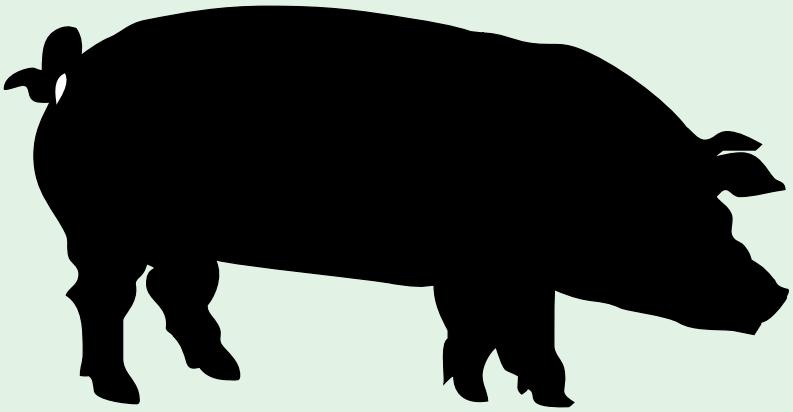
28th Annual



CENTRALIA SWINE RESEARCH UPDATE

January 28th, 2009

CentraliaSwineResearch.ca

In Memory of Andy J. Bunn

Andy J. Bunn passed away on Oct 2, 2008 in his 81st year. Andy was one of the original Swine Specialists with the Ontario Ministry of Agriculture and Food. Andy officially retired in July of 1993 after serving in that position for 24 years. He continued to be involved with industry events for several years after. Andy left many hallmarks in the Ontario swine industry with the most notable being the Pork News and Views newsletter which is now in its 35th year.

The origin of this newsletter started in 1972 as an information letter that Andy sent to selected County Agricultural Representatives. In May 1973 Andy sent it to the pork producers in the counties of Essex, Kent, Elgin, Lambton, and Middlesex. The present "Monthly Swine Budget" first appeared under the title "Current Feed Costs & Calculated Returns" in January of 1974.

Andy was also a strong advocate for producers and worked on many popular swine events such as the Ontario Pork Congress, Centralia Swine Research Update and the Southwest Pork Conference. He volunteered graciously to do the work most would pass on. In 1993 he received the Ontario Pork Congress "Swine Industry Leadership Award".

He was a very skilled and avid writer for OMAF, editing several factsheets, progress reports and industry position papers. Andy was always a defendant of the swine industry by never hesitating to provide the appropriate statistics and information to set the record straight. Only his compatriots will know his feistiness at board meetings to support the little guy. Many times Andy never got credit for his achievements and that's just the way Andy preferred it. In his last Pork News & Views article he signed off with this…

> *"I shall pass through this life but only once.*
> *If there is any kindness I can show or any good I can do any fellow being,*
> *Let me do it now, for I shall not pass this way again.*
>
> *Andy J. Bunn, Swine Specialist, OMAF London"*

CENTRALIA SWINE RESEARCH UPDATE

Kirkton-Woodham Community Centre
January 28, 2009

Adjourn

WRITTEN-ONLY TOPICS

ACKNOWLEDGMENT

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PRRS Interventions Study

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Introduction

Emergence of PRRS in early 1990's changed the way we look at infectious diseases in the swine industry at the global level. Although prevalent since then, new strains are constantly emerging. Strains that appeared in 2004 seemed to have high virulence, increasing the devastation caused by the disease. Once a herd is positive, numerous intervention strategies could be considered in order to contain clinical outbreak and minimize losses due to PRRS. However, quantitative data to show benefits of intervention strategies under a variety of scenarios are lacking. The objective of this project was to assess production and economic parameters for intervention strategies typically used in Canadian sow herds and taking uncertainty in production and economic parameters into account. This objective was addressed in close cooperation with OSHAB (Ontario Swine Health Advisory Board).

Methods

Swine veterinarians in Ontario and Quebec were contacted and asked to provide computer records from sow herds that experienced PRRS outbreaks between January 2004 and 2008. This initial period is now extended to the end of 2009. They were also asked to fill a questionnaire with demographic information and data about diagnostic data before and during outbreak, as well as about intervention and its cost. Computer data were extracted and collapsed by week and duration of outbreak was determined using outbreak detection algorithm. After that, production parameters were determined: (i) during outbreak, (ii) 6 months before the outbreak, and (iii) 6 months after the outbreak. For each herd, the average number of pigs weaned per week during outbreak and 6 months after outbreak were compared with the production of during 6 months before the outbreak. Data were examined using descriptive statistics, deterministic partial budget model was built for all interventions. Stochastic partial budgeting model using Monte-Carlo simulations was built for interventions that had at least five cases.

Results and conclusions

At the time of writing we had 25 outbreaks that were completely extracted and analyzed with the following frequency distribution in each category: (i) no intervention (n=7, 28%), (ii) early homologous exposure (n=1, 4%), (iii) late homologous exposure (n=5, 20%), (iv) homologous exposure and Tilmicosin (n=3, 12%), (v) Tilmicosin alone (n=7, 28%) and, (vi) vaccination with commercial vaccine (n=2, 8%). Currently, 60% of processed data is coming from Quebec and 40% from Ontario.

With respect to production parameters, duration of outbreak on-average was 13 weeks in the no intervention, 10 weeks in the late homologous exposure, 17 in the homologous and Tilmicosin, 16 in the Tilmicosin group alone, and 22 weeks in the commercial vaccination group. Drop in the number of pigs weaned per week during outbreak was proportionally largest in the no-intervention group (on average 69% of the pre-outbreak level), followed by late homologous exposure (29% of the pre-outbreak level). Homologous and Tilmicosin (84%), Tilmicosin (88%), and vaccination (91%) had lower drop in production parameters. Interestingly, the average production during six months after outbreak was declared over was still lower in the no-intervention strategy group (93% of the pre-outbreak level) and homologous exposure (95%), whereas it returned on the pre-outbreak level in the homologous and Tilmicosin, Tilmicosin, and vaccination group. This needs to be interpreted with

great caution as estimates were based on very small number of herds in each intervention strategy and we need to have more data available and analyzed in order to be able to draw more accurate conclusions.

With respect to intervention cost, we could divide interventions into three categories: (i) no intervention that served as a baseline comparison group in our economic model, (ii) inexpensive strategies – homologous exposure, where the cost per sow was marginally higher than in the no intervention group, (iii) costly intervention strategies where cost per sow was much higher than in the no intervention group (Tilmicosin strategies and commercial vaccination). What needs to be pointed out is that cost of intervention in each group was summation of all medications and biologicals concurrently used during intervention.

With respect to production and economic parameters that are based on stochastic model and three intervention strategies (no-intervention, late homologous exposure and Tilmicosin) we draw several conclusions. Firstly, no intervention strategy yielded most dramatic production and economic loses and under our scenario was the worst decision. Secondly, late homologous exposure had higher benefit/cost ratio (% return; mostly due to lower initial cost), but had lower revenue than Tilmicosin group. In addition, approximately 30% of the time the homologous exposure intervention was expected to show results that are no better than in the no-exposure group. Although the Tilmicosin group yielded higher revenue, 10% of the time it was expected to be no better than no intervention strategy.

In order to be able to provide better information we would encourage industry to include any new outbreak (as well as retrospective outbreaks that are not currently in our dataset) by providing us with computer records and cost information. The project is continuing throughout 2009.

Acknowledgements
This is a joint project between the Department of Population Medicine of the University of Guelph and Ontario Swine Health Advisory Board. The project is financially supported by the Agricultural Management Institute. We are grateful to veterinarians and producers who supported this project by providing data and to PigCHAMP and Herdsman who provided license to use their software for this project.

Ontario Swine Veterinary-based Surveillance (OSVS) Project – An update

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Introduction and background

There is a strong interest in developing reliable surveillance systems to provide "early warning" systems to identify outbreaks of disease in animal populations. Practicing veterinarians play an important role in detecting the initial cases of novel infectious diseases or changes in the incidence of specific syndromes (e.g respiratory disease and mortality) that may provide the first warning of an outbreak, allowing more rapid and efficient collection of diagnostic samples and implementation of disease control strategies.

The objective of this project was to determine the feasibility of a swine practice-based surveillance system and to make recommendations for longer term implementation for syndromic animal health surveillance in a sentinel veterinary-practice system. Currently the program is continuing to record the occurrence/incidence of different syndromes as reported by practitioners to identify any increases in rates of disease after months of reference data have been collected.

Methods

Seven veterinarians from five clinics have recorded information and transmitted data from July 1st, 2007 to December 31st, 2008. The practitioners are summarizing the number of farm visits and calls according to the body system affected and in what manner production is being affected. Epidemiological data and information on treatment response is also recorded. Methods of collection of data involved either paper forms, or an electronic version of the form designated for Palm®, a personal digital assistant (PDA). Currently an internet-based form linked through a web-page with different levels of access to other OSVS reports has been created (Available at: http://www.ontarioswinesurveillance.com/).

The evaluation of the program was performed during a pilot phase of the study from July 1st, 2007 to June 31st, 2008. The evaluation was based on compliance among practitioners, the completeness of the data recorded, the coverage of the system, and timeliness. To estimate the level of compliance among practitioners, the OSVS calculated the weekly ratio of the OSVS submissions to submissions made by the same veterinarians to the AHL. Completeness of data was assessed by measuring the frequency of data entered for each of the form's fields/elements of the questionnaire. The coverage of the program was assessed by determining the proportion of farms visited by practitioners compared to the number of farms registered in the Canadian Agricultural census of 2006 in each agricultural region of Ontario. The evaluation of timeliness was evaluated by calculating the difference between the date when the practitioners recorded the case and the date when the information was transmitted to the program coordinator.

The OSVS group has continued receiving information from practitioners and has looked for trends of syndromes on a monthly basis up to December 2008. If an increase in the incidence of a syndrome (cluster of disease) is found, then we will support veterinarians within the network to carry out investigations determine if there is a problem of public or swine health significance.

Results

Compliance

A total of 1,611 records were obtained during the pilot study. The overall quality of compliance was poor for the first three months of the project (Figure 1). However, similar analyses for individual veterinarians indicated that compliance was variable among veterinarians and the month when the submissions were made.

Completeness of data

The completeness of fields that were requested for all records (such as farm codes, postal codes, whether the call was related to a farm visit or a phone call, whether the visit was related to disease investigation or a routine monitoring visit and the type of production) ranged from 82-99% . A total of 948 records related to a

disease visit. Categories of production parameters affected and body systems affected were commonly reported. The fields with the lowest level of completeness in a disease report were the level of mortality (132 records) and if submissions were made to the Animal Health Laboratory (212 records).

Coverage of the OSVS program

The coverage of the OSVS program compared to the Canadian farm census data of 2006 is represented in Table 1. An increase in coverage of 4% was observed from June 2008 to December 2008 (updated data).

Timeliness

The average time to availability of data was 22.3 days. The time to availability of data from PDA users was shorter (3 days) and less variable than those completing the paper forms, however, high variation among veterinarians and months were observed. Practitioners found it difficult to complete free-text fields with the PDA. To improve timeliness, we have harmonized the data required for the OSVS program with the current recording or billing system/forms of four clinics and animal technicians have been involved in the transmission of the data. Currently we are obtaining OSVS data on a weekly basis from most practitioners.

Trends of syndromes and disease clusters

A total of 2,251 records were received by the program from July 1, 2007 to December 31, 2008. A total of 1,549 records were associated with farm visits and 702 with phone calls. A total of 997 visits/calls were related to disease problems and 1,254 with routine monitoring visits, however in 314 routine monitoring visits, a disease case was recorded (Figure 2). An electronic newsletter including the counts and percentages of body systems and production parameters affected is sent within the network on a monthly basis. In general, disease and routine submission counts increased during the winter months. An increase in respiratory, abortions and reproductive parameters counts and increase in morbidity and mortality were also observed in the winter months (Figures 2-3). Peaks of visits/calls related to nervous, integument-senses, and digestive categories showed peaks in the winter-spring period (Figure 4).

The OSVS program has identified several disease clusters. While many clusters required no additional investigation, one cluster identified between January 9, 2008 and January 30, 2008 involving the overlap of 17 cases farms with treatment failure and 7 case farms with respiratory problems was epidemiologically significant. During a practitioner's follow-up investigation of one of these farms, an unusual strain of Actinobacillus pleruopneumoniae (App) was identified.

Discussion

Swine disease outbreaks associated with swine influenza H3N2 virus, new strains of PRRS virus and porcine Circovirus Type 2b were reported in 2005 in Ontario. The presence of these outbreaks increased the interest of investigating options for improving swine surveillance. Practicing veterinarians are in close contact with livestock and producers. Consequently, they play an important role in detecting the initial cases of novel infectious disease or changes in the incidence of specific syndromes that may provide the first warning of an outbreak, allowing more rapid and efficient collection of diagnostic samples and implementation of disease control strategies. Our study showed that it is feasible to administer a swine veterinary-based surveillance system that is acceptable to practitioners, and can produce useful surveillance data from a large amount of farms. However, methods to assess different aspects of this veterinary-based surveillance program are being established to improve its performance. The OSVS program is currently investigating different approaches to improve compliance and timeliness.

Recording data through practitioners has permitted the monitoring of temporal and geo-spatial trends in the incidence of syndromes that affect the swine population in Ontario. We think that in subsequent years, if we continue collecting data, we will be able to determine whether the patterns observed during the study period are repeated and whether these patterns are associated with different pathogens, production systems, and/or environmental conditions.

Acknowledgements
We would like to acknowledge the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) and the Food Safety Initiative of the Canadian Food Safety & Quality Program of the Agriculture Policy Framework for financial and technical support.

Figure 1. Ratio of total cases submitted to the Ontario Swine Veterinary-based Surveillance System (OSVS) and the Animal Health Laboratory (AHL) (July 2007 – June 30, 2008).

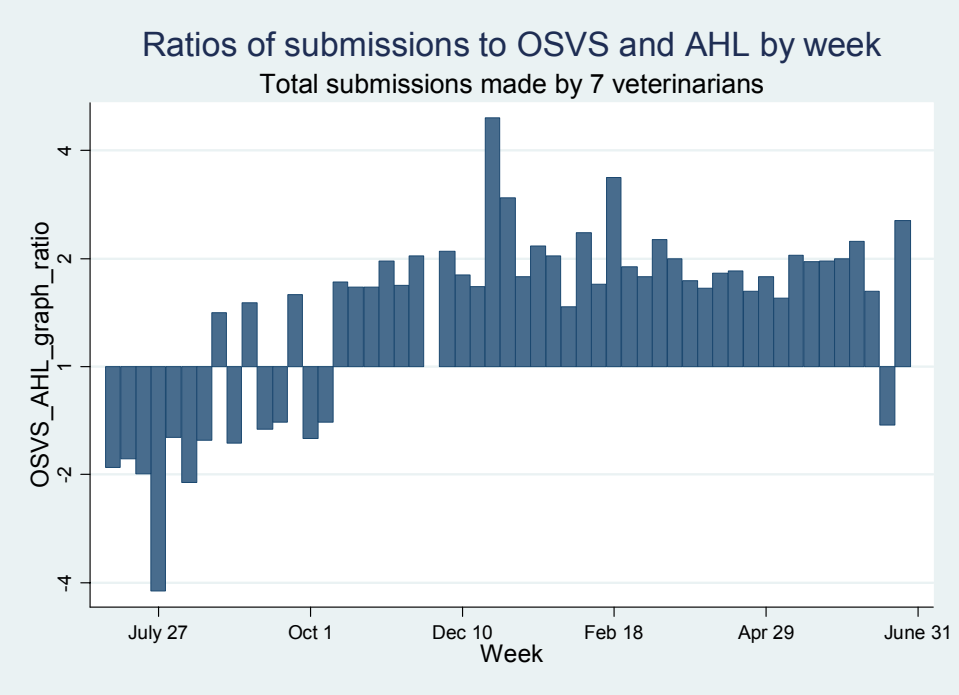


Table 1. Proportion of farms covered by the OSVS project compared to the Agricultural census of 2006 during the pilot study (July 2007- June 2008) and updated data up to December 31, 2008 by agricultural regions in Ontario.

	Total number of farms by region. Census 2006	**Number and proportion of OSVS farms visited up to June 31, 2008**		**Number and proportion of OSVS farms visited up to Dec 31, 2008**		**Frequency of calls by region (Dec 31, 2008)**
Geographic area		**Number**	**Proportion**	**Number**	**Proportion**	
Ontario	2,222	524	23.6	613	27.6	2152
Southern Ontario	823	229	27.8	267	32.4	981
Western Ontario	1,274	260	20.4	309	24.2	990
Central Ontario	62	24	38.7	24	38.7	129
Eastern Ontario	52	11	21.1	13	25	52
Northern Ontario	11	0	0	0	0	0

Figure 2. OSVS counts of respiratory, reproductive, and reproductive parameters affected by month.

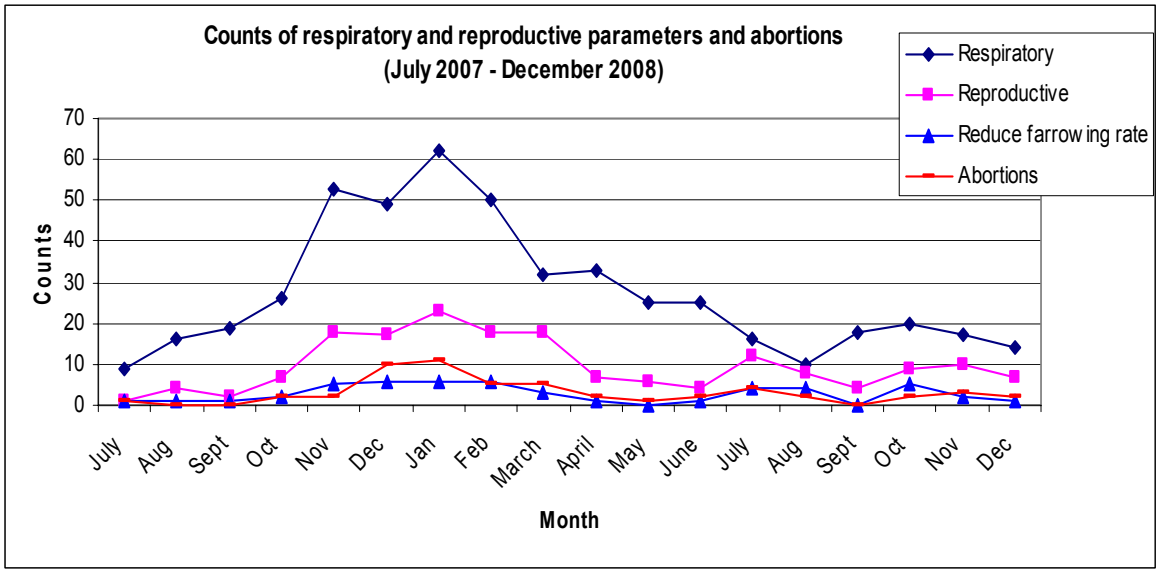


Figure 3. OSVS counts of increase in morbidity and mortality cases by month.

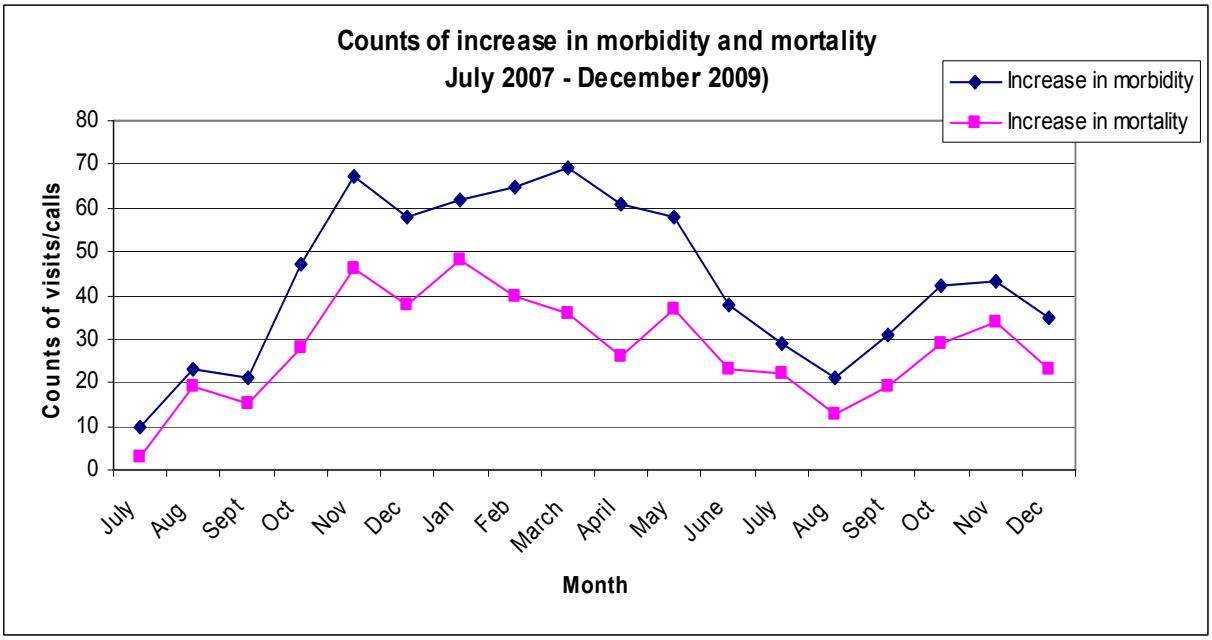
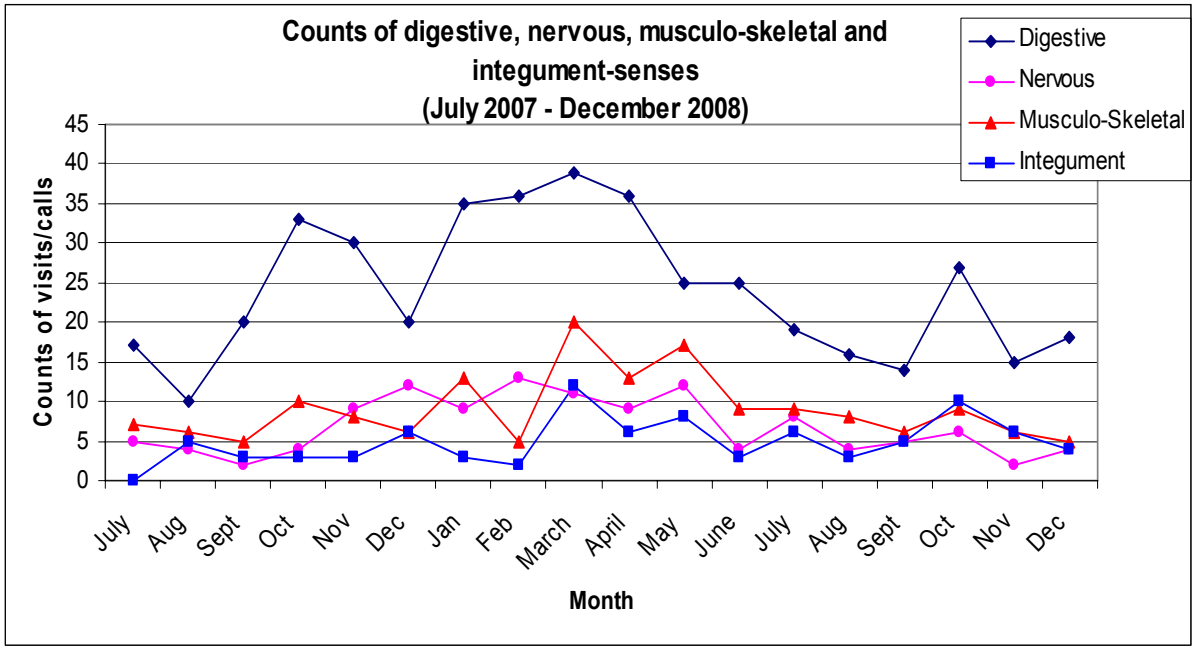


Figure 4. OSVS counts of digestive, nervous, musculo-skeletal and integument senses cases by month.



Foodborne Pathogens Linked to Pork and Significance to Food Safety

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In recent years there have been several high-profile foodborne illness outbreaks within the US and Canada which has made food safety the most significant issue facing today's food industry. In the summer of 2008 there was a major listeriosis outbreak linked to contaminated deli meats that resulted in 53 confirmed clinical cases and 20 deaths. Within the University of Guelph, there were two *Escherichia coli* O157:H7 outbreaks in 2008 and of course the major *Salmonella* outbreak in the US that was linked to tomatoes then subsequently peppers. Media reports would suggest that the food industry is in crisis which has negatively affected consumer perceptions and markets (domestic and international). Pork has been linked to a number of different human pathogen types and is considered as a high risk food. Pigs are very closely related to humans including their susceptibility to disease causing pathogens such as *Salmonella, Campylobacter* and *Listeria monocytogenes.* Therefore, control of human pathogens is not only important for food safety but also for the wellbeing of the pig herd.

In the following presentation a brief overview of the human pathogens linked to pigs will be provided with specific focus on *Salmonella, Listeria monocytogenes*, *Campylobacter jejuni* and *Yersinia enterolitica*. Pigs can also host parasites such as *Giardia*, *Cryptosporida* and *Ascaris*, in addition to viruses such as swine influenza which can be potentially passed human-to-animal or animal-to-human. In addition to the traditional foodborne human pathogens, pigs have also been linked to methicillin-resistant *Staphylococcus aureus* (MRSA or flesh eating bug) and *Clostridium difficile* both of which are normally associated with health care acquired infections. Despite MRSA and *Cl difficile* being highly prevalent in pig herds (Table 1) the significance of pork as a vehicle for either pathogen remains unclear. Nevertheless, there is evidence that both MRSA and *Cl difficile* can be passed from pigs to farms workers who can disseminate the pathogens further through person-to-person contact.

The prevalence of different pathogens within Ontario pig herds is relatively high especially with respect to *Salmonella*, *Yersinia* and *Campylobacter* (Table 1). Yet, the actual number of foodborne illness cases linked to pork are relatively low (Table 2) with other meats such as poultry or beef representing higher food safety risks. Despite the low incidence of foodborne illness linked to pork there are incentives to reduce the prevalence of pathogens within pig herds especially in terms of I) protecting export markets, II) enhancing herd health, III) reducing the dissemination of pathogens into the environment via manure disposal and IV) further reduce the incidence of foodborne illness linked to pork.

Table 1. The carriage of human pathogens within pigs or Ontario pig farms

Pathogen	Prevalence
Bacteria	
Campylobacter coli	87% (pigs)
Campylobacter jejuni	20% (pigs)
Clostridium difficile	28% (farms)
E. coli O157:H7	0% (farms)
Listeria monocytogenes	0.-9% (farms)
Salmonella	11% (pigs)
Staphylococcus aureus (MRSA)	20-28% (pigs)
Yersinia enterolitica	21% (pigs)
Parasites	
Giardia,	9% (pigs)
Cryptosporida	9% (pigs)

Table 2 Foodborne illness outbreaks within Canada linked to pork 1990-1997.

Pathogen	Outbreaks Linked to Pork	Total outbreaks
Salmonella	23 (3%)	789
Campylobacter	1 (2%)	41
E. coli O157:H7	1 (1%)	98
Staphylococcus aureus	14 (19%)	73
Yersinia	3 (100%)	3

Lameness as a Welfare and Productivity Concern

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Pork producers are faced with the plethora of demands, conditions and opportunities. Demands, by my definition, are those requests from the marketplace for different methods of production or qualities of product that hopefully have with them a financial benefit. Conditions are superimposed upon the industry and usually do not have financial benefit but are a pre-condition of sale. Finally, opportunities not only are in meeting demands but in modifying production methods and costs to create benefit.

Lameness is an interesting area to analyze in this manner. For dairy cattle welfare standards often the control of lameness is the preeminent demand from the marketplace to improve the welfare of dairy cattle. A number of audits spend a great deal of time focusing on the control and reduction of lameness. This is in concert with a large body of literature that shows that lameness control is also an opportunity as dairy cows produce more and are retained in the herd longer when the prevalence of lameness is lower. Finally, lameness is becoming a condition under which marketing of cull animals is limited.

In sows the story is quite different. Lameness has taken a relatively low position on the range of concerns of swine welfare. This has been reflected in a small proportion of audits that emphasize sow lameness. The literature is also very limited, with few studies on the subject beyond its relationship with culling, or the existence of osteochondrosis. The relationship between lameness and productivity has a limited description and often it is assumed that the only management requirement is to eliminate these sows from the herd.

So why the big difference between sows and cows? There are a few alternatives, but none are that attractive:

- There is less lameness in sows. This does not appear to be the case, as quite often we are finding prevalences of lameness at entry into the farrowing crate at approximately 20%, which is higher than often estimated in dairy herds.

- Lameness does not have as large an effect upon a sow as on a cow. This should also be questioned as the behavioral responses are similar, with a lack of willingness to walk, limping, and reduced feed intake being common to both. It is true that we do not have the estimates of effect upon productivity commonly available, but this does not preclude the fact that productivity insults can be similar.

- We do not see lameness as easily in sow herds. This can be partially true as in herds using gestation stalls there are a few opportunities to witness the extent of lameness through gait analysis.

- The causes of lameness are different in sows than cows and therefore cannot be controlled as easily. The main focus in cow lameness has been the condition of the claws. Claw lesions are very common in sows as well but have not been associated with lameness with as much detail. This is probably due to the fact that claws are rarely examined and mechanisms are rarely in place to record claw lesions.

- Sows have bigger welfare concerns than lameness. Gestation housing has been a major focus, but this has not been validated as the major concern to the sow. I would argue that if a welfare condition is identified, at least in part, by adverse behaviors lameness would be a higher concern to the sow and to the producer

The above points are fair points, but I think a major reason for ignoring lameness in sows is that we haven't measured it and studied it and therefore don't know how to control it. It is much more comfortable to ignore something when we don't know what to do with it. Secondly, I think we have consistently underestimated the cost of the disease.

Understanding lameness means that we need to understand what happens to the sow after a lameness event starts. We recently completed a study where we followed 700 sows entering the farrowing crate. Each sow was evaluated for lameness and we then compared the subsequent performance for the following year.

Our first observation did not surprise us. Sows were culled at a higher rate if they were lame and therefore survivability was a problem. This is often recorded in our record-keeping systems as the proportion of sows that are culled due to lameness. However this number was bigger than simply that proportion. We also found sows that were not culled due to lameness but instead were culled due to reproductive problems. We found that a proportion of sows that had, as the root problem, a lameness problem. However, it was buried under subsequent reproductive inefficiencies.

It is actually these reproductive inefficiencies that we have found to be the major problem associated with lameness. It is the lame sows that are retained and fill a sows space with an under-producing animal that is the major concern. Table 1 exhibits our estimates of economic losses associated with a single diagnosis of lameness in a sow entering the farrowing crate. Salvaged values are decreased as the value of these sows is less and more of them die. Replacement costs are higher as longevity is decreased. The quality of output decreases as the progeny are more susceptible to crushing and lower growth rates. However, the big number is simply the fact that, in our study, sows with the prior diagnosis of lameness produced approximately 40% less in that sows space.

Table 1: Estimates of losses due to a diagnosis of lameness in a sow space

Decreased salvage value	$4.28
Increased replacement costs	$48.60
Decreased output	$159.96
Decreased value of output	$18.15
Total	**$230.84**

The aim of the sow herd is to use its capacity efficiently and in a sustainable fashion. Lameness is a disease that impedes that capability. The performance axiom argues that if something is severely affecting the well-being of the sow it is likely to be reflected in performance indices. Hopefully this example shows that this is not a simple academic argument. In some ways it illustrates that improving the welfare of animals should first and foremost be a win-win situation.

Omega 3 Enriched Pork: Apparent Conversion of α-Linolenic Acid to Long Chain Omega 3 Fatty Acids

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Department of Animal and Poultry Science, University of Guelph, Guelph, Ontario, Canada

Background:

The health benefits of poly-unsaturated, omega-3 (**ω-3**) fatty acid (**FA**) in diets for humans have been well established. It can be estimated that consumption of 100 g pork loin or 20 g of bacon enriched with ω-3 FA would satisfy 50% of the daily recommended ω-3 FA requirements according to Health and Welfare Canada (Romans et al., 1995; Specht-Overholt et al., 1997). However, pork products enriched with ω-3 FA have not been marketed successfully, due largely to variability in ω-3 FA contents and the negative impact of unsaturated fat on various aspects of pork meat quality. The latter is especially a concern in pigs fed corn-based diets, because of the relatively high unsaturated fat content in corn (linoleic acid; **LA,** C18:2ω-6). Moreover, in order to generate ω-3 FA enriched pork products ω-3 FA (usually ALA from flax) are fed just prior to slaughter resulting in a preferential incorporation of ω-3 FA in extra-muscular fat pools (back fat), rather than the preferred intra- and inter-muscular fat.

Among ω-3 FA, eicosapentaenoic acid (**EPA**; C20:5ω-3), docosapentaenoic acid (**DPA**, C22:5ω-3) and docosahexaenoic acid (**DHA**; C22:6ω-3) are more beneficial to human health than linolenic acid (**ALA**, C18:3ω-3; the main ω-3 FA in vegetable oils like flax). Unfortunately, feeding fish oil (a good source of EPA, DPA and DHA) to pigs, results in pork with a distinct fishy flavor and aftertaste (Wood et al., 2003). The conversion ALA to EPA, DPA, and DHA by pigs may be an important mechanism for maintaining adequate EPA, DPA and DHA concentrations in cell membranes for optimal tissue function, and to produce pork that is relatively high in EPA, DPA and DHA. However, the extent to which growing pigs satisfy their metabolic demands for DHA - either through either dietary intake or endogenous synthetis from ALA -remains unclear. The objectives of this investigation were to determine the rate of retention and apparent conversion of ALA to EPA, DPA and DHA in the whole body in growing gilts.

Procedures:

A corn-wheat-soybean meal based diet with 10% ground flaxseed, containing 1.6% ALA & 1.4% LA, was fed for 30 d to growing gilts between 27.7 $\pm$ 1.9 and 45.7 $\pm$ 2.2 kg BW. Feed intake was fixed at 70% of ad libitum intake according to NRC (1998). Chemical body composition was determined at initial, intermediate (d 15; 39.2 ± 1.4 kg) and final BW in 4, 6 and 5 pigs, respectively. At slaughter on d 15 and 30 ileal digesta was sampled for measurement of apparent ileal digestibility (**AID**) of dietary FA and fat. Losses of ALA were calculated as the difference between available ALA intake and the sum of ALA retention and ALA apparent conversion to other ω-3 FA.

Results:

Whole body content of individual ω-3 and ω-6 FA increased linearly over time ($P < 0.01$; Table 1). Time had no effect on AID of fat (77%) and all analyzed FA (C14:0, 43; C16:0, 61; C18:0, 52; C18:1, 72; LA, 78 and ALA, 84%; $P > 0.10$). Expressed as a portion of intake, efficiency of retention declined numerically between the two periods (d0 to 15 vs. d15 to 30) for both ALA (68 vs. 58%; $P = 0.30$) and LA (94 vs. 67%; $P = 0.18$). Apparent conversion of ALA to C20:3ω-3, C20:4 ω-3 and DHA was reduced over time ($P < 0.05$; Table 1), whereas apparent conversion of ALA to EPA and DPA did not change over time ($P > 0.10$; Table 1). Within periods, total apparent conversion rate was higher for ω-3 FA compared to ω-6 FA (12.6 vs. 7.6% & 8.0 vs. 2.6% for d0 to 15 & d15 to 30, respectively; $P < 0.01$). Disappearance of ALA tented to increase over time (2.0 vs. 23.7% of available intake; $P = 0.07$). The rate of apparent conversion of ALA to C20:3ω-3 was much higher in this experiment than reported in other species and humans. This should be explored further.

Table 1. Whole body fatty acid mass (g/pig) in growing gilts fed flaxseed containing diets.

	0d	15d	30d	SE	P	L*	Q*
Number of pigs	4	6	5				
Empty BW	25.1	37.3	44.1	0.717	<0.001	<0.001	<0.001
C18:3ω-3 (ALA)	15.2	247	387	32.4	<0.001	<0.001	0.251
C18:4ω-3 (STD)	1.61	1.69	1.61	0.247	0.964	0.992	0.792
C20:3ω-3 (ETE)	2.05	27.5	36.1	3.92	<0.001	<0.001	0.091
C20:4ω-3 (ETA)	0.5	2.65	3.27	2.14	<0.001	<0.001	0.113
C20:5ω-3 (EPA)	0.717	4.86	8.33	0.608	<0.001	<0.001	0.648
C22:5ω-3 (DPA)	1.67	10.2	15.4	1.06	<0.001	<0.001	0.192
C22:6ω-3 (DHA)	2.39	6.45	6.16	0.587	<0.001	<0.001	0.008
Saturated	638	1148	1209	113	0.01	0.005	0.114
Monosaturated	947	1707	1580	156	0.014	0.018	0.031
Polyunsaturated	310	935	1186	93.6	<0.001	<0.001	0.113
Total ω-3	24.2	300	458	37.7	<0.001	<0.001	0.205
Total ω-6	1.14	1.7	1.64	0.118	0.0013	0.0014	0.042
Total ω- 3/ Total ω- 6	0.085	0.473	0.626	0.011	<0.001	<0.001	<0.001

* Linear (L) and quadratic (Q) effects of duration (0, 15 or 30 days) of feeding flaxseed containing diets.

Take home message:

The term ω-3 enriched pork might be misleading. More important than total ω-3 fatty acids content is the concentration of specific health promoting ω-3 fatty acids such us EPA, DPA and DHA. Moreover, the distribution of ω-3 fatty acids between lean and fat tissue and meat quality should be considered. This is the focus of a research project at the University of Guelph.

The efficiency of retention and apparent conversion of ω-3 fatty acids from flaxseed (ALA) decreases over time in growing gilts. Feeding ALA from flaxseed leads to modest increases in contents of health benefits providing EPA, DPA and DHA in the pig's body. Pigs appear unique in that they store the ω-3 FA C20:3ω-3, an intermediate between ALA and EPA, which deserves to be explored further.

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Canada's Pork Industry: Where We Have Been…Where We Are Going

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Past President Canadian Pork Council

In this presentation, we will take a layman's look at not only where our industry has been in the past, but also where we might go in the future. Many who predict the future extrapolate into the future what has happened in the past. Rather in this presentation, we will look at the mega-trends that are affecting our industry and the potential each has from both a risk and reward perspective for Canadian Stakeholders.

What are these mega-trends?

1) Globalization: Despite perhaps trying to deny this reality, I suggest it continues unabated. And its goal is to lower prices to consumers, not to make the supply chain more profitable. If one takes it to the limit, this movement over enough years is redefining in a modern world what it means for a country to be sovereign, including, "does a country have a right to feed itself?"

   Yet despite this movement, food and agriculture are only 15 years into the WTO rounds, and if it goes the way of manufacturing, it takes at least 50 years before we have a "globalized" marketplace. Evidence of a fully non-globalized marketplace is the fact that there is a North American pork market and not a world market that arbitrages efficiently. Evidence of this is varying standards around the world that prevent truly global competition (varying acceptable residue levels). And evidence of this is a variety of protectionist measures including farm bills, tariffs and export support programs. (Most recently MCOOL, but measures like this go well beyond the Canada/US border)
2) HACCP: The move from strictly output testing to monitoring the processes that lead to products is undeniable and speaks to the need for the more complex monitoring and verification necessary. This is not only true for food safety items (CQA at the farm, HACCP at the plants) and traceability (Canadian Swine Traceability) and animal welfare programs (ACA at the farm), but also for the differentiated products providing assurance of a product meeting a certain standard (i.e. organic, natural etc.) These phenomena push all to get larger, push all to have "head offices" and perhaps the only response is for farm organizations to become "head offices" for their members or accede to multi-nationals taking over the complete food chain including our farms.
3) Farmers becoming Managers instead of Stewards: This mega-trend is a fascinating one and I am not sure it is communally acknowledged, but it speaks to the fact that in previous years and within my lifetime, society expected farmers to be the stewards of the land and animals. And today, society is increasingly dictating the rules. While this may not be obvious at first blush, let's look at some examples. Most recently in various parts of the world including the US, restrictions are being placed on sow stalls. Other local examples are the Nutrient Management Act within Ontario, and the necessity to plan for the spreading of manure. This movement moves stakeholders within the chain to simply be required to obey the rules, rather than do what is best for the land or the animals. At best we become managers, and participants with society helping to shape the regulations. At its worst, we have fostered a "catch me if you can attitude" and lost the "conscience of land" attitude. I was taught growing up that one measure of success for our farm was to leave it in better shape then when I took it over. Have we lost that responsibility individually? Interesting!

4) Differentiation: Many suggest the future for Canadian pork production (including strategies developed in Alberta, Ontario, and at the national pork value roundtable) is differentiation. ("Canada will no longer be the lowest cost producer.") While differentiation is necessary, if it takes us away from focusing on cost reduction and increasing productivity, our production chain is in trouble because at the end of the day cost still matters and differentiation takes a long time. In fact during this last round from September '07 to the present, offers by Canadian buyers of market hogs went down relative to American buyers. And they are our competition. Looking at the marketplace around the world, there clearly are opportunities for high quality, branded and differentiated product. However, much of our product goes into further processing and really what is needed there is constant supply of a raw resource that meets minimum criteria. We will examine this trend in a little more detail to see how it potentially affects our future.

Probably for the first time in my farming career of approximately 30 years the success of an individual operation is more determined by macro events beyond an individual's control than what the farm manager does on the farm. Obviously I need to qualify as each of us has to continue to focus and refine our operations from both a cost reduction and increasing income perspective. However, with the change in the value of the Canadian dollar, and events such as new diseases affecting parts of the world including Canada (circovirus), and with potentials such as an FMD outbreak somewhere in the world, our futures are directly affected, either positively or negatively. To me, this points to the solution and realization that not only do we need to "fix problems we encounter on the farm" but we need others within the supply chain to "fix the larger problems" in this ever evolving world. And, I would suggest that a good bit of the future is known and is predictable.

How does all this affect the future of the Canadian Pork Industry? In my view it makes it or it breaks it! In my view, depending on a number of these factors, and almost all are beyond the farm, in 10 years we could look at a pork industry that is larger than today, or in the extreme…..it could go the way of the textile industry in Canada and disappear!! The correct question is not "what is the future for the industry in Canada?", rather it is "do we want and need a pork industry in Canada and what do we do to solve the macro problems that affect its future?"

Collecting Oral Fluid Samples for PRRS Monitoring

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INTRODUCTION

1. Composition of oral fluid

Oral fluid is a mixture of saliva from the salivary glands (parotid, maxillary, and sublingual); secretions from the gingival mucosa, serum and/or blood from wounds in the mouth, expectorated fluids form the respiratory tract, residual food/water, and desquamated mucosal cells[1]. Oral fluid is produced continuously and is promoted by mastication (chewing) and other factors.

2. Infectious agents found in oral fluid

Many viruses and bacteria are present in the oral fluids of infected animals. In some cases they replicate in the tissues of the oral cavity, but more frequently, they replicate throughout the body and are secreted into the oral cavity with saliva or other secretions.

Some viruses and bacteria, such as porcine reproductive and respiratory syndrome virus (PRRSv), are always pathogens when present in the animal[2]. Other agents—strains of *H. parasuis* for example—can be present normally in the oral cavity, but not pathogenic[3]. The significance of the presence of an agent in the oral cavity depends on the specific agent.

As well, antibodies against many diseases are present in oral fluid, either through secretion from immune cells throughout the body, or directly, through antibody-producing cells in the salivary glands.

3. Recent diagnostic efforts based on oral fluid

Diagnostic tests based on the detection of agents (antigens) on antibody in oral fluids are becoming common in human medicine and more recently, in veterinary medicine. Oral fluids may allow for easy, non-invasive diagnosis of infection, as in the case of hepatitis viruses and HIV[4-5]; detection of response to vaccination against such pathogens as measles virus or foot-and-mouth disease virus[6-7]; or even in forensic science, to identify agents which are exclusively associated with oral fluid[8].

In swine medicine, oral fluids have recently been evaluated under experimental conditions as a method for diagnosis is PRRSv infection, and oral fluid has also been collected and assessed in the field for monitoring of the common swine pathogens, swine influenza virus (SIV), PRRSv, and porcine circovirus type 2 (PCV2)[9,10].

In our practice we have recently undertaken two pilot projects to evaluate the use of oral fluids as diagnostic samples for PRRSv infection.

Project 1: Evaluation of oral fluids for monitoring PRRSv infection in replacement gilts following immunization with Ingelvac PRRS MLV.

This project was carried out in a 1200-sow farrow-to-wean herd in Ontario with no known history of field-strain infection with PRRS. This herd immunizes gilts against PRRSv on entry to isolation, but the sows are not immunized. The isolation barn consists of ten pens of 10-14 gilts per pen.

Blood was collected from 8-10 gilts per pen, 24 and 48 hrs after vaccination; weekly for the first 4 weeks post-vaccination; and biweekly thereafter (24hr, 48hr and weeks 1, 2, 3, 4, 6 and 8). At the same time, one 5/8 inch woven cotton rope was hung in each pen. Our ropes were sourced from Cancord Inc. (contact information below). Ropes were allowed to be manipulated by the pigs for 20-

30 minutes, and then retrieved for oral fluid collection. Blood samples and oral fluid samples were processed (centrifuged and decanted) and stored at -20 degrees Celsius until analysis. Blood samples were pooled 4-5:1 and PCR assays on oral fluids and sera were performed by Gallant Custom Laboratories, Cambridge, Ontario.

Results from this project will be presented during the meeting.

Project 2: Evaluation of oral fluids for monitoring PRRSv infection in weaned pigs exposed naturally to a field strain of PRRSv

This project was performed in a 1000-sow farrow-to-finish herd in Ontario with a history of infection with field strain of PRRSv. As of 2008, the sow herd is presumed to be weaning PRRSv-negative pigs; however, the continuous flow nursery has not been depopulated, so negative pigs seroconvert after weaning. This was a cross-sectional study; we sampled pigs of every age in the nursery using oral fluids and serum. The nursery contains 16 rooms of between 200-400 pigs; pen size is variable. In this study, two ropes are placed in two pens from every other week of pig production. Ropes will be preferentially placed in pens containing sick and small pigs, as above. Sera from one half of the pigs in the pen, up to 22 pigs per pen, were collected from each of the test pens. Samples were processed as above and the PCR assay was performed by Gallant Custom Laboratories, Cambridge, Ontario.

Results from this project will be presented during the meeting.

4. Future applications

The use of oral fluids for diagnostics has potential for various applications. The results from our projects are similar to preliminary investigations by practicing veterinarians in other regions, in that they indicate that there needs to be further validation of oral fluid testing at the diagnostic laboratories, as well as further epidemiologic information generated in the field. At this point it would imprudent to base high-value decisions on the results of PRRSv PCR tests on oral fluid.

The technology has the potential to be very effective to 1) monitor the infection and shedding status of pigs that have been exposed to PRRSv, such as gilts in acclimation barns; 2) monitor PRRSV-negative pig populations by testing large numbers of pigs simultaneously, for low cost. As well, the use of oral fluid testing may be valuable for diagnostic assessment of other swine diseases; for example, monitoring the amount of PCV-2 in oral fluids of grow-finish pigs could possibly help evaluate the efficacy of a PCV-2 vaccination program.

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Measuring Welfare: Balancing the Needs of Pigs, Producers and the Public

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Pig farming is complicated. There are a wide range of constituencies from owners to buyers to consumers to employees to pigs to the environment. Across that range we have to manipulate inputs including buildings, employees, pigs, health status, nutrition and risk management. There is not a computer model that can do a good job across all these needs and requirements. It is a huge and complex problem, and it is hard to identify another industry outside animal agriculture that is faced with the complexity of issues that we face.

It is also a problem that can never be solved and then ignored. A good definition of economics is using limited resources to meet unlimited needs. It fits the problem of allocating resources in pig production to the needs of pigs producers and the public. It emphasizes that if someone is completely content, someone else is being ignored. It creates a metric not only for the things that are done, but also for the things that are not done. The latter are often called shadow values, which can be expressed in terms of money, time, safety and even contentment that is forgone to meet another need.

The natural tendency is to simplify the problem, and we there are a few traps that we can fall into. A list has at least the following:

- Assume that you can change one thing and everything else stays the same. Examples range from emphasizing cost minimization and assuming the quality of the product won't change to reducing weaning age and assuming subsequent performance won't change. Though this seems like an elementary problem, the interpretation of scientific results almost invariably falls into this trap.

- Assume that all pigs are the same. Again, this is a common trap that scientific interpretation falls into. Though the welfare of animals can be reflected through things such as growth rates, this is often hidden behind the use of averages across a group of animals.

- Assume linear response functions. We assume that an input has an effect that is the same across different ranges of response. An obvious example would be temperature where an increase in temperature has an effect that is really dependent upon where you started. Likewise, an increase in birth weight is also very dependent upon where the pig started.

When we take all of the constraints of problem-solving into account it is very easy to throw up your hands and become a copycat. The most common solution is to let someone else trying new ideas and simply emulate common practices within the industry. This is safe, and engenders solidarity, but can lead us down the wrong path.

The demand for improved welfare of swine and increased transparency is really a call for innovation. This innovation should not be simply limited to a simple objective. All innovation should be beholden to the multiple constituencies that the farm serves. Once we start making considerations in that aspect we are drawn to three generalizations, in my opinion.

- We need win-win-win solutions. Solutions that are win-lose-lose are just dangerous. Solutions that improve the welfare of animals, improve the acceptance by consumers and improve the bottom line for owners should be pursued.

- Individual pig performance is the new metric. Welfare improvements that improve the bottom line are usually found in addressing partial populations of animals. These poor doing animals are often hidden from the public sight until there are exposés, but they are a major welfare and economic concern for producers.

- We may not know the full mathematical relationships between objectives, so elimination of extremes is almost always rewarding. Much of what we do can only be done between reasonable ranges. Overstocking of animals, extremes in poorer average daily gain and high mortality rates can all exhibit real compromises in meeting our objectives.

Though these generalizations seem obvious, I do think that they lead to different emphases on meeting multiple objectives. Our group have been pursuing what we feel are win-win-win objectives in three areas, but I'm sure there are many more. The first was to emphasize sow lameness. We have shown that it is a concern at time of slaughter and for producers. The inhibition of behavior due to pain makes it definitional as a welfare concern. We have also shown that the existence of lameness is correlated with a lower productivity.

The second area that we feel needs further emphasis is the slow-growing pig. Using Stan Curtis's performance axiom, along with higher mortality rates and cortisol levels, there can be a solid argument made that these pigs are often compromised. Secondly, the losses associated with these pigs is increasing as the market becomes more discriminatory. Finally, variation in growth rates can be argued to be an indicator of a lack of quality in progeny and can result in lower consumer demand.

Thirdly, even birth weight can be an opportunity for creating win-win-win situations. Euthanasia of lightweight pigs or decreases in their occurrence can result in a reduction of subsequent productivity problems. It also results in decreased usage of inputs such as antibiotics and reduces mortality rates.

My frustration is that these must be communicated and described in further detail. No longer can interventions be simply justified on the basis of economic return. We must claim constituencies of benefits while not being derogatory of current states of production. We have a story to tell of successes and we have areas that deserve further critique.

Strategies for Control of Boar Taint

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Why Castrate?

Young male piglets are castrated to prevent off-odours and off-flavours (boar taint) in the meat at slaughter weight. Boar taint is caused the accumulation of two compounds, androstenone and skatole, in the fat. Androstenone is a steroid produced in the testis as the boar nears puberty, and it acts as a sex pheromone to regulate reproductive development in gilts and induce a mating stance in sows. Skatole is produced as a bacterial breakdown product of the amino acid tryptophan in the gut. It is produced in equivalent amounts in the gut of both males and female pigs, but it is poorly metabolized and eliminated by males, so it accumulates in fat.

Castration prevents boar taint, but intact boars have improved feed efficiency, nitrogen retention and lean gain compared to castrates, which could result in significant economic gains to producers. There are also growing animal welfare concerns against castration. Several EU countries will ban surgical castration in the next few years (even with anaesthetic). Recently some major grocery stores in the Netherlands have decided not to sell pork from castrates. Controlling boar taint without surgical castration would, therefore, have dramatic benefits for production and consumer acceptance of pork products.

Options for Control of Taint

Nutrition

Boar taint from skatole is affected by diet and environment (management). The main source of the tryptophan for skatole production comes from the turnover of cells lining the gut, and this can be reduced by including sources of fermentable carbohydrates in the diet. Skatole can also be absorbed from the manure, so dirty pigs of any sex can accumulate high skatole levels in fat. Androstenone production is controlled by the sexual maturity of the boar, so diet does not have much of an effect on boar taint from androstenone. Androstenone levels could be decreased by slaughter at lighter weights before puberty begins, but this is not economical.

Immunocastration

A promising method for controlling boar taint is by immunocastration, instead of surgical castration. Immunocastration works by injecting a vaccine which stimulates the production of antibodies against gonadotropin releasing hormone (GnRH), which is normally produced by the hypothalamus in the brain to drive the development of the testis. The antibodies inactivate GnRH to shut down testicular development to the same extent as surgical castration. However, since the vaccine is given to pigs near slaughter, they grow as normal boars for most of their life and retain the performance advantages of intact boars.

Genetic selection

Genetics can affect both the production and metabolism of boar taint compounds, and these effects can be found both within breeds and among different breeds. For example, levels of androstenone are much higher in Durocs than in the white pig breeds. There is also a wide variability in the amount of boar taint that individual pigs have within a breed. The heritability of both androstenone and skatole is moderate to high, but previous attempts to select for pigs with low boar taint have resulted in

reproductive problems. The development of specific genetic markers for boar taint would minimize these negative effects on reproduction.

At the University of Guelph, we have developed genetic markers for boar taint based on candidate genes that encode the enzymes involved in the synthesis and degradation of the boar taint compounds, androstenone and skatole. We have a database of about 1300 animals representing 8 different lines that we have used for the discovery and validation of genetic markers, mostly single nucleotide polymorphisms (SNPs) in the DNA. We compared the sequences of 26 different genes from pools of DNA obtained from animals from the extremes of the boar taint phenotype in each line for SNP discovery. We then genotyped all the animals in our database for each SNP and conducted association analysis for each SNP with the boar taint phenotype.

54 effective SNPs were identified in these candidate genes for boar taint. The SNPs that were associated with fat skatole and androstenone varied among the eight lines of pigs, although some SNPs were effective in several lines. The strength of the associations of the SNPs with skatole and androstenone levels varied among the different lines of pigs. The strongest associations were in Duroc pigs, where 8 SNPs explained 43% of the phenotypic variation in fat androstenone content and 17 SNPs explained 70% of the variation in fat skatole content.

These findings represent significant progress towards a genetic solution to boar taint. Work is continuing to characterize additional SNPs for boar taint and to validate these markers in commercial swine populations. The control of boar taint by marker assisted selection will eliminate the need for castration. This will significantly improve the profitability of pork production and address animal welfare concerns about castration that are now a hot topic in several EU countries.

Take Home Message

Castration to prevent boar taint limits productivity and increases animal welfare concerns of commercial pork production, so alternative strategies for controlling taint are needed. Immunocastration effectively controls boar taint, but the development of low boar taint lines of pigs by marker assisted selection would provide a long term solution to the problem.

Evaluating the Spatial and Temporal Effects of Tile Drains on the Partitioning of Liquid Swine Manure Constituents Between Surface-Water and Groundwater

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University of Waterloo

Tile drainage has been extremely beneficial in creating favourable conditions for a wide variety of cropping practices in agricultural settings throughout southern Ontario. Concomitant with the increased use of tile drainage has been growing societal concern and expanding evidence that tile drains can potentially increase the risk of rapid mobilization of surface applied nutrients, which may in turn adversely affect surface water quality, while diminishing nutrient availability to crops. Additionally, soil macropore features such as abandoned roots, worm holes and fractures can significantly enhance the downward migration of nutrients and further exacerbate the potential environmental impacts of tile drainage. Quantifying the influence of tile drain systems on the movement of nutrient species in active agricultural settings has been problematic for a number of reasons, which include the complexity of infiltration through macroporous soils and variability associated with climatic and subsurface conditions. A conceptual model that shows the interactive nature of tile drains, the unsaturated zone and the groundwater system is presented in Figure 1. Intuitively, water and nutrients applied close to a tile are more likely to rapidly migrate towards the tile drain and as such influence surface water quality than water and nutrients applied away from the tile. It is the objective of this research project to quantitatively evaluate the ability of tile drain systems to capture liquid precipitation and surface applied liquid manure.

To ensure that this research accurately reflects conditions commonly found in southern Ontario, an agricultural field site was selected in the Upper Thames watershed, approximately 20km north-west of the City of Woodstock, with systematically tile drained, macroporous silt loam soils. The nature of this work necessitated actively flowing tiles, so although the water-table at the field site is generally quite shallow, during 2007 the tile drains were not running until late September so the experiments could not commence until that time. In total there were three infiltration experiments conducted, two of which were in October and one, which was in November. To replicate natural precipitation/irrigation during the experiments, a large-scale rainfall simulator, with an $85m^2$ coverage area, was set overtop of a tile drain that had been installed at a depth of 90cm in the mid 1980s. Water for the first two infiltration experiments was trucked in from the City of London, whereas for the third experiment, it was pumped directly from a small stream adjacent to the site. It was the objective of the first two experiments to assess the hydraulic response of tile drains under different ambient soil moisture content. For the first experiment, the soil was relatively dry and the tiles were barely trickling, whereas by the time the second experiment commenced, natural precipitation had increased both the soil moisture content and the tile discharge rate. In each case, irrigation was applied at a rate of 8mm/hr for three hours total, which was intended to replicate a medium duration precipitation event with an intensity that could be expected once or twice a year. The third experiment was slightly different than the first two since it was designed to mimic a late fall liquid manure application immediately followed by a rainfall event. To emulate liquid manure application, dissolved non reactive chemical tracers were applied to the ground surface at a rate of 2130 gallons/acre. Following tracer application, irrigation water was applied at a rate of 5mm/hr for nine hours, approximately representing a rainfall event with a two-year return period. The soil was extremely wet during the third experiment; accordingly, the experimental results represent worst-case environmental conditions for liquid manure application. During each of the experiments, volumetric moisture content, water-table geometry and tile drain discharge were all automatically monitored in intervals that ranged from 15 minutes to 1 hour. During the November experiment tracer movement was tracked by extracting water samples from the tile effluent in 15 minute time intervals for the first

48 hours following application and in 1 hour intervals thereafter. The water samples were subsequently brought back to the University of Waterloo for chemical analysis.

Results from the first irrigation experiment indicate that under relatively dry soil conditions, a typical 3 hour rainstorm had virtually no influence on the amount of tile drain discharge largely because the soil matrix was able to absorb all of the incident precipitation and the soil macropore network did not become hydraulically active. During both the second and third experiments, soil conditions were much wetter and the tile discharge was observed to increase rapidly in response to irrigation. Results from the second and third irrigation events illustrate both the importance of soil moisture in controlling the downward movement of meteoric or irrigation water and the influence of the macroporosity in rapidly transmitting water and solutes when conditions are wet. When macropore networks become hydraulically active there is increased likelihood that surface applied nutrients will be rapidly transported to tile drains. However, even under the most vulnerable soil moisture conditions, where tile response to irrigation was relatively rapid, and macropores were actively transmitting water, experimental results show that only 10 to 15% of the volume of water applied during irrigation was discharged by the tile drain within 24 hours of irrigation. These results suggest that the majority of the infiltrating water enters the groundwater flow system and is either slow to reach the tile or bypasses the tiles completely. When movement of the tracer, which had been applied on a 2.25m strip adjacent to the tile, was analysed, it was found that some tracer was able to reach the tile drain within 1 hour of application and peak concentrations were observed in the tile effluent approximately 11 hours after application. Mass balance calculations for the tracer experiment show that after 1 day, 7% of the tracer had been captured by the tile and by 20 days, 20% had been captured. The remainder of the tracer had entered the regional groundwater flow system and bypassed the tile drainage system or had not yet reached the tile drain. To relate the tracer experiment to a 13.5 acre field scale liquid manure application, with a loading rate of 2130 gal/acre, and 12m spacing between tile drains installed at a depth of 90cm, the plot scale experiment results were extrapolated to a field scale. Results of the extrapolation calculations show that from a total applied volume of 28760 gal, 2.6% (723 gal) and 7.5% (2170 gal) would have been discharged from the tile drain network by 1 day and 20 days respectively.

Results from these experiments indicate that even under conditions that might be considered extremely risky with respect to impact on water quality from the surface application of liquid manure, including high soil moisture, fall application time frame and existence of significant macroporosity, the amount of manure rapidly delivered to surface water via tile drains is quite low relative to the total amount applied. That being said, if the tile effluent is not adequately diluted, the surface water quality could be significantly impaired.

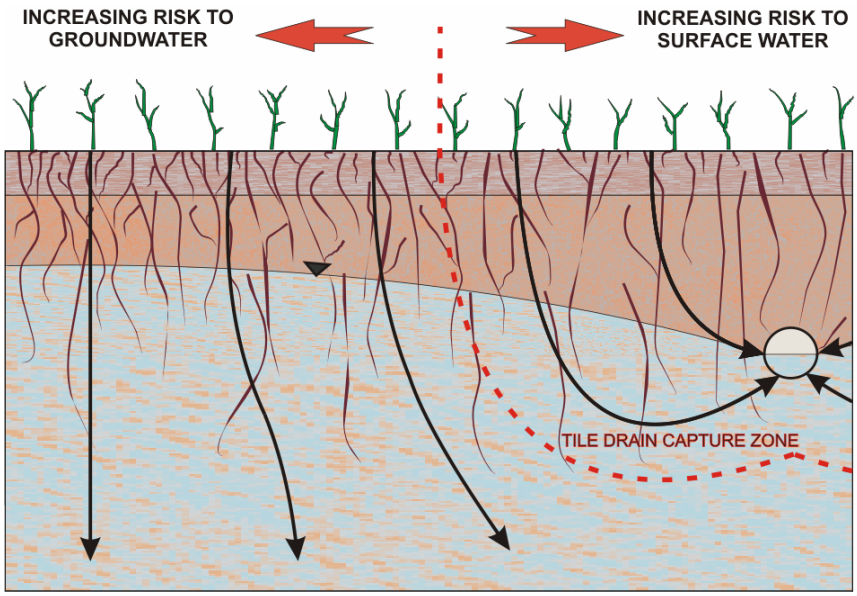

Figure 1. Conceptual model of water / nutrient capture by tile drains versus flow into groundwater.

Use of Infrared Thermography for Early Detection of Disease Causing Sudden Death in a Swine Finishing Barn

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Introduction

In a finishing barn situation, pathogens that lead to mortality can be devastating to a producer. Infectious diseases such as *Actinobacillus pleuropneumoniae* can display few clinical signs before pig mortality occours. This is complicated by the economic infeasibility of inspecting individual pigs for early signs of clinical disease in a large finishing operation. A pen-level method for detecting early stages of the disease would therefore be beneficial from both a production and a herd health point of view. The objective of this study was to evaluate the use of infrared thermography as an early detection method for mortality-causing disease in a finisher barn setting.

Materials and Methods

Over a consecutive 19 day period in June 2008, 56 finisher pens in a finishing barn experiencing an outbreak of mortality due to *Actinobacillus pleuropneumoniae* were imaged using a Fluke Ti45 Infrared Camera. The finisher barn operated as a naturally ventilated, continuous flow operation divided into four rooms with a common airflow, with each pen housing 20 pigs on average. Each morning, two consecutive thermal images were taken of each pen. Humidity, environmental temperature, age class, maximum temperature within the pen, and number of mortalities for each pen were recorded. For the purposes of classification, a case was defined as a pen that had at least one mortality recorded that day. Each case pen was randomly matched with three control pens. Matching was performed with a statistical software package, using day of the study and approximate age category. The data was imported into the STATA Data analysis package and was analyzed using a conditional logistic regression model. The pen-level temperature data was compared using values for the day of, day before, and two days before mortality occurred. Statistical repeatability studies were also performed on the camera to evaluate the precision of the camera upon itself.

Results

Using the odds-ratio as a measure of association, it was found that case pens had significantly higher maximum temperature than control pens, not only on the day that the mortality was recorded (OR=3.65, $p<0.0001$), but also the day before (OR= 3.58, $p<0.0001$) and two days before (OR=3.64 $p=0.004$) mortality (n=27). Thus, with each 1 degree C increase in maximum temperature of a pen, the odds of a pen having mortality increased 3.6 times. It was also found that the odds ratio was similar (OR= 1.85 for day of mortality, OR = 2.31 for the day before, and OR = 2.45 for two days before mortality) when only considering the first time that the pen experienced mortality, and although the results were not significant, the low sample size (n=10) may have led to the non-significant p-values.

Significance to Practitioners and Producers

These findings are an important first step in the development of a cost-effective system for detecting diseases such as *Actinobacillus pleuropneumoniae*. The data collected by a producer could allow them to avoid having to institute barn-wide antibiotic protocols when an outbreak of APP occours. Instead, a producer could isolate and treat specific pens, thereby saving costs and also preserving niche-market operations, such as those that operate antibiotic-free. As well, the operation of the thermal camera, if properly cared for, is fairly straightforward, not unlike a digital camera. It is conceivable that a producer could image pigs as a supplement to a daily routine such as feeding,

while not adding a significant amount of extra time into an already busy schedule. Mounting cameras on in a barn and taking still shots over a set period of time could also be possible, thereby reducing the input required by the producer further.

For practitioners, thermal imaging provides another tool to diagnose a disease that is particularly difficult to diagnose ante-mortem. The infrared image (Figure 1, and optional digital picture), along with the relevant quantitative data, extracts to any personal computer using a standard camera SD card, where it can be reviewed, analyzed, and trended. As well, it provides an extra level of epidemiological data that allows swine practitioners to determine what occurred leading up to an outbreak, potentially leading to effective, targeted recommendations for control of disease. Thermal imaging can also indicate the early presence of potentially poor-performing pigs due to conditions such as ulcers and superficial or joint inflammation, allowing a practitioner to discuss these issues with a producer and develop an appropriate plan to maximize the herd's welfare and overall health status.

Although preliminary to conclusively link the trends between pen temperature and finisher-barn disease mortality, the results seen in this study are promising enough to warrant further investigation into this and other topics into which thermography can be implemented to assist producers and practitioners alike.

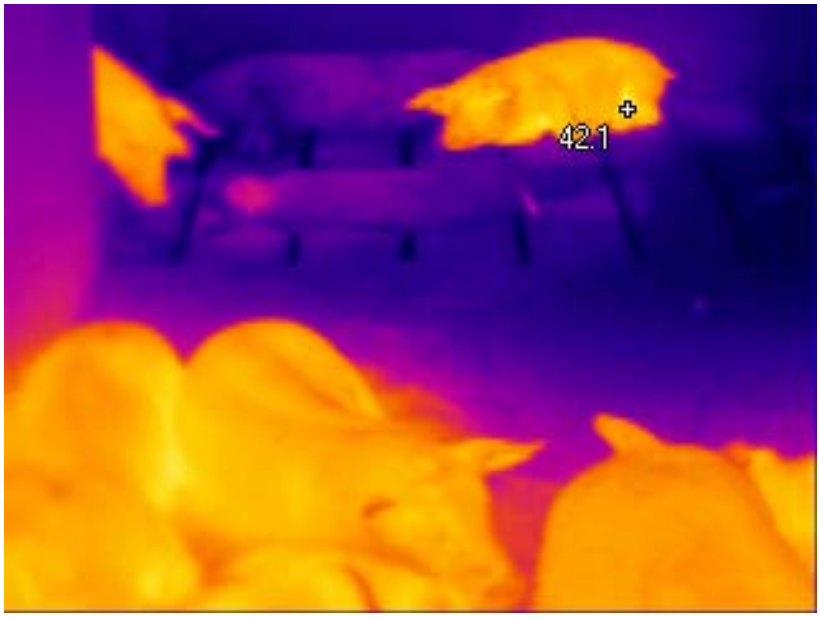

Figure 1. Thermal image taken on day 4 from pen 1L4, which experienced a high APP-suspect mortality rate during the study. The lone pig at the back right of the pen is reading a maximum temperature of 42.1°C. For reference, the ambient temperature was 24.8 °C and the humidity was 62%. On the day following this image, there were 3 recorded mortalities in this pen.

Teething in Baby Pigs

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Introduction

Adequate feed consumption prior to and at the time of weaning is of critical importance. Failure to consume enough feed at weaning can increase susceptibility to disease, decrease the absorptive capacity of the gastrointestinal system, exacerbate other stressors and result in increased time needed to reach market weight. Although the swine industry has grown in leaps and bounds with regards to improvements in feeds, feeding systems and genetic potential for growth, studies considering the 'hardware' required to consume that feed (i.e. teeth), and thus fulfill that potential, have largely been neglected. Given that the majority of a piglet's pre-weaning nutrition is derived via suckling motor patterns and not chewing, we wanted to determine whether newly piglets have the necessary dentition for chewing of their post-weaning diet. Surprisingly, dental eruption in commercial large breed pigs has not been formally examined except in classic growth experiments conducted in the 1970's. As such, normal profiles for the eruption of the deciduous (primary) teeth are generally unknown. Likewise, no previous studies have investigated the influence of having teeth or teething on feed-oriented behaviour or feed intake in young pigs.

Objectives

1. To determine the natural time course of deciduous dental eruption in commercial piglets from birth to 5 weeks of age, examining influential sow, litter and piglet factors.
2. To determine if premolar eruption or premolar occlusion (i.e. the contact of premolars in opposing jaws) is associated with creep feeding behaviour or creep feed intake in piglets under 28 days of age.

Methods

Twenty-four litters of Yorkshire piglets (N=233) were given dental exams at ages 2, 6, 9, 13, 16, 20, 23, and 27 days. On day 5, piglets were provided with creep feed that was mixed at 1% inclusion with chromic oxide (Cr_2O_3) that colours the feces green. Fecal samples were obtained from each piglet on the same days as dental exams and were visually assessed for the presence of Cr_2O_3 indicating prior ingestion of creep feed. The duration of time piglets spent with their head in the creep feeder and the number of feeder visits were determined from continuous video recordings for 6 hr/day (07:00-10:00, 13:00-16:00) on days 7, 10, 14, 17, 21, and 24. Birth and weekly weights were recorded, as were sow parity, sow age, number of piglets born alive, number of stillbirths, number of mummies, and male:female ratio of the litter.

Results

Figure 1 gives a diagrammatic representation of the pig's deciduous dentition. All piglets had their 8 'needle' teeth present at birth (c^1, c_1, i^3, i_3). The mean age of eruption for all other teeth seen to erupt during the course of the experiment are presented in Table 1. Gilts were found to have earlier eruption than barrows for m^3, m_4, m^4, and i_1 ($P < 0.05$). Heavier piglets at birth had earlier eruption of all teeth except i^1 ($P < 0.05$). Piglets gaining more in week 1 had earlier eruption of m^3, m_4 and i^1 ($P < 0.05$), and this trend continued into week 2 for m_4 ($P < 0.05$). Older sows and sows of higher parity had piglets with earlier eruption of i_1 ($P < 0.05$).

Piglets 17 days of age and younger that had their premolars erupted and occluded spent less time at the feeder and visited it less frequently, possibly in response to the gingival sensitivity and inflammation that was occurring. However, piglets 21 days of age and older that had their premolars erupted and occluded spent more time at the feeder and visited it more often compared to piglets without these dental conditions. However, ingestion of creep feed was not found to be associated with dentition, though problems with detecting consumption may have occurred.

Conclusions

In summary, this study determined the normal time course of "teething" in commercial piglets. In general, gilts and larger-weight-for-age piglets got their teeth earlier. Feeding behaviour was influenced by dentition though it was an age-dependent response. This aspect of a piglet's biology should be considered with regards to when

piglets are weaned given certain premolars associated with increased feeding behaviour (eg. m_3 and m^4) did not erupt until after 19 days of age.

Acknowledgements
This research was supported by NSERC and OMAFRA. The authors wish to thank William Sears for his assistance with statistical analyses and the many summer students who helped with data collection.

Figure 1. The deciduous dentition of the domestic pig (incisors $^3/_3$, canine $^1/_1$, premolars $^3/_3$, molars $^0/_0$, 28 teeth). All incisors, canines, and premolars are referred to by a lowercase i, c, or m with a superscript (or subscript) number indicating position within the maxilla (or mandible), respectively.

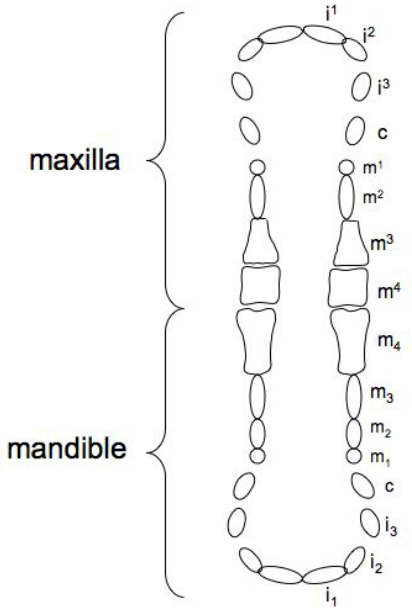

Table 1. Age (in days) of deciduous tooth eruption in the maxilla[1] and mandible[1] for gilts and barrows (N=233).

	Gilts (N=114)			Barrows (N=119)			Piglet Variation	Litter Variation
	Mean	SEM	Range	Mean	SEM	Range	*P*-value	*P*-value
Maxilla								
i^1	9.32	0.52	0.0-32.0	9.98	0.51	4.0-25.0	0.815	0.001
m^3	5.60	0.25	0.0-14.5	6.41	0.25	4.0-14.5	0.001	0.002
m^4	23.93	0.56	14.5-**	24.94	0.54	14.5-**	<0.001	<0.001
Mandible								
i_1	4.64	0.15	0.0-11.0	5.22	0.19	0.0-11.0	0.004	0.016
m_3	19.15	0.41	11.0-32.0	19.56	0.38	11.0-32.0	0.733	0.002
m_4	6.68	0.32	1-18.0	7.72	0.30	4.0-16.25	0.006	0.002

[1]data from left and right dental arches are pooled
** 7 piglets still did not have eruption of their m^4 by the end of the study

Cost of Production Benchmark for Ontario, Manitoba and Iowa

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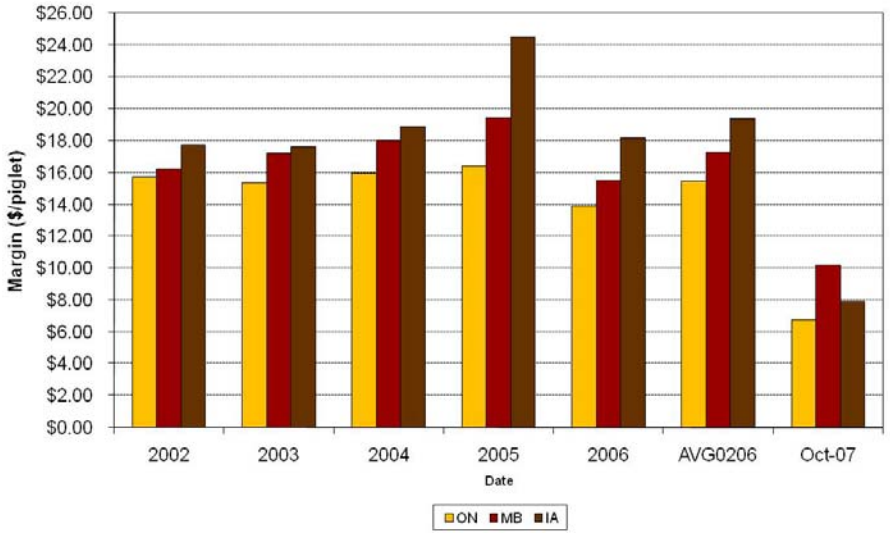
Background

History has shown that production advantages for Ontario include good sow productivity, high health status, a well-established swine system and infrastructure, plentiful land and feed grains, and close proximity to the U.S. border for exporting. Production advantages for Manitoba include plentiful and relatively cheap land, low input prices especially for feed grains, close proximity to the U.S. border for exporting, high health status, good sow productivity and more recently Maple Leaf's business decision to focus it's pork operations in the province and intention to double-shift it's Brandon plant. Production advantages for Iowa include cheap input prices especially for feed grains, good hog prices due to packer demand, low production expenses, and a well-established swine infrastructure.

Results for Farrow-to-Wean

Based on the model results for 2002 to 2006, it would appear that the greatest profit potential for farrow-to-wean based on $C margin/pig was in Iowa followed by Manitoba and Ontario (Figure 1).

Figure 1. Farrow-to-Wean Partial COP Margin ($C/piglet).



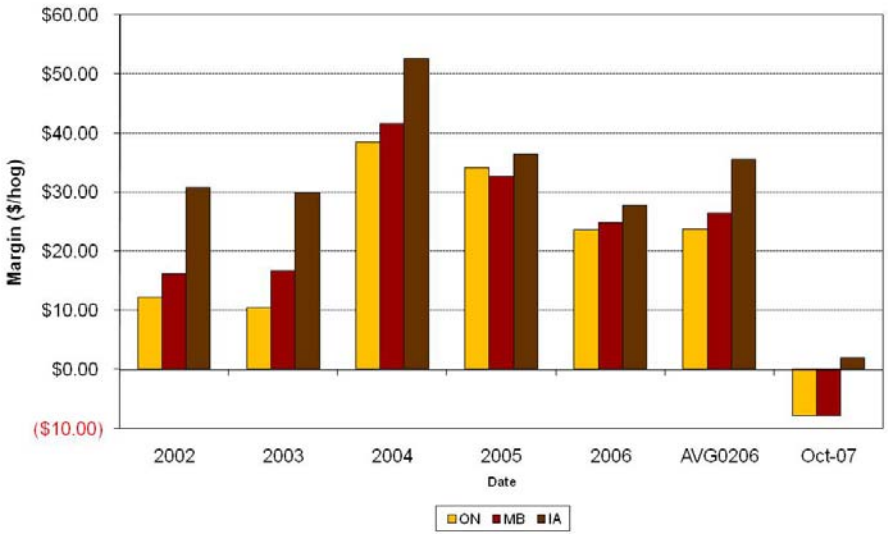
Iowa had the highest revenue and margin per piglet. Manitoba had slightly lower total expenses than Ontario for the key input bundle (i.e. feed grains, labour, building and equipment costs, interest rates). However, the question of which region has the advantage in farrow-to-wean really depends on the relative efficiencies of the breeding herds. In the study model, it is assumed that Ontario and Manitoba wean 21.28 pigs/sow/year while Iowa weans 19.8 pigs/sow/year. If this gap of 1.48 pigs/sow/year were to widen, then the advantage clearly shifts to Ontario and Manitoba relative to Iowa. Haley (2004) observed that Canadian breeding operations were significantly more efficient than U.S. herds in terms of pigs/litter and pigs/breeding animal/year. In 2003, Haley observed that the gap between Canada and the U.S. was 3.4 pigs/animal/year up from 1.9 pigs/animal/year in 1995.

Haley states that the U.S. breeding herd has become more efficient over time with the exit of small, inefficient farrow-to-finish operations. Anecdotal evidence suggests that sow productivity differences are small, if any, when comparing large, commercial herds between Ontario, Manitoba and Iowa.

Results for Finish

Based on the model results for 2002 to 2006, it would appear that the greatest profit potential for finishing hogs based on $C margin/hog was in Iowa followed by Manitoba and Ontario (Figure 2).

Figure 2. Finish Partial COP Margin ($C/hog).



Iowa also had the highest revenue and highest expenses. Manitoba had the lowest feeder pig costs and total expenses for the key input bundle (i.e. feed grains, feeder pig prices, labour, building and equipment costs, interest rates) but Ontario had feed grain costs similar to Iowa during the period. With Iowa having the higher margin, this is important as it has allowed producers in that region to make more money and pay down debt.

The question of which region between Ontario and Manitoba has the advantage in finishing market hogs depends on the relative hog prices and feed grain costs used since most other input costs are relatively similar. The exception is land costs where Manitoba has a clear advantage. According to industry sources, even labour rates are relatively similar between the two provinces although Manitoba is feeling some effects from the Alberta labour market.

With the Canadian dollar approximately at par with the U.S. dollar, it would appear that the greatest profit potential (as of October 1, 2007) for producing piglets is in Manitoba while the greatest profit potential for finishing market hogs is in Iowa. For finishing market hogs, Ontario appears to be comparable with Manitoba. Again, this depends on which prices are used to compare hog revenue between Ontario and Manitoba. Sensitivity analysis using October 1, 2007 data in the farrow-to-wean model showed that if sow productivity was the same in all three regions, then Iowa would have the advantage followed by Manitoba and Ontario. If sow productivity and building & equipment costs were the same in all three regions, then Manitoba would have the advantage followed by Iowa and Ontario. Sensitivity analysis using October 1, 2007 data in the finishing model showed that if feed conversion was the same in all three regions, then Iowa would have the advantage followed by

Manitoba and Ontario. If feed conversion and building & equipment costs were the same in all three regions, then Iowa would have the advantage followed by Manitoba and Ontario.

However, as of October 1, 2007, after total costs of production were accounted for, none of the three regions were profitable in either raising piglets or finishing market hogs.

Conclusions

Although the results indicate that Ontario appears to be at a competitive disadvantage to Manitoba and Iowa, Ontario is still a good location for pig production. A couple of dollars of higher costs should not be interpreted to mean a region is uncompetitive. It depends a lot on what assumptions are used to determine revenue and costs. There are many factors that need to be considered before determining if a region has a clear advantage compared to another region. For example, productivity, exchange rate, pig prices, feed grain prices, building costs, labour availability and costs, environmental regulations and costs, land costs, energy costs, tax rates, and etc. all are important. Over time many of these factors can change which may cause the relative advantages or disadvantages for a particular region to change. For example, if the Canadian dollar weakens relative to the U.S. dollar, then Ontario becomes much more competitive relative to Iowa. Also, if Ontario achieves higher productivity through higher health status, more pigs weaned/sow/year or grow-finish rates then any of these factors makes Ontario more competitive relative to Manitoba or Iowa. This study is not intended to be a perfect or complete cost of production comparison.

The report “Cost of Production Benchmark for Ontario, Manitoba and Iowa” was made possible due to the financial support of Ontario Pork through funding from Agriculture and Agri-Food Canada through the Canada-Ontario Research Development (CORD) Program.

Pig Tales From Africa

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Introduction

In rural Western Kenya, 90% of subsistence farmers live on less than a dollar a day. Everyone family has a large number of mouths to feed because half of the children in the community are orphaned due to AIDS. These children live with extended family members or neighbours. Farmers raise one or two pigs as a way to bank the money they earn from selling their corn harvest. The income from the pig pays for necessities such as medicine, hospital fees, food and school fees. The purpose of this research work is to ensure the sustainability of the pig industry and to enhance the livelihood of the pig farmers through addressing the limitations of the farmer and the butcher.

Materials and Methods

The study was conducted in 2 districts in the Western province of Kenya where most people live in extreme poverty and farmers raise pigs. We interviewed a random sample of 287 farmers, some from each of village. Each farmer was interviewed 3 times at 4 to 8 month intervals. After the first visit, we provided workshops to train livestock, veterinary and public health government officers about pig breeding, management by phase of production, feeding, record keeping, estimating the weight of the pig, diseases and prevention of the pig tapeworm that causes epilepsy in people. We then facilitated the government workers to teach the material to the farmers in their own language. Farmers were given measuring tapes, record keeping sheets, pens and plastic bags to store the supplies when they completed the workshop.

In subsequent farm visits, we asked questions to determine whether their knowledge level had changed after the workshop. Farmers who had not attended the workshops were given one-on-one training. The age and weight of all the pigs were estimated by the farmer and the length, girth and weight were measured. Each pig was injected with ivermectin to treat internal and external parasites. We determined the models that predicted the weight of the pig based on the body measurements. We taught the farmer how to estimate their pig's weight prior to its sale. All pig butchers in the area were interviewed to identify the challenges they experience in their businesses.

Results

The farmers' pig rearing challenges were; feeding the pig (feed was hard to get or expensive) (60%), pigs bothered their neighbour (60%), getting the sow bred (60%), high cost of a weaned pig (50%), not getting sufficient money for the pig they sold (50%), and pre-weaning mortality (30%). Farmers did not know what their pigs weighed and underestimated the weight by 7 kg or more, 25% of farmers underestimated the weight by at least 14 kg. The price of the pig is negotiated between the pig buyer and the farmer – so the farmer need to know the pig's weight. Farmers received approximately $9 for a weaned pig, $20 to $40 for a 6 – 10 month old pig and $60 for a sow.

We measured 840 pigs in the following age categories; weaned pigs (1 – 2 months), 3 - 5 months, 6 to 10 months or older than 10 months. The average live body weights by category were 6 kg, 12kg ($\pm$ 6.1), 30kg ($\pm$ 11.4), and 42 kg ($\pm$ 17.0) respectively. The models gave the farmers a more accurate prediction of the pig's weight. The estimation was usually within 1 kg of the actual weight but 25% of the estimates were wrong by 2.6 kg. As an example, the equation for market age pigs was weight = 0.39 (length) + 0.64 (girth) – 48.

Fifty percent of the pigs sold to butchers at 6 – 10 months of age weighed between 22kg and 35kg live weight. Even if the farmer only paid for half of the pig's feed and was able to use "free" waste food for the other half, the farmer could not make a profit by selling a 22 kg pig. It was important that the farmer feed the pig up to 30 kg live weight for the butcher and the farmer to make a profit of $6. If the pig reached 35 kg, the profit for the farmer was higher ($9).

Pig butchers averaged 9 years of experience, 3 employees and most owned the butcher shop (89%). Butchers purchased 4 pigs per week and traveled 5 hours and 25 km per day to source pigs. In town, butchers traveled to the farms to find pigs but in the small villages, the farmers came to the butcher to tell him they had a pig to sell. The butchers' challenges were that the farmers demanded a high price for the pigs (95%), there were insufficient pigs available (82%), the pigs were unhealthy (79%), the pigs were too small (76%), transport of the pig was difficult (39%), pork spoiled before it was sold (31%), selling all of the pork (28%), and earning a profit (27%).

The workshops and research farm visits enabled the farmers to improve. Many farmers (54%) estimated the weight of their pigs and recording the measurements on a monthly basis after the workshops. They also improved their pig's feeding (58%), built a barn (34%) or confined the pig more (2%), gave the pig medication for disease or parasites (29%), and/or bred the sow twice rather than once during estrus (17%). The workshops also increased the knowledge of the farmers about the pig tapeworm and how to prevent this cause of epilepsy. More farmers knew about the disease after the workshop and one-on-one training (70%) than after the workshop alone (64%) or before the training (40%). However, the information about the tapeworm was not shared amongst family members in the farm. Whereas 81% of people knew about the cyst form of the disease in pigs if they personally attended the workshop, only 48% knew if another family member attended and only 42% knew if no one in the farm attended. Similarly, 50% of people who attended the workshop knew how people became infected but only 34% knew if another person from the family attended and only 22% knew if no one from the family attended.

This model of education and research has been useful for these farmers. We hope to receive additional research funding so that the research results will be used to facilitate participatory workshops with farmers, government workers and butchers to enable them to work together to enhance the sustainability of the pig industry.

Acknowledgements: Thank you to: Veterinarians without Borders, Canada for the financial support and for the air travel, the participating farmers, butchers, village elders, and government officers, International Livestock research Institute in Kenya for research infrastructure support, and the University of Guelph.

University of Guelph / OMAFRA Partnership Pork Research Program Projects

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Under the research partnership agreement between The University of Guelph and OMAFRA, pork research is now managed as part of the ***Sustainable Production Systems Research Program***. This program supports large, multi-disciplinary and integrated research projects.

Based on an extensive review process two large swine and pork related research projects were approved in 2006. In addition, swine reproduction research is managed as part of a larger reproductive technology research project. The three approved projects are:

1. **Sustainable pork production: Healthy pigs and safe pork.** Leader: **B. Friendship (**Department of Population Medicine; rfriends@)ovc.uoguelph.ca); team members: **C. Dewey** (swine health management and epidemiology), **P. Boerlin** (bacteriologist), **C. Gyles** (bacteriologist), **S. McEwen** (public health), **K. Warriner** (meat scientist) **T. Widowski** (ethologist), **S. Millman** (ethologist), **A. Brooks** (pathologist), **B Wilkie** (immunologist), **J. MacInnes** (microbiologist), **C. deLange** (nutritionist), **T. Hayes** (pathologist), **J. Squires** (biochemistry and gene expression).

2. **Sustainable pork production: from gene expression to nutrient utilization efficiency and pork meat quality.** leader **C. de Lange** (Department of Animal and Poultry Science; cdelange@uoguelph.ca); team members: **S. Barbut** (meat science), **C. Dewey** (swine health management and epidemiology), **M. Fan** (swine nutrition and ecology), **C. Forsberg** (microbiology), **J. France** (mathematical modeling), **I. Mandell** (meat science), **P. McEwen** (pork production), **P. Purslow** (meat science), **A. Robinson** (genetics), **J. Squires** (biochemistry and gene expression), **A. Weersink** (Agriculture economy), **T. Widowski** (ethology).

3. **Reproductive technologies – from test tubes to animals.** Leader **W.A. King** (waking@uoguelph.ca) Department of Biomedical Sciences;); team members: **P. Bartlewski** (Reproductive imaging and endocrinology, **G. Bédécarrats** (Neuroendocrine control of reproduction), **D. Betts** (Gene expression, epigenetics and cloning), **M. Buhr** (Cryobiology, sperm technology), **A. Croy** (Reproductive immunology and uterine function), **A. Hahnel** (Spermatogenesis, spermatogonial transplantation), **W. Johnson** (Reproductive health and management), **J. LaMarre** (Gene expression and message stability, **J. Leatherland** (Fish brood stock health markers), **J. Li** (Gamete and Stem cell biology), **J. Petrik** (Ovarian biology).

Highlights of these programs are presented in this issue of the Centralia Swine Research Update. For further information on these research programs contact the project leaders.

Sustainable pork production: From gene expression to nutrient utilization efficiency and pork meat quality

Project leader: C. de Lange
cdelange@uoguelph.ca

Research objectives

The main aim of this integrated and multi-disciplinary research program is to explore the underlying molecular, biological and physiological mechanisms that contribute to interactive effects of the pigs' genotype and environment (sensory environment, feeding management) on pork meat and carcass quality, nutrient utilization, and pig behavior. The ultimate goal is to develop cost-effective strategies to enhance pork meat quality, minimize the negative impact of pork production on the environment, and enhance animal well-being.

The following faculty at the University of Guelph is involved in the project: **S. Barbut** (meat science), **C. de Lange** (swine nutrition), **C. Dewey** (swine health management and epidemiology), **M. Fan** (swine nutrition and ecology), **C. Forsberg** (microbiology), **J. France** (mathematical modeling), **I. Mandell** (meat science), **P. McEwen** (pork production), **P. Purslow** (meat science), **A. Robinson** (genetics), **J. Squires** (biochemistry and gene expression), **A. Weersink** (Agriculture economy), **T. Widowski** (ethology).

Research activities and main results

Following an analysis of on-farm behavioural assessments and meat quality data from 19 commercial herds and 6 university-based cohorts, we have published our initial findings of the ***sources of variability in meat quality*** found in commercial Ontario hog production. Although the range of values found is not hugely different from those in other major pork-producing countries, there is a large opportunity to reduce variability and improve overall end-product quality. Variations between individual producers and day to day variations in packing plant conditions are prime factors.

In terms of muscle physiology responsible for variations in quality, a small but significant negative correlation between activity of calpain (endogenous muscle protein degrading enzyme) and drip loss was found. Following on from initial gene expression analyses, a more robust method of analyzing consistently up- and down-regulated genes has been introduced and we are now following a small set of genes identified as being involved in tenderness and water-holding capacity.

The central role of 5'AMP-activated protein kinase (AMPK) was identified in controlling post-mortem glycolysis, and thus changes in muscle acidity and degeneration after slaughter. Methods to analyse the activity of AMPK have now been established in our laboratory and work to examine the role of this biochemical pathway in influencing meat quality has been initiated.

Further analyses of encouraging results of modifying the type and amount of ***human interactions with the animals on farm*** on end-product quality have been conducted. Even short-duration exposure of animals to humans walking through their pens each day during the finishing phase or to being herded into crowds or through doorways resulted in significant reductions in drip loss from their pork compared to controls.

We have extended our set of management trials designed to test ***effects of nutritional strategies on pork quality***. Dietary supplementation with tryptophan (a precursor of serotonin in the brain) did not significantly affect growth performance or any meat quality measure. Similarly, a corn plus vitamins diet with low protein levels yielded no effects on growth performance or meat quality. A low glycogenic diet comprised mainly of beet pulp feed decreased average daily weight gain (ADG) and increased overall feed efficiency, but also resulted in small reductions in intramuscular fat (marbling) and increased tenderness. Ractopamine (paylean) showed an increase in both ADG and feed efficiency over control diets, but was associated with decreased pork tenderness. None of these four dietary strategies improved drip loss. Further nutritional trials involving diets supplemented with chicory, high dietary potassium levels, magnesium aspartate, ractopamine, or lipoic acid have been initiated and are close to completion.

Evaluating (thermal) stress responses to environmental conditions is important for studying the ***welfare of pigs during transport***. Observations of over 46,000 pigs on 250 trucks arriving at the 3 largest abattoirs in the summer in Ontario indicate that as waiting time at the abattoir increased by 30 minutes, trucks were 2.2 times more likely to have a pig die in transit and 2.3 times more likely to have a fatigued pig. As environmental temperature increased by 10^{o}C, trucks more likely to have pigs die in transit (27X), one or more fatigued pigs (26X) and one or more panting pigs (2.3X). Pigs panting as they are unloaded may be an indication of poor welfare as trucks with a pig that died in transit were 2 times more likely to have pigs panting ($P<0.001$). A study was conducted to determine core body temperatures (CBT) of pigs during transport to a commercial abattoir using Thermocron iButton temperature loggers. Over six weekly trials (June-July 2007), loggers were orally administered to 252 (42/trial) pigs. Pigs were randomly assigned to one of 12 compartments in either a three-deck pot-belly trailer with internal ramps (PB) or a double-decked hydraulic trailer without ramps (10W). When Stationary, PB pigs had a higher mean CBT than those on the 10W (40.62±0.05°C, 40.15±0.07°C respectively, $P<0.001$). However, pigs on the PB truck were loaded first and had a longer period of waiting before transit. Within the PB, CBT was higher when Stationary compared to all other periods (Pre-loading: 40.11±0.07°C; In-transit: 40.18±0.07°C; In-Lairage: 39.82 ±0.06°C; $P<0.01$) and in two of the top-deck compartments of the PB than for all other compartments in that trailer ($P<0.02$).

In performance studies aimed at evaluating inexpensive ***co-products from the biofuel and food industry***, such as corn distillers grains plus solubles (DDGS), corn steep water and whey permeate showed that these co-products can be effective feed ingredients for pigs. However, the high potassium content in these ingredients appears to limit the maximum inclusion levels: when pigs were fed diets with elevated potassium levels (1.4% total potassium), slight reductions in pig growth performance were observed and a buildup of calcium salts in the kidney was noted at slaughter. However, feeding increasing levels of high potassium containing co-products does not appear to influence a range of ***meat quality characteristics*** of frozen loin samples. In nutrient balance studies it was shown that the negative effects of feeding high potassium levels can be overcome by supplementing diets with calcium chloride. The latter is being confirmed in a large scale pig performance study.

A feeding trial was conducted with 10 Cassie finisher barrows (specific line of ***transgenic pigs expressing endogenous phytase production from salivary glands; Enviropig^{TM}***) and 10 conventional age matched Yorkshire barrows with the objective to compare feed and water consumption and manure production, to assess phosphorus and calcium digestion, to collect health information on seventh generation pigs, and finally to collect manure for environmental impact studies. The Cassie and Yorkshire pigs gained a similar weight over the duration of the trial. However, the Cassie pigs retained 34% more of the cereal grain phosphorus consumed than did the Yorkshire pigs. These

results show that production of phytase by Cassie barrows was efficacious, and furthermore, demonstrated that supplementing the Yorkshire pig diet with the recommended level of phytase was not as efficient as the salivary phytase at digesting plant phosphorus. Hematological and clinical biochemistry data indicated that all parameters were within the literature ranges, except that the albumin-globulin ratio was high in relation to a single value reported in the literature. Submissions have been made to the FDA to approve the use of Enviropig in commercial pork production.

In metabolism and isotope tracer studies it was shown that the low efficiency of body protein growth is mainly determined by postnatal developmental programming, as affected by hormones, environmental stressors and nutrient availability in the pig. Postnatal changes of skeletal muscle calpain and calpastatin mRNA expressions are correlated with lean growth in the pig, suggesting protein degradation in involved in control of muscle protein growth. The surge of the stress hormone cortisol can be quickly induced and reach a peak level in the blood with 30 mina and lasts to about 50 min after animals' handling in weanling pigs. The surge in blood cortisol can rapidly reduce skeletal muscle protein synthesis within 30 min of stressful handling.

Chronic ***immune system stimulation*** reduces whole body protein deposition in growing pigs. The reduction in body protein deposition can be reduced by supplying the pigs with additional amounts of the sulfur containing amino acids methionine and cysteine.

The growth rate of pigs in a commercial herd affected by Porcine Circovirus 2 (PCV2), *Actinobacillus pleuropneumonia*, and *Mycoplasma hyopneuomia* did not differ by whether they were given one dose of a one-shot PCV2 vaccine versus one dose of a two-shot PCV2 vaccine that was given to alternate pigs within a litter. The disease challenges impacted the overall weight gain as can be seen by the average weights of pigs at weeks 4, 10, 18 and 25 of age were 8.5 ($\pm$ 2.4), 19.7 ($\pm$ 5.7), 43.8 ($\pm$ 13.0) and 76.3 ($\pm$17.9) kg respectively.

Different ***mathematical modeling approaches*** are used to improve or simplify the prediction of growth performance and nutrient utilization in growing pigs, or to better represent the specific aspects of the biology of growth in the pig. On-farm studies are being conducted to demonstrate the value of applying models on Ontario pig farms. Fine-tuning feeding programs, based on monitoring actual performance levels and the application of mathematical pig growth models, can reduce feed costs by at least $1.00 per pig, and improve profits by at least $1.50 per pig.

Take home messages

- A large multi-disciplinary research program at the University of Guelph is aimed at develop cost-effective strategies to enhance pork meat quality and/or minimize the negative impact of pork production on the environment, while enhancing animal well-being.

- Considerable variations in pork quality exist in the Ontario pork industry, in common with the pork industry worldwide. Drip loss represents a large economic loss to the industry and can be significantly reduced by either pen walking or crowding treatments. These strategies reduce the susceptibility of animals to stress at slaughter, and so improve animal welfare as well as pork quality.

- Several case studies on Ontario farms have shown that fine-tuning feeding programs, based on monitoring actual performance levels and the application of mathematical pig growth models, can reduce feed costs by at least $1.00 per pig, and improve profits by at least $1.50 per pig.

Ontario Pork Research

Jean Howden, Ontario Pork

Ontario Pork each year funds basic and applied on behalf of producers. The research committee is made up of producers, veterinarians and industry representatives that are active in our industry.

The committee reviews numerous research proposals and recommends funding to those proposals with merit to producers and the industry, while not duplicating other research initiatives.

Projects funded by Ontario's pork producers have improved our understanding of animal husbandry, the environment, nutrition, genetics and reproduction, as well as food safety and meat quality.

For the past five years, Ontario Pork has published a special supplement to Better Pork called Pigs, Pork and Progress which highlights the research and results producers have funded. Look for the 2009 edition of Pigs, Pork and Progress with your June Better Pork!

Research serves as the fundamental building block for the advancement of our industry and is the cornerstone of the industry's success.

In 2008 the following research was approved, and the projects are in various stages of progress.

Project No. 08/011 **Researcher:** Robert Friendship
Title: An investigation of treatment failure in Ontario swine herds
Synopsis: Veterinarians in Ontario will identify herds with disease problems. We will visit a minimum of 30 herds with a a history of a recent disease outbreak that has not responded to treatment. A thorough history will be taken, 3 pigs will be sacrificed for post mortem examination, and blood samples form pen mates taken and other procedures as necessary to establish a sound diagnosis. The results will be shared with the herd veterinarian. A follow-up visit will be conducted to determine if response was improved in the case where treatment was modified based on the additional information. Causes of treatment failure will be documented in they can be determined.

Project No. 08/018 **Researcher:** Paul Luimes
Title: Mycotoxin Detoxification Using Sodium Bisulfite
Synopsis: This is a pilot study to determine whether lab results to lower the mycotoxin level of corn can be duplicated in a practical field test and to determine how growing hogs perform on this corn compared to clean corn.

Project No. 08/020 **Researcher:** Laima Kott
Title: Development of Fusarium resistant corn in-breds for pork production
Synopsis: This is the final year of developing a protocol that entails use of pollen grains that are induced to develop as embryos and plants. During the process pollen is exposed to a UV mutagen to produce minor genetic changes, and subsequently with in vitro fusarium resistant corn genotypes are identified.

Project No. 08/021 **Researcher:** Art Schaafsma
Title: Development of an integrated mycotoxin management system in Ontario corn
Synopsis: This project stresses the importance of preventive measures to manage mycotoxin contamination in corn. The propose control program is based on the HACCP approach that involves

strategies for identification of factors leading to mycotoxin contamination and the establishment of preventive control procedures. The control system will include: 1 - Evaluation of the contamination process through surveillance of corn;2 - Investigate practical and innovative analytical methods, using near infrared for DON and liquid chromatography techniques for multitoxin detection, to improve the accuracy of mycotoxin detection in corn and derived products;3 - Investigate preventative measures for reduction of risk of contamination through the evaluation of the sensitivity of commercial corn hybrids to Fusarium infection or mycotoxin accumulation; and4 - Evaluation of early warning forecasting systems and fungicide management tools to control fusarium infection and/or mycotoxins accumulation in corn field trials.

Project No. 08/022 **Researcher:** Ron Ball
Title: Reducing feed cost per unit of pork produced
Synopsis: 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.

Project No. 08/023 **Researcher:** C.F.M. de Lange
Title: Swine Liquid Feeding Research II: Increase co-product usage, reduce energy input costs, impact on meat quality, gut health and the environment
Synopsis: This is continuation of liquid swine research at the University of Guelph which has been developed in close consultation with the Ontario pork industry. The research involves in vitro steeping and fermentation studies, nutrient balance and digestibility studies, laboratory scale rheology studies, and pig performance studies that involve evaluation of meat quality and nutrient excretion, all aimed at achieving the following objectives:1 - To explore manipulation of dietary electrolyte balance and use of enzymes or bacteria to increase usage and nutritional value of co-products , and reduce feed costs.2 - To explore physical aspects of liquid feed delivery to enhance feed intake, gut health and gut development in pigs, and to minimize feed spoilage.3 - To quantify overall energy usage, impact on the environment, pork meat quality and gut health associated with liquid feeding diets that contain large amounts of co-products.4 - To extend the positive effects of liquid feeding to conventional dry feeding systems.

Project No. 08/025 **Researcher:** Phil McEwen
Title: Rapid Determination of the Feeding Value of Co-Products for Corn-Based Ethanol Production and Subsequent Impacts on Swine Performance and Pork Quality
Synopsis: This project will evaluate rapid methods of determining the feeding value of co-products for corn-based ethanol production. The methods will include: 1 - Use of a colorimeter for rapid determination or co-product feed quality; 2 -New and traditional chemical analyses available in a typical feed testing laboratory; and3 - Development of an in vitro assay for quick assessment of feed quality.

Project No. 08/027 **Researcher:** Roy Kirkwood
Title: Addition of seminal plasma to thawed semen and sow fertility
Synopsis: The objective of this proposal is to develop a boar semen thawing protocol that will result in frozen sperm having fertility comparable to fresh sperm. Estrous gilts will be inseminated with fresh semen or frozen-thawed (FT) semen extended with or without 50% seminal plasma and the number of sperm in the sperm reservoir determined. Sows will be inseminated with FT semen extended with or without 50% seminal plasma at different times relative to predicted ovulation. This will allow us to examine the effects of seminal plasma on sow fertility and on the time limit requirements for successful use of FT semen.

Project No. 08/028 **Researcher:** Anne Croy
Title: Mechanisms underlying a successful therapeutic intervention that promotes litter size in swine
Synopsis: This project is an extension of a clinical trial. In a small controlled study it has been demonstrated that the number of ova released is increased, progesterone and the number of implanting blastocysts are increased which promotes uniform growth of gestation day 15 -30 fetuses and reduces the early wave of fetal loss in commercial swine. This trial will address the mechanism for these phenomena and to characterize offspring growth rates to market weight and assess carcass quality.

Project No. 08/029 **Researcher:** Paul Luimes
Title: Synchronizing sows to farrow later
Synopsis: The objective of this project is to determine whether two products can consistently delay parturition. If so, by how many days? The data will provide groundwork to develop a tool that can optimize the use of synchronized farrowing without as much of a risk for less viable piglets.

Project No. 08/032 **Researcher:** Julang Li
Title: Production of epidermal growth factor expressing Lactococcus Lactis and its potential for enhancing early-weaned piglet growth.
Synopsis: The objective of the project is to generate Lactococcus Lactis that secrete epidermal growth factor and to test their potential for enhancing early-weaned piglet growth. Diarrhea and the associated reductions in growth rates during the period immediately after weaning is one of the major problems in nursery pig management. Developing a diet to stimulate intestinal development of early weaned pigs may help to optimize their performance in this critical stage. Epidermal growth factor (EGF) is known to stimulate the development of intestine and its supplementation into formulas was shown to facilitate the recovery of intestines in piglets from rotavirus infection. We hypothesized that locally deliver EGF to the GI tract using food-grade Lactococcus Lactis may be beneficial for improving early-weaned piglet performance. We will use a genetic engineering approach to generate Lactococcus Lactis that secrets epidermal growth factor and test if
including these EGF delivering bacteria into feed enhances piglet intestinal development, and thus, early-weaned piglet performance.

Project No. 08/034 **Researcher:** Martin Misener
Title: OSHAB Centralized PRRSV Database
Synopsis: This pilot project is proposing the development of a centralized PRRSV database at the animal health lab at the University of Guelph. This tool would allow comparisons of percent similarity between PRRSV isolates already in the database from farms throughout Ontario and isolates from new PRRSV cases. The pilot will have significant value to Ontario swine veterinarians and producers and would help in understanding viral spread and prevalence and severity of clinical symptoms seen with specific variants through improved communications between veterinarians. It holds the potential to assist veterinarians and producers in identifying possible routes of entry of the virus, offering opportunities to improve on-farm biosecurity. Confidentiality issues will be address in this project.

Project No. 08/037 **Researcher:** Kathy Zurbrigg
Title: Presenting cost effective and practical group housing designs to swine producers in a video format.
Synopsis: This objectives of this project: 1 - Provide producers with new concepts in animal behaviour that are important in making group sow gestation housing work well.2 - Show the feeding strategies and pen design concepts used by Ontario producers that ensure equal feed distribution between sows and that minimize or eliminate aggression at mixing and feeding times.3 - Provide the

building or renovation and operational costs along with pen diagrams for each of the group housing systems featured in the video.

Project No. 08/038 **Researcher:** C.F.M. de Lange
Title: Impact of immune system stimulation on nutrient utilization and response to dietary methionine plus cysteine intake in growing pigs
Synopsis: Previous studies in the lab indicate that there are opportunities to manipulate the response of growing pigs during an immune challenge, in order to reduce the negative impact of sub-clinical levels of disease on pork production efficiencies. The researcher hypothesize that the supply of dietary methionine plus cysteine is an important determinant of the pigs' immune and growth response to an immune challenge. Studies are proposed in which pigs are exposed to controlled levels of immune system stimulation (based on repeated injections of increasing doses of LPS) to evaluate its impact on nutrient digestibility, whole body protein growth and utilization of methionine and cysteine, especially as it relates to the production of glutathione.

The Sentinel Herd Project Update – Prevalence of Bacteria on Ontario Pig Farms That Are of Public Health Importance

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Background

The control of foodborne diseases associated with pork is very important for public safety but also for consumer confidence. In the past year an outbreak of Listeriosis associated with contaminated luncheon meats illustrated the need for constant vigilance. In order to minimize the chance of a foodborne illness occurring, it is important that all stages, "from farm to fork" be continually monitored. The first step in controlling the spread of these potential disease agents is to investigate their prevalence on the farm and then work to develop strategies that will minimize their presence.

Objective

The aims of this study were to describe the distribution of *Salmonella*, *Campylobacter*, *Yersinia enterocolitica*, *Escherchia coli* O:157, and *Listeria monocytogenes* on a subset of Ontario swine farms, to investigate the difference in distribution of these pathogens in stored manure and among pigs in different stages of production, and to study whether the presence of the various pathogens are related.

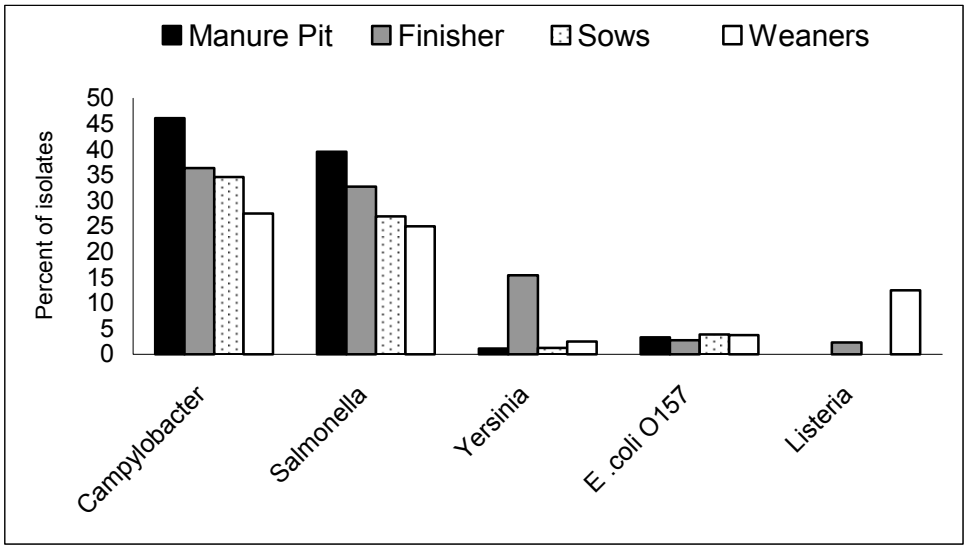
Materials and Methods

This project was conducted as part of the C-EnterNet project initiated by the Public Health Agency of Canada. Thiry-one swine farms located in the Regional Municipality of Waterloo were visited between March 2005 and November 2007. On each farm, pooled-fecal samples were collected from finisher pens, weanling-pens, and from 6 randomly selected sows, as well as one pooled-sample from the manure storage pit. In total, 359 fecal samples from manure storage tanks (91) and fresh-pooled feces (268) obtained from finisher pigs (110), sows (78), and weanlings (80) were collected and tested. The distribution of pathogens among different samples was reported, and the association between different pathogens was investigated.

Results

Campylobacter, *Salmonella*, *Yersinia enterocolitica*, *E. coli* O157 and *Listeria monocytogenes* were isolated from 36%, 31%, 6%, 3%, 3% of samples, respectively (see Figure1). *Salmonella* and *Campylobacter* were more likely to be detected from stored manure rather than fresh fecal samples. On the other hand, *Y. enterocolitica* tended to be detected more commonly from fresh samples than from manure pits. No *L. monocytogenes* was recovered from manure pits or from sow fecal samples and only infrequently found in the feces of weanling pigs and finisher pigs. The 113 *Salmonella* isolates belonged to 23 different serovars. The four most common serovars were Typhimurium var. Copenhagen, Derby, Typhimurium, and Agona. Of 131 *Campylobacter* isolates, 118 isolates were *C. coli* and 13 isolates could not be speciated. Fifteen of 21 *Y. enterocolitica* isolates were detected in finisher pigs and the most common sero/biogroups was O: 3 / biotype 4. All 12 *E. coli* O:157 isolates were tested but none were determined to be *E. coli* O:157:H7. The isolation of *Salmonella* from fecal samples was correlated with the presence of *Campylobacter*.

Figure1. Distribution of *Campylobacter*, *Salmonella*, *Y. enterocolitica*, *E. coli*, and *L. monocytogenes* among fecal samples collected from manure pits, finishers, sows, and weaners.



Discussion

The findings of this study are similar to previous work and suggest that *Salmonella*, *C.coli*, and *Y. enterocolitica* are commonly found in pig manure whereas *E. coli* O157:H7 and *L. monoctyogenes* are rarely isolated. This study provides baseline information on the epidemiology of important zoonotic pathogens in different stages of swine production and the prevalence of these organisms in stored manure. The high prevalence of Salmonella and Campylobacter makes it unlikely that these two pathogens can be eradicated from the Ontario pig population. Strategies to minimize bacterial numbers via methods such as vaccination may hold more promise than attempts to create populations free of the organisms.

Acknowledgments

The Public Health Agency of Canada, the Laboratory for Foodborne Zoonoses, Guelph and St. Hyacinthe units, the *Escherichia coli* Laboratory, OIE reference laboratory, Faculté de médecine vétérinaire of University of Montreal, Bureau of Microbial Hazards research laboratories and Toronto Regional Public Health Laboratory.

Strep. suis – an update

Robert M. Friendship and Janet I. MacInnes
University of Guelph

Streptococcus suis infection is a well known pathogen on Ontario pig farms. Generally the disease is recognized as a sporadic outbreak of meningitis, but there are other manifestations such as heart disease, pneumonia or arthritis. It has long been known that *Strep. suis* can cause disease in humans, but the cases have been extremely rare. However, in China from mid-July to the end of August 2005, a major outbreak occurred with a total of 215 cases of human *Strep. suis* infections. All infections involved backyard farmers who were directly exposed during the slaughtering process of pigs that had died of unknown causes or that had been killed for food because they were ill. Sixty-one farmers (28 percent) had streptococcal toxic shock syndrome; 38 (62 percent) died. The other illnesses reported were sepsis (24 percent) and meningitis (48 percent) or both.
One significant outcome of this catastrophic event is that the world medical community is now much more familiar with *Strep. suis* as a potential cause of human disease. For example, the first case of human *Strep. suis* meningitis in the United States was diagnosed only a few months after the China outbreak and more recently, two cases in Australia were reported. This disease has the potential to strongly and negatively impact consumer confidence.

Recently, we conducted a study to determine the prevalence and to characterize the types *Strep. suis* present in Ontario pigs (MacInnes et al., 2008). Tonsillar and nasal swabs were collected from weanling pigs in 50 representative herds. All but one herd tested positive. Of the 35 different serovars of *Strep. Suis* characterized to date, serovar 2 is by far the most important pathogen in people. On almost half of the farms tested in our study had either serovar 2 *Strep. suis* or the closely related serovar 1/2. One important implication of this finding is that *Strep. suis* is very common in the Ontario pig population and the zoonotic threat, *Strep. suis* serovar type 2 appears to be present in the Ontario pig population. Pork producers need to be aware that a low but real risk may be present during manipulation of *S. suis*-diseased animals. These pigs may shed very high numbers of bacteria, and wearing gloves and/or washing hands with soap and water immediately after handling is prudent.

There is still a great deal that is unknown about how *Strep. suis* causes disease and why certain strains seem to be more dangerous than others. At present there are no effective means to eradicate the organism from pig herds and even control of disease outbreaks has proven difficult.

Reference:

MacInnes J. I, M. Gottschalk, A. G. Lone, D. S. Metcalf, S. Ojha, T. Rosendal, S. B. Watson, R. M. Friendship. Prevalence of *Actinobacillus pleuropneumoniae, A. suis, Haemophilus parasuis, Pasteurella multocida,* and *Streptococcus suis* in representative Ontario swine herds. Can J Vet Res. 72: 242-248. 2008.

Clostridial Diseases in Pigs and Public Health Concerns

R. Friendship, J. Gallant, K. Warriner and S. Weese
University of Guelph

Introduction

There are several species of *Clostridia* that are very commonly found in the intestines of pigs. The extent of disease associated with these bacteria is not well known and their impact in Ontario maybe under-estimated. They are reported to be the most frequently diagnosed cause of diarrhea in suckling piglets in the swine producing areas of the United States. One type of *Clostridia* (*C. difficile*) is also a concern from a public health standpoint. *C. difficile* in hospitals has created major problems.
Clostridium perfringens type A is a normal inhabitant of the pig intestine but is also occasionally a cause of diarrhea in piglets during their first week of life. One reason it may escape diagnosis is that this bacteria does not cause gut damage. It is believed that beta2 toxin plays a role in causing the diarrhea and generally the bacteria isolated from disease cases produce this toxin.
Clostridium difficile is also a cause of diarrhea in piglets during the first week of life, and is sometimes associated with antibiotic use as a predisposing factor. On post mortem examination the lining of the colon is swollen with fluid (edema) and the contents of the large intestine is pasty-to-watery and yellow. Piglets generally don't die from the diarrhea but as in most cases where piglets are sick the lack of nursing may cause the sow to develop a swollen udder and milk production is reduced, and weaning weights of piglets are negatively affected.

Research Findings

There are no formal studies examining the prevalence of Clostridial diarrhea in the Canadian pig population, however there are anecdotal reports from swine practitioners that the problem has increased recently or is becoming more commonly diagnosed. Gallant Custom Laboratories report that in 2007 there were 7 swine clients who requested autogenous *Clostridium* bacterins and that number jumped to 40 in 2008. Most vaccines were for *C. perfringens* type A strains that produced beta 2 toxin, but a few bacterins also included *C. difficile*.

Longitudinal evaluation of *Clostridium difficile* in piglets on one farm

The objective of this study was to characterize the prevalence of *C. difficile* colonization in piglets over time on a commercial swine farm.
Sows were sampled 30, 23 and 15 days prior to farrowing and rectal swabs were collected from piglets from positive and negative sows on days 2, 7, 30, 44 and 62 for enrichment culture. *C. difficile* colonization rates were high initially and decreased over time. *C. difficile* was isolated on one or more occasions from 97% (117/121) of piglets. The prevalence of *C. difficile* colonization on days 2, 7, 30, 44 and 62 was 74%, 56%, 40%, 23% and 3.7%, respectively. The reason for the change in prevalence over time is unclear and requires investigation to determine whether factors can be modified to reduce the risk of transmission. The use of a single farm limits making broad conclusion, but this study provides insight into age-related effects on colonization that should be considered in future studies. While colonization status of the sow influences the piglets, there is not an absolute relationship and other sources of infection need to be considered.

Prevalence of *C. difficile* in 52 Ontario herds

Faecal and effluent samples (133) were collected from 52 farms located within Southern Ontario. *C. difficile* was recovered from 15 farms (28% prevalence). The majority of isolates recovered belonged to ribotype 078 (16/20 isolates) with ribotype 027 being less prevalent (1/20). All the isolates produced toxin A & B, in addition to binary toxin confirming potential pathogenicity towards

neonatal pigs and humans. The prevalence of *C. difficile* is high within Ontario pig herds and a shift from the dominance of ribotype 027 to the strain implicated in community acquired CDAD (ribotype 078) has occurred providing further evidence of a foodborne link.

Implications

This preliminary work suggests that *Clostridium perfringens* and *Clostridium difficile* are extremely common in Ontario pig herds and that they are likely both associated with piglet diarrhea at times but more importantly C. difficile from pigs might be a serious public health concern and needs to be further investigated.

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Methicillin-resistant *Staphylococcus aureus* (MRSA)

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Methicillin-resistant *Staphylococcus aureus* is a multidrug resistant bacterium that is a tremendous problem in people. MRSA was originally a concern mainly in hospitalized individuals but there has been a dramatic increase in community-associated disease (infections in people in the general population) over the past 10 years. MRSA is now a leading cause of skin and soft tissue infections in people in the general population and can also cause severe diseases such as necrotizing fasciitis ('flesh-eating disease') and severe pneumonia. This bacterium is emerging concern in a variety of animal species and a potential problem for the pork industry because of real or perceived public human health risks associated with contact with pigs or pork. While not an important cause of disease in pigs themselves, there is tremendous concern about MRSA because of its role as an important (and high-profile) cause of disease in people.

Concerns about MRSA in pigs came to the forefront a few years ago, with reports from Europe identifying high rates of MRSA carriage in the nose and intestinal tracts of a large percentage of healthy pigs in different countries. This was identified following diagnosis of 'unexpected' cases of MRSA infection in pig producers, swine veterinarians and their families. High rates of MRSA carriage were also found in people that work with pigs, and a Dutch study reported that pig farmers in that country were 760 times more likely to carry MRSA compared to the general population. One unique aspect was the finding that virtually all pigs (and people associated with pigs) that carried MRSA had one specific strain, called ST398. This strain has historically been very rare in people and it is suspected that it is actually of pig (or pig and cattle) origin. Since the initial finding of MRSA in pigs, there have been various reports implicating pigs as a source of human infections in Europe, with increasing rates of ST398 MRSA infection. Contact with pigs (or cattle) has been identified as a significant risk factor for MRSA carriage or infection in multiple European studies. The association between pig contact and MRSA is so strong in some regions that pig farmers and veterinarians are automatically isolated if they are admitted to hospital based on the assumption that they are carrying MRSA.

Since the first reports of MRSA in pigs in Europe, there has been considerable interest in this organism internationally. Studies have been performed in various countries evaluating the presence of MRSA in pigs and the possible role of pigs in human MRSA infections. The first study of pigs in North America identified MRSA carriage in 20% of healthy pigs on a sample of Ontario farms. 25% of producers were also carrying MRSA, and in every instance where MRSA was found in a producer, the same strain was found in one or more pigs on the farm. This was followed by a report of MRSA in pigs in Iowa and it is likely that MRSA is widely distributed in pigs throughout North America. Currently, studies are ongoing to evaluate the prevalence of MRSA carriage by pigs across Canada. Results should be available in early to mid 2009.

Not surprising, the finding of MRSA in pigs led to concerns about food as a source of infection, either through ingestion of MRSA or from people inoculating themselves (i.e. their nose or wounds) with MRSA from meat. A preliminary European study found MRSA in a small percentage of retail pork samples. A Canadian study then found MRSA in a larger percentage of retail pork products, with a combination of ST398 and common human-origin strains. More information on the sources of MRSA contamination of pork and the human health implications is needed. There is

currently no evidence that food is an important source of MRSA transmission but this is an area that has only been minimally investigated to date.

Despite the finding of MRSA in pigs and pork in Canada, the potential role on human health is unclear. Unlike the situation that is currently present in Europe, human infections caused by ST398 MRSA are very rare in North America. In comparison with some European countries where ST398 MRSA accounts for 20% of more of community-associated MRSA infections in people, there have only been a handful of ST398 MRSA infections diagnosed in Canada. However, this should be interpreted with caution since only a small percentage of MRSA isolates are typed in Canada, and that typing tends to focus on hospital outbreaks (where ST398 would be less likely to be involved). Further, it is possible that the Canada is simply a few years behind Europe in the epidemiology of ST398 MRSA and that ST398 infections could be silently on the rise. Only time and ongoing surveillance will determine that. Another complicating factor is the diversity of MRSA types in pigs and pork in Canada. Unlike in Europe, when almost all pigs with MRSA carry ST398, other strains have been found in Canadian pigs, including common human strains. Similar results have been obtained with pork. This makes it more difficult to determine the role of pigs and pork in human disease.

Some of the more important points to remember about MRSA, based on our current knowledge are:

- MRSA is present in pigs in Canada, and pig producers appear to be at much higher risk than the general public for carrying MRSA in their nose. It is likely that pig producers (and their families) are at higher risk for MRSA infections as well, and they should make sure that their physicians realize this.
- MRSA infections are typically skin infections such as wound infections and boils. Any pig producer (or a family member) with infections like this should see a physician and make sure they are aware of the MRSA risk.
- General hygiene practices might be important for reducing the risk of MRSA exposure, particularly avoiding touching your nose in the barn and good handwashing.
- MRSA rarely causes disease in pigs so farms can easily be infected without anyone knowing.
- MRSA can be found on retail pork but there is currently no evidence that this poses a significant risk. Standard meat handling and cooking recommendations should greatly reduce any risks.
- We currently have no means to control MRSA on pig farms, however further research will hopefully identify practical infection control and biosecurity measures.

Disease Resistance Genes

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We have been looking for genetic variations associated with the occurrence or severity of pneumonia in young pigs infected with common agents involved in the respiratory disease complex. Various single nucleotide polymorphisms (SNPs) were identified in genes for some innate immune lectins (mannan binding lectins [MBL], ficolins and SP-A) that bind to saccharide patterns on the surfaces of some respiratory bacteria (1). Expression of MBL-C in pigs was linked to polymorphisms in the MBL2 gene promoter region (2). One allele (MBL2 –1081A) that was most associated with low MBL-C expression was significantly more frequent in pigs with various pneumonias at post mortem (2). Young pigs have variable amounts of ficolin α that binds and neutralizes the PRRS virus at physiological concentrations (3,4).

A panel of 27 SNPs in 12 porcine innate immune genes, including MBLs, ficolins and SPA, was developed on the basis of expected roles in resistance to respiratory disease (4). This panel was used to genotype pigs diagnosed at post mortem with various common diseases (N = 464), in comparison with healthy pigs of various breeds (N = 1283), and with pigs (N = 440) in a single farm in which pre- and post-weaning growth rates were measured. Several alleles including the MBL2 –1081A allele were associated with pneumonia at postmortem but were not significantly associated with severity of pneumonia or with growth rate. Three SNPs linked on chromosome 14 (MBL1 271T, SPA 439A, SPA 500T) were associated with more severe necrosis and inflammation in 75 pigs with PRRSV positive pneumonia, but this haplotype was not related to the occurrence of pneumonia, or growth performance in weaned pigs. A galectin-4 allele (GAL4 96T) was significantly more frequent in pigs with pneumonia and with PRRSV and PCV2 infection, and less frequent in pigs with higher growth rates. These studies have identified several polymorphisms in microbe-binding lectins that might affect occurrence or severity of pneumonia or other infectious diseases, and these should be considered as candidate disease resistance genes in large-scale studies.

This work is a collaboration with Drs Brandon Lillie, Natalie Keirstead, James Squires and Robert Friendship, with support of Ontario Pork, NSERC, OMAFRA, and CIHR.

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Transport Losses in Finisher Pigs

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Introduction

Transport losses in finisher pigs refers to the pigs that die in-transit – that is after they leave the farm and before they are stunned at the abattoir. Losses may also include pigs that are fatigued and therefore result in lower carcass quality. For the purposes of this report, in-transit losses refer to deaths. The purposes of these projects were to understand the factors associated with in-transit losses in finisher pigs in Ontario.

Methods and Results

Records from Ontario pork and abattoirs and environmental temperature and humidity data were collected and merged and then the association between in-transit losses and herd size, distance traveled, temperature and humidity, and farm, transport and abattoir.

Losses averaged 17 pigs per 10,000 shipped in 2001. Small farms, those marketing less than 2000 per year, had higher losses than larger farms and accounted for 50% of the dead pigs although they accounted for only 35% of the pigs marketed. The majority (74%) of pigs were trucked at least 200 km to the abattoir. Losses were highest for long distances (700 to 900 km) and were much higher in June through August than in other months of the year. In hot months, losses averaged 36 pigs per 10 000, whereas in the mild and cold months, the losses were 13 and 11 pigs respectively. The farm was associated with more of the variation in loss (25%) than either the abattoir receiving the pig ((16%) or the transport company trucking the pig (8%). Thus, future research must focus on the farm factors associated with losses. Previous research has identified factors that may be important such as exposure to people and moving in and out of pens during the growing/finishing phase of life, having the same flooring in the pen and the hallway, gentle handling without a prod when moving pigs, removing the feed from the pigs several hours before loading, ensuring pigs are moving in a hallway that is conducive to good flow, moving small numbers of pigs at a time, and ensuring that the ramp is at a angle of less than 25 degrees. This work needs to be done in Ontario to determine which factors are most important. The 3,434 Ontario farms that marketed pigs in 2001, 2002 and 2003 were selected. Using linear regression, we found that in-transit losses in one year were associated with losses in previous years. As losses in one year increased by 1%, losses in subsequent years increased by 0.1% to 0.16% ($p<0.001$).

Researchers visited the 3 largest abattoirs in Ontario during the summer months. Every 5th pig leaving the truck was observed for up to 30 pigs per truck. On 250 trucks, transporting over 46,000 pigs, 7,351 individual pig observations were made. Of all pigs transported, 0.27% were classified as subject pigs, and of these, 48% were fatigued or affected by heat stress. As waiting time at the abattoir increased by 30 minutes, trucks were 2.2 times more likely to have a pig die in transit and 2.3 times more likely to have a fatigued pig. As environmental temperature increased by 10^{o}C, trucks more likely to have pigs die in transit (27X), one or more fatigued pigs (26X) and one or more panting pigs (2.3X). Pigs panting as they are unloaded may be an indication of poor welfare as trucks with a pig that died in transit were 2 times more likely to have pigs panting ($p<0.001$). It may be concluded that the welfare of all pigs on the truck is compromised if there is one pig on the truck that dies in transit.

Temperature and humidity loggers were placed in three compartments of trucks and a GPS unit was put in the cab of the truck transporting pigs in the summer. Over a 3 month period, 108 loads of pigs from 3 transport companies and 8 trailers were recorded. The compartment temperature

increased by 1°C as the outside temperature increased by 1°C or the humidity increased by 10%. As the pigs/m^2 increased the compartment temperature increased exponentially. Dramatic and steady increases in compartment temperatures occur when the density was at 2.4 pigs/m^2or higher than 2.4 pigs/m^2.Therefore, it is essential that the numbers of pigs on a truck be reduced substantially when the temperatures are high – because both the outside temperature and the number of pigs on the truck increase the temperature in the compartment. As the distance increased by 100 km, the compartment temperature decreased by 2°C. This is likely a reflection of trucks traveling at high speeds on highways.

The hottest part of the trip is likely responsible for the most significant stress on the pigs. We therefore looked at the temperature at that hottest 10% of the trip. As this temperature increased by 1°C, pigs were 1.2 times more likely to die in-transit. However, as the trip either increased by 50 km or the trip time increased by 2.5 hours, the pigs were 0.8 or 0.5 times less likely to die in-transit. This is likely a function of air movement cooling the compartments of the truck.

Acknowledgements: Funding for these projects was provided by Ontario Pork, the Intransit Loss Committee of Ontario Pork and the OMAFRA/U of Guelph agreement. We appreciate the cooperation of Ontario Pork and the personnel at the transport companies and the abattoirs that enabled us to do this work.

Take home message

- In-transit losses in finisher pigs can be reduced and the industry needs to work together to decrease the losses
- Losses are associated with hot weather
- Trailer temperatures are impacted by environmental temperature and the number of pigs in the compartment
- The numbers of pigs in each compartment must be reduced in hot weather
- Moderate distances are associated with fewer losses than very short or extremely long distance trips
- Farm is responsible for more of the variation in losses than either abattoir or transport company
- Further research must be done at the farm level to understand the factors associated with in-transit losses so that producers can be given the information they need to make the right management changes to reduce the losses

Developments on the Enviropig™ File

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The Cassie line of Enviropig™ is a transgenic line of pigs that secrete phytase enzyme in the saliva. This unique trait enables the pigs to digest plant phosphorus more efficiently than conventional pigs. Therefore, it is unnecessary to include either supplemental phosphorus or phytase in the diet. In growing Cassie pigs there is up to a 60% reduction of phosphorus in the manure compared to age and gender matched conventional Yorkshire pigs. The trait is inherited in a Mendelian fashion through 7 generations without loss in salivary phytase activity. Seventh generation Cassie finisher barrows retained 35% more cereal grain phosphorus than conventional Yorkshire barrows receiving 750 Units of phytase per kg of feed.

Tissue analysis of 3rd generation Cassie and conventional University of Guelph Yorkshire pigs maintained at the Arkell Swine facility demonstrated similar compositions. To assess the health of the pigs we have analyzed hematology, clinical chemistry and urology. These data for 3rd, 6th and 7th generation pigs did not revealed any substantive differences, except improved phosphorus retention by the Cassie pigs.

A submission has been made to the Food and Drug Administration (FDA) in the United States under the New Animal Drug legislation to obtain regulatory approval of Cassie pigs for human food consumption. At this time over 2000 pages of data has been submitted covering aspects including, development of the Cassie pigs, location and DNA sequence of the phytase transgene in the genome, stability of the phytase transgene through generations, meat cuts and tissue composition, lack of allergenicity and toxicity of the novel phytase, swine health and performance. Several components of the submission have been reviewed and approved. If clearance were obtained this would permit both production and sale of Cassie pigs in the United States. A similar application is in preparation for the Canadian Regulatory Authorities including Health Canada, Canadian Food Inspection Agency and Environment Canada.

The objective of this report is to present data on the growth and conformation of Cassie pigs through the 2nd to 7th generation assessed on a yearly basis by the Sire Line Index (SLI). The numbers of pigs used are listed in Table 1, and this included all Cassie pigs raised to maturity. The SLI is an estimate of the economic breeding value of a pig and a higher number indicates a more valuable pig. The SLI is calculated by an algorithm using the Estimated Breeding Values (EBVs) for Age (days to reach 110 kg), Lean muscle yield, Loin eye area and Feed conversion ratio (FCR). For detail contact http://www.ccsi.ca/. Cassie pigs were fed a cereal grain diet without supplemental phosphorus or added phytase. At Arkell Swine the conventional Yorkshire pigs were fed a similar diet, but with a combination of added phosphorus and phytase, except for finisher phase conventional pigs that were fed a diet with phytase in the place of supplemental phosphorus. We do not have information on the diets of Canadian breeder pigs, but obviously they would be similar to the conventional Arkell Swine diets.

The Sire Line Index (SLI) of the Cassie hemizygous pigs was on average 20% higher than that of the conventional pigs in the Arkell breeding herd during 2004 to 2007, and 26% higher than that of Canadian Yorkshire breeding pigs during 2004 to 2006 (Fig. 1). The SLIs were significantly higher for the Cassie hemizygous pigs in 2004, 2006 and 2007 and the homozygous pigs were significantly different from the Yorkshire pigs in 2006 and 2007. However, the number of homozygous Cassie pigs was insufficient for a strong statistical comparison, but it is obvious that they performed similar to the Cassie hemizygous pigs. There were no differences in SLI between the boars and gilts of either the Cassie or the Arkell Yorkshire pigs, except that in 2007 the hemizygous boars had a higher SLI than the homozygous gilts. The higher SLI of the Cassie pigs as compared to the Arkell and Canadian Yorkshire pigs was due to a combination of fewer days to market weight

(4.4 days less than for the Arkell Yorkshire pigs and 10 days less than for the Canadian Yorkshire pigs, Fig. 2) and increased lean yield (Fig. 3) which was inversely related to a reduced back fat. As stated above, these results were achieved with Cassie Enviropig diets lacking supplemental phosphorus and supplemental phytase in contrast to diets for conventional pigs that contained these supplements.

Conclusion: This growth and conformational data demonstrates that the Cassie Enviropigs are healthy, grow rapidly, have highly desirable marketing characteristics (high protein content), are marginally cheaper to produced, and exhibiting lower manure pollution potential.

Table 1. Numbers of pigs including males and females used to derive SLI and adjusted breeding values for each year from 2000 to 2007.

Year	2000	2001	2002	2003	2004	2005	2006	2007
Cassie Hemizygotes	2	-	-	16	23	70	49	21
Cassie Homozygotes	-	-	-	-	9	2	3	5
Arkell Yorkshire	1842	438	845	520	466	495	759	1057
Canadian Yorkshire	44465	40030	41597	41821	38609	42018	48455	-

Figure 1: Sire Line Index

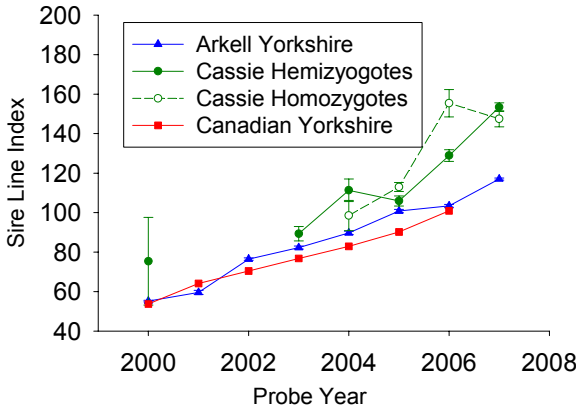


Figure 2: Adjusted Age to 100 kg

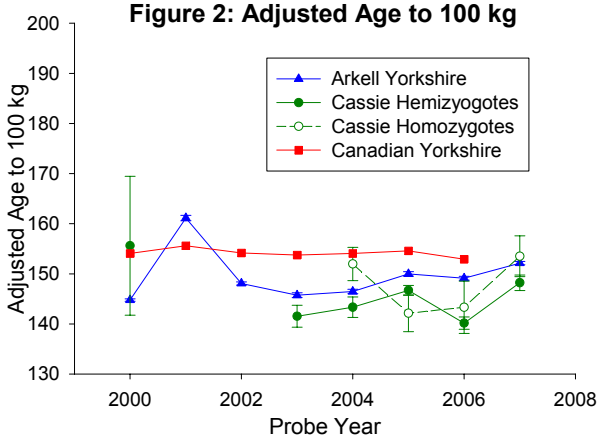
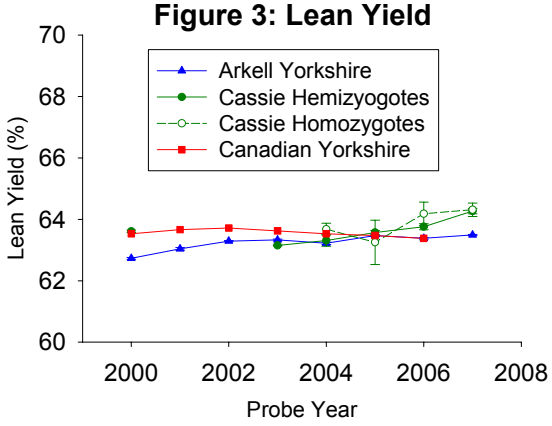


Figure 3: Lean Yield



What Goes Wrong When We Freeze Boar Sperm?

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The Problem: Artificial insemination is used to breed a higher percentage of Ontario's swine herd than its dairy cattle, but swine producers have to use perishable liquid semen, while dairy producers can use frozen bull semen that allows them access to genetics from around the world, thawed the moment before it is convenient to breed the female. Pig scientists have been trying for years, with limited success, to identify exactly how freezing damages swine sperm, so that a specifically-designed preventative system can be developed.

The Theory: Oxidation is a natural process that degrades living and non-living things; rust is oxidation at work on iron. Living cells have lots of different oxidative reactions going on that, when properly controlled, can do useful things, and cells contain various natural anti-oxidants to help control these reactions. The anti-oxidant defence systems in boar sperm are limited, and if those that are present are damaged during freezing, then the oxidation products could rapidly build up and hurt the sperm. We thought that freezing might cause the natural oxidants in boar sperm to run amok, and so we set out to identify exactly which oxidants are present in fresh and frozen boar sperm, and if oxidants could cause the kind of damage that freezing does.

The Outcome: As expected, freezing and thawing killed many sperm, although most of those left alive could swim, and swim in a normal, forward-moving pattern. Unexpectedly, freezing and thawing did not affect the sperm concentrations of one oxidant, hydrogen peroxide, and, even more surprisingly, living frozen-thawed sperm had *less* of another oxidant known as superoxide anion ($O_2^{\cdot -}$) than did living fresh sperm (See Table 1 for actual data). It is, however, possible, that the only sperm that can live after freezing and thawing are those with very low levels of $O_2^{\cdot -}$.

The Conclusion: Freezing and thawing does not increase the detectable amounts of oxidants present in boar sperm, suggesting it is unlikely that these cellular pathways are controlling the damage that happens when boar sperm are frozen for artificial insemination. Unfortunately, this means we need to continue looking for what damages boar sperm during freezing and thawing.

Table 1. The functional characteristics, and oxidant content, of fresh and frozen-thawed boar sperm. Four ejaculates from different boars were tested.

Sperm condition	% Alive	Movement		Type & Amount of Oxidants			
		% Moving	% moving forward	Superoxide Anion			Hydrogen peroxide
				Average for all sperm	Live sperm only	Dead sperm only	Average for all sperm
Fresh	84	84	66	31	29	28	13
Frozen-thaw	38	38	20	14	4	16	12

The Sponsors: We sincerely thank OMAFRA and NSERC for supporting this work. Also thanks to Rachel Mixer and Katie Hickey for great technical help.

Impact of Immune System Stimulation on Apparent Ileal Digestibility of Amino Acids and Whole Body Nitrogen to Sulfur Balance Ratio in Growing Pigs

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Introduction

Immune system stimulation (ISS) can cause morphological and physiological changes in the gut of pigs, such as edema, change in gut motility, permeability, and microflora (Yamada, 1995). However, the impact of ISS on protein and amino acid (AA) digestibility has not been evaluated. Also, ISS alters whole body nutrient utilization by redirecting the nutrients away from growth and towards organs involved in animal's immune response (Klasing and Leshchinsky, 2000). A distinctive feature of sulfur amino acids (SAA; methionine and cysteine) is the considerable storage of cysteine in non-protein stores, e.g. glutathione (GSH). GSH has lower nitrogen to sulfur ratio (N/S) than body protein (Hou et al. 2003). Therefore, measurement of whole body nitrogen and sulfur balances and the ratio between them (N/S-balance) provides a means to evaluate partitioning of sulfur amino acids during the ISS. Objectives of this study were to determine the impact of ISS on apparent ileal digestibility (AID) of AAs and whole body N/S-balance ratio.

Experimental procedures

Thirty six barrows (BW 21.5 ± 3.5 kg) were fed restricted (800 $g.d^{-1}$) and assigned to three levels of sulfur amino acid (SAA) intake (1.1, 2.1 and 3.2 $g.d^{-1}$; L1, L2 and L3, respectively) from SAA limiting diets. Following adaptation, eight pigs at each SAA intake level were injected intramuscularly and every 48 h, for seven days, with either saline (control) or increasing amounts of *Escherichia coli* lipopolysaccharide (LPS) as a means to achieve ISS. Seven-day N and S balance were then conducted. At the end of balance period, pigs were euthanized and digesta were collected from the last 1.5 m of small intestine for measuring AID of nutrients. Eye temperature was monitored during the ISS period using infrared imaging technique; ThermaCamTM SC 2000 (FLIR System, Inc.).

Results

Repeated injection with LPS increased eye temperature, which remained elevated throughout the post-challenge study period (36 vs. 38ºC in ISS- vs. ISS+, SE 0.2; $P < 0.05$), suggesting effective ISS.

AID (%) of amino acids were not affected by ISS (ISS- vs. ISS+; methionine 82.0 vs. 79.0, SE 4.0; cysteine 69.2 vs. 61.0, SE 7.9; lysine 82.0 vs. 77.6, SE 5.1; threonine 71.1 vs. 64.3, SE 6.8; isoleucine 80.5 vs. 76.8, SE 5.2; $P > 0.50$).

Whole body N and S retention increased with SAA intake ($P < 0.01$; Table 1). Fecal N and S excretion were not affected by ISS and SAA intake level ($P > 0.05$). ISS reduced N retention but had no effect on S retention (Table 1). Whole-body N to S-balance ratio increased with SAA intake, but was reduced by ISS (Table 1). The latter indicates that ISS increases retention of SAA in non-protein pools in growing pig's body, and reflects an increased need for dietary SAA to support the immune response during ISS in growing pigs.

Table 1. Impact of immune system stimulation (ISS) and sulfur amino acid (SAA) intake on nitrogen (N) and sulfur (S) metabolism

SAA intake g/d	L1		L2		L3		SE	*P value*		
ISS	-	+	-	+	-	+		ISS	SAA	ISS×SAA
N metabolism mg/kg BW/d										
Intake	340	327	664	657	798	715	25	0.10	0.01	0.16
Excretion	132	228	231	252	296	344	14	0.01	0.01	0.05
Balance	207	101	443	410	500	376	19	0.01	0.01	0.04
S metabolism mg/kg BW/d										
Intake	38	37	50	49	57	51	2	0.10	0.01	0.30
Excretion	25	27	30	26	30	28	1	0.12	0.03	0.07
Balance	13	10	20	24	27	24	1	0.30	0.01	0.03
N/S-balance	**16**	**10**	**20**	**18**	**19**	**16**	**1**	**0.01**	**0.01**	**0.04**

Take home message

Immune system stimulation *per se* does not affect apparent ileal digestibility of amino acids in growing pigs. At low levels of SAA intake and during ISS, SAA are preferentially preserved or repartitioned in favor of non-protein body stores. For diseased pigs the dietary levels of SAA (methionine plus cysteine) should be increased relative to other amino acids (i.e. lysine), in order to reduce the negative effect of disease.

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Rapid Determination of DDGS Feeding Value for Swine Diets

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Background:
The production of ethanol from grain (corn) continues to expand in North America creating more demand and competition for corn, and raising corn prices. For livestock producers, an ethanol co-product, distillers dried grains with solubles (DDGS), can be used as an alternative source of protein, energy and phosphorus in livestock diets to offer feed cost savings and help reduce the burden of higher grain prices.

While DDGS have been traditionally used in ruminant rations, swine consume approximately 15% of the DDGS produced in the United States. Ontario researchers (McEwen and Lackey, 2008) have successfully fed up to 20% DDGS in swine diets with no adverse effects on growth performance or carcass traits. However, concerns still exist within the swine industry about DDGS nutrient variability and quality. For example, product color (light versus dark color) may vary from batch to batch; product color may be used as an indicator of the feedstuff's available amino acid and energy contents. Therefore this trial was undertaken to evaluate new methods to quantify the quality differences in DDGS from plants supplying this feedstuff to Ontario swine producers.

Objectives:
The project will evaluate rapid methods of determining the feeding value of DDGS from corn-based ethanol production based on product color, nutritional analyses and different rapid in vitro assays. The following objectives will be 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 neighboring 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 potential factors that may contribute to the observed variation in product quality as related to distillation and the drying processes used to produce DDGS.

Experimental Procedures:

<u>Corn co-product sample collection and analyses</u>
Seventy-two (12 samples per plant over a three month period) samples of corn DDGS will be collected from participating ($\leq$ 6) plants. Each sample (1 kg) will be analyzed for dry matter, organic matter, crude protein, ether extract, neutral and acid detergent fibre and acid detergent insoluble nitrogen (ADIN) contents. In addition, objective measures of product color will be determined on all samples using a Minolta colorimeter with data collected using the CIE, L^* a^* b^* scale. Colorimetric data will be used to classify DDGS samples based on color (light, intermediate, dark) with

approximately 18 of the samples (6 for each of the light, intermediate, dark color classifications) analyzed for amino acid content. Relationships between co-product color and nutrient profile will then be determined.

In vitro digestibility evaluation of DDGS samples

The eighteen samples will be evaluated using three different in vitro assays: (i) Danish method (Boisen, 2000) for determining energy and amino acid digestibility values (ii) An Immobilized Digestive Enzyme Activity (I.D.E.A.) assay for determining ileal amino acid digestibility (digestibility in the small intestine) (NOVUS International, St. Louis, USA), and (iii), the reactive lysine assay to determine lysine availability (Fontaine et al., 2007). The Danish method involves an in vitro digestion system to determine prececal digestion of dry matter, organic matter, as well as small intestinal (ileal) digestion of amino acids. Residue remaining after in vitro incubations will be analyzed for organic matter and nitrogen for determining in vitro nutrient digestibility values. We will also determine the extent of lysine damage using the reactive lysine assay (Fontaine et al., 2007) on the original DDGS sample and the residue remaining after in vitro incubations for determinineg ileal digestibility. For this assay, samples will be submitted to the Dr. Fontaine's laboratory (Degussa Germany). Finally, an Immobilized Digestive Enzyme Activity (IDEA.) assay will also be run on the eighteen DDGS samples in the laboratory of NOVUS (St. Louis, USA) to determine a second measure of lysine availability and digestibility. Relationships between in vitro digestibility values, chemical composition, and color classification (L^* a^* b^* scale) will then be explored to identify rapid predictors of the feeding value of individual DDGS samples. The DDGS samples will then be ranked within a color classification on the basis of in vitro nitrogen digestibility.

In vivo digestibility assessment of ileal digestible amino acid contents and fecal digestible energy content in selected samples

Based on analyzed reactive lysine content and in vitro digestibility values, the ileal digestible amino acid content and fecal digestible energy content will be determined in vivo for 6 DDGS samples (likely 2 DDGS samples from each color classification, light, medium and dark). Ileal amino acid digestibility will be determined using surgically modified pigs with a T-cannula at the distal ileum to enable sampling of ileal digesta. Fecal energy and nutrient digestibility will be determined with a separate group of conventional pigs. Again, correlations between in vivo and both in vitro measures of amino acid avalability will then be determined.

Results and benefits to swine industry:

DDGS samples are presently being collected from participating plants. They will then be analyzed as described above and we hope to share some of the results with you at next year's Centralia Swine research Update. It is hoped that the results will help develop reliable evaluation guidelines for feed manufactures and producers to increase the use of DDGS in swine diets.

Reference:

McEwen, P. and R. Lackey, 2008. DDGS in Swine Rations. 27Th Centralia Swine Research Update. Pg 3-4.

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Learning From 2006 to Reduce Future Impacts of *Fusarium* Epidemics to Stakeholders of the Corn Industry

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During the 2006 outbreak of *Gibberella zeae* ear rot, which is the sexual reproductive stage of *Fusarium graminearum*, corn grains were significantly contaminated by deoxynivalenol (DON). In this study, among the 2029 corn samples analyzed, 83.4% contained toxin levels ranging from 0.5 to 54 ppm. The average concentration (4.8 ppm) exceeded levels for recommended tolerance specified in the Canadian regulatory guidelines for swine, young calves and lactating dairy animals. Furthermore, 27.2% were contaminated with DON levels greater than 5ppm exceeding levels for recommended tolerance for grains and grain by-products destined for ruminating beef and feedlot cattle older than 4 months and chickens (not exceeding 50% of the cattle or chicken total diet.

Initial estimates indicate that the episodic *Fusarium* event of 2006 cost Ontario's corn industry over $60 million (200 million bushels at $0.30/bu). This does not account for the multimillions lost in the swine industry because of limited access to clean corn and increased cost of replacing contaminated corn. The lack of coordinated effort in the industry created some misunderstanding amongst stakeholders. However, natural wide-spread epidemics of *Fusarium* also offer a unique opportunity to collectively investigate, validate and challenge our level of understanding of the disease and the efficiency of different control measures under heavy pathogen pressure.

The proposed model predicted a low incidence of *Giberella* ear rot in 2007 including some "hot spot areas" south of Ridgetown. In 2008, because the climatic conditions were conducive to *F. graminearum* infection, the same model predicted significant contamination levels of DON in corn. However, the magnitude of the contamination was dependent upon the distribution of hybrids highly susceptible to *F. graminearum* infection and/or mycotoxin accumulation. The frequency and intensity of *Fusarium* infection and mycotoxins accumulation in corn was severe because of a combination of factors that included:

1) The use of highly susceptible corn hybrids to *F. graminearum*. Corn hybrids had a huge range in their response to DON accumulation. On average, only 28.7% of commercially available corn hybrids were moderately resistant to DON accumulation, whereas 61.8% and 9.6% were susceptible and highly susceptible to DON contamination, respectively.

2) OCC performance trial method rated many hybrids accurately across relatively few environments. However, since natural infection is not consistent from year to year, the control of environmental conditions was the most important limiting factor on determining hybrid performance underscoring the need for several years of data to satisfactorily rank maize hybrids.

3) DON contamination levels were significantly affected by the incidence of *F. graminearum* ($P<0.01$) and field location, or local weather conditions, ($P<0.05$). Concentration of DON and *F. graminearum* distribution were highly variable from field-to-field, ranging from non detected to 28 ppm and 50%, respectively.

4) Favourable weather conditions for mycotoxin accumulation. The period from 4 to 7 days before full silking and 3 to 10 days after silking were considered critical to *F. graminearum* infection with the subsequent accumulation of mycotoxins in grains. It is clear that frequent wet days from either

precipitation or heavy dews shortly before, and during silking and in the weeks flowing pollination coupled with sustained moderate temperatures (24-30°C daily highs) are important.

The root causes of the epidemic and the consequent mycotoxin accumulation in grains are complex and multi-factorial. One possible approach for reducing contamination levels is using an integrated management system. The implementation of strategies for prevention, control and surveillance from planting to pre-utilization of whole grain, in order to mitigate mycotoxin contamination in *Fusarium* epidemic years is highly recommended. Based on the data analysis from the 2006 epidemic an integrated program for Ontario corn should include:

Hybrid Selection: One of the most important challenges to the pre-harvest forecast system is the difficulty to find consistent data on the sensitivity of corn hybrids to *Fusarium* infection or mycotoxin accumulation. Also, because the set of hybrids change over location and years, the resulting data set are unbalanced with regard to hybrid location and year. The evaluation of large number of commercial hybrids through a controlled environmental corn hybrid screening program on campus is highly recommended. Information on commercial hybrids will aid pork producers in selecting hybrids that may lower the risk of mycotoxicoses in swine and perhaps, keep the highly susceptible hybrids out of the food production chain.

Analytical Support: Investigate practical and innovative analytical methods, using near infrared (NIR) for DON and liquid chromatography (LC-MS) techniques for multitoxin detection, to improve the accuracy of mycotoxin detection in corn and derived products is important. The co-occurrence of several Fusarium species that produce different kind of toxins demands the development of a reliable and sensitive analytical method for the detection of multiple mycotoxins. LC-MS is emerging as the laboratory technique of choice for the simultaneous determination of structurally diverse mycotoxins in complex food and feed matrices in a single sample preparation. NIR is a non-destructive technique that can be applied with little or no sample preparation.

In Crop Surveillance: Evaluation of the contamination process through surveillance of corn and bio-monitoring of toxins and their producers. The co-occurrence of different Fusarium species also emphasizes the need to know which species predominates at which critical stage in corn development. Research into new techniques for identification of active growing mycelium in proportion to biomass in corn kernels is needed.

Fungicide Application: Research the effect of application technology parameters such as spray volume, droplet size, timing, targeting, etc. on fungicide efficacy for control of *Gibberella* ear rot and/or mycotoxin accumulation. Differentiate fungicides on multiple hybrids with different levels of resistance under disease disease-conducive environments. Need to estimate grower benefits of fungicides under natural conditions with elite hybrids.

Weather Base Forecasting: Further investigations are needed toward developing more accurate hybrid coefficients as indicators of tolerance to mycotoxin accumulation and for evaluating/calibrating the models in different environments. Accurate silking dates are critical in the timing of predictors for model development and mycotoxin assessment.

Variability of Water Flow Rates and the Impact on Therapy Using Tetracycline Powder

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Introduction

Considerable time, effort and expense are devoted to the treatment of pigs in commercial grow/finish barns. However, with large numbers of pigs in facilities, labor constraints, and the ability of some pathogens to spread to a high proportion of a herd, producers rely on therapeutic approaches for a 'population' of pigs. This approach typically involves the oral administration of antibiotics through the drinking water. Tetracyclines are widely used for water medication; however, the bioavailability of tetracyclines is low following oral dosing compared to intravenous injections of grow/finish pigs (Mevius et al., 1986; Nielsen & Gyrd-Hansen, 1996). Concerns regarding the administration of antibiotics through the drinking water prompted us to conduct a multiple phase study. The objectives of the study were:

- *Evaluate drinker flow rates in commercial finishing barns*
- *Determine the relationship between water flow rate and plasma tetracycline concentrations in pigs housed in different pens in finishing barns*
- *Characterize plasma tetracycline concentrations in grow/finish pigs following the administration of tetracycline hydrochloride at various concentrations in drinking water.*
- *Establish pharmacokinetic parameters for plasma tetracycline concentrations in grow/finish pigs consuming water medicated with tetracycline hydrochloride.*

Materials and Methods

Drinker Flow Rates in Finishing Facilities: The first phase of the project was conducted on 13 finishing sites (farms). All finishing sites were within the same system of one company. The number of barns (n=100; 36-44 pens/barn) per site ranged from 5 to 9. Six of the sites used drinkers (Trojan®; 2/pen) mounted on the pen divider. The other seven sites used swing-type drinkers with two water nipples (Trojan®) per drinker line. Water flow rates (liter/min) were determined for all drinkers in the previously described pens and barns.

Water Medication with Tetracycline Hydrochloride: The second phase of the study was conducted on two sites from the original 13 sites. The first site had low and uniform flow rates (1.44 $\pm$ 0.65 l/min). In contrast, the second site had high and variable flow rates (2.63 $\pm$ 1.17 l/min). Other than the flow rates, the barns had similar numbers of pens, stocking density and age of pigs (11-12 weeks of age). For each barn, 10 pigs were randomly selected and ear tagged in the designated sick pen and in four additional, randomly selected pens (total 50 pigs/barn). Tetracycline hydrochloride soluble powder (AmTech -324®) was diluted (1:128) in a stock solution for the administration through a Dosatron® medicator. Farm personnel set the medicator to deliver tetracycline hydrochloride (22 mg /kg BW). The medicated water was provided to the pigs for three days. Water flow rates were determined daily for each drinker in the pens.

Blood samples were collected from pigs prior to medication (Time 0) and at 4, 8, 24, 48, and 72 hours after the initiation of water medication. Water samples were collected from the drinkers at the same time points. Water and plasma samples were analyzed with ultra-high performance liquid chromatography (UPLC) to quantify tetracycline concentrations.

Phase 3 Procedures, Animals and Treatments: A randomized design experiment was performed with 24 barrows (7-8 weeks of age). Pigs were weighed four days prior to the initiation of treatments and at the completion of the study. Pigs were randomly assigned to treatment (n=6 pigs/treatment) with 0, 125, 250, or 500 ppm tetracycline (324 g/lb tetracycline, AmTech Inc.) in the drinking water.

Pigs were housed in individual pens (1 m x 2.2 m) at the University Swine Educational Unit. Each pen was equipped with one drinker and one feeder. For each pen, a 20 liter carboy was used as the sole source of drinking water and water medicated with tetracycline hydrochloride. Aratowerk 80™ drinkers were used to minimize water spillage.

Sample Collection and Analysis: Blood samples were collected from each animal immediately prior to treatment and 4, 8, 12, 24, 32, 48, 56, 72, 80, 96 and 104 h after treatment. In addition, water samples were

collected from each pen at the time of blood collection. All plasma and water samples were analyzed via HPLC techniques.

Conventional PK analysis was performed using WinNonLin (Pharsight, Mountain View California). Concentration of steady state (*Css),* time of steady state *(Tss)*, maximum plasma concentration *(C_{max})*, observed time of maximum plasma concentration (T_{max}.), and area under the curve (AUC) were determined. In addition, the mean residence time (MRT) was based on concentrations at 32-48 hours (the elimination curve at steady state) and the half-life was defined as the time (h) to clear one-half of the concentration of the drug from the body. Bioavailability (*F*) also was determined.

Results and Discussion

Drinker Flow Rates: The initial linear regression of flow rates indicated that farm, barn, drinker type and medication were significant (*P<0.01*) in the overall model. Conversely, pen, sick pen and drinker placement were not significant. Drinker flow rates varied among farms and barns (Table 1). The mean drinker flow rates ranged from 1.44 to 2.77 liters/min. Variations in flow rates were evident in barns, and the pen-to-pen variation within a barn was quite dramatic. Differences among pens were not apparent (Figure 1). Evidently, differences in flow rate among pens within barn reflected the drinkers and not the pressure in the water lines. Water medication (typically tetracycline) was being used in at least one barn per farm. Flow rates were less (*P<0.05*) from drinkers with medicated water (1.96 $\pm$ 0.03 liters/min) than from drinkers without medication (2.3 $\pm$ 0.01 liters/min). Flow rates also differed (*P <0.05*) between drinker type. The swing drinkers provided 2.17 $\pm$ 0.015 liters/minute (n=4584 drinkers). In contrast, the flow rate for mounted drinkers (n = 2538 drinkers) was 2.43 $\pm$ 0.02 liters/minute.

Phase 2 - Plasma Tetracycline Concentrations: Plasma tetracycline concentrations increased from time 0 to reach peak concentrations at 8 h and 48 h after the initiation of water medication (Figure 2). The time of the peak was evident at 8 h in Farm 38 for all pens. Tetracycline concentrations did not differ among sick pens and healthy pens. In both farms, two pigs died in the sick pens before the completion of the study. Tetracycline was not detected in the plasma of these particular pigs before death, thereby indicating that these pigs likely failed to consume water.

Overall, the mean plasma tetracycline concentrations, excluding concentrations at time 0, were greater (*P<0.05*) in Barn 39 (0.27 $\pm$ 0.01 μg/ml) than in Barn 38 (0.16 $\pm$ .006 μg/ml). It should be noted that considerable variation was evident in the tetracycline concentrations among individual pigs. Drinker flow rates were greater (*P<0.01*) in Farm 39 (3.9 $\pm$ 0.04 liters/min) than in Barn 38 (1.4 $\pm$ 0.03 liters/min). Subsequent Spearman rank correlations indicated that drinker flow rate (r = 0.2) and farm (r = 0.23) were correlated (*P<0.01*) to tetracycline concentrations, while pen was not significant.

The initial correlations to drinker flow rate are misleading. The correlations indicated that additional factors influenced plasma tetracycline concentrations. Thus, it was not surprising that tetracycline concentrations in the drinker water were 85.03 $\pm$ 2.1 and 153.1 $\pm$ 7.4 μg/ml for Barns 38 and 39, respectively. Therefore, the pigs in Barn 39 had access to greater drinker flow rates *and* higher water concentrations of tetracycline than the pigs in Barn 38. For both barns, it is likely that mixing errors or malfunctioning medicators contributed to the modest tetracycline concentrations in the water.

Based on previous reports (Mroz et al., 1995, Almond 2002), the pigs in the present study likely consumed between 2-3 liters of water each day. With water tetracycline concentrations of 153 μg/ml, the pigs in Barn 39 would have consumed 306-450 mg tetracycline/pig/day. In contrast, pigs in Barn 38 would receive $\leq$ 255 mg. Although these doses of tetracycline may be suboptimal, the provision of tetracycline chloride at 400 mg/liter and 800 mg/liter in drinking water resulted in serum concentrations of < 0.6 μg/ml (by 60 hr) and 0.8 μg/ml (10 hr), respectively (Luthman et al., 1989). Furthermore, a single oral dose of 40 mg/kg in 200 ml water resulted in serum concentrations of <1 μg/ml in non-fasted animals. Collectively, the present study confirmed previous observations (Luthman et al., 1989, Nielson and Gyrd-Hansen, 1996) that medication of drinking water provides inconsistent and low plasma concentrations of tetracycline. In fact, the inclusion of 0.55 g of OTC/kg feed to 30 kg BW pigs resulted in similar plasma OTC concentrations (Hall et al., 1989) as noted in studies using water medication.

The relatively low plasma concentrations achieved by water medication with tetracycline raises concerns about absorption of the antibiotic. It is obvious that feed interferes with absorption since fasted animals had greater plasma tetracycline concentrations than non-fasted animals (Luthman et al., 1989). Secondly, treatment of pigs with doxycycline (DOX; 90 μg/ml of drinking water) resulted in mean plasma

concentrations from 0.83 - 0.96 µg/ml (Croubels et al., 1998) to 1.37 ± 1.2 µg/ml (Prats et al., 2005). Despite marked inter-animal differences, these plasma concentrations were higher than the minimum inhibitory concentrations (MICs) described for bacterial pathogens of the respiratory tract (Prats et al., 2005). Evidently, the absorption of DOX is sufficient, at the aforementioned concentrations in controlled experiments, to provide therapeutic plasma concentrations.

Phase 3 – Plasma Tetracycline Concentrations In Individual Pigs: As shown in Table 2, initial body weights, total body weight gain, drinker flow rate, and daily water use did not differ among groups. Total protein and PCV of the blood was not affected by treatment. The HPLC analysis indicated that the water concentrations of tetracycline were at the desired levels of 125, 250 and 500 ppm.

Animals in the 500 ppm group had the highest plasma concentrations, with steady state concentrations at 0.74 ppm, while the pigs receiving 250 ppm and 125 ppm had tiered concentrations below this (Table 3). Similarly, the AUC total was higher in the 500 ppm group than in the 125 and 250 ppm groups. The T_{max} was earlier in the pigs treated with 500 ppm than the other groups. Due to the variation in tetracycline concentrations, few means differed among the three tetracycline groups. In general, the mean concentrations were greater ($P< 0.05$) in the 500 ppm group than in the 125 ppm group (Figure 3). The notable exceptions were at 24 and 48 h. There were no differences in the mean plasma concentrations between the 125 ppm and 250 ppm groups. However, it was noted that a doubling in the tetracycline dose did not double the expected average plasma concentration seen in a treatment group. Therefore, as tetracycline dose is increased, the steady state plasma concentrations increased linearly, but to not as rapidly as dose increased.

Twice daily clinical evaluations did not reveal clinical signs of disease in the pigs prior to or during the study period. Thus, the pharmacokinetic evaluation of the three levels of tetracycline in water was conducted on normal animals without the need to account for the influence of disease on water uptake. Since the blood TP and PCV values were within normal limits, it can be assumed that the frequent blood sample collection did not interfere with the hemodynamics of the pigs. Based on the failure to detect differences in weight gains, it was evident that five days of water medication did not influence growth. As anticipated, the Aratowerk™ drinkers provided uniform flow rates of water to all pigs. In contrast, daily water use was reduced when the water was medicated with tetracycline. Regardless of concentration, it was evident that medication of water with tetracycline impairs water use and presumably consumption. This must be taken into consideration if the tetracycline is intended to be used for therapy.

When pigs received tetracycline water medication, plasma concentrations were less than 1 ppm, even under non-competitive circumstances. The *Vdss* values were somewhat lower than values previously reported for tetracycline (Nielsen and Gyrd-Hansen, 1996) and oxytetracycline (Mevius et al., 1986); however, previous studies used 20- 45 mg/kg, administered as a bolus dose through a stomach tube or as a drench. Although the *Vdss* are low in the present study, there is reasonable distribution in the body. In regard to other pharmacokinetic parameters, the *Tmax* values indicated that greater than 48 hours is required to reach the *Cmax* values with 125 and 250 ppm tetracycline. If the *Cmax* values were sufficiently elevated to be therapeutic, the pigs must be medicated for a minimum of two days. The failure to achieve plasma tetracycline concentrations greater than 1.0 ug/ml is consistent with previous studies that used bolus oral doses of 45 mg/kg (Nielsen and Gyrd-Hansen, 1996). Regardless of the method of administration, it is evident that water medication provided sub-therapeutic plasma concentrations, as observed in phase 2, which was conducted in commercial finishing barns. Furthermore, the bioavailabilities for the three doses, albeit similar to the aforementioned studies, are indicative of reduced absorption. The causes of the reduced absorption are speculative; however, bioavailability was higher in fasted pigs than in fed pigs (Nielsen and Gyrd-Hansen, 1996). Evidently, the presence of feed in the gastrointestinal tract impairs tetracycline absorption.

The therapeutically active plasma concentrations for tetracycline or other antimicrobial agents are speculative since the susceptibility of various bacterial pathogens are highly variable. Based on the minimum inhibitory concentration (MIC) for *Escherichia coli* AT2259 (quality control strain), an MIC of at least 1-4 ppm (1-4 µg/ml) is necessary to prevent growth of bacteria. The tetracycline MIC's (50% and 90%) for other bacterial pathogens, such as *Actinobacillus pleuropneumoniae* and *Streptococcus suis*, typically range from 8 to > 32 ug/ml (Salmon et al, 1995). Based on this information, it is apparent that water medication with tetracycline hydrochloride does not offer a therapeutic level of drug in the plasma to treat a septicemia. Tissue levels (lung, liver, kidney) of this medication will have to determined in the future. Despite the provision of optimal housing conditions, elimination of pig-to-pig competition and doubling the manufacturer's recommended dose of tetracycline hydrochloride, the plasma tetracycline concentrations apparently were less

than therapeutic levels. Finally, the present results confirm our concerns, raised in the previous investigation, that medicating pigs with tetracycline in the drinking water has inherent problems and questionable efficacy.

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Table 1. Drinker flow rates (liters/min) for 13 finishing farms (5-9 barns/farm). Drinker types were either mounted (**M**) on the pen divider (1-2 drinkers/pen) or swing-type drinkers (**S**; 2 nipples/drinker). The numbers of pens ranged from 36-44 per barn. Within column, values with different superscripts differ ($P < .05$).

Farm	Drinker Type	No. Barns	No. Drinkers	Flow Rate (Mean ± SEM)
1	M	8	672	2.33 ± 0.038^{de}
2	S	5	440	2.37 ± 0.055^{ab}
3	S	9	648	1.44 ± 0.025^{g}
4	S	9	648	1.85 ± 0.028^{g}
5	S	9	648	2.63 ± 0.046^{bc}
6	M	6	424	2.32 ± 0.073^{e}
7	S	9	704	2.48 ± 0.034^{cd}
8	M	8	272	2.58 ± 0.040^{abc}
9	S	9	648	2.06 ± 0.037^{f}
10	M	8	702	2.30 ± 0.030^{e}
11	S	7	560	2.20 ± 0.042^{ef}
12	M	7	504	2.77 ± 0.050^{a}
13	M	7	252	2.62 ± 0.062^{abc}

Table 2. Descriptive statistics of parameters assessed during the study. Means did not differ among treatment groups. Pigs were weighed four days prior to the initiation of treatments and again after the last blood samples were collected. Thus, total gain is for a 9 day interval. One animal in the 125 ppm group used 12 liters of water each day and was excluded from the analysis.

	Treatment Group				
Parameter	**0**	**125 ppm**	**250 ppm**	**500 ppm**	**SEM**
Starting Wt (lb)	43.6	41	42.9	42.1	1.5
Finishing Wt (lb)	57.3	54.8	55.8	55.2	2.1
Total gain (lb)	13.7	13.8	13	13	1.2
Drinker flow rate (ml/min)	635	628	602	653	37.7
Daily water use (ml/pig)	3921	2818	2828	2851	647
Blood - total protein (g/dl)	5.6	5.7	5.7	5.8	0.26
PCV (%)	34.5	39.7	37	38.3	2.0

Table 3. Pharmacokinetic parameters (means) for the three treatment groups.

	Treatment Group			
Parameter	**125**	**250**	**500**	
Css	0.33	0.47	0.74	ug/ml
Tss	32	32	32	hours
Cmax	0.80	1.26	1.29	ug/ml
Tmax	80	56	12	hours
AUCtotal	30.71	44.93	73.74	ug*h/ml
AUC32-48	3.54	6.55	10.46	ug*h/ml
MRT	6.64	6.61	6.44	hours
Half-life	4.60	4.58	4.46	hours
Clbody	0.14	0.12	0.18	L/kg/h
Vdss	0.919	0.803	1.188	L/kg
F	5.2	3.3	3.4	%

All parameters were calculated in WinNonLin (Pharsight).
Css, concentration of steady state; *Tss*, time of steady state.
C_{max}, the maximum plasma concentration; T_{max}, the observed time of peak plasma concentration. C_{max} and T_{max} were calculated from individual animals.
AUC, area under the curve. The AUC total is not extrapolated to infinity.
MRT (mean residence time) was based on 32-48 hours (the elimination curve at steady state).
Half-life, the time (h) to clear one-half of the concentration of the drug from the body.
Cl body, clearance rate from the body.
Vdss, volume distribution of steady state.
F, bioavailability.

Figure 1. Drinker flow rates (mean + SEM) by pen for 13 farms (n = 100 barns). Only pens 37 and 21 differed.

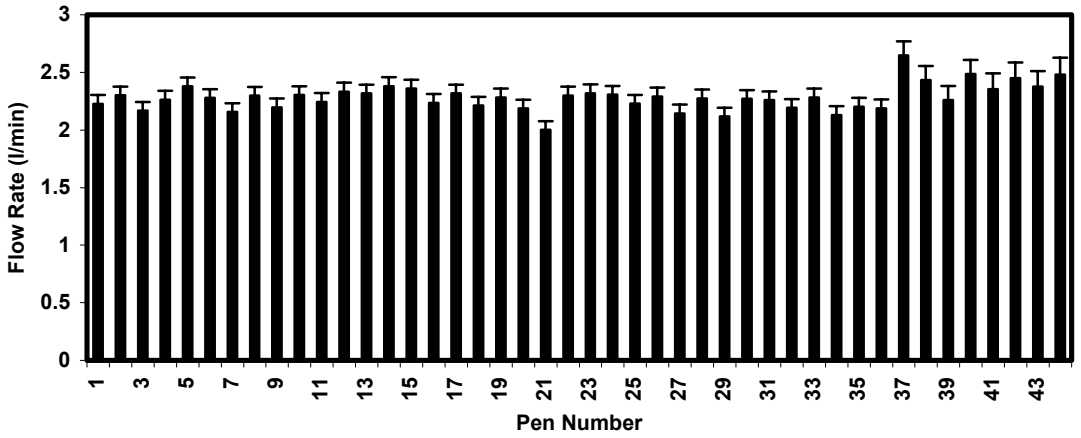
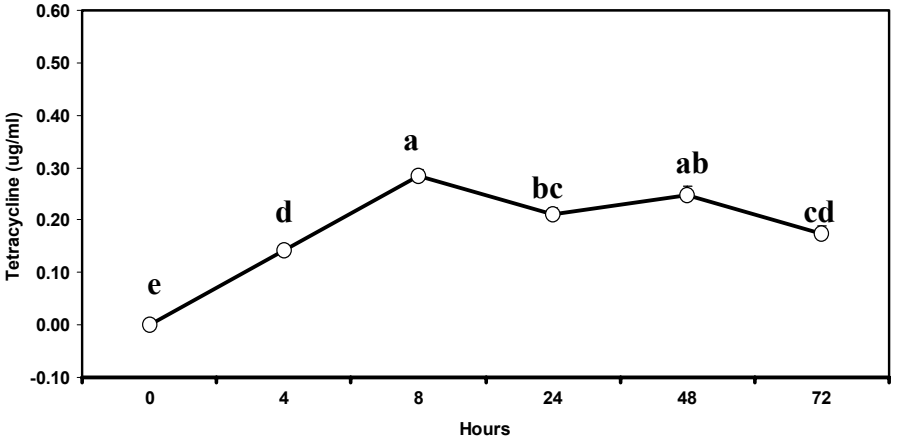


Figure 2. Plasma tetracycline concentrations (mean + SEM) in pigs (12 weeks of age; 10/pen; 5 pens/barn) treated with tetracycline hydrochloride as a water medication. The top figure shows the overall means (+SEM) for the time points for all pigs and all pens. The bottom figure shows the means (+SEM) for each time by barn. Points with different superscripts differ (*P<0.05*).



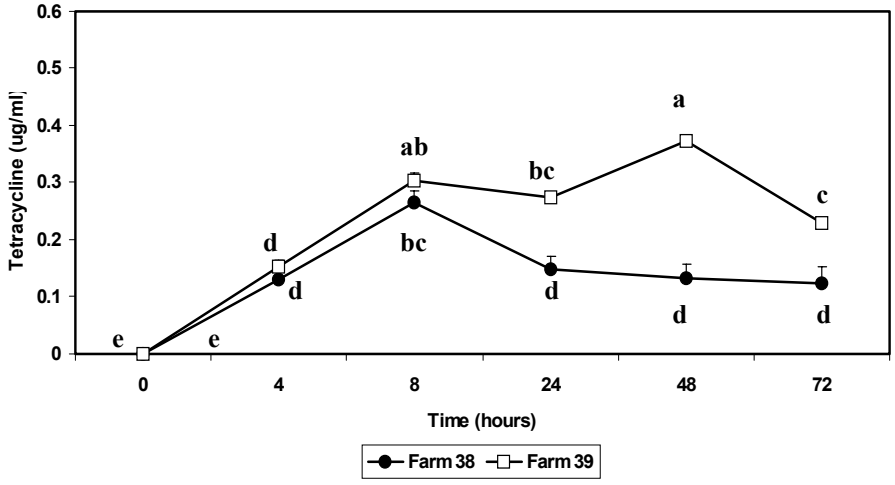
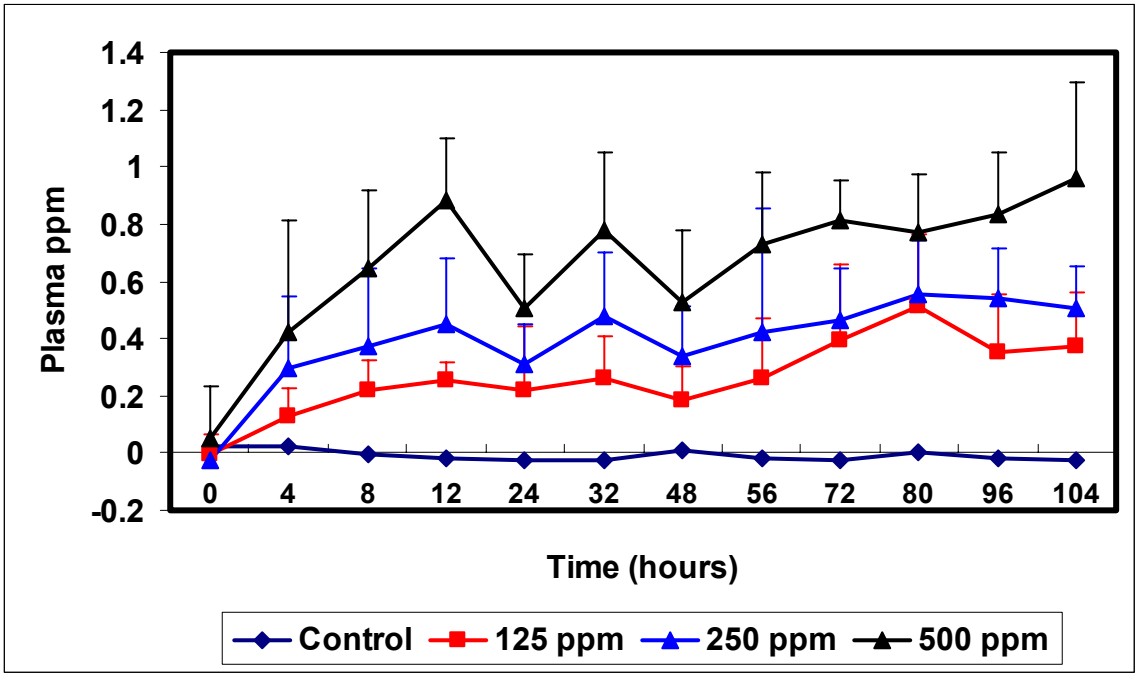


Figure 3. Mean (+STD) plasma tetracycline concentrations in the control and three treatment groups.



Survival of Manure Pathogens in Swine Manure

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Background

This swine manure study is part of a larger research program to examine the effect of manure storage conditions on the survival of indicator and pathogenic microorganisms in major livestock manure types under Ontario conditions, to establish typical indicator and pathogen loads to fields at land application time, and to identify possible low-tech options for reducing pathogen loading rates by storage management. In particular, the decline in pathogen levels in liquid swine manure over time was compared for static (no fresh manure addition) versus dynamic manure storage (periodic fresh manure addition) during summer and winter storage. The following report summarizes the results for liquid swine manure.

Methods

Four sets of liquid swine manure trials were established in on-farm storages in February 2007, August 2007, January 2008, and July 2008. Aboveground, open concrete tanks were used for "dynamic" and "static" storage for all trials except "dynamic", winter 08, which was an in-ground covered storage. Declines rates of indicator (*E.coli*) and pathogen (*Salmonella* and *Campylobacter*) in bulk manure and in "captive" populations in manure held in vials within on-farm manure storages were measured. *Salmonella* was also spiked into vials to ensure a consistent presence at high enough numbers to enable monitoring over the course of all trials.

Results

Storage of liquid swine manure without fresh manure addition consistently resulted in pathogen reduction compared to the standard practice of periodic additions of fresh manure to storages. This held true for both native and spiked populations of *E.coli, Salmonella*, and *Campylobacter*, in both winter and summer storage (e.g. Figure 1). Table 1 summarizes the microbial populations at land application time for the four storage trials.

Decline rates of *E.coli* and *Salmonella* were much slower during winter compared to summer storage. For swine manure, storage times for 90% pathogen reduction (decimal reduction time, DRT) during summer are in the order of 2-3 weeks (Table 2). To achieve the same reduction under winter storage conditions (frozen surface) well over 8 weeks would be required (Table 2). Populations remained relatively stable over the frozen period; spring thaw and increased manure temperatures improved reduction rates. The seasonal effect was less consistent for *Campylobacter* reduction, which has been noted to be more cold-sensitive than the other organisms tested.

Conclusions and Recommendations

Static storage of liquid manures results in substantial pathogen die-off compared to dynamic storage. The time required to reach a 90-99% reduction is much greater in the winter than in summer. Data from the broader study indicates that pathogen decline rates are directly related to temperatures achieved storages. The data enables predictions of storage conditions and times required to achieve significant pathogen reductions prior to field application.

Figure 1: *E.coli* in liquid swine manure storage, Summer 08

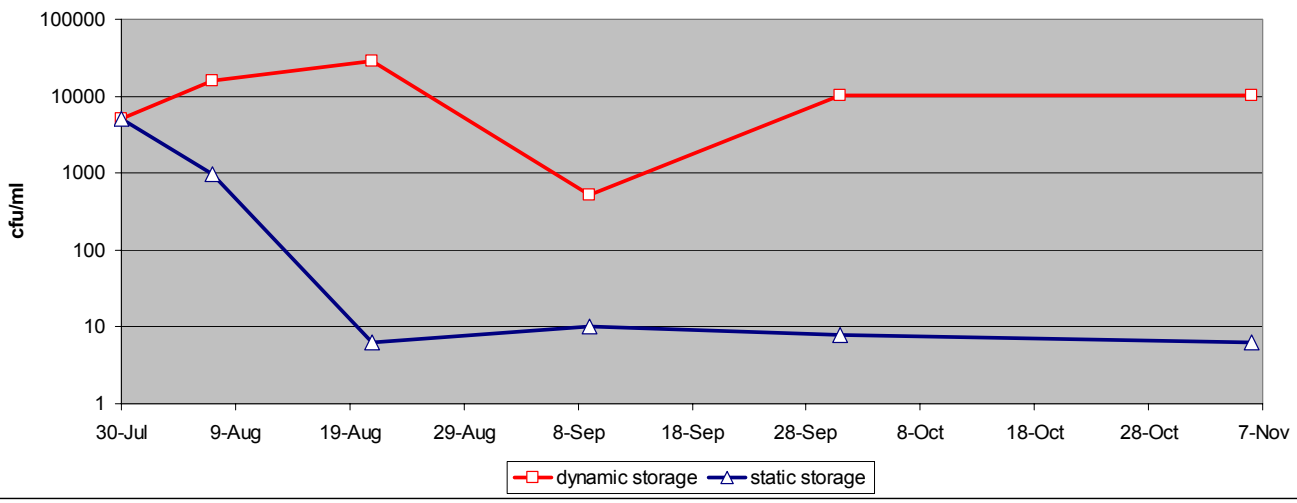

Table 1. *E.coli, Salmonella* and *Campylobacter* in bulk liquid swine manure at beginning of trials and at land application time.

Organism	Storage	Microbial populations in bulk manure			
		Winter 07	Winter 08	Summer 07	Summer 08
E.coli	Initial	8772	1563	6600	39659
(cfu/ml)	Static final*	27	132	13	6
	Dynamic final	16727	354	8933	10288
Salmonella	Initial	-	180	-	653
(cfu/ml)	Static final	-	<0.2	-	<0.2
	Dynamic final	-	8	-	462
Campylobacter	Initial	43	72	4	10
(mpn/ml)	Static final	<0.2	0.2	<0.2	<0.2
	Dynamic final	258	9	110	2

*: final samples taken at land application time; <0.2: below detection level

Table 2. Average decimal reduction time in microbial populations in liquid swine manure held in storage without fresh additions.

Trial	90% Reduction Time (days)		
	Salmonella	*E.coli*	*Campylobacter*
Winter	125 ±85	67±20	37±2
Summer	13±4	23±6	59±76*

** low initial populations in summer greatly increases variability (see Table 1)*

Acknowledgements

This research program was funded through the OMAFRA, Ontario Pork, and Ontario Cattlemen's Association, with in-kind support from Agri-Foods Laboratories and Kari Dunfield, University of Guelph.

Presenting Cost-effective and Practical Group Gestation Housing Designs to Swine Producers in a Video Format

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Introduction

In 2002 the Ontario Pork Producers Marketing Board, in conjunction with OMAFRA and the Agricultural Adaptation Council, funded the production of a video on group sow gestation housing. Three different group housing systems were presented and producer commentary was given on how each system worked. The video was well received and numerous copies have been distributed throughout Ontario and North America. Recently requests for the video have been received from Western Canada, Quebec, USA and Europe. Numerous others have watched the video via the OPPMB's website.

Since 2002, many new feeding strategies and design concepts have been introduced by Ontario producers using group housing to improve sow productivity and decrease producer labour. These new systems are making group sow housing work well and these modifications should be shared with producers who are preparing to renovate or build new sow gestation barns.

Project objectives

1. Provide producers with new concepts in animal behaviour that are important in making group sow gestation housing work well.
2. Show the feeding strategies and pen design concepts used by Ontario producers that ensure equal feed distribution between sows and that minimize or eliminate aggression at mixing and feeding times.
3. Provide the building or renovation and operational costs along with pen diagrams for each of the group housing systems featured in the video.

Return to the industry

Crated gestation barns will need to be replaced as they age. Many Ontario producers will be considering pen gestation systems. Producers supplying Maple Leaf will be forced to switch from crated gestation to pen gestation in nine years. In addition, the premiums paid to producers for being part of an organic or humane-raised certification program are significant but require group gestation housing.

Building on the first, a second video will provide producers with a chance to see more working sow gestation pens and hear from producers the pros and cons of these systems. This will allow producers to make informed choices about pen designs and feeding systems when renovating or building new sow gestation facilities. Producers can thus make these choices confident that the systems are in use and working well.

Procedure

Through contact with Dr. Robert Friendship at the University of Guelph, Dr. Tim Blackwell from OMAFRA and Franklyn Kains, an agricultural engineering consultant, a list of farms successfully using group sow gestation housing will be created. Farms will be categorized by their pen design and feeding system. Farm owners will then be contacted to determine if they would participate in the video. All farms agreeing to participate will be visited and a brief preliminary video of the pen design and sow behaviour at feeding will be recorded. Farrowing rate, liveborn, pigs per sow per year, and the average number of sows per group that do not adjust to group housing will be recorded.

The final video will include video footage from 4-5 different group housing systems. Farms will be selected based on their unique design features along with demonstrated productivity. A professional videographer will be hired to film on the selected farms. The footage will include the layout of the pens on each farm as well as routine management practices such as feeding, cleanout, mixing new groups of sows, pregnancy ultrasounding and vaccination. Emphasis will be placed on design concepts and feeding strategies that limit competition for resources thereby limiting aggression between sows. The recordings will be professionally edited and the final video will be approximately 40 minutes in length. Building and operational costs as well as a diagram of the pen will be shown in the video and also provided in a handout included with the video.

Results to date

Four farms were selected to be in the video based on their pen designs and management strategies. All four producers agreed to participate in the video. A professional videographer was hired to record the video footage and to edit the footage and create the final video. Each farm was visited for approximately half a day. Video footage of the farm layout and the group gestation pens were recorded. Interviews with the producers were also conducted and recorded. During the interview producers discussed why they chose group housing, the gestation pen layout, their feeding and maintenance strategies and what techniques they use to reduce or eliminate aggression among the sows when they are mixed into a group.

The video footage is currently being edited by the videographers under the direction of a script written collaboratively by Kathy Zurbrigg and the videographers. Computer generated plans for the layout of each gestation pen included in the video are being created. These plans will be included within the video to assist viewers with understanding all the elements of the pen design. They will also be included as a handout to be distributed with the video. The finished video is expected to be completed and ready for distribution in March 2009.

Producers interested in a copy of the either the first group housing DVD or the second (upon completion) can contact Kathy Zurbrigg at 519-846-3418 email: Kathy.zurbrigg@ontario.ca.

Country of Origin Labeling Update

Bridgette Dyce
Business Intelligence Officer, Ontario Pork

Background

Mandatory Country of Origin Labeling (COOL) was implemented in the U.S. on September 30th, 2008 under an Interim Final Rule. On January 12th, the United States Department of Agriculture issued an advance Federal Register notice of the Final Rule for COOL. The Final Rule will be published on January 15th and will take effect 60 days following publication, on March 16th, 2009.

The rule will be enforced at the retail level, requiring retailers to label covered commodities according to their country of origin. Commodities affected by the current rule include muscle cuts of pork, beef/veal, lamb, goat and chicken; ground pork, ground beef, ground lamb, ground goat, and ground chicken; fish and shellfish; perishable agricultural commodities; peanuts; ginsing, pecans and macadamia nuts. Processed foods are exempt from COOL, as are foods sold in the food service (restaurant) industry. Full enforcement of COOL is not expected until April 2009, following an industry education and outreach period which is currently underway.

Label Requirements

Requirements for labeling muscle cuts of pork (and other meats) are broken into four categories, outlined below:

Category A, U.S. Country of Origin – Product derived from livestock born, raised, and slaughtered in the U.S.

Category B, Multiple Countries of Origin – Product derived from livestock born in Canada, raised and slaughtered in the U.S., from animals imported not for immediate slaughter (i.e. Canadian weaner pigs).

Category C, Imported for Immediate Slaughter – Product derived from livestock born and raised in Canada, slaughtered in the U.S., from animals imported for immediate slaughter (Canadian market hogs).

Category D, Foreign Country of Origin – Product derived from livestock born, raised and slaughtered in a country other than the U.S.

Trade Challenge

On December 1st, the federal Government announced that Canada is seeking formal consultations regarding COOL with the United States under the World Trade Organization (WTO) dispute settlement process. Formal consultations typically run for 60 days and provide a forum for the two countries to settle the dispute themselves. The entire dispute settlement process can take years. Mexico has also filed a complaint with the WTO regarding COOL.

The Government of Canada will continue to assess the impact of COOL as the Final Rule is implemented.

Harmful Effects of COOL

The harmful effects of COOL are already apparent within Ontario as several U.S. processors have made public statements reporting that they will no longer accept livestock with Canadian origin, including Canadian market hogs and Canadian weaner pigs raised in the U.S., due to the added costs

of segregating these animals. As a result, Ontario Pork's shipments to the U.S. declined once COOL was implemented.

Ontario Pork staff continues to work with domestic processors and U.S. processors who are still accepting Canadian market hogs in an effort to maintain competitive and consistent marketing of Ontario hogs. Producers shipping directly to the U.S. on contract with a processor should have received documentation forms from the plant that will be required for future swine shipments. The documentation will serve as proof of origin. For producers whose hogs are shipped to the U.S. on Pool loads, Ontario Pork will be responsible for providing origin documentation on behalf of these producers.

Ontario Pork, in coordination with the Canadian Pork Council, is working to submit evidence of harm as a result of COOL to the Federal Government. Evidence of harm could include reduced livestock exports to the U.S. or a reduction in the price of Canadian livestock in the U.S. which is a direct result of COOL.

Ontario Pork is also working with the Canadian Cattlemen's Association to create a questionnaire to solicit and document injury to the industry. It is envisioned that this questionnaire could be put on the Ontario Pork website and distributed in hard copy to industry stakeholders. The questionnaire format will provide a more systematic process for gathering anecdotal reports of harm from producers, transporters, and other industry stakeholders.

OSHAB Update

Dr. Doug MacDougald, Chair of the OSHAB Board
Lori Moser OPIC/OSHAB Managing Director, 519-684-6805 www.opic.on.ca

The mandate of the OPIC Swine Health Advisory Board (OSHAB), a non-profit volunteer industry organization, is to take a leadership role in industry communication, foster collaboration among sectors and jurisdictions and provide direction for primary research and resource allocation for major swine health issues in Ontario. Since its establishment as a sub-committee of the Ontario Pork Industry Council (OPIC) in 2006, OSHAB has been leading the drive to understand, control and ultimately eliminate porcine reproductive and respiratory syndrome (PRRS) in this province. To further these objectives, OSHAB has undertaken two new projects in 2008 – an assessment of the cost/benefit of commonly used PRRS interventions, and development of a centralized Ontario PRRSV sequence database.

Quantifying the Cost/Benefit of PRRS Interventions

Although there are numerous control options available when dealing with a PRRSV break, to date, the industry has not had a quantitative way to assess the cost/benefit of the available interventions. OSHAB has undertaken a project to address this industry concern by providing a best practices business management tool for use by pork producers and their veterinarians when assessing control strategies in the face of PRRS with the help of project funding through the Agricultural Adaptation Council – Agricultural Management Institute (AAC-AMI) program.

The goal of this project is to develop a tool that allows analysis and selection of the most cost effective control strategy. Dr. Doug MacDougald, an Ontario swine veterinarian and chair of OSHAB explains "The severity and frequency of the occurrence of this disease indicates that a tool of this nature would be highly valuable to producers who are struggling with devastating new PRRSV breaks to help them to quantitatively assess the available options. Use of this tool will also allow a more accurate estimate of expected costs based on industry averages to assist with the decision making process." Dr. Julie Ménard of Ferme Ménard, an integrated company which produces 11% of the pigs raised in Quebec agrees "The majority of our farms have faced PRRS outbreaks over the last 20 years and it is a very costly disease. The OSHAB cost/benefit project will allow us to choose the most cost effective intervention plan to control PRRS breaks."

Dr. Isabelle Moreau, a Quebec based technical service associate and swine veterinarian from Elanco Animal Health indicates "In today's economically challenging business scenario, producers cannot afford to add risk to their business and so it is necessary to quantify the economic impact and risk of those options proposed to control PRRSV clinical signs after it infects a herd. This project will provide a means to achieve this objective." OSHAB will work collaboratively with Dr. Zvonimir Poljak of the University of Guelph, the Ontario Pork Producers' Marketing Board, and national and international swine veterinarians to advance this project.

Creation of a Centralized Ontario PRRSV Database

OSHAB has received a $25,000 grant from the Ontario Pork Producers' Marketing Board to develop a centralized Ontario PRRSV database in collaboration with the Animal Health Laboratory (AHL), Laboratory Services Division, University of Guelph. The database will allow comparisons of percent similarity between PRRSV isolates already in the AHL database and isolates from new PRRS cases.

PRRS viruses have high genetic mutation rates resulting in great strain diversity. Producing a wide variety of strains is advantageous to the survival of the PRRS virus as new strains are able to overcome their hosts' immune systems. Monitoring of virus spread and mutation, as well as minimizing the introduction of new strains, is therefore critical in the long-term quest to reduce the

prevalence of PRRS in the Ontario swine population. The comparison reports generated by the database system will also allow for improved veterinarian to veterinarian communication which is expected to assist in regional eradication programs and help veterinarians to provide producers with improved management plans in the face of new PRRSV breaks. An example of the data provided in the comparison reports is provided in Figure 1.

"This new database tool will allow comparisons of percent similarity between PRRSV isolates from farms throughout Ontario," says Dr. Doug MacDougald, chair of OSHAB. "This is of significant value to Ontario swine veterinarians and producers. We need help in understanding viral spread and prevalence and severity of clinical symptoms seen with specific variants through improved communications between veterinarians." Dr. Cathy Templeton, vice-chair of OSHAB adds, "It may also assist veterinarians and producers in identifying possible routes of entry of the virus. This gives us opportunities to improve on-farm biosecurity."

The $25,000 grant is being used to support the development of standardized release and submission forms, to address issues of producer confidentiality, and a pilot project to assess the effectiveness of the program. The project works as follows. Upon observing a case of PRRS, the veterinarian takes a sample of blood and sends it to the AHL for analysis. The genetic make-up of the virus is then sequenced and compared to all other sequences of PRRS viruses in the OSHAB Ontario PRRSV database. A summary report is then issued to the veterinarian who submitted the new case, including cases in the OSHAB database with 98% or greater degree of homology to the new sequence. The location and producer name from which the comparison sequences were taken are kept confidential, with only case # and veterinary contacts listed on the report for those submitted from different clinics. The results can then be shared among appropriate researchers and veterinarians. This project has been underway for 2 months, with 381 sequences from 8 participating veterinary clinics included in the Ontario database, and with 11 outbreaks highlighted. The project shows great promise, and will be enhanced with the addition of more sequences from more participating farms.

Figure 1. Example of Sequence Homology Reports Generated by AHL.

OSHAB Ontario PRRSV ORF5 Sequence Database Comparison Report				
Submission case # with predicted RFLP type, owner's name, date received, referring vet, clinic name				
ex. case#, predicted RFLP, owner A, date received, referring vet, clinic name				
Previous cases with % sequence homology equal to or greater than 98.0%				
Cases	**% homology**	**Date received**	**Referring Vet**	**Clinic Name**
case#, predicted RFLP owner B*				
case#, predicted RFLP owner C*				
case#, predicted RFLP **				
case#, predicted RFLP owner B*				
case#, predicted RFLP **				
case#, predicted RFLP owner D*				
case#, predicted RFLP owner D*				
* owners name given if the case is from the same veterinary clinic that submitted the sample ** owner's name is not given if the case is from a different veterinary clinic that submitted the sample, however the reference vet and clinic's name will be given to allow vet to vet communications				

Funded in Part Agricultural Adaptation Council
Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

Handling Stress During Marketing of Pigs from Large Groups

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SUMMARY
When handled through the same facilities, pigs from large and small groups required similar levels of force during handling. However, pigs from large groups tended to load more quickly. Pigs from the two treatments had similar physiological responses to handling. When given adequate lairage time to recover from handling and transportation, meat quality was similar between group size treatments.

INTRODUCTION
We have previously shown that pigs from large groups are more socially tolerant than pigs from conventional small groups and will fight less when re-grouped, as happens during marketing. Anecdotal evidence from producers and truckers indicates that pigs from large groups are easier to handle and load. These two factors could combine to result in less marketing stress for pigs from large groups, with a potential to improve meat quality. Indeed, farms using large group autosort housing have been reported to have fewer death losses during marketing than conventional farms (Brumsted et al., 2004).

This study was conducted to compare handling attributes, stress responses, and meat quality of pigs from conventional and large group auto sort pens marketed through the same facilities.

RESULTS AND DISCUSSION
Two hundred forty pigs raised in either conventional small groups (16-18 pigs/pen) or in large groups with auto-sort facilities (approx. 250 pigs/pen) were marketed on 10 days to assess differences in response to handling and meat quality. Pigs were loaded in groups of 4 pigs up a ramp onto a trailer. Transportation to the packing plant was 45 min in length and lairage was approximately 4 hours. Behavioral and physiological measures were taken prior to, during and after the handling and transport process. Standard meat quality assessment was conducted on loins from the animals 24 h after slaughter.

Although the time taken to load a group of 4 pigs varied considerably, it took approximately 50% longer to run pigs from small groups up the loading ramp (Table 2, $P < 0.10$). The need for electric prods, as defined in this study, was similar for both treatments. However, the number of shocks applied to a group, although similar statistically, reflected the amount of time needed to load pigs from each treatment.

The only differences observed in heat balance variables (temperatures, skin colour and breathing) were early in the handling of the pigs, with an increase in rectal temperature after removal from the pen, and an increase in ear temperature once on the transport trailer for the pigs from small groups (Table 1, $P < .05$). Cortisol levels, reflective of acute stress, increased approximately 3-fold from in the barn prior to loading, to after unloading at the plant. However, these values did not differ between large and small group treatments.

Meat quality measures evidenced significant differences between treatments for marbling, and three of the Minolta light variables. Pigs from small groups had a higher degree of marbling and higher light reflectance (L*), but also a redder colour (a*), (Table 3, $P < 0.05$). The trends, although not statistically significant, among other meat quality scores would suggest slightly less response to stress in large group pigs (see pH, color, and Japanese color).

This study represents a comparison of responses to handling of pigs from large and small groups on the same farm, and through the same loadout and transportation vehicle. As such, confounding that may occur when analysing treatments when farms represent different treatments was avoided. Under these conditions we found only minor differences in handling, although pigs from large groups did tend to load more quickly.

Meat quality effects due to handling stress may have been masked by the 3-4 hour lairage time used in this study. This length of holding is preferred within the industry because it does attenuate problems during marketing, particularly if short transportation times are involved.

CONCLUSIONS
Pigs from small groups evidenced elevated rectal and ear surface temperatures early in the handling process, but no differences were found after arrival at the packing plant. Difficult groups of pigs were encountered when loading in both treatments, and similar levels of force, generally involving the use of the electric prod, were used. Pigs from small groups tended to take longer to load up the ramp than did pigs from large groups (78.7 vs 52.6 sec/group; $P < 0.10$). Meat quality differences were minor, with pigs from small groups having more marbling. No differences in meat quality scores reflective of differential responses to handling were evident.

ACKNOWLEDGEMENTS
Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork and the Saskatchewan Agricultural Development Fund. Specifi c program funding was also provided by the (U.S.) National Pork Board project #05-137. Technical support was provided by Sierens Equipment Ltd, Swan Lake, MB

(reprinted from Prairie Swine Centre Inc. Annual Research Report)

Table 1. Physiological data of pigs from large and small groups during various stages of the marketing process.

BARN (prehandling)	Group Size Large	Small	SE	P-Value
Ear Temp.	34.0	34.5	0.33	0.18
Rectal Temp.	39.2	39.5	0.09	0.02
Cortisol	11.4	10.4	0.70	0.32
Breathing Score	1.0	1.02	0.03	0.34
Skin Score	1.01	1.11	0.08	0.21

TRUCK	Group Size Large	Small	SE	P-Value
Ear Temp.	32.2	33.8	1.19	0.01
Rectal Temp.	40.0	40.1	0.26	0.68
Breathing Score	1.08	1.10	0.05	0.68
Skin Score	1.20	1.21	0.10	0.93

PLANT	Group Size Large	Small	SE	P-Value
Ear Temp.	32.7	33.5	0.66	0.10
Rectal Temp.	39.1	39.1	0.12	0.95
Cortisol	31.8	27.1	3.25	0.13
Breathing Score	1.07	1.04	0.03	0.35
Skin Score	1.38	1.33	0.08	0.64

Table 2. Assessment of handling of pigs from large and small groups during the loading process.

	Group Size Large	Small	SE	P-Value
Level of Encouragement.	2.83	2.90	0.08	0.47
Number of Shocks/group	8.30	12.03	3.37	0.21
Duration of Loading/group	52.58	78.71	10.84	0.09

Table 3. Meat quality assessment of pigs from large and small groups.

	Group Size Large	Small	SE	P-Value
pH	5.75	5.71	0.02	0.12
Texture	3.36	3.25	0.08	0.29
Colour	3.43	3.24	0.08	0.08
Marbling	2.51	2.71	0.13	0.04*
L*	51.8	53.4	0.91	0.02*
a*	2.60	2.95	0.23	0.05*
b*	10.25	10.18	0.72	0.92
Japanese Colour	3.45	3.36	0.12	0.21
Drip Loss	9.74	9.88	0.45	0.77

The Efficacy of Eight Different Feed Additives on Mitigating the Effects of Deoxynivalenol (DON)

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SUMMARY

An experiment was conducted with nursery pigs to test the efficacy of 9 different feed additives on mitigating the effects of DON (2 ppm) contaminated feed. Sixty pens of pigs, 4 pig/pen were fed one of 12 diets for the 22 day experiment, beginning 7 days post-weaning. Treatments were a positive control, (non-contaminated corn) a negative control (2 ppm DON) and the negative control supplemented with one of 8 different feed additives, or in two cases a combination of feed additives. Consuming diets containing 2 ppm DON resulted in a 10% depression in feed intake which the feed additives did not reverse.

INTRODUCTION

Deoxynivalenol (DON) is a trichothecene mycotoxin produced by fusarium moulds contaminating cereal and other grains, including corn and wheat. Gross
symptoms of DON ingestion include vomiting and feed refusal and it can have serious if not dramatic effects on the financial viability of a commercial pig farm. There are several feed additives available which are reported to reduce the effect of the mycotoxin. Modes of action include binding the mycotoxin in the gut and preventing absorption, chemically transforming the toxin to decrease its toxicity, or enhancing immune system function. The overall objective of this experiment was to determine the effect of these feed additives on the performance of nursery pigs fed diets contaminated with DON.

MATERIALS AND METHODS

This experiment used 5 nurseries, with 24 pens per nursery and 4 pigs/pen (initial BW 9.02 ± 0.36 kg). All pigs were fed 0.5 kg of Provision 1, then Provision 2 (FeedRite, Winnipeg, MB), until day 14 and treatment diets from day 15 to 35 post-weaning. Pigs were weighed on day -7 (7 days post-weaning) and on days 0 (14 days post-weaning, initiation of treatment diets) 8, 16, and 24 (nursery exit, day 35 post-weaning).

Treatment diets were formulated to meet or exceed all requirements for pigs of this age (Table 1). Samples of corn contaminated with known amounts of DON.were used for 35 % of the corn in diets 2 to 12 to provide 2 ppm DON in the fi nal diet. This amount was used because a preliminary experiment indicated this level would cause a measurable reduction in feed intake but would not be fatal.

RESULTS AND DISCUSSION

The concentrations of DON in diet samples are shown in Table 2. Concentrations ranged from “not-detected” in the positive control to 2.61 ppm in diet #11. Effects of treatment on overall performance are shown in Table 2. Pigs on the positive control tended to be heavier than those on the negative control by day 22 (0.50 kg, $P = 0.09$). Overall, pigs consuming diets contaminated with DON had reduced ADG and ADFI compared to those consuming the positive control diet free of DON ($P < 0.001$). Average daily gain and ADFI of pigs on the positive control was superior to those consuming the DON contaminated diet, regardless of the feed additive used. None of the feed additives ameliorated the eff ects of DON on feed intake or gain. Feed efficiency was unaffected by treatment ($P > 0.05$).

CONCLUSIONS

Based on our preliminary experiment and a literature search we formulated the diets in this experiment to contain approximately 2 ppm DON. Analyses of the diets indicated a mean concentration in the DON containing diets of 1.99 ppm, however, concentrations ranged from 1.57 to 2.61 ppm. We are unable to determine if the variability shown in the treatment diets is the result of mixing, sampling, or analytical error. We suspect it may be a combination, and this illustrates some of the difficulties when working with mycotoxins. Very small amounts (ppm, parts
per million) are toxic and it may exist as “pockets” within a grain which makes accurate sampling difficult.

None of the feed additives in this experiment effectively reduced the effects of the mycotoxins. There is no obvious explanation for this, but it could be because the response to the DON was so variable. The feed intake of the pigs on diets 4,5,and 8 was similar to the negative control, however, it didn’t approach the feed intake of pigs on the positive control diet, and the feed intake of pigs on the other diets was actually less than those consuming the negative control.

In conclusion, approximately 2 ppm DON in the diet of nursery pigs will decrease growth and feed intake by almost 10 % if consumed for 3 weeks. The feed additives used in this experiment had no eff ect on ameliorating the eff ect of the mycotoxoin, regardless of their mode of action.

ACKNOWLEDGEMENTS
Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. Project funding from Hubbard Feeds, Mankato, MN is gratefully acknowledged.

(reprinted from Prairie Swine Centre Inc. Annual Research Report)

Table 1. Basal diet composition (as fed basis)[a].

Ingredient	Percent
Corn[a]	50.61
Soybean Meal	29.25
Whey	10.00
Fish Meal	4.00
Canola Oil	2.00
Dicalcium Phosphate	1.40
Limestone	0.50
Vitamin Premix	0.50
Trace Mineral Premix	0.50
Celite	0.40
Salt	0.30
Lysine-HCl	0.15
Calcium Propionate	0.10
Antibiotic	0.10
Choline Chloride	0.08
DL-Methionine	0.07
Copper Sulphate	0.04

[a]Composed of appropriate proportions of contaminated and "clean" corn.

Table 2. Analyzed concentrations of DON and moulds in treatment diets and eff ect on performance of nursery pigs (initial BW 9.02 kg) fed DON contaminated corn.

				Performance			
Trt #	Treatment	DON ppm	Mould CFU/g[a]	BW Day 24	ADG, kg/d	ADFI, kg/d	Gain:Feed
1	Positive control[b]	Neg[c]	850	21.72	0.58	0.88	0.67
2	Negative control[d]	1.57	900	21.10	0.55	0.80	0.69
3	Trt 2 + Ing. A	1.33	650	20.83[e]	0.54[e]	0.75[e]	0.72
4	Trt 2 + Ing. B	1.75	3,000	21.27	0.56[e]	0.80[e]	0.71
5	Trt 2 + Ing. C	1.95	9,000	20.74[e]	0.53e	0.80[e]	0.68
6	Trt 2 + Ing. D	1.76	4,500	20.75[e]	0.53[e]	0.79[e]	0.69
7	Trt 2 + Ing. E	1.81	700	20.74[e]	0.53[e]	0.78[e]	069
8	Trt 2 + Ing. F	1.87	2,000	21.06	0.55	0.80	0.69
9	Trt 2 + Ing. G	2.09	1,550	21.03	0.55[e]	0.79[e]	0.69
10	Trt 2 + Ing. H	2.56	650	20.46[e]	0.52[e]	0.74[e]	0.70
11	Trt 2 + Ing. F + G	2.61	1,500	20.46[e]	0.52[e]	0.76[e]	0.69
12	Trt 2 + Ing. E + B	2.57	2,000	20.33[e,f]	0.52[f]	0.75[e]	0.69
STATISTICS							
	SEM			0.25	0.01	0.03	0.02
	Overall P-Value			0.009	0.009	0.11	0.81
	P-Value (Pdiff)	Trt 1 vs. Trt 2		0.09	0.08	0.06	0.36
	P-Value (Contrast)	Trt 1 vs. Trt 3-12		0.0004	0.0003	0.0008	0.13
	P-Value (Contrast)	Trt 2 vs. Trt 3-12		0.20	0.20	0.35	0.77

[a]Colony forming units.. Moulds were primarily Penicillium ssp, Fusarium ssp and Mucor ssp.
[b]Used exclusively non-contaminated corn.
[c]Negligible
[d]Formulated to contain 2 ppm DON
[e]Different from trt 1, positive control ($P < 0.05$).