regulations may turn animal welfare into merely a “food quality attribute” that is defined largely through technical prescriptions and is compatible with large-scale professional agriculture. This would be a shift away from many consumers’ and also quite many producers’ conceptions of what constitutes a good animal life in important respects. Paradoxically, animal welfare regulations may thereby contribute to redefining the divide between animal and food: making the animals become more “food”, rather than fundamentally “animals”. “The regulated farm animal” may then contrast with what has emerged as a main aspect of good animal welfare: that farm animals are animals, and not just food (Skarstad et al. 2007).

The worst outcome possible would be for legislation to go forward without the participation of the livestock producing community. Perhaps the “Ohio Solution” where a socially responsible animal care board, sets standards for livestock production is a model most likely to best serve the interests of animals, the consumer, the citizen and the producer.

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## Health Surveillance Data: What Does It Tell Us?

Terri O'Sullivan DVM<sup>1</sup>, Robert Friendship DVM, MSc, Dip ABVP<sup>1</sup>, Tim Blackwell DVM, PhD<sup>2</sup>, David Pearl DVM, MSc, PhD<sup>1</sup>, Beverly McEwen DVM, MSc, PhD, Dip ACVP<sup>3</sup>, Susy Carman DVM, PhD<sup>3</sup>, Durda Slavic DVM, MSc, PhD<sup>3</sup>, Catherine Dewey DVM, MSc, PhD<sup>1</sup>.  
 Department of Population Medicine, University of Guelph, Guelph, Ontario, Canada<sup>1</sup>  
 Ontario Ministry of Agriculture Food and Rural Affairs, Fergus, Ontario, Canada<sup>2</sup>  
 Animal Health Laboratory, Laboratory Services Division, University of Guelph, Guelph, Ontario Canada<sup>3</sup>

### Introduction

Disease monitoring and surveillance are important activities of any animal population whether it is the disease monitoring of a private swine herd, a commercial swine breeding herd, or our national herd. We conduct surveillance to achieve and maintain a high level of animal health, secure international trade agreements, and to produce safe and nutritious pork. Any monitoring or surveillance program however, is only as good as the data behind the program. For example, how do we know what test to use to monitor for Porcine Reproductive and Respiratory Syndrome Virus (PRRSV)? Or better yet, what sample to collect? The evaluation of health data and different data sources helps us to answer such questions.

The primary purpose of the following study was to evaluate the utility of sampling tonsils as a data source for monitoring the health of Ontario market hogs. Tonsils are part of the immune system of mammals and act as a protective barrier to diseases affecting the respiratory and gastrointestinal tracts. Their function and location in the body make them an excellent site for detecting both normal flora and pathogens. For example, the emergence of PRRSV in the USA in the 1980's was documented when an unknown arterivirus was isolated from the tonsils of affected pigs and, more recently, an outbreak of *Streptococcus suis* in humans in China was caused by a highly virulent strain of *S. suis*, a pathogen that can be isolated in the tonsils of clinically healthy pigs.

Collecting tonsil samples from the live pig is technically difficult. Because of this, collecting tonsils at the time of slaughter is an obvious alternative for disease monitoring purposes. Also, during the slaughter process, a large number of animals from many sources are funnelled into one location, providing an ideal opportunity to sample pigs from many different farms. Further objectives of the study were to determine if sampling tonsils from normal or abnormal (condemned carcasses) hogs would provide different results, and if a slaughter plant would provide a suitable environment for detecting and monitoring important pathogens that have health implications in both swine and humans.

### Materials and Methods

Tonsil samples were collected from swine carcasses for 20 consecutive weeks in 2008 at an abattoir in southern Ontario. A total of 395 samples were collected, of which 180 were tonsils from normal carcasses and 215 were from carcasses that were on the hold rail. The samples were identified by the slap tattoo with 264 different farms represented. Microbiological analysis of the tonsils was conducted by the Animal Health Laboratory (AHL) at the University of Guelph. Testing included bacteriological culture and identification as well as testing for PRRSV and for Porcine Circovirus-2 (PCV-2).

## Results

The most commonly isolated bacterial pathogens included: *Streptococcus suis* 53.7%, *Acrinobacterium pyogenes* 29.9%, *Pasteurella multocida* 27.3%, and *Streptococcus porcinus* 19.5%. PRRSV and PCV-2 were identified in 22.0% and 11.9% of the samples respectively. Tonsils were more likely to be positive for *S. suis*, *S. porcinus* and *Staph hyicus* if sampled from the holdrail vs. normal carcasses. However, tonsils that were positive for PRRSV or PCV-2 were no more likely to be from the hold rail than from the normal carcasses. Being PRRSV positive did not increase the odds of the sample being positive for any other bacteria or PCV-2. Tonsils that were positive for PCV-2 were more likely to be positive for *S. porcinus*. However, being positive for PCV-2 did not increase the odds of a sample being positive for any other bacteria or PRRSV.

## Discussion

The slaughter plant and the sampling technique proved to be an efficacious way to collect swine tonsil tissue. Accurate tissue recovery occurred (99.7%), the sampling protocol was not technically challenging, and the personnel at the plant were willing to collect the tonsils during normal plant operations. Tissue collection during the slaughter process was a superior method of tonsil tissue collection compared to reports of ante mortem techniques where only 48.9% of samples were correctly obtained by tonsil biopsy methods.

This study provides information regarding the normal flora of swine tonsils. Documenting what grows normally on tonsils aids in future investigations into potential disease outbreaks as it is difficult to address disease concerns if what is normal isn't properly understood. The benefit of having multiple farms represented at the abattoir is beneficial as it reduces the need to visit multiple farms directly. This study highlights that collecting tonsils at slaughter is an effective way to monitor a large population of hogs from many different sources for disease surveillance purposes.

## Acknowledgements

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Corresponding Author: Dr. Terri O'Sullivan. Department of Population Medicine. University of Guelph. [tosulliv@uoguelph.ca](mailto:tosulliv@uoguelph.ca) Telephone: 519-824-4120 ext 54079 Fax: 519-763-3117

## **Spread of Common Viral Pathogens between Herds in Ontario: Current Knowledge and Future Work**

Zvonimir Poljak\*, Cate Dewey\*, Robert Friendship\*

\*Ontario Veterinary College, University of Guelph, Guelph

### **Introduction**

In the last decade, a variety of swine pathogens and their variants have had a large detrimental impact on many individual farms and on the Ontario swine industry as a whole. Emergence of these pathogens and diseases influenced disease monitoring and control measures in individual swine units. Design and implementation of disease control measures at the level of a region will require some additional tools. This includes use of geographic information systems for management of disease control programs and spatial epidemiological methods to understand disease processes between herds. The primary objective of this work is to present findings related to spread of several viral diseases in Ontario in the last decade. These findings were possible only because geographical coordinates of herds were available to researchers. The secondary objective is to provide an update on some current research that utilizes geographical information in order to inform disease monitoring and management.

### **Data gathering**

Data for this study were obtained using three different mechanisms. Data for swine influenza were obtained using Ontario Swine Sentinel Project and included between 48 and 72 herds in a period between 2001 and 2005. Data for Porcine Circovirus Associated Diseases were obtained using Ontario PRRS Mapping Project between 2006 and 2007 and included 278 herds of interest. Data for biosecurity assessment included 161 sow herds and were collected using the PRRS Risk Assessment questionnaire.

### **Swine influenza**

Swine influenza in Ontario during the study period could clearly be divided into two distinct periods, before and after 2005. Up to 2005, classical swine H1N1 was a dominant type and high herd-level prevalence was found in pig-dense areas. This was particularly evident for sow herds. However, during this time, apparently positive H3N2 sow herds were distributed in areas of low-pig density. Year 2005 was characterized by introduction of H3N2 in a pig dense area.

### **Porcine circovirus associated diseases**

The risk of PCVAD-positivity varied geographically before and after it was adjusted for PRRS positivity of included herds. The risk of PCVAD when the study was concluded was higher in eastern areas of Ontario with a tendency of lower risk in western parts of the province. Herds that were closer than 4.5 kms of distance to herds experiencing the PCVAD outbreak, were under an increased likelihood of experiencing an outbreak for 5 months. However, this association disappeared once the ownership of neighboring sites was taken into account. This illustrates that ownership information should also be routinely recorded (or available) for management and particularly for research purposes.

### **Distribution of biosecurity practices**

Ontario sow herds participating in this project could be divided into three major groups on the basis of biosecurity measures practiced on-site. These groups were tentatively described as high, medium, and closed herds. Herds in these groups clearly differ in their philosophy towards management practices, including biosecurity. Evaluation of spatial distribution could help in prioritizing areas for disease monitoring or disease control (e.g., risk-based surveillance).

### **Implications**

Successful disease control options at the level of areas require regular availability of certain tools and technologies. These tools require collection of standardized information related to site location, time, and ownership structure as a bare minimum. Even with limited data available to us, we were able to gain insight into epidemiology of several diseases that would otherwise not be possible. We are convinced that availability and use of this information will become better in the future and the rapid collection and analysis of these data will be key to the implementation of timely control programs to minimize the impact of the next new disease.

### **Acknowledgements**

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## Plant-to-Plant Differences in DDGS Nutrient Content and Availability

Phil McEwen, Kees de Lange, Ira Mandell and Marko Rudar - University of Guelph  
and Ron Lackey, OMAFRA, Feed Ingredients & Byproducts Feeding Specialist  
519-674-1541, [pmcewen@ridgetownc.uoguelph.ca](mailto:pmcewen@ridgetownc.uoguelph.ca)

### Background:

Many swine producers are now feeding up to 20% corn distillers dried grains with solubles (DDGS) in grower/finisher diets. When properly formulated, diets with DDGS can help reduce feed costs with no adverse effects on growth performance or carcass traits (McEwen and Lackey, 2008). However, for accurate diet formulation, concerns are still present within the swine industry about the variability that can exist in the nutrient content and availability of DDGS. For example, product color (light versus dark color) can vary from batch to batch. Presently product color is often used as an indicator of the feedstuff's available amino acid and energy contents, with a darker colored product often associated with lower nutrient availability for the pig. Therefore, this trial was undertaken to evaluate new methods that can more accurately quantify the quality differences in DDGS from corn based ethanol plants supplying this feedstuff to Ontario swine producers.

### Objectives:

The project is presently evaluating methods of determining the feeding value of DDGS from corn-based ethanol production based on product color, nutritional analyses and different *in vitro* assays. The following objectives are being specifically addressed:

- a) To determine how the feeding value of DDGS (amino acid and energy availability) can be assessed using an objective measure of product color (CIE,  $L^* a^* b^*$  scale), simple nutrient analyses, different *in vitro* digestibility assays, and conventional digestibility studies.
- b) To determine how much variation exists in DDGS color and nutrient content from Ontario, Quebec and neighbouring US ethanol production facilities that supply this co-product to Ontario.
- c) To determine the relationship between color and other measurements of DDGS quality (*in vivo* and *in vitro* measurements of amino acid and energy digestibility).
- d) To examine the protocols of ethanol manufacturing and co-product drying in order to identify the potential factors that contribute to the observed variation in nutrient content and availability for determining overall quality of DDGS for pork production.

### DDGS sample collection and analyses completed:

Seventy-two (12 samples per plant) DDGS samples have been collected from six participating ethanol plants (3 from Ontario, 1 from Quebec, 1 from Michigan and 1 from New York). Each sample (1 kg) was analyzed for dry matter, organic matter, crude protein, ether extract, starch, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent insoluble nitrogen (ADIN) contents. In addition, objective measures of product color were determined on all samples using a Minolta colorimeter with data collected using the CIE,  $L^* a^* b^*$  scale. *In vitro* digestibility values for organic matter, dry matter and crude protein have also been completed with more *in vitro* and *in vivo* analyses scheduled for 2010.

**Results to Date:**

Some significant plant differences for DDGS nutrient content, *in vitro* nutrient digestibility, and colour differences ( $L^*$   $a^*$   $b^*$  scales) are presented in Table 1. These data will be used to examine relationships (correlations) between colour and nutrient analytical and digestibility values. Colour readings were conducted before and after samples were ground through a 1-mm screen using a Thomas-Wiley mill. A more complete and detailed explanation of findings will be available by September 2010 when all of the analyses has been completed.

**Table1. DDGS nutrient content and availability for six participating ethanol plants**

	Location A	Location B	Location C	Location D	Location E	Location F
<b>Nutrient Content (% as fed)</b>						
<b>Dry Matter</b>	87.4 <sup>b</sup>	88.2 <sup>bc</sup>	88.5 <sup>c</sup>	87.6 <sup>b</sup>	88.1 <sup>bc</sup>	86.3 <sup>a</sup>
<b>Crude Protein</b>	26.8 <sup>bc</sup>	28.9 <sup>d</sup>	25.3 <sup>a</sup>	25.2 <sup>a</sup>	27.3 <sup>c</sup>	26.1 <sup>ab</sup>
<b>NDF</b>	29.7 <sup>a</sup>	29.2 <sup>a</sup>	33.8 <sup>c</sup>	33.6 <sup>c</sup>	30.9 <sup>ab</sup>	32.4 <sup>bc</sup>
<b>Fat</b>	9.6 <sup>a</sup>	10.6 <sup>b</sup>	10.1 <sup>ab</sup>	10.1 <sup>ab</sup>	9.7 <sup>a</sup>	9.9 <sup>ab</sup>
<b>Starch</b>	2.2	3.1	3.5	2.5	3.7	2.5
<b>Phosphorus</b>	0.77 <sup>ab</sup>	0.74 <sup>a</sup>	0.76 <sup>ab</sup>	0.79 <sup>b</sup>	0.78 <sup>ab</sup>	0.85 <sup>c</sup>
<b>Sulphur</b>	0.44 <sup>a</sup>	0.84 <sup>c</sup>	0.47 <sup>a</sup>	0.47 <sup>a</sup>	0.65 <sup>b</sup>	0.58 <sup>b</sup>
<b><i>In vitro</i> Nutrient Digestibility (%)</b>						
<b>Dry Matter</b>	62.2 <sup>b</sup>	67.4 <sup>c</sup>	59.5 <sup>a</sup>	61.4 <sup>ab</sup>	61.4 <sup>ab</sup>	62.6 <sup>b</sup>
<b>Crude Protein</b>	80.9 <sup>b</sup>	86.1 <sup>c</sup>	80.7 <sup>b</sup>	77.9 <sup>a</sup>	80.1 <sup>b</sup>	79.9 <sup>b</sup>
<b>Colour Evaluation (CIE, <math>L^*</math> <math>a^*</math> <math>b^*</math> scale) for Unground Samples</b>						
<b>Colour <math>L^*</math></b>	55.4 <sup>bc</sup>	50.2 <sup>a</sup>	57.8 <sup>cd</sup>	59.3 <sup>d</sup>	53.8 <sup>b</sup>	59.3 <sup>d</sup>
<b><math>a^*</math></b>	10.7 <sup>c</sup>	11.0 <sup>c</sup>	9.2 <sup>ab</sup>	8.9 <sup>a</sup>	9.7 <sup>b</sup>	9.2 <sup>ab</sup>
<b><math>b^*</math></b>	48.4 <sup>d</sup>	39.9 <sup>a</sup>	46.2 <sup>bc</sup>	50.0 <sup>d</sup>	44.6 <sup>b</sup>	48.2 <sup>cd</sup>

<sup>a,b,c,d</sup> LS means within row that do not share a common superscript differ significantly ( $p < 0.05$ ).

$L^*$  = lightness of color (0 = black, 100 = white). Higher values for  $a^*$  and  $b^*$  are indicative of increased redness and yellowness, respectively.

**Results and benefits to swine industry:**

Further analyses on the DDGS samples will be completed during the winter of 2010. It is hoped that the results will help develop reliable evaluation guidelines for feed manufacturers and producers to increase the use of DDGS in swine diets.

**Reference:**

McEwen, P. and R. Lackey, 2008. DDGS in Swine Rations. 27<sup>th</sup> Centralia Swine Research Update. Pg 3-4.

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## **Effects of Stage of Transport and Vehicle Design on Deep Core Body Temperature of Market Pigs**

T. Widowski<sup>1</sup>, E. Tamminga<sup>1\*</sup>, R. Bergeron<sup>1</sup>, J. Correa<sup>2</sup>, T. Crowe<sup>3</sup>, C. Dewey<sup>1</sup>,  
L. Faucitano<sup>4</sup>, H. Gonyou<sup>5</sup>, N. Lewis<sup>6</sup>, S. Torrey<sup>4</sup>

<sup>1</sup>University of Guelph <sup>2</sup>Laval University <sup>3</sup>University of Saskatchewan <sup>4</sup>Agriculture and Agri-Food  
Canada <sup>5</sup>Prairie Swine Centre <sup>6</sup>University of Manitoba

email: [twidowsk@uoguelph.ca](mailto:twidowsk@uoguelph.ca)

### **Introduction**

Pigs are exposed to a large number of potential stressors during transport that can contribute to transport losses, compromise meat quality and reduce welfare. Of particular concern is thermal stress. The temperatures that pigs experience inside of trailers depend not only on weather conditions, but also on ventilation rates within the trucks, which can vary with trailer design and location within the trailer. Handling stress may also play a role, with the exercise and excitement of loading adding to the heat load of pigs.

There is considerable variation in transport conditions in Canada, with extremes in weather and haul durations differing across region. In order to tackle the issues important to the Canadian pork industry, a multidisciplinary project led by Harold Gonyou (Prairie Swine Centre) and Luigi Faucitano (AAFC, Quebec) was launched in 2007. Researchers from four provinces have been examining the effects of transport conditions on trailer temperatures, pig behaviour, physiological measures of stress and meat quality. Trials were conducted in the West, with pigs shipped from Saskatoon to Brandon, Manitoba and in the East, with pigs shipped a short distance in Quebec. Both sets of trials included both summer and winter shipments. Results presented here are from the Eastern trials.

### **Objectives**

To determine the effects of vehicle, location within vehicle and stage of transport on the core body temperature of market pigs during a short haul.

### **Methods**

A total of 3,757 crossbred pigs were transported in 6 weekly shipments per season in the Summer (June-July 2007) and in the Winter (February-March 2008) from a commercial grower-finisher unit to a commercial slaughter plant located near Montreal. Each week, two types of transport vehicles were used: a triple-deck pot-belly (PB) tractor-trailer and a 10-wheel double-deck hydraulic truck (10W). The PB trailer held a total of 228 pigs in 10 compartments; internal ramps led to four compartments on the upper deck and to two compartments in the belly of the trailer. The 10W held a total of 85 pigs in four compartments with no internal ramps; pigs were loaded straight onto the floor of the two upper compartments, a hydraulic lift raised the upper deck and then pigs were loaded straight onto the lower deck. The PB was always loaded first. Both trucks left the farm simultaneously and traveled ~ 1 hr 51 min to the plant. After a 10 min wait at the plant the PB was unloaded first. Pigs were lairaged for ~ 1 h 55 m before slaughter.

Each week 3-5 pigs from each of the different compartments were orally administered Thermocron iButton temperature loggers (Dallas Semiconductor, TX, USA). The data loggers recorded the core body temperature (CBT) from the intestinal tract of pigs once each minute for entire the duration of loading, transport and lairage. The data loggers were harvested from the intestinal tracts after slaughter. Data were divided into the 5 stages of transport corresponding to the actual events for each



pig: **Resting** prior to loading, **Waiting at the Farm** between loading and departure, **Transport** between departure and arrival at the plant, **Waiting at the Plant** between arrival and unloading and **Lairage** between unloading and 5 min prior to stunning.

## Results

During the Winter, there were no differences between vehicles, overall or within stage of transport. CBT decreased during transport in both trucks and was significantly lower during Waiting at the Plant and Lairage than during Resting and Waiting at the Farm ( $P < 0.05$ ).

During the Summer, there was a significant interaction between vehicle and stage of transport (Figure 1). CBT was higher in the PB than in the 10W during Waiting at the Farm ( $P < 0.05$ ), but this effect reversed during Transport ( $P < 0.05$ ). Pigs in the PB always waited at the farm for a longer duration of time when the 10W was being loaded. However, once the vehicles were in motion, pigs appear to be cooled more rapidly in the PB than in the 10W. After arrival at the plant, mean CBT was lower than pre-shipping values and was similar for both vehicles.

There were also significant differences among compartments within the vehicles during some stages of transport. In the summer, mean CBT in the top-front and top-rear (dog-house) compartments in the PB during Waiting at the Farm was higher than in all other compartments ( $P < 0.05$ ). These compartments were always the first to be loaded and required that pigs climb a ramp during loading. During transport, CBT in these compartments decreased significantly, and by the time the vehicle arrived at the plant the mean CBT in the rear-most compartment of the middle deck was higher than all other compartments ( $P < 0.05$ ).

Our data indicate that during periods of waiting, the core body temperature of pigs can increase significantly. Our results also suggest that heat loads and air flow patterns may vary considerably for different vehicle designs and also for different locations within a vehicle, leading to significant variation in the thermal status of pigs when the vehicles are in motion.

## Acknowledgements

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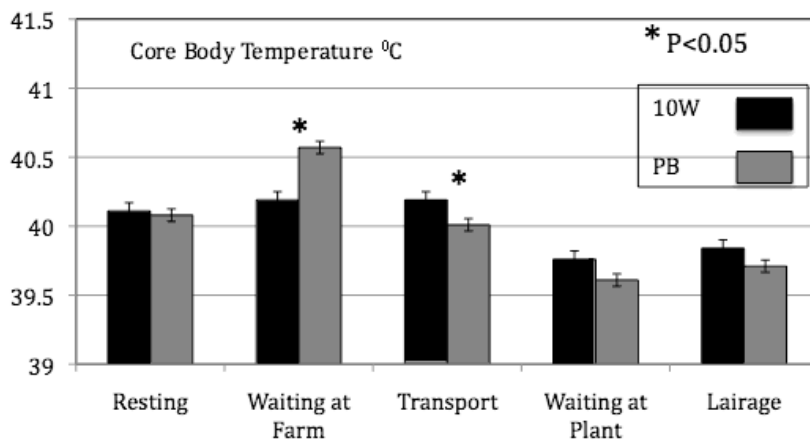


Figure 1. Mean CBT (°C) in each vehicle during each stage of transport during the Summer.

## Pain Relief in Pigs

Dr. Derek Haley

Department of Population Medicine, Ontario Veterinary College, University of Guelph

E-mail: [dhaley@uoguelph.ca](mailto:dhaley@uoguelph.ca), Telephone: 519-824-4120 \*53677

Pain and injury in pig production systems can happen by accident or as the result of something specific that we do to the animal, such as the way we house it, or particular management practices that we impose on the animals. Pain has a sensory component, but also an emotional component, and based on comparative anatomy, physiology and behaviour it is assumed that animal pain is similar to that in humans. At this point in time there is difficulty in precisely decoding the emotional component of pain in humans, let alone in other animals and so at present it is not easy to assess *how* painful something is. Regardless, there is strong evidence about the aversive nature of pain, which leads us to consider this topic as something of concern to the well-being of the pigs in our care. Rather than presenting the results of a specific research trial, this presentation will offer a brief overview of the subject of pain and what we might do to provide pain relief in pigs.

Although the adage of ‘short-term pain for long-term gain’ perhaps best summarizes our approach to the issue of pain in pig production, and animal agriculture in general, the rise in profile of animal welfare gives us cause to re-evaluate this subject area. With more science-based studies focusing on this topic there are now better ways of assessing pain in animals, and we are now faced with more evidence about the perception of pain by neonates, which we once thought were probably less sensitive to pain.

Work by Prunier et al. (2005) used physiological measures of stress as an indicator of pain and found that 30 minutes post-procedure piglets castrated at 7-8 days of age had blood cortisol levels that were roughly 6 times higher than those piglets that were sham treated (handled for the same amount of time, and in the same way, but not castrated). These authors also found that blood cortisol levels did return to baseline levels 3 hours after castration.

Hay et al. (2003) looked at the effects of castration on the behaviour of piglets and found that suckling and udder massaging behaviour of piglets was significantly affected during the first few hours after castration. Similarly they found that compared to sham treated animals, castrated piglets spent more time trembling during the first 2.5 hours after the procedure. Although there were no significant behavioural differences detected 24 h after the procedure, a lack of observations during the interim period means that we do not know for how long during that 24-h period, behavioural indicators may persist.

Whether they experience pain differently than adult pigs or not, providing pain relief to piglets is probably an area where we should tread lightly. After all, it seems that the young of any species have a special place in the hearts and minds of consumers, and so should be given special consideration. Also we must be cognisant of the fact that compared with pigs of other age classes, piglets probably experience more pain because of things that we intentionally *do* to them. In particular we should consider that piglets have their tails docked, teeth clipped and, in addition, that male piglets are castrated without the use of analgesic drugs. Marx et al. (2003) have shown that following castration, vocalizations by piglets that are indicative of pain are reduced by the use of anesthesia.

Setting aside the economic issue of providing pain relief for piglets in particular, perhaps the key remaining issue of providing pain relief for piglets is primarily a logistical one. Any drug

administered would require some time to take effect, which would, it seems, necessitate catching and handling the piglets twice – once to administer the drug, and once again some time later, to perform the management procedures. Colleagues at the Western College of Veterinary Medicine at the University of Saskatchewan have started some investigation into a novel method to possibly provide pain relief to piglets.

Drs Joe Stookey and Alex Livingston combined their respective expertise in farm animal behaviour and biomedical science to begin exploring the possibility of delivering pain relief to piglets via the sow. The underlying principle being investigated was whether drugs administered to the sow could be delivered to the piglets through the dam's milk at subsequent suckling. Their preliminary studies have examined attempts to deliver the non-steroidal anti-inflammatory drug Ketaprofen via the sow, and the work is ongoing and seeking more funding in order to be completed.

The evidence to date suggests that castration at any age is painful and that anesthesia can help to reduce the behavioural signs of post-operative pain. The question remains, as is often the case, how we might administer pain relief in a way that is practical for implementation in day-to-day pig production.

Acknowledgement: Thank-you to Dr Tina Widowski (Animal and Poultry Science, University of Guelph), Dr Joe Stookey (Western College of Veterinary Medicine at the University of Saskatchewan), and Penny Lawlis (Ontario Ministry of Agriculture, Food and Rural Affairs) for information they provided to me, for this presentation.

## Pig Trace Canada - An Update on National Swine Traceability in Canada

Clare Schlegel  
Chair, National Working Group

Swine traceability in Canada has been evolving since 2002 in Canada. Canada has actually identified hogs from the last farm to the processing plant using slap tattoos since the 1950's, so the system is being enhanced, rather than traceability just starting.

During the time period between 2002 and 2004, a major study was done with the support of Agriculture Canada to determine such things as ID of swine during movements between farms and to packing plants, researching various individual ID systems, including RFID, tags, tattoos etc. As well, group lot ID systems, rather than individual ID were investigated. The conclusion was that Canada should move towards a premises based ( monitoring movements), group lot ID system for the majority of movements, and only require individual ID for animals that move where pigs are "co-mingled or heading to destinations unknown". This means pigs going to fairs etc. need individual ID. As well, it was decided supported by government through CFIA that the Canadian sow herd should be individually identified with the standard Canadian tag.

These decisions all meet international standards. CFIA believes they will aid Canadian authorities to defend the Canadian heard in the event of a major disease outbreak. It is a balance between robustness and cost effectiveness.

The system is also being designed that stakeholders who contribute information will have access to their information for marketing and management purposes. This is different then a government only system that strictly build for disease mitigation purposes.

### What are the basics of the system?

- 1) The system is **premise based**. Every "swine" premise in Canada will have its own unique number. Land is the responsibility of the provinces within the Canadian constitution. Numbers were distributed to stakeholders throughout most of Canada in 2006-07. Greater then 90% of the premises are identified within Canada
- 2) The system **tracks the movement of livestock from one premise to another**. An example is from the farrowing barn to the nursery barn, or from the finishing barn to the processing plant. For many single site farms, this will require no change, except that farmers will need to make sure that the movement to market is reported to the database. One of the requirements will be that these movements be reported within 48 hours. For many multiple site operations, this will require a reporting event that currently does not happen to anyone, except for their own farm records. Tracking movements is set to begin with pilot systems early this year, with hopefully the system being available to early adopters in the summer/fall of 2010 and then be generally available after that.
- 3) The ID of the pigs for the system will be combination of both **group/lot ID numbers and individual IDs** through the "National tag". National tags have been available since September of 2009. All sow herds in Canada are encouraged to use the national tag. The national tag has both the unique national number as well as space for the use of a management number. The tag also includes the national logo. It is yellow in colour and available in both trapezoid or rectangular shape.

Most pigs moving in Canada will be identified as a group, rather than individually. The system will generate a number for each group moved. This part of the program will be implemented as part of the movement implementation mentioned above except for market hogs currently moving to the processing plant. Each of the provincial boards and the western packers are cooperating currently provincial and the information will flow to the national database hopefully starting in the next months.

- 4) The system will require **reporting to the national database**. This makes this system unique and sets Canada apart from the US system. It is also rather invasive in the sense that a lot of information is reported and stored. We believe this will work well, but will have to monitor to make sure it can be done cost effectively. Movements are required to be reported within 48 hours. There is technology available similar to what is currently used by couriers that will make this requirement easier and more efficient.

### **Additional Principles of the system**

- 1) Multi-use: It is thought that this system should not only give traceback in the case of a disease but also that it should be available for industry stakeholders to use for other purposes such as market segmentation or branding. Each stakeholder will have the ability to release their information.
- 2) Continuous Improvement: It is believed that we have planned well, but also realized that much will be learned as the system is implemented. Already, it was evident that some farms require a 6 digit management number on the national tag instead of a 4 digit number. We commit to at least semi-annual improvement changes.
- 3) Efficient yet cost effective: While the most robust system with a 100% accuracy is desired, it must not be cost prohibitive. We know that government is providing funding to help build the system, but in the longer run, some of the costs will be born by industry.
- 4) Phased in Implementation: This means that we will be aiming to capture the majority of the movements in the system at the start and then talking about difficult movements to track in subsequent years.

### **Barriers to Complete Implementation**

Canada is not unique. Many other countries are implementing systems and the barriers are similar.

- 1) Privacy of Information: Firms are concerned that the information collected will be used for unintended purposes or available to undesired parties
- 2) Ownership of the Program: Is this a government program or an industry program? This requires a partnership between them that in most cases has never before been tried in any program.
- 3) Who pays: both to build to system, but also to implement and do. What about the additional costs required (example-48 hour reporting). Inevitably, this becomes a discussion about whether the system is being implemented to protect the public good or to aid in profit for the private sector.
- 4) Commitment: Just because a producer or industry participant is told they should participate because it is the right thing to do, does not translate into daily participation in the program, and because the producer will get paid for their hogs anyway, there is little financial incentive to participate accurately and fully.

The Canadian swine traceability system is well on its way to being fully implemented. However, there are obstacles and details to be worked out over the next few years. Premises are identified within Canada, each one has been assigned a unique tattoo number under the national tattoo program. The national database is currently being build and populated. Swine slaughter information will be put in within the next months. The national tags are available and encouraged. And over the next year or two, movement monitoring and reporting will be phased in.

At its conclusion Canada will have one of the best systems in the world.

## Clean Water Act/Source Protection Planning Process Status Report

Chris Attema, Environmental Policy, Ontario Livestock Group, Guelph  
Sam Bradshaw, Environmental Communications Specialist, Ontario Pork

The passage of the Clean Water Act on October 19, 2006 has set a 6-Step, Source Water Protection planning process in motion. The Clean Water Act is enabling legislation. Additional Regulations, Guidance Documents and Directors Rules continue to be developed and released as the process moves forward.

<b>Clean Water Act Legislation</b>	October 19, 2006. 3 <sup>rd</sup> Reading and Royal Assent
<b>1. First phase of Regulations Released</b>	July 3, 2007
<b>2. Formation of Source Protection Committees</b>	Completed by December 2007
<b>3. Local Committee Terms of Reference</b> <ul style="list-style-type: none"> <li>Rules of Operation</li> <li>List of drinking water systems</li> <li>Work plan for the Assessment and the Source Protection Plan Reports</li> </ul>	Completed Terms of Reference submitted to the Ministry of Environment by Aug-September 2008
<b>4. Local Assessment Report</b> <ul style="list-style-type: none"> <li>Completion of groundwater and surface water vulnerability analysis (How much land and where?)</li> <li>Complete a Hazard Assessment for existing and future drinking water Threats</li> </ul>	<b>Anticipated Timeline : Spring 2010</b> 5 of the 36 Draft Assessment Reports currently posted on the Conservation Ontario website (January 13/10) <a href="http://www.conservation-ontario.on.ca">http://www.conservation-ontario.on.ca</a>
<b>5. Local Source Protection Report</b> <ul style="list-style-type: none"> <li>Develop policies to address activities that are or could be a significant drinking water threat (What additional restrictions for livestock agriculture?)</li> </ul>	<b>Anticipated Timeline : 2011-2012</b> Source Protection Plans approved for implementation
<b>6. Implementation &amp; Enforcement of Approved Source Protection Plans</b>	<b>Anticipated Timeline: Beyond 2010-2012</b> Municipalities will be responsible for the implementation & enforcement of Approved Source Protection Plans

An approved Source Protection Plan may contain policies which restrict or limit certain activities on for activities identified as a 'significant drinking water threat' in designated wellhead protection and surface water intake zones. The scope and power of the Source Water Protection Plan could result in restrictions on normal farm practices and additional production cost for livestock agriculture. Policy options to be considered by the Source Protection Committees include softer tools like education, outreach and incentives to more stringent tools like requiring risk management plans and prohibition of certain activities. Livestock organizations continue to lobby for fair compensation, regulatory impact analysis and selection of the most cost effective policy actions in order to appropriately manage identified 'significant drinking water threats.'

### Synopsis of Current Situation

1. The Assessment Report will assign vulnerability score the Wellhead and Intake Protection zones. Activities will be labeled as a 'significant drinking water threat' if the rating is 80 or higher based on the following formula. [Vulnerability Score x Activity Score]. Most livestock related activities are assigned an "Activity Score" of '10' and will be labeled as a 'significant drinking water threat' in areas with a vulnerability score of '8' or higher.
2. The anticipated impact is directly related to the location of the municipal water intake. The impacted area is likely to be relatively small [10 -200 acres] in areas with properly located wells [confined aquifer] and properly located Great Lake intakes. In areas with a) wells located in vulnerable "Ground Water Under Direct Influence of Surface Water" [GUDI] areas and b) surface intakes from non-Great Lake water supplies the area with a vulnerability score of '8' or higher could be several hundred to several thousand acres. These details will only be available after the release of the local Assessment Reports.

The attached Table is a summary of all 'significant threats' identified in the Ausable-Bayfield-Maitland Source Protection Region (Brucefield, Carriage Lane, Clinton, Harbour Lights, SAM, Seaforth, WadeWetering, Zurich)

#### All\* WHPAs: Enumeration of Potential Significant Threats

Threat (numbered according to Clean Water Act, 2006)	Significant Instances		
	Chemicals	Pathogens	DNAPL
1. Waste Disposal Site	57	1	
2. Sewage System		166	
3. Agricultural Source Material Application	10	1	
4. Agricultural Source Material Storage	3	3	
5. Agricultural Source Material Management	3	3	
6. Non- Agricultural Source Material Application	10	1	
7. Non- Agricultural Source Material Handling/Storage	3	2	
8. Commercial Fertilizer Application	12		
9. Commercial Fertilizer Handling/Storage	1		
10. Pesticide Application	1		
11. Pesticide Handling/Storage	12		
12. Road Salt Application			
13. Road Salt Handling/Storage			
14. Snow Storage			
15. Fuel Handling/Storage	154		
16. Dense Non-Aqueous Phase Liquid handling/Storage			1921
17. Organic Solvent Handling/Storage			
21. Grazing/Pasturing Livestock	3	3	
<b>Total:</b>	<b>269</b>	<b>180</b>	<b>1921</b>

3. It is unlikely that agricultural lobby efforts will significantly alter the vulnerability scores assigned by the respective Assessment Reports.
4. The livestock group focus continues to be on influencing the development of policies for 'significant', 'moderate' and 'low' drinking water threats. Principle 5 remains the key and consistent message.

#### PRINCIPLE 5 - NO COMPETITIVE DISADVANTAGE

Business owners inside designated municipal drinking water protection zones should not be placed at a competitive disadvantage

**Source Protection Plans under the Clean Water Act, 2006: A Discussion Paper on Requirements for the Content and Preparation of Source Protection Plans.**

[EBR Registry 010-6726]. This “Discussion Paper” suggests that municipally controlled “Land Use Planning Approaches” could apply to “moderate” and “low” threat situations. Livestock agriculture activities could be classified as a moderate to low threat over very large areas. The livestock group position is that additional municipal authority over-and-above normal Provincial Nutrient Management Act requirements is not necessary or warranted in “moderate” and “low” threat situations.





## **University of Guelph/OMAFRA Partnership Pork Research Program Projects**

Bob Friendship  
Pork Research Coordinator, University of Guelph  
[rfriends@uoguelph.ca](mailto:rfriends@uoguelph.ca) (519 824-4120 ext 54022)

Under the present arrangement swine related research can be included under a number of themes and there is not a distinct pork research program. However it needs to be clearly stated that the amount of pork research at the University of Guelph has not decreased because of the restructuring but it is possibly harder to find. There is a 2009 swine research review posted at <http://www.uoguelph.ca/~ovcswine> which includes a large number of one-page summaries of on-going work.

The University of Guelph/OMAFRA partnership research program is organized under the following themes: [Agricultural and Rural Policy](#); [Bioeconomy - Industrial Uses](#); [Emergency Management](#); [Environmental Sustainability](#); [Food for Health](#); [Product Development and Enhancement through Value Chains](#); and [Production Systems](#). Most of the traditional swine work can be found under the Production Systems and Dr Kees deLange is the director of this theme. There are 3 major projects under this heading that have been operating for the past 4 years involving about 30 faculty members. As these projects are wrapping up this year, new projects have or will be starting.

Details regarding the structure of this research program can be obtained by going to the following website: <http://www.uoguelph.ca/research/omafra/> where there is contact information for the University research directors and their OMAFRA counterparts. One important change that has been included in the recent University of Guelph-OMAFRA partnership agreement is for funds to be assigned for what is being called “knowledge translation and transfer” which could presumably be used to make access to the research conducted at Guelph and Ridgetown easier and more timely.

One reason that pork researchers at the University of Guelph have been highly successful in securing UofG-OMAFRA research partnership funds as well as other government support has been that the Ontario pork industry has strongly supported research through generous funding and keen participation. This support will be even more important in the coming years.

## Ontario Pork Research

Jean Howden, Ontario Pork

In 2009, as in previous years, Ontario Pork's research expenditures have focused on production. Included below is a brief synopsis of projects that received funding from Ontario Pork in 2009.

Moving forward in 2010, the plan is to develop a more balanced approach to research that will correspond with the strategic direction of Ontario Pork while maximizing value for producer dollars. Research funding will include new areas such as product and marketing development. Work is also continuing to improve research efforts with other provincial organizations and nationally.

Research is an industry cornerstone that requires continual development and refinement to create growth and improvement. Research funded in 2009 and prior has established a foundation that will be built upon.

### Production Priority

### Animal Welfare

<b>Project No.</b>	09/08	<b>Researcher</b>	Harold Gonyou
<b>Title</b>	Effects of handling procedures at loading and of the transport vehicle design on the welfare of meat quality of pigs		
<b>Synopsis</b>	This is a collaborative project involving multiple research groups in major pork producing provinces focusing on handling stress and transport conditions on trucks, their effects on animal welfare and pork quality. Alternative methods of handling and transport design will be developed and assessed.		

<b>Project No.</b>	09/05	<b>Researcher</b>	Glen Cassar
<b>Title</b>	Effect of pain relief at piglet castration and farrowing on welfare and performance of piglets		
<b>Synopsis</b>	<p>The objectives of the research are:</p> <p>To evaluate whether analgesia at piglet castration will result in better welfare or less pain, and whether these treatments will provide any positive benefits to the producer in the form of improved weight gain or reduced mortality.</p> <p>To evaluate the effect of analgesia at farrowing on sow discomfort as well as piglet mortality and performance.</p>		

### Production Priority

### Environment

<b>Project No.</b>	09/024	<b>Researcher</b>	Art Schaafsma
<b>Title</b>	Development of an integrated mycotoxin management system in Ontario grains		
<b>Synopsis</b>	<p>This project stress the importance of preventive measures to manage mycotoxin contamination in corn. The risk management system includes: 1) Evaluation of the contamination process through surveillance 2) Investigation of practical and innovative analytical methods to improve the accuracy of mycotoxin determination using near infrared for DON and liquid chromatography techniques for multitoxin detection; 3) Evaluation of the sensitivity of commercial corn hybrids to Fusarium infection or mycotoxin accumulation for risk reduction purposes; and 4) Evaluation of early warning forecasting systems and fungicide management tools to control Fusarium infection and/or mycotoxins accumulation in corn and wheat field trials.</p>		

<b>Project No.</b>	09/023	<b>Researcher</b>	Ming Fan
<b>Title</b>	Determination of Optimal True Digestible Calcium to Phosphorus Ration in Grower-Finishing Pigs for Improving Feed Efficiency and Maximizing Phosphorous Excretion		

**Synopsis** This project is to address the following specific objectives in developing a practical low-Phosphorus (P) and low - Calcium (Ca) hog-feeding regime based on formulation of diets on the basis of true digestible P and Ca supply. The major objectives are to: 1) Determine optimal true digestible Ca to P values; 2) and examine the effect of changing Ca to P ratio on growth performance and efficiency of Nitrogen (N) and P utilization as well as manure N and P excretion in growing-finishing pigs fed corn and soybean meal based diets.

**Production Priority****Herd Health**

**Project No.** 09/015      **Researcher** Zvonimir Poljak

**Title** Epidemiological and cost/benefit analysis of PRRS intervention strategies

**Synopsis** The proposed project is continuation of a PRRS interventions cost/benefit project undertaken in cooperation with the Ontario Swine Health Advisory Board (OSHAB). Computer records from the sow herds are made available by veterinary clinics and after producers agreed to participate in the project. Data is extracted from a database and processed in statistical software to determine duration of outbreak and production losses during outbreak, as well as production before and after outbreak. Questionnaire is filled by veterinarians to provide diagnostic information pre- and during outbreak, and costs that were associated with intervention. After processing data, relative change in number of pigs weaned per week and cost per sow is determined. Epidemiological analysis will be performed using simple descriptive statistics and economic analysis. This additional data will enhance the reliability of the information already obtained.

**Project No.** 09/014      **Researcher** Bruce Wilkie

**Title** Enhancement of Immune Response in Piglets

**Synopsis** This research will test heat-killed bacteria, bacterial products and probiotic bacteria as positive immune response (IR) modulators for piglets ultimately to enhance health and productivity

**Project No.** 09/010      **Researcher** Robert Friendship

**Title** Disease Surveillance Using Farm-Based Mortality Data

**Synopsis** Randomly selected pork producers will submit mortality numbers on a weekly basis as well as report disease problems. The mean and range of mortality for each stage of production will be monitored over a one year period. Associations with management facility design and geographical location will be analyzed. The value of using farm level data compared to veterinary clinic activity or submissions to a diagnostic lab will be assessed

**Production Priority****Nutrition**

**Project No.** 09/028      **Researcher** Julang Li

**Title** EGF expressing *Lactococcus lactis* for enhancing health, well-being and productivity of early-weaned pigs

**Synopsis** With past support from Ontario Pork, NSERC and Agriculture and Agri-Food Canada, the researcher has generated epidermal growth factor (EGF) expressing *Lactococcus Lactis* via a bio-engineering approach. In early-weaned mice, oral delivery of these recombinant food grade bacterium stimulated intestine development, and increased the body weight. This research tests the hypothesis that locally delivered EGF to the digestive tract using food-grade EGF expressing *Lactococcus Lactis* will be beneficial for improving early-weaned piglet performance. In addition, the research will also further manipulate the

bacteria so that they will be unable to survive after they are expelled from the animals, and thus eliminating the risk of transgenic bacterial contamination to the environment.

<b>Project No.</b>	09/027	<b>Researcher</b>	Laima Kott
<b>Title</b>	Development of Fusarium resistant corn inbreds for pork production		
<b>Synopsis</b>	The objective of this research is to develop an efficient protocol to produce Fusarium resistant corn inbreds. The project entails use of pollen grains that are induced to develop as embryos and plants. During this process pollen is exposed to a UV mutagen to produce minor genetic changes, and subsequently in vitro Fusarium resistant corn genotypes are identified.		
<b>Project No.</b>	09/025	<b>Researcher</b>	C.F.M. de Lange
<b>Title</b>	Impact of reduced starter pig growth performance, induced by feeding antibiotic free or inexpensive diets, on subsequent growth performance and carcass quality		
<b>Synopsis</b>	The main objective is to investigate the effect of growth rate during the starter phase - as affected by diet quality (low versus high quality and cost) and/or high versus low usage of in-feed antibiotics - on subsequent growth performance of pigs up to market weight. A secondary objective is to explore potential indicators (bio-markers) of health status, immune function and growth performance (i.e. cytokines, hormones, expression of genes regulating nutrient use, growth and immune function) to assess and predict the impact of external stressors on growth performance during both the starter and growing-finishing phase		
<b>Project No.</b>	09/021	<b>Researcher</b>	Ron Ball
<b>Title</b>	Determination of sow amino acid requirements using the indicator amino acid oxidation method		
<b>Synopsis</b>	This research is to determine the Dietary Net Energy for sows. It will also determine the amino acid requirements and availability in gestation and lactation. Better Dietary Net Energy and Amino Acid requirements could lead to lower dietary protein requirements which allows for valuation of alternative feedstuffs and reduced feed costs.		

## Update on U.S. Country-of-Origin Labelling (COOL)

Canadian Pork Council

After several delays, U.S. mandatory country of origin labelling legislation, first passed in the 2002 Farm Bill, went into effect in the fall of 2008.

The major developments of the past year have been the publication of the final COOL rule and the launching of separate WTO dispute panels by Canada and Mexico against the United States on COOL.

### **Final Rule:**

Early in 2009, U.S. Agriculture Secretary Tom Vilsack, shortly after the installation of the new Obama administration, announced the Final Rule that had been published in January would go into effect as planned on March 16.

This would have been welcome news for the Canadian livestock and meat industry, as the Final Rule contained the additional flexibility which Canada had sought to permit use of the label “Product of the United States and Canada” when meat products are derived from both U.S.-origin hogs and Canadian hogs raised in the U.S., so long as the animals are commingled in a single production day. This would have provided U.S. processors the flexibility to continue sourcing Canadian hogs raised in the U.S and imported for immediate slaughter.

Unfortunately, Secretary Vilsack largely eliminated U.S. packer interest in this flexibility by requesting that processors “voluntarily” include additional information about what production step occurred in each country when multiple countries appear on a label.

While there have been no further regulatory actions to make COOL more onerous, as had been suggested in his remarks earlier in the year, the Secretary's suggestions created enough uncertainty in the market that many U.S. processors withdrew entirely from purchasing Canadian born pigs, both ones finished in Canada and the United States. The CPC believes COOL has had a very significant negative impact on Canadian livestock producers.

### **WTO Challenge:**

The Government of Canada also believes mandatory COOL has had a negative impact and initiated the WTO dispute settlement process by requesting formal consultations with the United States, as did Mexico, an important supplier of feeder cattle to the Texas beef industry.

Consultations were held with the U.S. and failed to arrive at a solution that would avoid a formal dispute settlement. On October 23, 2009, Canada requested the establishment of a WTO panel at the WTO Dispute Settlement Body. The United States exercised its right under the WTO procedures and blocked the first request.

Then on November 19<sup>th</sup>, Canada made a second request for the establishment of a panel, which the United States was unable to block and at which time a panel was established. They are in the process of selecting panel members at this time.

It has been agreed that a single panel be established to hear the cases of both Canada and Mexico and that the panel will be open to the public (except for business confidential information).

The following Members have reserved their third party rights: Australia, Argentina, Brazil, China, Chinese Taipei, Colombia, the EU, Guatemala, India, Japan, Korea, New Zealand and Peru.

The date of first submissions and hearings will be outlined in the terms of reference that will accompany announcement of the panel. The first submission could be due as early as three weeks after the panellists have been selected with the panel report in late summer or early fall in 2010.

While the potential exists for either side to appeal the panel results, such that a final result could be some months later than when the panel result comes down this fall, there is a binding obligation on the WTO member countries to actually implement the results.

*Prepared for the Centralia Swine Research Update by the Canadian Pork Council with the assistance of officials at Agriculture and Agri-Food Canada. January 11, 2010*

## 2009 Update on the Development of an Integrated Mycotoxin Management System in Ontario Corn

Schaafsma\*, A.W., V. Limay-Rios

University of Guelph, Ridgetown Campus, Ridgetown, Ontario. N0P2C)

\*[aschaafs@ridgetownc.uoguelph.ca](mailto:aschaafs@ridgetownc.uoguelph.ca) 519-674-1505

In 1996 Ontario experienced the worst *Fusarium* epidemic in recent history in wheat. This event precipitated a gathering of industry stakeholders including: producers, grain handlers, millers, crop protection experts, breeders, federal and provincial government representatives and academia to design strategies to collectively prevent further harm to the sector. The stakeholders supported and developed an integrated management system to diminish the effect of mycotoxins during future epidemics. In 13 years this strategy has yielded significant progress on: breeding for more tolerant varieties, an improved variety registration system, implementing fungicide recommendations and improving application technologies, developing a pre-harvest forecasting system (DON-Cast) as well as setting up surveillance strategies and mycotoxin testing.

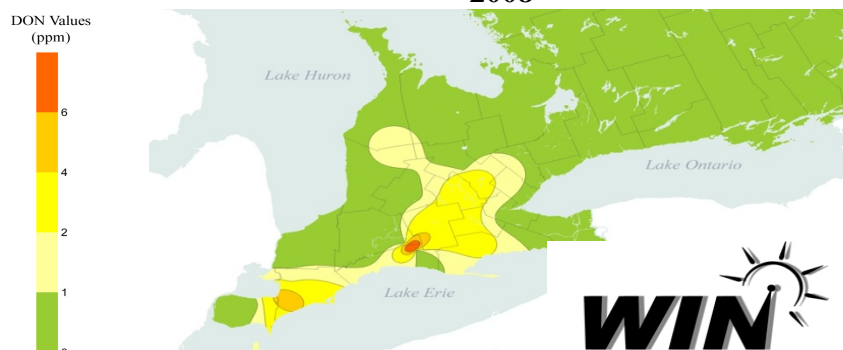
In contrast, more than 20 years have passed since the first severe epidemic of *Fusarium* in Ontario corn in 1986 and very little progress has been achieved toward the development of an integrated approach as was seen in the severe epidemic of 2006 in corn. This report is a compilation of data from our first year of monitoring and study of strategies for prevention, control and surveillance of mycotoxins in corn in order to mitigate mycotoxin contamination in *Fusarium* epidemic years. This report also provides an overview of the studies being conducted in the areas of in-crop surveillance, weather based forecasting, hybrid selection, fungicide application and analytical support in the current cropping season.

In this project, Hazard Analysis Critical Control Points (HACCP) was used as reference method to develop an integrated mycotoxin management system in Ontario. These critical points, identified based on the data analysis from the 2006 epidemic, include: crop surveillance, analytical support, weather based forecasting, hybrid selection and fungicide application. The following are the conclusions and the recommendations related to each control point:

### Crop Surveillance:

In 2008, a total of 100 corn samples were collected randomly at harvest from across the corn growing region of southern and eastern Ontario. Deoxynivalenol (also known DON or vomitoxin) contamination was predominant in the Lake Erie north shore area (Fig 1). A database is currently under development to incorporate surveillance data within the initial research phase.

**Figure 1, Variation of DON concentration in corn samples from across southern Ontario in 2008**





**Weather based forecasting:**

Our first attempt to develop a pre-harvest forecast system to predict DON was carried out during the 2006 *Gibberella* outbreak in corn. The difference found between the predicted and actual forecast values for DON in 2006 was explained by the distribution of hybrids with different degrees of sensitivity to *F. graminearum* infection and/or mycotoxin accumulation. Data obtained during the current cropping season will be used to correlate weather information with various stages of the corn crop development to determine which stage is most susceptible and which stage shows the highest correlation to the final production of DON (measured at harvest) across a series of corn hybrid types. Furthermore, levels of disease control by fungicides tested, corn hybrids, tillage and crop rotation practices in the years prior to planting corn will be incorporated into the regression analysis.

**Analytical support:**

Near Infrared technology shows promising results to predict the percentage of *Fusarium* damaged kernels in corn samples. However, using ELISA as a reference method, the model was not very accurate when predicting DON concentrations for whole and ground grains. The analysis error for ELISA was  $\pm 2$  ppm which exceeded the limits established in the calibration process ( $\pm 0.5$  ppm). In order to overcome some of the drawbacks associated with the ELISA method, liquid chromatography mass spectrometry (LC-MS) is currently used in this project as the reference analytical method. LC-MS quantification gave superior precision values. DON recovery levels (78%) are comparable to other LC-MS methods reported. In this experiment mass identical 3-AcetylDON and 15-AcetylADON isomers could not be separated. To resolve this limitation, a polar-RP C18 column was used to separate the two isomers by a ternary gradient with water, methanol and acetonitrile. This system was able to chromatographically separate 3-AcetylDON and 15-AcetylDON. Recovery experiments are underway at the Food Research Program Laboratory of Agriculture and Agri-Food Canada in Guelph.

**Hybrid selection:**

In 2008 high infection rates in corn ears were achieved through late planting, inoculation at silk browning when ears are most susceptible to infection, followed by application of an overhead mist irrigation system. Valuable information confirms the feasibility to evaluate large numbers of commercial hybrids through a controlled environmental screening program on campus. Using this methodology, a total of 55 advanced and commercial hybrids are being evaluated in the current cropping season.

**Fungicide application:**

A new generation of triazoles, including prothioconazole and metconazole were evaluated for their ability to reduce DON contamination levels under strong pathogen pressure under a misting trial and on farm scale application. Up to 60% toxin reduction was observed in inoculated corn ears under misting irrigation. Up to 50% reduction was observed in on-farm trials using a high clearance sprayer equipped with flat fan drop nozzles. Multi-year data needs to be collected to confirm these results. In the current cropping season the influence of spray volume and nozzle configuration, and the interaction of corn hybrids, fungicide application and DON levels are being studied in three and two commercial fields, respectively. The timing of fungicide applications on the efficacy of these treatments for control of *Fusarium* infection/DON accumulation is being studied under inoculated and artificially irrigated plots.

## Potential Application of Genomics for the Canadian Swine Industry

Mohsen Jafarikia, Laurence Maignel, Brian Sullivan, Stefanie Wyss  
 Canadian Centre for Swine Improvement  
 Central Experimental Farm, Building #54, 960 Carling Ave, Ottawa, ON, K1A 0C6

### Background

During the 1990s, application of genetic markers for use in animal breeding programs began and is now growing rapidly. One early example of this has been the widespread use of the Halothane gene test developed by researchers at the Universities of Guelph and Toronto. Much of the early focus has been on single genes having a large effect, such as the Halothane gene, where the benefit would be universal from selecting for one favorable type of the gene (or conversely against an unfavorable type). However, in practice there have been relatively few success stories like Halothane in any of the livestock species. Often the tests haven't been broadly applied in the field or attempts to apply them have shown inconsistent results. Nevertheless, more and more markers are being discovered and there is an increasingly better understanding of livestock genomics. In fact, there are thousands of genetic markers available for different species of domestic animals. Moreover, there has been a rapid transition to make use of panels of genetic markers rather than focusing on individual genes. The very recent sequencing of the pig genome has opened the door to tremendous opportunities for new approaches and discoveries. Researchers are now working with a commercially available porcine test for over 64,000 genetic markers (60K SNP panel) and we can expect to see practical applications developing rapidly in the coming years.

### Genetic Markers for Individual Genes

For a genetic marker to be useful, the targeted gene firstly needs to have adequate variability in the population of interest, and secondly the gene must have a significant effect on a trait of economic importance. The Canadian Centre for Swine Improvement has been assessing the variability and effects of some important major genes in the last few years (Jafarikia *et al.* 2009a, 2009b, 2009c). Substantial variability was found for most of the genetic markers in the Canadian samples and research is continuing on optimal approaches to use these tests taking into account the economic importance for the Canadian industry. There could be considerable economic benefit from making use of known markers and new discoveries for specific genes in the next few years.

### Genome-Wide Approaches

Recently scientists are trying to develop methods to estimate breeding value of animals using high density Single Nucleotide Polymorphism (SNP) panels. Genomic evaluation has already been applied by the Canadian Dairy industry in partnership with the US and Mexico in 2009 resulting in a huge increase in accuracy on young bulls (VanRaden *et al.* 2009). Successful application of a SNP panel in beef cattle also significantly increased the accuracy of bull evaluations (Northcutt, 2009), and research in many countries is now focused on use of the 60K SNP panel for pigs.

### Implications for the Canadian Swine Industry

Canada is among the world leaders in application of state of the art genetic improvement programs for pigs. In fact, Canada was the first country to implement a national B.L.U.P. animal model for genetic evaluation of pigs. This was done under the leadership of the late Dr. B.W. Kennedy at the University of Guelph in the 1980s. The sequencing of the pig genome and the availability of the 60K SNP panel open the door to a new generation of applications for genetic improvement. Not only does this offer the opportunity for increased accuracy, there is great potential to improve traits such as resistance to disease and pork quality. More generally, we now have tools to target traits with low

heritability, that are difficult or expensive to measure, that can't be measured on the live animal, that can only be measured in one sex or that can only be measured later in life.

Many countries are now focused on developing associations between phenotypes such as those mentioned above and SNPs from the 60K panel. Canada was among the first to use the new 60K SNP panel for swine, and the results to date are very encouraging. So far about 2000 pigs have been genotyped in Canada and a new project has been initiated which will test another 1000 pigs. The initial focus is on carcass and meat quality traits, but this can be expanded to include many other areas. Discussions are taking place on collaboration with researchers in the United States and Europe who are looking at the application of genomics to improve swine health. In Canada a new organization called PigGen Canada was recently created in order for the genetics sector to join forces on application in genomics, with swine health as a top priority. More genotyping of pigs with important phenotypes is required along with the related bioinformatics research to ensure Canada remains among the leaders in genetic improvement.

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## Elimination of the Negative Effect of Feeding Vomitoxin (DON) Contaminated Corn on Pig Growth Performance by Microbial Detoxification

T. Zhou<sup>1\*</sup>, X.Z. Li<sup>1</sup>, C. F.M. de Lange<sup>2</sup>, C.H. Zhu<sup>2</sup>, J. Gong<sup>1</sup>, H. Yu<sup>1</sup>,  
J. C. Young<sup>1</sup>, H. Zhu<sup>1</sup> and W. Du<sup>3</sup>

<sup>1</sup>Guelph Food Research Centre, Agriculture and Agri-Food Canada; <sup>2</sup>Department of Animal and poultry Science, University of Guelph; <sup>3</sup> Ontario Ministry of Agriculture, food and Rural Affairs;  
\* [ting.zhou@agr.gc.ca](mailto:ting.zhou@agr.gc.ca)

### Background

Vomitoxin (deoxynivalenol or DON) is a mycotoxin that often presents in small grains and corn. The contamination of DON in swine feed has been a great challenge for the industry because it can cause feed refusal, vomiting and weight gain reduction. Bio-detoxification by transforming mycotoxins into less or non-toxic metabolites is an alternative strategy in controlling mycotoxins in swine production (Zhou et al., 2008). Our research team has developed an innovative strategy that combines conventional microbial methods with advanced molecular techniques to identify active microorganisms from a vast number of microbial populations (Zhou et al., 2005). Application of this strategy has resulted in the successful isolation of highly potent DON-transforming bacterial isolates from chicken guts (Zhou et al., 2007). These bacterial isolates are able to effectively transform deoxynivalenol (DON) into its de-epoxidized form, DOM-1, which is significantly less toxic than DON. Further evaluations have indicated that certain isolates, e.g. Isolates LS100 and SS33, are also able to convert other trichothecene mycotoxins such as nivalenol and T-2 toxin to different derivatives. Two patent applications (US 2007 and PCT 2008) have been filed on the isolates. This update demonstrates that the bacterial isolate LS-100 can eliminate the adverse effects of DON on swine performance when appropriately applied.

### Experimental procedure

Twenty Yorkshire starter pigs, 14 gilts and 14 barrows (average initial BW  $16.0 \pm 1.6$  kg), were housed individually in floor pens and fed a conventional pig starter diet for a nine day pre-trial period. Pigs were then assigned to one of four dietary treatments: (1) Control (non-contaminated corn and soy bean meal based diet), (2) DON contaminated corn (5 ppm DON in complete feed; same ingredient composition as treatment (1)), (3) fermented DON (equivalent to (2) but DON contaminated corn was fermented under closely controlled anaerobic conditions with bacterial isolate LS-100), and (4) fermented control (equivalent to (3) based on non-contaminated corn). Pig growth performance and blood chemistry was monitored for another nine days.

### Results

DON contaminated corn, when added in the diet to supply 5 ppm of DON, decreased daily gain, daily feed intake and feed efficiency by 48, 29 and 29%, respectively, compared with those pigs fed the clean corn diet (Table 1). However, the performance of pigs was significantly improved by the biological detoxification treatment. The weight gain, feed intake and feed efficiency of pigs fed contaminated corn that had been fermented by bacterial isolate LS-100 were 82, 45, and 32% greater, respectively, than those of pigs fed DON contaminated corn. The improvements were all significant. Pigs fed clean corn and the fermented clean corn had similar weight gain, feed consumption, and feed efficiency, suggesting that the small amount of corn treated with LS-100 did not yield obvious adverse effect on the pig performance.

No meaningful differences in blood chemistry were observed.

**Table 1.** Growth performance of starter pigs fed DON contaminated diets (nine day trial period).

	Control	DON	Fermented DON	Fermented control	SEM
Gain, g/d	882 <sup>b</sup>	458 <sup>a</sup>	835 <sup>b</sup>	835 <sup>b</sup>	49.1
Feed intake, g/d	1,337 <sup>b</sup>	943 <sup>a</sup>	1,367 <sup>b</sup>	1,347 <sup>b</sup>	48.2
Gain:feed	0.66 <sup>b</sup>	0.47 <sup>a</sup>	0.62 <sup>b</sup>	0.61 <sup>ab</sup>	0.036

<sup>a,b</sup> Values followed by different superscripts differ (P<.05).

### Conclusions

The large negative effect of feeding DON contaminated corn on pig growth performance was eliminated when the contaminated corn was fermented under closely controlled conditions with bacterial isolate LS-100. Effective means to routinely treat DON contaminated feed ingredients with bacterial isolate LS-100 should be explored further.

### Acknowledgement

Financial support was provided by Ontario Pork and Agriculture and Agri-Food Canada.

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## **Are We At a Stage Where We Know How to Handle a PRRS Break in a Sow Herd?**

Lori Moser, Managing Director, Ontario Pork Industry Council  
519-577-6742  
[lori.moser@rogers.com](mailto:lori.moser@rogers.com)

Pig producers and veterinarians have several options when facing a PRRS break. Some will allow the disease to follow its course while trying to address the clinical signs with individual or population treatments, some will inoculate or expose all sows with PRRS virus recovered during the outbreak while others will use Pulmotil in the immediate 4 weeks following the PRRS onset with or without virus exposure. To help make a more informed decision, the OPIC Swine Health Advisory Board (OSHAB) developed this project to allow veterinary practitioners from Ontario and Quebec to group their PRRS experiences into one study to look at the losses from the PRRS break, the cost of different PRRS strategies and the net benefit of each strategy.

Each strategy has its cost and reward; no strategy provides the perfect solution in every case. The net benefit was calculated by measuring the reduction in weaned pigs for a standard number of weeks post outbreak and calculating the cost of intervention. Our goal was thus to determine which intervention resulted in the smallest losses in revenue. One thing became clear from this study; doing nothing is the most expensive decision.

Assuming each piglet would be sold at \$36, we estimated that if a farm chooses to do nothing, a PRRS break will typically result in a loss of \$80/sow/outbreak in potential revenue from reduced weaned pig sales over a period of 6 months. At the extremes, in the best case a farm will lose as little as \$29/sow/outbreak while the worst case, a farm will lose as much as \$158/sow/outbreak when no treatment is selected. The farms under study that chose to do nothing still incurred additional expenses from increased number of individual treatment. These comfort treatments cost on average \$2.60/sow/outbreak.

In farms that chose to try a PRRSV exposure control strategy, the PRRS break either was shorter in duration or fewer piglets were lost (less abortions or smaller PWM or higher BA). This resulted in higher revenue from wean piglets sale. The farms that exposed sows to PRRS virus, showed \$20 higher revenue/sow/outbreak on average, than farms that chose to do nothing, while farms that included Pulmotil in the gestation diet after the outbreak, showed an average of \$55 higher revenue/sow/outbreak than farms that chose to do nothing. Total intervention expenses related to individual animal treatment on farms that chose to expose sows with the PRRS virus averaged \$2.90/sow/outbreak while farms that chose Pulmotil showed total average medication expenses of \$12.80/sow/outbreak. Even with this higher additional cost for medication, the net average advantage to the Pulmotil treatment group was found to be \$44.80/sow/outbreak over no treatment.

***'The most expensive decision was to do nothing resulting in a loss of \$80/sow/outbreak while loss after viral inoculation was limited to \$60/sow/outbreak and loss after use of Pulmotil with or without inoculation was reduced to \$25/sow/outbreak'***

The analysis based on current data suggests that letting a PRRS break run its course is the most expensive strategy under most scenarios. Intervention such as PRRS virus exposure or Pulmotil would allow a farm to wean more pigs following a PRRS outbreak which results in smaller net loss. PRRS continues to threaten the economical performances of the swine industry. It is by sharing our experience that we will make a more informed decision. This project is ongoing and welcomes any farm willing to share its computer records either recent or historic. We wish all confirmed PRRS cases from Ontario and Quebec herds to be included in our study, regardless of their severity. This will greatly enhance validity of our final results. To participate into this OSHAB PRRS project please have your veterinarian contact Dr Poljak at [zpoljak@uguelph.ca](mailto:zpoljak@uguelph.ca).

This study was led by OSHAB. Dr. Zvonimir Poljak, University of Guelph was the principle researcher. Project funding was provided by the Agricultural Adaptation Council, through the AMI program with assistance from Ontario Pork, PigChamp, and Herdsman.

**Table 1: Estimated net impact of 3 strategies used to control a PRRS outbreak in a sow farm**

PRRS control strategy	N (Cases Analyzed)	\$/sow/outbreak		
		Total cost <sup>1</sup>	Loss <sup>2</sup>	Net impact <sup>3</sup>
Do nothing	7	2.6 [0.1,7.7]	-80 [-158,29]	Baseline
PRRS exposure virus recovered during the outbreak	6	2.9 [0.8,5.3]	-60 [-117,-16.1]	20 [-51,+106]
Pulmotil with and without inoculation	10	12.9 [5.8,22.1]	-25 [-112,+15]	55 [-43,+143]

*1: Individual treatment and feed medication*

*2: Pigs not weaned during 32 weeks following the outbreak*

*3: Net impact on revenue in comparison to “no intervention” strategy*

## Update on Swine Liquid Feeding Research

C. de Lange, C.H. Zhu, D. Wey, J. Guimaras, D. Columbus and M. Or-Rashid  
 Department of Animal and Poultry Science, University of Guelph, Guelph, ON  
[cdelange@uoguelph.ca](mailto:cdelange@uoguelph.ca)

### Introduction

The use of relatively inexpensive co-products from the bio-fuel and food industries continues to be an important means to reduce pork production costs. This applies in particular to the use of liquid co-products in computer controlled liquid feeding systems. At the University of Guelph a research program is in place aimed at further developing liquid feeding technology for pigs, based on liquid and dry feed ingredients that are available in Central North America.

Specific objective are to:

1. explore manipulation of dietary electrolyte balance and use of enzymes or bacteria to increase usage and nutritional value of co-products;
2. explore physical aspects of liquid feed delivery to enhance feed intake, gut health and gut development in pigs, and to minimize feed spoilage;
3. quantify overall energy usage, environmental impact, pork quality and gut health associated with liquid feeding diets that contain large amounts of co-products; and
4. extend the positive effects of liquid feeding to conventional dry feeding systems.

### Main results of research activities in 2009 (objectives 1 and 2)

A number of studies were conducted to explore dietary interventions to *overcome the negative effects of feeding high dietary potassium levels from co-products*. High dietary potassium levels were generated by feeding a combination of corn steep water (CSW; about 5% of diet dry matter) and condensed whey permeate (WP; about 20% of diet dry matter). First it was established that part of the negative effects of feeding these high levels of CSW and WP can be attributed to high dietary potassium levels from potassium carbonate. Various dietary interventions were then explored to reduce these negative effects, including feeding additional salt (sodium chloride), sodium nitrate and different levels of calcium chloride. Among these interventions the use of calcium chloride appeared most promising and this was explored further in a full-scale finishing pig performance study. In high potassium diets (corn-SBM with added potassium carbonate to achieve total potassium levels of about 1.3%) additional calcium chloride improved feed:gain (2.36 with added calcium chloride vs. 2.56 without added calcium chloride). However, the negative effects of feeding high co-product diets could not be entirely eliminated by adding calcium chloride to a diet that contained 5% CSW and 22% WP on a dry matter basis (feed:gain 2.80 for co-products vs. 2.69 when adding calcium chloride). Only minor effects of dietary treatments on carcass and meat quality were observed.

A series of in vitro studies were conducted to *explore the use of combinations of enzymes to enhance the nutritional value of wheat shorts (WS) and dried corn distillers grain with solubles (DDGS)*. It was anticipated that the use of enzymes is more effective when they are mixed with feed and water and left to steep before feeding these co-products to pigs. Simply steeping wheat shorts with a 0.30% (w/w) xylanase and 0.30% glucanase (enzymes supplied by AB Agri, Germany) increased release of soluble sugars during a 3 h incubation at 40 °C by more than 70%. This increase is equivalent to 3.4% of the original weight of WS. When steeping DDGS with different combinations of enzymes the release of soluble sugars was lower when compared to WS. Likely because of fermentation of corn for the production of ethanol the amounts of substrate for enzymes is



lower in DGGS than WS. We are now testing the use of xylanase and glucanase in the liquid feeding of wheat shorts based diets.

A growing finishing pig performance study was conducted to explore *interactive effects of the particle size of dry corn (fine vs medium) and feeding method (conventional dry meal feeding vs liquid feeding)*. It was anticipated that the value of fine grinding of corn is smaller in liquid feeding than in conventional dry feeding. The mean analyzed particle sizes - based on three samples that were taken at the start middle and completion of the experiment – were 525 and 652 um for fine and medium, respectively. There were no interactive effects of the two main effects on growth performance. In this experiment, there were clear performance benefits of liquid feeding corn and soybean meal based diets, which is consistent with European studies where pigs were fed wheat and barley based diets. In this experiment, we did not observe a significant growth performance response to feed particle size, even though numerically a 2.5% improvement in feed utilization was observed across the two feeding systems. This numerical improvement in feed utilization was consistent with significant improvements in digestibility of dry matter, organic matter and crude protein. It is of interest to note, even though this is not supported by results of statistical analyses, that the improvement in feed efficiency was larger for conventional dry feeding (feed:gain; 2.80 vs 2.90; 3.5% difference) than for liquid feeding (2.54 vs. 2.50; 1.5% difference). There were no treatment effects on routine carcass measurements. Another experiment has been completed, using a larger number of pens per treatment to evaluate the impact of finesse of grinding of high-moisture corn on liquid fed finishing pigs. These results will be available shortly.

### **Acknowledgements**

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## The Effects of Docked Tail Length and Nursery Space Allowance

K. Bovey<sup>1</sup>, C. Dewey<sup>2</sup>, T. Widowski<sup>3</sup> and S. Torrey<sup>1</sup>

<sup>1</sup> *University of Guelph Department of Animal and Poultry Science; Agriculture and Agri-Food Canada*

<sup>2</sup> *University of Guelph; Population Medicine*

<sup>3</sup> *University of Guelph; Department of Animal and Poultry Science*

Contact: [kbovey@uoguelph.ca](mailto:kbovey@uoguelph.ca), 519-824-4120 ext. 58580

### Introduction

Tail docking is routinely performed on the majority of farms in North America in an attempt to decrease tail biting behaviour. It is believed that the removal of a portion of the tail results in neural damage sufficient to cause sensitivity of the remaining tail stump (Simonsen et al., 1991). However, tail docking has not been entirely effective in reducing tail biting behaviour, with upwards of 2% of tail-docked pigs bearing evidence of tail-biting damage at the slaughter plant. In addition, tail biting has been associated with abscesses (Huey, 1996) and diseases such as vertebral osteomyelitis and arthritis, which have been identified as main reason for carcass condemnation at slaughter (Martinez et al., 2007). In tail biting outbreaks, on-farm losses may increase due to cannibalism (Schroder-Peterson and Simonsen, 2001).

The problem of tail biting is complex and multi-factorial. Associated factors include: gender, feed type (liquid or meal), bunk space, social factors, group size, stocking density, ventilation, lighting schedule, and barren environments (Ewbank, 1976; Hunter et al., 2001; Kritas and Morrison, 2004). However, in a producer survey by Paul et al. (2007), tail length and stocking density were considered very important factors in tail biting behaviour.

The length at which to dock tails varies widely between codes of practice. While DEFRA (2003) recommends leaving at least 2 cm of tail after docking, the CARC (1993) advises to remove the last third of the tail. However, both lack empirical justification. Research into the role tail length plays in tail biting behaviour has reached opposing results. While Kritas and Morrison (2004) found no clear association between the two, Hunter et al. (2002) identified docked tail length to be the most important single factor in reducing tail biting. Tail dock length may also play an important role in other production issues like rectal prolapses. Studies in lambs have shown that short tail docking results in the increased incidence of rectal prolapses due to nerve damage to the anal sphincter and perianal muscles (Anderson and Miesner, 2008).

Contrasting conclusions have also been reported from studies examining the role of stocking density in tail biting behaviour. While Krider et al. (1975) and Moinard et al. (2003) reported that pigs housed at increased densities had greater levels of tail biting damage, Kritas and Morrison (2004) did not find that to be the case.

Given the relatively few empirical studies examining the roles of docked tail length and stocking density, it is clear the topic warrants additional research.

### Objective

The objective of this experiment was to examine the behavioural and physiological effects of docked tail length and nursery stocking density in swine.

## Methods

This trial took place from June through December 2009 on commercial farms in Quebec. One thousand eleven pigs were included in the initial phase of this trial. At 2 to 3 days of age, all piglets were assessed for viability, sexed, weighed, and ear tagged. Each was randomly assigned to one of two docked tail lengths (“long” 4.5 cm; “short” 1.2 cm) and nursery stocking density (“crowded” 0.15 m<sup>2</sup>/pig; “not crowded” 0.23 m<sup>2</sup>/pig). At weaning ( $18.8 \pm 0.05$  days) 51 pigs were removed from the trial due to mortality, morbidity or extremes in weight. Each of the remaining 960 pigs was weighed and randomly assigned to a nursery pen (balanced for weight and sex). Each concrete-slatted nursery pen measured 3.05 metres x 1.83 metres. All combinations of tail length and stocking density were present: “short tail crowded” (SCR); “short tail not crowded” (SNCR); “long tail crowded” (LCR); and “long tail not crowded” (LNCr). The “crowded” pens contained 36 pigs while the “not crowded” pens contained 24 pigs. Pigs remained in the nursery for approximately 5 weeks. During this time, a sub-sample of the pens was video-recorded for 24 hour periods for behavioural analyses. At the end of the nursery period, pigs were weighed, scratch scored (Meat and Livestock Commission, 1985), and tail-health assessed (Fig 1). Prior to transfer to the grower-finisher barn, 80 pigs were removed from the trial due to mortality, morbidity, or extremes in weight. Each of the remaining 880 pigs was then randomly assigned to a grower-finisher pen (balanced for weight and sex). Each concrete-slatted grower-finisher pen measured 3.49 m x 2.07 m and contained 10 pigs. Pigs were also weighed, scratch scored, and tail health assessed every 4 weeks. As per standard practice on the farm, pigs with tail lesion scores of “2” had an elastrator placed proximal to the lesion, while those more severely affected were removed from the pen. If this occurred to a minimum of 10% of pigs in a given pen, the pen was designated as having a “tail biting outbreak”. If an outbreak occurred, enrichment in the form of suspended metal chains and a strip of poly-board was provided. At the slaughter plant, pigs were observed for the presence of rectal prolapses. Morbidities and mortalities were recorded throughout the trial.

## Results

It was confirmed that tail-in-mouth and tail-biting behaviour began to occur in the nursery, with over 50% of pigs having evidence of bitten tails when examined at 8 weeks of age. By 12 weeks of age, 97.8% of pigs had evidence of bitten tails. The greatest numbers of tail-bitten pigs in the nursery were seen in the “crowded” pens of pigs, regardless of tail length. However, pigs with “long” tails from either space allowance had the greatest degree of tail damage.

When assessed for scratches on the body (used as an indication of aggression) in the nursery, the greatest degree of damage was seen on “crowded” pens of pigs with “short” tails.

In the grower-finisher barn, average scratch scores were similar between treatment groups. Average tail scores were also similar between groups, with the exception of LCR pigs, which had an increased rate of tail score “3” (8.6%) when compared to other treatment groups (1.3% for SCR, 1.6% for SNCR, and 4.0% for LNCr).

Of the 44 pens of “short” tailed pigs in the grower-finisher barn, 5 pens (11.36%) were classified as tail-bitten (at least 10% of pigs with a tail score “2”). Of the same number of “long” tailed pens of pigs, 28 pens (63.64%) were classified as tail-bitten.

ADG in the nursery was highest in the “not crowded” pens of pigs, regardless of tail length (401 g/pig/day for “not crowded”, 362 g/pig/day for “crowded” pens).

ADG in the grower-finisher barns was similar across treatment groups (951 g/pig/day for LCR, 954 g/pig/day for LNCr and SNCR, 965 g/pig/day for SCR).

Overall, the nursery cull rate was 2.30%, with an equally low number of losses in the “not crowded” pens of pigs as in the “crowded” pens (1.04% each for “short” and “long” tail treatments). “Short” tailed pigs in “crowded” pens had slightly higher losses at 2.70%, while the highest mortality rate was recorded for the “long” tailed “crowded” pigs (3.47%).

The grower-finisher cull rate was 9.09%. The “not crowded” pens of pigs had fewer losses (3.64%) when compared to the “crowded” pens (5.45%). When considering tail length, the “long” tailed pigs had a greater number of losses (5.91%) when compared to the “short” tailed pigs (3.18%). By treatment, the highest losses were recorded for LCR pigs (3.30%), followed by LNCR (2.61%) and SCR (2.16%) and lastly, SNCR (1.02%).

Rectal prolapses occurred at a rate of 2.39% in grower-finisher pigs. Twice as many prolapses were seen in “short” tailed (1.59%) versus “long” tailed pigs (0.80%).

### Conclusion

Analyses of tail biting behaviour are on-going. However, it appears that tail length and nursery stocking density have some influence on tail biting.

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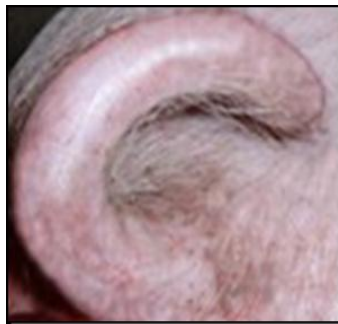
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## Tail Health Assessment

(Adapted from Hunter et al., 1999)

### Score 0: No damage

- No evidence of lesions (fresh or healed)



### Score 1: Mild

- Healed and/or mild scratches/punctures
- NOT longer and/or wider than a pinhead
- $\leq 10$  in total



### Score 2: Moderate

- Scratches/punctures that are wider and/or longer than a pinhead, but smaller than a dime
- Excessive ( $>10$ ) mild scratches/punctures



### Score 3: Severe

- As above WITH swelling and redness
- Possible pus and necrotic tissue
- Possible signs of cannibalism: lesions/loss of tissue dime-sized or larger



## **Patterns of Condemnation Rates in Swine from a Federally Inspected Abattoir in Relation to Disease Outbreak Information in Ontario (2005-2007)**

Rocio Amezcua, David L. Pearl, Alejandro Martinez <sup>2</sup>, Robert M. Friendship <sup>1</sup>

<sup>1</sup>Department of Population Medicine, Ontario Veterinary College, Guelph, Ontario

<sup>2</sup>Canadian Food Inspection Agency

Email: mamezcua@uoguelph

### **Introduction**

Syndromic surveillance is a method that focuses on symptoms or lesions rather than specific diagnoses and has become important part of surveillance since this approach may identify natural disease outbreaks more quickly than surveillance systems based on laboratory diagnoses. This type of surveillance involves the use of data from farms, veterinary clinics, and abattoirs. Correlation between the occurrence of clinical signs at the farm level and the presence of lesions at slaughter have been reported for pneumonia and diarrhea and the detection of changes in condemnation rates has been used in some studies to evaluate the health status of pig populations to develop control strategies. However, the usefulness of slaughter condemnation information as a source of surveillance data to detect specific outbreaks has not been evaluated.

An outbreak of Porcine Circovirus Associated Disease (PCVAD) occurred in Ontario in 2005 as documented by a sudden rise in cases submitted to the Animal Health Laboratory (AHL). The disease continued to cause high mortality and reduced performance in grower-finisher pigs until vaccines became widely available in late 2006.

The objective of this retrospective study was to determine if condemnation rates during this period of disease and recovery reflected the information collected by the AHL and thus suggesting that slaughterhouse data could be useful in providing additional data for the surveillance of disease outbreaks in finisher pigs.

### **Methods**

The data were obtained from the database of one federally-inspected packing plant in Ontario from January 2005 to December 2007. The data included total condemnations due to various lesions. For the purpose of this project only pathological lesions that were associated with problems related to PCVAD infection were analyzed (pneumonia, enteritis and nephritis). Descriptive statistics were generated. In addition, negative binomial models were used to model the effect of year, season and the interaction of season and year on the rate of the specific lesions and predictive rates were calculated and graphed after fitting the models.

### **Results and Discussion**

A total 6.2 million animals were slaughtered in this packing plant during the study period and a total of 23,000 were condemned (Table 1). Although the total animals slaughtered increased from 2005 to 2007, the number and rates of condemned decreased. Around 3,500 of the condemnations were due to pathological lesions possibly associated with PCVAD. In general the number of animals and rates of condemnation due to pneumonia decreased while the number of animals condemned due to nephritis and enteritis increased from 2005 to 2007 (Table 1).

In agreement with AHL reports, the pneumonia patterns observed in this study reflected the field infection of PCV-2 in 2005 and the first half of 2006 followed by a decrease in cases in 2007 due to widespread use of PCV-2 vaccines. AHL reported the beginning of the decline of PCV-2 cases from 10.2% of the total swine submissions in the first trimester of 2006 to 8.4% by the fall of 2006.

Although the PCVAD outbreak in Ontario was associated with an increase in lesions associated with enterocolitis and nephritis, these were not observed in the present study. In contrast peaks of these two lesions were observed at the end of the study period, which is difficult to explain.

In conclusion abattoir statistics may be a valuable diagnostic tool for detection of potential new diseases, particularly if into a surveillance program and validated with additional swine health data sources.

**Table 1. Numbers and rates per 10 000 hogs slaughtered per year of total condemned and condemned due to pneumonia enteritis, and nephritis and from a federally inspected abattoir in Southern Ontario from 2005-2007**

	<b>Total</b>	<b>Condemned</b>	<b>Arthritis</b>	<b>Enteritis</b>	<b>Nephritis</b>	<b>Pneumonia</b>
	Num*	Num	Num	Num	Num	Num
	slaughtered	Rate †	Rate	Rate	Rate	Rate
2005-2007	6 204 702	22 980	1 911	658	1 595	1 255
		<b>37</b>	<b>3.0</b>	<b>1.0</b>	<b>2.5</b>	<b>2.0</b>
2005	1 991 726	9 707	783	86	346	589
		<b>4.9</b>	<b>3.9</b>	<b>0.4</b>	<b>1.7</b>	<b>2.9</b>
2006	2 047 321	7 000	610	230	516	383
		<b>34</b>	<b>2.9</b>	<b>1.1</b>	<b>2.5</b>	<b>1.8</b>
2007	2 165 655	6 276	518	342	733	283
		<b>2.9</b>	<b>2.3</b>	<b>1.5</b>	<b>3.4</b>	<b>1.3</b>

\*Num: Number of animals

†Rates per 10 000 animals slaughtered per year

### Acknowledgements

Support was received from OMAFRA and the Animal Health Research Strategic Initiative as well as the Sustainable Production Systems Program of the UofG-OMAFRA research partnership.

## **One Stone -Two Birds: Can Vaccination Against *Salmonella* Make Pork Safer and Improve Growth in Pigs?**

A. Farzan and R. M. Friendship

*Department of Population Medicine, University of Guelph, Guelph, N1G 2W1*

Email: [afarzan@uoguelph.ca](mailto:afarzan@uoguelph.ca)

### **Background**

Immunization appears to be one of the most promising methods for control of *Salmonella* on swine farms and live attenuated vaccines are considered ideal because they stimulate local gut immunity. The only live oral vaccines available for pigs in Canada are *Salmonella* Choleraesuis vaccines although this is not the serovar that commonly causes a problem, however, it is thought they may provide cross-protection against other *Salmonella* serovars. *Salmonella* Typhimurium var. Copenhagen has become the most frequent serovar recovered on Ontario swine farms and is also a serovar commonly associated with human disease. *Salmonella* is often found in pigs that show no clinical signs of disease and therefore this pathogen may go undiagnosed.

### **Objective**

The objectives of the present study were i) to determine if an injectable autogenous *S. Typhimurium* vaccine or a commercial live *S. Choleraesuis* vaccine can reduce the prevalence of *Salmonella* shedding in pigs, ii) to determine if *Salmonella* shedding is associated with reduced weight gain in pigs.

### **Materials and Methods**

The trial was conducted on one farrow-to-finish pig operation with a history of clinical and sub-clinical salmonellosis. Nine cohorts of weaned pigs, with approximately 350 pigs in each group, were randomly assigned to 1 of 3 treatment groups (*S. Typhimurium* bacterin, *S. Choleraesuis* vaccine, or as non-vaccinated controls). A *S. Typhimurium* var Copenhagen DT104 strain was used in the autogenous vaccine prepared at Gallant Custom Laboratories, Cambridge, Ontario. In each cohort, one pen was randomly selected in the nursery stage and 30 pigs were ear-tagged and weighed. The tagged pigs were weighed again when marketed. Pooled fecal samples were collected bi-weekly from manure found on the pen floor and cultured for *Salmonella*.

### **Results**

The number of *Salmonella*-positive samples in each group is shown in Table 1.

The control pigs which had the lowest average of *Salmonella* shedding showed the best growth performance compared to the vaccinated groups (Table 2). In addition, the pigs from pens with a higher *Salmonella* recovery rate were deemed to have a lower average daily gain.



**Table 1:** Culture of *Salmonella* from pooled manure samples collected from pens housing pigs assigned to one of three treatments: *S. Choleraesuis* live oral vaccine, *S. Typhimurium* autogenous bacterin given intramuscularly and non vaccinated controls

Number of positive samples / total (%)				
Treatment Group	Nursery one	Nursery two	Finisher	Total
<i>S. Choleraesuis</i> vaccine	Not sampled	14/75 (18.7)	30/156 (19.2)	44/231(19.0)
<i>S. Typhimurium</i> vaccine	4/20 (20.0)	8/78 (10.3)	19/156 (12.2)	31/254 (12.2)
Control	Not sampled	4/48 (8.3)	6/120 (5.0)	10/168 (5.9)
Total	4/20 (20.0)	26/201 (12.9)	55/432 (12.7)	85/653 (13.0)

**Table 2:** The impact of vaccination against *Salmonella* on average daily gain in pigs

Group	Coefficient	Standard error	95% Confidence interval	P value
<i>S. Choleraesuis</i> vaccine	-26.6	13.5	-53.0, 0.27	0.048
<i>S. Typhimurium</i> vaccine	-90.8	16.2	-122.5, -59.0	<0.001
Control	Reference			
Weight at weaning (kg)	4.7	2.1	0.7, 8.7	0.022
Intercept	694.5	31.2	633.3, 755.8	<0.001

## Discussion

It appeared that vaccination did not protect pigs from *Salmonella*. It is possible that an oral live attenuated *S. Typhimurium* vaccine might have produced more promising results. This was a field trial and therefore some circumstances were beyond our control such as the age of vaccination, the group size and animal movement and initial prevalence of *Salmonella* shedding. It is likely that vaccination was performed after pigs had been exposed and that efficacy might have been improved had the pigs been vaccinated sooner. At least one study suggests that it might be prudent to establish a vaccination strategy for pregnant sows to control *Salmonella* in their piglets. The decrease in *Salmonella* shedding as the pigs aged may have occurred naturally and is difficult to assess in this trial because the controls started with relatively low numbers of positive animals. Despite the imperfections of the study there was one very interesting finding and that was that pigs that appeared clinically healthy but were found to be shedding *Salmonella* grew slower than pigs not shedding *Salmonella*. This suggests that there is an economic cost to subclinical *Salmonella* infection and provides an economic incentive for producers to implement *Salmonella* control measures.

## Acknowledgments

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## **Epinephrine-induced MMP Expression and its Relationship with AMPK Signalling in Muscle Cells and Fibroblasts (connective tissue-forming cells)**

M.C. Cha and P.P. Purslow

Department of Food Science, University of Guelph, Guelph, Ontario,  
Canada N1G 2W1

519-824-4120 ext 52099 : [ppurslow@uoguelph.ca](mailto:ppurslow@uoguelph.ca)

### **Introduction and objective**

Acute stress at or around the point of slaughter is known to impact on post-mortem development of pH and subsequent pork meat quality. Much focus has been given recently to a signalling pathway involving AMP-activated protein kinase (AMPK) as a “key regulator” of energy metabolism in muscle and correlations between AMPK activity and post-mortem glycolysis (Scheffler and Gerrard 2007). The amount and physiological maturity of intramuscular connective tissue is known to have a strong relationship to the eating quality of cooked meat.

Connective tissue turnover is principally regulated by the matrix metalloproteinase family of proteases (MMPs) and elevated levels of epinephrine (adrenaline) in the circulation are known to increase MMP expression in muscle (Carmeli et al. 2005).

Using a cell culture model, we have therefore investigated:

- (1) whether epinephrine increases the expression of matrix metalloproteinases (MMPs) from muscle cells and connective tissue-forming cells (fibroblasts) isolated from muscle, and
- (2) Any relationship changing MMP expression may have to AMP-activated protein kinase (AMPK) signalling.

**Methodology** Mouse skeletal fibroblasts (NOR-10) and myoblasts (C2C12) in plate culture with DMEM medium were treated with or without a low (2ug/ml) or high (10 ug/ml) doses of epinephrine for 2 or 6 hours. The intracellular and secreted expression of MMPs was determined by zymography and AMPK expression was examined by immune blotting.

### **Results**

Intracellular MMP-3 expression was increased in muscle cells by both the high and low doses of epinephrine at longer (6 hour) treatment times, but in fibroblasts this is only seen in the high dose treatment. Intracellular MMP-2 and MMP-13 expression were also amplified by the low dose, longer time epinephrine treatment in the myoblasts, but this is not observed in fibroblasts. AMPK expression was elevated only at the shorter treatment time at both epinephrine dose levels and in both cell lines. At the higher epinephrine dose level and at short incubation times, fibroblasts also show transient expressions of MMP-2 and -13.

### **Implications**

Our data suggest that MMP expression is increased by epinephrine, but the response is different between fibroblasts and muscle cells; at the lower dose of epinephrine (closer to physiological levels) it is the muscle cells that respond more in terms of increased MMP expression. Epinephrine treatment does increase the activity of AMPK signalling, but the time-course of MMP expression from muscle cells is not well correlated to the time-course of AMPK activity. On the other hand,

fibroblasts only respond to higher levels of epinephrine and on a much shorter timescale, better correlated to AMPK activity.

**Relevance to pork meat quality**

At normal physiological levels, epinephrine, stimulation of adrenergic receptors in the muscle cells of live animals leads to an increase in the enzymes responsible for degrading intramuscular connective tissue, and this may impact on meat toughness post mortem. However, the signalling pathway within the muscle cells leading to increased expression of these enzymes appears to be different than the AMPK pathway, which controls the response of muscle to epinephrine in terms of increased glycolysis and lipolysis.

**Publication**

A manuscript based upon this work has been submitted to the journal “Cells, Tissues, Organs” in November 2009.

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## Changes in Energy Metabolism During Gestation and Lactation in Sows

R.S. Samuel<sup>1</sup>, S. Moehn<sup>1</sup>, P.B. Pencharz<sup>2</sup>, and R.O. Ball<sup>1\*</sup>

<sup>1</sup>Swine Research and Technology Centre, 4-10 Agriculture/Forestry Centre, University of Alberta, T6G 2P5, Edmonton, AB, Canada.

<sup>2</sup>Research Institute, Hospital for Sick Children, M5G 1X8, Toronto, ON, Canada.

\*Correspondence: [ron.ball@ualberta.ca](mailto:ron.ball@ualberta.ca)

### Introduction

Nutrition of sows has received little attention compared to growing-finishing pigs, despite the fact that sows consume approximately 20% of the all the feed consumed in pork production. Currently, NRC (1998) recommends constant nutrient and energy intake during gestation. However, practical experience (Jackson 2009) has shown that feed and nutrient intake must be increased during late gestation to maintain performance and sow longevity. Conceptus gain increases rapidly after day 68 of gestation (McPherson et al. 2004) and has a greater priority for nutrient supply than maternal gain. However, maternal body weight gain is necessary for sows to cope with the following lactation. Ignoring the increased nutrient demand in late gestation by applying a single phase feeding program will lead to underfeeding during late gestation, which leads to sows entering lactation in a catabolic state.

Lactating sows, in most cases, lose weight during lactation because they cannot achieve the feed intake needed to supply the full amount of nutrients needed. Milk production has priority for nutrient use over maintenance of the sow's body tissues, so that sows mobilize body tissues to cover any nutrient shortfall. Key to successful lactation nutrition is the correct balance between dietary protein and energy; protein deficiency, compared to dietary energy content, increased body protein mobilization; protein excess depresses feed intake and reduces the efficiency of energy utilization. The objective of this experiment was to monitor the changes in energy and protein metabolism during gestation and lactation, without nutritional intervention, to derive recommendations for sow feeding regimens.

### Material and methods

Five second parity pregnant Hypor Hybrid (Hypor Inc) sows ( $192 \pm 2$  kg) were fed  $2.4 \pm 0.1$  kg of a barley-wheat-SBM diet of 12.5 MJ ME/kg, 0.65% total lysine, and 15% crude protein twice daily throughout gestation. Lactating sows were fed *ad libitum* (14 MJ DE/kg, 20.7% crude protein, 1.02 % total lysine).

Sows were individually housed in respiration chambers for 24-h measurements of energy and protein metabolism. Heat production was measured by indirect calorimetry (Brouwer 1965). A simultaneous primed-constant IV infusion of L-[1-<sup>13</sup>C]leucine (1.0 mg/kg/h) was used to measure protein metabolism. Real-time ultrasound measurements of backfat and loin thickness and area were collected at each study day. All measurements were made at d 30, 45, and 105 of gestation and with their litters on days 7 and 19 of lactation.

The mixed model procedure (SAS 2002) was used to determine differences between study days within gestation or lactation.  $P < 0.05$  was regarded as significant,  $P < 0.1$  as a tendency.

### Results and discussion

At constant feed intake, sow weight gain increased ( $P = 0.004$ ) from 190 g/d (d 30) to 390 g/d (d 45) and 558 g/d (d105). This happened despite the energy balance (energy intake minus heat production) decreasing ( $P = 0.01$ ) from its maximum at d 45 (+2.8 MJ/d) to below zero (-3.0 MJ/d) on d 105 of gestation. This was confirmed by the gain of backfat between d 30 and d 45, and the loss of backfat between d 45 and 105. This shows a that constant feed allowance does not supply enough energy for

sows in late gestation. Protein retention was constant throughout gestation. The increase in leucine oxidation in late gestation was probably a consequence of changing ideal amino acid pattern caused by a shift from maternal protein to fetal protein gain. The fetal gain of 10.4 piglets in late gestation accounted for almost the entire daily gain of sows, and is an indication that dietary protein intake was insufficient for fetal and maternal protein deposition. To achieve zero energy balance in late gestation, sows needed an additional 250 g/d of a corn-soy diet. To allow sow maternal growth in late gestation, the additional feed allowance should be at least doubled to 500 g/d in the last 4 weeks of gestation.

Sows consumed 4.7 kg/d and 6.1 kg/d on d 7 and 19 of lactation. This was not enough to prevent weight loss, which amounted to 720 g/d up to day 7, and to 600 g/d between day 7 and 19 of lactation. Sows produced 7.1 kg/d and 9.9 kg/d to support piglet weight gain of 170 g/d and 250 g/d per piglet between d 0 and 7, and d 7 and 19 of lactation, respectively. Sows lost a similar ( $P = 0.97$ ) amount of energy on d 7 and d 19 of lactation (on average 19.6 MJ/d) but had a greater ( $P = 0.09$ ) protein retention on day 19 than d 7. In confirmation, the sows' backfat thickness decreased while the lean content increased between d 7 and 19 of lactation. This indicates that energy intake was equally limiting in early and late lactation, and protein intake may have been marginal in early lactation. To achieve zero energy balance, sows would need to eat 1.5 kg/d more of a corn-soy diet throughout lactation. To address the possible protein deficiency, diets with increased protein content, or a more aggressive step-up feeding may be considered for the first week of lactation, as suggested by Jackson (2009).

### Conclusions and implications

Sows were clearly suffering an energy deficit during late gestation. To avoid loss of body condition, sows should receive at least an additional 500 g/d of a corn-soy diet for the last 4 weeks of pregnancy. Although the current experiment was inconclusive regarding increased protein needs in late gestation, subsequent work (Levesque et al, Samuel et al; this conference) showed that threonine and lysine requirements, respectively, increased dramatically in late gestation. Therefore, a phase feeding system for gestating sows should include not only increased feed allowance in late pregnancy but also an increase in dietary amino acid contents.

The energy deficit of sows was constant throughout gestation, equivalent to an intake of an additional 1.5 kg/d of a corn-soy diet. In addition, protein intake of sows was marginal in early lactation. Therefore diets higher in protein, or with a better balance of amino acids, are suggested for early lactation to reduce the loss of body protein.

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## **Dietary Lysine Requirement for Maintenance is 49 mg/kg<sup>0.75</sup> in a Population of Modern, High Productivity Sows**

R.S. Samuel<sup>1</sup>, S. Moehn<sup>1</sup>, P.B. Pencharz<sup>2</sup> and R.O. Ball<sup>1\*</sup>

<sup>1</sup>Swine Research and Technology Centre, 4-10 Agriculture/Forestry Centre, University of Alberta, T6G 2P5, Edmonton, Alberta, Canada; <sup>2</sup>Research Institute, Hospital for Sick Children, M5G 1X8, Toronto, Ontario, Canada. \*Correspondence: [ron.ball@ualberta.ca](mailto:ron.ball@ualberta.ca)

### **Introduction**

The recommended daily lysine requirement of non-pregnant sows at maintenance, 36 mg/kg<sup>0.75</sup> (NRC 1998), was estimated from research in the 1960's with growing pigs and sows (Pettigrew, 1993). Selection for positive production traits, including larger and faster growing litters, has resulted in larger sows with increased body protein mass. Sow performance improvement along with concomitant changes in body composition suggests that the current estimate may be too low for modern sows. Therefore, it is necessary to determine the lysine maintenance requirement of modern, high productivity sows.

### **Materials and methods**

Non-pregnant Hypor Hybrid (Hypor Inc) sows (n=4, parity=2), from the University of Alberta's Swine Research and Technology Centre, were adapted to 2.2 kg of a semi-synthetic diet containing 14.0 MJ ME/kg and 1.09 g/kg lysine. Two semi-synthetic base diets based on corn were formulated and mixed to provide 55% and 115% of the lysine requirement suggested by NRC (1998). Additional lysine was added to the base diets to deliver six graded levels of lysine intake. Each sow received 6 test diets, in random order, providing lysine intakes of 19.8, 25.2, 30.6, 41.4, 46.8 and 52.2 mg/kg<sup>0.75</sup>. Sows were housed individually and fed one-half of their daily feed allowance twice daily, except on study days, when they received 11 meals equivalent to 1/26<sup>th</sup> of their daily ration every 30 minutes during the 5.5 hour total study period (Moehn et al, 2004). Comparability of this protocol to once daily feeding was previously verified. Phenylalanine, equivalent to the isotope dose, was mixed into individual batches and fed for adaptation periods between study days. Individual nipple drinkers provided free access to water. An indigestible marker was mixed into the base diets at 10 g/kg of diet and analyzed as acid insoluble ash for determination of energy and nitrogen digestibility (McCarthy et al, 1977).

After adaptation to each diet, sows were individually housed in respiration chambers for the measurement of indicator amino acid oxidation (IAAO) during a primed, constant infusion of L-[1-<sup>13</sup>C]phenylalanine and, simultaneously, heat production (HP) over 4 h. The gas exchange was recorded for O<sub>2</sub>, CO<sub>2</sub>, and CH<sub>4</sub> in 1 min intervals. Expired CO<sub>2</sub> and blood plasma were collected in 30 min intervals for determination of <sup>13</sup>C enrichment.

Statistical analysis was performed using mixed procedure and breakpoint analysis was performed using the non-linear mixed procedure in SAS (2002). The classification variable was lysine intake and individual animals were treated as random variables. Model statements were tested using the Kenward-Roger degrees of freedom method. Least square means were compared using the 'pdiff' option. Data are presented as means ± SEM. Values were considered significant at P < 0.05.

## Results

Total tract digestibility of nitrogen ( $P=0.83$ ) and carbon ( $P=0.15$ ) were not different by base diet at  $73.7\pm1.0\%$  and  $93.7\pm0.2\%$ , respectively. Phenylalanine flux was not different by dietary lysine intake ( $P=0.39$ ). Plateaus in oxidation were achieved within 1.5 h from the start of infusion. Oxidation of the indicator amino acid was lowest ( $P<0.05$ ) when lysine intake was greater than  $46.8 \text{ mg/kg}^{0.75}$  and was echoed by results from breakpoint analysis which determined the requirement as  $49\pm11 \text{ mg/kg}^{0.75}$  ( $R^2=0.65$ ). Heat production per 30 minute period and the mean RQ were lowest ( $P<0.05$ ) and there was a trend ( $P<0.10$ ) for lower  $\text{CO}_2$  production when sows were fed  $46.8 \text{ mg/kg}^{0.75}$  lysine. These results were echoed by breakpoint analysis; the breakpoint ( $46.8\pm0.02 \text{ mg/kg}^{0.75}$ ) for heat production per 30 min period and RQ had  $R^2$  values of 0.67 and 0.63, respectively;  $\text{CO}_2$  production  $R^2$  value was 0.40.

## Discussion

The dietary lysine requirement for this population of sows was determined to be  $49 \text{ mg/kg}^{0.75}$  (or 2.6 g/d for a 200 kg sow); this exceeds the NRC (1998) recommendation by 30% but is similar to the recommendation of Pettigrew (1993) and GfE (2008). The combined results of lower HP, RQ, and  $\text{CO}_2$  production when sows received adequate intake of dietary lysine demonstrate that energy metabolism was also most efficient.

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## Dietary Lysine Requirement is Greater in Late- than in Early-Gestation in Sows

R.S. Samuel<sup>1</sup>, S. Moehn<sup>1</sup>, P.B. Pencharz<sup>2</sup> and R.O. Ball<sup>1\*</sup>

<sup>1</sup>Swine Research and Technology Centre, 4-10 Agriculture/Forestry Centre, University of Alberta, T6G 2P5, Edmonton, Alberta, Canada; <sup>2</sup>Research Institute, Hospital for Sick Children, M5G 1X8, Toronto, Ontario, Canada. \*Correspondence: [ron.ball@ualberta.ca](mailto:ron.ball@ualberta.ca)

### Introduction

Current feeding recommendations specify that pregnant sows be fed a fixed diet through pregnancy. Growth of the placenta declines as pregnancy advances and fetal weight linearly increases after day 70 of gestation (McPherson et al, 2004). Development of the mammary gland occurs very late in gestation, close to parturition (Kim et al, 1999). The relative contribution to dietary amino acid requirements by the products of conception clearly changes during gestation. Thus, a fixed diet during the entire pregnancy seems illogical. Therefore, objective of this study was to determine the lysine requirement of 2<sup>nd</sup> and 3<sup>rd</sup> parity sows in early- (day 24 – 45) and late- (day 86 – 110) gestation.

### Material and methods

Hypor Hybrid (Hypor Inc) sows, pregnant after their first (n=4) or second (n=3) litters (185.7±9.6 kg BW) were adapted to individual lysine intakes. Three semi-synthetic diets (14.0 MJ ME/kg) based on corn were formulated and mixed to produce a base diet (60% of NRC (1998) requirement) and summit diets for early- and late-gestation (150% and 185% of NRC (1998) requirement, respectively). Each sow received 6 different test diets, in random order, from 60 to 150% of the requirement suggested by NRC (1998) in early- and from 60 to 185% of the requirement suggested by NRC (1998) in late-gestation. Sows were housed individually and fed one-half of their daily feed allowance twice daily, except on study days, when they received 11 meals equivalent to 1/26<sup>th</sup> of their daily ration every 30 minutes during the 5.5 hour total study period (Moehn et al, 2004). Comparability of this protocol to once daily feeding was previously verified. Individual feed allowances were determined based on body weight and P2 backfat depth at breeding. Phenylalanine, equivalent to the isotope dose, was mixed into individual batches and fed for adaptation periods between study days. Nipple drinkers provided free access to water.

After adaptation to each diet, sows were individually housed in respiration chambers for the measurement of indicator amino acid oxidation during a primed, constant infusion of L-[1-<sup>13</sup>C]phenylalanine and, simultaneously, heat production (HP; Brouwer, 1965) over 4 h. The concentrations of O<sub>2</sub>, CO<sub>2</sub>, and CH<sub>4</sub> were recorded in 1 min intervals. Expired CO<sub>2</sub> and blood plasma were collected in 30 min intervals for determination of <sup>13</sup>C enrichment.

Statistical analysis was performed using mixed procedure and breakpoint analysis was performed using the non-linear procedure in SAS version 9.1 (SAS Inst. Inc., Cary, NC). The classification variable was lysine intake and individual animals were treated as random variables. Model statements were tested using the Kenward-Roger degrees of freedom method. Least square means were compared using the 'pdiff' option. Data are presented as means ± SEM. Values were considered significant at P < 0.05.

### Results

The average number of piglets born alive was 13.7±1.9, but ranged from 4 to 20. The average piglet birth weight was 1.5±0.1 kg. Sows gained 600 g/d from breeding and weighed 258.8±8.3 kg at parturition. Actual dietary lysine intakes ranged from 7.5 to 19.3 g/d in early- and 8.1 to 23.7 g/d in



late-gestation. Breakpoint analysis of phenylalanine oxidation indicated that the lysine requirement of 2<sup>nd</sup> parity sows was 13.1 g/d and 18.7 g/d in early- and late-gestation, respectively. For 3<sup>rd</sup> parity sows, the dietary lysine requirement was 8.2 g/d and 13.0 g/d for early- and late-gestation, respectively. Similar breakpoints were calculated using HP as the dependent variable.

## Discussion

The dietary requirements for lysine in early- and late-gestation are greater than previously reported by NRC (1998) and are similar to values reported by Srichana (2006) and GfE (2008). Phase feeding at least two diets would improve productivity by more correctly providing the necessary nutrients for the growth of the placenta, the piglets, and the mammary gland. Ultimately, phase feeding would provide positive economic returns by reducing feed cost and maximizing lifetime productivity of the sows.

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## The Threonine Requirement in Early and Late Gestation and the Availability of Threonine in Common Feedstuffs in Sows

Crystal L. Levesque<sup>1</sup>, Soenke Moehn<sup>1</sup>, Paul B. Pencharz<sup>2</sup>, and Ronald O. Ball<sup>1\*</sup>

<sup>1</sup>Swine Research and Technology Centre, 4-10 Agriculture/Forestry Centre, University of Alberta, T6G 2P5, Edmonton, AB, Canada. <sup>2</sup>Research Institute, Hospital for Sick Children, M5G 1X8, Toronto, ON, Canada. \*Correspondence: [ron.ball@ualberta.ca](mailto:ron.ball@ualberta.ca)

### Introduction

The current NRC (1998) amino acid requirement recommendations for sows are outdated. The requirement for a particular AA in gestation is the sum of the requirement for maternal gain, gain of the products of conception and the maintenance requirement (NRC, 1998). The AA requirement for maintenance and maternal growth suggested by NRC (1998) are based on growing pig data from 1977 and 1989. Genetic selection has increased litter size by 20 % in the last ten years (CCSI, 2007). Additionally, NRC (1998) recommends a single AA requirement level throughout gestation which assumes that there is a constant demand throughout the gestational cycle. However, the metabolic focus changes from maternal tissue gain in early gestation to fetal and mammary tissue growth in late gestation resulting in an increase in requirement in late gestation.

Metabolic availability (MA) of amino acids represents the proportion of feedstuff amino acids that are digested, absorbed and available for metabolic activities such as protein synthesis. Amino acid digestibility represents the proportion of feedstuff amino acids that are digested and absorbed and assumed to be available for metabolic processes. Digestibility values are based on data in growing pigs and assumed to be relevant to mature animals (i.e. sows); however, Stein et al (2001) determined that the digestibility of amino acids from corn was 10% higher in gestating sows than growing pigs. An accurate estimate of amino acid availability in feedstuffs is important to ensure adequate intake of dietary protein, which includes minimizing the amount of excess protein intake while reducing the risk of deficiency.

Over the past 2 years our research program has examined the change in amino acid requirements of sows during gestation and lactation as well as testing the assumption that the digestibility of amino acids from feedstuffs determined in growing pigs was relevant in sows.

### Material and methods

The requirement for threonine in sows in early (25 – 55 d), mid (60 – 75 d) and late gestation (80 – 111 d) was determined. The initial study attempted to determine the threonine requirement in early, mid and late gestation of 2<sup>nd</sup> parity sows using threonine intakes from 5 to 15 g/d. The threonine requirement according to NRC (1998) for sows of similar BW, targeted maternal gain and expected litter size was 10 g/d. The results indicated that the threonine requirement in early gestation was 6 g/d, mid gestation was 7 g/d and late gestation was 13.6 g/d. The study was repeated using 3<sup>rd</sup> and 4<sup>th</sup> parity sows using threonine intakes from 2 to 12 g/d in early gestation and from 6 to 19 g/d in late gestation. The threonine requirement in early and late gestation was determined to be 5 g/d and 12.3 g/d, respectively. The data for all parities was pooled and breakpoint analysis indicated a requirement of 6 g/d in early gestation and 13 g/d in late gestation. The results of these studies clearly indicate that the requirement for threonine increases 2-fold in late gestation regardless of parity and that phase feeding sows during gestation will more closely meet the changing demand for amino acids. The results also indicate that the current practice of feeding a single level of amino acid throughout gestation results in overfeeding amino acids in early gestation and underfeeding amino acids in late gestation.

To test the assumption that sows and growing pigs have an equivalent ability to digest and utilize dietary amino acids we determined the MA of threonine from corn and barley in sows. In order to compare the determined MA to published digestibility values the MA of corn was also determined in growing pigs. The MA of threonine from corn in growing pigs was 81.7 %, similar to the standard ileal digestibility of THR in corn (82 %) according to NRC (1998). The MA of threonine from corn and barley in sows was 88.0 % and 89.3 %, respectively indicating that gestating sows have a greater capacity for digestion and absorption of amino acids from feedstuffs than growing pigs.

### **Implications**

Nutrition of the sow can have implications on all levels of pig production so ensuring optimal nutrition during gestation and lactation impacts production efficiency. The current research results indicate that the practice of feeding a single level of dietary protein throughout gestation results in overfeeding amino acids during early gestation and underfeeding amino acids in late gestation. Overfeeding amino acids increases diet cost and environmental contamination through excretion of excess amino acids. Underfeeding amino acids in late gestation can reduce subsequent litter performance and sow longevity. In both cases the efficiency of production is reduced. The greater amino acid availability of feedstuffs for sows may exacerbate the excess supply of amino acids in early gestation. However, in late gestation, the greater amino acid availability may mask the amino acid deficiency when feeding a single amino acid requirement throughout gestation.

Ensuring optimal nutrition of the sow has always been important but given the current economic climate, changes to production practices that not only reduce costs but potentially improve reproductive performance are vital. Phase feeding sows in gestation must become a standard part of the sow nutritional strategy.

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## Ractopamine, at 5 or 10 mg /kg, Increases Protein Deposition in the Carcass

K.A. Ross <sup>1,2</sup>, A.D. Beaulieu <sup>1</sup>, J. Merrill <sup>3</sup>, G. Vessie <sup>3</sup> and J. F. Patience <sup>1,4</sup>

<sup>1</sup> Prairie Swine Centre Inc., P.O. Box 21057, 2105 8<sup>th</sup> Street East, Saskatoon, SK Canada. S7H 5N9.

<sup>2</sup> Dept. Animal and Poultry Science, University of Saskatchewan, Saskatoon, SK Canada S7N 5N8

<sup>3</sup> Elanco Animal Health, Guelph, ON Canada

<sup>4</sup>Department of Animal Science, Iowa State University, Ames, IA. USA

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### Summary

A comparative slaughter experiment utilizing 120 barrows was conducted to measure growth performance and nutrient retention in the carcass when either 0, 5 or 10 mg/kg ractopamine hydrochloride was added to the diet at 3 levels of dietary lysine. Therefore, there were 9 different dietary treatments (3 ractopamine x 3 lysine:DE ratios). Growth performance and nutrient retention in the carcass were determined.

Ractopamine did not affect ADG, ADFI or the gain to feed ratio ( $P > 0.10$ ). With increasing lysine G:F improved (0.35, 0.35 and 0.39;  $P < 0.05$ ), ADG and ADFI were unaffected ( $P > 0.10$ ). Protein deposition rates tended to increase (162.1, 185.4 and 189.2 g/d with 0, 5 and 10 mg/kg ractopamine;  $P < 0.11$ ) and lipid deposition rates tended to decrease (619.8, 461.6, and 542.3 g/d) with 0, 5 and 10 mg/kg ractopamine, respectively,  $P < 0.10$ ).

### Introduction

Ractopamine hydrochloride, (RAC) is a  $\beta$ -adrenergic agonist that belongs to the class of chemicals that includes, for example, clenbuterol. Ractopamine hydrochloride is the active ingredient in Paylean®, widely used in the swine industry due to benefits such as increased growth rate, feed efficiency and carcass lean deposition. We (Patience et al. 2006 PSCI Annual Report) have shown improvements in growth performance and carcass quality when RAC was included in the diet at 5 mg/kg. The following experiment is part of a larger series of experiments examining the potential to utilize Paylean as a tool to reduce the environmental impact of pork production. We hypothesized that including Paylean in the diet would improve N retention, thus decrease N output in the urine and faeces of finishing swine. The specific objective in the experiment reported herein was to examine the effect of Paylean, added to the diet to supply 5 or 10 mg/kg RAC, on carcass nutrient deposition.

### Materials and Methods

A growth experiment was conducted which compared 9 different treatments. These included Paylean added to the diet to supply 0, 5 or 10 g/tonne RAC x 3 levels of dietary lysine (1.75 g/Mcal, 2.25 g/Mcal and 2.75 g standardized ileal digestible lysine/Mcal DE. Additionally, because we know that the efficacy of Paylean reaches an optimum and then decreases (Patience et al. 2009) we included two slaughter weights as an additional factor.

Diets were based on wheat, barley, and soybean meal and also contained canola oil, vitamin/mineral premix, synthetic amino acids and Paylean. All diets were formulated to contain 3,300 kcal DE/kg and formulated to meet or exceed the nutrient requirements of the finisher pig (NRC, 1998).

The experiment began when the barrows reached  $95 \pm 3$  kg bodyweight and ended when they reached a final weight of either of 108 or  $120 \pm 3$  kg. Pigs were euthanized by captive bolt stunning, followed by exsanguination; all blood was collected and returned to the carcass. The carcass was

split down the midline from the groin to the chest cavity and the entire gastrointestinal tract (GIT) was removed, emptied of digesta and patted dry. The gall and urinary bladders were also drained of contents. The emptied GIT was then returned to the carcass and an empty body weight recorded. Carcasses were ground, freeze-dried and subsequently analyzed for moisture, N, fat and ash (indicative of total mineral content).

## Results

Paylean had no effect on ADG, ADFI or G:F (Table 2;  $P > 0.10$ ). Lysine had no effect on ADG or ADFI ( $P > 0.10$ ). However, G:F increased with high dietary lysine concentration ( $P < 0.05$ ). ADFI was higher in the 120 kg slaughter weight treatment ( $P < 0.05$ ) when compared to the 108 kg slaughter weight. Slaughter weight did not affect ADG or G:F ( $P > 0.05$ ).

Paylean tended to increase protein deposition in the carcass (25 g/d increase, 0 vs 10 mg/kg RAC;  $P < 0.12$ ; Table 3), increased water deposition rate ( $P < 0.05$ ), and tended to reduce fat deposition rate ( $P < 0.10$ ; Table 3). The lowest fat deposition was observed with the 5 mg/kg RAC level (620, 462, and 542 g/d fat deposition for 0, 5 and 10 mg RAC/kg feed). Protein, but not fat deposition rate increased in response to lysine ( $P < 0.05$ ). The 120 kg slaughter weight pigs had increased deposition rates of protein, fat and water ( $P < 0.05$ ) compared to the barrows slaughtered at 108 kg however, there was no RAC by slaughter weight interaction ( $P > 0.10$ ).

**Table 1.** Ingredient composition of experimental diets (% as fed)<sup>1</sup>

SID Lys (g/Mcal DE)	1.75	2.25	2.75
<b>Ingredient, %</b>			
Wheat	59.27	54.52	47.93
Barley	30.00	31.00	32.00
Soybean Meal	6.40	10.00	15.50
Limestone	0.750	0.750	0.750
Dicalcium Phosphate	0.550	0.500	0.450
Salt	0.500	0.500	0.500
PSC Mineral Premix <sup>2</sup>	0.500	0.500	0.500
PSC Vitamin Premix <sup>3</sup>	0.500	0.500	0.500
Lysine HCl	0.135	0.250	0.310
dL-Methionine	-	0.010	0.050
L-Threonine	-	0.070	0.115
Canola Oil	1.000	1.000	1.000
Celite <sup>4</sup>	0.400	0.400	0.400
Paylean <sup>3</sup>	0.000	0.000	0.000
<b>Formulated Analysis</b>			
DE, kcal/kg	3,300	3,300	3,300
Crude Protein, %	16	17	19
Total Lysine, %	0.650	0.840	1.030
SID Lysine, %	0.580	0.750	0.850

<sup>1</sup> Each of these diets was fed with either 0, 5 or 10 mg/kg RAC added to provide 9 different treatments.

<sup>2</sup> Provided per kg of diet: zinc, 100 mg as zinc sulphate; iron, 80 mg as ferrous sulphate; copper, 50 mg as copper sulphate; manganese, 25 mg as manganous sulphate; iodine, 0.50 mg as calcium iodate; selenium, 0.10 mg as sodium selenite.

<sup>3</sup> Provided per kg of diet: Vitamin A, 8250 IU; Vitamin D, 825 IU; Vitamin E, 40 IU; niacin, 35 mg; D-pantothenic acid, 15 mg; menadione, 4 mg; folacin, 2mg; thiamine, 1 mg; D-biotin, 0.2 mg; Vitamin B<sub>12</sub>, 25 ug.

<sup>4</sup>Included as a marker for digestibility measurements.

## **Discussion**

The lack of a growth response to Paylean in this experiment is contrary to the preponderance of previous research. The response to Paylean diminishes after it has been fed for about 28 days. The average time on Paylean in these experiments was 17 and 9 days for the 120 and 108 kg slaughter groups, respectively, therefore a growth response was expected.

A response to increasing dietary lysine : DE ratio was observed. ♂ received 18.9, 23.6 and 25.8 g SID lysine per day which exceeds NRC (1998) lysine requirements. However, present day pigs may require more lysine than the NRC (1998) recommendations. Additionally, because of the improvement in lean growth with Paylean, the finishing pig's requirement for lysine increases when Paylean is added to the diet. However, if lysine was limiting the response to Paylean we would expect to see a lysine by Paylean interaction due to a greater response to Paylean at the higher lysine levels. This, however, was not observed (Table 2).

It is interesting that even though we didn't observe a growth response to Paylean we did see an increase in protein and water and a decrease in lipid deposition when Paylean was added to the diet. Overall, this would be expected to result in a leaner carcass. Moreover, the rate of protein deposition (g/d) was higher for the pigs slaughtered at 120 than at 108 kg ( $P < 0.05$ ). The opposite was seen with lipid deposition ( $P < 0.05$ ). Lean tissue is approximately 80 % water, while adipose tissue contains only about 15 % water, thus we expect increased water deposition to accompany the higher protein deposition. It should be noted that the baseline protein deposition rates in these pigs was high. This can be attributed to a multitude of factors including genetics, diet, environment or due to the slaughter process used in this experiment (entire carcass was ground). Regardless, even at the 5 mg/kg level, RAC improved protein deposition above the baseline.

## **Implications**

Although there was no response in growth rate, 5 mg/kg RAC improved protein deposition. The response to RAC may not be evident if growth rate is the only criteria measured. Lysine requirements may be higher than recommended when Paylean is used in a herd with high rate of protein deposition.

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**Table 2** Effect of Paylean, lysine, and slaughter weight on growth rate, feed intake and feed conversion in finishing barrows<sup>1</sup>

Item	Initial Body Weight, kg	ADG, kg/d	ADFI, kg/d	G:F, kg/kg
RAC (ppm)				
0	96.5	1.4	4.0	0.35
5	95.9	1.4	3.9	0.36
10	96.0	1.5	3.8	0.38
Lysine (g/Mcal)				
1.75	95.9	1.4	4.0	0.35
2.25	96.3	1.4	3.9	0.35
2.75	96.3	1.5	3.9	0.39
SEM <sup>2</sup>	0.56	0.06	0.11	0.01
Slaughter Weight (kg)				
108	95.9	1.4	3.8	0.37
120	96.4	1.5	4.0	0.36
SEM	0.52	0.05	0.10	0.01
Statistics	P-value			
RAC	- <sup>2</sup>	0.775	0.277	0.164
Lysine	-	0.232	0.783	0.029
RAC x Lysine	-	0.636	0.108	0.756
Slaughter Weight	-	0.307	0.009	0.636

<sup>1</sup> Data expressed as least square means. Data analyzed with initial body weight as a covariate.

<sup>2</sup> (-) indicates no statistics were calculated on that parameter

**Table 3** The effect of Paylean (RAC), lysine and slaughter weight on carcass nutrient deposition rates in finishing barrows<sup>1</sup>

Item	Protein	Fat	Ash	Water
	g/d		ml/d	
RAC (ppm)				
0	162.1	619.8	26.3	466.3
5	185.4	461.6	25.2	608.7
10	189.2	542.3	27.1	572.5
Lysine (g/Mcal)				
1.75	160.0	574.2	24.1	479.0
2.25	178.8	553.3	28.7	548.9
2.75	198.0	496.2	25.8	619.7
SEM <sup>3</sup>	10.77	49.68	2.18	45.80
Slaughter Weight (kg)				
108	166.1	600.1	24.2	476.7
120	191.7	482.4	28.3	621.7
SEM	9.20	42.22	1.78	38.97
Statistics	P values			
Paylean	0.111	0.055	0.837	0.050
Lysine	0.027	0.461	0.329	0.066
Paylean x Lysine	0.786	0.754	0.338	0.726
Slaughter Weight	0.027	0.029	0.109	0.004

# Evaluating Energy Usage and Various Energy Conservation Strategies for Swine Barns

B. Predicala, E. Navia

Prairie Swine Centre Inc., P.O. Box 21057, 2105 8<sup>th</sup> Street East, Saskatoon, SK Canada. S7H 5N9

## SUMMARY

Energy usage in swine barns and potential energy conservation measures were evaluated in this study. A survey of 28 swine facilities showed large variability in energy used per hog produced between barns. Energy audits conducted in four selected barns identified the various areas, equipment, and practices in the barn that contributed significantly to the total overall energy consumption, thereby aiding in prioritizing areas for intervention. Using computer simulation, various potential strategies that can be applied in a barn in terms of lighting, creep and space heating, fans, feed motor, and heat recovery were examined. Simulation results for a typical 600-sow operation showed that potential annual savings up to 47,391 kWh electricity (79 kWh/sow) or 88,404 m<sup>3</sup> natural gas (147 m<sup>3</sup>/sow) can be attained.

## INTRODUCTION

Swine production in temperate regions like Canada requires substantial energy input. With the recent upward trends in energy prices, the cost of energy input to swine operations have been steadily rising such that for many operations, utilities now represent the third largest variable cost component of the total cost of production. The goal of this work is to assess the current energy usage and examine energy conservation measures that can improve the energy use efficiency in swine production operations, thereby reducing overall energy costs.

## EXPERIMENTAL PROCEDURES

A survey questionnaire was developed and sent out to various swine producers to collect pertinent data from each operation over the past 3-year period to be able to calculate the average monthly utility cost per animal marketed (\$/pig marketed) for each operation.

Based on the survey results, two barns which used the most energy per hog produced and two which used the least energy were selected for energy audits and monitoring of actual energy consumption during winter and summer seasons.

Following the barn monitoring, a mathematical model which simulated the energy use in a typical barn operation was developed based on fundamental principles of heat transfer, thermodynamics, and other engineering concepts. The model was applied to a typical 600-sow operation to simulate the theoretical energy consumption in the barn based on the building properties, climatic factors, barn management and practices, number and growth stage of animals, and equipment used in the barn. The baseline model was validated by comparing the predicted energy consumption in different operations within the barn with actual values obtained from barn monitoring. Finally, a number of potential energy conservation strategies were incorporated into the model and the projected energy savings resulting from each measure were calculated.

## RESULTS AND DISCUSSION

### *Benchmarking results*

Table 1 shows the range and average values of utility cost per animal marketed (\$/head) based on the three-year information obtained from the survey. The average utility cost between types of barns were significantly different ( $P < 0.05$ ) for all comparisons except between grow-finish and farrow-wean barns ( $P > 0.05$ ). The survey results also showed almost 4x difference in energy consumption (per head) between the lowest and highest energy user barns. This indicated significant opportunities for improving energy use practices in some barns in order to reduce overall energy costs.



Monitoring of energy use in the four selected barns showed that the grow-finish rooms had the highest contribution to electrical energy consumption in the barn during summer months followed by farrowing, nursery, and gestation. The high energy consumption in the grow-finish area can be explained partly by the relatively larger footprint of this part of the barn compared to the other production stages in a typical farrow-to-finish operation and to the lower temperature set-point in grow-finish rooms (which meant all fan stages were operating almost continuously at full capacity during warm months). During winter, the highest natural/propane gas consumption was observed in nursery rooms followed by the grow-finish and farrowing rooms. This can be attributed to the high temperature set-point in nursery rooms relative to other production rooms. The gestation room had the lowest gas energy consumption because the heat generated by the sows was adequate to maintain the room at its set-point temperature.

**Table 1. Results of benchmark survey of utility cost per animal marketed in different types of barns.**

Type of barns	Size range	No. of barns, n	Utility cost per animal marketed			
			\$/head pig sold		\$/100-kg pig sold	
			Range (min – max)	Average (SD)	Range (min – max)	Average (SD)
Farrow-Finish	300 to 1,500 sow	9	3.0 - 12.0	6.8 (3.41)	3.5- 12.0	6.56 (3.05)
Farrow-Finish (excluding feedmill)	300 to 2,000 sow	7	3.8- 13.0	6.5 (2.98)	6.0- 11.5	6.75 (2.31)
Grow-Finish	10,000 to 40,000 feeders/weanlings	6	1.3-2.1	1.7 (0.58)	1.2-2.6	1.7 (0.74)
Nursery	130,000 to 140,000 feeders/weanlings	2	0.5-0.7	0.6 (0.12)	1.7-2.2	2.0 (0.41)
Farrow-wean	150 to 1,200 sow	4	0.8-4.3	1.9 (1.64)	8.2- 17.8	12.2 (4.67)

Ventilation plays an important role in keeping the environment of the pigs at a level where production performance is optimized. The results of this study showed a medium to high negative correlation (i.e. -0.6 to -0.9) between the fan energy consumption and concentrations of NH<sub>3</sub>, H<sub>2</sub>S and CO<sub>2</sub> gases which are indicators of indoor air quality. This correlation indicated the need for careful consideration of conservation measures to reduce energy cost so as not to compromise the health of workers and animals the barn.

### Simulation results

Simulation of the baseline case and the cases in which energy-conservation strategies were applied showed that significant energy savings can be attained in the areas of ventilation and heating as shown in Table 2. Using higher efficiency fans can reduce electrical energy consumption by 21% while the natural/propane gas consumption can be reduced by 70% using a heat recovery system (i.e. air-to-air heat exchanger). Furthermore, replacing conventional space heaters with gas-fired radiant heaters can reduce the gas consumption by 40%. Applying conservation strategies to other areas such as recirculation fans, feed motors, lighting, and creep heaters can reduce energy consumption by 12% and 20%, 26%, and 39%, respectively.

**Table 2. Average annual energy savings associated with different energy-saving strategies.**

Areas	Average energy savings	
	kWh/yr	kWh/yr/sow
1. Lighting (from T12 to T5 fluorescent)	25, 957	43
2. Creep Heating (Heat lamps to Heat pads)	47, 391	79
3. Recirculation fan (High efficiency motor)	9,872	16.4
4. Exhaust fan (High efficiency motor)	42, 501	71
5. Feed motor (High efficiency motor)	1,846	3.1
6. Heat recovery (air-air heat exchanger)	88, 404 m <sup>3</sup> /yr	147 m <sup>3</sup> /yr/sow
7. Radiant heater (propane gas-fired)	52, 707 m <sup>3</sup> /yr	87.8 m <sup>3</sup> /yr/sow

## CONCLUSIONS

Benchmarking showed that the average utility cost (electricity and gas) per animal marketed is about \$6.80/head, but can be as high as \$12.0/head for some types of operations. Energy audits identified areas and operations in the barn such as ventilation and space heating in the grow-finish and nursery rooms as significant contributors to the overall energy consumption in the barn. Examination of a number of energy conservation strategies using computer simulation quantified the potential impact of the application of each measure on the overall energy use. Simulation results also identified the most promising measures that would merit further evaluation under actual swine barn conditions. Overall, the findings from this study would aid pork producers in focusing on specific areas and practices in the barn and in prioritizing conservation strategies to be considered for implementation, which would result in the most significant energy savings.

## ACKNOWLEDGEMENTS

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## **Temperatures Within a Truck Transporting Pigs During Winter and Summer Months in Western Canada**

Hayne, S.<sup>1</sup>, T. S. Samarakone<sup>1</sup>, T. Crowe<sup>2</sup>, S. Torrey<sup>3</sup>, R. Bergeron<sup>4</sup>, T. Widowski<sup>4</sup>, N. Lewis<sup>5</sup>,  
C. Dewey<sup>4</sup>, L. Faucitano<sup>3</sup> and H. W. Gonyou<sup>1,2</sup>

<sup>1</sup>Prairie Swine Centre Inc., P.O. Box 21057, 2105 8<sup>th</sup> Street East, Saskatoon, SK S7H 5N9,

<sup>2</sup>University of Saskatchewan, Saskatoon, SK, <sup>3</sup>Agriculture and Agri-Food Canada, Lennoxville, PQ,

<sup>4</sup>University of Guelph, Guelph, ON, <sup>5</sup>University of Manitoba, Winnipeg, MN

### **SUMMARY**

This study investigated the temperatures within a truck transporting pigs in western Canada, during summer and winter months. Pigs were transported from PSC Elstow Research Farm, and involved approximately 8 hours of travel to the Maple Leaf plant in Brandon. The temperature conditions pigs were exposed to during transport varied considerably between seasons and among compartments within the vehicle, and pigs were exposed to temperatures as low as -15°C or as high as 30°C.

### **INTRODUCTION**

Transportation, which is an unfamiliar and threatening episode in an animal's life, is one of the most critical periods in pig handling before slaughter. It involves economic losses due to deaths, 'suspect' animals on arrival at the processing plant, and reduced meat quality. Death losses during transportation in Canada are reported to range from 0.05 to 0.17%, which accounts for approximately 16,000 pigs per year. Losses are reported to be higher in summer and vary among compartments within a truck. However, little is known about micro-environmental conditions that develop within compartments during transportation and its relationship to pig welfare and quality of meat. As part of a larger project on handling and transport of pigs, we examined the temperature conditions in trucks to determine if differences exist among compartments during summer and winter months.

### **EXPERIMENTAL PROCEDURE**

All animals used in the study were market animals weighing approximately 115 kg. Animals included both males and females and were assembled from multiple pens. The pigs were transported from the PSC Elstow Research Farm to the Maple Leaf plant in Brandon and it involved approximately 8 hours of travel. Pigs were loaded in the evening and transported overnight to arrive at the packing plant at 6 am. Trials were conducted in both winter and summer months and the range of outdoor temperatures encountered were 7.7 to 22.9°C for summer and -24.5 to -3.8°C for winter. The truck used for transportation was a dual (cattle and pigs) purpose, pot-belly trailer. Compartments in the upper deck were numbered from 1, at the front, to 4, at the back and in the middle it was numbered from 5 to 8 (front to back). The bottom was numbered from 9 at the front, to 10, at the back. Compartment 6 was not used due to load limitations. Loading density was 0.41 m<sup>2</sup>/pig. Eleven loads of 195 pigs (six loads in the summer and five loads in the winter) were used in the study. The temperature and humidity within each compartment were measured using iButtons. Five iButtons per compartment were mounted 5-6 cm below the ceiling. These were positioned in the centre of the compartment, and 15 cm in from the centre of each wall of the compartment. The values of temperature and humidity were recorded at 5 minute intervals. Temperatures reported here represent the mean of all five sensors within each compartment. Temperatures were determined at the time each compartment was filled with pigs (loading), at the time the vehicle left the farm (departure), at arrival at the processing plant (arrival), and at the time of unloading of each compartment (unloading).

## RESULTS AND DISCUSSION

There were significant differences between summer and winter truck temperatures for all time periods assessed (Table 1). The temperatures were highest during loading and at departure from the farm, and then cooled during transport. In the summer temperatures tended to increase while waiting to unload, however, they decreased in the winter.

**Table 1.** Average temperatures at the time of loading, departure from the farm, arrival at the processing plant, and unloading for summer (6 loads) and winter (5 months) months

Season	Loading	Departure	Arrival	Unloading
Summer	20.3*	21.7*	15.0*	19.1*
Winter	11.8	12.3	1.6	-1.8

\* indicates a significant difference between summer and winter ( $P < 0.05$ ).

The temperatures within each compartment of the truck during summer and winter trials are presented in Figures 1-4. At the time of loading, during the winter, compartment 5 was considerably colder than the rest, with compartments 9 and 10 being intermediate. Compartment 5 is at the front of the truck and its divider is relatively solid. Warm barn air being ventilated through the truck 30 minutes prior to loading in winter does not effectively reach this compartment. The compartment is generally the first to be loaded, and is considered to be difficult to fill. The very cold temperatures that exist here in the winter may add to the difficulty. Compartments 9 and 10 are also likely to be poorly ventilated during the warming period, but they are not loaded until the entire upper deck has been filled. By this time the heat from the pigs has warmed the trailer considerably. By the time of departure, the compartments in the middle deck and compartment 10 were the warmest in both summer and winter. All of these compartments have pigs immediately above them, and compartments 7 and 10 have low ceilings. These factors would contribute to their warming from the heat of the pigs.

By the end of the journey, temperatures in all compartments had decreased significantly. In both seasons the middle and the bottom decks remained the warmest. The temperatures in the top deck fell below freezing during the winter. These decks had no pigs above them to warm the ceiling and heat loss through the roof was likely considerable. Between arrival at the plant and unloading, approximately 30 minutes in these trials, the truck is stationary and the compartments warm up in the summer. The hottest temperatures are seen in compartments 5 and 10. Compartment 5 has relatively poor ventilation as the front of the compartment is solid. It also is immediately above the tractor drive wheels and transmission which will be dissipating heat. Compartment 10 is also poorly ventilated and has a low ceiling. During the winter the temperature in the warmer compartments decreases during the waiting period prior to unloading. This is surprising as we could assume that heat loss would be greater while the truck was in motion. It may be that pigs begin to arouse themselves during this stationary period and this facilitates heat loss from the compartment.

Figures 5 and 6 indicate patterns of temperatures within each compartment during the first 90 minutes of travel during warmest summer and coolest winter days. Within 30 minutes of travel the pattern of temperatures seen at the time of arrival at the packing plant has become evident. All the compartments cool somewhat, however, the compartments in the upper deck and compartment 8 (rear, middle deck) are the coolest during travelling. During the coolest day of travel, temperatures in the 'cool' compartments averaged  $-10^{\circ}\text{C}$ , with that in compartment 3 going below  $-15^{\circ}\text{C}$ .

## CONCLUSION

The temperature conditions pigs are exposed to during transport vary considerably between seasons and among compartments within a vehicle. It may be possible to better standardize these temperature variations by changing ventilation and insulation values in each section/compartment of the trailer. The results found in this study will provide direction for important studies in the future.

## ACKNOWLEDGEMENTS

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Figure 1. Temperatures at Loading

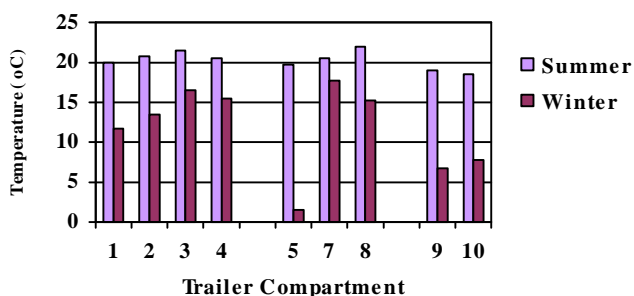


Figure 2. Temperatures at Departure

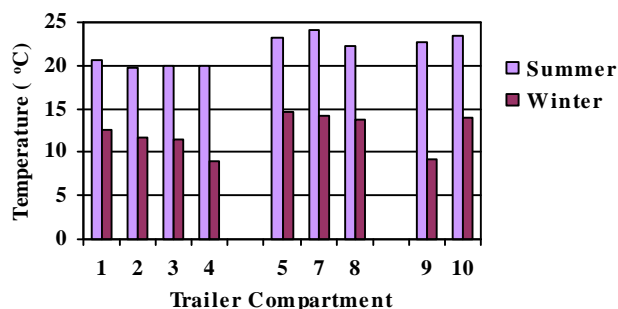


Figure 3. Temperatures at Arrival

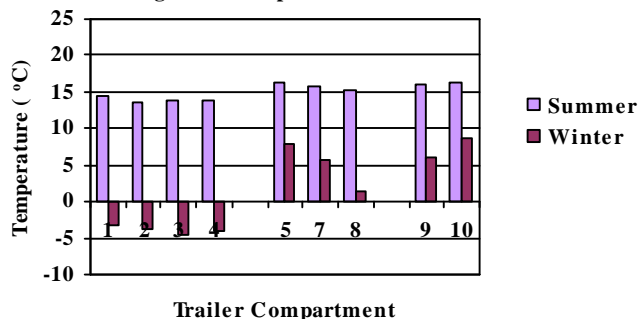
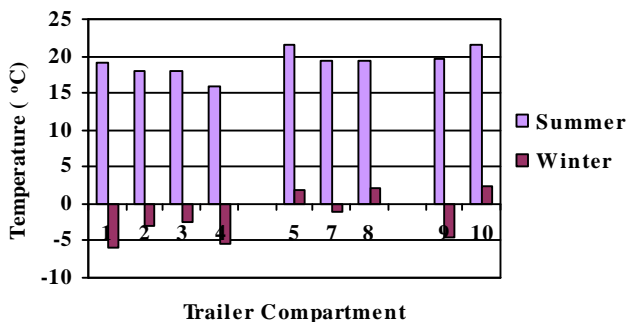


Figure 4. Temperatures at Unloading



Figures 1 - 4. Temperatures at loading, departure, arrival and unloading of each compartment during winter (5 loads) and summer (6 loads).

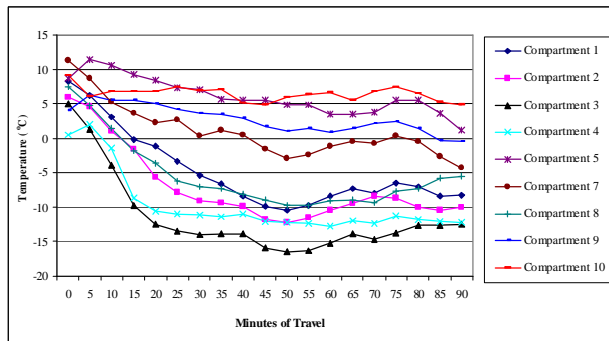
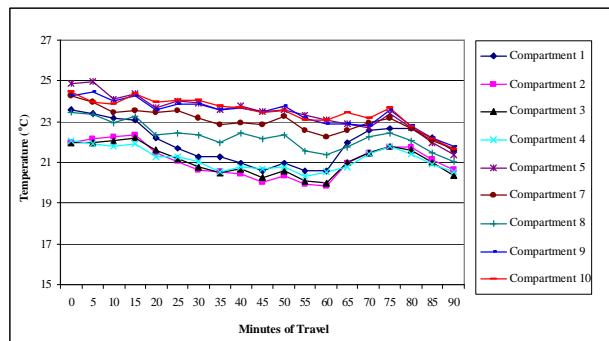


Figure 5 and 6. Compartment temperatures during the first 90 minutes of travel in a warm summer and cooler winter day.