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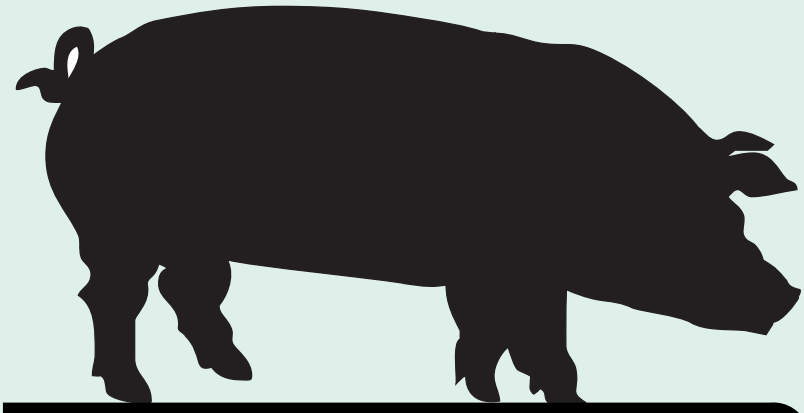

CENTRALIA SWINE RESEARCH UPDATE

January 28th, 2004

CENTRALIA SWINE RESEARCH UPDATE
Kirkton-Woodham Community Centre
January 28, 2004

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On-farm Animal Welfare Assessment

Penny Lawlis, Ontario Ministry of Agriculture and Food

In 2002, the Canadian Pork Council (CPC) formed an animal care working group to develop an appropriate on-farm animal welfare assessment for the Canadian swine industry.

The CPC animal care working group agreed that a Canadian on-farm assessment program should serve as the foundation of a swine animal welfare program and be a production tool for producers. Completion of the on-farm assessment should help to identify areas on the farm which compromise welfare as well as, over time, identifying changes (both positive and negative) in animal welfare (Sørensen 2001).

The working group agreed that animal welfare must be viewed within the context of other goals (i.e., food safety) and that the animal care assessment program would most likely be incorporated into the on-farm food safety program.

The key elements that would need to be included in an animal welfare assessment were identified using a HACCP approach as the framework and the Codes of Practice for content. Critical control points (CCP's) were considered relative to the vulnerability of pigs, the interaction between pigs and their environment and the interaction between pigs and stockpeople. With this in mind, a thorough review of the existing Codes of Practice was undertaken to explore those points that could be taken and measured at the farm level.

It is essential to find the important critical control points, but to not have too many things to measure (Grandin, www.grandin.com). The critical limits for each identified CCP must involve a measurable parameter.

Animal welfare can be assessed using environmental or animal based parameters. Environmental parameters describe such things as size of stalls, feeding and drinking facilities and space allowance. Animal based parameters record the animal's reaction to its environment using behaviour, health and physiology (Johnsen 2001).

The first CPC draft was developed using a combination of animal based and environmental and management based parameters (Johnsen 2001). This draft included animal based welfare measures that are widely adopted throughout various segments of the livestock industry (e.g. body condition scoring) and mortality records. Space allowance and air quality are examples of the environmental parameters used.

Animal welfare is influenced by a combination of factors, such as environmental conditions, stockmanship and the type of production system (Bartussek 2001). For an assessment to work, you need measures that assess welfare under an enormous different set of circumstances (production systems). It's a big job, yet it is best to keep it as simple as possible.

The current on-farm assessment consists of four sections:

1. **General:** This general section applies to all farms and includes sections on staff training, euthanasia, mortalities and transportation.

2. **Sows and piglets:** This section applies to sow barns and nurseries only and will require that sows be scored for body condition.
3. **Weaned pigs**: Weaned pigs require special care and this section will apply to any facility that handles weaned pigs.
4. **Grow/Finish:** Facilities that feed from weaned to market weight will be required to fill out this section, along with the general section.

After completing the booklet, the producer should be provided with an overview of the current welfare state of their herd. The producer will then be able to use this information to provide staff training or to purchase new equipment (Johnsen 2001). The CPC animal care working group is committed to providing such a tool for Canadian producers and will continue with the development and implementation of this program.

The working group has asked producers to identify areas where they require more information. Many of the practical aspects of the program (ie. who will do the auditing, how often will observations have to be recorded) need to determined through open dialogue among producers and other interested stakeholders.

References:

Grandin, T. Livestock Handling and Quality Assurance – page 5 of 16. http://www.grandin.com/livestock.handling.qa.html

Johnsen, P.F., Johannesson, T. and Sandøe, P. 2001. Assessment of Farm Animal Welfare at Herd Level: Many Goals, Many Methods. Acta. Agric. Scand. Sect. A. Animal Sci. 30: 26-33.

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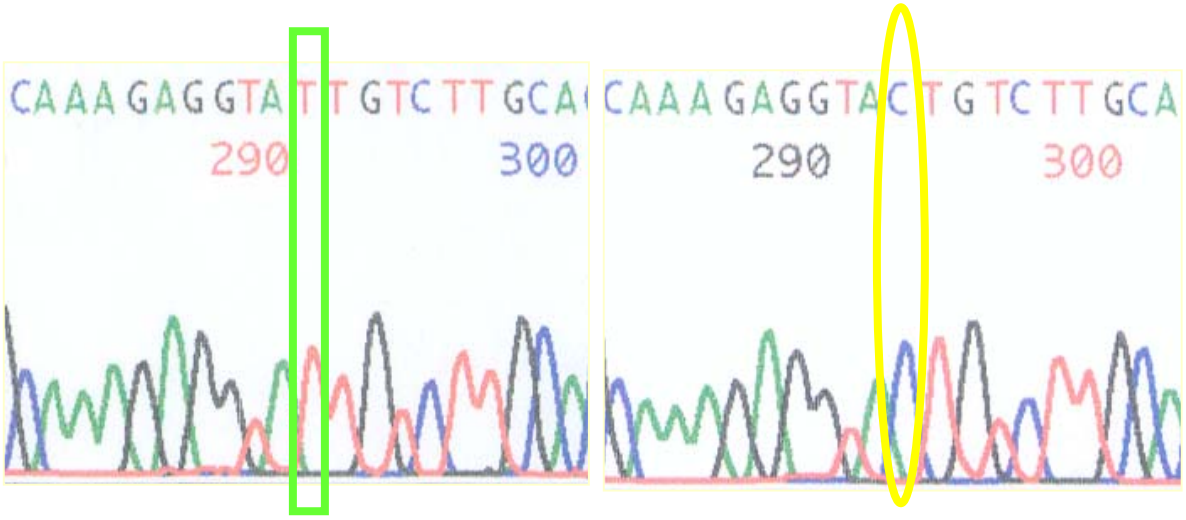
Molecular Genetic Markers: Signposts to the Future

Dr. Andy Robinson,
Centre for Genetic Improvement of Livestock,
Department of Animal and Poultry Science,
University of Guelph

Traditional genetic improvement has relied on measuring performance for specific traits and applying a statistical analysis to the performance and pedigree information to calculate the genetic superiority of potential breeding stock. This traditional procedure assumes that many genes influence a trait and we don't worry about which genes are involved as long as the trait responds to selection. This has worked very well and the lean, fast growing hogs we have now are testament to the effectiveness of this process. However, there are many traits that we can't easily measure because they require post-slaughter processing (like meat quality traits) or because they are expressed by only one gender (like litter size). In these circumstances, if we are to make similar progress in these traits we need to look for additional information to replace or enhance the measurement of these traits. One of the best sources of information for these traits is a marker or signpost built right into an animal's DNA.

The ability to detect molecular genetic (DNA) markers has been available for about 30 years but the ease with which we can detect and exploit these markers has progressed rapidly in the last decade. The latest example of this technology is the single nucleotide polymorphism (or SNP pronounced "snip"). The DNA alphabet consists of 4 letters called nucleotides. Substitution of one letter for another is a SNP. An example is shown below from the DNA sequence of a specific gene in a Yorkshire pig on the left and the sequence of the same gene in a Meishan pig on the right. The SNP is shown by the overlaid box and oval.



SNPs that we use as signposts do not directly affect the differences that we see between pigs but we use them as a reference point when trying to find a particular variant of a gene much as you would an address when trying to find someone's house. Using these SNPs as signposts, we can develop simple lab techniques to follow the signs to the variants of genes we are interested in.

For example, suppose we are interested in finding markers for meat quality traits. We would do a detailed meat quality study on a group of pigs. For all of the pigs, we study connections between the

differences in these SNP signposts and the pigs that have the best meat quality. Once we have established a connection between good quality pork and a specific signpost, we can use that signpost to find other pigs with the potential for superior quality pork using a blood, ear notch or tail dock sample and a molecular genetic lab test. Since the tissue sample doesn't require sacrificing the animal, we can determine the potential for meat quality and still have a pig that can be used for breeding. The test for the PSS or "halothane gene" is an example of such a test.

Research is proceeding to develop a large number of these signposts, much like the 400 highway concept, so we can rapidly navigate our way throughout a pig's genetic makeup. Several groups are working on sequencing the pig genome, much like the process to sequence the human genome although we can borrow a lot of . With this information, we can locate even more genes and their corresponding signposts to increase our understanding of how a pig works.

Evaluation Of Swine Liquid Feed Ingredients: Food Safety And Nutrient Profiles

K. Braun and C.F.M. de Lange[1]
Dept. of Animal and Poultry Science, University of Guelph
[1]Tel: (519) 824-4120 ext. 56477, Fax: (519) 836-9873, Email: cdelange@uoguelph.ca

Objectives
This study was conducted to get a better understanding of swine liquid feeding practices in Ontario and to fully evaluate complete diets and the individual liquid feed ingredients for nutritional value and aspects of food safety.

Introduction
Currently about 20% of grower-finisher pigs in Ontario are raised using computerized liquid feeding systems. As the extent of swine liquid feeding and the use of co-products from the food industry in swine feeds are likely to increase, more information on swine liquid feeding practices in Ontario is needed.

Studies have shown that liquid feeding can reduce the occurrence of *Salmonella* and other food borne pathogens. This is likely due to the use of acidic feed ingredients or the presence of large numbers of beneficial lactic acid producing bacteria in the feed. Other benefits include reduction in feed waste, reduced dust within pig units, improved growth performance, reduction on antibiotic reliance, and increased flexibility in use of alternative ingredients and adjustment of feeding programs.

There is a wide range of co-products from the food industry available for use as ingredients in liquid swine diets, including by-products from dairy processing, candy manufacturing, alcohol production and also bakery waste. These feed ingredients have not been evaluated for pathogens or harmful chemicals and may represent a food safety risk and this can directly impact pork safety. Moreover, limited nutritional information is available on these ingredients.

The purpose of this study was to get a better understanding of swine liquid feeding practices in Ontario and to fully evaluate complete diets and the individual liquid feed ingredients for nutritional value and aspects of food safety.

In this study, 25 pig units using liquid feed systems were visited during the summer of 2003 and samples of co-products, liquid feed and wastewater were collected. The liquid feed samples were collected from the mix tank and at a trough near the beginning and end of the feed line. Corresponding fresh samples of the co-products were collected at the manufacturing source to determine the effects of storage. Dry feed samples were collected from 10 farms to serve as controls for aspects of food safety.

Results
For complete liquid feeds, dry matter content ranged from 14.5 to 24.5%, while the average content in the dry matter was 21% protein, 5% fat, 6% ash, 0.56% calcium, 0.70% phosphorus and 0.30% sodium. The large variation in dry matter content reflects the extremely high water to dry feed ratios in some samples (5.9 to 1), which is double than the lowest and more typical value of 3.1 to 1. The target range should be between 3 and 4 to 1. At extremely high water to feed ratios feed intake of pigs is likely to be compromised. The low average calcium to phosphorus ratio (0.80) is below the target minimum ratio of 1 and reflects that phosphorus levels are too high in several of the samples. The latter is an environmental concern and increases feed costs unnecessarily.

The dry matter content in samples taken from feeders relative to that in the mix tank is an indicator of accuracy of feed delivery. Differences between samples from feeders and mix tanks varied between 0.2 % and 74%. A reasonable target is to have this difference smaller than 5 %.

The main liquid co-products are whey and corn distillers solubles (CDS), while bakery meal, sugar syrup, brewer's yeast and buttermilk are used on a few farms. Table 1 shows the nutritional analysis of co-products. It is clear that the nutrient profile of whey samples differs substantially between suppliers, particularly regarding dry matter and protein content. The variability within suppliers is smaller, but still

substantial for some suppliers. CDS and brewer's yeast show relatively small variability between samples, while nutrient profiles of bakery and buttermilk appear to be highly variable. Variability warrants a routine monitoring of nutrient profiles and large changes in nutrient profiles should result in formulation changes. Whey samples should be analyzed for dry matter, protein, and Na (salt) content.

In terms of microbiology, samples were analyzed for lactic acid producing bacteria (LAB), which are considered to be beneficial for feed preservation and pig growth performance, as well as moulds, yeast, *Salmonella* and *Yersinia*. In particular, in fresh condensed whey (whey 2 and 3) high LAB counts were observed (more than 54,000,000 cfu/g). In contrast, in regular whey (whey 1) LAB counts increased during storage, up to about 1,000,000 cfu/g. During storage, LAB counts in CDS increased more than 100 fold to 21,000,000 cfu/g, which may reflect the addition of inoculants to some of the CDS stored samples. Storage resulted in a 4-fold decrease of LAB (9000-2000 cfu/g) in the bakery product and a 2.5-fold decrease in brewer's yeast (190,000,000 – 75,000,000 cfu/g). There was a 350-fold increase (260 – 92,000 cfu/g) in the sugar syrup and a 350-fold increase in LAB in buttermilk (3,000,000 – 195,000,000 cfu/g) during storage. These results indicate that some co-products can supply substantial amounts of beneficial LAB to pigs.

Salmonella and *Yersinia* were not detected in any of the samples. Yeasts and mold counts were higher in stored samples than in fresh samples, except for the bakery product and brewer's yeast. Provided that no toxins are produced, yeast and molds are not harmful to pigs. However, yeast fermentation results in nutrient losses (as CO_2) and can increase pressure in feed lines.

Complete liquid feed contains approximately 4 times more LAB than dry feed (43,000,000 vs. 11,000,00 cfu/g), twice the yeast (3,860,00 vs. 2,000,000 cfu/g) and two thirds less mold (314,000 vs. 970,000 cfu/g). The latter suggests that there is less chance for mycotoxin formation in liquid feed than dry feed.

Mycotoxins levels in liquid feed ingredients and liquid feeds were low in stored co-products and liquid diets. In fact, for CDS they were below the detection limit of the assay (<0.1 ppm) for zearalenone and only one samples for DON was above the detection limit at 0.96 ppm in the stored samples and fresh CDS samples were1.3 ppm and 1.5 ppm for DON and zearalenone, respectively. This suggests that storage of CDS may result in a breakdown of harmful toxins. However, this should be confirmed in more controlled studies.

Contents of potentially harmful heavy metals (arsenic, cadmium, lead, selenium and mercury) were within the normal dietary range or below the detection limit of the assay for all samples analyzed. In some samples, elevated levels of copper (up to 192 ppm in buttermilk), zinc (up to 255 ppm in the bakery product, 170 ppm in sugar syrup) and iron (up to 1200 ppm in stored CDS) were observed, but these levels are no cause for concern. High iron levels may be a result of leaching from the storage tanks.

Summary and implications

Liquid feeding of swine is gaining in popularity in Ontario as it represents a means to improve various aspects of pork production, and to reduce pork production costs in particular. A study was conducted to evaluate swine liquid feeding practices in Ontario, with special emphasis on characterizing co-products used in liquid feeding systems.

The current evaluation of the main co-products that are used in swine liquid feeding systems show that they are safe to feed to animals and that they do not represent a risk to the consumer. In fact, liquid feeds supply more beneficial lactic acid bacteria to pigs than dry feed, which is likely to results in increased gut health, reduced reliance on in feed medication and reduced risk of *Salmonella* contamination of pigs and pork. Moreover, storage of liquid feed ingredients appears to degrade mycotoxins, which should be explored further. However, the nutrient content of co-products is quite variable and should be monitored based on co-product supplier and routine nutrient analyses.

Acknowledgments

This research was initiated in close collaboration with the swine liquid feeding association (www.slfa.ca) and is supported by Ontario Pork and OMAF. The assistance from all the pig producers and manufacturers of the co-products is greatly appreciated. A complete list of references is available upon request.

Table 1: Acidity (pH), dry matter content (%DM) and nutrient content (% in dry matter) of selected co-products used in liquid feed*.

Sample		n	pH	% DM	% Protein	% Fat	% Ash	% Ca	% P	% Na
Whey 1	Mean ± SD	3	3.49±0.42	4.88±0.64	15.27±1.64	1.39±1.25	13.56±0.44	1.88±0.27	1.32±0.08	0.86±0.08
stored	Min - Max		3.06-3.89	4.33-5.58	13.97-17.11	0.59-2.83	13.06-13.9	1.60-2.13	1.24-1.40	0.80-0.95
Whey 1	Mean ± SD	2	4.48±0.04	5.40±0.12	13.33±0.11	0.31±0.44	12.26±0.13	1.79±0.08	1.26±0.00	0.74±0.01
fresh	Min - Max		4.45-4.50	5.32-5.49	13.24-13.41	0.00-0.63	12.17-12.36	1.74-1.85	1.26-1.27	0.74-0.75
Whey 2	Mean ± SD	6	4.24±1.17	24.56±8.94	7.07±1.98	0.49±0.75	12.24±2.48	0.84±0.57	1.09±0.52	1.07±0.29
stored	Min - Max		3.03-6.43	9.49-35.52	4.47-10.21	0.00-1.93	9.88-16.92	0.32-1.83	0.68-2.07	0.83-1.44
Whey 2	Mean ± SD	5	5.43±0.19	31.14±6.31	8.18±2.22	1.06±0.42	11.06±1.59	0.56±0.04	0.65±0.02	1.42±0.42
fresh	Min - Max		5.17-5.62	22.27-40.10	4.34-9.83	0.74-1.53	8.62-13.07	0.49-0.60	0.64-0.68	0.71-1.73
Whey 3	Mean ± SD	3	2.95±1.80	25.74±3.55	5.83±2.15	0.80±0.70	14.56±5.74	1.10±0.35	1.65±0.78	1.36±0.47
stored	Min - Max		1.76-5.03	21.65-27.94	3.34-7.09	0.00-1.32	7.97-18.53	0.69-1.33	0.75-2.12	0.82-1.68
Whey 3	Mean ± SD	3	5.44±0.02	22.52±0.24	2.97±0.32	0.29±0.09	7.62±0.62	0.66±0.06	0.70±0.01	0.78±0.05
fresh	Min - Max		5.42-5.46	22.31-22.78	2.76-3.34	0.20-0.37	7.00-8.23	0.61-0.72	0.68-0.71	0.72-0.81
CDS	Mean ± SD	5	3.54±0.11	27.23±3.58	25.22±1.63	22.44±1.23	10.04±1.09	0.06±0.01	1.64±0.15	0.21±0.03
stored	Min - Max		3.36-3.65	22.51-31.21	23.49-27.80	20.71-23.65	9.01-11.83	0.04-0.07	1.47-1.85	0.18-0.25
CDS	Mean ± SD	5	3.67±0.21	30.49±0.58	22.31±1.28	18.94±1.36	8.4±0.59	0.04±0.01	1.43±0.12	0.21±0.04
fresh	Min - Max		3.50-3.95	29.69-31.07	20.80-24.12	17.42-20.95	7.78-9.14	0.02-0.06	1.25-1.58	0.15-0.27
Bakery	Mean ± SD	3	na	92.64±0.39	16.70±5.44	10.92±0.84	6.82±0.99	0.98±0.31	0.33±0.06	0.59±0.17
stored	Min - Max		na	92.26-93.05	12.61-22.88	9.99-11.64	5.70-7.56	0.65-1.27	0.28-0.39	0.40-0.73
Bakery	Mean ± SD	3	na	92.70±1.01	15.21±0.29	10.89±2.15	7.61±1.99	1.84±0.62	0.33±0.03	0.61±0.04
fresh	Min - Max		na	91.58-93.54	14.88-15.39	9.45-13.36	6.27-9.90	1.40-2.55	0.31-0.37	0.56-0.65
Sugar Syrup	Mean ± SD	3	4.21±0.82	64.43±2.20	2.41±1.59	0.89±1.54	0.86±0.62	0.03±0.02	0.03±0.02	0.11±0.07
stored	Min - Max		3.73-5.15	62.20-66.60	1.41-4.25	0.00-2.67	0.47-1.58	0.01-0.05	0.01-0.05	0.05-0.19
Sugar Syrup	Mean ± SD	3	3.62±0.35	69.21±1.82	0.32±0.12	1.83±1.53	0.42±0.03	0.02±0.01	0.01±0.00	0.03±0.01
fresh	Min - Max		3.32-4.01	67.12-70.43	0.22-0.46	0.67-3.57	0.40-0.46	0.01-0.03	0.01-0.01	0.03-0.04
Brewer's Yeast	Mean ± SD	3	4.65±0.62	12.46±1.37	52.45±1.98	2.62±1.88	7.55±0.66	0.27±0.13	1.58±0.17	0.05±0.01
stored	Min - Max		4.10-5.32	11.46-14.02	50.72-54.59	1.16-4.74	7.16-8.32	0.15-0.41	0.00-1.76	0.04-0.06
Buttermilk	Mean ± SD	3	4.80±0.92	16.41±6.73	35.47±4.01	15.83±6.62	17.36±9.36	1.08±0.06	0.98±0.13	3.45±2.62
stored	Min - Max		3.86-5.69	8.88-21.86	31.14-39.05	11.07-23.39	7.58-26.23	1.01-1.14	0.89-1.12	0.53-5.59

*n represents the number of samples per co-product. Whey 1, 2 and 3 represent different suppliers. Stored sample are taken from storage tanks at the farm, while fresh samples are obtained directly from the supplier. Fresh and stored samples were not taken from the same batch and may not accurately present changes during storage. A value of 0.00 means that the content for a nutrient is below the detection limit.

Gestation Housing for Sows/Group Systems and Stalls

Harold W. Gonyou, Ph.D.
Research Scientist – Ethology, Prairie Swine Centre

INTRODUCTION

One of the more controversial aspects of pig production is the housing of gestating sows. Gestation stalls have been identified as one of the three most restrictive practices, along with battery cages for hens and crates for veal calves, throughout the history of the modern animal welfare movement. One of the earliest government sponsored reports on intensive animal management, coming from a committee comprised primarily of agricultural experts, expressed the opinion that:

"An animal should at least have sufficient freedom of movement to be able without difficulty, to turn around, groom itself, get up, lie down and stretch its limbs." (Brambell Report, 1965).

However, this same committee recognized that confinement "may well confer some advantages, notably shelter from the weather and freedom from predators and bullying, . . ." Thus, we have the ongoing conflict between 'freedom from bullying' and 'freedom of movement'.

GESTATION SYSTEMS

'Comparisons of group vs. individual systems are difficult not only because several types of criteria are used (productivity, behavior, physiological responses, etc.) but also because there is no single representative group or individual system. . . . It should also be remembered that modern group systems are relatively new developments and are likely to improve rapidly as efforts are directed toward controlling problems such as aggression, claw disorders, and manageability of sows' (den Hartog et al., 1993).

Group Housing Systems

We tend to think of 'group housing' as a single system in comparison to stalls. In fact, there are at least four major group systems, with several management options within each, that are available to the industry. The question is, are all or any of these systems suitable in terms of animal welfare and efficient production?

Before looking at these four systems, we should recognize that all group-housing systems will involve some degree of regrouping animals, with the accompanying aggression. There are two distinct management programs that apply to this aggression. Static management programs, within each group system, will minimize the frequency of re-grouping, in that animals are grouped early in their pregnancy, or even before breeding, and no additional animals are subsequently added. Dynamic management programs involve frequent addition and removal of animals as they are bred and taken to farrowing. The animals in the group encounter frequent social disturbances during their pregnancy. Dynamic systems are used to improve the efficiency of a system by maintaining the maximum number of animals in a pen or on a feeding system. A dynamic management program is more flexible than a static program for day-to-day operation.

Group housing systems are generally classified on the basis of feeding method. In addition to providing freedom of movement, group housing systems are increasing being described in terms of control of individual feed intake and provision of protection during feeding. It is my opinion that the ultimate success of a group housing system will depend upon how well we can achieve the nutritional and other standards expected in modern pig production.

Floor Feeding

Many producers assume that group housing means floor feeding. The group of animals is fed by spreading their feed on the floor or outside lot. This is a very competitive situation, with dominant sows able to monopolize the feed and subordinate animals encountering both social and nutritional stress. Control over individual feed intake is never very good, but some management options can be used to improve the situation. Forming groups of similar sized animals will result in more even competition for and distribution of feed. It is therefore important that all animals have similar feed requirements as well. To achieve these conditions, it is necessary to allocate animals into several groups, and the resulting group size is small. Floor feeding groups are generally managed on a static basis. Providing more space in the feeding area, and

ensuring that the feed is widely spread, will make it more difficult for sows to claim a disproportionate amount of the feed. However, this additional space increases the cost of the system, and low cost is the greatest advantage of floor feeding.

I believe that floor feeding is unlikely to be widely adopted as a solution to the welfare concerns of stall housing. The competition involved in feeding can be intense, and at least 5% of the sows will need to be pulled from such a system. European legislation is already suggesting that highly competitive systems will not be acceptable. Our industry has embraced the importance of good sow nutrition, and this can only be achieved when control over individual feed intake is possible. If we are required to adopt group housing, then floor feeding will be used by producers who are concerned about capital costs in the transition. But in the long run, systems that provide better control over feed intake will be necessary in order to achieve the productivity that we have come to expect on modern farms.

Trickle or Bio-fix Feeding

In the trickle system, sows are fed in partial stalls, providing protection to their head and shoulders, but not extending further into the pen area. This arrangement conserves space compared to feeding stall systems, yet still attempts to achieve uniform distribution of feed among sows within a pen. In each feeding space, feed in metered in at a set rate, representing the eating speed of the animals in the pen. Because feed is distributed at the same rate that the sow can eat it, no feed accumulates and it does not benefit a sow to move from space to space attempting to steal from other animals. Animals must be sorted by eating rate (sows eat much faster than gilts) and by feed requirement. The result is a number of small, uniform groups. Trickle feeding depends on social management of the animals. It has not been used extensively on large farms. Although popular for a time in the U.K., it is not widely used within the rest of Europe. Conventional stall barns have been renovated to incorporate an inexpensive, modified trickle feeding system. It is not clear that such modified systems can adjust the rate of feed drop in different groups, and the importance of this to the system has yet to be determined. The cost of the feed delivery system and intensive social management involved in trickle feeding will probably preclude its use on large farms in our industry.

Individual Feed Stalls

Before our industry adopted gestation stalls, many farms used feeding stalls as a means to control individual feed intake. Although housed in a loafing area for most of the day, animals are moved into stalls for feeding. The system can easily achieve uniform intake among all members of a group, and sows requiring additional feed can be topped up by hand. Traditionally, sows have been housed in relatively small groups and the feeding stalls have been located within each pen. Larger groups are feasible, although provision must then be made for individual supplementary feeding. The greatest drawback to within pen feeding stalls is the requirement for both stall and loafing space. In our indoor systems, this added expense is substantial.

The feeding stall system can be made more efficient in terms of space and capital costs by 'time-sharing' the feeding stalls among several groups of sows. Each pen of sows is released from their loafing area in rotation and has access to the feeding stalls once a day. Although some mechanization of sow movement is possible, essentially you trade space and capital cost for labour. Sharing of feeding stalls in this way allows stockpersons to observe each group of animals as they go to eat, and various procedures, from treatment to pregnancy-checking or breeding can be accomplished easily while the sows are confined. Large herds can be managed in this way, using static social groups. However, sow movement to the feeding stalls resembles a stampede and facilities must be design for both animal and stockperson safety. Preliminary results from a study using large social groups and time-shared feeding stalls indicates that sows in groups had better locomotion scores and fewer abrasions than did sows in conventional stalls, but had more scratches.

Feeding stalls are perhaps the most expensive of the various group systems available, but are easily managed and minimize aggression during feeding. The system is very flexible in terms of housing types. Throughout Europe, feeding stalls are gaining in popularity and is one of two systems that are emerging as predominant in the post-gestation stall industry.

Electronic Sow Feeder

Electronic sow feeders provide the greatest control over individual feed intake of all group housing systems. Each pen of animals has one or more feeding stations which animals cycle through and obtain their specific

daily allowance. Each animal can be fed a different amount of feed, and may even be fed different diets or a blended ration of two basal diets. Daily feed allowances can be programmed to change as an animal progresses through pregnancy. Theoretically, all size and body condition combinations can be housed together as each can have a separate feeding program.

The electronic sow feeding system is a technically complex one, involving computer programming, electronic identification, and the mechanics of station gates and feeders. Early systems had many problems but most companies have now developed reliable equipment and support services. Nevertheless, a producer who is not adept at computer records should recognize that they would have to develop those skills to operate such a system effectively.

The relative cost of an electronic sow feeding system is highly dependent upon the number of sows fed from a station. The larger the number of sows, the lower the cost per sow. It is recommended that the entire group of animals be able to complete feeding in 14-18 hours. For mature sows, this limits the number of animals per station to 55-65. Gilts eat more slowly than sows, and the number of animals may have to be reduced if a group contains a large number of gilts. Increasing the number of sows beyond this point will result in increased competition and aggression at the feeder entrance, and more animals will miss a feeding.

The large group sizes required to efficiently use an electronic sow feeding system has implications for social management of the herd. Aggression does occur when animals are grouped, and in the area of the feeder on a daily basis. Because of this, most recommendations indicate that gilts should be penned separate from older sows. True static programs, in which a single week's breeding is grouped together and no other animals are added later, can only achieve efficient group sizes on farms of 1,000 or more sows (55 breedings/week). Smaller herds must use a less efficient static or some form of dynamic management. Several weekly breeding groups can be combined into a pen with a single station, or large groups can be formed using several stations. In a preliminary study, we found that size-sorted dynamic groups worked quite well. This program kept gilts separate from older sows, and the frequent regrouping did not appear to be a problem. We are currently studying large groups using several stations.

Electronic sow feeding systems are likely to form a major component of the industry if we move away from gestation stalls. Their greatest advantage is their ability to provide control over each sow's feed intake. Using electronics to manage animals is an emerging field, and it will take some time for producers to achieve its full potential.

Studies at the Prairie Swine Centre using Electronic Sow Feeders

Our projects involving electronic sow feeders are conducted at the Elstow research unit. Approximately half of the 600-sow herd is now on electronic sow feeders. Our system currently operates on partially slatted floors without bedding. We are studying social management of the groups in order to identify and correct problems with specific age classes. We house gilts with older sows even though we recognize this may result in some problems. However, our belief is that a combined gilt/sow program would be easier for producers if we can resolve the problems. Similarly, we recognize that first parity animals may also be at risk in groups. We are currently involved in a six reproductive cycle study in which we are comparing:

1. The productivity and behaviour of gilts and sows of different parities.
2. The relative benefits of grouping animals immediately after breeding or after implantation (at 7 weeks; 'add-in'), and its interaction with parity.
3. The management of animals in static (45 sows) and large (135 sows) dynamic groups.
4. All electronic sow feeder groups are compared with animals managed in conventional stalls.

The results of the first three reproductive cycles (60 weeks of breedings) have been summarized and presented in table 1. The values presented represent live piglets born per 100 animals bred. This is a combination of farrowing rate and live litter size. The 'Adjusted' values represent a herd comprised of 25% gilts, 25% 1st parity, and 50% older sows. These results are only preliminary as they represent a limited number of animals in each category.

Productivity increased from gilts to 1st parity to older sows as expected in both electronic sow feeder and stall systems. However, the younger animals tended to perform better in stalls, and the older sows better in

ESF. There was considerable variation in performance of age groups in the different electronic sow feeder management systems.

The 'add-in' or post-implantation animals performed better (945) than those grouped shortly after breeding (840). Somewhat surprisingly, all parity groups performed much better as add-ins than when re-grouped early.

The Static program (combined pre and post-implant, 902) outperformed the Dynamic (883). However, gilts did relatively poorly in the Static system (698) but fairly well in Dynamic (758). The older animals (including 'add-ins') did better in the Static program.

Overall, the stall system (917) outperformed the electronic sow feeder system (892), but this was not the case for all electronic sow feeder management programs. The Add-In (945) animals in electronic sow feeders (both programs combined) produced more piglets than did the Stall animals (917). The post-implant static program for electronic sow feeders outperformed the stalls by 5%. The 'add-in' static gilts performed about as well as those in stalls, but the 1st parity animals and sows exceeded those in stalls by 4% and 8%, respectively.

As we continue this study we will be including behavioural and physiological observations. We are also collecting data on injuries, lesions, and mortality throughout the six cycles.

Gestation Stalls

Conventional gestation stalls are criticized for denying freedom of movement to sows. Although it may seem obvious that stalls will never provide freedom of movement as defined by some welfare advocates, as an industry we have done little to avoid criticism. When a 'turn-around' stall was developed in the 1980's, the industry failed to adopt it. Yet this stall did allow animals to 'without difficulty, turn around'. Also, as mature sow size has increased over the years, we have narrowed gestation stalls rather than widened them. The system is more restrictive today than when it first drew criticism.

The Code of Practice suggests that sows should be housed in wider stalls as they increase in size with each parity. Few producers manage their sows in this way. I suspect that many studies involving stalls have looked at animals only as gilts and young sows. Are we confident that productivity in older sows is not limited by stall size?

We are studying the relationship between sow and stall size and sow behaviour, and have initiated a long-term project looking at stall size and productivity this past summer. In our initial study we observed females from gilts to mature sows in stalls from 55-70 cm (22-28in) in width. Our results are summarized in Figure 1.

We found that when observed during the 14th week of gestation, sows spent 50-60% of the time lying laterally, that is, on one side. The proportion of time that they were in contact with both sides of the stall was highly dependent upon both their size and the width of the stall. It would appear that spending 45% of the time lying laterally with both sides in contact with the stall could be used as indicative of a crowded condition. In this case, all of the animals were crowded in 55 cm stalls. Gilts and small sows (1st parity) were noticeably less crowded in 60 cm stalls. Only the large sows (3rd parity and up) were crowded in 65 cm stalls. And all animals were relatively uncrowded in 70 cm stalls.

Our studies will continue to look at productivity, behaviour and stress levels of sows in different widths of stall, but the industry should consider what they must do if they want to retain gestation stalls in a high welfare environment. Increasing the width of stalls, particularly for larger sows, would seem to be an appropriate action.

The Future

Concern about the welfare of farm animals will ebb and flow with other societal issues. But it will not disappear. The industry can wait to be forced to make changes, make some changes voluntarily, or resist all change. It would be prudent to thoroughly investigate alternatives and remain open to new systems that prove themselves both economical and welfare-friendly. Not all group housing systems are equal, and the industry should be careful not to accept single issue solutions.

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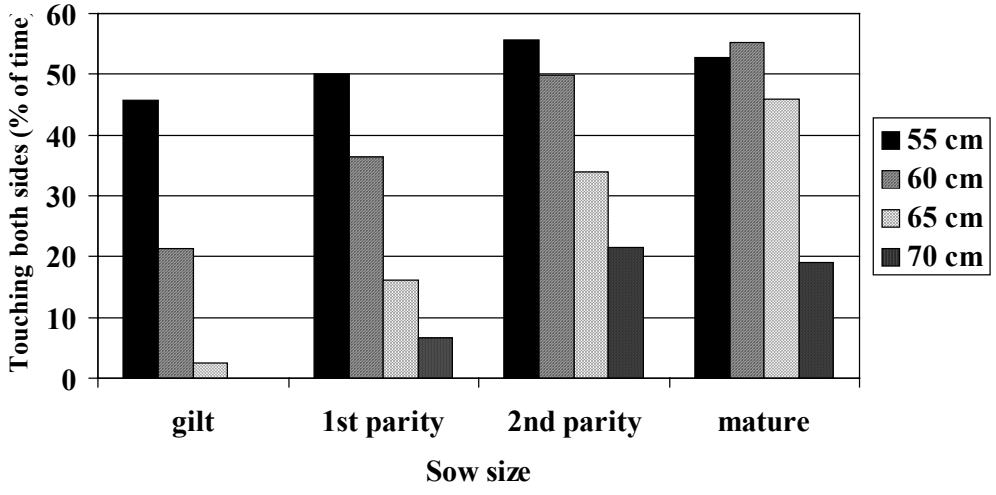
Table 1. Productivity (live piglets/100 females bred) of gilts and sows in Stalls and various management programs within an Electronic Sow Feeder system.

	Stall	Static	Dynamic	Add-in Static	Add-in Dynamic
Gilt	771	633	739	762	776
1st parity	930	872	794	967	942
Mature	983	932	907	1059	998
Adjusted[1]	917	842	837	962	929

[1]Based on a herd comprised of 25% gilts, 25% 1st parity, and 50% mature sows.

Figure 1: Effect of sow size and stall width on the lying posture of sows.



Probiotics – "Using good bugs to control bad bugs"

Rocio Amezcua,
Department of Population Medicine, University of Guelph, Guelph ON, Canada N1G 2W1

The potential removal of antibiotics from farm animal feeds has led to renewed interest in the use of probiotics as growth promoting agents and for prevention of disease like post-weaning *E.coli* diarrhea. Probiotics are "mono- or mixed cultures of live microorganisms, when applied to animal or man, beneficially affect the host by improving the properties of the indigenous microflora" (Havenaar et al, 1992). The most commonly used probiotics for farm animals include species of bacteria such as *Lactobacillus, Enterococcus* and *Bidobacterium and* yeast particularly *Saccharomyces*.

These probiotics are usually targeted for use in intestinal disorders in which specific factors (change of diet, antibiotic therapy and stress) disrupt the normal flora of the gastrointestinal tract, making the host animal susceptible to disease.

To have functional probiotic strains with health benefits, the screening and selection of the probiotic includes testing *in-vitro* and/or *in-vivo* for the following important criteria:

1. Be nonpathogenic and non-toxic, and proven safe for humans and animals. The overall risk of LAB is very low with the exception of Enterococci (*E. faecium and E. faecalis*). These later bacteria are associated with the possible acquisition of multiple antibiotic resistance.
2. Proven stability against gastric acid (pH2-4) and bile, because they should have the ability to resist the digestion process in the stomach and the upper part of the intestinal tract, which may be critical for controlling growth of intestinal pathogens entering the digestive tract.
3. Adhere to gut epithelial tissue, and be able to persist. However, some studies suggest that probiotic microorganisms are very unlikely to invade a fully developed and stable microbial community because of the homeostatic mechanisms operating in that community. It would seem therefore, that the best method of administration is continuous feeding.
4. Attachment of LAB to epithelial cells is very host specific, and therefore candidate bacteria should originate from pigs.
5. Before launching a probiotic product on the market, it is important to verify that bacteria do not contain transferable resistance genes against certain antibiotics.
6. In addition, a probiotic must be able to grow rapidly, retain viability and stability of the desirable characteristics of the strain during commercial production as well in the final product. It is essential that products sold with any claims meet the criterion of a minimum of 10^{6-7} cfu/ml or g of probiotic bacteria at the expiry date.

Probiotics can be presented to the animal in various ways. Fermented feed is characterized by high levels of LAB (9 log cfu/g), yeasts and lactic acid, and also low pH (<4.2) and enterobacteria counts (<3.2 log cfu/g). Low pH in combination with high concentration of organic acids can impair bacterial metabolism in the gut. It has been found that fermented feed decreases the levels of enterobacteria along the GI tract and decrease the incidence of diarrhea in weaned pigs when compared with fresh liquid feed. Lactobacilli are present in the feed not only as viable cells, but also with the primary and secondary metabolites they have produced during the fermentation process.

It has been hypothesised that using carbohydrate rich feedstuffs for fermentation is a more favourable fermentation concept than using complete compound diets. These co-products have a high feeding value for pigs. Liquid wheat starch, potato steam peels and whey is the most used liquid co-products. Therapeutic fermented feeds are produced by using of specifically selected lactobacilli with the properties to survive the passage through the intestinal tract. It is suggested that

if the fermentation pattern of liquid feed could be controlled by the use of such bacteria inoculant, then the risk of coliform scours developing post-weaning could be reduce. The use of bacterial inoculants could replace expensive organic acids and/or antibiotics in piglet diets.

Identification and evaluation of lactic acid bacterias of swine origin:
Fecal samples of healthy pigs: 2 nursing, 2 early and 2 late weaning pigs were taken from 8 different farms. A total of 117 LAB isolates were recovered from these samples. Each sample was tested for its proportion of resistance to pH (2 and 4) and to levels of bile (.15% and .30%). In addition, their ability to inhibit an O149:K88 *E. coli* was tested .

Results:
25 isolates were selected based on their ability to inhibit O149:K88 *E coli* (>15mm) with 13 of these chosen based on at least a slight resistance to pH4 and moderate resistance to the two bile levels. All the isolates were shown to be poorly resistant to pH2. These 13 LAB isolates were tested for their ability to inhibit another 9 *E.coli* strains. Inhibition test among these isolates was performed to determine which ones could be combined in one product.

Fermented liquid feed *in vivo* trial:
Two trials were performed at the Arkell swine research station. In each trial, a total of 70 weanling pigs were randomly allocated to one of the following treatments.
1. Fermented feed with no antibiotics and inoculated with LAB of human origin
2. Fermented feed with no antibiotics and inoculated with 3 LAB of pig origin (Pig 1)
3. Fermented feed with no antibiotics and inoculated with 3 LAB of pig origin (Pig 2)
4. Fermented feed with no antibiotics and no LAB
5. Dry feed with antibiotics.

Pigs were followed for 4 weeks after weaning, weights were recorded on weekly basis. Scores of diarrhea and mortality were recorded every day for each pig during the trial.

Results and Discussion
Pigs receiving the probiotic did not grow better or have less diarrhea than other treatments. The one positive aspect of this study and others that we have performed is that we consistently culture fewer *E. coli* from the intestinal contents of probiotic treated pigs compared to antibiotic medicated groups. Consequently, probiotics may be related to the production of a more favourable gut environment and result in less contaminated pens.

There is a need for probiotics to be subjected to rigorous on farm evaluation.

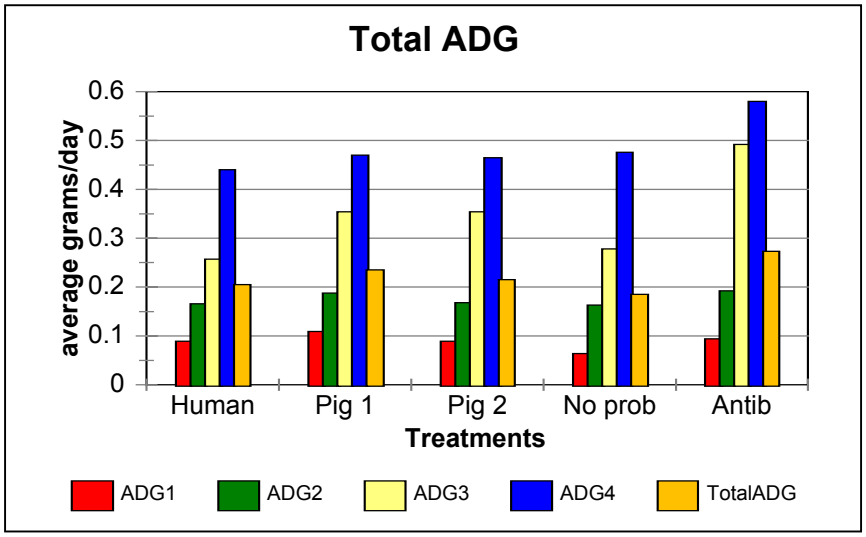


Figure 2. Average daily gain of the first, second, third and fourth week and total average daily gain of pigs by treatment.

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Hemmorrhagic Bowel Syndrome - Why it happens

An investigation of the Association between Feed Intake Patterns and Death due to Hemorrhagic Bowel Syndrome in Finishing Swine

Barbara Straw*, Dennis Langstraat**, Roger Johnson***
*E. Lansing, MI, **Nicollet, MN, ***Denison, IA

Introduction

HBS primarily affects rapidly growing pigs between 4 and 6 months of age (150-260 lbs). The size and otherwise excellent health of the affected animals makes this condition of particular economic importance.

Hemorrhagic Bowel Syndrome is a term applied to finishing swine that die suddenly without noticeable diarrhea or other clinical signs, and on post mortem examination, there is pale skin and obvious distention of the abdomen which contains a thin-walled intestine filled with either clotted or unclotted blood, tarry fecal material in the large intestine and absence of lesions suggestive of gastric ulceration, necro-proliferative proliferative enteritis, salmonellosis, swine dysentery or other identifiable disease processes. A recognizable twist of the intestine is a variable finding (Smith and Shanks 1971, Rowland and Lawson 1973). In a Swiss report of 436 cases of HBS, intestinal volvulus was confirmed in 56% of cases examined in the first 8 years of the study, however by more careful examination in the next 2 years it was found in 80% of cases (Hani et al 1993).

Pigs employ a feeding pattern of discrete meals with relatively long intermeal intervals, Most of the meals are taken during the daylight hours. Pigs weighing 50 lbs eat 15 to 20 times per day compared to 7-13 times per day for pigs at market weight. Possibly, the delivery of larger volumes of food to the intestine, due to larger, less frequent meals as pigs get older predisposes pigs to HBS through purely mechanical mechanisms, ie the weight of the material in the gut is sufficient to cause rotation. Or a combination of mechanical and physiologic mechanisms may be in play, ie "in pigs feeding disrupts the pattern of neurologic control of intestinal movement according to the volume of food eaten at one meal. The motor activity of the pig's stomach and intestine after one large meal resembles that seen in carnivores, and the duration of this effect is approximately halved when two meals/d are given. When pigs are fed ad lib, the motility pattern resembles that seen in ruminants, where the neurologic pattern persists regardless of feeding" (Rucklebusch and Bueno 1976). Therefore interruption of feeding such as would occur if feed was unavailable for a period of time could be an inciting factor.

Fighting, horseplay, mounting and other puberty-related behaviors could mechanically produce a twist of the gut.

Microbiologic investigations have focused on clostridia, *E coli* and salmonellae, and while investigators have failed to identify a specific infectious agent associated with HBS, there are clinical reports that the addition of antibacterials to the ration was successful in reducing the number of cases (Shultz and Danieal 1984a, 1984b).

Clinical Study

A test station that had a history of deaths due to HBS agreed to cooperate in the study. At this station, electronic feeding stations were employed to record individual feed intake data.

Procedure:

1. When a pig died Test Station personnel made a gross assessment of the external appearance to determine if it was possibly due to HBS, with: 1) Sudden death of a good-doing pig, 2) No other

signs of disease such as diarrhea, emaciation, etc., 3) Very pale skin, and 4) Pronounced distention of the abdomen

2. HBS suspects were necropsied by Dr. Dennis Langstraat, Nicollet-New Ulm Veterinary Clinic, to confirm a diagnosis of HBS - i.e.: 1) Thin-walled small intestine filled with either clotted or unclotted blood, tarry fecal material in the large intestine and 2) Absence of gastric ulceration, necropro-liferative enteritis, salmonellosis, swine dysentery or other enteric disease
In addition he:

- Recorded the position of cecum/spiral colon when carcass opened
- Confirmed the presence/absence and location of intestinal twist
- Weighed the amount of feed in the stomach

3. Feed intake data from the affected pig and other pigs in its pen were collected and examined for:
HBS pigs:

- Frequency of meals
- Average size of meals
- Total number of meals/day
- Time when eaten and size of last meal

Pen Mates: Daily feed intake patterns

- Frequency of meals
- Average size of meals
- Total number of meals/day
- Pattern of occupancy of the feeder

Necropsy data
In three sequential groups that were finished at the test station there were 21 pigs necropsied. Six of these were confirmed as meeting the criteria for HBS, were named and data on their eating patterns and other activities prior to death were analyzed.

All six HBS pigs exhibited displacement of the abdominal viscera with rotation of the intestinal tract varying from slight to 180^0 . Their stomach contents weighed (to the nearest half pound) 0.5, 3, 4, 4, 4.5, and 6 lbs.

Feed Intake data
Just prior to the deaths of 4 of the pigs the electronic feeders in their pens were operating normally and provided detailed information on the pigs' eating patterns in the days just prior to and immediately following death. In the two other cases the electronic feeders were not functioning correctly and feed intake data for the pen was unavailable.

Pigs at this test station had feed intake patterns similar to those reported in the literature. They averaged 5-10 meals per day and ate mostly during the day.

Pigs that died of pneumonia, ileitis, gastric ulcer, other or unknown causes exhibited reduced feed intake for several days prior to death. Alteration in feed intake (either engorgement nor diminishment in appettite) was not seen in pigs that died of HBS.

All six HBS pigs experienced some disruption of feeding routine shortly before their deaths. In two cases the electronic feeder was not working properly around the time of death. In another case the feeder was not working properly for several days prior to death and then was returned to normal

function a day before the pig died. In three cases, pigs were sorted, tattooed and weighed the day before they died. For two of these pigs there was an unusually long interval between the time of their last recorded meal and when the next pig entered the feeder.

Table 1. Necropsy and feed intake data for pigs dying of HBS.

Pig	Death	Gut rotation	Unusual occurance
Andy	11-12-01	270^0	feeder not working
Bart	11-16-01	spiral colon & cecum displaced forward	feeder not working -2 and -3 day before death, then functional -1 and 0 days Big pig and long interval after Bart's last meal
Carl	4-15-02	slight	feeder not working
Doug	8-29-02	270^0-360^0	Sorted, tattooed, & weighed -1 day Big pig and long interval after Doug's last meal
Earl	8-29-02	90^0-180^0	Sorted, tattooed, & weighed -1 day
Fred	8-29-02	270^0-360^0	Sorted, tattooed, & weighed -1 day

Conclusions

HBS in pigs is likely to be synonymous with torsion of the intestine. Precipitating factors are interruption in normal feed intake and unusual physical activity.

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Manure Gas, What You Don't Know Can Kill You

Robert Chambers P Eng MSc (Ag Eng), OMAF
Wellington Place, RR#1 Fergus, ON N1M 2W3
Tel (519) 846-3406 Fax (519) 846-8178
robert.chambers@omaf.gov.on.ca

Manure gas is a term used to describe gases being generated by the anaerobic decomposition of manure such as occurs in liquid manure storages. While there are many gases generated, the 4 main gases of concern in terms of human and animal safety are H_2S (Hydrogen Sulfide), CO_2 (Carbon Dioxide), NH_3 (Ammonia), and CH_4 (Methane). While the actual levels of gas produced may vary with type, temperature and pH of the manure along with other factors, the best approach is to assume that these gases are being produced and are present in liquid manure storages and spreaders. Producers, their families and their employees must be made aware of the nature of each gas and the suitable precautions to take.

H_2S and CO_2 are by far the most dangerous of the manure gases. They are extremely lethal to both humans and animals. H_2S at levels greater than 1000 ppm it will cause death on the first breath, and loss of consciousness and possible death in quantities greater than 500 ppm. While this gas can be detected at levels around 1 ppm by its rotten egg smell, at 100 to 200 ppm humans lose their ability to smell it, often resulting in the victims not realizing the danger until it is too late. This gas has a Specific Gravity of 1.19 relative to air, causing it to accumulate above the surface of the manure. Its most hideous property is that it dissolves in the liquid portion of the manure much like CO_2 in soda pop and like soda pop when shaken, it is released in a sudden burst of gas.

The main concern with this gas is during manure removal. Proper ventilation will normally remove any quantities that make it up into the barn on a daily basis. Tips to limit the risk include:

1. Remove if possible any animals from the barn and limit human access to the barn during manure agitation and removal.
2. Have a minimum of one foot of headspace between the surface of the manure and the bottom of the slats. More is better.
3. Stir, don't shake the manure when agitating. Ensure that the mixing nozzles do not cause the manure to shoot up into the air. This causes the H_2S and CO_2 to "strip" out of solution and levels rise to lethal levels immediately. Researches have measured levels up to 1600 ppm of H_2S gas and greater than 17% CO_2 gas by doing this technique.
4. Assume the gas is there even after the manure is gone. Many people have died entering empty or near empty manure tanks or spreaders assuming that the gas had left with the manure. Any time you must enter a confined space where this gas may be present, a trained individual must wear a self-contained breathing apparatus. Limit access to all confined spaces at all times.
5. Check the ventilation system to verify that the barn fans are pulling air from the air inlets and not from a manure pit. Many animal deaths have resulted from air coming into the barn through the manure tank after the pit access covers are removed or a pull plug was left open.
6. Manure gas can rise around the outside open access hole to dangerous levels. While this may not pose a risk while standing, if the situation requires that someone bend down to repair or adjust a pump component, they may be overcome with fumes and fall into the pit.
7. Small children and pets should also be kept away during agitation and manure removal as both H_2S and CO_2 gas are heavier than air and may be exposed to a fatal dose before someone who is taller.
8. If something goes wrong whether it be with animals in the barn or someone entering or falling into a pit or manure spreader DO NOT GO IN. Shut down the pump if operating and phone the

fire department. Under no circumstances should you attempt to perform a rescue. Many multiple deaths have occurred as person after person has died trying to rescue the initial victim. The dangers with H_2S do not permit mistakes - always assume it is present in and around any liquid manure storages, pumping pits or spreaders. Make sure everyone on the farm is aware of the dangers as well.

There are several companies that manufacture H_2S detectors primarily for the oil and gas industry but can be used in barns as well. Be sure to purchase detectors that can handle the rigors of in-barn use. The dusty humid gassy environment of a swine facility is not friendly to sensitive electronic equipment such as a detector unless that equipment has been designed for that situation. Consult the vender to question whether their product to which you and your family and employees trust your life to, is going to function as required if the situation arises. Follow the operating instructions to the letter, most of these units are fail safe, but recognize and respect any limitations or maintenance schedule the unit may have. Like the brakes on you truck, it must work flawlessly when you need it the most.

CO_2 shares many of the properties however it is much less toxic. It has no odor at any concentration and could be fatal after few minutes at levels exceeding seven to ten percent. Levels of CO_2 gas have measured to exceed 17%, well in excess of fatal levels. It has a Specific Gravity of 1.53 so it is found in the same locations as H_2S. The levels of CO_2 gas rise during agitation after H_2S gas, and as it requires a longer relative time to cause death, any precautions taken for H_2S gas will work for CO_2 gas. The caution is that any breathing apparatus MUST be rated for BOTH H_2S gas and CO_2 gas. Ignoring one or the other may very well lead to your death.

While NH_3 can cause respiratory spasms in levels greater than 5000 ppm, it has several properties that make it less of a danger than H_2S. The main safety issue with NH_3 is one of long term exposure to this gas, in constant average values greater than 25 ppm, on the health of both humans and animals. This gas has a specific gravity of 0.6 so rises into the barn space from the manure storage. The easiest method to maintain proper levels is to ensure that the ventilation system is functioning properly. Levels of 30 – 50 ppm will cause eyes irritation. One of the major factors that affect the production of NH_3 is pH. Liquid manure with a pH above 7.5 will cause NH_4 (Ammonium) in the manure liquid to be converted more readily to NH_3, a gas. If high levels of NH_3 are a concern have the manure tested with a pH meter. There are many products on the market that cause the pH to drop to an acceptable level.

CH_4 is the most benign of all the manure gases in terms of toxicity. It could asphyxiate by displacing oxygen at levels greater than 500,000 ppm. This works out to 50% of the volume of the air would be CH_4, by comparison, H_2S at 0.1 % by volume is deadly on the first breath. The main danger with CH_4 is with explosions. CH_4 is one of the main constitutes of natural gas. CH_4 is odorless and has a specific gravity of 0.5 so, being lighter than air, it tends like NH_3 to be removed through ventilation as the gas is being produced. The main danger is when the gas accumulates over time in an unventilated room over manure storages and is exposed to a spark or flame. All such places should be opened up or constantly ventilated.

Improper exposure to manure gases can lead to injury or death of farm workers. By knowing each of their properties and the precautions to take, the hazards associated with them can be minimized. More information can be obtain from the Ontario Farm Safety Association in Guelph, (519) 823-5600, from the OMAFRA factsheet “Hazardous Gases” Order No. 99-001, Agdex 721 or from Canada Plan Service plan M-8710 “Manure Gas” by e-mailing “ john.johnson@omafra.gov.on.ca” or telephoning (519) 873-4096 and requesting the plan.

Space Requirements for Grow/Finisher Pigs

Harold W. Gonyou, PhD
Research Scientist - Ethology, Prairie Swine Centre

Introduction

Floor space allowance represents one of the clearest conflicts between animal welfare and production efficiency. Although it is evident that crowding results in a reduction in individual animal productivity (growth rate) and welfare, the fact that productivity per unit of area increases results in improved efficiency (cost/product). In establishing floor space allowance standards for the industry it is important to ensure that production efficiency is not unduly compromised while achieving acceptable levels of animal welfare. In addition to establishing acceptable standards, leaders in the industry must also address acceptable means of managing animals to achieve those standards as cost-effectively as possible.

Most studies on floor space allowance have been empirical in nature, establishing the productivity of animals under specific conditions, with little emphasis on extrapolation of the results to the range of practices reflected in the industry. The body of current knowledge is further limited by expressing space allowances in terms of area/pig rather than reflecting the change in requirements based on body weight. The use of an allometric expression of space allowance that reflects the relationship between required floor surface area and body weight over a wide range of pig size (Area = k x Body Weight$^{.667}$) has been developed and implemented rather recently (Petherick, 1983; Edwards et al., 1988; Gonyou and Stricklin, 1998). Even so, individual studies have failed to identify the point at which crowding begins to affect performance.

A series of analyses were conducted using data available in the literature to establish the critical k value, below which growth performance is limited by crowding. The application of these findings is discussed in terms of establishing acceptable standards for the industry and managing within those standards.

Requirements for growth

A model for predicting the effect of floor space allowance on productivity in pigs was developed based on the allometric relationship between body weight (BW) and surface area, and a modification of broken line analysis. Space allowance was expressed as k=A/BW$^{.667}$, where A is in m^2, and BW is in kg. It was hypothesized that productivity would be maximized at levels of k above a critical value, and that average daily gain (ADG) would decrease in a linear relationship with k at levels below that value. To test this hypothesis, data from 7 peer-reviewed articles that met the following criteria were analyzed: grower-finisher pigs, fully slatted floors, final k values could be determined, ADG for the final 2-4 weeks were reported, and treatments resulted in final k values both above and below 0.031. To standardize values across reports, ADG for all treatments within a study were indexed against a value of 100% assigned to the most spacious treatment. The resulting critical value for k was 0.0329, with a slope of 1053 (r^2=0.94). An additional three sets of data that met less stringent criteria were analyzed. Studies that only reported overall ADG, not restricted to the final 2-4 weeks, were included. For grower-finisher pigs on fully slatted floors, the critical k value was 0.0327, with a slope of 1067 (r^2=0.52). For grower-finisher pigs on partially slatted floors, the critical k value was 0.0337, with a slope of 696 (r^2=0.39). For nursery pigs, the critical k value was 0.0315, with a slope of 1018 (r^2=0.56) (Gonyou et al., 2004).

For a grow/finish facility in which the average weight of the pigs in a pen at first market is 100 kg, a k of 0.033 represents 7.12 m^2/pig. Reducing that to only 6.50 m^2/pig would limit growth during the final week by 4.5%.

Acceptable standards

Having determined a critical *k* value reflecting the average point at which crowding begins to affect productivity, a decision must be made to establish acceptable standards for the industry. This decision should take into account: the statistical reliability of the determined value; whether deviations from the average should be allowed to ensure animal welfare or production efficiency; and, if any reduction in productivity (animal welfare) can be allowed to accommodate improved efficiency.

More detailed analysis of the results is needed to establish the confidence interval about the mean value of *k* obtained. However, it should be recognized that some error is involved in establishing the critical *k* value, and a range of values may be accepted as being within our best statistical estimate. By selecting a value at the lower end of this range for our standard, we reduce space requirements and the effect of these standards on production efficiency. By selecting a value at the high end of this range, we ensure animal welfare and avoid crowding.

The final consideration in the decision to establish an acceptable standard is the degree, if any, that animal welfare may be compromised to minimize the effect of crowding on production efficiency. This decision should involve additional information on the effects of crowding on aspects of animal welfare other than productivity. Little information applicable to this approach to establishing space requirements is currently available. Based on production results alone, it must be decided if any reduction in growth can be tolerated, and if so, what degree of depression is acceptable (eg. 1, 3 or 5%). Although the industry may suggest a degree of depression that it finds acceptable, the ultimate decision will be made by our consumer; either the general public, wholesale and retail distributors, or packers.

In the end, an acceptable standard value for *k* will be established and included into any recommendation, production contract, or on-farm assessment program designed to ensure the welfare of pigs from nursery to market. The impact of various *k* values on the space requirements of pigs from 25 to 130 kg are presented in Table 1.

Managing within the standards

Once standards are determined, it becomes an issue of how to most efficiently manage production within those standards. Several possibilities exist in marketing and fill management.

It is critical to know the average weight of pigs in a pen when the first animals are removed for market. In a typical production unit marketing heavy pigs (125 kg), the first 'pull' is likely to occur when the pen average is approximately 110 kg. The difference between the 'market' weight and average weight is dependent upon the proportion of pigs removed (the larger the proportion, the smaller the difference) and the variation in pig weights (the greater the variation, the larger the difference). By managing your operation to market a smaller proportion of pigs in the first pull, you can reduce the space requirement.

It is also possible to market your first pull at a lighter weight, perhaps under a different pricing grid. By reducing the market weight by 5 kg, the average weight of the animals in the pen at the first pull is also reduced, and a space savings of approximately 3% can be realized.

Many operations currently manage the 'unused' space that exists in finisher barns when small pigs first enter by double-stocking. It is important to identify at what weight these extra pigs will have to be removed to meet the floor space allowance standards. In a finishing barn with an average pig weight of 110 kg at first market, a floor space allowance of 0.759 m^2/pig is a likely standard (k=0.033). Assuming a true double-stock, that is, twice as many pigs enter the barn as are present for finishing, each weaner pig has 0.379 m^2/pig. This is sufficient space until the pigs average 39

kg. Alternatively, if the barn is stocked at 1.5 times finishing capacity, each pig initially has .506 m^2/pig, which is adequate up to 60 kg.

Conclusions

Floor space allowance will be a key issue in establishing any animal welfare assurance program. It is important that the industry be prepared to defend their suggested standards, and to negotiate such standards in terms of risk to animal welfare and economic efficiency. Once standards are established, producers will have several options to manage their barns to improve the efficiency of their space use. The average weight of all pigs in the pen at first marketing, rather than the weight of those marketed, is the basis for determining floor space requirements.

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Table 1: Floor space requirements for pigs from 25 to 130 kg using *k* values of 0.032 to 0.034.

Pig weight (kg)	Floor space allowance (m^2/pig)		
	k=0.032	*k*=0.033	*k*=0.034
25	0.273	0.282	0.291
35	0.343	0.354	0.364
45	0.405	0.418	0.431
55	0.463	0.478	0.492
65	0.518	0.534	0.550
75	0.570	0.588	0.606
85	0.620	0.639	0.658
95	0.667	0.688	0.709
105	0.713	0.736	0.758
110	0.736	0.759	0.782
115	0.758	0.782	0.805
120	0.780	0.804	0.829
125	0.801	0.826	0.851
130	0.823	0.848	0.874

Area = k * Body weight$^{0.667}$, where Area is in m^2 and Body weight in kg.

Sow Body Condition and Herd Reproductive Performance

Barbara Straw*, Cate Dewey**
*E. Lansing, MI, **Guelph, Ont

There are numerous research trials in the literature that correlate weight and backfat depths with reproductive performance. Researchers intentionally fed groups of sows to predetermined weights or backfat depths and then compared performance in order to develop feeding guidelines for practical use. These studies form the basis of our feeding programs for sows. Below are listed the highlights of the research findings:

Weight at mating and reproductive performance

- Levis (1997) 7 studies: sow longevity and reproductive performance not affected by live weight, backfat or age of gilt at 1st mating; but 3 studies where increased age/backfat did enhance longevity and performance
- Swan (1998) gilts mated at 280-350 lb and 18-22 mm BF produced 3 more piglets over 5 parities compared to gilts < 260 lb and < 14 mm at mating
- Second parity litter size depression (Clark 1986)

Late gestation feeding level

- Common practice to increase feed in late gestation in order to increase birth weights
- At 4 lb/da (6 Mcal) there is no benefit (Pluske '95, Close & Mullen '96, Aherne 98, Neil '95)
- Extra feed may reduce the amount of parenchymal tissue in the mammary gland and reduce milk production (Weldon 1991)
- Really thin sows see some benefit

Gestation feed level

- High feed intake in gestation reduces intake during lactation (Weldon & Lewis 1990)
  Greater weight loss
  Poorer reproductive performance

Body Condition at Farrowing

- Thin sows at farrowing produce lighter piglets
- Hulten et al 1993: sows w/ 18.8 mm BF at farrowing produced heavier piglets than 12.9 mm sows
- Klaver 1981: thin sows (360 lb) produced 13% less milk than 440 lb sows
- Overly fat sows are more likely to lay on piglets

Lactation weight loss

- Sows, especially 1st parity that have excessive weight loss during lactation have
  Increased weaning to estrus interval
  Decreased conception rates
  Reduced embryo survival
  Increased culling due to the above
  Aherne et al 1998, Aherne & Williams 1992, Everts 1994, Foxcroft et al 1995, Close & Mullen 1996, Edwards 1996

Pattern of backfat depth by stage of production

- Gradual increase during gestation ~ 2 mm
- Decrease during lactation ~ 2-3 mm

Pattern of backfat depth by parity from literature

- No change across parities
- Decrease in backfat with increasing parity especially from P1 to P3

Variation in backfat depths: sample size

- Standard deviation of BF is 4 mm
- To determine the mean BF of a group of sows within 10% of the actual BF requires testing 30 animals

Backfat was measured on sows in 18 herds between June and September 1999. Herds ranged in size from 310 to 2,770 sows. Thirteen of the herds had PIC breeding stock and 5 of the herds had Monsanto Choice Genetics. All used confinement housing and gestation stalls with an automatic drop feeding system. Backfat measurements were made on one or two days, usually Wednesday, or Tuesday and Wednesday. On farms with less than 500 sows, an attempt was made to measure all sows. On larger farms at least 400 animals were measured according to the following protocol: All sows in the farrowing rooms, all sows in the re-breeding area and approximately every second or third sow in gestation as needed to total at least 400 animals. Each sow's parity and day of gestation or lactation were recorded from their sow cards. For data analysis, the production cycle was broken into 9 stages.

Clinical observations during data collection All farms used automatic feeders with individual adjustable hoppers in gestation. While the capability existed to adjust feed allowance for individuals, it was not being done. On all of the farms the hoppers were set at either 2 or 4 lbs depending on whether they fed once or twice a day. During the process of measuring backfat, if a particularly fat or thin animal was identified, the setting on that sow's hopper was checked and it was never different than for other sows on the farm. A few farms increased feed just prior to farrowing and in these herds the hopper settings reflected that an entire group of sows was being fed more.

All farms hand fed in lactation. Researchers usually arrived at the farm at 9 or 10 am and the first animals measured were those in the farrowing rooms. At 10 am nearly all of the sows in the farrowing rooms had emptied their feeders. Sows were easily encouraged to stand for backfat measuring by adding a couple handfuls of feed to their feeders. The fact that offering feed was highly effective in getting sows to stand up indicated that sows were not being fed to appetite.

Backfat measurements on individual sows ranged from 2.5 to 42 mm. Within a herd for any one stage of production the standard deviation of backfat was about 4 mm, which was comparable to values given in the literature. Backfat measurements for each herd were plotted on a graph by parity and stage of production. Examination of these graphs revealed: 1) the overall depth of backfat in this herd compared to other herds, 2) the trend in backfat with advancing parities and 3) the extent of gain or loss within the production cycle, especially late gestation gain and lactation loss.

Overall depth of backfat in this herd compared to other herds The four fattest herds had mean gestation backfat depths of 18.8 to 20 mm, compared to 13.8 to 14.8 mm in the 3 thinnest herds.

Trend in backfat with advancing parities For each herd, mean gestation backfat (the mean of the four quarters of gestation) was calculated for each parity and plotted. Similar to what has been reported in the literature, some of our herds ("constant BF") showed no decrease in backfat with increasing parity while in others backfat of sows decreased for successive parities ("decreasing BF"). Three herds fit neither pattern. In the decreasing BF herds, the decrease was most noticeable through the first 3 parities and then tended to level out.

Gain or loss within the production cycle In many of the higher backfat herds sows gradually gained backfat throughout gestation and then lost an equivalent amount during lactation. This gain and loss was particularly noticeable in herds that provided additional feed during the last few weeks of gestation. The lower backfat herds tended not to loose as much backfat during lactation.

Gilts Between herds, backfat measurements of gilts in the first quarter of pregnancy ranged from 14 to 22 mm.

Associations with reproductive performance

Various measures of sow longevity and reproductive performance were evaluated with respect to backfat data from the herds (Table 1). Regression and categorical comparisons were performed.

Table 1. Outcomes examined by sow condition.

Sow Longevity	Reproductive Performance
Mean parity in the herd	Litter size
Percent gilt litters	Pre-weaning mortality
Culling rate	Days from weaning to estrus
Mortality rate	Percent sows in estrus within 1 week after weaning
	Conception rate
	Farrowing rate

There was no association between mean backfat measurement at any stage of production and sow longevity or reproductive performance. Similarly backfat loss during lactation was not associated with sow longevity or reproductive performance. Herds with constant backfat did not differ from herds with decreasing backfat in either sow longevity or reproductive performance.

On a herd basis we had same findings as reported in the literature for individuals within the same herd in three areas:

- Weight at mating and reproductive performance
  In our study, sow longevity and reproductive performance were not affected by live weight, backfat or age of gilt at 1st mating, which was similar to 7 of 10 studies.
- Variation in backfat depths: sample size
  Standard deviation of BF is 4 mm
- Additional feed in late gestation
  Not a difference in piglet survival
- Gestation feed level
  Fat sows in gestation have reduced intake during lactation
  Greater weight loss
- Pattern of backfat depth by parity from literature
  No change across parities
  Decrease in backfat with increasing parity especially from P1 to P3

However, on a herd basis we did not observe the same findings as reported in the literature for individuals within the same herd for may other parameters:

- Body Condition at Farrowing
  We found no difference in baby pig survival between herds with fat and thin sows at the time of farrowing
- Body condition at any stage of the production cycle
  No association with any measure of longevity or reproductive performance
- Lactation weight loss: Herds with higher lactation backfat loss did not have
  Increased weaning to estrus interval
  Decreased conception rates
  Increased culling

Reasons why on a herd basis our results may have differed from those reported in the literature:

- The range of backfat depths between our herds was not as extreme as the range of backfat depths between individuals created by researchers.
- In the field situation, sows were able to compensate for low/high feed intakes in gestation whereas in research trials, feed intake was controlled.
- Reproductive performance is probably affected to a much greater extent by management than nutrition. In research trials where management and housing are the same for all animals, it may be easier to detect a small different in performance due to nutrition.

Practical application

- Do not breed gilts before they reach 18 mm backfat, but do not exceed an average of 20 mm.
- Maintain an average backfat of 16-18 mm in gestation.
- On the low end check nutrient density and hopper settings.
- On the high end you are wasting feed
- Feed to appetite in farrowing

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Pigs and People Have Many Things in Common, Including a Few Diseases

Z. Poljak, T. Rosendal, R. Friendship, C. Dewey, B. Ciebin
Dept. of Population Medicine, University of Guelph

Introduction

In the past meetings we have reported the presence of various pathogens that can be harboured by pigs and under certain circumstances infect people and cause disease. Often these organisms do not cause illness in pigs and may go undetected on most farms. In the last two years we have reported finding *E. coli* O157:H7 and *Salmonella sp* in the feces of pigs as well as detection of antibodies to Swine Influenza virus and *Toxoplasma gondii*. In this paper we will focus primarily on *Yersinia enterocolitica*, a human pathogen often linked to the contact with pork.

Yersinia enterocolitica infection in people and pigs

Yersinia enterocolitica are bacteria that can be found in samples from different animal species and the environment. They are not a unique organism and can be divided according to different biological properties into several different serogroups and biotypes. Both serogrouping and biotyping are used for the purpose of classification of these bacteria.

Only certain bio/serotypes are known to cause illness in people, and these specific types are frequently found in samples from pigs. This correlation as well as frequent tracing of the infection in people back to preparation or consumption of pig products is the basis of today's belief that pork is the main source of infection with *Yersinia enterocolitica* in people. Symptoms in people depend on age and other characteristics, and serotype of bacteria. Usually, disease occurs in the form of gastrointestinal symptoms, with diarrhoea (watery or bloody) as the dominant sign. Occasionally, even more serious forms are recorded with fatalities, especially where infection with serogroup O:8 is present.

Serogroups O:3 and O:9 usually do not have such an impact in the intestines but their virulence could increase under some conditions. In Ontario during the period from 1997 until 2001 the reported incidence of *Yersinia enterocolitica* infection was 3.0 cases per 100,000 per year. The highest incidence was in the age group between 0-4 years of age with 14.4 cases per 100,000 per year. Of those cases that identified food as a source of infection - 73% of cases identified pork as a source. In pigs infection is usually asymptotic and does not cause production problems but occasionally, bacteria are isolated from pigs with diarrhoea.

Prevalence of *Yersinia enterocolitica* at the pig and farm level.

As a part of Ontario Sentinel Herd Project we submitted 15 fecal samples taken from animals and 1 environmental sample collected from different places in the pen for testing for *Yersinia enterocolitica.*

Fourteen farms out of 92 tested had positive pigs in 2001. Similarly 13 farms out of 78 had at least 1 positive pig sample in 2002 (Table 1). Four farms were positive both in 2001 and 2002.

Within-herd distribution varied from 1 positive animal up to 11 out of 15 tested, with overall prevalence of shedding of 1.67% and 3.08% in 2001 and 2002, respectively (Table 2). Farms were less likely to be positive by sampling from environment, and in environment there were proportionally more strains that were human non-pathogenic.

All farms that were repeatedly positive on subsequent sampling were positive for the same serotype. Out of 4 farms, 1 was repeatedly positive for O:5, 27 and 3 were repeatedly positive for O:3. One pig was positive for mixed infection with O:3 and O:5,27 in 2001.

Table 1. Farm level prevalence on the basis of shedding and environment.

Serotype	Animals		Environment	
	2001	2002	2001	2002
1A, O Untypable	-	-	-	1
1A, O:7,8	-	-	-	1
1A, O:34	-	-	1	-
2, O:5,27	4	2	-	-
4, O:3	9	10	1	3
4, O:3 and 2, O:5,27	1	1	-	-
4, O:7,8 and 1, O:7,8	-	-	-	1
Negative	78	65	90	72
Farm level prevalence (%)	15.2	16.7	2.2	7.7

Table 2. Prevalence of fecal shedding and distribution of serotypes in 2001 and 2002.

Serotype	2001	2002
2, O:5,27	7	13
4, O:3	15	23
4, O:3 and 2, O:5,27	1	0
NEGATIVE	1358	1134
Prevalence	1.67%	3.08%

Additionally, in 2002 one farm had both of those strains cultured from 2 different pigs. Preliminary results of analysis done at the pig level indicated several management practices as potential risk or protective factors. Those variables belong to the category of either flow or hygiene. All-in/ all-out by room or barn flow for the nursery phase, using disinfectant and/or detergent and using more barns as a source for finisher pigs were all protective factors. Continuous flow of the pigs in the finisher barn was a putative factor in these analyses. Once accounted for, similarity of pigs within farm, and similarity of farms over repeated years of sampling, only multiple source of finisher pigs was left as significant and a protective factor. This however might be only a reflection of the higher standard of hygiene on these farms. Additionally, the duration of shedding of *Y. enterocolitica* differs. It could be as short as 10 days but also as long as 30 weeks. So it might be that we missed some pigs that shed before but did not shed at the time of sampling. These pigs could still carry bacteria and act as a potential source of infection for people or a source of cross-contamination in the abattoir. Finally, results of the preliminary analysis serve primarily for the purpose of detecting what kind of management practices are likely to contribute to the problem and as a guideline for more analytical type of studies.

In conclusion, the most important findings of this study is that *Yesinia enterocolitica* serotypes associated with food borne illness in humans was isolated in Ontario pig farms and that the presence of this disease organism warrants further investigation.

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The Enviropig™: The Next Steps in This Technology for Swine Producers

John M. Kelly [*], Cecil W. Forsberg[**], Serguei P. Golovan[+], Ayodele Ajakaiye[+], John P. Phillips[#], Roy G. Meidinger[#], Ming Fan[+], and Roger R. Hacker[+]

[*]MaRS Landing, Medical and Related Sciences, Guelph, Ontario, Canada [**]Department of Microbiology, [#]Department of Molecular Biology and Genetics, [+]Department of Animal and Poultry Science

In an effort to address the environmental issues surrounding pork production, researchers at the University of Guelph developed a technology which has the potential to revolutionize the pork industry. A key element in environmental stewardship is phosphorus, which has direct impact on the eutrophication of water courses, leading to algal growth and potential for negative impact on water quality and fish survivability. Pigs do not have the ability to digest phosphorus which is bound in the phytate form. This is the most common form of phosphorus in plants which make up the bulk of the feed for pigs. Phytase is an enzyme which breaks the bond between phytate and the phosphorus, thereby freeing up the phosphorus for absorption by the pig. Current practices allow for the addition of phytase to the swine ration, which results in approximately 30% of the phosphorus being liberated for use by the pig. This amount of phosphorus released is not enough to meet the nutritional requirement of the pig, so that either inorganic phosphorus or phytase must be added to the diet to increase available phosphorus.

The Enviropig™ offers the market a key technology in the positioning of swine production with regards to phosphorus pollution from pig operations. It is leading edge technology with benefits to the producer, consumer, environment and the public at large.
The Enviropig is a Yorkshire pig which has been modified such that it can produce phytase itself in its salivary glands, thereby eliminating the need for supplemental phytase. This in itself has several advantages for Ontario swine producers. This technology is friendly to the environment, in that there is a reduction in phosphorus excretion in the manure by greater than 60%.

The strategic path forward for the Enviropig includes completion of experimentation to address regulatory requirements for this technology, as well as development of the business and marketing program for global distribution of the technology. Acquiring regulatory approval in Canada and the United States is certainly key to this program. The lead agency for this technology in Canada is Environment Canada, with Health Canada and the Canadian Food Inspection Agency also having specific requirements. The United States Food and Drug Administration is responsible for this type of technology south of the border. The US FDA also requires for technologies to be submitted and evaluated that they must have a US-based agent.

The Enviropig is not currently available on the market, but features and benefits of the technology are readily apparent (Table 1).

Table 1. ENVIROPIG™ FEATURES AND BENEFITS

FEATURES	BENEFITS
1. Advanced technology	• State of the art enhanced swine production • Industry leading technology
2. Proven technology	• In development for 7 years • Independent University of Guelph technology • Effective in all successive generations
3. Friendly to the environment	• Reduce phosphate output from pigs by greater than 60%! • Phosphorus is the key nutrient involved in water course pollution and eutrophication
4. Reduces Costs of Production	• Eliminates the need for supplemental phytase in the ration • Eliminates the need for supplemental phosphorus in the ration
5. Nutrition Friendly	• Allows for further nutrition additives for optimal swine growth (eg added probiotics or amino acids)
6. Nutrient Management Friendly	• Allows producers to effectively meet government nutrient management regulations head on! • Effective at reducing the impact of swine manure on land requirements
7. Information can be easily added to Nutrition Formulation Software	• Monitors entire phosphorus process utilization effectively • Minimizes operator intervention
8. Balance Ca:P Cost Effectively	• Two nutrients critically required for growth • Meet phosphorus demands from grain-sourced phosphorus
9. Equivalent optimal growth	• Experiments have shown no impact on growth rate
10. No impact on reproductive characteristics	• No change in numbers of live born, still births or mummies compared to controls • No change in number of piglets weaned compared to controls
11. Keep swine producing regions competitive	• Reduce the exit of swine operations from traditional swine production regions

Environmental Assessment of On-Farm Dead Stock Cremation Units

B. Van Heyst, School of Engineering
University of Guelph, Guelph, ON, N1G 2W1
tel: 519-824-4120 ext. 53665, fax: 519-836-0227
bvanheys@uoguelph.ca

Introduction

Under the current Dead Animal Disposal Act (DADA) in Ontario, pork producers are limited in their on-farm mortality disposal methods to: pickup by a licensed dead stock collector, burial under 60 cm of soil, or composting of the carcass. Recently, rendering facilities have stopped accepting carcasses that cannot be guaranteed free of sulphur-based drugs. Although the rendering facilities have started to re-accept these carcasses, there is no guarantee that they will continue to do so for any extended time period. Ontario swine farmers thus face more restrictive approved methods to properly dispose of their dead stock than some other commodity producing groups.

To determine the extent to which on-farm cremation is being used in Ontario as a dead stock disposal method, a targeted questionnaire was mailed, in the spring of 2003, to farmers who use small incinerators. Approximately 160 questionnaires were mailed out with 49 questionnaires returned. Of the responses, over half came from swine producers (see Figure 1) in spite of the fact that cremation is not a legally sanctioned method under the DADA for disposing of swine carcasses.

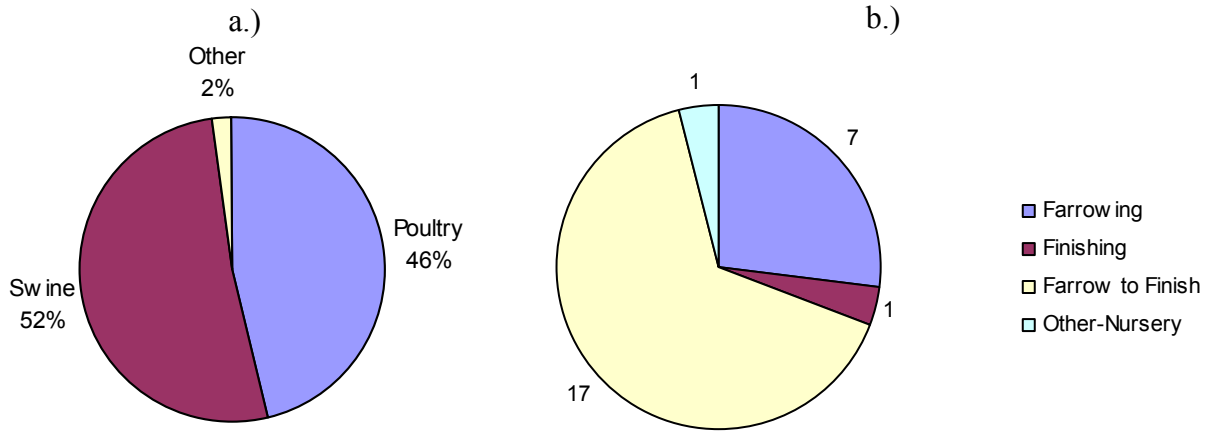

Figure 1. Panel a.) Distribution of commercial on-farm cremation units between commodity groups and Panel b.) distribution of on-farm cremation units for different swine producers as of spring of 2003.

Environmental Characterization of Small On-Farm Cremation Units

Before provincial regulators will endorse on-farm cremation as a legal disposal method, the technology has to be subjected to a full environmental characterization study that not only looks at the pollutants being released to the air but also any pollutants that are concentrated in the ash. To this end, two commercially available cremation units were tested in the fall of 2003 at the University of Guelph. Both units were equipped with a secondary combustion chamber or afterburner. For each unit, two different animal species (swine and poultry) were used and, for each species, triplicate experiments were conducted to determine the level of variability in the data. The

experimental overview is given in Table 1. Note that the fuel consumption data are low on the last two tests on Unit #1 due to a malfunction with the fuel flow meters.

Table 1. Summary of Cremation Unit Tests.

Test Number	Date	Primary Burner Start Time	Species	Initial Weight (kg)	Final Weight (kg)	% Initial Mass Remaining	Fuel Consumed (litres)	Burn Duration - Primary (hrs)
U1-P-01	Sep 24/03	10:52	Poultry	185.1	6.4	3.4	134.2	5.1
U1-P-02	Sep 25/03	10:45	Poultry	210.9	6.8	3.2	106.2	5
U1-P-03	Sep 26/03	10:55	Poultry	200.5	5.2	2.6	125.3	5.2
U1-S-01	Sep 28/03	10:20	Swine	239.0	6.1	2.6	145.8	6
U1-S-02	Sep 29/03	10:07	Swine	190.5	5.4	2.9	82.1	5.8
U1-S-03	Sep 30/03	10:15	Swine	214.6	6.1	2.9	55.8	6.1
U2-P-01	Nov 27/03	9:55	Poultry	180.1	18.8	10.5	68.0	7.5
U2-P-02	Nov 28/03	9:35	Poultry	183.3	10.7	5.8	84.4	9
U2-P-03	Nov 29/03	10:37	Poultry	144.2	6.4	4.4	77.0	8.25
U2-S-01	Dec 01/03	9:22	Swine	146.5	5.9	4.0	86.0	8.5
U2-S-02	Dec 02/03	9:10	Swine	193.2	5.9	3.1	65.4	8.75
U2-S-03	Dec 03/03	9:00	Swine	205.0	7.0	3.4	68.6	9

- fuel flow metre malfunction

For each test, approved methods were used to sample the flue gas leaving the cremation unit for particulate matter, heavy metals, carbon monoxide, sulphur dioxide, oxides of nitrogen, acid gases, volatile organic compounds (VOCs), and semi-volatile organic compounds (SVOCs) (for example, dioxins and furans). Samples of ash were also collected for analysis of heavy metals and semi-volatile organic compounds as well as to determine the toxic leachate potential. Due to the long laboratory turnaround time associated with some of the required lab analyses, results are not expected to be back from the labs until February or March , 2004.

Figure 2. Before and after the cremation process pictures for Test #U2-S-01.

Determining Timing of Ovulation in Sows for Successful Artificial Insemination.

Glen Cassar DVM, PhD [1]; Roy N. Kirkwoood DVM, PhD[2] ;
Kristina Bennett-Steward, BSc, DVM [3]; Robert M. Friendship DVM, MSc, Diplomate ABVP[1]

[1]Department of Population Medicine, Ontario Veterinary College, University of Guelph, Guelph, ON N1G 2W1; [2]Department of Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University; [3]Bioniche Animal Health 231 Dundas St. E., Belleville, ON K8N 5J2

Artificial insemination (AI) has gained widespread acceptance in the swine industry. With intensification of swine production, AI offers producers the opportunity to improve their financial competitiveness. Among sows, there is a great variation in the duration of estrus (24 to 108 hours) and consequently also in the estrus-to-ovulation interval. This presents a challenge in determining a reliable AI schedule. The lifespan of eggs after ovulation and the lifespan of a sufficient number of sperm cells capable of fertilization within the oviduct define the time during which inseminations can lead to successful fertilization relative to ovulation. The use of exogenous pharmaceutical products for the synchronization of estrus and ovulation would allow for the development of intensive methods of estrus detection and the determination of the appropriate timing of successful AI.

In weaned sows, the most common protocol for the induction of estrus and ovulation is the injection of a combination of 400 IU of equine chorionic gonadotrophin (eCG) and 200 IU of human chorionic gonadotrophin (hCG) (PG600). While efficacious for estrus induction, injection of PG600 does not permit an accurate timing of ovulation. By inducing an earlier onset of estrus with either PG600 or eCG, the mean estrus onset-to-ovulation interval will increase, making the prediction of time of ovulation more difficult. However, because gonadotrophin treatment results in a sow population having a longer estrus onset-to-ovulation interval, this knowledge can be used in a protocol of induced ovulation to allow a more precise timing of insemination relative to ovulation.

It is known that ovulation will occur at about 42 hours after hCG injection. When ovulation is induced using gonadotrophin releasing hormone GnRH or porcine luteinizing hormone (pLH), the interval from injection to ovulation will be 36 to 38 hours. Therefore, if sows are expected to ovulate at greater than 36 hours after estrus detection, the induction of ovulation using pLH followed by a fixed-timed artificial insemination becomes commercially feasible. Optimal sow fertility is achieved by insemination of fresh extended semen during the 24-hour period before ovulation. If time of ovulation can be accurately predicted, breeding management becomes relatively simple. The objective of this study was to determine the time of ovulation in weaned sows treated with pregnant mare serum gonadotrophin PMSG (or equine chrionic gonadotrophin (eCG)) at weaning and pLH (Lutropin-V®) 80 hours later. Following this pilot study, a larger study is underway to investigate the reproductive response of sows treated with or without PMSG and pLH and timed insemination, and to a single insemination.

Materials and methods

A pilot trial was performed with 17 mixed parity sows administered 600 IU PMSG (Novormon ®) at weaning and 5 mg pLH (Lutropin-V®) 80 hours later. The approximate time of ovulation following pLH injection was determined using transrectal real-time ultrasonography (RTUS) for visualisation of the ovaries. Starting at 16 hours after estrus detection RTUS was performed every 8 hours. Then, from 32 hours after pLH injection, RTUS was performed at 2 to 4 hour intervals until ovulation was complete. Ovulation was considered to be complete when there were fewer than four follicles of >6.5 mm diameter remaining on the ovaries. The time of ovulation was documented.

Following the pilot study, 500 mixed parity sows will be assigned on the basis of number of piglets weaned and parity to the following treatments:

Treatment 1: 600 IU PMSG at weaning and am and pm inseminations on day 5 after weaning (n = 100).
Treatment 2: 600 IU PMSG at weaning, 5 mg pLH 80h later and 2 inseminations at 36 and 44 h after pLH (corresponds to am/pm on day 5) (n = 100).
Treatment 3: No PMSG, 5 mg pLH at 80h after weaning and 2 inseminations at 36 and 44 h after pLH (corresponds to am/pm on day 5) (n = 100).
Treatment 4 (control): No hormone treatments and am and pm inseminations on day 5 after weaning (n = 100).
Treatment 5: 600 IU PMSG at weaning, 5 mg pLH 80h later and a single insemination at 36 h after pLH (am on day 5) (n = 100).

In treatments 1 to 4, inseminations will only be done for sows in standing heat, and sows not in estrus by day 5 after weaning will be excluded from the study, but will be recorded. Sows in treatment 5 will be inseminated 36 h after pLH regardless of estrus status. Pooled semen from two proven boars will be used for AI. Each insemination will contain not less than 3 X 10^9 viable sperm.

Data to be recorded for each sow are pre-treatment litter size suckled, lactation length, wean-estrus interval, duration of estrus, estrus to ovulation interval, service outcome (whether or not the sow farrowed to the first service), and subsequent litter size (total born and numbers born alive).

Results

The pilot study was conducted on a 700-sow farrow-to-feeder pig operation. The mean parity of sows on the study was 7.5, with 5 sows of parity 1 to 5, 4 sows of parity 4 to 8 and 8 sows with parities greater than 8. The time from pLH treatment to ovulation ranged from 34 h 16 min to 42h 30 min. The mean was 38h 11 min. We conclude from this initial trial that ovulation was controlled and predictable using this treatment regimen. Single insemination may be a feasible alternative when the time of ovulation is known. Preliminary results of the larger study will be presented at the 2004 Centralia Swine Research Update meeting.

Acknowledgements

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Boar Sperm Hate Summer Heat

Mary M Buhr* and D. Sibblies
Department of Animal and Poultry Science
University of Guelph
*Tel: 519-824-4120 ext 56377; email mbuhr@uoguelph.ca; fax: 5190767-0573

Introduction

Artificial insemination (AI), using semen from commercial and on-farm boar centres, serves over 70% of all swine breedings in Ontario. AI gives more offspring from our best sires, provides excellent pregnancy rates and litter size, reduces inbreeding and has low health risks. Because fewer males breed all the females, semen must be consistently available and of uniformly excellent quality. Pregnancy rates typically drop for 2-6 weeks in very late summer/early fall, and companies producing boar semen may discard twice as much semen due to poor quality. Late summer's hot spells are generally assumed to be affecting the sows and gilts as well as the boars, but seasonal factors (e.g. daylength, feed) are also changing and could contribute to the problem. Heat stress studies on boars done 20-30 years ago found various types of sperm damage, but the studies were limited in scope and our modern lean fast-growing pig may be more, less or differently susceptible. We do not know longevity of the damage nor impact on fertilising ability of the sperm. A heat spell might reduce semen doses produced, conception rate and/or litter size by 5-10% for 4-6 weeks, or by 2% for two weeks, or permanently damage certain boars. We wanted to clearly identify the impact of high environmental temperatures on boar semen production, specifying precisely how heat waves affect semen production, and for how long. Clearly spelling out the costs of heat-induced semen damage will help producers to determine the cost-benefit ratio of installing building cooling devices. These findings will become even more relevant if the predictions of global warming and increasingly frequent weather extremes come to pass.

Procedures

Boars 7-8 months old were trained for semen collection and then held in an environmental chamber at 60% humidity and 12 hours light: 12 hours dark for 10 days. For the "Heat" group, temperatures were 34°C for 8 hours and 31°C for 16 hours daily. The "Control" boars were treated identically except that temperatures were 24 and 21°C. After 10 days in the environmental chamber, all boars were housed at 24°C. Semen was evaluated before boars went into the chamber and for six weeks after, testing semen volume, sperm concentration and sperm quality both immediately after collection and after 3 days in a commercial extender. We have completed two Heat groups and two Control groups so far. We have to test one more group of each, and we still have much data still to analyse from the groups that have been done.

Results

The heat treatment was devastating to the boars' reproductive ability, with the first problems becoming noticeable anywhere from two days to several weeks after the heat treatment.

Two boars completely lost interest in sex, showing no interest in the collecting dummy, and one of these never regained interest. Sperm concentration plummeted in all other boars starting one week after the hot spell, declining to essentially zero for periods ranging from one to four weeks, depending on the boar. None of the heat-treated boars had fully recovered their sperm concentration by six weeks after the heat treatment. In addition, of those sperm that were produced, fewer were alive. This decline in the percent of live sperm started one to two weeks after the heat treatment,

lasted for two to five weeks, and had recovered by six weeks. Heat did not affect semen volume. The motility of the sperm was also affected; analysis of this data is still underway.

Conclusions

Although the work is not complete, it is already very clear that temperatures equivalent to an extreme August heat wave, or to tropical swine production, greatly harm the sperm produced by boars. When the project is complete, we will be able to give very precise information as to the type of damage and how long it lasts, and advise producers as to the financial impact of such weather.

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Sick Pig Behaviour

Suzanne T. Millman
Department of Population Medicine, University of Guelph, Guelph, ON, N1G 2W1
Email: smillman@ovc.uoguelph.ca

Livestock producers, in Ontario and elsewhere, are under pressure to respond to public concerns about animal welfare and on-farm antimicrobial use. Understanding mechanisms by which pigs respond to states of illness provides oppportunity to better manage, treat and prevention disease. Hence, investigation into relationships between behaviour and disease is timely and necessary. In acute states of illness, animals display overt behavioural changes such as lethargy, anorexia, increased thermoregulatory behaviour, increased slow-wave sleep, increased sensitivity to pain, avoidance of social contact and reduced exploratory behaviour. Rather than being a consequence of disease, there is increasing evidence that these behavioural changes are necessary to mount a fever and represent an evolved strategy by which animals combat disease.
Currently, little information exists to help swine producers make decisions about management of ill pigs, or about when euthanasia would be appropriate. My research program explores behavioural needs of ill pigs, and how ill pigs might be able to meet these needs in current commercial environments.

Since social stress has been shown to increase shedding of *Salmonella typhimurium* by early-weaned piglets (Callaway *et al.,* 2002), behavioural responses to illness by individuals and by groups is warranted. Weaning is a critical phase for piglets due to stressors associated with changes in diet, social and physical environments. Prior to weaning, behaviour of piglets is coordinated by the hourly nursing bouts, which sets the rhythm for feeding, resting and drinking activity (Fraser, 1980). Hence, in the absence of the sow, piglets may not be able to meet their behavioural needs. Greater understanding of the behavioural needs of piglets will facilitate manage to increase the survivability and performance of ill and “at risk” newly weaned pigs. The objective of this research project was to determine if piglets would benefit from intermittent lighting programs at weaning.

First, we needed to determine the amount of rest piglets typically obtain prior to weaning, so that an appropriate lighting regimen could be developed. Behaviour patterns by groups of piglets were examined during the week prior to weaning and the week following (days 14-20, 21-28). Eight litters of piglets were observed, with behaviour recorded using time-lapse video with frequencies and durations of resting and active periods analysed on a group basis. Preliminary results suggest that resting behaviour increased during the days following weaning, so that weaned piglets rested 85-90% of the time (20-21 hours per day) versus 60-65% (15-16 hours per day) when piglets were with the sow. It is interesting that during the week prior to weaning, piglets remained fairly consistent in their behaviour throughout the day and night periods. However, in the days post-weaning, active periods occurred almost exclusively during the hours when staff were active in the barn (7am-4pm). Since the piglets in our study remained in their farrowing crates at weaning and were not mixed with other litters, this increase in resting behaviour may represent a “behavioural need” resulting from stressors associated with changes in diet and social environment.

In the second phase of the study, we develop an intermittent lighting schedule to facilitate more frequent bouts of rest, activity and feeding during the transition of weaning. Groups of four piglets were formed at 21 days of age, when the piglets were weaned. Each group consisted of gender pairs involving the largest and smallest piglets from two litters. For example, the largest male and

smallest male from one litter were paired with the largest female and smallest female from a different litter. Half of the piglets received an intermittent lighting schedule so that the 24-hour period was broken into four 2L:4D blocks. The other half of the piglets received a 8L:16D light cycle. Behaviour was recorded using timelapse video, and on days 20, 24 and 28, piglets were weighed and fecal swabs collected. Analysis of behavioural and fecal microflora data are in progress, but preliminary results suggest that intermittent lighting improved the performance of unthrifty (small) piglets. Weight gain during Days 20-24 was 0.54 kg for piglets that received Intermittent lighting versus 0.39 kg for the control pigs. Differences were more pronounced for unthrifty piglets, who gained 0.64 kg and 0.44 kg in the Intermittent and Control groups respectively. Analysis of the behavioural and fecal microflora data will provide further information about what occurred as a result of Intermittent lighting to facilitate improved performance by the unthrifty piglets, and whether these differences set the stage for how unthrifty piglets will respond to disease challenges in the future.

In conclusion, preliminary results suggest that stresses associated with weaning result in an increased need for rest by piglets during the first few days following weaning, and that intermittent lighting programs may be helpful for newly weaned piglets, particularly those with low weaning weights, during this transition period. It is important to note that these results should be interpreted with caution until full analysis is completed.

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Composting Large Number of Dead Stock

Helmut Spieser, OMAF, Ridgetown Ontario
Phone: 519 674-1618 Fax: 519 674-1564 E-mail: helmut.spieser@omaf.gov.on.ca

When unexpected circumstances result in the loss of a whole herd of finishing pigs, producers want to clean out the barn as quickly as possible so that the dead animals can be dispatched and the barn cleaned and sanitized. Your normal method of dead stock management may not be adequate to handle these large animal numbers. Described below is the method used to compost about 1000 dead feeder pigs.

An electrical failure in late summer of 2003 resulted in the death of most of the feeder pigs in a 1000 head barn. With predicted temperatures to be in the 30's (ºC), time was of the essence. The farmer contacted his normal dead stock collector. The dead stock company could not pick up this large number of mortalities. The farm grows a variety of field crops as well as sugar beets and processing vegetables and is systematically tiled.

Reasons for Choosing the Composting Option

- Dead stock companies would not pick up the nearly 1000 dead feeder pigs
- Burial of this many pigs would take time, be costly and take up valuable field space
- Burial option is further complicated by the fact the farm is systematically tiled
- Recommendations for burial include a maximum of 1500 kg of beast per hole with at least 0.6 metres of soil cover. There should be 5 metres of undisturbed soil between adjacent holes or pits.
- Composting could be done quickly
- Composting could be done with a tractor and loader
- Composting could be done on grade and would be all gone when the finished compost pile had been spread on the field
- Spent mushroom compost was used as the substrate

Spent mushroom compost is the growing medium that is left after mushroom picking is finished. This material is pasteurized in the growing rooms before it is taken to outdoor storage piles. This compost is moist and therefore very dense. Wind and normal weathering will not move this material. It stays pretty much where you put it. This spent compost is readily available and reasonably priced. It is ideally suited for use in composting livestock mortalities.

The Recipe

- ✓ select a site for the compost pile that is not in a natural or man-made water course
- ✓ select a site that can sit undisturbed for sufficient time for the complete decomposition of the livestock mortalities inside the compost pile
- ✓ the 1000 dead feeder pigs were put in alternating layers separated by spent mushroom compost
- ✓ two trailer loads or 70 Tons of compost was used to build the compost pile
- ✓ an additional two trailer loads of compost, another 70 Tons, was used to cap the pile using a bark elevator (a cleated belt conveyor)
- ✓ final pile dimensions 15 m by 15 m by 4 metres high
- ✓ a leachate collection trench with a pump out was dug on the down-slope side of the completed compost pile

For larger compost piles, something more than a front-end loader will be required to place the last of the compost on the top of the pile. The old corn elevators would work for this job if you kept it after you stopped using corn cribs. Another alternative is to use a bark elevator or materials handling conveyor with a cleated belt.

Observations

- the pile has settled to about 1.75 metres high
- there has been no wildlife activity on or near the compost pile
- There has been no liquid in the leachate collection trench
- There have been no odours from the pile even though the pile is only 50 metres from the owner's house

Summary

The plan now is to leave the pile undisturbed for 12 months, then land apply the material onto cropland after harvest. The use of spent mushroom compost allowed the producer to get all the swine mortalities covered in one day. No further work has been necessary on the pile. With the composting option, there will be no evidence of this event after the compost has been spread and the site is reseeded.

It's interesting to note that what was done at this farm does not coincide with the recommendations for large scale composting. Yes, there was layering of the carcasses and mushroom compost, but it was not done in windrows and definitely not in multiple windrows.

Testing of Mechanical Liquid/Solid Manure Separators

Ron Fleming - Ridgetown College, University of Guelph
Prepared for: Centralia Swine Research Update, Jan. 28, 2004

This is the second portion of a 2-part study looking at mechanical separators for liquid manure. The first part (presented last year) summarized the various types of separators and discussed reasons for using separators. This report will look at some of the features of separators that should be considered if making a purchase.

We set out to develop a standard test procedure that could be used to measure the performance of separators. In the test, we used three different liquid manures – to represent different dry mater levels and different livestock types. We ran six separators through the test procedure. Following is a brief discussion of the measurements that should be made and reported by the manufacturer, in order for the buyer to be able to make comparisons between systems.

1. Separator Capacity

As expected, separator capacities in the test were quite variable and changed with the manure separated. The commercial version of the membrane filter system we evaluated was rated at 150 L/min. At the other end of the scale, the Maximizer units in our tests ranged from 300 to 600 L/min depending on the manure. In most cases, the capacity is highly dependent on the dry matter content of the manure. The livestock producer must decide if capacity is an issue or not. It may not be an issue as long as the unit can operate unattended.

2. Power Requirements

Mechanical separators rely on energy inputs. Therefore, it is important to know the volume of manure separated per unit of energy. In our tests, the reverse osmosis system handled 94 L manure per kW-h electricity. One of the systems separated over 10,000 L per kW-h electricity (though, of course, the effluent quality was different). One system relied on a diesel engine for power, and handled 1200 L manure per L fuel.

3. Particle Size Distribution

Not all manures are created equal. Besides having different dry matter concentrations, the sizes of the particles in the manure vary. Most separators have an easy time of removing large particles (for example, those trapped on a 50 mesh screen) but swine manure doesn't contain many large particles. It is important to know how small a manure particle can be removed by a system. This requires screening of the manure and effluent sample. If this data is not available, try to get test information for swine manure (as opposed to cattle manure), preferably based a feed program similar to what you use.

4. Removal of Solids

This is one of the most commonly quoted performance items. However, there are different ways of calculating this and it is important to know which was used. The most useful for a wide range of applications takes into account the flow rate through the system. The % of initial solids removed into the separated solids is calculated by dividing the "flow rate of DM in the separated solids" by the "flow rate of influent DM". This result ranged from about a 1% removal of solids (for a prototype rotating drum system) to 100% (for the reverse osmosis system).

5. Removal of Nutrients
A similar calculation should be used to find the amount of N or P (or other nutrient) removed into the separated solids. Most of the systems we tested removed less that 10% of the N and P into the solids (though it was 100% for the reverse osmosis system).

6. Removal of Bacteria
Most separators are not effective at removing bacteria from manure, nor do they generally claim to do so (a reverse osmosis system can accomplish this, however). Be careful of any claims about removing bacteria.

7. Labour Requirements
Most of the commercial systems are designed to operate with little or no supervision. Labour consists of the regular operation of the system, plus any routine maintenance, or unscheduled maintenance. Some systems are more robust that others. Also, some require flushing or washing that may not be automated.

8. Odour Levels
Odours from the separated solids appeared to be dependant on the moisture level of the solids after separation. The separators most effective in drying the solids were also the most effective in reducing or removing odours. Look for odour test data, if this is an important purchase consideration.

9. Economic Considerations
There is a considerable range of purchase prices of separators. Most are in the range $20,000 to $100,000 but it is also possible to pay $400,000 for a system. Of course, consider extra set-up costs – wiring, plumbing, providing shelter (if needed).

Further Information – For more background on the testing carried out at Ridgetown College (sponsored by Ontario Pork) refer to the report:
"Evaluation of Mechanical Liquid/Solid Manure Separators"
This report may be downloaded from the Ridgetown College web site:
http://www.ridgetownc.com/research/Subject/manure.cfm

Pigs Drink Separated Water From Liquid Manure

Jim Morris, Ron Fleming, Malcolm MacAlpine,
Ridgetown College, University of Guelph.

The efficacy of separated clean water from liquid swine manure as a source of drinking water for pigs was evaluated in a trial at Ridgetown College, University of Guelph.

To evaluate the impact of separated clean water as a source of drinking water on:

- Quality of water
- The growth performance of starter pigs
- The health status of starter pigs.

Water was recovered from liquid manure using the Vibratory Shearing Enhanced Processing (VSEP) unit. The VSEP was fitted with an reverse osmosis (RO) filter pack. The quality of the recovered water (permeate) was assessed and provided for drinking water to young pigs.

A study involving the 3 water treatments (regular barn water, half barn water and VSEP permeate, and VSEP permeate) was completed. A total of 54 pigs were allocated to 9 pens of 6 pigs each. All pens will be balanced for sex with 3 barrows and 3 gilts being allocated to each pen. The data collected include initial and weekly body weights, daily feed consumption and feed consumption on a pen basis. Mortalities and their causes were recorded. Morbidity of the pigs were assessed in several ways including their growth performance, frequency of treatment and the levels of feed consumption.

Results showed that the VSEP unit produced permeate (separated water) from liquid manure at a quality level acceptable to pigs. The data revealed that no performance or health effects resulted from providing the recovered water from liquid manure to young weaner pigs (12 - 26 kg liveweight).

Benefit of Research to the Ontario Pork Industry:
The ability to separate clean water and reuse it in the barn is important for water conservation considerations in livestock systems. The ability to extract water clean enough without the presence of pathogens potentially will produce a water quality good enough for drinking water to pigs. Such a capability would offer a tremendous benefit in reducing the amount of liquid spreading and to reduce the amount of water used in swine units and a

For further information visit the Ridgetown College Website at **www.ridgetownc.uoguelph.ca**

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Acknowledgments:
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Greenhouse Gas Mitigation Program for Canadian Agriculture

Cedric MacLeod
Canadian Pork Council

The issue of greenhouse gas emissions is receiving increased attention in the Canadian agricultural industry. Internationally, many scientists agree that the global climate is warming due to increasing atmospheric concentrations of greenhouse gases (GHG) such as carbon dioxide, methane and nitrous oxide. The Canadian agriculture industry has been identified as having a role to play in reducing the quantity of greenhouse gas produced, but also to absorb a portion of the gases created by other industrial processes.

The Greenhouse Gas Mitigation Program for Canadian Agriculture (GHGMP) was launched in April 2002, as a means of raising awareness within the ag-industry as to where GHGs are produced in the sector and options that exist for producers to curb these emissions. Increased awareness is being achieved through the development of demonstration farms across Canada featuring new and innovative technologies and practices that can be economically employed by the industry to reduce GHG emissions. A national communication strategy has also been developed to provide background information on the beneficial management practices (BMP) being demonstrated.

A partnership between four national agricultural industry groups: Soil Conservation Council of Canada, Dairy Farmers of Canada, Canadian Cattlemen's Association and the Canadian Pork Council has been formed to deliver the program. The inclusion of the four industry partners allows the program to be tailored specifically to individual commodity producers, as well as provide an opportunity for the entire sector to work together to find solutions for reducing GHG emissions.

The pork sector specific program is focusing on the following areas for GHG mitigation:

- Maximizing barn heat retention and climate control efficiency
- Maximizing feed use efficiency
- Use of wet/dry and/or liquid feeding systems
- Reducing manure nitrogen output: Reduced feed crude protein
- Manure storage covers: Reduce manure methane production
- Anaerobic digestion systems: Electricity generation with manure
- Maximizing manure nitrogen use efficiency:
    - Spring and in-crop manure application
    - Hog manure application in pasture and forage systems
    - Tailored application rates to crop requirements
    - Manure sampling and nutrient analysis
- Farm shelterbelt establishment

Numerous partnerships between the Canadian Pork Council and Canadian research and extension organizations have been established to deliver the demonstration component of the GHGMP. To date, these partners include:

- Atlantic Swine Research Partnership Ltd.
- Conseil pour le développement de l'agriculture du Québec
- Fédération des producteurs de porcs du Québec
- University of Guelph
- University of Manitoba
- DGH Engineering Ltd.
- Prairie Swine Center
- Alberta Pork

New projects are currently being developed to supplement the existing programs. Numerous new partnerships are being developed across Canada to increase the scope and reach of the GHGMP.

The GHG Mitigation Program is focused solely on the demonstration of technologies and increasing awareness of GHG related issues in the Canadian ag-sector. However, the facilitation of research, pertaining to production efficiencies and reducing the cost of production, has remained a high priority throughout the planning of this GHG program. Foe example, research on the effect of low crude protein diets on manure nitrogen excretion is currently being conducted alongside GHG mitigation demonstrations at the University of Guelph. It is thought that the inclusion of a demonstration component in research programming, will ensure a wider distribution of research knowledge to the Canadian pork producer community.

Much information is being compiled, and awareness of greenhouse gas production related to the Canadian agriculture sector is being generated through the Greenhouse Gas Mitigation Program. More detailed information about the GHG program being delivered by the Canadian Pork Council can be found online at:
http://www.cpc-ccp.com/envir/GHGMP.htm

For more information on specific projects, or to inquire about demonstration or communication venues in your local area contact the Canadian Pork Council or your provincial pork association office. Inquiries to the Canadian Pork Council should be directed to:

Cedric MacLeod, M.Sc.
Greenhouse Gas Mitigation Program Coordinator
75 rue Albert Street, Suite 907
Ottawa, Canada K1P 5E7
Tel.: (613) 236-0011
Fax: (613) 239-0619
E-mail: macleod@cpc-ccp.com

Demonstration of BMPs For Mitigating Greenhouse Gas From Swine Production Operations in Ontario

D. Barry, M.J. Goss, C. Wagner-Riddle, R. Fleming[1]
Department of Land Resource Science and [1]Ridgetown College, University of Guelph

Introduction

The Greenhouse Gas Mitigation Program of Agriculture and Agri-Food Canada aims to demonstrate technologies that can decrease greenhouse gas emissions from farms and have agronomic or other environmental benefits. In this program, the University of Guelph in cooperation with Ontario Pork and the Canadian Pork Council is operating a three year demonstration project of best management practices for liquid swine manure at Arkell Research Station and Ridgetown College. Self-guided tours and producer days will allow farmers to see the benefits of BMPs that reduce the impact of manure on the environment, particularly those that aim at reducing odours and greenhouse gases. The main demonstrations are described below.

Diets to Decrease Manure N and P

Feed trials will be conducted to compare a standard diet with those formulated to decrease manure N and P from grower-finisher pigs at Arkell Research Station and Ridgetown College. Dietary protein concentration can be decreased by 3 to 4% and result in a 35% decrease in N excretion without affecting animal performance. Agronomic benefits of reduced N and P excretion include an improved balance of manure N and P for crop requirements and it allows more manure to be applied per unit land area. Decreased manure nutrient levels can result in less odour and methane emissions from liquid manure in storage. Decreased manure N content is expected to result in less nitrous oxide emission after field application.

Covering the Liquid Manure Storage

A negative air pressure (NAP) cover was installed on a concrete manure storage tank at Arkell Research Station (Fig. 1). The main agronomic benefits of the cover are it reduces odour emissions, increases the capacity of storages to accept manure from the barns, and conserves ammonium nitrogen. Greenhouse gas emissions are being measured for the NAP system and an adjacent tank without a cover by Dr. Claudia Wagner-Riddle. Continuous monitoring of methane and nitrous oxide emissions started in November 2003 and are recorded as half-hourly average gas concentrations. Methane concentrations from the exhaust fan of the covered tank in November were usually 100 ppm to 500 ppm but values of 1000 and 2000 ppm occurred presumably when gas bubbles are expelled from under the cover. The addition of covers may allow farmers to use their existing storage to meet the more stringent requirements of the Nutrient Management Act.

Composting of Liquid Swine Manure

Demonstration of farm-scale liquid swine manure composting using straw at Ridgetown College continues under the direction of Ron Fleming. Agronomic benefits of this technology include reduced odours associated with manure handling and reduced manure volumes resulting in decreased transportation costs. Greenhouse gas emissions from the compost system are as low as 30% of those from a liquid manure storage. Adequate aeration of the composting mixture is essential for decreasing greenhouse gas emissions. The composter consists of a concrete channel with a compost turner on rails above the channel. Liquid swine manure is added to straw in the channel during the mixing process by the compost turner as it moves the length of the channel. Air is periodically forced through vents in the channel floor into the compost.

Figure 1. Pockets of gas under the NAP cover are removed by ducts connected to an exhaust fan. Water on top of the cover can be removed with a small pump. An agitation system using compressed air is installed on the floor of the storage.

Manure Applied for Crop Production

Crop growth trials will be conducted using manure from the various diets, manure storages, and manure processing methods. Measurements will include greenhouse gas emissions after field application, and crop yield and nutrient content.

Conclusion

The goal of these projects is to help producers become aware of BMPs that improve nutrient use efficiency and decrease odours from manure. Improving grower pig diet to reduce plant nutrients in the manure is profitable. Composting and covers can both be used to reduce odours from liquid manure and will be attractive to operations close to non-farm residences.

Contact Person

Dr. Dean Barry, Department of Land Resource Science, University of Guelph, Guelph, ON N1G 2W1. Phone: (519) 824-4120 ext. 54263. E-mail: dbarry@lrs.uoguelph.ca

Development of Best management Practices for Fall Applied Manure

John Lauzon, Bill Deen, Jason Nagasawa, Stephanie Serran, Steve Crittenden, Gary Parkin,
and David Fallow,
Land Resource Science, University of Guelph

Within Ontario, approximately 30% of the supplied drinking water is obtained through groundwater sources. This makes it increasingly important that a high quality be maintained (Goss et al., 1998). In May 2000, the failure to uphold a high drinking water standard was observed in Walkerton, which resulted in the death of seven people and nearly 2300 becoming ill (O'Connor, 2002). Investigations conducted by the Ministry of the Environment revealed that the well water contamination was attributed to the bacteria *Escherichia coli,* which is found within agricultural manures. Since the Walkerton inquiry, the government has introduced new legislation, which aims to reduce groundwater contamination, such as the Nutrient Management Act and the Safe Drinking Water Act (OMAF, 2002). The strategy the Nutrient Management Act is to implement regulations on the land type, time of year and method in which nutrient amendments such as manures can be applied as to reduce groundwater contamination.

Nitrogen is an essential plant nutrient that is often in short supply relative to plant requirements. Animal manures contain a relatively large quantity of Nitrogen (N), which can be of considerable agronomic value in crop production. Beauchamp and Burton (1985) estimated that there is enough manure N produced through livestock to supply the N requirements of more than half the corn grown in Ontario. The timing of application of nitrogen is critical in obtaining optimum efficiency and utilization of the nitrogen source. If the nitrogen source is applied at the incorrect time, improperly, or too much is applied, than there is an increased potential for lost through denitrification, leaching of nitrate to groundwater, volatilization, soil erosion and runoff. Fall applied N sources in particular present a greater risk of loss of nitrogen to the environment than spring applied. Manure nitrogen exists as ether organic nitrogen or ammoniacal nitrogen. Although neither of these forms of nitrogen will easily leach or are susceptible to denitrification, soil transformations will quickly convert them into nitrate nitrogen, which is susceptible to these losses. Nitrate nitrogen travels in the soil with the soil water, so if the soil water is moving downwards then soil nitrate will also be moving downwards to ground water. Since precipitation in Ontario is relatively constant all year round, and evapotranspiration is very low in the fall and spring there is typically an excess of water at these times. For this reason, downward movement of water is likely to occur in the fall and spring in Ontario, resulting in the greatest potential for leaching loss. The conversion of organic nitrogen to ammonium and the conversion of ammonium to nitrate are both biologically controlled processes. Therefore, if the manure is applied late enough in the fall when soil temperatures are cool than it is likely that the conversion process will be slowed if not stopped. For this reason the risk of loss of nitrogen in the fall will likely be reduced with late fall applications over late summer or early fall; however, spring losses are still likely to occur.

Including a cover crop may minimize losses from manure applied earlier in the fall provided that the cover crop can produce a significant amount of biomass in the fall. A cover crop has the potential to utilize some of the manure nitrogen as such making it less susceptible to leaching loss.

Three projects were initiated in the fall of 2003, with the overall goal of determining the influence of different management on the loss of nitrogen, and the agronomic benefit from fall applied manure. One of the studies is considering the impact of timing and type of manure application on the losses and agronomic value of the manure N. The second study considers the impact of various cover crops on the losses of manure N from fall-applied manure. The third study The specific objectives of the first study were:

Experiment One: A Comparative Study of the Losses of Nitrogen From Various Forms of Manure Applied Either in the Fall or in The Spring

i) to compare the relative agronomic value of fall versus spring applied manure N for four different types of manure (liquid hog manure, liquid cattle manure, solid cattle manure and solid poultry manure);

ii) to assess the impact of time of application and manure type on nitrate leaching and ammonia volatilization losses; and

iii) to assess the impact of pre-application tillage on manure N losses from latesummer applied manures

Experiment Two: Influence of Different Cover Crops and Cover Crop Control Timing on Losses of Nitrogen and the Agronomic Benefit to a Subsequent Corn Crop.

i) Determine if legume and non-legume cover crops play a significant role in reducing the n leaching losses from fall applied manure.
ii) Compare the agronomic merit of fall-applied manure with various cover crops, which have fall or spring control.
iii) Determine if soil water content affects nitrogen dynamics in the soil and the cover crops.

Experiment Three: Quantifying Leaching of Nutrients and Bacteria and Amount of Preferential Flow Under Different Management Practices.

i) To assess the impact of tillage on manure N, P and bacteria losses from latesummer applied manures compared to that of spring applied manure using application methods consistent with Best Management Practices.

ii) To determine the potential pathway of nutrient and bacterial movement through the soil to groundwater as a result of manure application practices. Experiments One and Two each have two field sites. The first site is located at the Elora Research Station situated 20 km north of Guelph. The soil at the site is classified as a Conestogo silt loam (Gleyed Melanic Brunisol) (Paul and Beauchamp 1996). The second site resides on the Couldhart farm located just east of St. Mary's. The soils are classified as a Huron clay/silt loam (Hoffman and Richards. 1952). Experiment Three is located at the Elora Research Station on a Conestogo silt loam (Gleyed Melanic Brunisol) (Paul and Beauchamp 1996). Elora receives approximately 2600 Ontario Crop Heat Units and St. Mary's receives approximately 2800 Ontario Crop Heat Units. The treatments used for each experiment and an example of the plot plans used in the investigations are given in Figures 1, 2 and 3. In Experiments One and Two, the losses of nitrogen from the crop-rooting zone are being evaluated with soil sampling to a depth of 80 cm. For both trials, soil sampling began after the application of the early fall applied manure treatments in late August of 2003. Soil sampling continued on a biweekly basis until the soil froze in December 2003. In total approximately 5000 soil samples were taken over this period. These samples are currently being analyzed for ammonium and nitrate nitrogen content. Soil sampling will resume in the spring and continue until the soil freezes in the fall of 2004. Ammonia losses from the fall-applied manure were assessed with ammonia collectors, which were placed on the manure, and control plots. Readings were taken a few hours after the initial application (time 0) and subsequently, to determine the net ammonia volatilization flux from the plots. These readings collected in the fall are currently being corrected for the environmental conditions at the time of reading. Further ammonia loss measurements will be made in the spring of 2004.

In Experiment Three, a gently sloping field approximately one hectare in area was divided into 20 plots, each measuring 15 m x 15 m (Figure 3). The experimental design consisted of five treatments with four replications of each treatment for a total of 20 plots. The five treatments shown in Figure 3 were designed to compare nutrient (N and P) and bacteria leaching and runoff losses between three different manure management systems and two control treatments without manure. The three treatments with manure applied include spring manure (incorporated), fall manure (incorporated) and fall manure (not incorporated). The two control treatments (without manure application), were fall tilled and not fall tilled. Barley was planted in the spring of 2003 on all plots. Instruments to obtain water samples for nutrient and bacteria analyses were installed from summer of 2002 until the early fall of 2003. On October 17th, 2003 liquid dairy manure was applied to the eight fall manure plots shown in Figure 3. A volume of manure was applied to each plot equivalent to a rate of 200 kg total N/ha in the manure. Manure application was completed on all eight plots in one day, followed immediately by incorporation using a swept-toothed cultivator on the four fall tillage with manure plots.

Four sets of instruments were installed in each of the 20 plots to obtain water samples for laboratory analyses of nutrients and bacteria. Groundwater monitoring wells were installed near the centre of each plot to depths between 2.5 - 3.0 m below the ground surface. The 5 cm diameter plastic well pipe was screened below 1 m depth. Pan lysimeters were installed 60 cm below ground level under each plot. The steel pans were installed to divert water flowing downwards through the soil into a plastic pipe where the water could be pumped to the surface for nutrient and bacteria analyses. Clay tile drains of 10-cm diameter were installed at the Elora Research Farm 15 m apart at a depth of 70 cm below ground surface in the 1960's. The plots were positioned on the landscape so that a tile drain passed beneath the center of each plot (Figure 3). Then, a 15 m length of the tile drain was isolated in each plot by re-routing incoming tile drainage water through a solid plastic pipe buried below the original tile drain system along the edge of the plots. Tile drainage volume and water samples will be collected using an automated system designed and assembled for this research. The system is connected to a data logger that automatically records when the monitor fills with water and then flushes (similar to a toilet's plumbing system). Each flush represents a known volume of tile drainage water. Since the field site has a gently slope towards the northeast, a system was installed to capture water running off the surface of each plot. Steel barriers of 15 cm height were pounded into the ground to a depth of 3 cm along the low side of each plot to divert run-off water into a barrel. The barrels were installed in the lowermost (northeast) corner of each plot so that the top of each barrel was about 20 cm below the ground surface. Then, a funnel with neck inserted through a hole in the lid of each barrel captured and diverted the runoff water from each plot. Water samples collected from the four instrument systems were transported to the laboratory for nutrient and bacteria analyses. To date, only preliminary results of the bacteria counts from water samples obtained in late fall of 2003 are available. Bacteria (*E. coli* and total coliforms) in the water samples were counted using a commercially available plating method (Environmental Bio-Detection Products Inc. (EBPI)).

The results from these trials will increase our knowledge on the losses from and agronomic availability of manure. It is hoped that this information can then be used to develop management practices that will result in less loss of nitrogen to the environment and greater availability of the manure nitrogen for subsequent crops.

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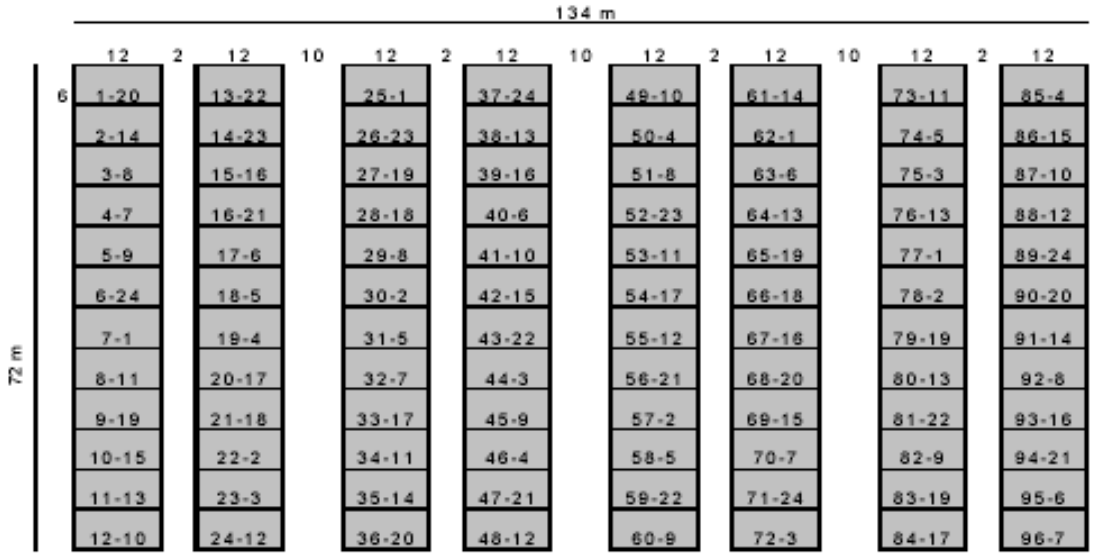
Figure 1: A comparative study of the losses of nitrogen from various forms of manure applied either in the fall or in the spring

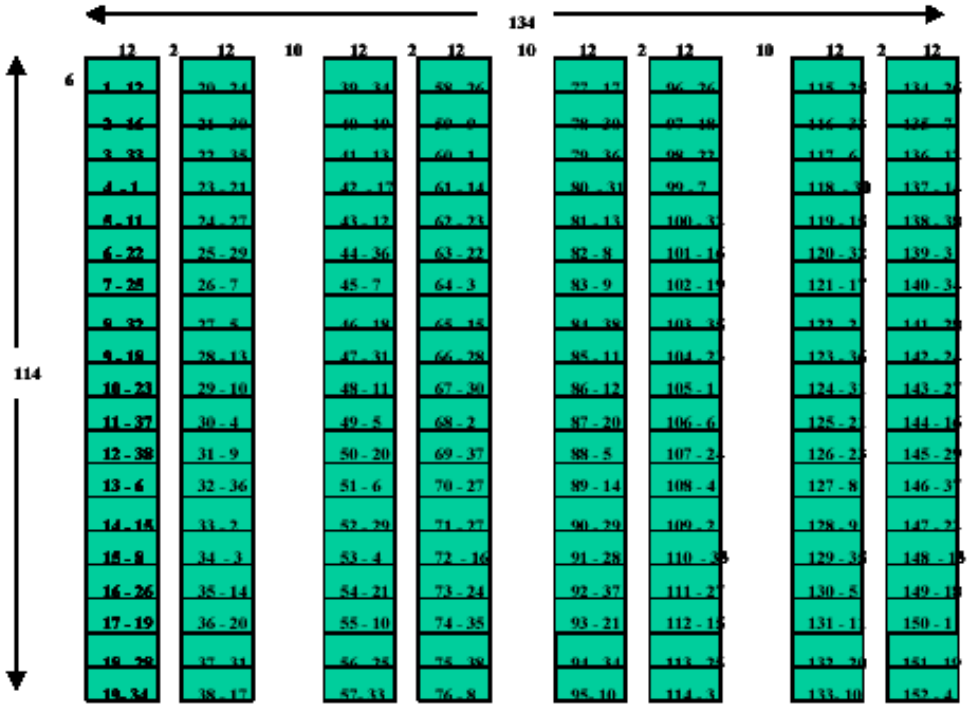


Plot size = 6 m x 12m
10 m pathway between repetitions
2 m roadway between ranges in repetition

Treatment List

1. RC 0 kg N ha^{-1} manure Fall control
2. RC 100 kg N ha^{-1} manure Fall control
3. RC 200 kg N ha^{-1} manure Fall control
4. Oilseed 0 kg N ha^{-1} manure Fall control
5. Oilseed 100 kg N ha^{-1} manure Fall control
6. Oilseed 200 kg N ha^{-1} manure Fall control
7. Oats 0 kg N ha^{-1} manure Fall control
8. Oats 100 kg N ha^{-1} manure Fall control
9. Oats 200 kg N ha^{-1} manure Fall control
10. No cover 0 kg ha^{-1} manure
11. No cover 100 kg ha^{-1} manure
12. No cover 200 kg ha^{-1} manure
13. RC 0 kg N ha^{-1} manure Spring control
14. RC 100 kg N ha^{-1} manure Spring control
15. RC 200 kg N ha^{-1} manure Spring control
16. Rye 0 kg N ha^{-1} manure Spring control
17. Rye 100 kg N ha^{-1} manure Spring control
18. Rye 200 kg N ha^{-1} manure Spring control
19. 0 kg Fert N ha^{-1}
20. 50 kg Fert N ha^{-1}
21. 100 kg Fert N ha^{-1}
22. 150 kg Fert N ha^{-1}
23. 200 kg Fert N ha^{-1}
24. 250 kg Fert N ha^{-1}

Figure 2: A comparative study of the losses of nitrogen from various forms of manure applied either in the fall or in the spring.

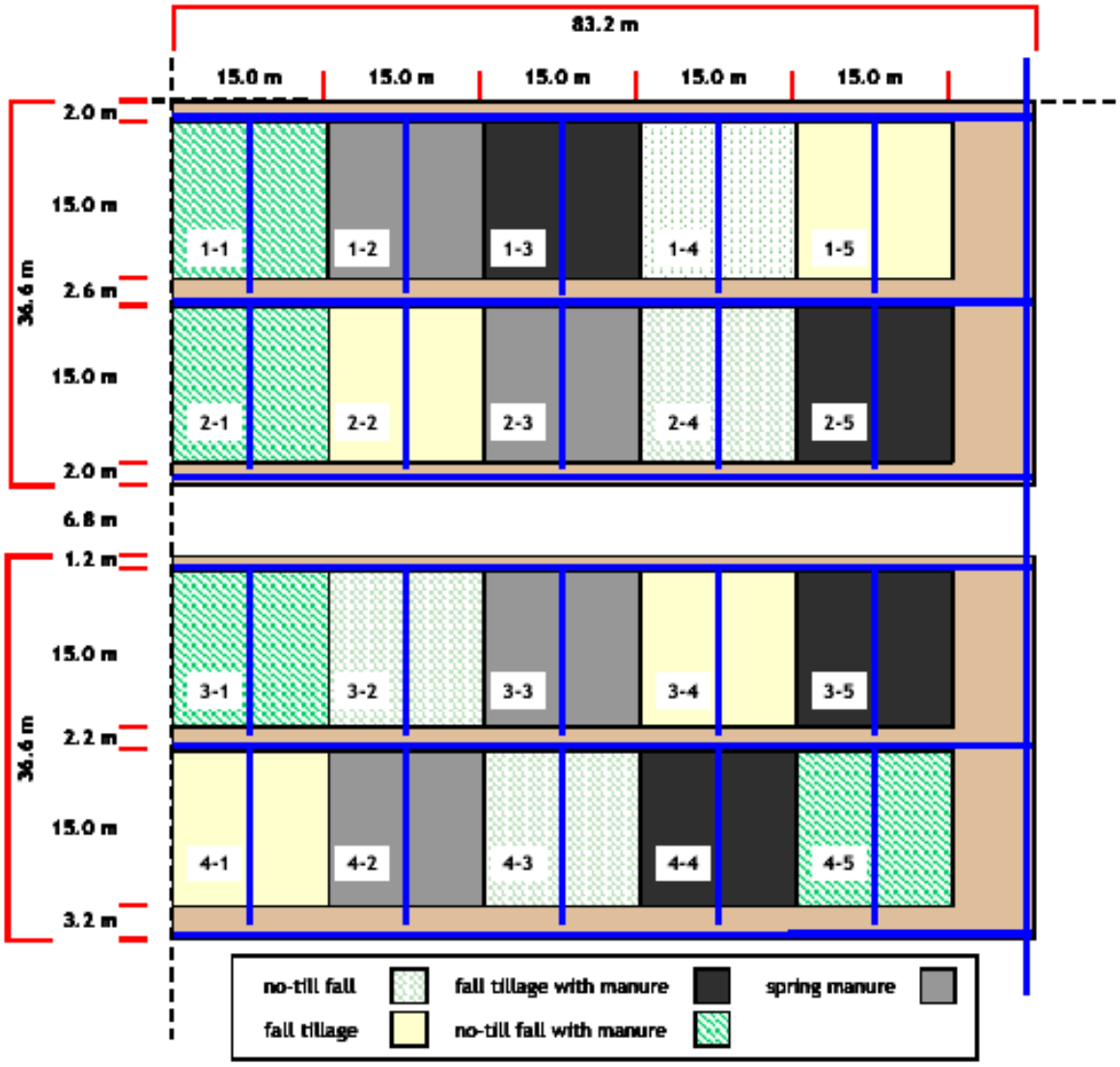


Treatment List

1	Liquid Hog Manure 100 kg N ha^{-1}	(EF)	**20**	Liquid Cattle Manure 200 kg N ha^{-1}	(LF)
2	Liquid Hog Manure 100 kg N ha^{-1}	(EF) (PT)	**21**	Solid Cattle Manure 100 kg N ha^{-1}	(LF)
3	Liquid Hog Manure 200 kg N ha^{-1}	(EF)	**22**	Solid Cattle Manure 200 kg N ha^{-1}	(LF)
4	Liquid Hog Manure 200 kg N ha^{-1}	(EF) (PT)	**23**	Solid Poultry Manure 100 kg N ha^{-1}	(LF)
5	Liquid Cattle Manure 100 kg N ha^{-1}	(EF)	**24**	Solid Poultry Manure 200 kg N ha^{-1}	(LF)
6	Liquid Cattle Manure 100 kg N ha^{-1}	(EF) (PT)	**25**	Liquid Hog Manure 100 kg N ha^{-1}	(S)
7	Liquid Cattle Manure 200 kg N ha^{-1}	(EF)	**26**	Liquid Hog Manure 200 kg N ha^{-1}	(S)
8	Liquid Cattle Manure 200 kg N ha^{-1}	(EF) (PT)	**27**	Liquid Cattle Manure 100 kg N ha^{-1}	(S)
9	Solid Cattle Manure 100 kg N ha^{-1}	(EF)	**28**	Liquid Cattle Manure 200 kg N ha^{-1}	(S)
10	Solid Cattle Manure 100 kg N ha^{-1}	(EF) (PT)	**29**	Solid Cattle Manure 100 kg N ha^{-1}	(S)
11	Solid Cattle Manure 200 kg N ha^{-1}	(EF)	**30**	Solid Cattle Manure 200 kg N ha^{-1}	(S)
12	Solid Cattle Manure 200 kg N ha^{-1}	(EF) (PT)	**31**	Solid Poultry Manure 100 kg N ha^{-1}	(S)
13	Solid Poultry Manure 100 kg N ha^{-1}	(EF)	**32**	Solid Poultry Manure 200 kg N ha^{-1}	(S)
14	Solid Poultry Manure 100 kg N ha^{-1}	(EF) (PT)	**33**	0 kg N ha^{-1}	(S)
15	Solid Poultry Manure 200 kg N ha^{-1}	(EF)	**34**	50 kg N ha^{-1}	(S)
16	Solid Poultry Manure 200 kg N ha^{-1}	(EF) (PT)	**35**	100 kg N ha^{-1}	(S)
17	Liquid Hog Manure 100 kg N ha^{-1}	(LF)	**36**	150 kg N ha^{-1}	(S)
18	Liquid Hog Manure 200 kg N ha^{-1}	(LF)	**37**	200 kg N ha^{-1}	(S)
19	Liquid Cattle Manure 100 kg N ha^{-1}	(LF)	**38**	250 kg N ha^{-1}	(S)

(EF) Early Fall Application **(LF)** Late Fall Application
(S) Spring Application **(PT)** Pre-Till

Figure 3: Layout of the 5 treatments for Experiment three.



* please note: blue lines denote tile drain and bypass flow tile locations

AMMTO Project Update

Richard St. Jean, AMMTO Project Manager, Geomatrix Consultants

The AMMTO project was initiated to develop a decision making process and tools to be used by livestock producers and regulators to determine the viability, capabilities and limitations of advanced manure management technologies for Ontario livestock farms. AMMTO has provided an information source for all sectors of agriculture through direct contact as well as the tools developed.

The decision-making tools developed by AMMTO are available from the AMMTO website and include the following:

1. **Manure Management Technology Information Request Form.**
   A standard form was developed that can be used to solicit the information from technology suppliers necessary to evaluate manure management technologies.
2. **Economic Evaluation Template.**
   A template was developed to compare the economics of different manure management technologies against current practices. The template allows the user to consider capital and operating costs, salvage value of existing systems, effect on land base requirements and soft factors such as reduced soil compaction and reduction in greenhouse gas emissions.
3. **Steps To Implement Database.**
   The database allows the user to choose the management issue(s) they wish to resolve by implementing new technology, and the database provides a list of technologies that can be used to address the management issue selected.
   The database allows the user to select a technology from the database list and the database provides information about 10 factors that affect the implementation of the selected technology. The database provides a list of suppliers of each technology listed and a summary of manufacturer information for the technology. The database provides AMMTO's review of the manure management technologies listed in the supplier database.
4. **Evaluation Process**
   A process was developed to allow individuals to come up with a numerical ranking of the technical capabilities of different technologies to help in the process of deciding what manure management technology is most appropriate for a particular livestock operation.
5. **Manure Management Technology Supplier List**
   A list of 320 companies worldwide that sell manure management technologies was developed including contact information to help farmers and regulators obtain information from a wide variety of technology suppliers.

AMMTO project funding ended December 31, 2003 and steps have been taken to try and obtain funding to continue the project activities. For further information contact Richard St. Jean, AMMTO project manager at Geomatrix Consultants 519-8867500 ext. 225 or rstjean@geomatrix.com.

Hydrogen Sulphide Concentration While Pulling Pit Plugs And Power-Washing Rooms

Liliane Chénard, Stéphane Lemay and Claude Laguë
Prairie Swine Centre, Inc.

Summary
Six pig farms were studied to assess the barn worker exposure to hydrogen sulphide (H_2S) while pulling pit plugs and power-washing production rooms. Results indicated that plug pulling generated high concentrations of H_2S reaching 1,000 ppm in some cases. All of the farms used in this study had plug pulling events that exceeded limits defined by the Occupational and Safety Regulations of Saskatchewan. The H_2S released when a plug was pulled did not follow a predictable pattern over time and within the room. Power washing generated lower H_2S concentrations than plug pulling but workers were exposed for a longer time period. Based on that study, swine barn workers may be exposed to H_2S concentrations that exceed acceptable limits when pulling pit plugs and power-washing rooms. Personal monitors should be provided to all barn workers and training and standard operating procedures are needed so workers can learn how to deal with routine operations and emergency situations generating high H_2S concentrations.

Introduction
Hydrogen sulphide (H_2S) is a life threatening gas produced by the anaerobic degradation of liquid manure. As most swine barns are equipped with gutters accumulating manure, H_2S can be released when manure flows or is being mixed. Saskatchewan Labour regulates H_2S exposure in the Occupational Health and Safety Regulation and stipulates that a person should not be exposed to more than an average concentration of 10 ppm of H_2S for a period of 8-h (TWA: 8 hour time weighted average exposure limit) and an average of 15 ppm for a period of 15-min (STEL: 15-min time weighted average contamination limit). Saskatchewan Labour does not have a defined ceiling value for H_2S, but defines the level of H_2S immediately dangerous to life or health (IDLH) at 100 ppm, level at which no body should even be exposed to.

Recent events in Saskatchewan led us to believe that barn workers may be exposed to high H_2S concentrations while pulling pit plugs and power-washing rooms and monitoring was performed to evaluate this hypothesis.

Experimental Procedures
Six swine production sites were assessed to determine levels of H_2S exposure while workers performed specific manure management tasks in gestation, farrowing, nursery and grower-finisher rooms. The room concentration and distribution of H_2S were measured when pits were emptied (plug measurement: 1 m from the floor level and within a 1 m radius of the plug), and the concentration of H_2S was measured when workers were power washing rooms (worker chest level).

Results and Discussion
Results from four barns monitored in this study indicate that plug pulling generated high concentrations of H_2S, where in some cases, the maximum recorded reached 1,000 ppm (Table 1). All of the farms used in this study had plug pulling events that could present health and safety risks to workers and exceeded limits defined by the Occupational and Safety Regulations of Saskatchewan.

The H_2S released when a plug was pulled did not follow a predictable pattern (Figure 1). In some cases, the maximum value was reached within less than 4 min after the plug had been pulled. In others, the concentration increased and went through a number of intermediate peaks before reaching the maximum.

While most of the highest concentrations were generally recorded at the plug or sewer hole, sometimes it was recorded elsewhere in the room (Figure 2). No predictable distribution pattern was observed for a specific location where the peak would be reached.

Power washing generated lower H_2S concentrations than plug pulling. As power washing generally takes time, in some cases, the STEL was reached a while after the task started and was exceeded for a long period of time, which in some of the monitored events was more than 30 min.

Implications

Swine barn workers may be exposed to H_2S concentrations that exceed acceptable limits when pulling pit plugs and power-washing rooms. Locations of peak H_2S concentrations vary within the room. A worker pulling the plug and walking away from it may not be in a safer position if staying in the room, and the same comment applies to a bystander. Monitors should be provided to all swine barn workers as H_2S may be present in other areas than where the plug is pulled (ex: transfer pit room, plug popping situations). Training and standard operating procedures are needed so workers can learn how to deal with routine operation and emergency situations generating high H_2S concentrations. Further research is needed to improve the design of swine buildings and manure management systems to prevent H_2S exposure.

Acknowledgements

Strategic program funding provided by SaskPork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by SaskPork.

Table 1. Overall maximum H_2S concentrations obtained during the plug pulling events performed in the four farms and the number of events where the concentration obtained exceeded IDLH.

Barn section	Maximum H_2S concentration (ppm) [number of events with concentration higher than IDLH / total number of plug pulling events monitored]			
	Farm number			
	1	2	3	4
Farrowing	810 [7/7]	610 [5/8]	75 [0/8]	123 [1/8]
Gestation	1000* [6/7]	1000* [6/9]	79 [0/8]	66 [0/8]
Grow-Finish	202 [2/4]	494 [3/8]	452 [2/8]	61 [0/8]
Nursery	1000* [1/3]	280 [2/9]	69 [0/8]	51 [0/8]

* Maximum concentration that could be read by the H_2S sensor.

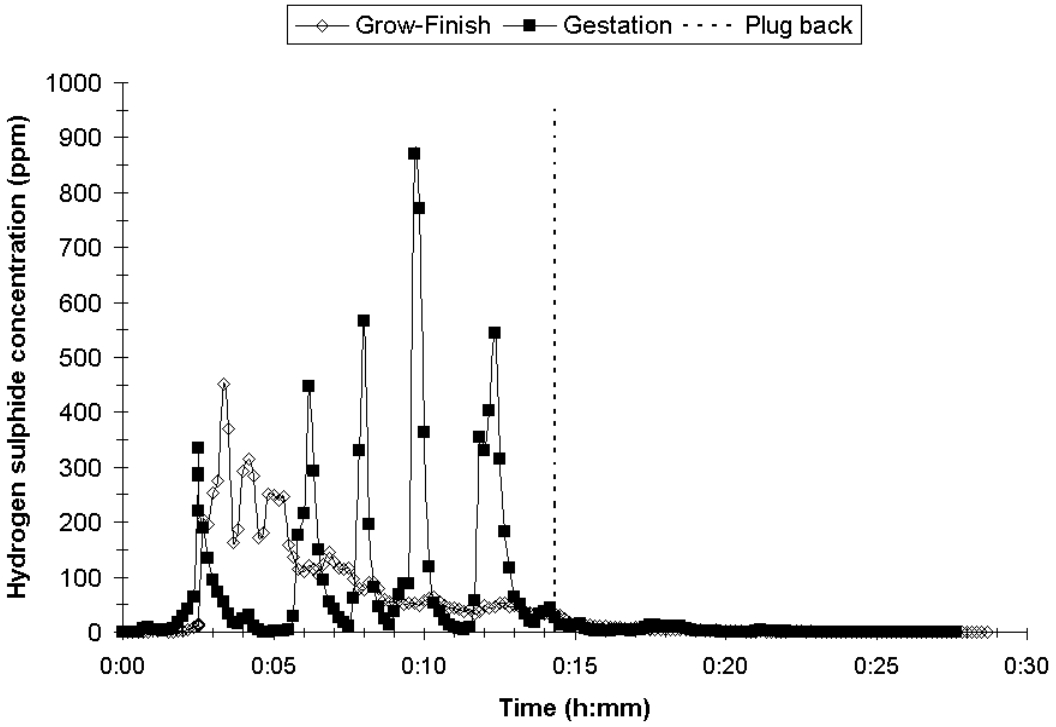


Figure 1. Hydrogen sulphide concentration during plug pulling events performed in a grow-finish room and a gestation room during the summer and winter period, respectively.

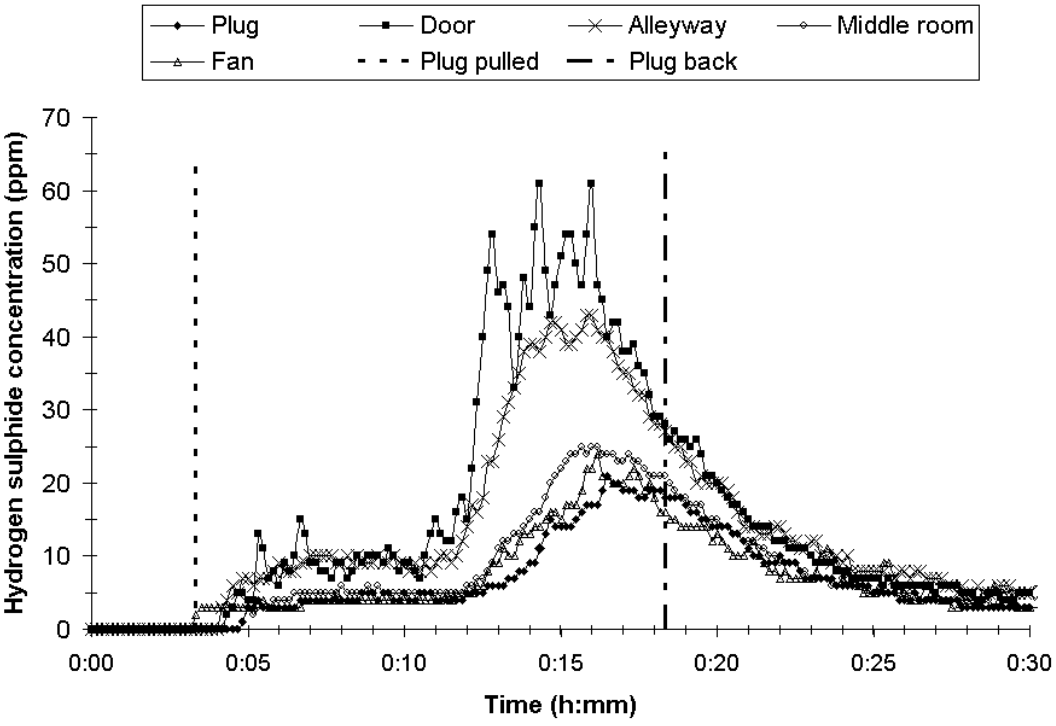


Figure 2. Hydrogen sulphide concentration distribution within the room during a plug-pulling event in a grower-finisher room during the summer period.

Draeger microPac Performance for Hydrogen Sulphide Monitoring in Commercial Swine Operations

Liliane Chénard M.Sc, Stéphane P. Lemay Ph.D and Shala K. Christianson M.Sc.
Prairie Swine Centre, Inc.

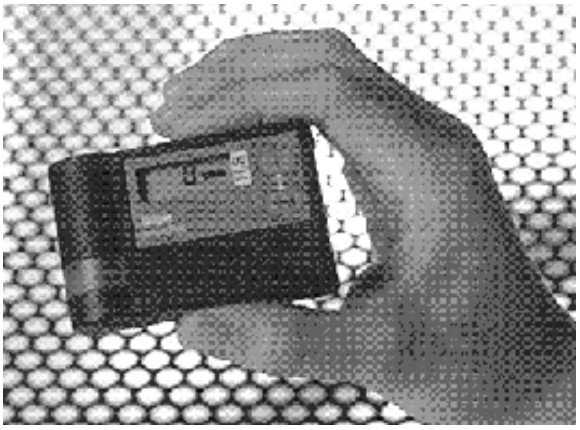
Summary
The swine industry needs reliable and affordable tools to monitor the air quality in the barn to ensure that their workers are fully aware of unsafe conditions. Sixteen Draeger microPac hydrogen sulfide (H_2S) monitors were followed over a year to determine the performance of the monitors. The monitors performed consistently under barn conditions with only a small drift in the accuracy.

Introduction
Until recently systematic H_2S monitoring was not performed in the swine industry. A few incidents involving the detrimental effects of H_2S have increased the awareness of the possible hazards related to H_2S and more intensive swine operators want to ensure that their workers are provided with a safe working environment. Monitors in swine buildings are subjected to a harsh environment where dust, humidity and gases may be present. Since workers wear monitors, the monitors may have accidental falls on the concrete or in the manure. As a result, the swine production conditions are likely to challenge the H_2S monitor. The objective of this project was to evaluate the performance of the Draeger microPac unit for H_2S monitoring in pig barns.

Experimental Procedures
Over the course of a year, four Draeger microPac monitors were used in office conditions, and 12 monitors were used in both the PSCI Floral and Elstow barns. The working conditions for each monitor was similar for all monitors, including power washing, pit pulling and exposure to outdoor conditions, except for the monitors used in the office. Eight of the monitors used in the barns were subjected to extreme tests after four and eight months of use; four monitors were dropped on concrete, and four monitors were dropped in the manure pits. A calibration gas was used to regularly check the accuracy drift of each of the monitors six times during the project.

Results and Discussion
The absolute average drift of all the monitors after 328 days was from 0.6 to 2.0 ppm, with an absolute maximum drift of 2.7 ppm. This maximum drift was much less than the maximum drift Draeger specified, which was 12 ppm after one year. There was a significant difference in the drift of the monitors after the first six months ($p<0.05$), but after six months, there was no significant drift of the monitor accuracy. There were also no significant differences between the monitors ($p>0.05$).

Implications
Use of the Draeger microPac monitors with regular calibrations has shown to be an effective tool to ensure worker safety in a swine environment to help prevent exposure to H_2S. Any effects of repeated abuse on the monitors is unknown, but the monitors performed consistently under normal swine housing conditions and the accuracy drift of the monitor was acceptable to help ensure safe working conditions in the swine operation.



Draeger microPac H_2S monitor.

Acknowledgements
Strategic funding for this project was provided by SaskPork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by Draeger.

A Low Protein Diet and Oil Sprinkling to Reduce Ammonia Emissions from Pig Barns

Michel Payeur[1], Stéphane P. Lemay Ph.D., Ruurd T. Zijlstra Ph.D., Stéphane Godbout, Ph.D.[2], Liliane Chénard M.Sc., Ernie M. Barber Ph.D.[3] Claude Laguë Ph.D.[4] and Shala K. Christianson M.Sc.

[1]PSCI and Department of Agricultural and Bioresorce Engineering, University of Saskatchewan,
[2] Institut de Recherche et de Développement en Agroenvironnement (IRDA), Deschambault, QC,
[3]Dean, College of Agriculture, University of Saskatchewan,
[4]Dean, College of Engineering, University of Saskatchewan

Summary
Ammonia concentrations in swine barns have an adverse impact on the health and safety of workers and animals. Ammonia also has the potential to cause eutrophication and acidification of water and soil. The impact of raw canola oil sprinkling and a low protein diet with fermentable carbohydrates (FC) on ammonia emissions of grower-finisher rooms) was investigated. Ammonia emissions were reduced by 42% with the low protein diet with FC, and oil sprinkling did not affect the ammonia levels.

Introduction
Previous research has shown that reducing dietary protein and inclusion of FC both result in reduction of ammonia emissions. Oil sprinkling in swine barns has also been shown to have varied results on the impact on ammonia emissions. The objective was to perform a full-scale study to investigate the results on ammonia emissions when both a low protein diet with FC and oil sprinkling are used.

Experimental Procedures
Four commercial rooms at PSCI were used to measure the impact of the different treatment combinations on ammonia emissions over three grower-finisher cycles. Two raw canola oil application rates (0 and 10 $ml \bullet m^{-2} \bullet day^{-1}$) and two feed formulations (normal protein diet and low protein diet with FC) were investigated. The ammonia emissions and pig performance were monitored.

Results and Discussion
Figure 1 presents a typical result of the ammonia emissions from the four rooms. Ammonia emissions were reduced by 42% over the three cycles ($p<0.05$) with the low protein diet with FC. The oil application did not have any impact on ammonia emissions ($p>0.05$) and pig performances were not affected by the treatments ($p>0.05$).

Implications
Reducing the protein level and including FC in pig diets is effective to decrease ammonia emissions of swine buildings. Sprinkling canola oil in the room does not significantly impact the ammonia emissions.

Acknowledgements
Strategic funding for this project was provided by SaskPork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by the Canadian Pork Council and Agriculture and Agri-Food Canada through the HEMS program.

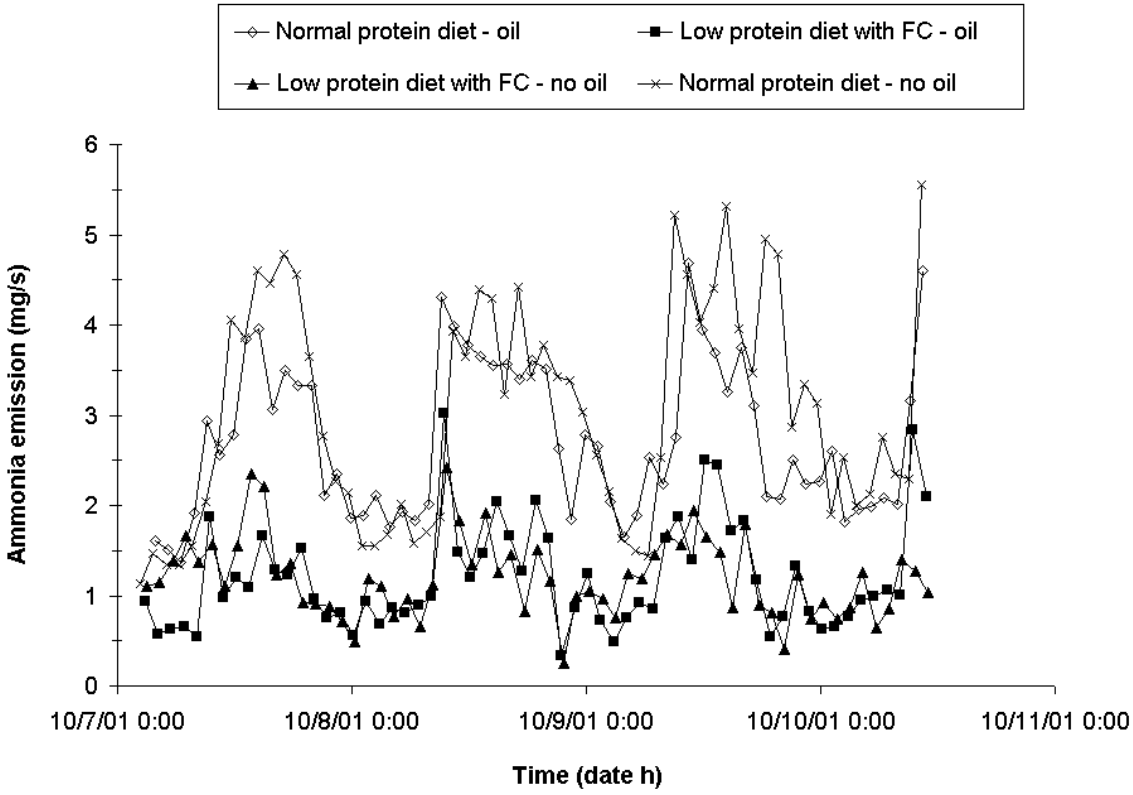


Figure 1. Ammonia emissions from each room between October 7 and October 10, 2001.

Impact of Combining a Low Protein Diet and Oil Sprinkling on Odour and Dust Emissions af Swine Barns

Michel Payeur[1], Stéphane P. Lemay Ph.D., Ruurd T. Zijlstra Ph.D., Stéphane Godbout, Ph.D.[2], Liliane Chénard M.Sc., Ernie M. Barber Ph.D.[3] Claude Laguë Ph.D.[4] and Shala K. Christianson M.Sc.

[1]PSCI and Department of Agricultural and Bioresorce Engineering, University of Saskatchewan, [2]Institut de Recherche et de Développement en Agroenvironnement (IRDA), Deschambault, QC, [3]Dean, College of Agriculture, University of Saskatchewan,
[4]Dean, College of Engineering, University of Saskatchewan

Summary
Odor from intensive swine operations are a significant limiting factor in the expansion of the pork production industry, and dust in pig housing is suspected to be the cause of work-related respiratory symptoms in pig farmers. The impact of canola oil sprinkling and a low protein diet on dust and odor emissions of grower-finisher rooms was examined. Sprinkling oil reduced total dust emissions by 76% but the effect of oil sprinkling and/or low protein diets on odor was unclear.

Introduction
A dust control strategy shown to be promising in reducing dust in pig housing is oil sprinkling. Oil sprinkling has also been shown to reduce gas emissions, possibly affecting the odours emitted from the barn. The objective of this study was to investigate the effect of a low protein diet with fermentable carbohydrates (FC) and oil sprinkling on dust and odor emissions of grower-finisher rooms, and to determine the relationship between the two parameters.

Experimental Procedures
Four commercial rooms at PSCI were used to measure the impact of the different treatment combinations on dust and odour emissions over three different grower-finisher cycles. Two raw canola oil application rates (0 and 10 $mL \bullet m^{-2} \bullet day^{-1}$) and two feed formulations (normal protein diet and low protein diet with FC) were used. During the experiment, the dust and odour concentrations were monitored in the four rooms.

Results and Discussion
Figure 1 shows the dust emission from the rooms over the experimental cycle. The oil application significantly reduced total dust emissions by 76% ($p<0.05$) and pig performances were not affected by the treatments ($p>0.05$). The experimental diet did not significantly affect dust emissions ($p>0.05$). Figure 2 presents the results from the odour evaluations. Because of the high variability of the results for odours, neither the oil sprinkling nor the experimental diet affected odour emissions and the hedonic tone ($p>0.05$). In this experiment, there was no relationship between dust and odour emissions.

Implications
Sprinkling of canola oil was effective at reducing the dust emissions in grower/finisher rooms, but the low protein diet with FC did not reduce dust emissions. The results from the odour measurements were so variable that future research will be done to ensure the odour is characterized in a more effective manner.

Acknowledgements
Strategic funding for this project was provided by SaskPork, Alberta Pork, Manitoba Pork and Saskatchewan Agriculture and Food Development Fund. Project funding was provided by the Canadian Pork Council and Agriculture and Agri-Food Canada through the HEMS program.

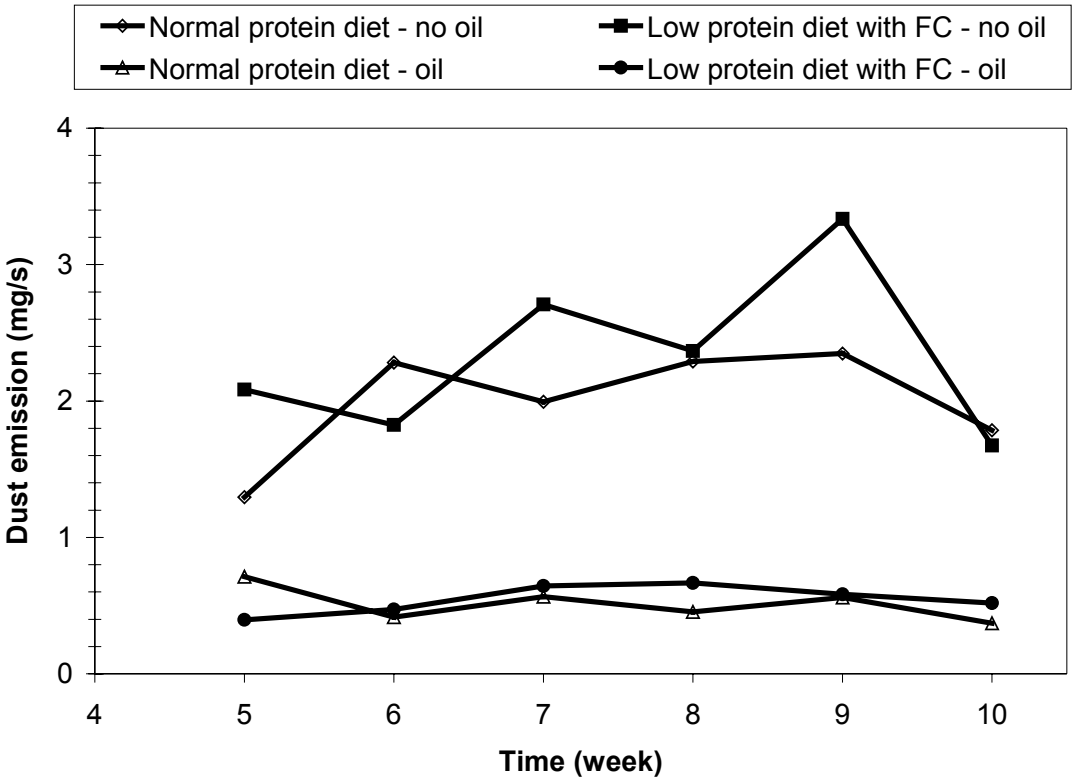


Figure 1. Evolution of total dust emissions for the different treatment combinations.

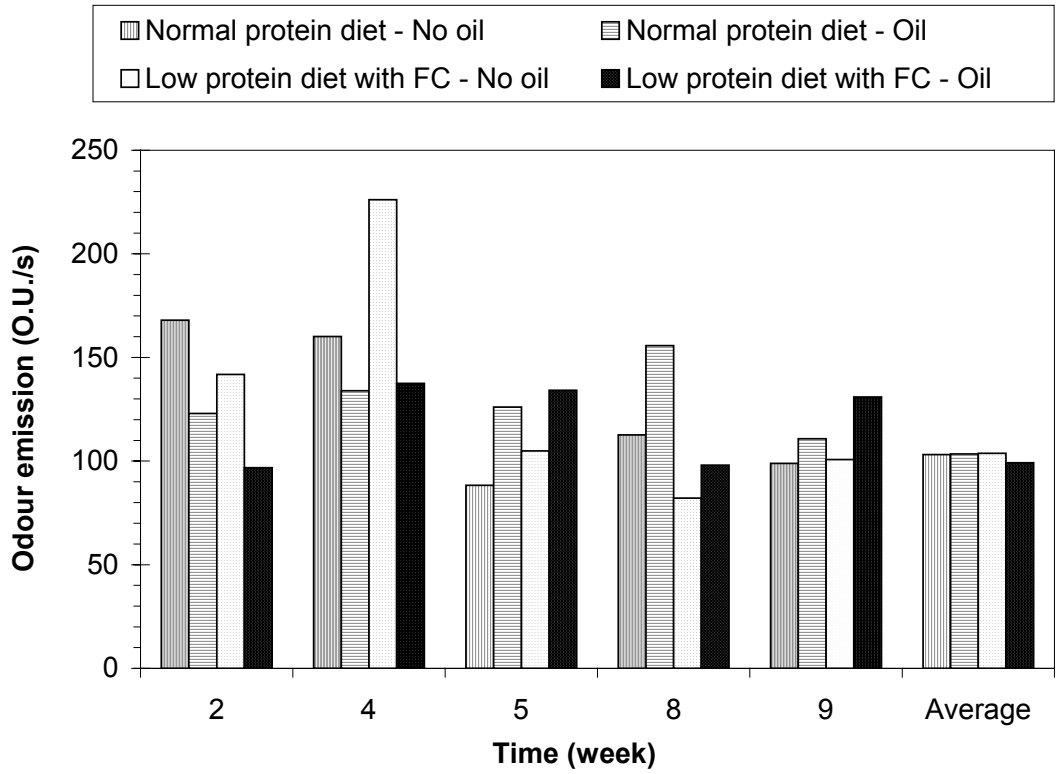


Figure 2. Odour emissions for the different treatment combinations.

Pork Industry Interpretive Centre Becomes a Reality

Prairie Swine Centre, Inc.

When Prairie Swine Centre sought industry input for a proposed new research facility in 1998 the concept of allowing the public to view inside the barn came to the fore as a significant and unique role the facility could provide in addition to its research mandate. Fast forward to 2003, The Pork Industry Interpretive Centre and Sask Pork Viewing Gallery is nearly complete. Many people have contributed to getting the facility to this point including; 90 donors who have contributed over $900,000 toward the construction, display development and operation of the facility; and a Development Committee with pork producer and association members from Saskatchewan, Alberta, Manitoba and Ontario. The end product has an inviting and fun look as it delivers the experience the pigs provide combined with a series of messages about how pork is produced.

Objectives of the Project

The Interpretive Centre and associated Sask Pork Viewing Gallery have four operational objectives:

1. **Allow groups and individuals to see a typical commercial pork-producing farm.**
2. **To provide a resource to the prairie pork industry to focus communication resources.**
3. **To permit an "open door' through which to view the industry.**
4. **To allow pork producers greater access to see research taking place at the Centre.**

These objectives will be met using a combination of interpretive signage, hands-on displays and of course viewing the behaviours and activities of the pigs themselves. These will be complemented with a knowledgeable tour guide to assist groups to better understand what they are seeing and how this relates to the larger industry and its contribution to the food chain.

The Interpretive Centre uses the science and social studies of everyday life in a pig barn to capture the visitor's attention and separate fact from myth. The experience of watching pigs is expected to be the highlight for the visitors to the Centre. School groups (primarily grades 6-10), young adults seeking careers in agriculture, municipal councils, regulatory authorities, prospective neighbours to a planned barn and investors are among the main groups the Centre hopes to attract.

The facility was substantially finished in March 2003 and began providing tours immediately to the industry and selected groups. A wide range of groups has been invited to the facility to gauge their reaction and look for ways to improve the presentation of facts about the industry. Without exception, the reaction to the facility has been tremendous. The signage and interactive displays like "Where's Agriculture", a seek-and-find game modeled after the "Where's Waldo" game, as well as the "What Pigs Eat" display with pyramid-shaped ingredient containers that let kids touch the grains, oils seeds and vitamins - are popular and fun but the real attraction is to see the pigs!

What we in pork production have come to see as routine, children and adults alike find interesting and entertaining. Sows farrowing and nursery pigs wrestling provide entertainment and hold the visitor's attention long enough for them to become interested in other aspects of production, environment, air quality, pork quality, etc.

Our next goal with the Centre is to attract large numbers of school-aged groups and then evaluate their reaction during the tour and the days following the tour to assess how well we are able to communicate the facts about the Canadian pork industry. To date the results in this area look very encouraging. For example, the ability to find the answers to questions on the evaluation card has revealed that the signage is working. We have recorded over 70% correct answers to the questions on evaluations to date.

It is hoped that the experiences gained with the Pork Interpretive Gallery can be duplicated across Canada with similar Centres helping to show visitors a positive and accurate experience about pork production.

Canadian Quality Assurance® - 2003 Year in Review

Christine Ritter, CQA® Coordinator for Ontario Pork
655 Southgate Drive, Guelph, Ontario, N1G 5G6
519-767-4600 Fax: 519-829-1769 christine.ritter@ontariopork.on.ca

Participation
This year, the CQA® program has seen a steady increase in the number of recognized farms, with 2,380 validated as of Dec 31st, 2003. This represents an estimated 3.5 million market hogs and includes 250 non-market hog producers. There are now over 4,000 producers enrolled in the program with estimated annual hog sales of over 4.4 million head. In comparison, the national numbers reported for market hogs under the CQA® program is currently at 63.9% recognized and 78.9% enrolled.

CFIA Technical Review
The CQA® program has faced several challenges this year, one of them being the delay of the CFIA technical review recognition process. In 2002, the CQA® program was thoroughly reviewed and submitted to the Canadian Food Inspection Agency (CFIA) for technical review in December 2002. In April 2003, following a response submitted to CFIA for our pre-screening review, we were informed that all activities related to the technical review process were being suspended pending a review of the process itself and the resolution of certain challenges that had arisen within CFIA. The technical review has since begun and the CQA® program is being reviewed now with the Technical Review Teams.

Re-launch Postponed
Given these events and the fact that we had targeted a re-launch of the CQA® program in September 2003, the CQA® Advisory Committee decided to suspend the re-launch of the program until after the technical review was completed. Although we would like to get the updated materials into the hands of the producers, it was determined that it would be best to wait until after the completion of the technical review and incorporate any changes that arise from the CFIA review at that time. We are now aiming for mid-2004 to re-launch and update the CQA® program material.

Administrative Enhancements
Ontario Pork has also been working to enhance the administrative process of the program throughout the past year to ensure adequate and timely notifications for Partial and Full validations. Producers now receive notice of their overdue and/or expired CQA® status if they do not complete their validation within the allotted timeframe. We also increased the number of Validators available to our producers by hosting a training session for veterinarians who were not yet recognized as CQA® Validators.

Drug Use Policy
Although the program will not be re-launched until later this year, it was decided to continue with the release of the CQA® Drug Use Policy as planned. The policy came into effect October 1st, 2003 for all farms recognized under the CQA® program. The first phase of the policy requires that all drugs used on CQA® recognized farms to be licensed for food animal use in Canada. This includes the active pharmaceutical ingredients used to make those products. In general, if the drug label says anything to the effect "Not to be slaughtered for meat, food, or human consumption", then it cannot be used. Producers have been made aware of this change through the Ontario Pork newsletter and will also receive official notice when they receive their yearly renewal notification letters.

CQA® Requirements from Processors
Recently three federally inspected processing plants in Ontario, Conestoga Meats, Quality Meat Packers, and Maple Leaf Pork, have conducted a review of their direct contract producers' CQA® status. Letters have been sent to producers who are not CQA® validated informing them that these processors will be enforcing the terms of their agreements unless their CQA® status is corrected. In addition, all producers under the Pool Plus program must be CQA® validated to sign up and those currently on the Pool Plus program must be fully validated by May 29th, 2004 to avoid having their contracts cancelled. Ontario Pork has been working with both producers and processors to ensure the information is accurate and to assist in the completion of these requirements.

Swine Herdsperson Apprenticeship Program

Bill Weaver
Swine Herdsperson Apprenticeship Program Coordinator

The swine apprenticeship program is one of the 130 formal apprenticeship programs offered by the Ministry of Colleges, Training and Universities.

What is Apprenticeship?

- Apprenticeship is the opportunity to "earn while you learn"
- Apprenticeship is a professional designation that applies to many certified trades in the service, construction, and motive power sectors, and now agriculture.
- 90% on farm training and 10% classroom training

Program Description

The Swine apprenticeship program allows you to earn while you learn, working on a progressive Ontario swine operation. Apprentices find an employer willing to hire them and then complete the training standards as developed by the Ministry of Training, Colleges and Universities. The program will require 2 to 2.5 years of skill development.

The Swine Apprenticeship Program is:

- A building block for youth or adults to develop valuable skills in Ontario's agri-food system.
- A hands-on opportunity to work with people and animals in preparation for a career in animal care and food production.
- A chance for skills training that will lead to rewarding jobs and opportunities for advancement in Ontario's pork industry.

Frequently Asked Questions

How does Apprenticeship relate to current high school studies?

High school students can take part in co-op studies, which would involve a farm placement. A portion of the hours spent can be credited to their apprenticeship requirements. The student would register as an apprentice after graduation.

Can a current employee qualify?

Yes – as long as the employee has a Grade 12 diploma or equivalent. Credit for hours worked may be given, based on the on-farm skills learned prior to formal enrolment as an apprentice.

What does the program cost?

The only cost is the cost of in-class instruction. At $1.50/hr, the total cost to the student is approximately $720 over 24-36 months.

What is the responsibility of the employer?

The employer must allow the apprentice time to attend the in class instruction. As well the employer must provide the on farm instruction and record the apprentice's progress as each specified skill is learned.

Do other provinces have such a program?

Yes – both Saskatchewan and Manitoba have had a successful apprenticeship program in place for several years.

Admission Requirements: 2003/2004 - Grade 12 OSSD or Grade 12 Equivalency

Career Opportunities for Swine Apprentices Working on Ontario Swine Farms
Production Manager- Breeding Manager -Farrowing Manager -Breeding Technician Nursery Stock Manager - Artificial Insemination Manager - Etc.

Opportunities for industry
A shortage of skilled labour has been identified as a problem for the swine sector – many suggest that is one of the primary limiting factors for the Ontario pork industry.
Development of a pool of skilled workers will benefit the whole industry- raising the profile of employment in the field of swine herd management, and aiding in the attraction of an ever improving source of labour, both for primary production and the agricultural service sector.

A project to promote apprenticeships in both the swine and dairy sector began in November 2003. This project is primarily funded by the Agricultural Adaptation Council. The project partners include Dairy Farmers of Ontario, Ontario Pork, the Ridgetown and Kemptville Campuses of the University of Guelph, the Ontario Pork Industry Council, Ag Careers (a division of Farms.com), and the Ministry of Training, Colleges and Universities.

Further information contact:
Bill Weaver - Coordinator
RR 6
Dresden, ON
N0P1M0
Phone: 519 351 2592
Fax: 519 351 6883
apprentice@farms.com
http://www.edu.gov.on.ca/eng/training/apprenticeship/appren.html
http://www.farms.com/careers/apprenticeship/

An Update On Country Of Origin Labeling

Ken McEwan, Ridgetown College

1. Introduction

Country-of-origin labeling (COOL) is part of the 2002 Farm Bill and was passed by the U.S. Congress with the hope of aiding farmers and ranchers. Covered commodities include: cattle/beef, lamb, hogs/pork, various types of fish and seafood (i.e. wild and farm raised), produce (i.e. fresh/frozen fruits and vegetables), and peanuts but not poultry. The guidelines clearly state in order for pork products to receive a "Product of USA" label, they must come from hogs which were born, raised, and slaughtered in the United States. Given current USDA guidelines, processed products are taken to be combinations of raw products that produce a materially different product or a commodity that is altered by the addition of other ingredients or by further processing (e.g. cooking or curing) to produce a different product. Grinding a product to produce ground beef, pork, or lamb is not sufficient alteration to exclude it from COOL provisions. Hogs born in one country, such as Canada, and raised and slaughtered in the United States would be labeled "From hogs born in Canada, and raised and slaughtered in the United States.

The COOL legislation is slated to become mandatory beginning October, 2004. This means that sows bred in November, 2003 and have their litters born on/about April 1, 2004 would be subject to the new law. However, the deadline for implementation maybe extended to fall 2006. This extension of 2 years in enforcement dates has been approved by the U.S. House of Representatives (i.e. December 8, 2003) but not the Senate. At the time of writing this article, some democratic senators are trying to connect the necessity of COOL with the recent case of Mad Cow in Washington State.

2. COOL Impacts

The immediate impact will be to drive down the prices of all Ontario pigs (not just those exported) and produce a glut of market hogs and weaners. If compliance with COOL costs the average Ontario producer $C7.50/head (i.e. industry estimate), then much of the profitability within the Ontario industry is gone. The estimated impact on Ontario farm gate sales could be a decrease of $C55.3 million which would generate a loss of $368 million to the Ontario economy. These figures do not include the price impact of COOL on pork exports. While it is not known the size of the price discount on pork sales, the economic spin-off of any discount on Ontario exports could be easily worth $C100 million.

A profile of Ontario pork production and exports looks as follows. In 2002, Ontario had total production of 7,367,086 head. Of these animals only 62.7% were processed within the province while 37.3% were exported out of the province as live animals (i.e. 9.1% are shipped to Quebec as market hogs, 22.3% are shipped to the U.S. as feeder pigs, and 5.9% are shipped to the U.S. as market hogs). When feeder pig exports, market hog exports, and pork exports were totaled, Ontario ships to the U.S. market approximately 43.8% of it's total production (i.e. 28.2% as live animals and 15.6% as processed pork) based on 2002 statistics (note: the 43.8% figure might be slightly underestimated because of the possibility that pork from Ontario market hogs processed in Quebec could be exported to the U.S. marketplace).

Other COOL impacts on the Ontario industry include:

(i) Probable loss of U.S.-based pork trading partners (i.e. fabricators) due to difficulties in keeping Canadian and U.S. products separate. Primal meat cuts quickly lose their identity when they reach the cut floor because of the multiple end uses for the meat (e.g. tray ready product, speciality cuts and etc.).

(i) Greater dependency on Quebec processors because fewer pigs will be exported to the U.S.. Using U.S. processors to leverage higher prices for Ontario producers will no longer be possible.

(i) Possible erosion in supply chain power caused by retailers knowing that Ontario processors have lost access to the U.S. market unless they are willing to accept significant price discounting. Before COOL, Ontario processors could easily move pork product into the U.S. with no price discount when retailers were feeling uncooperative. This will no longer be possible.

(i) Perhaps the most important impact of all, is the loss of the U.S. as a reference market from which to create Ontario's base price for market hogs. U.S. price equivalency has been one of the pillars of hog marketing in Ontario for well over a decade. The current producer/packer arguments over which U.S. based price series to use with respect to volume, geographic representation, accuracy of information and etc. will no longer happen. Instead the debate will be about how much is the discount on Ontario pigs and pork shipped to the U.S.. It should be noted that the lack of the U.S. as a reference market will affect all pigs raised in Canada, not just Ontario.

3. Summary

In the short-term it would appear that the COOL legislation will be extended to 2006. Longer-term, Ontario needs to develop a strategy on how to handle the extra hog marketings expected to occur and begin work on constructing a new pricing mechanism for market weight animals. There are some studies that show Americans prefer to purchase domestic product and would like greater food safety. Thus, work on developing a system which offers greater traceability for export markets would seem prudent.

Reducing Piglet Mortality by Early Treatment

H. Y. Zhang, V. Osborne, W. Szkotnicki, M. Z. Fan and R. R. Hacker
Department of Animal and Poultry Science, University of Guelph
Summarized by: R.R. Hacker and Wayne Du, Ontario Ministry of Agriculture and Food

Introduction

Piglet survival has improved dramatically in the pork industry over the last three decades (Lay et al. 2002). However, producers are still suffering from significant losses, especially with increasing litter size, resulting in more lightweight piglets being produced which often experience higher mortality during the first week of life. Many factors lead to preweaning mortality, such as trauma, chilling, starvation, scours, as well as unpredictable events.

Researchers have been continuing in searching for ways to improve piglet viability. Zhang and Hacker (2001) reported that administering 40% oxygen for 10 min immediately after birth could reduce piglet mortality. However, it may not be practicable due to labor cost. It was also hypothesized that an additional heat lamp positioned in farrowing zone along with supplementing energy and immunoglobulin products has the scientific base and practical potential to improve piglet survivability. Thus the present experiment was designed to investigate the best treatments and methodology for solving the piglet mortality problem.

Objective

The objective of this study was to investigate how oxygen, cream, immunoglobulins, dextran and dexamethasone improve piglet survival.

Materials and Methods

Four groups of piglets from 160 sows (40 each) exposed to 5 different treatments. The four groups were: (A), piglets from a control group of sows farrowed and nursed in the normal farrowing crate routine; (O_2), piglets farrowed in the routine environment but exposed to 10 minutes of oxygen inhalation at 0700 or 1900; (H), piglets farrowed into a zone maintained at or above 31°C with a heat lamp directly behind the sow and also in the creep area; (HO_2), piglets farrowed into a zone at or above 31°C and 10 minutes oxygen inhalation at 0700 or 1900. When farrowing was completed at 0700 or 1900, all piglets were subjected to force-feeding of 6 ml of treatment product at room temperature. Products were 1.) C: Parmalat, 10% Half-and-Half cream, Parmalat Canada; 2.) CB: homogenized C plus 1g bovine colostrum powder (30% IgG, Mary's Herbal Garden Nature's Promise colostrum, Providence, UT, USA); 3.) CBD: CB plus 0.3g dextran powder (molecular weight of 20,000 Dal, supplied by Dextran Products Ltd., Scarborough, ON, Canada); 4.) CBDM: CB plus 1mg dexamethasone (Sigma, Canada) and 5.) CBP: CB plus 1g porcine serum powder (supplied by APC, Inc., IA, USA). The dried porcine serum contained 80% crude protein and 20% IgG. Piglet mortality was recorded as dead day and dead reason. Piglet initial weight was recorded while processing and weight was again recorded on day 7 for weight gain analysis.

Results and Discussion

Mortality. The experiment confirmed the result from the previous work of Zhang and Hacker (2002) that the H group had a 21% lower mortality than non-heat group. Oxygen did not significantly improve piglet survival when it was administered to piglets within 12h after the sow completed farrowing. There were differences between treatments within the H group combinations (Table 1 and Figure 1). CBDM had a lower survival rate when compared to CB and CBP. Heat, when combined

with C and CB, had an obvious positive influence on piglet mortality (Table 1). CBP had a similar influence on mortality for both the heat and non-heat groups.
The major cause of recorded liveborn mortality within 7 days after parturition was crushing, accounting for 62%, followed by weakness, injury, starvation, splayleg, chilling and other factors.

Weight gain. There were no differences between the heat and non-heat groups for weight gain within 7-d after birth, but there was a significant difference between CBP and the other treatments.

Results from this study demonstrated that temperature is the key factor influencing newborn piglet surviability. To survive after birth, it is very important that:

- underweight piglets immediately receive adequate warmth and comfort to stabilize body temperature;
- newborn pigs need to be provided with energy to keep them vigorous to compete for colostrum from the sow;
- immunoglobulins are necessary to help porcine neonates resist pathogens.

Conclusions

The 7-d mortality of piglets can be reduced significantly by positioning a heat lamp behind a sow during farrowing, combined with the administration of cream plus bovine colostrum. With or without a heat lamp behind a sow during farrowing, early administration of a combination of cream, plus bovine colostrum and porcine serum can also improve survival and weight gain of neonatal pigs.

Table 1. Piglet 7-day mortality (%).

Group	Treatment	Farrowing zone	
		Heat	**Non-heat**
C:	(Cream)	3.97	7.55
CB:	(Cream + Bovine colostrum)	2.52	9.88
CBD:	(Cream + Bovine colostrum + Dextran)	9.82	6.08
CBDM:	(Cream + Bovine colostrum + Dexamethasone)	10.43	9.33
CBP:	(Cream + Bovine colostrum + Porcine serum)	3.59	4.93

References

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Zhang. J. H., and R. R. Hacker. 2002. Reducing Piglet Mortality with Oxygen & Heat. (OMAF research report #25600).

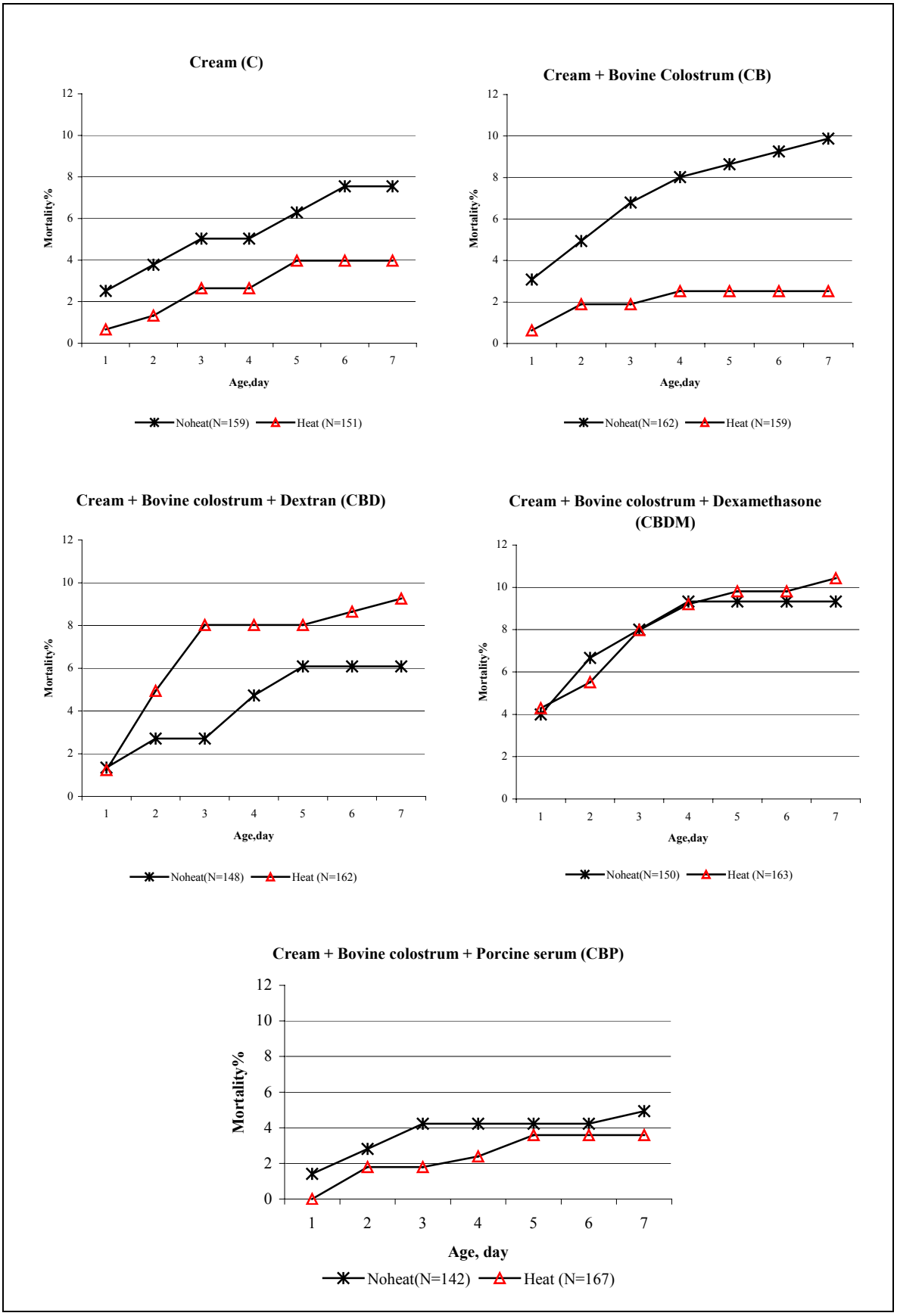


Figure 1. Profile of piglet mortality in various treatments with heat/non-heat groups.

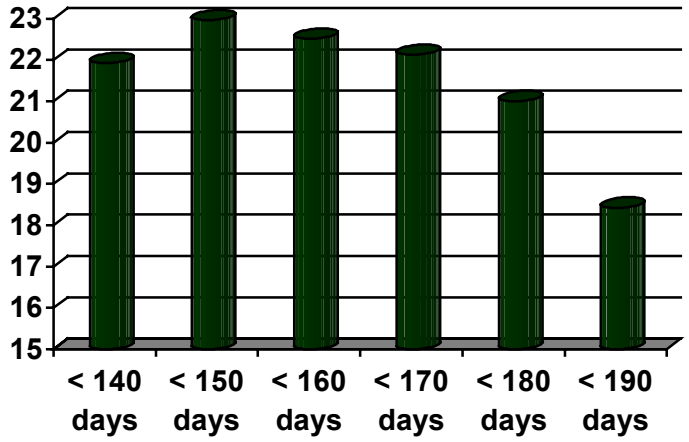
2003 Ontario Pork Congress Carcass Evaluation

Cathy Aker, Technical Manager – Genetics
Ontario Swine Improvement Inc.
(519)469-8109 ext. 28; caker@osi.org

A total of 16 commercial pork producers representing almost 17,000 sows participated in the 2003 Ontario Pork Congress Commercial Product Test. Test pigs (barrows) were identified and tagged with electronic ear tags prior to weaning and weighed on test at approximately 30 kg. At slaughter, pigs were transported to Conestoga Meat Packers for grading and carcass dissection. The first pigs were slaughtered at 129 days of age whereas the last pigs were slaughtered at 189 days of age. The following table outlines the distribution of pigs by age at slaughter:

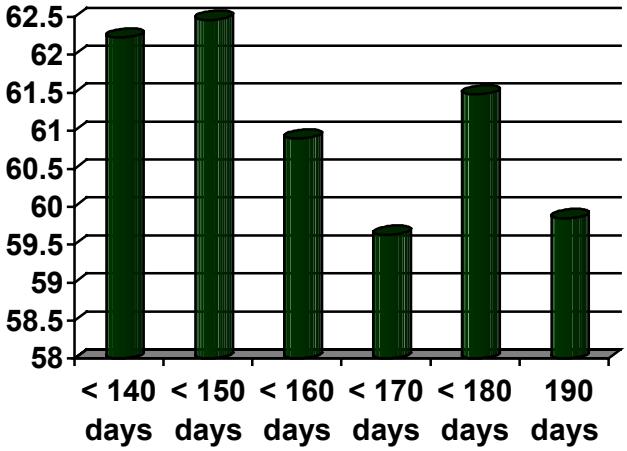
Age	% of Pigs	Cumulative %	Avg. Car. Weight
Less than 140 days	7.1 %	7.1 %	89.28
141 to 150 days	12.6 %	19.7 %	89.46
151 to 160 days	29.1 %	48.8 %	90.63
161 to 170 days	30.8 %	79.6 %	86.34
171 to 180 days	13.2 %	82.8 %	94.98
Greater than 180 days	7.2 %	100 %	85.58

The correlation between days to market and carcass weight was actually very low at only –0.08. Typically, it is assumed that the fastest-growing pigs are the fattest. The correlation between days to market and backfat depth was only slightly larger at –0.17, indicating only a modest relationship between growth rate and fat levels in this dataset. That finding is also confirmed in the following graph which shows the trend in backfat depth relative to days to market:



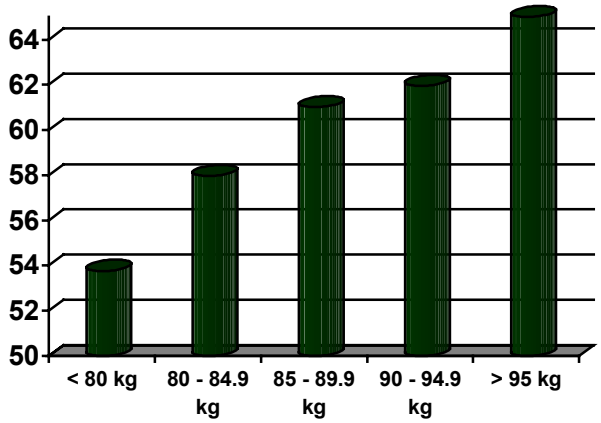
Relationship between days to market and backfat depth

There was also no clear relationship between days to market and loin muscle depth as depicted by the following graph. The correlation between the two traits was low at only –0.11:



Relationship between days to market and loin muscle depth

The correlation was much higher, however, between loin muscle depth and carcass weight at 0.45. The close relationship between the traits is clearly depicted in the following graph:



The following table provides the overall averages for the trial:

Trait	Average	Minimum	Maximum	S.D.**
Days to Market	159.51	129	189	12.016
Lean Gain per Day*	403	288	540	48.497
Carcass Weight	88.69	69.2	118.8	7.550
Backfat Depth	21.50	8.0	37.0	5.274
Loin Muscle Depth	60.29	28.0	79.5	6.778
Est. Lean Yield	59.45	54.9	65.8	2.066
Carcass Index	103.41	10	114	15.798
% Lean in Loin	51.51	39.76	64.15	3.557
% Lean in Ham	65.91	54.48	75.39	3.219
Belly Yield	64.69	53.78	73.53	3.592
Loin Colour	3.16	1.5	5.5	0.750
Loin Marbling	1.80	1.0	4.0	0.865

* from 30 kg to market weight

** describes the amount of variation in the trait

Nutritional Effects on Pork Quality

Ira Mandell
Department of Animal & Poultry Science, University of Guelph
Guelph, Ontario N1G 2W1
Tel. (519)-824-4120, Ext. 5-3337 Fax. (519)-767-0573 E-mail: imandell@uoguelph.ca

Carcass, processing, and eating quality of pork is affected by numerous factors including breed, genotype, feeding, pre-slaughter handling, stunning, slaughter method, chilling, and storage conditions. Genetic effects on pork quality have been well known with studies pointing out that the presence of halothane and RN genes can deleteriously affect eating quality of pork. Antemortem preslaughter handling of pigs from farm to slaughter can significantly impact pork quality along with how the carcass and meat are handled after slaughter. Over the last 10 years, researchers have started investigating how processing and eating quality of pork can be influenced by long term feeding and short term modification of finishing diets prior to shipping hogs to market.

Source and amount of carbohydrate in the diet have been investigated to reduce the incidence of poor pork quality. Dark, firm , and dry (DFD) pork can arise due to the depletion of muscle glycogen stores during transport and lairage. The feeding of high amounts of sucrose for a few days prior to slaughter increased muscle glycogen stores such that development of DFD pork was prevented though moderation of ultimate pH. Conversely, this feeding strategy may increase the incidence of PSE pork depending on the genetic background of the pigs being fed. The feeding of low digestible carbohydrate diets with high amounts of fat and protein has been used to decrease muscle glycogen stores for the prevention of PSE pork. By lowering muscle glycogen stores at slaughter, rate of pH decline may be reduced with impacts on rates of lactic acid production, decreasing protein denaturation and improving water holding capacity of muscle.

Another approach to modifying hog finishing diets short term prior to slaughter is by increasing dietary concentrations of specific minerals or vitamins. The mode of action with this approach is to reduce stress in pigs at slaughter. Short and long term feeding of various magnesium compounds has been shown to improve pork quality by counteracting stress-induced release of hormones in the pig which act to alter muscle metabolism during the conversion of muscle to meat. As little as 1 day feeding of supplemental magnesium increased pH, and decreased drip loss and muscle lightness when compared to pork from pigs fed the control diet. An added value of magnesium supplementation may be increased marbling scores; this has also been the case with chromium supplementation where marbling was increased along with improved water holding capacity. The actions of short term feeding of chromium may be related to alleviating short term stress but the mode of action is unclear. Betaine has been added to increase the ultimate pH of pork and improve water holding capacity; an added benefit of betaine supplementation has been better utilization of feed energy. The addition of niacin to the diet has increased muscle pH after slaughter , while improving water holding capacity and pork color. These effects have been linked to niacin possibly decreasing muscle glycogen stores and resultant production of lactic acid after slaughter.

Vitamin E supplementation of beef cattle has long been known to protect lipids and cholesterol from oxidation, increasing shelf life, and preventing the development of off-flavors. While Vitamin E supplementation of beef cattle has been known to consistently maintain color stability in beef, this is not necessarily the case with pork. Muscle glycogen concentrations increased with Vitamin E supplementation in one study, increasing drip loss (decreasing water holding capacity). In contrast,

megadoses of Vitamin E along with a cocktail of other vitamins and minerals have been found to decrease rate of pH decline after slaughter, decreasing the incidence of PSE pork.

The use of dietary modification of hog finishing diets to improve pork quality has resulted in varying success rates. The addition of a specific vitamin or mineral to a hog finishing diet may improve pork quality in one study with no effects in a second study. These inconsistent results may be providing evidence that the additive in question may not be able to provide consistent responses for improving pork quality. However, this lack of consistency may also be due to different hog genetics between studies where the additive in question can not elicit the same response in reducing stress across a wide range in differences in animal metabolism. We at the University of Guelph are planning to conduct extensive research in developing a nutritional program for reducing stress in pigs going to slaughter in order to improve pork quality for the wide range of hog genetics found in Ontario.

Towards identifying genes important in disease resistance, growth performance, and behaviour in pigs: a functional genomics approach

Project Leader: Dr. E. James Squires
Dept. of Animal and Poultry Science, University of Guelph
jsquires@uoguelph.ca, Phone 519-824-4120 ext 53928, fax 519-836-9873

Collaborators: Dr. Kees de Lange, Dr. Cate Dewey, Dr. Tina Widowski, Dr. Julang Li (University of Guelph) and Dr. Joshua Gong (Agriculture Canada).

Introduction

The goal of this research is to identify genes that affect economically important traits in pigs. We will achieve this goal using newly developed microarray technology to investigate differences in gene expression associated with these traits. We report here on phase 1 of this study - the validation of the use of human microarrays for use with pigs

Under commercial conditions, pigs typically only achieve 60 to 80% of their genetic (lean tissue) growth potential. Obviously, this loss in production efficiency represents a substantial cost to the Ontario Pork industry. An understanding of how, when and which external stressors (disease, thermal, social, insufficient nutrient intake) contribute to this loss in production efficiency would allow us to reduce the negative impact of these stressors on pork production efficiencies. New microarray techniques are now available that will allow us to monitor which genes are actively expressed and which are silenced in different tissues of individual pigs at various stages of growth, or under disease stress, or in pigs that exhibit undesirable behaviours. This presents an extremely powerful tool to identify: (1) critical genes that influence growth performance and that are silenced in stressed pigs, (2) what genes are responsible for disease resistance, (3) what are the genes that lead to undesirable behaviours, (4) what the critical stressors are that control expression of genetic performance potentials (5) the critical periods in a pig's life when environmental stresses are most damaging to lifetime performance of the pig, (6) pigs which have compromised performance potentials, so that subsequent management can be modified for these pigs (separate them, euthanize them, adjust feed formulation) and (7) the means to restore expression of key genes that increase expression of performance potentials and (8) evaluate gene expression before and after gene manipulation, including gene transfer between organisms and cloning.

Microarrays are readily available for humans and laboratory animals but are not yet widely available for many commercial species, including pigs. The technology can also be quite expensive (up to $1000 per array), but we obtain our microarrays at cost from the Ontario Cancer Institute (OCI) through funding from the Ontario Research and Development Challenge Fund. These microarrays are made using human genes, but our preliminary experiments suggest that they may be suitable for work with pigs. The immediate objective of this study was to validate the use of human microarrays for pig work, so that we can then use them to identify the genes that are responsible for economically important traits.

Methods

Microarray technology is based on the knowledge that single-stranded DNA can hybridize (bind) to another piece of single-stranded DNA. It is a high-throughput technique with as many as 30,000 or more genes of known sequence can be spotted on a single microscope slide. In a typical microarray experiment, RNA is isolated from tissue samples obtained from two different animals that vary widely in the trait of interest (eg. disease resistance), and the RNA is converted to a single-stranded DNA sequence (cDNA). The two samples are labeled with different coloured dyes, Cy 5 and

Cy 3, so that both samples can be mixed together and hybridized to the same microarray allowing for a direct comparison between samples. The cDNA from the samples binds to the DNA on the slide and a laser scanner is used to measure the intensity of the green and red colour in each spot. Those spots that have more red colour represent a gene that is expressed more in the Cy 5-labelled sample, spots showing more green are more highly expressed in the Cy 3-labelled sample, spots that are yellow show equal expression in both samples, and spots that are black represent genes that are not expressed in either sample. This technology allows us to screen thousands of genes simultaneously between two samples to identify with genes are expressed in a particular tissue of animals under different conditions.

Microarrays consisting of 1,718 human genes spotted in duplicate on glass microscope slides were obtained from The Microarray Centre, Clinical Genomics Centre, University Health Network, Toronto, ON and used in this work. Testis samples were obtained from 100 kg Yorkshire boars and frozen at -70C until used.

Results

In our first experiment, we asked whether RNA from pig testis would produce a signal on a significant number of genes on the microarray. Using the pig testis sample, approximately 89 % of the total number of spots on the microarray had signal intensities of greater than two standard deviations above background. When human RNA was used fro comparison, 93% of the total DNA spots on the array had intensities greater than two standard deviations above background. This suggests that human microarrays can be used for pig samples.

We next wanted to know if the microarrays were sensitive enough to detect differences in gene expression that could be measured using other laboratory methods. For this work, we used a marker gene, cytochrome b5, which was present on the microarrays. We selected testis samples with either high or low levels of cytochrome b5 as determined by Western blotting. We then confirmed that levels of mRNA for cytochrome b5 in the samples were either low or high using the sensitive method of Quantitative Real Time PCR. Six microarray hybriizations were then conducted using these samples. The microarray results show that cytochrome b5 was 1.8 fold higher ($P < 0.05$) in the high cytochrome b5 sample, verifying the difference detected by quantitative real-time PCR.

Analysis of the standard deviations of each gene across the six arrays was used assess the reproducibility of the data. The average Log_2 ratio of the majority of genes (1643) falls within 1 standard deviation of the mean, indicating the data was reproducible. We then wondered if the variability in the microarray data was related to differences in the homology between human and pig gene sequences. In particular, we wanted to know if there was a relationship between low sequence homology and high standard deviation. Our analysis showed that there was no correlation between sequence homology and expression variability.

Conclusion

This report represents a pre-validation of cross-species microarray hybridizations. The results show that the human arrays have sufficient sensitivity and specificity to detect a known gene expression difference between two samples from pigs. Analysis of the standard deviations of the expression ratios shows that the human microarrays generate reliable and reproducible results, and are a suitable starting point for the analysis of gene expression in pigs. As more sequence data becomes available from various genome projects, these species-specific arrays will become more commercially available and at a reasonable cost to researchers.

Canadian Research Network on Bacterial Pathogens of Swine

Patrick Wolput, Network Manager
Université de Montréal, Faculté de médecine vétérinaire, 3200 rue Sicotte, C.P. 5000
Saint-Hyacinthe (Québec) J2S 7C6
Tel.: (450) 773-8521 ext.: 8421 Fax: (450) 778-8108 e-mail: patrick.wolput@umontreal.ca

Overview

The **Canadian Research Network on Bacterial Pathogens of Swine** is the first collective research effort of specialists in porcine bacterial diseases across Canada. The Network, now approaching the end of its fourth year of operation, regroups more than 31 researchers from 11 research-based institutions across Canada, including the Ontario Veterinary College (OVC), the Atlantic Veterinary College (P.E.I.), the Faculty of Veterinary Medicine of the Université de Montréal (Québec) and the Vaccine and Infectious Disease Organization (VIDO).

The total five year funding period (2000-2005), which represents an investment of more than 4.2 million dollars, is insured at 73% by the Natural Science and Engineering Research Council of Canada (NSERC), at 7% by the provincial hog producer organizations, and at 20% by the private sector i.e. Elanco Animal Health, Pfizer Animal Health and the Institute for Veterinary and Alimentary Biotechnology of the Université de Montréal.

The primary objective of our Network is to establish nation-wide collaborations that foster the sharing of knowledge and expertise in the development of new products destined to improve the health of Canadian swine herds. Our main objectives are: **a)** to study and characterize virulence factors associated with bacterial diseases of swine, **b)** to develop molecular diagnostic tools aimed at more efficient diagnosis of porcine bacterial diseases, **c)** to develop new vaccines and immunization strategies to prevent bacterial diseases of swine and **d)** to train highly qualified personnel by providing opportunities for collaborative graduate studies and post-doctoral fellowships. To fulfill these objectives, the Network has developed 6 research themes:

- Infections caused by *Escherichia coli*
- Infections caused by *Actinobacillus spp*.
- Infections caused by *Streptococcus suis*
- Vaccine Development and Improvement
- Development of Molecular and Immunological Diagnostic tools
- Public Health

We are particularly proud of the work that has so far been accomplished during our first three years of operation. Our team of researchers has the potential to control major bacterial diseases, and ultimately eradicate them through the development and/or improvement vaccines and diagnostic tools. Two provisional patents have been filed, some diagnostic tools have been validated while others are in validation or in preparation, excellent graduate students and post-doctoral fellows are working on different research projects and a bilingual website as well as a bilingual Newsletter and Brochure are available to the public. We believed that the concerted effort on behalf of pork producers and scientists across Canada will yield a net benefit for all parties involved and will assist in maintaining the internationally acclaimed superior reputation of the Canadian pork industry.

Novel Vaccine Delivery Systems for Swine

Philip Willson, DVM PhD, Program Manager (Vaccine Development),
Vaccine & Infectious Disease Organization, 120 Veterinary Road, Saskatoon, Saskatchewan S7N 5E3

Overall Introduction Infections due to mucosal pathogens are among the most common diseases of piglets worldwide and cause substantial economic loss to swine producers. Effective immunity to these infections is based on specific response at the mucosal surface (Bozic *et al.,* 2002). However vaccine formulation and delivery to this surface remains a major challenge. Recent evidence of the regional expression of immune response in the intestinal mucosa using a unique animal model system developed at VIDO supports the importance of delivering antigen directly to the site (targeting) where an effective immune response is desired (Gerdts *et al*., 2001). An alternative mucosal immunization can be achieved by aerosol delivery to the upper respiratory tract (Alcon *et al.,* 2002). This is described below in the section dealing with immune development of the swine upper respiratory tract.

One of the ways to improve the mucosal immune response is by including immuno stimulatory (CpG) DNA motifs in the vaccine formulation (Alcon *et al*., 2003). We have observed a higher immune response and better protection against *Actinobacillus pleuropneumoniae* (APP) challenge when combining the APP OmlA-antigen with certain amounts of CpG DNA. Subcutaneous or combined (subcutaneous and intranasal) immunization using an intranasal device (Alcon *et al*., 2002) induces systemic and nasal antibodies at mucosal surfaces. The impact of oligonucleotides on swine vaccination is described as use of CpG motifs to stimulate immunity in pigs

Another way to use DNA technology to improve vaccines for pigs is by developing platform technology using adenovirus vectors to carry the DNA encoding the relevant antigen(s). The overall approach is to select a common swine virus that causes no disease (porcine adenovirus) and replace non-essential genes with DNA encoding a vaccine antigen to produce an engineered vaccine. The engineered vaccine acts something like a modivied live vaccine; however one significant difference is that MLV can revert to virulence; whereas the engineered vaccine is based on a harmless virus so that there is no potential to become virulent. The steps to produce this novel vaccine are described in development of porcine adenovirus as a vaccine platform.

Effective vaccines require understanding of how the pathogenesis or disease process occurs. The factors of the infecting organism that make it able to cause disease are called virulence factors and these virulence factors often make good candidates for vaccine development. We have been investigating the virulence factors of *Streptococcus suis* in order to identify vaccine targets.

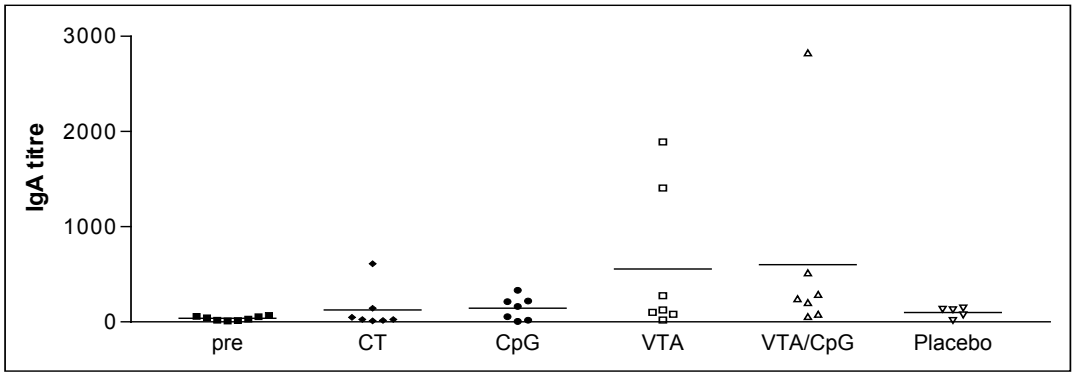
Finally, I conclude with a report of a pilot experiment to demonstrate the practical potential of a low-pressure jet to administer vaccine to swine.

IMMUNE DEVELOPMENT OF THE SWINE UPPER RESPIRATORY TRACT

Introduction Mucosal surfaces are the first point of encounter between many bacterial pathogens of swine and their potential host. Current vaccines delivered subcutaneously or intramuscularly may provide effective systemic immunity, but leave the mucosal surfaces largely undefended against colonization, the first step in pathogenesis. Mucosal delivery of vaccine, such as orally or intranasally, can have the dual benefit of stimulating mucosal immunity and avoiding the hazards of using a needle.

Result and discussion Groups of pigs were given a subcutaneous (SC) initial immunization followed 21 days later with an intranasal (IN) boost with experimental intranasal vaccine. Samples of sera and nasal secretions were taken 10 days after the last immunization to evaluate the immune responses. As

shown in the graph below, the experimental vaccines containing VTA and VTA/CpG formulations resulted in significantly higher antibody levels than placebo or other formulations.



Needle-free administration of a booster to the nasal mucosae after SC immunization was effective for stimulating nasal IgA antibodies. The IgA class of antibodies are the first line of specific immune defence at the nasal surface. This work was presented at the 11th International Congress of Mucosal Immunology, The Society for Mucosal Immunology (SMI), *June 16-20, 2002* Orlando, Florida, USA. Title: Combination of CpG-DNA and Biphasix™ -Vaccine Targeting Adjuvant (VTA-2) promotes strong systemic and mucosal immune responses after subcutaneous and intranasal immunization in a swine model. Alcón V, Vega-López MA, Willson P, Susantha G, Hecker R, Foldvari M, Baca-Estrada ME. The abstract was published in the Mucosal Immunology Update (2002) Vol. 10(2 and 3) abstract 1640.

INDUCTION OF PROTECTIVE MUCOSAL IMMUNE RESPONSES USING NOVEL ADJUVANTS, DELIVERY SYSTEMS AND IMMUNIZATION PROTOCOLS

Introduction Many studies demonstrated the immunostimulatory effects of CpG oligonucleotides (ODN), particularly in mice. In our studies, we evaluated the ability of lipid-based delivery systems to enhance the adjuvant effect of CpG-ODN, protect against pleuropneumonia and limited reaction at the vaccination site. It is important that vaccines for food-producing animals protect against disease while also preserving high meat quality.

Results and Discussion Increased levels of OmlA-specific antibody were detected in animals immunized with OmlA and CpG-ODN formulated in the delivery system Biophasix™-vaccine targeting adjuvant (VTA), compared to pigs immunized with various controls. In addition, the protection induced by VTA/CpG formulation was similar to that induced by the commercial adjuvant VSA; however, VTA formulations caused significantly less tissue damage than VSA. Examination of the tissues revealed that the commercial adjuvant, VSA, caused cell infiltration consisting predominantly of mononuclear cells, and necrosis; in contrast, VTA formulations containing CpG and OmlA induced mild or no inflammation. The degree of inflammation induced by VTA formulations was significantly lower ($P<0.001$) than those induced by the commercial adjuvant VSA.

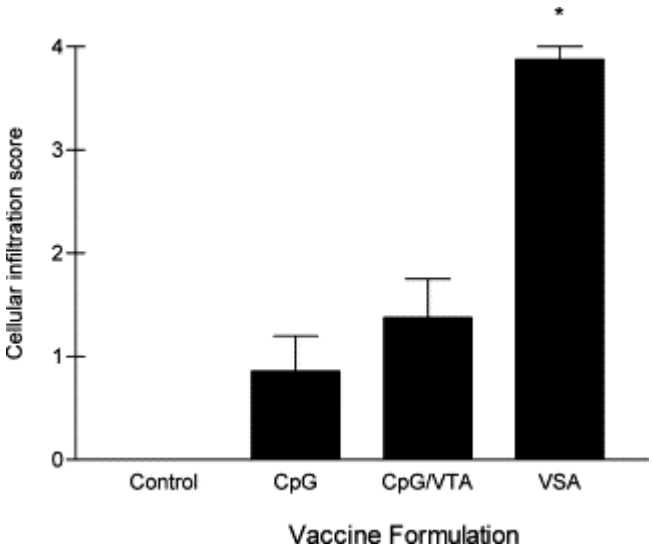


Figure 3. Cellular infiltration induced by VTA and CpG-ODN. Pigs were immunised subcutaneously twice, 21 days apart, and histological examination of the injection site was performed 10 days after the last immunisation. Scores represent mean ± S.E.M. of eight pigs. *P<0.001 vs. all groups.

This has been peer-reviewed and published: Alcon VL, Foldvari M, Snider M, Willson P, Gomis S, Hecker R, Babiuk LA, Baca-Estrada ME. Induction of protective immunity in pigs after immunisation with CpG oligodeoxynucleotides formulated in a lipid-based delivery system (Biphasix). Vaccine. 2003 May 16;21(17-18):1811-1814.

PORCINE ADENOVIRUS-3 (PAV-3) VECTOR BASED PORCINE VACCINES (VIDO)

Introduction The use of vaccines is an effective method of stimulating the naïve animal to develop protective immunity against the disease causing organism. Since many disease causing organisms enter at mucosal surfaces (respiratory and gastrointestinal tract), immunity is required at the mucosal site to block the initial infection and thus reduce the chances of development of disease.

Production of live vaccines is cost effective. However, use of live vaccines produced by conventional means ensures that the live organism is always present in the animals, which many times can mutate back to virulent form (in vivo recombination) and cause fatal disease. Thus, new approaches have to be developed for the efficient delivery and the production of safe and cost effective viral vaccine antigens. One way to achieve this is to develop live vectored vaccines. Such attenuated live viral vectors can be engineered to carry genes for other pathogens thus making it possible to immunize animals to produce protective immunity at the mucosal surface to various disease organisms at one time.

Our recent objectives have been to construct recombinant porcine adenovirus expressing vaccine antigens of disease causing organisms (starting with PRRS) and then test immune response to vaccination and protection from disease.

Results and Discussion Since we could not develop a small animal model for testing PAV3, we tested the safety and immunogenicity of recombinant PAV-3 expressing PRRS proteins in pigs. Five to six week old crossbred pigs seronegative for PRRS were randomly allocated in different groups. All pigs had low serum anti-PAV3 titers. The pigs were vaccinated twice, 25 days apart with recombinant PAV310, PAV312 or PAV300, either oro-nasally or subcutaneously ($5X10^7$ IU / ml). At day 40, all pigs were challenged intranasally with 10^6 $TCID_{50}$ / ml of PRRS virus (ATCC VR-2332). Serum

samples were collected at different times and analyzed for PRRS specific antibodies using HerdCheck PRRS Virus antibody test kit 2XR (IDEXX Laboratories Inc.) and virus neutralization tests.

Very low levels of PRRS specific IgG antibodies were detectable before challenge in animals vaccinated oro-nasally. However, after 13 days post challenge, PRRS specific IgG titers were higher in animals immunized with PAV310 or PAV312 compared to the control (PAV300) group. After 21 days post challenge, the PRRS IgG titers of animals immunized with PAV310 or PAV312 were the same as the control (PAV300) group. Similarly 13 days post challenge, PRRS specific IgG titers were higher in animals immunized subcutaneously with PAV310 or PAV312 than the control (PAV300) group. Interestingly, PRRS specific IgG titers remained higher in animals immunized subcutaneously with PAV310 or PAV312 compared to the control (PAV300) group .

At 13 days post challenge, few pigs vaccinated oro-nasally developed PRRS virus neutralization antibodies. At 21 days post challenge, pigs immunized oro-nasally with PAV310 developed a higher PRRS virus neutralization response compared to the control (PAV300) group. However, pigs vaccinated subcutaneously developed weak PRRS virus neutralizing antibody response even after 21 days post challenge. Only one pig from each group (PAV310 or PAV312) showed high levels of PRRS virus neutralizing antibodies.

After challenge, pigs developed mild fever. There was no difference in rectal temperatures of animals vaccinated oro-nasally or subcutaneously. In addition, lungs showed changes consistent with interstitial pneumonia. However, there was no evidence of proliferation of type 2 pneumocytes or necrosis (alveolar or bronchiolar). We have been awarded one patent and have filed three additional patents on use of PAV3 as a live virus vector.

VIRULENCE FACTORS OF STREPTOCOCCUS SUIS TYPE 2

Introduction Serotype 2 *Streptococcus suis* infection can cause meningitis, septicemia, arthritis, and sudden death in young pigs. The virulence factor(s) of *S. suis* remain unclear. We have identified a DNase that is produced by virulent strains of S. suis and may be involved in pathogenesis

Results and Discussion We have identified a cell wall-anchored DNase of *Streptococcus suis* serotype 2: A secreted nuclease enzyme, SsnA, was identified in the virulent *S. suis* isolate SX332, and subsequently in each of the type strains of capsular serotypes 1 through 9. Screening of 258 porcine clinical isolates from surface (nasal mucosa or palatine tonsil) or internal (joint, brain or other internal organ) locations revealed a significant relationship ($p<0.001$) between expression of nuclease and isolation from an internal site. A 3126 bp gene, encoding SsnA, was cloned from a phenotypically nuclease negative mutant, and analysis of the predicted SsnA sequence revealed a 35 aa secretion signal sequence, a 22 aa DNA-binding domain, and a typical Gram-positive cell wall sorting motif. A requirement of Ca^{2+} and Mg^{2+} for SsnA activity was determined, and the substrate specificity was found to be for single- and double-stranded linear DNA. RT-PCR experiments revealed that *ssnA* is expressed throughout all stages of *S. suis* growth, and Western blots with porcine anti-*S. suis* immune sera against a recombinant, truncated SsnA derivative (rSsnA□) confirmed that SsnA is expressed *in vivo*. Furthermore, anti-rSsnA□ antibodies were sufficient to neutralise SsnA activity. Analysis of subcellular fractions of SX332 and derived mutants, on DNA-containing polyacrylamide gels and by Western blot, revealed that SsnA is cell wall located This work has been peer reviewed and accepted for publication Fontaine MC, Perez-Casal J, Willson PJ. Investigation of a novel DNase of *Streptococcus suis* serotype 2. Infect Immun. In press.

PRACTICAL NEEDLE-FREE VACCINE DELIVERY

Introduction This vaccination and challenge experiment was designed to demonstrate protection in pigs vaccinated at 6 and 9 weeks of age with Pleurostar-APP® delivered by Agro-Jet™ or conventional IM routes and challenged at 10 weeks of age with *Actinobacillus pleuropneumoniae* serotype 1 (strain AP-37). A secondary objective was to measure the amount of residual vaccine left on the skin surface after each method of administration.

Healthy, crossbred piglets from an *A. pleuropneumoniae*-free herd without previous vaccination against *A. pleuropneumoniae* were used. At approximately 5 weeks of age, the piglets were randomly assigned to 2 vaccination groups of 8 pigs per group. These experiments were done with the approval of the University of Saskatchewan Animal Care Comittee and have been assigned protocol number 20020026.

The commercial vaccine PleuroStar-APP®, was administered intramuscularly to the IM group using a 1" x 18 ga needle and was administered to the AJ group using Agro-Jet® at a pressure of 220 psi. Pigs were vaccinated at 6 weeks of age (Day 0), and 3 weeks later (Day 21). An absorbant cotton swab (Swube) was applied to the vaccination site immediately after the vaccine was administered. The amount of residual vaccine remaining on the skin surface was determined as the change in weight of an absorbent cotton swab.

Results and Discussion All pigs were housed together in a pen and five pigs from both treatment groups were exposed to the aerosol as a group. The challenge consisted of exposing the pigs to aerosols generated from a suspension of bacteria 5.3 x 10^5 CFU/mL of *Actinobacillus pleuropneumoniae*, serotype 1 for 10 minutes while the pigs were confined in a plexiglass chamber. Confirmation of lung infection in pigs was not associated with the challenge group ($p > 0.8$).

The antigen-specific IgG1 and IgG2 subclasses were measured separately. The group mean antibody titres of these sub-classes at each time point (first immunizatioin, booster immunization and challenge) are illustrated in Figures 4 and 5. As expected there was a very significant ($p < 0.001$) effect of time on the antibody response and all vaccinated pigs seroconverted (more than four-fold increase in titre). There were no significant effects of treatment group or interaction of treatment group with time for the immune response to OmlA (Fig. 4) or ApxII (Fig. 5).

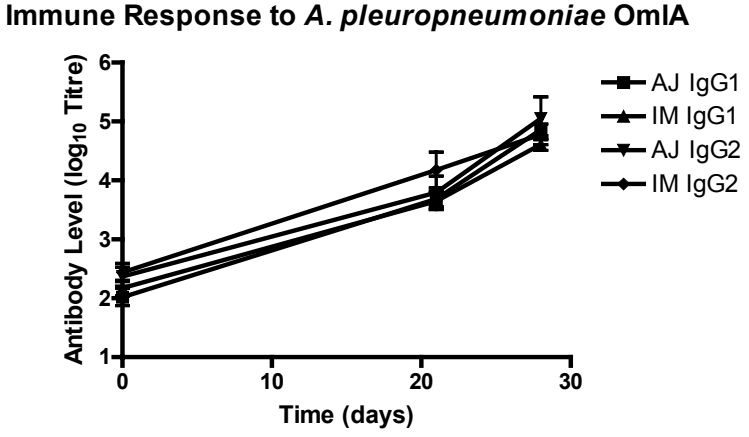


Figure 4

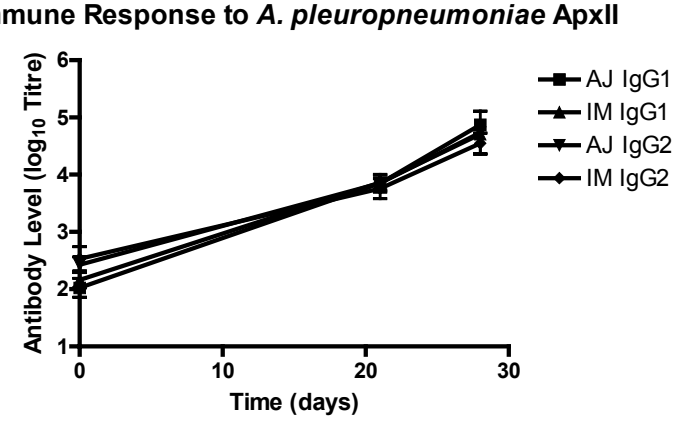


Figure 5

The average mass of vaccine swabbed from the skin surface after immunization administered by IM needle injection was 2.1 mg (StDev 0.6). The amount swabbed from the skin surface after

immunization using Agro-Jet® was much greater 124 mg (StDev 49). Note that the Agro-Jet® application was done without optimization for skin penetration.

Table 1. The vaccinated pigs that received vaccine by either route were equivalently protected from death and disease. In addition, clinical disease was significantly less in the group of pigs that received vaccine using the Agro-Jet® .

		Treatment Groups		Significance
		AGRO-JET®	NEEDLE IM	p
Mortality (Dead/Total)		2/7	4/8	> .6
Sick Days (median)		0.0	3.5	> .4
Clinical Score	Day 1	0.6	1.0	< .05
	Day 2	1.4	2.3	
	Day 3	1.4	2.0	
	Day 4	1.3	2.1	
	Day 5	1.1	2.1	
	Day 6	1.3	2.1	

In summary, there were no post-vaccination reactions in the pigs given the commercial vaccine by either technique that were attributable to the vaccination process. Significantly more vaccine material remained on the skin after vaccination using Agro-Jet® compared to needle injection; however the vaccine was administered without optimization for skin penetration. All immunized pigs seroconverted to both antigens tested and developed a significant antibody titre after the second immunization. There was a tendency for pigs immunized by the Agro-Jet® to have higher IgG2 titers to both antigens; however the difference was not significant. There was a tendency for pigs vaccinated using the Agro-Jet® to have better survival, lower mortality and fewer sick days; however these differences were not significant. The Agro-Jet® treatment group had significantly ($p<0.05$) lower clinical score after challenge. Postmortem examination showed that pigs immunized using the Agro-Jet® tended to have less pneumonia and a lower rate of infection; however these differences were not significant. Hence, pigs immunized using the Agro-Jet® developed protective immunity that was as good as or better than was developed by pigs immunized using a conventional needle and syringe.

Funding Sources: Ontario Pork, Manitoba Pork Council, Sask Pork, Alberta Pork, Alberta Agricultural Research Institute, Saskatchewan Agriculture Development Fund, Canadian Network for Bacterial Pathogens of Swine, NSERC, HSRUC PDF Fellowship & commercial partners

Researchers: V.L. Alcon, L. Babiuk, M Baca-Estrada, A Ficzycz, M. Foldvari, M Fontaine, S. Gomis, R. Hecker, J van Kessel, S Lun, J Perez-Casal, M Singh, M. Snider, S Tikoo, M. Vega-Lopez, P. Willson, L Xing, A Zakhartchouk

Ontario Pork 2003 Research Projects

Ontario Pork

Researcher Cate Dewey
Title Improving health and growth performance of newly weaned piglets without the use of in-feed antimicrobials.
Synopsis
This is additional funding to the project approved last year. The additional funding is for the probiotics aspect of the project. The overall aim of the complete project approved in 2002 is to improve health and growth of nursery pigs in the absence of routine antimicrobial medication. The complete study will determine:
I - the effect of feeding (a) specific mixtures of dietary acids, (b) varying diet fermentable protein levels and (c) pre and probiotics targeted towards E. coli and salmonellas, on performance of newly weaned pigs exposed to E. coli and on the presence of harmful bacteria in feces;
II - the immune status, histology and microflora in the various segments of the gut in subsamples of pigs used in the performance studies;
III - the timing of respiratory disease outbreaks in nursery barns and the best time to target pulse medication.

Researcher Ming Fan
Title Assessing the Impact of Low-Protein Feeding in Pigs on Reducing Detrimental Impacts on the Environment
Synopsis
Dietary protein, as the major source of nitrogen and sulfur, is responsible for the production of ammonia, volatile sulfides, and other odorous compounds in swine manure. Application of a low-protein feeding regime is a major dietary strategy to decrease the major adverse environmental issues associated with the pork industry.

Researcher Jim Morris
Title Separated drinking water from liquid manure for swine
Synopsis
A study involving the 3 water treatments (regular tap water, half tap water and VSEP permeate, and VSEP permeate) is planned. A minimum of 24 pigs will be allocated to 6 pens of 4 pigs each. All pens will be balanced for sex with 2 barrows and 2 gilts being allocated to each pen. The data collected will include initial and weekly body weights, daily feed consumption and feed consumption on a pen basis. Mortalities and there cause will be recorded. Morbidity of the pigs will be assessed in several ways including their growth performance, frequency of treatment and the levels of feed consumption. The cost of gain will be determined for each pen. All data will be subjected to appropriate analysis of variance procedures.

Researcher Simon Yang
Title Integrated Modeling Techniques for Odours from Pork Production Systems
Synopsis
This project is to develop an enhanced electronic nose to reliably measure odours in and around swine facilities. Integrated modeling techniques for odour emissions from Ontario pork production systems will be developed for the intelligent electronic nose and to achieve a systematic understanding of the complex odour emission problem.

Researcher Wayne Caldwell
Title Conflict Resolution in Rural Ontario: Strategies for Responding to the Intensification of Agriculture
Synopsis
The research will focus on environmental issues related to agriculture in Ontario. If we are not more successful in the management of conflict, agricultural production will be increasingly threatened by poor community relations. This research will provide the following tangibles:
- The research will monitor different approaches and the success of local conflict resolution and identify best practices.
-The experience of the farm community with the Farm Practices Protection Board and the Ontario Municipal Board will be documented and analyzed.
-The research will evaluate the opportunity for local committees to assist in mediating disputes as envisioned under Bill 81 - The Nutrient Management Act.
- A manual will be prepared to assist local initiatives to mediate agricultural disputes. This will occur in the context of the Nutrient Management Act. Parallel materials will be established for farmers as a guide to these processes and more formal hearings (such as FFPPA).

Researcher Ron Fleming
Title Survival of Pathogenic Bacteria in Liquid Manure Storages
Synopsis
On-farm project involving 20 swine farms - liquid manure samples collected throughout the year, and levels of three types of bacteria measured.

Researcher Suzanne Millman
Title Effects of synchronized resting behaviour on the well-being, health and performance of newly weaned piglets
Synopsis
Behaviour of piglets is highly synchronized due to hourly intervals of nursing by sows which sets the rhythm for feeding, resting and activity. Hence, in addition to nutrition, sows provide for the behavioural needs of their piglets. Rest is critical for digestion, growth and recuperation from stress, and forms an integral aspect of an

animal's behaviour response to infection. Due to the behavioural immaturity of young piglets, absence of the sow to cue appropriate behaviour likely results in disrupted and insufficient rest, and poor appetite in piglets. Observations of litters in the presence and absence of sows will provide data about time budgets of young piglets and management interventions(lighting intervals) will be developed to help piglets, particularly unthrifty piglets, cope with stresses of weaning.

Researcher Serguei Golovan
Title Artificial Insemination Mediated Modification Of Pig Genome
Synopsis
We will attempt to use methods of AI-mediated modification to add a new gene (phytase) to pig genome and in separate experiments to modify two economically important genes: fucosyl transferase, which should produce pigs resistant to pathogenic Escherichia coli F18, and myostatin, which may lead to pigs with the "doubled-muscled" phenotype with increase in muscle mass, and an improvement in lean meat and tenderness.

Researcher Hugh Cai
Title Field validation of a Mycoplasma hyopneumoniae PCR assay
Synopsis
In our 2001/2002 project funded by the Ontario Pork and OMAF, we developed a PCR assay for the detection of M. hyopneumoniae in swine lung tissue. We completed analytical validation and a small-scale field validation of the assay. In this proposal, we propose to further validate the assay using a large number of field samples. Swine lung tissues from 200 cases (1-3 specimens/case) will be tested using the M. hyopneumoniae PCR assay in parallel with the fluorescent antibody (FA) tests, currently the most sensitive diagnostic method. Statistical analysis will evaluate the clinical sensitivity and specificity of the PCR assay.

Researcher Patrick Boerlin
Title Molecular Edipemiology of Antimicrobial Resistance in Pathogenic and Commensal Escherichia coli from Pigs in Ontario
Synopsis
Assess antibiotic susceptibility of E. coli using internationally recognized methods. Identify resistance and virulence genes found in E. Coli from pigs using molecular methods. Assess links between ability to cause disease and antibiotic resistance with statistical and molecular methods.

Researcher Robert Friendship
Title Sentinel Herd Project Continued
Synopsis
One hundred herds representing the Ontario pig industry will be visited for a third consecutive year to collect samples and management information. Analysis of samples will be preformed to establish benchmark data for disease prevalence.

Researcher Jim Squires
Title Towards identifying genes important in disease resistance, growth performance, and behaviour in pigs: a functional genomics approach
Synopsis
Key genes will be identified to determine if a pig is affected by, or is susceptible to, disease pathogenes (PRRS and mycoplasma), or specific environmental stresses, or undesirable behaviours that can compromise growth performance and welfare.OBJECTIVES OF THE RESEARCH

Researcher Mario Jacques
Title Canadian Research Network on Bacterial Pathogens of Swine
Synopsis
The Network is focusing on major pathogens of swine: E. coli, A. pleuropneumoniae, A. suis, H. parasuis and S. suis. Collaboration with Researchers across Canada in the development of diagnostic tools and vaccines.

Researcher Mary Buhr
Title Ontario Summers and Boar Semen Quality
Synopsis
Lean modern boars just past puberty will be held for 10 days at 30+ ° C and high humidity (or 23 ° C and moderate humidity; Controls). Semen quality and quantity will be evaluated intensively for 6 weeks. Commercial semen producers will be asked to share, anonymously, appropriate data which we will analyze and compare to the experimental findings

Researcher Roger Hacker
Title Solving the stillbirth and small piglet mortality problem
Synopsis
The Researchers will attempt to decrease piglet mortality by treating small piglets so as to enhance their ability to compete, so that treated small piglets will wean with equal status to littermates. The proposed experiment will also determine true stillbirths by checking stillborn lungs and studying farrowing sow behaviour.

Researcher Cate Dewey
Title Trouble shooting reproduction problems in Ontario swine herds
Synopsis
The purpose of this project is to identify the most common causes of poor reproductive performance in Ontario Swine units. Forty farms that are experienced poor farrowing rates will be evaluated to determine the most likely factors impacting the performance. Both infectious diseases and management practices will be included in the evaluation. Farm visits by a herd health veterinarian and a breeding barn technician will include data collection on estrus detection and breeding, vaccination protocol, housing and moving of breeding animals, laboratory tests for infectious diseases, and semen evaluation if AI is used on the farm. Further analysis will include a complete examination of reproduction records. (PigCHAMP or

PigWin)

Researcher Cate Dewey
Title Understanding the impact of early weaning on the reproductive performance in Ontario swine herds
Synopsis
The purpose of this project is to examine the relationships between reproductive performance as measured by farrowing rate and litter size and management changes that have occurred in the swine industry. Specifically the factors of interest include; shorter lactation lengths, longer weaning to breeding intervals, artificial insemination, fewer number of matings per estrus, "blanket" breeding on a specific day post weaning, large herd size, high culling rates, and high mortality. For this project, we will analyze existing production records, either PigCHAMP or Pig WIN.

Researcher Heidi Engelhardt
Title Protozoal parasites in the Pregnant Uterus: A New Porcine Pathogen
Synopsis
In cell suspensions prepared from pig uterine tissue, we have discovered a microbe closely resembling Trichomonas, a parasite associated with infertility and abortion in cattle and humans. This proposal establishes techniques that are required to determine whether this organism is also implicated in reproductive failure in the pig.

Researcher Ken McEwan
Title The Economic Impact of Country of Origin Labeling on the Ontario Pork Industry by the United States
Synopsis
To examine the implications of the U.S.'s Country of Origin Labeling on the Ontario pork supply chain

Researcher Harold Gonyou
Title Gestation Housing for Sows: Studies on Electronic Sow Feeders and Stalls
Synopsis
The four studies will examine questions critical to the management of pregnant sows in both group housing and stalls. These questions are directed at reducing social stress in groups, and issues of crowding in stalled sows.

Researcher George Lazarovits
Title Optimization of liquid swine manure for control of soilborne diseases of high-value crops
Synopsis
1) Determine why LSMs from different sources have different amounts of volatile fatty acids,
2) formulate LSM to improve its efficacy to reduce disease
3) minimize health risks by eliminating animal and human pathogens from LSM, and
4) develop inexpensive methods for removal of water from pasteurized manure.

Researcher C.F.M. de Lange
Title Liquid Feeding of Swine: Potential for Reducing Environmental Impact & Improving Productivity and Food Safety
Synopsis
1. To explore and assess beneficial effects of liquid feeding technology (control and
flexibility in developing feeding programs, gut health, carcass and pork quality, nutrient
excretion, animal well-being, production efficiencies) that may be transferred to dry feeding
systems.
2. To further support development of liquid feeding technology for swine in Ontario.

Researcher Ken Hough
Title Fusarium resistance in corn through biotechnology
Synopsis
Research Objectives and Anticipated Deliverables:
I - Genetic Modification of Corn for Improved Fusarium Resistance.
II - Development and Application of Molecular Markers for marker-assisted selection of fusarium-resistant corn.

Researcher Bonnie Mallard
Title Sequencing of Swine Leukocytes Antigen (SLA) Genes and Microarray Analysis of Differential Gene Expression Following Tolerance Induction to Xenografts Derived from Canadian Yorkshire Pigs
Synopsis
Pigs offer a potential source of tissues for use in transplantation medicine where human donations fall significantly short of clinical demand. Ontario is a world leader in transplantation medicine and xenotransplantation research, yet it lacks a source of SLA - defined pigs for use by the Guelph-London transplantation research group in which the University of Guelph leads the efforts to develop a pig transplant model that will aid in tolerance induction. Major histocompatibility complex (MHC) antigens (known as swine leukocyte antigens in pigs) are the primary targets of immunololgical rejection. Currently there are no complete coding sequences available for MHC alleles in Canadian pig breeds. Direct sequencing of MHC genes from three breeding pairs in an Ontario pig herd will allow a small SLA-defined colony to be established. Secondly, development of a microarray database derived from transplanted pig tissues may allow candidate genes associated with graft survival to be identified. This would provide clues about the mechanisms of zenograft rejection and more precisely identify the criteria used in the selection of donor pigs. This research was funded because of the genetic information that will be gathered, that can be utilized in further health studies.