



PRAIRIE  
SWINE  
CENTRE

Research Profits Everyone

# 2011

# Annual Report



*Celebrating* **20** *Years*  
OF INNOVATION





## **MISSION STATEMENT**

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

# Table of Contents

|  |    |   |    |
|--|----|---|----|
| <b>2011 Report Highlights</b>  | 4  |   |    |
| <b>REPORTS</b>   |    |   |    |
| Chairman's Report  | 6  |   |    |
| President's Report   | 7  |   |    |
| Technology Transfer Report   | 9  |   |    |
| Operations Manager Report  | 11 |   |    |
| <b>MANAGEMENT</b>  |    |   |    |
| Friends of the Centre  | 12 |   |    |
| Corporate Objectives   | 13 |   |    |
| Research Objectives  | 14 |   |    |
| <b>ENGINEERING</b>   |    |   |    |
| Using Zinc Oxide Nanoparticles to Control Emissions - Pig Performance, Manure Properties, and Production Cost      | 15 |   |    |
| Evaluation of Heat Exchanger, Ground Source Heat Pump, and Conventional Heating Systems in Swine Grow-Finish Rooms | 18 |   |    |
| Reducing Water Consumption in Swine Barns: Alternatives for Animal Drinking and Barn Cleaning                      | 21 |   |    |
| <b>MANURE MANAGEMENT</b>   |    |   |    |
| Impact of Repeated Applications of Liquid Swine Manure and Biogas Production By-Products on Soils and Crops        | 24 |   |    |
| <b>ETHOLOGY</b>  |    |   |    |
| Assessment of Lameness, Productivity and Longevity in Group and Individually Housed Gestating Sows                 | 26 |   |    |
| Loading Facilities for Market Hogs: Saskatchewan's Top 10  | 29 |   |    |
| Effect of Transport Duration on the Stress Response and Pork Quality of Pigs                                       | 32 |   |    |
|  |    | <b>NUTRITION</b>  |    |
|  |    | Dietary Omega-6 to Omega-3 Fatty Acid Ratios Affect Body Fat Mobilization During Lactation in High Producing Sows | 35 |
|  |    | Creep Feed Provision in the Farrowing Room Provides Benefits to Piglets Showing Evidence of Intake                | 37 |
|  |    | Determining the NE Content of Diets and Ingredients   | 39 |
|  |    | The Efficiency of Energy Utilization by Growing Pigs Selected for Potential Growth Rate                           | 41 |
|  |    | <b>PUBLICATIONS LIST</b>  | 44 |
|  |    | <b>FINANCIAL SUPPORT</b>  | 48 |

# 2011 Report Highlights

*Mixing Zinc Oxide to Reduce Hydrogen Sulphide Amounted to 40.2% of the Average Total Cost of Production while Filtering Zinc Oxide Amounted to Only 3.8% of the Total .....page 15*

*After two heating seasons, the use of the heat exchanger and ground source heat pump systems resulted to 54% and 45% reduction in energy consumption .....page 18*

*Using Alternative Water Management Practices could Translate to Savings of \$9.23/pig ..... page 21*

*Rates of raw liquid swine manure or biodigestate of 3,000-4,000 gallons per acre (~75-100 lbs N / acre /yr) per year provided optimum yields .....page 24*

*Lameness is one of the most important welfare issues in sows.....page 26*

*Farms with High Prod use Actually had the Longest Loading Time.....page 29*

*Improvements in truck design and optimization of handling and transport practices will reduce most of the stress experienced by pigs during long transport.....page 32*

*When included correctly into sow diets, n3 fatty acids may have positive impacts on body condition and longevity.....page 35*

*Creep feeding improves weaning and nursery exit weights for those pigs that actually eat it.....page 37*

*Net Energy system provides better characterization of the efficiency with which energy is used for growth and/or production .....page 39*

*Segregating pigs and feeding based on potential growth rate does not improve the ability to match feed to requirements.....page 41*



Prairie Swine Centre circa 1998



Prairie Swine Centre circa 2011

# Chairman's Report

## *Finding Solutions in Challenging Times*

SHANNON MEYERS, Chairman of the Board



The last five years in the pig industry have been interesting to say the least. The last two have been much improved in terms of industry profitability but there are certainly times and segments of the industry that have continued to be challenged. With recent pressure on world wide pork demand and high feed costs, pondering what the future will look like is always interesting.

Yet with all the uncertainties that we have all learned to live with in any business and in particular, the pork business, one key fact seems to stand the test of time. Despite the ups and downs, the best of the best seem to survive and prosper. And if you survey these groups, among other traits, they tend to be adopters of leading edge technology which drives down their costs and improves their revenue.

That point again magnifies the importance of research and development facilities and centers such as Prairie Swine Centre (PSC). PSC has certainly shown its ability to survive and prosper in challenging times while continuing to provide near market research that we can quickly adopt in the industry. As an industry, we need to remember this and continue to support the initiatives of PSC, not only at a local level, but at a national and international level.

Turning to production issues and opportunities, feed conversion continues to sit at the top of the list in terms of cost opportunity. I would like to congratulate PSC staff on their recent webinars to bring the most recent information on feed conversions to the industry. Feed and nutrition has and continues to be a core competency of PSC.

Sow housing continues to dominate discussions wherever you are in the world. The Sow Research Unit at PSC was designed specifically to lead us through the questions we will all face. I would encourage the industry to continue to look to PSC for leadership and guidance in the area of sow housing and to utilize this tremendous barn resource in answering some of the tough questions.

Finally, it is great to see a bolstered team at PSC with the addition of a Manager of Contract Research and a Manager of Information Services. These positions along with some other key team additions have positioned PSC as a leader into the future.

As I step down from the board since my involvement beginning in 2003, I want to thank my fellow board members along with Lee Whittington and all the staff of PSC for their hard work and commitment to success.

All the best in the future,  
Shannon Meyers



*Board of Directors*

*Back Row L-R: Ray Price, Rick Prejet, Dr. Mary Buhr, Dr. Jim Bassinger, Harvey Wagner, Dr. Walter Heuser, Arlee McGrath*

*Front Row L-R: Darcy Fitzgerald, Lee Whittington, Judy Yungwirth, Shannon Meyers*

# President's Report

## *Innovative Research Addressing Industry Challenges*

LEE WHITTINGTON, B.Sc. (Agr) • MBA • CEO / President



This year has been one of rebirth for the Centre. After four years of industry focus on survival it is refreshing to be thinking about growth and development. The Centre has fared well in seeking competitive grants in our areas of traditional strength (nutrition, engineering and behavior) but has also been successfully applying our skills in these scientific disciplines to challenges and opportunities in health, environment and using the pig as a model for human health and nutrition. These are growth areas for the Centre as we seek to take the practical and applied multi-disciplinary science approach developed at the Centre to address a broader scope of industry challenges. This growth in scope of Centre expertise is possible due to the working relationships established with other institutions and industry consultants in Canada and abroad.

Our VISION - To be an internationally recognized source of original, practical knowledge providing value to stakeholders throughout the pork value chain was significantly reinforced this year with new findings. The conclusion of a 5 year project in transportation research involving the combination of 5 institutions and companies in 4 provinces proved to be a powerful formula in defining transport issues and potential solutions. There is an article in this annual report that focuses on which compartments have the greatest influence on meat quality, but perhaps even more significantly the work begins to answer the question of the effect of transport time on welfare and meat quality. In a nutshell, the impact of time in transit was non-existent in summer and very small in winter (see page 32 for more details). Using this multidisciplinary and multi institutional model we have projects that will conclude in the next year on the subjects of sow housing and lameness, development of building and operating standards to drive costs down, the use of filtration to prevent PRRS re-infection, and many more.

Prairie Swine Centre is entering its 20th year in 2012. We are performing a major review of the Centre's programs and outputs complete with external industry and academic review. This is an excellent process at this time in our history, combined with work on our next 5 year plan, questioning the very strategy of why and how Prairie Swine Centre should function in the future. We are planning various industry interviews and on-line evaluations to ensure we have your opinion included in this review process.

My sincere thank you to our staff as they have adjusted well to changing conditions that come with changes in industry fortune, while maintaining their enthusiasm and output of applied and economically relevant information.

I leave the last word for our funding sponsors. They are the reason and the means by which we do what we do. Our many meetings over the fall and winter have resulted in tremendous attendance and some of our best ever scores on evaluations. We thank you for your ongoing support and encourage you to contact our people often – the more time we spend understanding industry challenges, the better we get at providing answers.

Sincerely,  
Lee Whittington  
President/CEO



Lee Whittington speaking at the 2012 producer meeting in Lethbridge, Alberta

**Our Mandate**

To produce and distribute knowledge derived through original research, scientific review and economic analysis.

**Our Vision**

To be an internationally recognized source of original, practical knowledge providing value to stakeholders throughout the pork value chain.

**Our Mission**

We provide solutions through knowledge that ensure a profitable and sustainable pork industry and in so doing secure a prosperous future for our stakeholders and staff.



# Technology Transfer Report

*Providing Producers Answers at Their Fingertips*

KEN ENGELE, B.S.A. • Manager, Information Services



## Reinvesting in the Industry and the Centre...

Prairie Swine Centre like other pork producers needed to tighten their belts to weather the financial storm that hit the Canadian pork industry. Light at the end of the tunnel has pork producers cautiously optimistic regarding what the future of the pork industry holds. As we see producers starting to reinvest in the industry, so too is Prairie Swine Centre.

Over the past number of years Prairie Swine Centre made the difficult, but necessary approach to reduce the communications activity with the industry. This resulted in fewer issues of Centred on Swine being published, fewer producer meetings, conversion of publications such as the Annual Research Report and fact sheets to electronic format; and most substantially no full-time staff dedicated to technology transfer initiatives. Communication initiatives over this time were focused on maintaining our industry presence, largely dedicated to improving our web presence ([www.prairieswine.com](http://www.prairieswine.com)).

2011 marks a turning point for the Technology Transfer program at Prairie Swine Centre. March saw Prairie Swine Centre host 6 producer meetings throughout Alberta, Saskatchewan, and Manitoba attracting more than 200 participants; this was the first series of producer meetings held in more than three years. Another



Swine Innovation Porc



important milestone included filling the position of Manager, Information Services in October. Filling the Manager, Information Services is significant in several ways - not only does it provide dedicated resources to delivering research results from Prairie Swine Centre to the industry; it marks a collaborative effort between CDPQ (Quebec) and Prairie Swine Centre to deliver national Technology Transfer initiatives associated with the Canadian Swine Research and Development Cluster (CSRDC, rebranded as Swine Innovation), as a large proportion of the funding for the Manager position is provided through the Swine Innovation program.

*“Visit us at [www.prairieswine.com](http://www.prairieswine.com) for the latest information”*

Swine Innovation is a multi-year \$9.6 million dollar program established within the Growing Canadian Agri-Innovation Program – Canadian Agri-Science Initiative of Agriculture and Agri-Food Canada, in addition to receiving financial support from private sector and provincial government organizations. Swine Innovation’s objectives are to facilitate research, technology transfer and commercialization initiatives designed to enhance the competitiveness and differentiation of Canada’s pork industry. This is accomplished through focusing on research projects that drive down the cost of production, or enhance the differentiation of Canada’s pork industry.

Prairie Swine Centre’s, Technology Transfer role within Swine Innovation, is to work with the Research Scientists associated with each one of the 14 Swine Innovation projects, articulate the project and deliver key messages through a communication strategy specifically designed for each project. One of the unique ways in which results will be delivered is through the development of a Lead-Users Program. This program will identify short-term results (7 projects have been identified), and to develop a series of on-farm demonstration sites to provide producers first- hand experience with new technologies or management strategies. The

demonstration sites may take the form of an on-farm (commercial) trial examining new feeding programs, a series of open houses looking at new air filtration technology, or a workshop designed to compare objective and subjective measures of sow lameness.

Swine Innovation will continue to play an important role in the Technology Transfer program into the future, but it is one component to ensuring the pork industry has access to the most current and relevant information from Prairie Swine Centre and abroad. Over the next year we will be increasing the frequency and consistency in which we speak to the pork industry, through traditional methods of print, electronic and personal, and non-traditional means such as the Lead-User program.



*2012 Producer Meeting, Lethbridge, Alberta*

### **Communicating with the Industry**

- We continue to focus resources on the development of our website, [www.prairieswine.com](http://www.prairieswine.com). PorkInsight is home to more than 6,000 articles related to pork production, encompassing Prairie Swine Centre research and other material that is relevant to the Canadian pork industry.
- Electronic Newsletters speak to specific opportunities or challenges in the pork industry in the short term. Topics they address are based on discussions our staff have with producers and the industry professionals at conferences, symposiums or meetings. Material within the newsletters will be a commentary format, and is supported by articles found within the PorkInsight database.
- While many of our publications including the Annual Research Report has converted to solely an electronic format, Centred on Swine will continue to be printed and distributed throughout Saskatchewan, Manitoba, Alberta, and Ontario. In recent years, the number of issues published was reduced as a cost cutting strategy. This year will see us incorporate an additional issue, and Centred on Swine will continue to highlight the research program at Prairie Swine Centre.
- Annual producer meetings will continue to be integral part of communicating with the industry. A total of six meetings are scheduled throughout the Prairie Provinces and one in Ontario, where our senior researchers present their newest information. 2011 saw more than 200 individuals from the pork industry attend these meetings. We would like to thank our sponsor Elanco Animal Health for their participation in the meetings.
- Prairie Swine Centre has incorporated the services of SwineWeb.com as a strategy to promote the Prairie Swine Centre brand and increase overall awareness within the North America pork industry. SwineWeb.com is a clearing house for swine related research, commentaries, market reports, and technical information dedicated to the North American pork industry. Currently SwineWeb.com attracts more than 50,000 unique visitors per month, and we will build upon this traffic through the addition of a weekly technical article linked to the PorkInsight database, in addition to posting the bi-weekly electronic newsletter.

Prairie Swine Centre will continue to work with the Canadian pork industry in providing timely, relevant information dedicated to delivering solutions through knowledge, ensuring profitable and sustainable pork industry. As always we encourage feedback from our stakeholders, as this input helps Prairie Swine Centre align future research needs.

# Operations Manager Report

## Managing Increased Productivity

BRIAN ANDRIES, BSA. • Manager, Operations



Production performance over the last fiscal year, July 2010 to June 2011, steadily improved from July 2010 to the end of the year when we hit a slight bump in numbers born alive and a drop in farrowing rate. This happened in June thru August of 2011. No prior changes were made in breeding procedures or breeding staff. The improved market outlook prompted management to increase production by increasing breeding targets from 14 to 16 animals per week, maximizing production in breeding gestation and farrowing. This decision required a slight change to culling procedures and resulted in a few sows being kept that would have normally been culled.

*“Whole herd farrowing rate has improved to 94.7%”*

The sow herd structure has also changed quite dramatically over the last couple years. The facility is operating at full production and implementing “normal” culling practices since September 2011. The percentage of the herd representing gilts to 3rd parity increased from 39% to 44% to 51% for 2009, 2010 and 2011 respectively. The average herd parity is 2.1, the herd’s stability has strengthened, giving us great optimism for things to come in the future.

The National Body of the Canadian Council of Animal Care visited the facility on April 13th, 2011. They tour research facilities every 4 years and make recommendations on facility and animal care in relation to research. They appeared quite interested in the facility and appreciated the construction and materials and equipment used in the sow barn particularly the free-access stalls and loafing areas as well as the different widths of A.I. stalls. They also emphasised the need for a veterinarian to more closely track research in relation to animal care and comfort ensuring no more animals are put on trial than required.

**Table 1.** Production parameters for the 2007-2011 fiscal years\*

| Category                    | 08-09 | 09-10 | 10-11 | 11-12<br>(Jul-Jan) |
|-----------------------------|-------|-------|-------|--------------------|
| Sows Farrowed, #            | 797   | 635   | 686   | 442                |
| Conception Rate, %          | 84.9  | 87.0  | 92.8  | 94.7               |
| Farrowing Rate, %           | 82.9  | 85.1  | 92.7  | 92.3               |
| Avg. Pigs Born Alive/Litter | 11.9  | 12.0  | 12.7  | 12.6               |
| Farrowing Index             | 2.48  | 2.46  | 2.48  | 2.48               |
| Average Weaned/Litter       | 10.3  | 10.6  | 11.7  | 11.6               |
| Pre-Wean Mortality, %       | 15.8  | 15.1  | 12.7  | 11.2               |
| Pigs Weaned / Sow / Yr      | 23.6  | 24.1  | 26.5  | 25.9               |
| Sow Non-Prod. Days/Sow/Yr   | 41.3  | 32.8  | 27.2  | 22.9               |

\*2008-09, 2009-10, 2010-11 (9 months)

The University Committee on Animal Care and Supply (UCACS) visited the Centre on August 3rd, 2011 for their annual inspection. Their only recommendation was the Centre like all University research facilities “work with the UCACS to ensure that all animal orders and animal use are checked against approved protocols for all protocols on an ongoing basis”. This refers to not only our scientists here at the Centre but all scientists using our animals in their research trials. Again they commended all staff at the Centre “for their high standards of animal care and facility management”. In 2011 the Centre started 18 new experiments and placed 7,071 animals on trial.



# Friends of the Centre

LEE WHITTINGTON, B.Sc. (Agr), MBA

## Objective

To allow a broader group of pork industry individuals and corporations to lend their support to the Prairie Swine Centre.

## Motivation

For the past several months and into the near-term most pork producers including the Prairie Swine Centre have faced significant financial challenges.

## Concept

"Friends of the Centre" is way for pork producers, suppliers, packers, processors and others to show their support. Benefits from having a dedicated swine research facility flows to all parts of the value chain. As a friend of the Centre you will ensure Prairie Swine Centre remains a viable part of the pork industry in the future.

## Benefits to our Friends

- The opportunity to play a visible and meaningful role in the continuation of the unique industry-orientated research and technology transfer programs offered by Prairie Swine Centre.
- Friends receive advanced notice of seminars, publications and special events sponsored by the Centre.
- Friends will have their business recognized as "Friends of the Centre" on the PSC Website.
- Friends will also be provided with exclusive opportunities to provide advertorial materials for insertion in newsletters, Centred on Swine publications and the Annual Research Reports.
- Friends will also benefit by knowing that they made a difference when it really mattered.

## Benefits to Prairie Swine Centre

- The Centre gains a voluntary source of funds to partially fill the gap in the business plan created by poor pig prices and the declining check-off funds available for pork associations to allocate to research.
- The Centre gains a group of motivated and interested champions that see value in maintaining a strong industry orientated research program.
- The sharing of costs incurred to generate knowledge is spread over a greater portion of the industry and better reflects the allocation of benefits to multiple members of the pork value chain. This way the number of champions that take ownership for the Centre as well as the knowledge it develops, increases.



## Meet our Friends

The following individuals and companies have made financial contributions:

- Maple Leaf Foods - John Carney
- PIC Canada
- Fast Genetics
- Standard Nutrition Canada
- Sunterra Farms
- Howard and Joan Fredeen
- Alwyn Woolley and Ken Woolley Memorial
- Dave Price
- Stan and Flo Price
- Red Willow Pork Farm
- Perkins Farm Inc.
- Hutterian Brethren Church of Standoff Colony
- Hutterian Brethren of Verdant Valley
- Hutterian Brethren Church of Lakeside
- Wild Rose Hutterian Brethren
- New Rockport Hutterian Brethren
- Hutterian Brethren Church of Birch Hills
- Clear Lake Hutterian Brethren of Alberta
- Cairlane Hutterian Brethren
- Neu Muehl Hutterian Brethren of Delia
- Rock Lake Hutterian Brethren
- Lone Pine Hutterian Brethren
- Neudorf Hutterian Brethren
- Starbright Hutterian Brethren
- Paradise Valley Pork Farms Inc.
- Lewisville Pork Farm Limited Partnership
- Poundmaker Pork Farm Limited Partnership
- Hutterian Brethren Church of Veteran
- Hutterian Brethren of Springview
- Suncrest Hutterian Brethren
- Hutterville Hutterian Brethren
- Clearview Hutterian Brethren
- Hutterian Brethren Church of Gadsby
- Big Bend Hutterian Brethren
- Hutterian Church of Wintering Hills Colony
- Fairville Hutterian Brethren
- Hutterian Church of Pine Haven
- Hutterian Brethren of South Bend
- Hutterian Brethren of Newell
- Hutterian Brethren Church of Jenner
- Blue Sky Colony
- Hutterian Brethren Church of Plain Lake
- Acadia Hutterian Brethren Ltd.
- Hillsburgh Stock Farm
- Neufeld Farms Ltd.
- Porcherie Prejet Ltee
- Porcherie Lac Du Onze Ltee

# Corporate Objectives

## **Objective #1**

To be a profitable organization operating in a marketplace that offers growth opportunities.

## **Objective #2**

To meet the technology needs of the pork value chain better than any competitor - defined as all stakeholders in the pork value chain from cereal development to consumer acceptance of pork. Using an industry-oriented and multidisciplinary approach that ensures timely adoption of knowledge.

## **Objective #3**

To leverage our strengths and capabilities as a 'knowledge-based' company.

## **Objective #4**

To provide scientific leadership in our areas of expertise to industry, university and government.

## **Objective #5**

To define 'Best in Class' and benchmark against critical efficiency, innovation and accountability metrics (in operations, human resource, financial, and scientific output).

## **Objective #6**

To empower our people – that they should feel Valued, Challenged and Engaged in a safe work environment. Assisting them to find the breakthroughs to take us to the next level.

## **Objective #7**

To enhance the Centre's effectiveness and sustainability, through successful collaborations, co-operative action and strategic alliances in our research, education and technology transfer roles. This objective applies equally to initiatives within Prairie Swine Centre as well as relationships with external institutions/agencies.

# Research Objectives

## *Serving the Needs of the Pork Value Chain*

### **Objective #1**

To increase net income for pork producers through improved nutrition. This includes the development of feeding programs which emphasize economic efficiency, meat quality, and market value. Also understanding feed and fibre sources and the modifications of these to meet the needs of the pig, changing economics and opportunities to favourably impact meat quality.

### **Objective #2**

Improve animal wellbeing by developing and modifying housing systems, animal management practices, and health of the pig.

### **Objective #3**

To improve barn environment through the development of economical and practical techniques ensuring the health and safety of barn workers and animals.

### **Objective #4**

To reduce the environmental footprint of pork production through breakthroughs in the science of odour and gas emissions, nutrient and water management, utility and resource efficiency.

### **Objective #5**

To address the needs of society by leveraging our knowledge of the pig. This includes for example, using the pig as a model for human health and nutrition, for pet nutrition.

### **Our Commitment**

To meet or exceed the research data and scientific analysis expected by our clients, and demanded by regulatory guidelines.



*Weighing grow-finish pigs; Raelene Petracek Assistant Manager Contract Research*

# Using Zinc Oxide Nanoparticles to Control Emissions - Pig Performance, Manure Properties, and Production Cost

Predicala, B. and A. Alvarado



B.ernardo Predicala



Alvin Alvarado

## SUMMARY

The impact of pig performance, manure nutrient characteristics and cost of production was evaluated with several mixing and filtration methods using zinc oxide (ZnO) nanoparticles to control hydrogen sulphide (H<sub>2</sub>S), ammonia (NH<sub>3</sub>) and odour emissions from commercial swine facilities. Conditions represented conventional swine production. Results indicate the application of mixing and filtration treatments had no significant effect on pig performance and manure nutrient characteristics. The cost analysis revealed that employing air filtration in a 100-head grow-finish room amounted to around 3.8% of the average total cost of production, while the mixing method was found to be cost prohibitive at about 40.2% of the average total production cost.

## INTRODUCTION

Our previous work demonstrated that mixing and filtration methods using zinc oxide (ZnO) nanoparticles were effective in controlling hydrogen sulphide (H<sub>2</sub>S), ammonia (NH<sub>3</sub>) and odour emissions from swine facilities (PSC Annual Report 2010, pp. 16-18). In order to assess the feasibility of its application in commercial swine facilities, the impact of these two treatments approach on pig performance and manure nutrient characteristics as well as on the cost of production was carried out.

## METHODOLOGY

The effectiveness of mixing and filtration methods using ZnO nanoparticles was evaluated in room-scale tests under commercial barn conditions. The experiment was conducted in two environmental chambers at PSC with each chamber housing 8 pigs at an average weight of 29 kg at the start of the trial. One chamber was configured as a normal swine room (Control) and the other one as a treatment room. Aside from monitoring odour and target gases (with results presented in PSC Annual Report 2010

pp. 16-18), the effect of the treatment on pig performance such as average daily gain and feed intake, manure production rate, water usage, and manure characteristics were also assessed.

Cost analysis of the application of nanoparticles in a typical swine operation was undertaken after the room-scale experiments. The analysis was carried out with the assumption that the treatment was applied at the grow-finish stage of production. Thus, all the expenses incurred for one complete growth cycle in a grow-finish room including the purchase of material (nanoparticles) and equipment, and labour and operating costs were estimated. The total cost associated with these gas and odour control techniques was then compared to the overall cost of production.

*“Mixing Zinc Oxide to Reduce Hydrogen Sulphide Amounted to 40.2% of the Average Total Cost of Production while Filtering Zinc Oxide Amounted to Only 3.8% of the Total”*

## RESULTS AND DISCUSSION

### *Impact on pig performance and manure nutrient properties*

During the entire 30-day trial period for both mixing and filtration tests, the average daily water usage and manure production rate of pigs in the control chamber were not significantly different ( $P>0.05$ ) from the treatment chamber as shown in Table 1. Furthermore, the average daily feed intake (ADFI) and average daily gain (ADG) of the pigs in the treated chamber were not significantly different ( $P>0.05$ ) than those in the control chamber. Thus, these results indicated that the application of mixing and air filtration methods

**Table 1.** Daily water usage, manure production rate, average daily gain, and average daily feed intake of pigs in the control and treated chambers during room-scale tests.

| Hog Performance Parameters   | Mixing <sup>1</sup> |           | Air Filtration <sup>1</sup> |           |
|--|---------------------|-----------|-----------------------------|-----------|
|  | Treated             | Control   | Treated                     | Control   |
| Avg daily water use (L day <sup>-1</sup> -pig <sup>-1</sup> )          | 2.2±0.8             | 2.4±0.1   | 2.4±0.7                     | 2.1±0.4   |
| Avg daily manure production (L day <sup>-1</sup> -pig <sup>-1</sup> )  | 2.28±0.24           | 2.33±0.15 | 2.09±0.05                   | 2.07±0.12 |
| Avg daily feed intake, ADFI (kg day <sup>-1</sup> -pig <sup>-1</sup> ) | 1.70±0.19           | 1.74±0.14 | 1.70±0.13                   | 1.68±0.20 |
| Avg daily gain, ADG (kg day <sup>-1</sup> -pig <sup>-1</sup> )         | 0.79±0.03           | 0.82±0.05 | 0.81±0.06                   | 0.80±0.07 |

<sup>1</sup>Mean (±SD) of 3 replicates, representing a total of 48 pigs for each treatment.

with ZnO nanoparticles had no significant adverse or beneficial effect on pig performance.

Table 2 shows the results of physical and chemical analyses conducted on the manure samples collected from each chamber. As expected, the installation of a filter system with ZnO nanoparticles in the treated chamber had no measurable impact on the characteristics of the manure in the tub. On the other hand, the addition of ZnO nanoparticles into the manure slurry (mixing) had caused a significant increase in the amount of zinc by 1,654 mg kg<sup>-1</sup> ( $P < 0.05$ ); all other physico-chemical characteristics were not significantly different from the control ( $P > 0.05$ ). In spite of the increase, the zinc content of the treated slurry was below the toxicity limit (2,800 mg Zn kg<sup>-1</sup>) set by the U.S. Environmental Protection Agency (USEPA, 1994) for biosolid applications. With this preliminary assessment, the treated manure is not expected to result to adverse effects when subsequently applied to crop lands but this would need to be verified by conducting a full evaluation of the land application of the treated manure.

#### Assessment of economic feasibility

A cost analysis was conducted based on the

**Table 2.** Characteristics of manure samples collected from each chamber during room-scale tests.

| Parameters                                     | Mixing <sup>1</sup> |               | Air Filtration <sup>2</sup> |            |
|--|---------------------|---------------|-----------------------------|------------|
|  | Treated             | Control       | Treated                     | Control    |
| Moisture (%)                                   | 86.40±3.58          | 89.00±4.56    | 84.95±5.02                  | 87.15±3.46 |
| Total Solids (%)                               | 13.60±3.58          | 10.99±4.57    | 15.05±5.02                  | 12.85±3.46 |
| Conductivity, EC (uS cm <sup>-1</sup> )        | 17020±9960          | 24330±1460    | 18350±11240                 | 23200±4670 |
| pH (pH)  | 7.27±0.21           | 7.09±0.04     | 6.86±0.21                   | 7.01±0.01  |
| Total Kjeldahl Nitrogen (mg kg <sup>-1</sup> ) | 9400±2200           | 8400±1700     | 12800±3300                  | 12000±2600 |
| Ammonia as N (mg kg <sup>-1</sup> )            | 5700±1400           | 5500±1100     | 7400±1300                   | 7000±1100  |
| Calcium, Ca (mg kg <sup>-1</sup> )             | 2400±1200           | 1700±700      | 3300±400                    | 2700±200   |
| Copper, Cu (mg kg <sup>-1</sup> )              | 50±28               | 38±15         | 74±13                       | 65±14      |
| Iron, Fe (mg kg <sup>-1</sup> )                | 294±131             | 223±127       | 346±25                      | 284±4      |
| Magnesium, Mg (mg kg <sup>-1</sup> )           | 1600±500            | 1200±400      | 1700±400                    | 1500±300   |
| Manganese, Mn (mg kg <sup>-1</sup> )           | 90±32               | 69±24         | 115±22                      | 97±13      |
| Phosphorus, P (mg kg <sup>-1</sup> )           | 3000±1200           | 2300±900      | 3600±800                    | 3000±300   |
| Potassium, K (mg kg <sup>-1</sup> )            | 4800±1100           | 4300±900      | 5100±200                    | 4700±300   |
| Sodium, Na (mg kg <sup>-1</sup> )              | 1400±300            | 1300±200      | 1300±100                    | 1300±200   |
| Sulfur, S (mg kg <sup>-1</sup> )               | 1600±400            | 1300±100      | 1500±400                    | 1300±300   |
| <b>Zinc, Zn (mg kg<sup>-1</sup>)</b>           | <b>1848±708</b>     | <b>194±82</b> | 327±35                      | 307±30     |

<sup>1</sup>Mean (±SD) of 3 samples; one sample per trial

<sup>2</sup>Mean (±SD) of 2 samples collected on Days 0 and 15 of the third trial



Manure samples collected from the manure tub of each chamber during room-scale tests. These samples were sent to a commercial laboratory for analysis.



assumption that the treatment was applied to a 100-head grow-finish room (20 – 110 kg) for one complete growth cycle of about 16 weeks. Using the application rate used in the room-scale experiments (PSC Annual Report 2010, pp. 16-18), the total amount of ZnO nanoparticles required in the room for a 16-week growth cycle was 68.67 kg for mixing method and 4.1 kg for air filtration test. As summarized in Table 3, the total cost associated with the application of mixing method with ZnO nanoparticles in a grow-finish stage of operation was around \$67.2 (CAD) per finished pig while the total cost of operating a filtration system with ZnO nanoparticles was about CAD\$6.3 per finished pig.

The result of the cost analysis revealed that the total cost associated with mixing and filtration methods with ZnO nanoparticles was about 40.2 and 3.8%, respectively, of the estimated total cost of \$167.15 (CAD) for the grow-finish stage of production (MAFRI, 2010). The total cost was relatively high especially for mixing because the assumptions used in the cost estimates were based on the findings from the room-scale experiments which were conducted with measures to intentionally produce extreme high levels of the target gases, i.e., if the treatment was found to be effective under these extreme conditions, then it would work as well under typical barn conditions with lower levels of the target gases expected.

Some considerations may be applied in order to lower the cost without substantially affecting its effectiveness in reducing the target gases. In mixing method, the total cost could be lowered by reducing the ZnO cost per pig which constituted about 98% of the total cost (\$66.2 of \$67.2). ZnO cost is dependent on the application rate, and frequency and time of application prior to each pit-pulling session. Thus, by lowering the application rate, for instance, to 1.5 g L<sup>-1</sup> which also showed considerable reduction on H<sub>2</sub>S and NH<sub>3</sub> levels, and applying the treatment 3 times per cycle, the total cost would be reduced from CAD\$67.2 to \$20.4. The same applies to filtration method; if the frequency of filter installation is reduced to 2 times (i.e. on the 1st and 10th week of the cycle) instead of 4 times, the total cost can be reduced from CAD\$6.3 to \$4.1. It should be noted as well that the ZnO nanoparticles used in this study were experimental materials purchased at an extremely high unit price; it has been documented recently that when wider applications were developed for certain nanoparticles, this allowed manufacturers to produce them in bulk quantities, thus the unit price for these nanoparticles were drastically reduced. Hence, it is anticipated that the total cost for this treatment could still go down significantly as new uses for nanoparticles are discovered.

## CONCLUSIONS

Room-scale experiments revealed that the pig performance and manure nutrient characteristics were not adversely affected by either mixing or filtration using ZnO nanoparticles. Cost analysis for a typical 300-sow operation (7,500 finished pigs per year) using

**Table 3.** Parameters used in the calculation of the total cost of applying ZnO nanoparticles in a grow-finish swine production barn.

| Operational information and associated cost      | Deployment Technique |                        |
|--|----------------------|------------------------|
|  | Mixing               | Filtration             |
| Application rate                                 | 3 g L <sup>-1</sup>  | 1.8 g in <sup>-2</sup> |
| Frequency of application per cycle               | 5                    | 4                      |
| Total amount of ZnO applied per room, kg         | 68.8                 | 4.1                    |
| ZnO unit price per kg <sup>1</sup>               | 87.7                 | 87.7                   |
| <b>ZnO cost per pig, \$</b>                      | <b>66.2</b>          | <b>4</b>               |
| Number of hours to apply treatment per cycle, hr | 7.5                  | 4                      |
| Labour cost per hour, \$/hr                      | 13                   | 13                     |
| <b>Labour cost per pig, \$</b>                   | <b>1</b>             | <b>0.5</b>             |
| Total costs for required equipment, \$           | 370                  | 5930 <sup>2</sup>      |
| Estimated life span, yr                          | 5                    | 5                      |
| Total cost of required material per pig, \$      | -                    | 1.66                   |
| <b>Capital cost per pig, \$</b>                  | <b>0.01</b>          | <b>1.77</b>            |
| Estimated energy consumption per year, kWh       | -                    | 1871                   |
| Energy cost per kWh <sup>3</sup> , \$            | -                    | 0.1                    |
| <b>Operating cost per pig, \$</b>                | <b>-</b>             | <b>0.2</b>             |
| <b>Total cost per pig</b>                        | <b>67.2</b>          | <b>6.3</b>             |

<sup>1</sup>based on the current price of NanoActive ZnO (www.nanoscalecorp.com)

<sup>2</sup>includes estimated cost of installation (\$4000)

<sup>3</sup>SaskPower rate

current cost estimates and application parameters indicated that the implementation of filtration treatment with ZnO nanoparticles would amount to about 3.8% of the total production cost, which was economically more feasible than incorporating ZnO into the manure slurry.

## ACKNOWLEDGEMENTS

Project funding provided by the Saskatchewan Agriculture Development Fund and the National Science and Engineering Research Council are gratefully acknowledged. Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Ministry of Agriculture to the research programs at PSCI are also acknowledged.

# Evaluation of Heat Exchanger, Ground Source Heat Pump, and Conventional Heating Systems

Dominguez, L and B. Predicala



B.ernardo Predicala

## SUMMARY

As part of the on-going effort to improve profitability, this study aims to reduce the energy use in swine barns by evaluating the performance of various types of heating systems. A heat exchanger and a ground source heating system were installed in grow-finish rooms at Prairie Swine Centre compared with a conventional forced-air convection heater. Data from two heating seasons showed that the use of heat exchanger and ground source heat pump led to 54% and 45% reduction in energy consumption for heating and ventilation, respectively, compared to the conventional heater.

## INTRODUCTION

Energy cost is one component of production cost that can be further reduced by using energy more efficiently or reducing overall energy consumption. Results from previous work showed that space heating is an area where energy reduction can be achieved (PSC Annual Report 2008, pp. 19-20). This study aimed to evaluate the performance of a heat recovery ventilator (HRV or heat exchanger), a ground source heat pump (GSHP), and a conventional heating system in grow-finish rooms in terms of energy consumption, in-barn environment, and animal productivity. To achieve a detailed comparison of the various heating systems, the study was conducted over several seasons.

## MATERIALS AND METHODS

To compare their performance, the three heating systems were installed separately in 120-head grow-finish rooms at PSC. The rooms had similar building construction, pen configuration, and pig capacity. For each grow-finish cycle, a total of 360 pigs were distributed equally to the three rooms. Metering equipment were installed to monitor the electric consumption of the heat pump, heaters, lights, ventilation and recirculation fans, as well as the

natural gas consumption of the forced-convection heaters in the heat exchanger and control rooms.

The HRV system was a 1500-cfm aluminum core heat recovery ventilator (Figure 1). The heat exchanger recovers the heat energy from exhaust air stream by heat transfer to the incoming fresh air stream.

*“After two heating seasons, the use of the heat exchanger and ground source heat pump systems resulted to 54% and 45% reduction in energy consumption”*

Figure 2 displays the components of the GSHP system, alternatively known as geothermal heat pump, geoexchange, earth-coupled or earth-energy system, used in the study. It is composed of a heat pump and 1800 ft of 3/4” diameter polyethylene pipes buried in 8.5 to 10 ft deep trenches on the ground beside the barn. The buried pipes contained 20% methanol - 80% water solution for absorbing heat from the ground for heating and for using the ground as heat sink when cooling is needed.

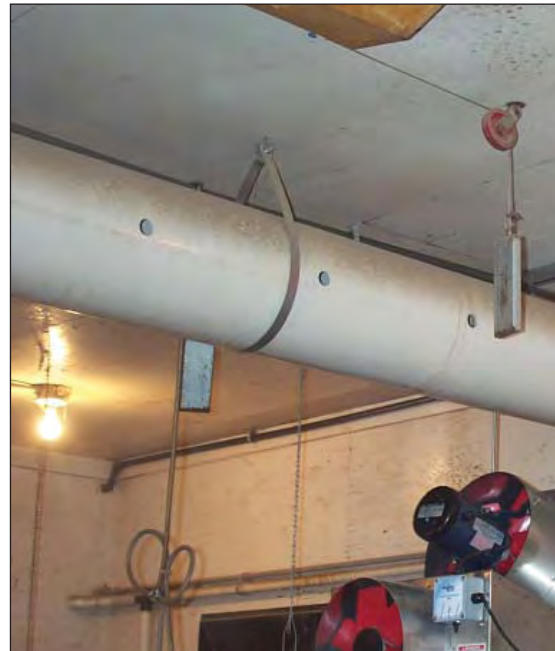


Figure 1. Heat exchanger installed in a grow-finish room.



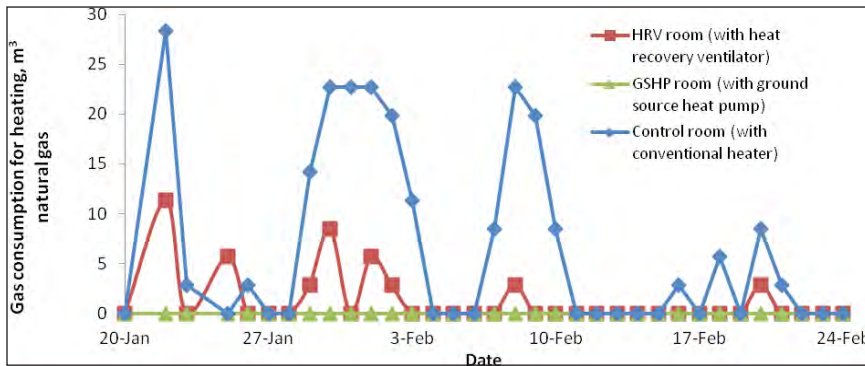
**Figure 2.** Installation of pipes for the ground source heating system installed in a grow-finish room.

**RESULTS AND DISCUSSION**

Three grow-finish cycles were completed to evaluate the impact of the various types of heating systems in swine rooms. The first grow finish cycle was conducted from October to December 2010 and the mild weather condition during the trial did not require the use of heating, thus no data for this cycle is presented. Data collection for the second and third cycles were conducted from January to March 2011 and from December 2011 to February 2012, respectively. For clarity, the January to March 2011 data collection is referred to as Trial 1 and the December 2011 to February 2012 data collection is Trial 2.

For Trial 2, the control room consumed a total of 224.0 m<sup>3</sup> of natural gas while the HRV room consumed 31.2 m<sup>3</sup> of natural gas for heating. The GSHP room consumed 714 kWh of electricity to heat the room.

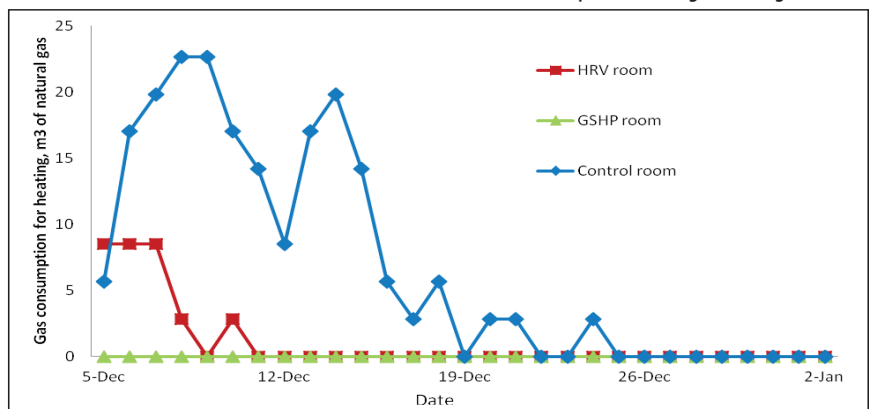
To compare the systems better, all energy consumption data were converted to gigajoules (GJ). Energy consumption for heating and ventilation of each of the three rooms for Trials 1 and 2 are presented in Figures 5 and 6. The energy consumption for heating included both the electrical and heating fuel consumption of the heat pump and heaters while that for ventilation included the electrical consumption for both ventilation and recirculation fans.



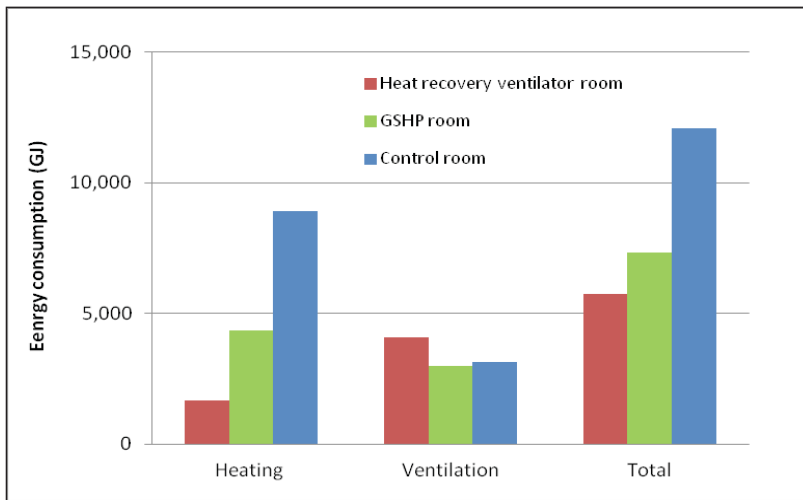
**Figure 3.** Daily natural gas consumption in the three rooms for Trial 1 (January to March 2011)

Data for both trials showed that among the three heating systems, the heat exchanger required the least energy for heating but had the highest consumption for ventilation. The heating requirement was reduced as the heat exchanger pre-heated the incoming cold air with heat from the warm exhaust air. In terms of function, the heat exchanger basically replaced the stage 1 fan and because its power rating was higher than

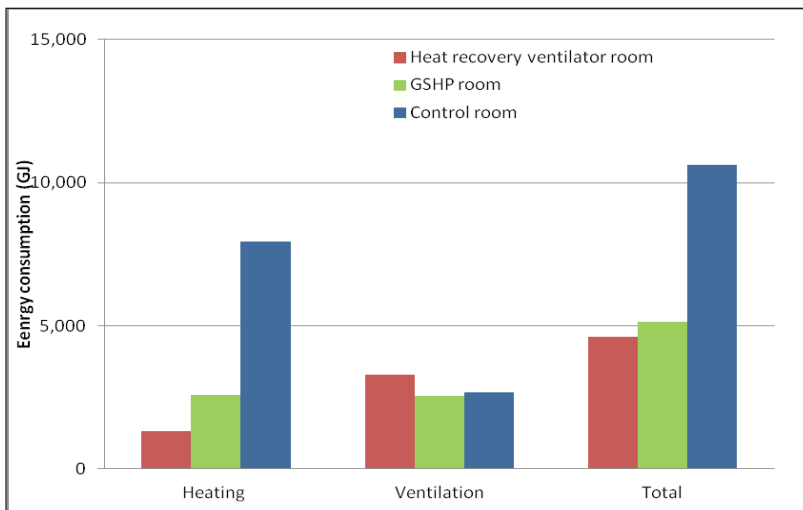
Daily gas consumption for heating each of the three rooms for the two trials are shown in Figures 3 and 4, respectively. For the duration of the Trial 1, the conventional forced convection heater (control) room consumed a total of 226.71 m<sup>3</sup> of natural gas while the HRV room consumed 42.51 m<sup>3</sup> of natural gas for heating. The GSHP room did not use any natural gas but it consumed a total of 1206 kWh of electricity (mainly to run the heat pump) to heat the room.



**Figure 4.** Daily natural gas consumption in the three rooms for Trial 2 (December 2011 to February 2012)



**Figure 5.** Energy consumption for the three rooms in the heating season of January to March 2011 (Trial 1)



**Figure 6.** Energy consumption for the three rooms in the heating season of December 2011 to February 2012 (Trial 2)

that of a regular stage 1 fan, the energy requirement to ventilate the HRV room was higher compared to the conventional room. Nevertheless, the use of heat exchanger led to 52% less total energy used for heating and ventilation in Trial 1 and 57% less in Trial 2 compared to the conventional room with forced-convection heater.

The GSHP required less energy to extract heat from the ground and to heat the room air compared to the conventional heater. The use of the GSHP system led to 39% reduction in total energy needed for heating and ventilation for Trial 1 and 52% reduction in Trial 2 compared to the control room.

When combined over the two heating trials, the HRV room and GSHP room used 54% and 45% less total energy for heating and ventilation, respectively, compared to the conventional room.

The performance of the pigs in terms of average daily gain, feed intake and feed efficiency were quite similar as shown in Table 1. However, the feed intake and feed efficiency values in the rooms with GSHP and heat exchanger are lower than that of the conventional heater room.

**CONCLUSIONS**

After two heating seasons, the use of the heat exchanger and ground source heat pump systems resulted to 54% and 45% reduction, respectively, in energy consumption for heating and ventilation relative to the conventional forced-convection heater. Pigs in the three rooms performed similarly in terms of ADG. Pigs in the heat exchanger and ground source heat pump rooms, however, have slightly lower feed intake and more favorable feed efficiency than those in the forced-convection heater room. Additional trials during the summer months are being conducted to assess the cooling effect of the GSHP system and its impact on overall energy use and pig performance.

**ACKNOWLEDGEMENT**

Project funding provided by Advancing Canadian Agriculture and Agri-Food Saskatchewan and Saskatchewan Agriculture Development Fund. Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund

**Table 1.** Average daily gain (kg/day), feed intake (kg/day-pig) and feed efficiency in the three rooms for the two heating trials.

| Room    | ADG (kg/day) | ADFI (kg/day-pig) | Feed Efficiency |      |
|---------|--------------|-------------------|-----------------|------|
| Trial 1 | Control      | 0.99              | 2.55            | 2.58 |
|         | HRV          | 0.97              | 2.37            | 2.44 |
|         | GSHP         | 0.99              | 2.48            | 2.51 |
| Trial 2 | Control      | 0.98              | 2.52            | 2.57 |
|         | HRV          | 0.97              | 2.44            | 2.52 |
|         | GSHP         | 0.98              | 2.42            | 2.47 |

# Reducing Water Consumption in Swine Barns: Alternatives for Animal Drinking and Barn Cleaning

Predicala, B. and A. Alvarado



B.ernardo Predicala



Alvin Alvarado

## SUMMARY

Evaluation of selected water conservation measures involving drinkers and different cleaning procedures revealed that 60% reduction in water wastage was achieved with a drinking trough (with side panel and constant water level) to nipple drinkers. The use of conventional nozzle for pressure washing led to reduced time and water consumption during cleaning. Cost analysis of the different measures showed reduction in water wastage achieved by a drinking trough translated to about \$4.76/pig savings or 29% reduction in total costs associated with water use when compared to a nipple drinker.

*“Using Alternative Water Management Practices could Translate to Savings of \$4.76/pig”*

## INTRODUCTION

More efficient water use in swine operations is essential both for economic and environmental considerations. Previous work demonstrated that there are various opportunities to improve water use in swine operations (PSC Annual Report 2010, pp. 24-25). Evaluation of conservation measures identified in the literature review and producer survey using an assessment criteria that considered effectiveness in reducing water use impact on manure production, and effect on pig performance and other operational aspects (i.e., air quality). Barn cleaning and animal drinking were identified as the areas in the barn where highest water savings can be potentially achieved, therefore these were further evaluated in commercial swine facilities.

## METHODOLOGY

The overall approach of this study was to evaluate the effectiveness of selected water conservation measures pertaining to animal drinking and cleaning in reducing overall water use and to assess their economic impact in swine barn operations. Two different experiments were performed. The first experiment involved installing three different types of drinkers in a grow-finish room at PSCI barn facility. The drinkers used included 1) nipple drinker (Control), 2) nipple drinker with side panel, and 3) a trough with side panel and constant water level (Figure 1). Performance of these drinkers in terms of water disappearance (use), water wastage, water contamination level as well as effect on ADG and ADFI were assessed throughout one growth cycle. The second experiment involved



**Figure 1.** Three types of animal drinkers used: nipple (D1), nipple with side panel (D2) and a trough with side panel and constant water level (D3).



**Figure 2.** Four different types of pressure-washing nozzles used: conventional nozzle (N1), Y-nozzle (N2), water broom (N3), and 4-in-1 nozzle (N4).

two different cleaning strategies in grow-finish rooms with either partially or fully slatted concrete flooring. The cleaning strategies included 1) water sprinkling (soaking) prior to high pressure washing and 2) use of different high pressure washing nozzles: conventional nozzle, Y-nozzle, water broom and 4-in-1 nozzle (Figure 2). The amount of water consumed, time spent during high-pressure washing, as well as the surface cleanliness were evaluated. A cost analysis of the use of different types of drinkers and cleaning strategies in swine operations was carried out after completion of the actual in-barn experiments.

**RESULTS**

*A. Animal drinking*

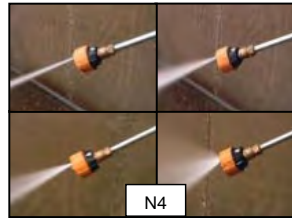
Figure 3 shows the performance of the test drinkers in terms of water disappearance (water use), water intake, and water wastage. Results showed that 60% less water wastage was achieved when a trough with side panel and constant water level (1.27 L/day-pig) was used compared to the nipple drinker alone (3.77 L/day-pig) and the nipple with side panel (3.57 L/day-pig) (Figure 3). This observation led to lower total water disappearance (consumed + wastage) in trough with side panel and constant water level compared to nipple drinkers. Even with the substantial decrease in water disappearance, the net water intake of the pigs from the trough with side panel and constant water level (after subtracting the water wastage) was still within the recommended water intake requirements for grower-finisher pigs (4.5 – 10 L/day-pig).

Water in the trough had significantly higher microbial ATP (adenosine triphosphate) levels (indicating contamination with organic material) than the water drawn from nipple drinkers. However, this did not affect pig performance since the use of the trough with side panel and constant water level had no significant effect ( $p>0.05$ ) on average daily gain and average daily feed intake of pigs. Further investigation is needed to find out

the type of microorganisms present in the water in the trough and its potential effects on the pigs apart from ADG and ADFI.

*B. Cleaning*

As expected, water sprinkling (or soaking) in fully and partially slatted concrete flooring resulted to significantly higher ( $p<0.05$ ) water consumption mainly due to the additional water used during the sprinkling phase. However, significantly more time ( $p<0.05$ ) was needed when washing a partially slatted concrete flooring without sprinkling than with sprinkling. As shown in Figure 4, the use of the conventional nozzle led to the lowest water volume consumed and time spent in washing rooms with partially and fully slatted concrete flooring among all test nozzles. Also, the use of the conventional nozzle and the Y-nozzle achieved the highest significant reduction ( $p<0.05$ ) in microbial ATPs on concrete and plastic surfaces (measured before and after washing), respectively.



*C. Economic analysis*

The economic analysis were based on the assumption that the treatment was applied to a 168-head grow-finish room with a floor area of 157.3 m<sup>2</sup> (14.3 m x 11 m) for one complete growth cycle of

**Table 1.** Operational information and associated cost of using the different types of drinkers in a swine production room.

| Operational information and associated cost                                       | Nipple       | Nipple with Side Panel | Trough with side panel and constant water level |
|---|--------------|------------------------|---|
| Cost of required materials & equipment, \$  | 546.0        | 826.0                  | 1,185.0   |
| Installation cost, \$   | 104.0        | 156.0                  | 156.0   |
| <b>Capital and installation cost (per pig basis), \$/pig</b>                      | <b>0.26</b>  | <b>0.39</b>            | <b>0.53</b>                                     |
| Number of hours per cycle for drinker maintenance, hr                             | 6            | 6                      | 8   |
| <b>Labour cost for installation and maintenance (per pig basis), \$/pig</b>       | <b>0.93</b>  | <b>0.93</b>            | <b>1.24</b>                                     |
| Total water use (consumed + wastage) (per pig basis), L/day-pig                   | 8.175        | 8.025                  | 6.7   |
| Total water consumption per year, gal/yr  | 397,281.2    | 389,991.7              | 325,600.5                                       |
| <b>Cost of water used (per pig basis), \$/pig</b>                                 | <b>6.30</b>  | <b>6.19</b>            | <b>5.16</b>                                     |
| Volume of additional water to the pit (due to wastage) (per pig basis), L/day-pig | 3.77         | 3.57                   | 1.27  |
| Total manure produced (in storage tank) per year, gal/yr                          | 262,804      | 253,084                | 141,311   |
| <b>Cost of handling the manure produced (per pig basis), \$/pig</b>               | <b>9.11</b>  | <b>8.77</b>            | <b>4.90</b>                                     |
| <b>Total cost per pig, \$/pig</b>   | <b>16.59</b> | <b>16.27</b>           | <b>11.83</b>                                    |

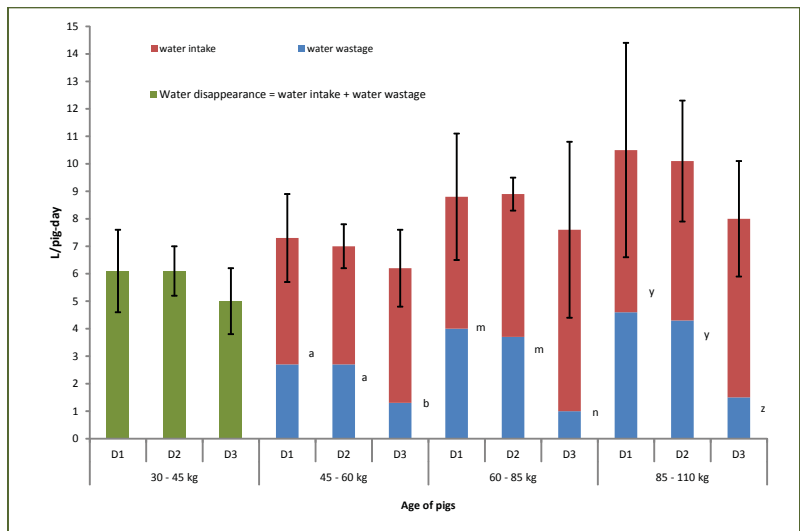
All costs in CAD\$  
Wage rate = \$13/hr; Cost of water = \$8.01/1000 gal; Cost of manure handling = \$0.0175/gal

about 16 weeks. Table 1 shows the summary of the operational information and associated costs of installing each type of drinker (nipple, nipple with side panel or trough with side panel and constant water level) in the grow-finish room. Costs were calculated for each drinker type and included the cost of water of \$8.01 per 1000 gallon for this particular barn as well as the costs associated with capital and installation, maintenance and operation, and manure slurry handling. The total cost of the use of the trough with side panel and constant water level was around \$11.83/pig, which translated to about 29% reduction in cost when compared to the use of nipple drinkers. For cleaning, the total cost per pig for pre-soaking with water sprinkling and pressure washing a fully slatted flooring was about \$0.54/pig, which is \$0.01/pig higher than without sprinkling. However, for partially slatted flooring, the use of water sprinkling prior to washing was about \$0.09/pig less than without sprinkling. Similarly, the use of the conventional nozzle for high-pressure washing resulted to a total cost of about \$0.78/pig (fully slatted) and \$0.80/pig (partially slatted), almost half of the other test nozzles.

Based on the results of the producer survey on barn water use (PSC Annual Report 2010, pp. 24-25), the most common practices associated with water use in the participating barns were the use of nipple drinker, pre-soaking the room prior to cleaning, and high-pressure washing using the conventional nozzle. The total cost associated with these current production practices is about \$17.13/pig for fully slatted flooring and \$17.31/pig for partially slatted flooring (using the above assumptions for water and slurry handling costs). In comparison, using a trough with side panel and constant water level for animal drinking, pressure washing using conventional nozzle, and pre-soaking only in rooms with partially slatted flooring (not in fully slatted flooring), the total cost would be about \$12.36/pig (fully slatted) and \$12.55/pig (partially slatted). Using these alternative practices then could translate to savings of about \$4.77 per pig or 28% reduction in costs associated with water use compared to the current conventional production practices in most barns.

**CONCLUSIONS**

The barn evaluation of selected water conservation measures indicated that relative to conventional nipple drinkers, the use of a drinking trough with side panel and constant water level saved significant amount of water mainly due to reduced water wastage without adversely affecting pig performance.

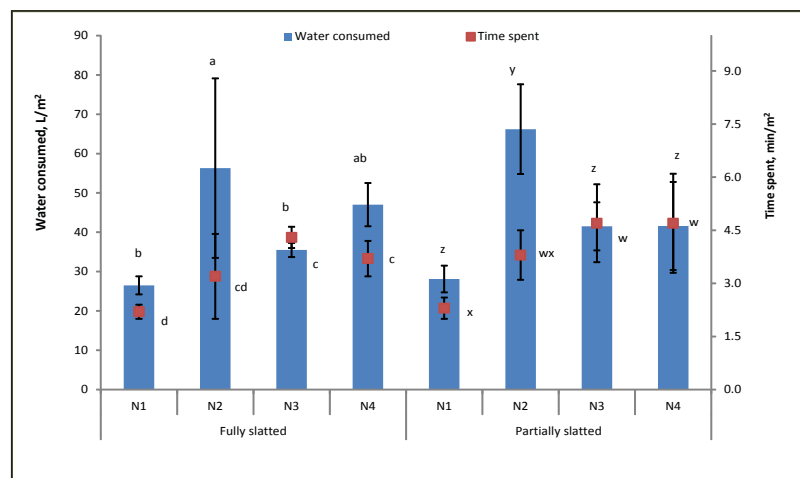


**Figure 3.** Effect of different types of drinkers on water disappearance and wastage, n=4. Means (water wastage) with the same letters are not significantly different (p>0.05) from each other. D1 – Nipple; D2 – Nipple with side panel; D3 – Trough with side panel and constant water level.

High pressure washing in fully slatted flooring can be done without prior water sprinkling (soaking). Compared to current conventional practices, the combination of using a drinking trough with side panel and constant water level for animal drinking, pre-soaking, and high-pressure washing with conventional nozzle for cleaning had the greatest potential for cost savings of up to \$4.77 per pig arising from reduced overall water use and accumulated manure slurry.

**ACKNOWLEDGEMENTS**

Project funding provided by the Saskatchewan Agriculture Development Fund (ADF) is acknowledged. Strategic funding provided by the Saskatchewan Pork Development Board, Alberta Pork, Manitoba Pork Council, and Saskatchewan Ministry of Agriculture to the research programs at Prairie Swine Center is acknowledged.



**Figure 4.** Effect of different types of nozzles on time and water consumption during high-pressure washing, n=5. Means with the same letters within the same type of flooring are not significantly different (p>0.05) from each other. N1 – Conventional nozzle; N2 – Y-nozzle; N3 – Water broom; N4 – 4-in-1 nozzle.

# Impact of Repeated Applications of Liquid Swine Manure and Biogas Production By-Products on Soils and Crops

Schoenau, J.J.<sup>1</sup>, T.N. King<sup>1</sup>, and S.S. Malhi<sup>2</sup>

<sup>1</sup>Department of Soil Science, University of Saskatchewan; <sup>2</sup>Agriculture and Agri-Food Canada, Melfort Research Station



Jeff Schoenau

## SUMMARY

Short and long-term application of fresh and processed liquid swine manure, to Saskatchewan soils, at agronomic rates of nutrients that balance crop removal over time contribute to significant yield and protein benefits in the crop while minimizing nutrient loading and risk of escape to soils and water.

## INTRODUCTION

In the spring of 2007, a new experiment was set up near Dixon, Saskatchewan to look at crop response to swine manure biodigestate that is produced from biogas production, in comparison to conventional liquid swine manure and urea fertilizer. Three rates of digestate and liquid hog manure (1,500, 3,000 and 6,000 gallons per acre) were applied along with three rates of urea: 50, 100 and 200 lbs N/acre. On long-term (since 1997) swine manure monitoring experiments at Dixon, fifteen treatments of liquid swine manure were applied by the Prairie Agricultural Machinery Institute (PAMI), continuing the sequence applied for the previous ten years. At the Melfort long-term liquid swine manure injection site, five treatments involving different rates and sequences of liquid swine manure were applied, with and without sulfur fertilizer as in the

previous seven years. Assessments of grain and straw yield, nutrient concentrations, soil nutrients and properties were made on plant and soil samples collected every fall in 2007, 2008 and 2009 to determine how manure applications affected crop growth and soil properties.

## RESULTS AND DISCUSSION

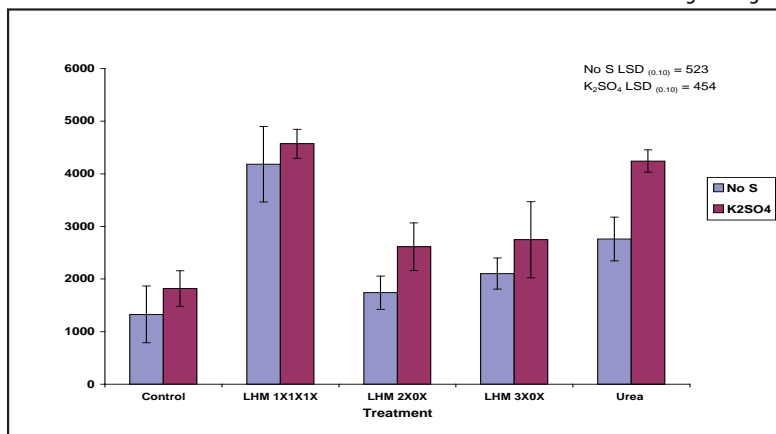
### Crop Yield

Significant yield responses to swine manure application were observed in 2007. An example of crop response to swine manure treatments is shown for the Melfort study site (Figure 1). At the Dixon site, there appeared to be little difference in behavior of the manure digestate compared to the conventional liquid manure in terms of yield responses observed. Annual applications of ~ 3,000 gallons per acre, 62-89 N/acre (~ 34,000 litres/ha, 70-100 kg total N/ha) as liquid hog manure and biodigestate resulted in maximum yield at all sites. This supports the concept that rates of addition of liquid swine manure in the order of 3,000 – 4,000 gallons per acre per year is the “agronomic or 1X rate”. Higher rates of application (6,000 gpa or 2X) made in the previous year showed good carryover into the next year. In 2007, the highest rates of application (4X agronomic rate) generally had reduced yield compared to the 2X and 1X rates.

*“ Rates of raw liquid swine manure or biodigestate of 3,000-4,000 gallons per acre (~75-100 lbs N / acre /yr) per year provided optimum yields”*

In 2008 a strong yield response of canola to manure application was noted at all sites. Annual applications of swine manure at 2X and 4X rates tended to produce the highest yields, likely reflecting better growing conditions than in 2007 and also the greater nutrient require-

ments of canola as compared to the oats and barley grown at the sites in 2007. Application at the 4X rate (13,200 gpa) every year results in excessive soil nitrate levels. As in previous years, there was no difference in agronomic effect of the biodigestate liquid swine manure compared to the raw liquid manure. As well, the addition of the nitrification inhibitor to liquid swine manure had no significant effect on yield. Injection of liquid swine manure produced superior yields compared to broadcast and incorporation. Liquid swine manure appears to supply close to sufficient amounts of phosphorus and sulfur, as response of the liquid manure treatments to supplemental P and S was muted in 2008.



**Figure 1.** Barley grain yield (Melfort 2007) response to injected liquid hog manure (LHM) in 1X1X1X (3300 gallons per acre every year including 2007), 2X0X (6600 gpa in 2006, no manure 2007) and 3X (9900 gpa in 2006, no manure 2007) treatment sequences, with and without supplemental sulfur fertilizer.

In 2009, close to maximum yield of oat was obtained at rates of ~3,000 gpa of raw liquid swine manure and



biodigestate. As in previous years, there appeared to be little difference in the agronomic performance of biodigestate from manure biogas production versus raw liquid swine manure when considered on a per kg of nutrient added basis. At the long-term liquid swine manure trial, the barley yield was maximized at the 4X annual rate, reflecting good growing conditions and high yield potential at the site. Consistent with results of previous years there was no response to addition of supplemental P fertilizer on the swine manure plots, and no response to addition of nitrification inhibitor. Treatments with skipped applications of nutrient the two previous years did not yield as high when manure was added in 2009. It appears that rates of addition of approximately 100 kg liquid swine manure - N/ha 90 lb N/ac (~ 3,000-5,000 gallons per acre per year) will maximize production over time in these soils without creating issues of nutrient loading. The results at Melfort long-term swine trial support this, as near maximum yield was observed at these rates. Application at double 1X rate every second year (6,000 – 10,000 gpa every second year) did not result in as high an oat yield in the second year 2009, pointing towards lower efficiency of total nutrient recovery in the “double up” approach. Some benefit was observed from the commercial S fertilizer application treatment made in 2008. In the 2009 oat crop it showed up in the urea treatments and also in the high rate liquid manure treatment and only for the elemental S form. Generally it appears that some benefit may be observed from fertilization with supplemental fertilizer S on liquid swine manured soils, but the variability in effects regarding crop, form and rates in which benefits are observed makes the benefits difficult to predict.

#### *Soils*

Generally, available N levels in the soil in the fall after harvest increased with increasing rate of liquid swine manure. Salinity was not significantly affected except at the 4X (13,200 gpa) annual application rate at the Dixon long-term site where, for example in 2008, it was elevated to 2.2 mS/cm, and in 2009 it was elevated to 1.3 mS/cm. Repeated application of liquid swine manure at these high rates may create potential salinity concerns for crop growth, and also resulted in greatly elevated nitrate (>200 kg /ha, 178 lb/ac) in the 0-30cm and 30-60cm depths, as did the 4X rate of urea. The content of nitrate in the 60-90cm and 90-120 cm depths was assessed in the Dixon long-term site in the fall of 2009 and revealed that only the 4X annual application of swine manure and urea had elevated concentrations of nitrate at these depths, with 60-100 kg NO<sub>3</sub>-N present in each depth increment compared to less than 10 kg/ha for the rest of the treatments. The 1X liquid swine manure rate (~3,000-4,000 gpa) does not result in soil nitrate or phosphate loading.

Accumulation of soil extractable P was not evident in either the raw liquid hog manure treatments or the biodigestate after three years of application. Reflecting the low P content of the liquid swine manure source used at the long-term site, soil extractable P levels were relatively unaffected by liquid manure application. The broadcast and incorporation treatment at Dixon had significantly lower nitrate than injected, again supporting that along with lower crop N recovery, N losses from the system are greater with broadcast and incorporate versus injection.

The application of swine manure either on a long-term or short-term basis did not affect soil organic carbon or soil sodicity values to any great extent, but there was a trend to higher organic carbon corresponding with manure application. A long period of animal manure application seems necessary to produce significant increases in soil organic carbon in these soils. Manure application tended to increase soil strength slightly but not significantly in the long-term manure trials.

The application of swine manure either on a long-term or short-term basis did not affect soil organic carbon or soil sodicity values to any great extent, but there was a trend to higher organic carbon corresponding with manure application. A long period of animal manure application seems necessary to produce significant increases in soil organic carbon in these soils. Manure application tended to increase soil strength slightly but not significantly in the long-term manure trials.

#### **CONCLUSION**

Rates of raw liquid swine manure or biodigestate of 3,000-4,000 gallons per acre (~75-100 lbs N / acre /yr) per year gave optimum yields of the oats and canola grown over the three years and did not result in excessive soil nutrient loading. As anticipated, application of swine manure at these rates over three years had little impact on soil properties like pH, salinity and organic carbon compared to the urea fertilized treatments and the unfertilized control. In the long-term (>10 yrs) liquid swine manure trials, application rates of 3,000 – 4,000 gallons per acre every year (~75 – 100 lbs N / acre / yr) gave near optimal yields for the crops examined (oats, canola, barley) and were not associated with any loading of nitrate or phosphate in the soil. As such, these rates of application are again confirmed as the “agronomic” optimum. Double these rates applied every second year also gave good yield response in the year of application, and provided significant residual benefits in the second year after application. However, especially in the moister environment encountered at Melfort, yields in the second year following application were not equivalent to the annual application rate, suggesting that larger applications intended to carry through for subsequent years may not be as efficient. High rates of liquid swine manure applied annually re 2X (~6,600 gpa) and especially 4X (13,200 gpa) often did not produce significant yield benefit above the 1X rate and lead to accumulation of excessive quantities of nitrate in the soil profile (0-60cm) and beneath. Furthermore, 4X rates of liquid swine manure and urea increased soil salinity slightly. Owing to the relatively low phosphorus content of the liquid swine manure used in this study, levels of soil test extractable P were only elevated significantly in the 4X rates.

#### **ACKNOWLEDGEMENTS**

Strategic funding provided by Saskatchewan Agriculture Development Fund and Sask Pork.

# Assessment of Lameness, Productivity and Longevity in Group and Individually Housed Gestating Sows

Lang, L.<sup>1</sup>, N. Devillers<sup>2</sup>, L. Connor<sup>3</sup>, J. Brown<sup>1</sup>, H. Gonyou<sup>1</sup>, D. Beaulieu<sup>1</sup>, R. Friendship<sup>4</sup>, P. Luimes<sup>4</sup>, R. Bergeron<sup>4</sup>, S. Kontulainen<sup>5</sup>, and G. Johnson<sup>3</sup>



Harold Gonyou



Jennifer Brown

## SUMMARY

The movement away from sow gestation stalls to group housing presents several major challenges in terms of facility design and sow management. Lameness is one of the most important welfare issues in sows, and factors affecting lameness and sow longevity are expected to change in group housing systems. Therefore, there is a need for objective, quantitative methods to assess lameness in pigs. This study uses several different methods of lameness detection including complex gait scoring, kinematics, accelerometers, and a force plate weigh scale. The use of these technologies in sows could lead to better early detection, quantification and understanding of sow lameness and advance our understanding of the relationship between housing, social factors, and sow lameness. Other measures studied include temperament testing and production measures. This is a 2 year study that will be concluded in 2012, with the objective of determining relationships among variables including body weight, age, social rank, body condition, health status and degree of lameness. Group and stall housed systems will also be compared, based on relative productivity, culling rate, health changes, aggression and injuries. Once the relative importance of these factors is identified, the data will be used to refine a longevity model for group housed sows, and will provide information on factors that can be expected to influence lameness and longevity in group housed systems.

## INTRODUCTION

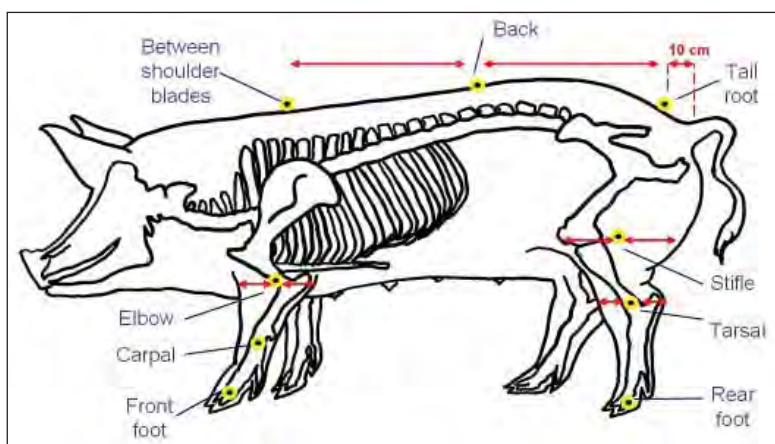
The movement away from sow gestation stalls to group housing presents several major welfare issues from the standpoint of facility design and sow management. In choosing the type of gestation housing to implement, it will be important to adopt systems that provide the greatest advantage in terms of their impact on sow welfare and longevity in the herd, as well as their impact on economic sustainability. Lameness in sows is one of the most

important welfare issues. Studies in Europe and North America have shown that lameness is the second major cause of culling after reproductive failure and represents between 8 and 15% of total culled sows (Friendship et al. 1986; D'Allaire et al. 1987; Boyle et al. 1998; Anil et al. 2005). Lameness also accounts for up to 25% of culling reasons in gilts (Tiranti & Morrison 2006; Tarres et al. 2006) and is an important criterion in gilt selection (Jorgensen 2000). Until now, qualitative visual scores of gait, standing posture or difficulty in ly-

*“Lameness is one of the most important welfare issues in sows”*

ing down have been the main methods used to measure lameness in pigs (Boyle et al. 2000; Bonde et al. 2004; Anil et al. 2005; Scott et al. 2006; Harris et al. 2006). However, accuracy of these qualitative methods can vary significantly among observers (Main et al. 2000). Therefore, there is a need for more objective quantitative methods to assess lameness in pigs. Several quantitative methods for assessing gait, such as kinematics and accelerometers, have been studied in dairy cattle and have recently been under investigation for use in sows. The use of these technologies in sows could lead to better early detection, quantification and understanding of sow lameness, and advance understanding of the relationship between housing, social factors, and lameness.

The objective of this study is to determine the relationship among variables such as body weight, age, social rank, body condition and health status, and degree of lameness on success within the different systems based on relative productivity, culling rate, health changes, aggression and injuries. Once the relative importance of



**Figure 1.** Position of the 15 reflective markers (3 on each leg and 3 on the back) on the sow



**Figure 2.** Sow walking along kinematic corridor with reflective markers

these variables has been evaluated, the information will be used to complement a group housed sow longevity model. The model will be subsequently validated and refined using data collected from each study site. The aim will be to develop a reliable model that can be used by producers to predict the economic outcome of different management practices related to longevity.

## EXPERIMENTAL PROCEDURE

Data collection is currently underway, and due to be completed in July 2012. The protocols developed in Phase I are being implemented at four research stations across the country, including the Prairie Swine Centre, University of Manitoba, University of Guelph and AAFC Sherbrooke. The use of four sites is of importance as it provides data on a variety of management and housing systems. Data from each site will be incorporated into the evaluation and validation of the sow longevity/profitability model.

### Assessing Lameness

#### *Complex gait scoring*

All sows are gait scored over 2 parities using a standardized qualitative scale from 0 to 4 (simplified version of Main et al., 2000). Selected sows then go on to be gait scored, and a more precise and detailed description of the gait is obtained.

#### *Kinematics*

Each selected sow is video recorded as she walks along a corridor lined with 4 ft high Plexiglas panels to ensure transparency and visibility of reflective markers by the camera. Fifteen reflective markers are placed in standardized locations on the sow's body (Figs. 1&2) in order to record her movement and speed. Recordings are being analyzed for gait characteristics including stride length, stance time, swing time, foot height, walking speed and angle variation of carpal and tarsal joints and back.

#### *Accelerometers*

An accelerometer (Hobo® data logger, Fig. 3) is placed on a rear leg of each selected sow for recording of posture and for evaluation

of stepping behaviour at feeding time. The Hobo® device is safely protected inside a Velcro®-pocket and a Vet-Rap® covering. Data on posture is collected by recording the acceleration on the x-axis (at intervals of 5 seconds) over 24 hours. Data on stepping is collected by recording the acceleration only on the x-axis, for one hour at feeding time.

#### *Force Plate Weigh Scale*

A weigh scale has been adapted for sows that uses 4 separate platforms for measuring weight distribution on each limb (Fig. 4). In Phase 1, a validation study was completed to assess accuracy and precision of the scale. Phase 2 aims to identify indicators of lameness (eg. un-balanced weight distribution, weight shifting) and comparing measures obtained with the force plate to other lameness detection methods, including kinematics, accelerometers and visual scoring.

### Temperament Testing

Dominance and temperament traits are likely to affect the ability of sows to compete in group housing. Dominance is closely related to relative size, age and parity of animals in groups (Drickamer et al. 1999), while temperament is defined as relatively stable individual characteristics (Koolhaas et al. 1999). Two major dimensions of temperament have been identified in pigs. These traits can be described as 'active-passive' and 'confident-fearful' dimensions, and they are expected to affect the ability of sows to compete for social rank within group systems and also the level of aggression displayed. Sow temperament will be measured by 4 tests: the Open Door Test (ODT), Pig Approaching Human (PAH), Human Approaching Pig (HAP) and Novel Object Test (NOT). Figure 5 shows the octagonal pen used in the PAH, HAP and NOT.

### Longevity Study

Data is collected regarding sow condition and lameness at 7, 16 and 20 weeks post-breeding, and production data are collected from on-farm records at the end of maternity. Sow data includes gait score, parity, weight, body condition score, and backfat. Production

data includes breeding, farrowing and weaning dates, total piglets born, total piglets weaned, and sow feed intake, as well as medical records and culling information.

### CONCLUSION

The need to monitor and assess animal welfare standards on commercial farms is becoming an increasingly important issue as quality assurance schemes are expanded in response to consumer demands. Information from this project will provide tools for the accurate assessment of lameness, which is an important welfare measure that may be affected by changes to sow housing. The findings should be of particular interest as many producers in North America will be converting to group housed systems in the near future.

### ACKNOWLEDGEMENTS

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agricultural Development Fund. Specific project funding was provided by the Canadian Swine Research and Development Cluster (Swine Innovation Porc).

### Footnotes to Authors

1. Prairie Swine Centre, Saskatoon, Saskatchewan
2. Agriculture and Agri-Food Canada, Lennoxville, Québec
3. University of Manitoba, Winnipeg, Manitoba
4. University of Guelph, Guelph, Ontario
5. University of Saskatchewan, Saskatoon, Saskatchewan



**Figure 3.** Hobo accelerometer inside a pouch to be held around the lower hind leg



**Figure 4.** Force plate weigh scale



**Figure 5.** Octagonal temperament testing pen

# Loading Facilities for Market Hogs: Saskatchewan's Top 10

Brown, J., T. Stevens and H. W. Gonyou



Harold Gonyou



Jennifer Brown

## SUMMARY

For many producers, loading pigs at marketing can be both stressful and time-consuming. Problems at loading also affect the welfare of animals, and can have a significant economic impact due to carcass damage, meat quality problems or increased death losses. The objective of this project was to identify components of swine loading facilities and handling at loading that have the greatest value for reducing pig stress and loading time. A total of 10 loadout facilities in Saskatchewan were visited in this study, and the facility design and handling methods at each was documented using photographs and video footage. Observations were compared against recommended practice to identify design features and practices that promote good handling in pigs. Suggestions to improve handling at loading include aspects of ramp design and lighting, as well as simple changes to management and handling technique.

## INTRODUCTION

Loading pigs for transport to market can be stressful for pigs and their handlers. Poorly designed loading facilities increase the incidence of prod use and rough handling, and result in longer loading times. Stress associated with loading can increase the incidence of downer pigs and death losses, as well as having adverse effects on carcass and meat quality. Methods for reducing stress at loading have been identified, however few producers have adopted these changes as construction costs are high and the benefits are uncertain.

This project documented loading facilities and handling methods in barns recognized for having good loadouts. The results provide clear suggestions for changes to facilities and management at loading, and will hopefully encourage the construction of better loadouts and adoption of practices at loading that can benefit pigs and producers.

The overall objective of the project was to document superior loading facilities and practices currently in used in the province of Saskatchewan. Specific objectives included; 1) the identification of 10 loading facilities that promote ease and speed of handling in market hogs; 2) evaluation of the design and management characteristics associated with each facility; and 3) preparation of a summary and educational materials for producers to aid them in improving the design and use of loading facilities.

*"Farms with High Prod use Actually had the Longest Loading Time."*

## EXPERIMENTAL PROCEDURES

Saskatchewan farms with good loading facilities were identified based on information supplied by pork producers and truckers.



Figure 1. Covered hydraulic loading ramp with manway (looking down ramp from truck entry)

Once a farm was identified, the producer was contacted regarding participation in the study. Participating farms were selected from locations across the province in order to document a wide variety of loadout designs. Participating farms included corporations such as Fast Genetics and Big Sky Farms, as well as individual producers across the province. Each farm visit included a brief questionnaire on basic housing and management practices, measurements of the loading facility, and observation of the handling techniques used to move pigs at loading.

Loadout measurements included the width, length, and height of pens, alleys and doorways. Light intensity was measured in lux using a light metre placed at pig height at various locations throughout the loadout. Ramp angle was measured using a framing square and level, and calculating the inverse tangent of the rise over run. Any corners, flooring changes, or obstacles were documented using a digital camera.

Handling of pigs during loading was also recorded. For each farm visit, a video camera was either mounted in the loadout or hand operated by the producer to record handling techniques at loading. For each site, either live observations or video footage of pigs at loading were reviewed in order to assess handling technique and pig flow. Handling techniques used on farm were also evaluated on the basis of appropriate/inappropriate use of tools, handler vocalizations, handler body position, attitude, and factors affecting the flow of animals.

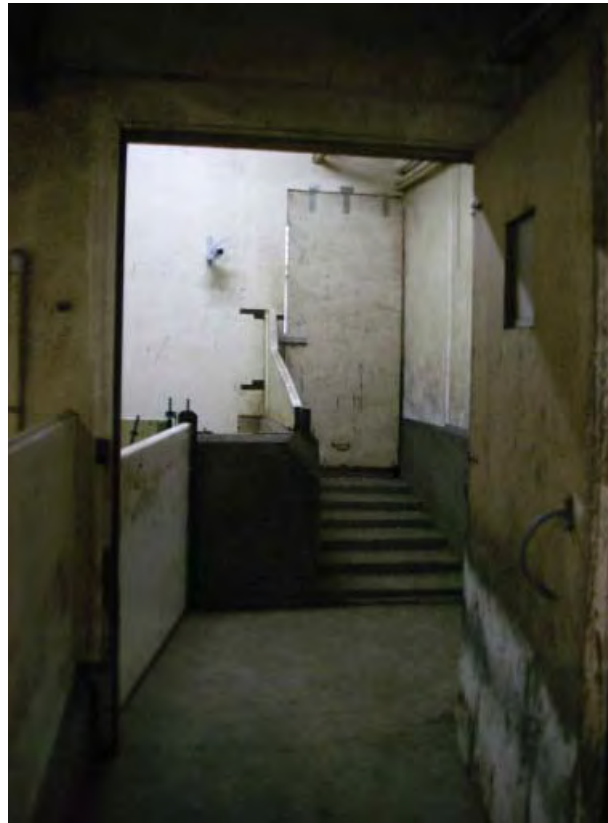
The results of this study were descriptive observations. By examining superior facilities and handling methods, and comparing them with codes of practice and recommended practice, we identified design and handling practices that were effective at reducing stress in pigs during loading.

## RESULTS AND DISCUSSION

The ten farms studied included 6 farrow-to-finish operations, 3 finishing barns and one farrow-to-wean operation. On 8 farms, the pigs were housed in small to medium groups (12 to 50 pigs per pen), and on the 2 remaining farms, pigs were housed in large groups of 600–700 animals. Hogs marketed per week ranged from 160 to 1100 animals, with an average of 500 hogs shipped/ week. Loading time needed to fill a standard potbelly trailer (approx 230 pigs) ranged from 30 to 90 minutes (45 min average). Key facility and handling measures at each loadout were compared against recommended practice.

### *Loadout design*

Recommended practice indicates that ramp angles should be less than 20°, that ramps should be fitted with cleats and have a non-slip surface. The ramps observed on all farms met these specifications, with ramp angles ranging from 0 to 11°. Figures 1 to 3 show examples of the ramps observed. The ramp designs varied considerably



**Figure 2.** Well lit loadout with concrete steps (30 cm treads). Although this loadout involves some corners the transitions are smooth and well-lit and the alley is wide enough for multiple pigs to pass

but all worked well. One farm had a covered adjustable hydraulic ramp with an attached man way, which was very efficient for moving groups onto the trailer (Fig. 1). As well, the adjustable ramp was used to load the top deck and reduced handling stress as it greatly reduced the angle pigs were required to climb compared to the internal truck ramp. Some farms had concrete step ramps with 30 cm treads, which the pigs readily negotiated (Fig. 2). Another farm fabricated a ramp extension which was used to reduce the slope of the internal truck ramp, making it easier to load pigs onto the top deck (see Fig. 3).

Lighting in the loadout area was also examined. It is recommended that loading facilities be well lit, with diffuse incandescent lighting preferred as it reduces contrast and shadows, which may cause animals to balk. Also, when moving into a new area such as the truck, lighting should ideally change from darker to lighter, as animals may balk if required to move into darkness. Lighting levels (recorded using a light meter) showed a large variation in lighting between farms, ranging from below 100 lux at some facilities to over 1000 lux at others. Lighting during loading was also affected by the time of loading and external weather conditions. Some facilities used an enclosed truck bay, which minimized the effects of time of day and weather conditions.

Other features of superior loading facilities were manways, dedicated loading pens near the loadout, and external truck sheds. Manways outside of the alley allow for more efficient handling, as the handlers can easily move around and past groups of pigs without affecting their movement. This improves not only pig flow, but also handler safety. Many barns had loading pens adjacent to the loadout that pigs were moved to up to a week before loading. This has the benefit of reducing mixing stress at transport and makes it much simpler to withdraw feed before transport, as well as making the loading process much faster, with reduced stress on pigs and handlers. Finally, some barns had truck sheds adjacent to the loadout. Sheds provide the advantage of having environmental conditions consistent between the barn and trailer, so pig movement onto the truck is not affected by wind, rain, cold temperatures or high contrast due to sunlight.

### **Handling practices**

Recommended practices related to group size, distractions and handler technique and attitude were reviewed. In terms of group size, smaller groups (5-10 animals) have been shown to be easier to move. If larger groups are moved, considerations must be made regarding the animals (level of fear and willingness to move), facilities (minimal blockage or distractions), and the handlers abilities. Distractions are known to cause pigs to slow, balk or turn back, and farm managers must be observant to detect and minimize distractions in order to reduce stress and keep pigs moving. One common distraction is too many handlers, or handlers that get ahead of pigs and cause them to turn back. Several examples of this were found in the video footage and demonstrate how important it is to observe animals and minimize distractions during handling.

Handler technique and attitude are very difficult to define and measure, however some general recommendations include minimizing prod use, using behavioural principles such as the flight zone and herd behaviour, and maintaining a calm and consistent attitude. Prod use on the farms observed was very low. In fact, the farm with highest prod use actually had the longest loading time. This is because when the prod is used frequently, pigs become less capable of responding and attempt to turn back. Several examples of good handling were found. In one example, the handler stood well behind a group of about 20 pigs as they exited the home pen, providing 'release'. When pigs are moving well a good handler will step back and let the animals move on their own. If the handler steps in closer in an attempt to get them moving faster, the closest pigs will often turn back and escape past the handler. In another example, groups of 12 pigs were moved using handling boards and minimal prod use,

and with minimal interference from handlers. The pigs exited a pre-loading pen, negotiated a turn and mounted the truck ramp calmly as there was plenty of space and the handlers provided an appropriate level of encouragement.

### **CONCLUSION**

There is a large variation in facilities and handling skills across the swine industry, and often little opportunity for producers or barn employees to gain new knowledge.

Lighting, flooring, alley and ramp dimensions and animal handling techniques all have the potential to cause problems when moving pigs through a facility. The best loadouts in Saskatchewan are ones which have taken these factors into account. Our conclusions highlight the fact that handling of pigs at loading can be improved by a variety of measures. This may include extensive load-out renovations, but frequently simple changes in lighting or handling techniques can also be effective. Producers appreciate seeing designs from other facilities and discussing the practical ideas and options presented in this work.

### **ACKNOWLEDGEMENTS**

We gratefully acknowledge the contribution of participating producers. Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council, and the Saskatchewan Agricultural Development Fund. Specific project funding was provided by Saskatchewan Ministry of Agriculture's ADOPT program.



**Figure 3.** External loading ramp allows trucker to assist without entering barn. Note also the ramp extension (on the left) used to reduce the angle of internal truck ramp to the top deck

# Effects of Transport Duration on the Stress Response and Pork Quality of Pigs

Brown, J.<sup>1</sup>, Seddon, Y.M.<sup>1</sup>, Crowe, T.<sup>2</sup>, Widowski, T.<sup>3</sup>, Bergeron, R.<sup>3</sup>, Faucitano, L.<sup>4</sup>, Gonyou, H.<sup>1,2</sup>

<sup>1</sup>Prairie Swine Centre Inc., Saskatoon, SK, S7H 5N9; <sup>2</sup>University of Saskatchewan, Saskatoon, SK; <sup>3</sup>University of Guelph, Guelph, ON;

<sup>4</sup>Agriculture and Agri-Food Canada, Sherbrooke, QU



Harold Gonyou



Jennifer Brown

## SUMMARY

The impact of the effects of transportation duration, season, and compartments (within trailers) was examined in relation to the stress physiology of market pigs and pork quality. Results indicate transportation of pigs over longer distances producing more significant results. Seasonal differences also indicate that pigs experience a greater amount of stress in summer months largely due to heat stress during summer transport. While compartmental differences indicate some compartments within the trailer produced a greater amount of stress on market hogs, and a reduction in meat quality.

## INTRODUCTION

The transport of market pigs within Canada presents a number of significant challenges, including long transport durations, and extremes of temperature. These conditions can cause significant stress in pigs, which is detrimental to their welfare and may also affect transit losses and meat quality. It is therefore important to understand factors influencing transport conditions of market pigs within Canada and how these affect the welfare of pigs and pork quality.

These findings were part of a larger project on the transport of pigs in Canada. This study examines the effects of transport times of 6, 12 and 18 hours on the stress physiology and subsequent meat quality of pigs transported to slaughter in western Canada, and effects of season (summer and winter) and compartmental variation in the truck.

## EXPERIMENTAL PROCEDURES

### *Animals and transport procedures*

Over a period of eight weeks (four weeks per season) three transport trailers were loaded with market pigs (mean live weight 121 kg) and transported from a commercial finishing operation to an abattoir. Each week, prior to leaving for market 16 focal pigs per truck

were weighed, identified with ear tags and given an individual tattoo number. Feed was withdrawn 8-9 hours before transport, but water remained available. To study the effect of durations of transport (6, 12 and 18 h), three trucks were loaded at six hour intervals, with the 18 h truck leaving the farm at 1 pm, the 12 h truck at 7 pm and 6 h truck at 1 am on the day before slaughter. Timing of loading was scheduled such that the three trucks arrived at the abattoir at the same time. The abattoir was located 300 km from the farm, and longer transport times were achieved by travelling by longer routes to the abattoir. Pigs travelled at a density of 0.38 m<sup>2</sup>/pig (4 ft<sup>2</sup>), in accordance with Canadian Agri-Food Research Council guidelines. Winter transport took place between January and February (average temperature -13.4°C) and summer transport between July and August (average temperature 25.9°C). In each week, the meat quality of 48 pigs was studied. These focal pigs were distributed 4 per compartment, across four compartments (C) of interest, C1, C4, C5 and C10 (Fig. 1).

*“Improvements in truck design and optimization of handling and transport practices will reduce most of the stress experienced by pigs during long transport.”*

Pigs were unloaded at the abattoir and rested in lairage for 1.5 hours with water provided, following which they were driven to an electrical stunner and processed. After evisceration carcasses were chilled (1-4 °C) for 24 hours pending cold deboning.

### *Stress physiology measures*

Indicators of physiological stress creatine kinase (CK), cortisol and lactate were measured in 48 pigs per week. Blood was collected at exsanguination. For the measurement of CK and cortisol a minimum of 10mL was collected without anticoagulant. Serum was collected and stored at -80°C until analysis. For lactate, 2 mL of blood was collected in tubes containing anticoagulant. These samples were centrifuged and the plasma was stored at -80°C until analysis.

### *Meat quality measures*

Muscle pH and temperature was measured in the longissimus dorsi (LD) and semimembranosus (SM) muscles at 24 hours postmortem. Light reflectance (color) was measured on SM and LD muscles with a Minolta Chromameter CR 300 (CIE L\*, a\*, b\*) after exposing the muscle surface to 45 min blooming time. Drip loss was assessed on



an adjacent chop according to a modified EZ-DripLoss procedure (Correa et al., 2006). The muscles were classified according to the following quality categories: pale, soft and exudative (PSE), moderate PSE, red, firm and nonexudative (RFN or normal), pale, firm and non-exudative (PFN), red, soft and exudative (RSE), moderate DFD and dark, firm and dry (DFD) as described by Correa et al. (2006).

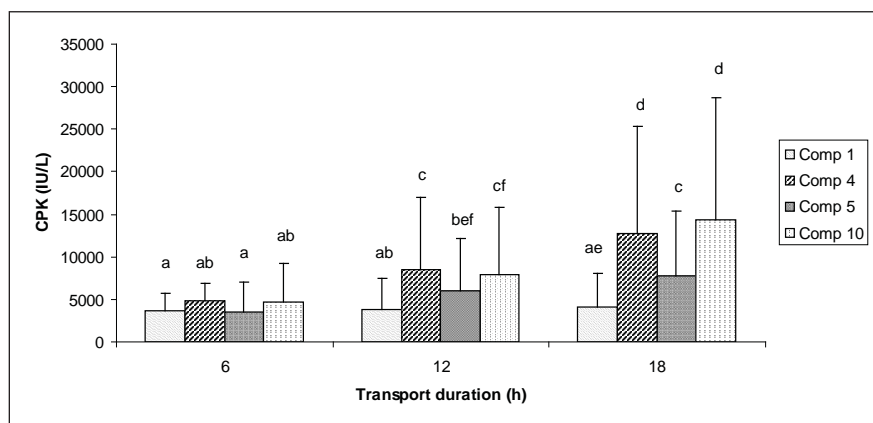
## RESULTS AND DISCUSSION

### Stress physiology measures

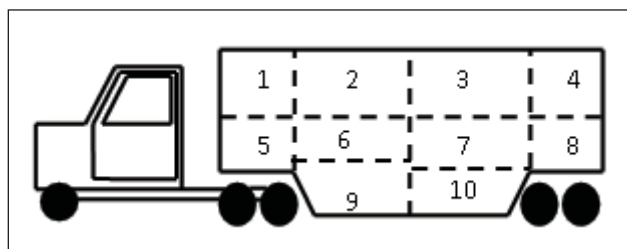
The mean concentration of CK in pigs was affected by compartment ( $P < 0.001$ ) and the duration of the transport ( $P < 0.05$ ). A significant interaction between the transport duration and the compartment (Fig. 2) indicates significantly higher concentrations of CK occur when pigs are transported for longer durations (12 & 18 h), and when housed in C4 and C10. As a measure of physical stress (Warris et al., 1994), these results demonstrate that the longer journeys are more physically demanding for pigs. The interaction with compartment demonstrates that some compartments can cause more stress (C4 and C10), while in others (e.g. C1) pigs traveled long journeys with no increase in CK.

Season affected the concentration of cortisol in pigs with levels being significantly higher during summer than winter (Summer: 36.11ng/mL, Winter: 27.42ng/mL,  $P < 0.05$ ) suggesting that pigs experienced a greater amount of stress in the summer months. This influence of season is most likely due to heat stress during summer transport, and other studies have frequently observed that more death losses occur in summer months (Vecerek et al., 2006).

The concentration of lactate in pigs transported in C10 was significantly lower than in the other three compartments ( $P < 0.01$ ). An interaction between season and compartment showed that in summer there was no difference in lactate concentrations between pigs in different compartments, however in winter pigs had significantly higher lactate concentrations when travelling in C1 and C4 (Fig. 3).



**Figure 2.** Mean concentration of CK (IU/L) in pigs transported for 6, 12 and 18 hours in different vehicle compartments. Where superscripts differ  $P < 0.05$ .



**Figure 1.** Truck design indicating location of compartments within. Focal pigs transported in C1, C4, C5 and C10

Levels of lactate increase in individuals experiencing physical exertion and stress, leading to increased anaerobic glycolysis for the release of energy (Husain et al., 2003). Lactate thus provides a good measure of acute physical stress (Warris et al., 1994). The elevated lactate levels found in compartments C1 and C4, located on the top deck of the trailer, suggest that pigs travelling on the upper decks experienced greater physical exertion during the winter.

### Meat quality

Multiple compartment and trip duration effects on meat quality were found. The longer the duration of travel, the lower the driploss observed in C4 and C10, whereas the rate of driploss did not vary for pigs transported in C1 or C5. Variation due to the interaction of compartment and trip length was greatest in C10, with driploss in SM muscle being higher following 6 hrs of transport compared to 18 hrs.

Within season, pigs traveling in summer in C4 had significantly lower driploss than pigs traveling in other compartments. In winter, pigs traveling in C10 had the lowest driploss, but this was only significantly different from C5. The variation in driploss from LD muscle due to compartment and season interactions differed from that in SM. In LD muscle, there were no significant differences between compartments in summer. Driploss in C10 was significantly greater in summer than in winter, and within winter, driploss from pigs in C1 was higher than in any other compartment.

The pH of LD muscle of pigs traveling in C10 for 18 h was highest compared to any other compartment (Fig.4). When traveling for 6 h the pH level did not differ between any of the compartments, while at 12 h, C4 was significantly higher than C1 and C10.

The colour ( $L^*$ ) of LD muscle was significantly darker in C4 and C10 than in C1 and C5, with C4 and C10 showing moderate DFD characteristics. The large number of compartment differences found suggest that improvements to truck design would aid in improving both the welfare and meat quality of pigs during long distance transport.

## CONCLUSIONS

Evidence from this study shows that the transportation of pigs over longer durations results in increased physiological stress on pigs and reduced meat quality, as longer durations (12 and 18 h) of transport generally produced more significant results. However, some compartments showing much greater effects than others. In particular, compartments C4 and C10 produced results demonstrating greater stress experienced by the pigs and reduced meat quality, while C1 and C5 produced fewer effects. Based on these results, it appears that much of the stress experienced by pigs during long transports can be ameliorated by improving truck design and optimizing handling and transport practices.

Some practical conclusions can be drawn from this work related to handling and transport of pigs. Pigs are highly susceptible to heat stress in summer, and this can be alleviated by several measures. The critical time for heat stress to occur is just after loading. Therefore, loading in hot weather should be done either very early or very late in the day, and loading documents should be prepared before loading to ensure speedy departure as air flow is needed to cool the pigs. Low stress handling, with minimal prod use, is also necessary to minimize heat stress. Loading density should also be considered, and reductions made in high temperatures and at higher marketing weights. Some truckers will shower pigs before transport, and

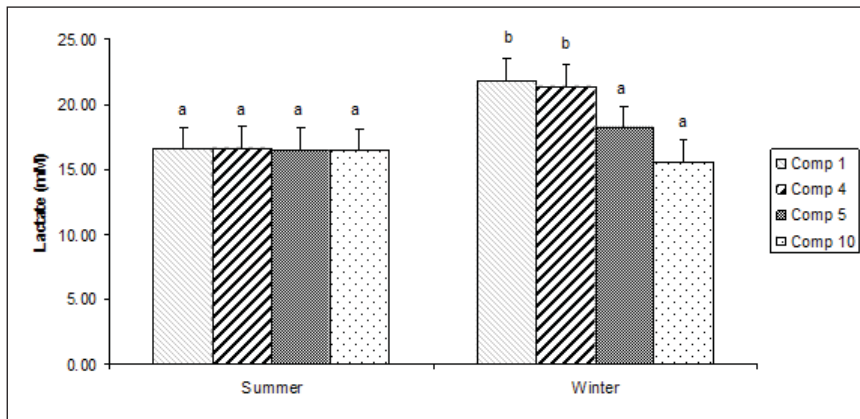
this can help to alleviate heat stress. However it should be noted that showering is only effective if transport begins immediately after showering, as air flow is needed to achieve evaporative cooling. Trucks in summer should remain moving for over 1 hour after leaving the farm in order to allow pigs to cool.

Stress and meat quality problems associated with winter transport, while causing fewer death losses, can be argued to be more severe than in summer months. Adequate boarding and bedding must be provided, with consideration given to the prevailing wind direction. Again, loading densities may need to be reduced to allow pigs room to avoid contact with truck siding.

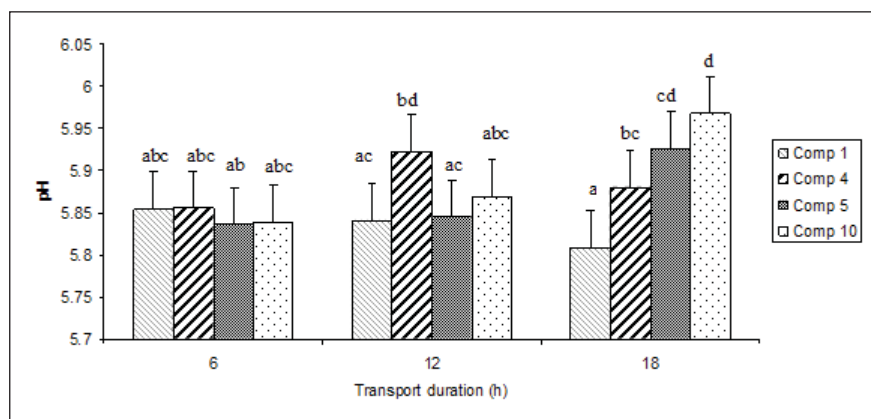
Future work to improve transport conditions should focus on differences between compartments, and how to ameliorate the conditions within problem compartments. For example studies of air flow, vibrations and G-forces, and improvements in trailer boarding patterns and insulation would be useful. Further studies on loading density are also recommended.

## ACKNOWLEDGEMENTS

Strategic program funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and the Saskatchewan Agricultural Development Fund. Specific project funding was also provided by Ontario Pork, Maple Leaf Pork, The Natural Sciences and Engineering Research Council, and Agriculture and Agri-food Canada.



**Figure 3.** Concentration of lactate (mM) in pigs transported in different seasons and different compartments of a truck. Where superscripts differ ( $P < 0.05$ ).



**Figure 4.** Final pH in longissimus muscle from pigs transported for 6, 12 and 18 h in different compartments within the truck. Where superscripts differ,  $P < 0.05$ .

# Dietary Omega-6 to Omega-3 Fatty Acid Ratios Affect Body Fat Mobilization During Lactation

Eastwood, L. and A. D. Beaulieu



Denise Beaulieu



Laura Eastwood

## SUMMARY

An experiment was conducted to determine the effects of altering the omega-6 (n6) to omega-3 (n3) fatty acid (FA) ratio in the diets of high producing sows on whole body metabolism. Results demonstrated that sows consuming diets with an n6:n3 ratio below 5:1 were more likely to be in a state of negative energy balance and body fat mobilization relative to sows with a greater n6:n3 ratio, with potentially negative consequences on reproductive performance and sow longevity.

## INTRODUCTION

Improved genetics and management practices over several years have led to dramatically increased litter sizes. Pre-weaning mortality however, has increased at even greater rates, suggesting that sows may not be able to keep up with the increased energy demands of the litter. At farrowing, sows undergo many metabolic changes associated with milk production which can put them into a negative energy balance. Hypophagia at farrowing contributes to the sows' inability to meet the energy demands for milk production. Over subsequent parities, severe negative energy balance and the loss of body condition have negative impacts on subsequent rebreeding performance and may lead to early culling.

Altering the FA's in adipose tissue can affect lipolytic activity and the ability of the animal to mobilize body fat. Omega-3 FA's alter lipid metabolism, and may also affect feed intake. Moreover, it is possible that the ratio of n3 FA's in relation to n6 FA's will differentially affect body fat mobilization in the sow.

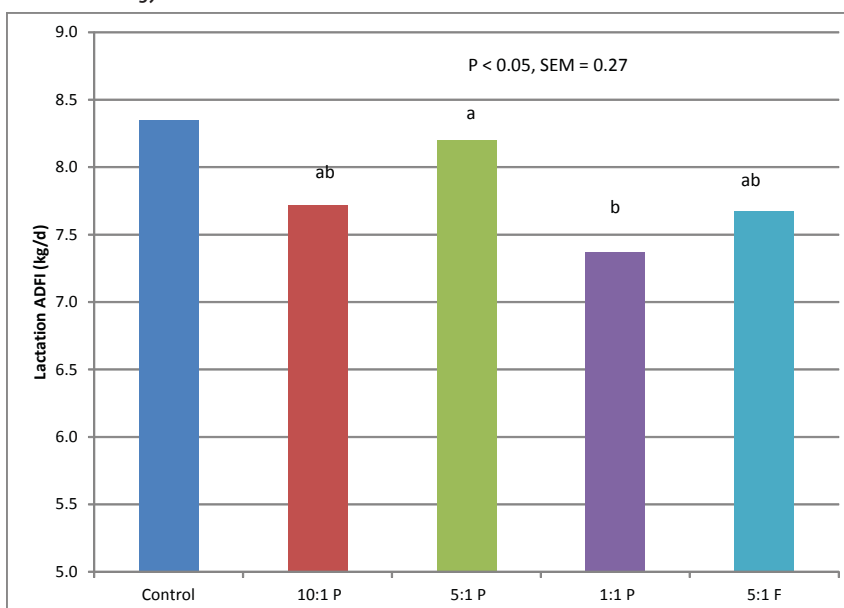
Our overall objective of a series of experiments is to improve the reproductive and productive functions of high producing sows. In this specific experiment, the objective was to determine how altering the n6:n3 FA profile of sow diets affects whole body metabolism and the ability to provide nutrients and energy to her offspring. Milk energy output, piglet growth rate, sow feed intake, plasma leptin and mobilization of fatty acids from sow adipose tissue in response to an epinephrine challenge were measured.

*“When included correctly into sow diets, n3 fatty acids may have positive impacts on body condition and longevity”*

## MATERIALS AND METHODS

The experiment used 5 dietary treatments, each divided into a gestation and lactation ration. Total fat concentration (5% crude fat) was the same among diets, but the ratio of n6 to n3 FA's varied. Treatment groups consisted of a control (tallow), 3 diets with plant oil based n6:n3 ratios (10:1, 5:1, and 1:1) and a 5:1 fish oil diet.

Sows (n=100) farrowing  $\geq 11$  piglets and nursing  $\geq 10$  piglets were assigned to 1 of the 5 diets. Piglet growth rate and sow feed intake was determined throughout lactation. Milk samples were collected on d 4 and 16, and the dry matter (DM), N and energy output of milk was estimated based on piglet growth. On d 5 of lactation, 8 sows from each of the 10:1 and 1:1 groups had jugular catheters inserted



**Figure 1:** Average daily feed intake of sows consuming diets with varied omega-6 to omega-3 fatty acid ratios during lactation (kg/d)

and were challenged with a single injection of epinephrine (epi) followed by serial blood collections to determine the effect of diet on maximal body fat mobilization. Blood was collected for leptin (a hormone which controls appetite and is negatively correlated with feed intake) analysis on day 5 and 15.

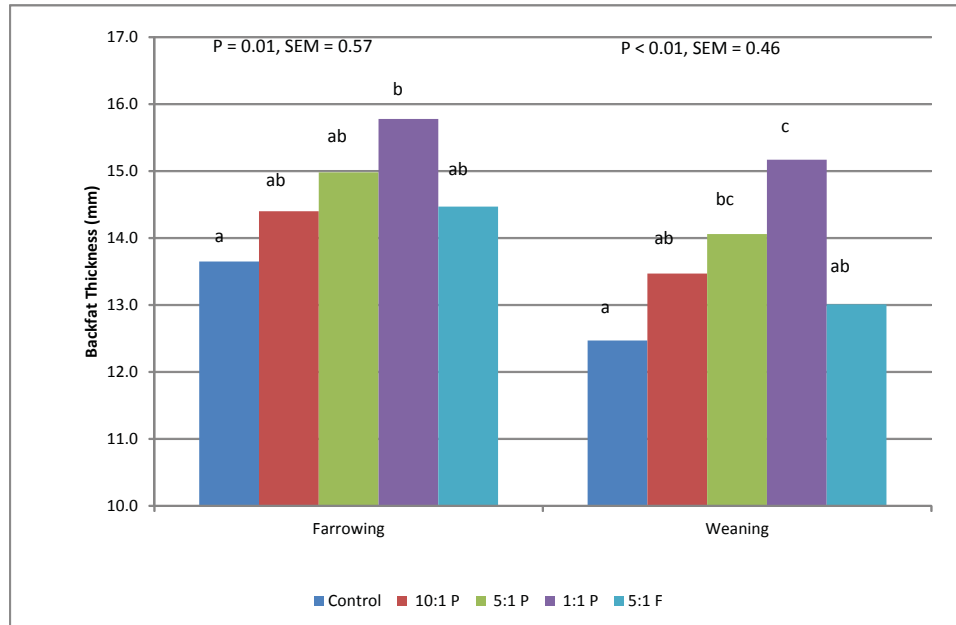
### RESULTS AND DISCUSSION

There was no effect of treatment on the number of piglets born or weaned. Piglets raised by sows consuming the 5:1 plant diet had higher birth and weaning weights, while those nursing sows on the fish based diet had the lowest ( $P < 0.05$ ). Control and 5:1 plant fed sows consumed the most feed, while the 1:1 and fish diet sows consumed the smallest amount ( $P = 0.05$ ; Figure 1). Sow body weight was unaffected by dietary treatment; however, sows consuming the 1:1 diet had greater amounts of backfat when compared to the sows consuming the other diets ( $P < 0.05$ ; Figure 2). Piglet growth rates were unaffected.

Altering the n6:n3 FA ratio in sow diets did not affect milk composition or output, suggesting that sows will compensate for changes in feed intake through body fat mobilization. Prior to any form of metabolic challenge, sows consuming the 1:1 ratio diet appeared to be in a state of body fat mobilization when compared to those consuming the 10:1 ratio (Table 1). Both NEFA and glycerol concentrations (indicators of body fat breakdown) were more than doubled in sows fed the 1:1 diet relative to those fed the 10:1 diet, however the variability associated with this determination was very high and thus significance was not reached. Leptin levels were also elevated in mid lactation in the 1:1 diet sows, which had reduced feed intakes relative to the 5:1 and control diet sows.

When sows were submitted to a metabolic challenge with exogenous epi, we found that the sows consuming a ratio of 10:1 had

a greater response, indicated by a lower area under the response curve for glucose ( $P < 0.05$ ) and tendencies for higher area under the curve responses for NEFA and glycerol concentrations. We hypothesize that since the 1:1 ratio sows were mobilizing more body fat prior to the challenge, they were less sensitive to a dose of exogenous epi. than the 10:1 ratio sows.



**Figure 2:** Backfat thickness (mm) of sows consuming diets with varied omega-6 to omega-3 fatty acid ratios at farrowing and weaning

### CONCLUSIONS

Reducing the n6:n3 FA ratio below 5:1 put sows into a state of increased body fat mobilization, which may have negative impacts on body condition and longevity. In order to ensure producers are not increasing their cull rates and cost of production due to body condition loss, diet formulations including n3 FAs should be formulated relative to n6 FAs. With the costs of raising replacements increasing, sow longevity is a key factor for producers to maximize profits. Producers can keep their most productive sows in the herd longer, and reduce the costs of raising replacements. When included correctly into diets, n3 FAs may help reduce the severity of the negative energy balance which occurs in early lactation.

### ACKNOWLEDGEMENTS

Strategic program funding was provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. Specific funding for this project was provided by Vandeputte s. a., Belgium and the National Pork Board.

**Table 1:** Pre-challenge NEFA and glycerol concentrations in sow plasma in early lactation

|                 | Diet   |        | Statistics |         |
|-----------------|--------|--------|------------|---------|
|                 | 10:1 P | 1:1 P  | SEM        | P Value |
| NEFA, uM        | 93.27  | 240.02 | 74.15      | 0.16    |
| Glycerol, mg/dl | 0.4    | 0.81   | 0.21       | 0.2     |

# Creep Feed Provision in the Farrowing Room Provides Benefits to Piglets Showing Evidence of Intake

Bandara, N., J. Shea, D. Gillis and A. D. Beaulieu



Denise Beaulieu

## SUMMARY

The consumption of creep feed improved growth rates and nursery exit weights. However, only about 40% of the piglets offered the creep feed consumed it.

## INTRODUCTION

Offering supplemental feed in farrowing (creep feeding) is thought to benefit piglets by 1) providing supplemental nutrition 2) aiding the adaptation of the gastrointestinal tract to nutrients not found in milk, including proteins and 3) introducing solid feed to the piglets. However, a study published in last year's annual report (Beaulieu et al. 2010. Annual Research Reports. Weaning at 28 days. Is creep feeding beneficial?) provided data showing that the provision of creep feed in the farrowing room for 7 days prior to weaning had no effect on weaning weights, suggesting offering creep didn't increase overall nutrient intake. Surprisingly, this conclusion was the same for the light and heavy pigs within a litter. Moreover, this data showed that piglets from litters offered creep in farrowing were less inclined to visit the feeder in the nursery immediately post-weaning. This implies that there were no behavioural benefits from the early introduction of solid feed.

This experiment however, was only able to describe the effects of offering creep feed to a litter on performance. We measured creep feed disappearance, but were unable to determine if consumption was equal among litter-mates. The objective of the current experiment, was to determine effects of creep feed provision in the farrowing room, specifically among those piglets who show evidence of consumption.

## MATERIALS AND METHODS

One hundred sows were randomly assigned to one of 2 treatments, creep or no creep. The creep treatment piglets received creep feed

(commercial) for one week prior to weaning. The creep feed was provided in multi-space creep feeders, added in 250 gram allotments as needed. The creep feed and the phase 1 nursery diets were marked with a non-toxic inert dye. Anal swabs taken from each piglet in the creep group 1 day prior to weaning and from all piglets on day 2 in the nursery allowed us to estimate performance responses to creep among those piglets who had actually consumed it and further if consuming creep in the nursery actually encourage intake of the phase 1 diet immediately post-weaning.

*“Creep feeding improves weaning and nursery exit weights for those pigs that actually eat it”*

## RESULTS AND DISCUSSION

Creep feed disappearance was approximately 240 grams per day per farrowing crate. Although birth weight was similar between groups regardless of subsequent creep feeding, weight at 21 days of age (when creep feeding actually began) was higher (Table 1). All litters had been treated exactly the same up to this point, thus, we can't attribute this difference to treatment. There was no difference

**Table 1.** Weaning weights, and nursery growth rate in response to creep feed offered in the farrowing room for 7 days prior to weaning.

| Variable                    | Creep  | No Creep | SEM   | P-Value |
|-----------------------------|--------|----------|-------|---------|
| N (litters/piglets at d 21) | 55/578 | 52/538   |       |         |
| Farrowing room              |        |          |       |         |
| Wean age                    | 26.20  | 26.05    | 0.265 |         |
| BW, birth, kg               | 1.48   | 1.47     | 0.022 |         |
| 21 days of age, kg          | 5.82   | 6.05     | 0.078 | 0.01    |
| Weaning, kg                 | 7.61   | 7.76     | 0.100 |         |
| ADG, 21 doa to weaning, g/d | 0.25   | 0.24     | 0.005 | 0.02    |
| Nursery                     |        |          |       |         |
| BW, d 3 (post-weaning), kg  | 8.03   | 8.18     | 0.101 | ns      |
| Nurs Exit, kg               | 20.46  | 20.35    | 0.339 |         |
| ADG, wean to d 3, g/d       | 0.14   | 0.14     | 0.019 |         |
| wean to d28, g/d            | 0.44   | 0.43     | 0.010 |         |

**Table 2.:** Growth of piglets offered creep in the nursery, separated by evidence of consumption of creep feed and the phase 1 nursery diet on day 1 post-weaning.

| Farrowing<br>Nursery   | Eater              |                     | Non-Eater           |                    | Pooled SEM |
|------------------------|--------------------|---------------------|---------------------|--------------------|------------|
|                        | Eater              | Non-Eater           | Eater               | Non-Eater          |            |
| Wean Age               | 26.63 <sup>a</sup> | 26.00 <sup>bc</sup> | 26.26 <sup>ab</sup> | 25.93 <sup>c</sup> | 0.318      |
| BW, birth, kg          | 1.50               | 1.46                | 1.47                | 1.48               | 0.039      |
| d 21, kg               | 5.53 <sup>a</sup>  | 5.70 <sup>ac</sup>  | 5.99 <sup>bc</sup>  | 6.03 <sup>b</sup>  | 0.164      |
| Weaning, kg            | 7.30 <sup>a</sup>  | 7.51 <sup>ab</sup>  | 7.68 <sup>b</sup>   | 7.80 <sup>b</sup>  | 0.196      |
| ADG, d 21 to wean, g/d | 0.25 <sup>ab</sup> | 0.26 <sup>a</sup>   | 0.24 <sup>b</sup>   | 0.25 <sup>a</sup>  | 0.008      |
| <b>Nursery</b>         |                    |                     |                     |                    |            |
| BW, d 3, kg            | 7.94               | 7.91                | 8.14                | 8.15               | 0.196      |
| Nurs Exit (d 28), kg   | 21.10 <sup>a</sup> | 20.68 <sup>ab</sup> | 20.64 <sup>ab</sup> | 20.04 <sup>b</sup> | 0.484      |
| ADG, Wean to d3, g/d   | 0.21 <sup>a</sup>  | 0.13 <sup>bc</sup>  | 0.15 <sup>b</sup>   | 0.12 <sup>c</sup>  | 0.025      |
| d 4 to 7, g/d          | 0.16 <sup>a</sup>  | 0.17 <sup>a</sup>   | 0.13 <sup>b</sup>   | 0.10 <sup>c</sup>  | 0.019      |
| Wean to d 28, d/g      | 0.48 <sup>a</sup>  | 0.45 <sup>ab</sup>  | 0.45 <sup>b</sup>   | 0.42 <sup>c</sup>  | 0.013      |

a,b,c,d. Numbers within a row with different superscripts, P < 0.05

weaning, of piglets classified as “creep and nursery eaters” was improved relative to other groups (Table 2). Moreover, there is evidence that this improvement was maintained throughout the nursery period.

**CONCLUSION**

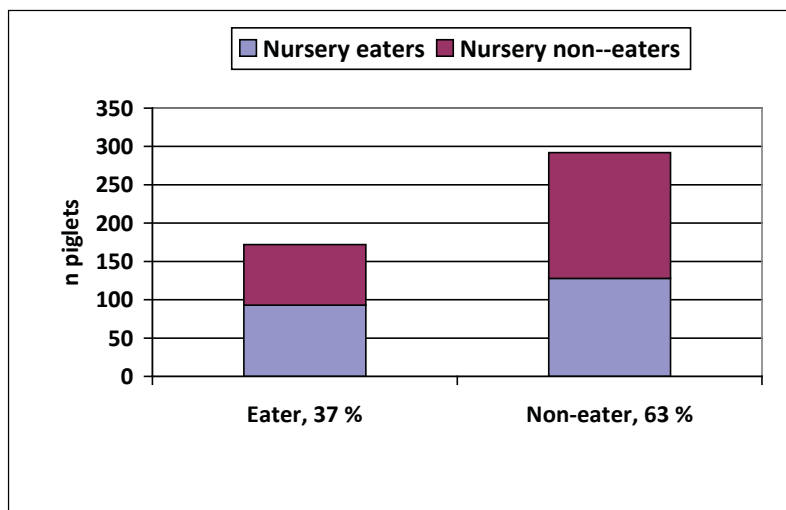
Creep feeding improves weaning and nursery exit weights, for those piglets who actually consume it. Further work is required to determine why not-all piglets consume the creep feed and if these piglets will show improvements in growth if they can be encouraged to consume the creep feed.

**ACKNOWLEDGEMENTS**

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. We appreciate the donation of the creep feed for this experiment from Masterfeeds.

in weaning weights and average daily gain (ADG) from day 21 (when creep was offered) to weaning was higher in those litters offered creep. Similar to what we had observed in previous experiments, providing creep in the farrowing room, had no impact on subsequent overall growth of those litters in the nursery (Table 1).

The data in Table 2 is only from those litters offered creep feed in the nursery. Approximately 37 % (175 out of 471) of piglets offered creep showed evidence of consumption after 5 days. Within the creep “eaters” 45 % had evidence of consuming the phase 1 diet when swabs were taken 48 hours after weaning. Within the creep “non-eaters” this figure was 55 %. This corroborates our previous experiment where video-tape observations showed that piglets from litters offered creep had fewer “feeder approaches” during the first 24 hours post-weaning. Growth rate during the first 3 days post-



**Figure 1.** Proportions of piglets classified as creep eaters (n=175) versus non-eaters (n=296) in the farrowing room and nursery (first 24 hours post-weaning) eaters (n=221) and non-eaters(n=243).



# Determining the NE Content of Diets and Ingredients

Rozeboom, G. and A. D. Beaulieu



Denise Beaulieu

## SUMMARY

Producers and those in the feed industry have heard for several years that compared to either DE or ME, the NE system does a better job of estimating the available energy in ingredients and diets. However, there is still confusion regarding the derivation of values used in the NE system. Determining the NE content of either an ingredient or a diet is much more complex than either DE or ME. The comparative slaughter technique determines retained energy and requires an estimate of fasting heat production. Indirect calorimetry provides a direct estimate of heat loss while predictive equations have been developed using indirect calorimetry as a reference. Each technique has benefits and limitations which should be understood by anyone using these values.

## INTRODUCTION

The hog industry is focused on producing a product with the greatest efficiency possible, and feed has the greatest impact on the ability to accomplish this goal. Feed cost accounts for over 65% of the total hog production cost. Within feedstuffs, the most expensive component is energy (90%). Therefore characterizing the available energy in a feed is required to estimate its overall feeding value.

## MATERIALS AND METHODS

### Net Energy Systems

Historically, the swine industry in North America has used metabolizable (ME) or digestible energy (DE). However, we know that a NE system does a better job of characterizing the energy available for productive purposes. Moreover while the ME/DE ratio is relatively constant (example 0.95, 0.94, 0.91) for barley, wheat and canola meal, respectively, the NE to ME (or DE) ratio varies. For example the NE/ME ratio for barley, wheat and canola meal is 0.77, 0.74 and 0.57 respectively, meaning that we can't convert from ME to NE with the use of simple conversion factors.

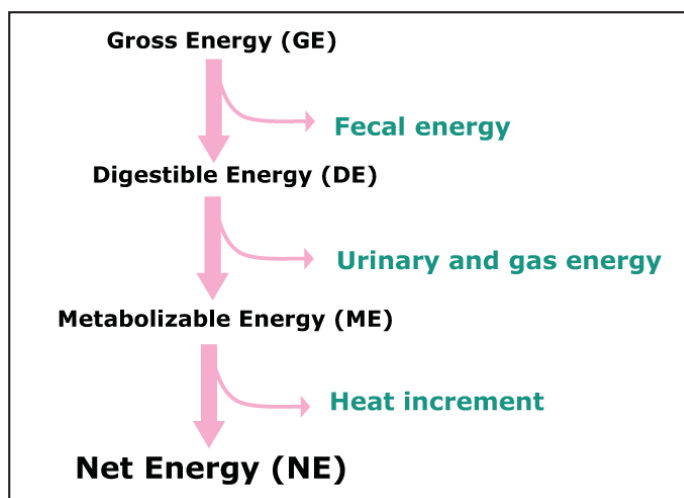
Net energy (NE) is defined as the metabolizable energy (ME) minus the heat increment. Essentially it is the efficiency of the utilization of metabolizable energy. The heat increment is the heat produced during the digestion and metabolism of nutrients. After subtracting the heat increment from the metaboliz-

able energy we are left with energy for maintenance and production. Maintenance energy is the amount of energy required for an animal to perform just the necessary functions to live. Energy used for production can be divided into energy for movement, lactation, growth, and gestation.

Theoretically, since NE is the energy available to the animal for productive functions it is the ideal energy system. However, the adoption of NE has been hindered, in part, because, relative to either DE or ME, it is difficult to measure. Direct calorimetry which measures the heat lost from an animal is difficult, requires extremely expensive equipment and is rarely done. At the Prairie Swine Centre, we often rely on nutrient tables (see references) for a listing of the NE values for feedstuffs, recognizing that they are estimates often derived from a limited number of experiments. When our research requires us to obtain our own estimates of the NE content of an ingredient or a diet we have 3 methods available to us.

*“Net Energy system provides better characterization of the efficiency with which energy is used for growth and/or production”*

1. **Comparative slaughter technique (CST).** In this method we measure the energy gained in the carcass over a specified period of time. Essentially we must euthanize a subset of animals at the beginning and at the end of an experiment, grind the entire carcass and take a sample, ensuring that this sample is representative of the entire carcass. In the lab we then measure the energy content of this subsample, which allows us to calculate the energy content in the entire carcass. By subtracting the energy in the carcass from the pigs slaughtered at the end of the experiment, from those at the beginning, we can calculate the energy gained over time or retained energy (RE). We also need a value for the fasting heat production (FHP) an estimate of the heat increment. This can be determined experimentally by measuring the RE in groups of pigs fed decreasing



amounts of their diet and then calculating the RE as if they had received no feed for a period of time (fasting). All production factors (i.e. genotype, sex, age, and diet) have to be exactly the same for this value to be used. It can be challenging to use this value from farm to farm because of confounding variables. Typically we estimate the FHP using an accepted value from the literature (ie. 110 kcal DE per kg BW<sup>0.75</sup>).

NE is then calculated as:  $NE = RE - FHP$

The advantage of CST is that animals are maintained in typical production conditions. The disadvantage is the cost, and the requirement to euthanize large numbers of animals. An estimation of FHP is required.

- Prediction equations.** Several researchers have developed equations which predict the NE content of a feed or diet. Depending on the equation chosen, these require knowledge of various nutrients or digestible nutrients in the feed as inputs. Most of these equations have been developed from experiments using indirect calorimetry (below). Examples of equations in common use are:

$$NE, \text{ kcal/kg DM} = 2.892 \text{ DCP} + 0.8.365 \text{ DEE} + 3.418 \text{ starch} + 2.84 \text{ sugars} + 2.055 \text{ Dres}$$

$$NE, \text{ kcal/kg DM} = 0.703 \text{ DE} + 1.58 \text{ EE} + 0.48 \text{ starch} - 0.98 \text{ CP} - 0.98 \text{ CF}$$

(cited as NE<sub>2</sub> and NE<sub>4</sub> respectively in Noblet (1994) and Sauvant (2004). DCP = digestible crude protein, DEE = digestible ether extract, Dres = digestible organic matter - (DCP + DEE + starch + DCF), DE = digestible energy, EE = ether extract, CP = crude protein and CF = crude fibre

Using these equations requires knowledge of digestible nutrient content of a feed. Moreover care has to be taken that characterization of the digestible nutrient content is conducted using similar methodology (lab analyses etc) that were used to develop the equation.

- Indirect calorimetry** is a measure of carbon dioxide (CO<sub>2</sub>) and oxygen (O<sub>2</sub>) exchange. Heat production is correlated to O<sub>2</sub> consumption and CO<sub>2</sub> production therefore indirect calorimetry allows an estimation of heat production. Pigs are maintained in chambers for several days and the air entering and leaving is sampled for CO<sub>2</sub>, O<sub>2</sub> and methane (CH<sub>4</sub>). Urine must also be collected and analyzed for nitrogen. The equipment required for indirect calorimetry is very expensive, to purchase and maintain. Typically the chambers can only accommodate one pig at a time. PSCI doesn't have calorimetry chambers, however we have collaborated with the University of Manitoba to use their chambers. This allows us to compare net energy values obtained from indirect calorimetry with the values we get using CST or regression equations.

Most of the equations today were established in Europe which has more experience with the NE system than Canada. They were developed using a series of digestibility and calorimetry experi-

ments, primarily in France (INRA) or the Netherlands (CVB) during the 1990's and while the values obtained will vary depending on the system used, there is relatively good agreement between these two systems and selection of a specific equation will often depend primarily on the information available to the user. When we conducted experiments comparing the different systems we found that different equations gave similar values for the NE content of a diet, and these agreed better with indirect calorimetry than the numbers we obtained from the CST. This is to be expected as the development of the equations used indirect calorimetry as their reference. Most producers or feed formulators should select a system which is available to them, and not obtain values from different systems.

Regardless of the system chosen, there is general agreement that any NE system provides a better estimate of the energy available for production. This is especially important when formulating diets with by-product or non-traditional feedstuffs. It has well established that the ME and DE systems tend to overestimate the energy of fiber and protein and underestimate the energy value of oils, fats, and starch. These factors are vital when it comes to formulating a diet and can be used to lower feed cost.

## SUMMARY AND CONCLUSIONS

Obtaining NE values for diets or feedstuffs is more complex than DE or ME values. However, the NE provides a better characterization of the efficiency with which energy is used for growth and/or production. Most feed tables now contain a value for the NE content. Commonly used and accessible tables are listed in the references. Most of the values are based on the INRA system. Unfortunately the values used by the CVB (Dutch) system are more difficult to obtain. It is important for producers and feed formulators to have a basic understanding of the derivation of these numbers and why these values may vary depending on the system used.

## ACKNOWLEDGEMENTS

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund.



# The Efficiency of Energy Utilization by Growing Pigs Selected for Potential Growth Rate

A. D. Beaulieu, J. Shea, D. Gillis and J. Marriott



Denise Beaulieu

## INTRODUCTION

Despite years of breeding for specific characteristics, variation still exists within our population of pigs with respect to growth, feed intake and feed efficiency. This trial is part of a series of experiments designed to improve our understanding of energy metabolism in growing and finishing pigs. The overall objective of this experiment was to determine if early growth rate (potential growth rate, PGR) is predictive of efficiency of energy utilization later in life. Understanding the differences in energy utilization among fast and slow growing pigs will help us to manage and develop cost-effective feeding programs that most closely meet the specific requirements of these groups of pigs.

## MATERIALS AND METHODS

Sixty barrows were assigned to either a slow, average or fast PGR group based on growth rate from birth to nursery exit. When the pigs reached 30 kg BW they were placed in individual pens and assigned to receive either a low or a high energy diet at 100 or 85 % of ad libitum intake. The experiment therefore, had a total of

*“Segregating pigs and feeding based on potential growth rate does not improve the ability to match feed to requirements”*

3 x 2 x 2 = 12 treatments, (3 growth potentials, 2 dietary energy concentrations and 2 intake levels). Diets are described in Table 1. The high energy diet had more wheat and canola oil and less barley than the low energy diet. Diets were formulated with a comparable standard ileal digestibility (SID) % lysine, therefore the lysine/energy ratio was lower in the high energy diet. Lysine, however, was formulated to be non-limiting in both rations. Diets contained 0.4% celite, a source of acid-insoluble ash used as a marker for digestibility calculations.

The pigs were slaughtered when they reached 60 kg BW, the carcasses ground, and analyzed for nutrient content. Comparing the data with a group of pigs slaughtered at the beginning of each experiment allows the calculation of nutrient retention within each growth period. Dietary NE was calculated as RE + FHP where RE = energy retained in the carcass and FHP = fasting heat production estimated as 179 kcal/kg BW<sup>0.6</sup> (Noblet et al. 2003).

Faeces were collected throughout the growing period to allow for the measurement of DE and estimation of NE using the equations developed by Noblet (2004) and the CVB (2005) which are predictive equations based on nutrient content and digestibility.

## RESULTS

The pigs were selected for PGR based on growth rate in farrowing and nursery. The targeted body weight to begin the experiment

**Table 1.** Ingredient and nutrient composition of experimental diets

| Item                        | Formulated NE Conc., Mcal/kg |       |
|-----------------------------|------------------------------|-------|
|                             | 2.18                         | 2.40  |
| Ingredient, % as-fed        |                              |       |
| Barley                      | 65.61                        | 4.00  |
| Wheat                       | 4.00                         | 63.03 |
| Soybean Meal                | 25.60                        | 25.60 |
| Canola Oil                  | 1.00                         | 3.50  |
| Limestone                   | 1.15                         | 1.15  |
| Mono / di Ca / P            | 1.35                         | 1.35  |
| Vitamin premix <sup>1</sup> | 0.056                        | 0.056 |
| Mineral premix <sup>1</sup> | 0.075                        | 0.75  |
| Salt                        | 0.50                         | 0.50  |
| DG200 Sel                   | 0.15                         | 0.15  |
| L-Lysine HCl                | 0.105                        | 0.155 |
| L-Threonine                 | 0.00                         | 0.03  |
| DL-Methionine               | 0.00                         | 0.005 |
| Celite                      | 00.40                        | 0.40  |
| Nutrients, formulated       |                              |       |
| DE, Mcal/kg                 | 3.25                         | 3.56  |
| NE, <sup>2</sup> Mcal/kg    | 2.18                         | 2.40  |
| Dlys, %                     | 0.93                         | 0.96  |
| Dlys/DE, g/Mcal             | 2.89                         | 2.69  |
| Dlys/NE, g/Mcal             | 4.27                         | 4.00  |

**Table 2.** Performance of barrows growing from 30 to 60 kg BW selected for potential growth rate and fed a high or low energy concentration diet at 85 or 100 % of ad libitum intake.

| Item                 | Projected Growth Rate |         |      | Dietary Energy Conc. |             | Feeding Level (FL), % Ad Lib. |             |
|----------------------|-----------------------|---------|------|----------------------|-------------|-------------------------------|-------------|
|                      | Slow                  | Average | Fast | Low                  | High        | 85                            | 100         |
| n                    | 32                    | 32      | 32   | 48                   | 48          | 48                            | 48          |
| BW per day of age, g | 0.31                  | 0.38    | 0.44 | 0.38                 | 0.38        | 0.38                          | 0.38        |
| Initial BW, kg       | 30.3                  | 29.9    | 30.4 | 30.2                 | 30.13       | 30.3                          | 30.1        |
| Final BW, kg         | 60.1                  | 60.2    | 60.0 | 60.2                 | 60.1        | 60.1                          | 60.1        |
| No. Days on Test     | 32.3                  | 32.1    | 31.3 | 31.9                 | 31.9        | <b>35.9</b>                   | <b>27.9</b> |
| ADG, kg              | 0.94                  | 0.95    | 0.97 | 0.95                 | 0.96        | <b>0.83</b>                   | <b>1.07</b> |
| ADFI, kg             | 2.02                  | 1.99    | 1.96 | <b>2.06</b>          | <b>1.93</b> | <b>1.79</b>                   | <b>2.19</b> |
| FCE (G:F), kg/kg     | 0.47                  | 0.49    | 0.50 | <b>0.47</b>          | <b>0.50</b> | <b>0.47</b>                   | <b>0.50</b> |
| FCE (F:G), kg/kg     | 2.13                  | 2.04    | 2.00 | <b>2.13</b>          | <b>2.00</b> | <b>2.13</b>                   | <b>2.00</b> |

was 30 kg for all pigs, therefore pig age differed. The slow-growing pigs were about 98 days of age, almost 4 weeks older than the fastest growing pigs, who had reached 30 kg BW at only 71 days of age. The average PGR group was 78 days of age. Despite this, ADG from 30 to 60 kgs BW was only slightly higher for the fast PGR pigs. A lower daily feed intake for these pigs resulted in a tendency for an improved feed efficiency ( $P = 0.07$ ; Table 2). Energy concentration of the diet had no effect on growth rate; feed intake was reduced on the high energy diet, therefore feed efficiency (kg/kg) was improved for pigs fed this diet.

As expected, pigs fed the diet at 100 % had improved growth relative to pigs allowed only 85 % of ad libitum. Feed efficiency (kg/kg) was also improved at the higher feed intake.

The efficiency of utilization of energy for growth, protein or lipid deposition was numerically lower for the fast growing pigs relative to the average or slower growing pigs, however, this difference was not significant (Table 3). The efficiency of energy utilization for protein or lipid deposition (g/Mcal intake) was improved with the low energy diet. Pigs fed the diet at 85% ad libitum utilized energy more efficiently relative to those allowed 100 % intake, regardless of PGR or dietary energy concentration. The ad libitum fed pigs had fewer days to reach 60 kg, grew faster, ate more and had improved feed efficiency. However, the efficiency of energy utilized for protein or lipid deposition was improved with the lower intake.



**Table 3.** The efficiency of energy used for retained energy or protein or lipid deposition in barrows growing from 39 to 60 kg BW.

| Item  | Projected Growth Rate |         |      | Dietary Energy Conc. |      | Feeding Level (FL), % Ad Lib. |      |
|---|-----------------------|---------|------|----------------------|------|-------------------------------|------|
|   | Slow                  | Average | Fast | Low                  | High | 85                            | 100  |
| Energy retention, Mcal retained/Mcal consumed |                       |         |      |                      |      |                               |      |
| <i>Deig</i>                                   | 0.60                  | 0.58    | 0.56 | 0.67                 | 0.49 | 0.67                          | 0.49 |
| <i>NEcStig</i>                                | 0.81                  | 0.79    | 0.76 | 0.86                 | 0.71 | 0.91                          | 0.66 |
| <i>NEINRAig</i>                               | 0.92                  | 0.90    | 0.86 | 1.04                 | 0.75 | 1.05                          | 0.74 |
| Protein deposition, g/Mcal energy in          |                       |         |      |                      |      |                               |      |
| <i>Deig</i>                                   | 41.2                  | 39.4    | 36.9 | 45.3                 | 33.0 | 45.5                          | 32.8 |
| <i>NEcStig</i>                                | 56.1                  | 53.5    | 50.0 | 58.5                 | 47.8 | 62.6                          | 43.8 |
| <i>NEINRAig</i>                               | 63.8                  | 60.8    | 56.7 | 70.1                 | 50.8 | b                             | 50.0 |
| Lipid deposition, g/Mcal energy in            |                       |         |      |                      |      |                               |      |
| <i>Deig</i>                                   | 37.6                  | 35.2    | 33.7 | 41.8                 | 28.5 | 39.6                          | 31.3 |
| <i>NEcStig</i>                                | 51.0                  | 47.6    | 45.4 | 54.8                 | 41.2 | 54.1                          | 41.9 |
| <i>NEINRAig</i>                               | 58.1                  | 54.3    | 51.7 | 65.7                 | 43.7 | 62.1                          | 47.3 |

The experimental DE and NE values obtained are shown in Table 4. The DE content of the diets was much lower than expected. We don't have an explanation for this. These diets were representative of others we have used and energy digestibility was higher. The NE values calculated using the INRA (French) equation were similar to the formulated NE concentration. The values used in our formulations are largely obtained from the INRA data base so this is evidence that this data base is useful for feedstuffs obtained in Western Canada.

### CONCLUSIONS

The efficiency of the utilization of dietary energy for growth was comparable among pigs selected for high or low potential growth rate. This implies that segregating pigs and feeding based on PGR is not a tool that will improve our ability to match feed to requirements.

**Table 4.** Experimentally derived DE and NE values

| Determined Energy Conc. Mcal/kg | Formulated NE Conc., Mcal/kg |      | Determination Method   |
|---------------------------------|------------------------------|------|--|
|                                 | 2.18                         | 2.40 |  |
| DE                              | 2.86                         | 3.25 | Total tract digestibility with marker  |
| <i>NEcST</i>                    | 2.37                         | 2.47 | $NE = RE + FHP$ (carcass slaughter method)   |
| <i>NEINRA2</i>                  | 2.14                         | 2.38 | $NE = 0.121 * Dig. CP + 0.350 * Dig EE + 0.143 * St + 0.119 * Sugars + 0.086 * Residue$ (Sauvant et al., 2004) |

### ACKNOWLEDGEMENTS

Strategic funding provided by Sask Pork, Manitoba Pork Council and Saskatchewan Agriculture and Food Development Fund. Funding specifically for this project from the National Sciences and Engineering Research Council of Canada (NSERC) and Cargill is gratefully acknowledged.



# Publications List

**Whittington, D.L.** 2011. Reinventing the Centre to Meet Changing Industry Needs. Centred on Swine. Prairie Swine Centre Inc., Saskatoon SK. Vol 17 (No 1)

**Whittington, D.L.** 2011. Handling Pigs in Large Groups. PSC Ezine. Prairie Swine Centre Inc., Saskatoon SK. Vol 1 (12)

**Whittington, D.L.** 2011. Heating and Ventilation Checklist. PSC Ezine. Prairie Swine Centre Inc., Saskatoon SK. Vol 1 (11)

**Whittington, D.L.** 2011. Starter Diet – Quantity and Quality Revisited. PSC EZine. Prairie Swine Centre Inc., Saskatoon SK. Vol 1 (10)

**Whittington, D.L.** 2011. Prairie Swine Centre and Production Research Impact on Canadian Pork Industry. BC Pork Producers Annual Meeting. Chilliwack, BC. Nov.3

**Whittington, D.L.** 2011. Hot Topics in Pork Production, VSTG meetings, Banff, AB, Jan. 17.

**Whittington, D.L.** 2011. The Canadian Pork Industry – Adapting to a Changing Environment. JSR annual industry conference, Nottingham University, Nottingham, UK, September 13.

**Whittington, D.L.** 2011. Swine Production Research at Prairie Swine Centre, Board of Manitoba Pork Council, Winnipeg, MB. May 12.

**Whittington, D.L.** 2011. Swine Production Research at Prairie Swine Centre, Fast Genetics Meeting, Saskatoon, SK. Apr. 26.

**Whittington, D.L.** 2011. Pig as Model in Human Research. Institute of Child and Adult Arthritis, College of Medicine and Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Apr. 26.

**Whittington, D.L.** 2011. Swine Production Research at Prairie Swine Centre, Big Sky Farms Management Meeting, Humboldt, SK. Mar. 28.

**Whittington, D.L.** 2011. Swine Production Research at Prairie Swine Centre, PSC/Elanco producer meetings, Lethbridge, AB Mar 24.

**Whittington, D.L.** 2011. Swine Production Research at Prairie Swine Centre, PSC/Elanco producer meetings, Red Deer, AB. Mar 23.

**Whittington, D.L.** 2011. Swine Production Research at Prairie Swine Centre, PSC/Elanco producer meetings, Morinville, AB, Mar 22.



**Whittington, D.L.** 2011. Swine Production Research at Prairie Swine Centre, PSC/Elanco producer meetings, Saskatoon, Sk. Mar 4.

**Whittington, D.L.** 2011. Swine Production Research at Prairie Swine Centre, PSC/Elanco producer meetings, Portage La Prairie, MB. Mar 2.

**Whittington, D.L.** 2011. Swine Production Research at Prairie Swine Centre, PSC/Elanco producer meetings, Niverville, MB. Mar 1.

**Whittington, D.L.** 2011. Hot Topics in Pork Production, VSTG meetings, Banff, AB., Jan. 17.

Jin, Y. and **B. Predicala.** 2011. Assessment of occupational exposure risk of swine production facility workers. Project#AB1101. Progress report submitted to Agriculture and Food Council of Alberta. December 2011.

Jin, Y. and **B. Predicala.** 2011. Use of nanoparticles to control greenhouse gas emissions and bioaerosols in livestock operations. Project#AB1103. Progress report submitted to Agriculture and Food Council of Alberta. December 2011.

**Predicala, B.** and Y. Jin. 2011. Monitoring occupational exposure of swine barn workers to dust and ammonia. 10th Conference of the Canadian Rural Health Research Society. Paper No. 3418. Vancouver, British Columbia. 21-22 October 2011.

Moreno, L., M. Nemat and **B. Predicala.** 2011. Application of microbial fuel cells in treatment of waters contaminated by short chain fatty acids. Western Canada Water Conference and Exhibit. Saskatoon, Saskatchewan. September 20 – 23, 2011.

Dominguez, L., **B. Predicala** and A. Alvarado. 2011. Comparative evaluation of the use of heat exchanger, ground source heat pump and conventional heating systems in grow-finish rooms. Centred on Swine. Fall 2011. Prairie Swine Centre Inc. Saskatoon, SK. pp. 6-7.

Alvarado, A., **B. Predicala** and Y. Jin. 2011. Developing strategies for water conservation for producers. Centred on Swine. Spring 2011. Prairie Swine Centre Inc. Saskatoon, SK. pp. 6-7

Alvarado, A. and **B. Predicala**. 2011. Controlling gas emissions from swine facilities using zinc oxide nanoparticles. Paper No.: CSBE 11-303. CSBE/SCGAB Annual Conference, Winnipeg, MB, Canada. 10-13 July 2011.

Dominguez, L., **B. Predicala**, J. Price, Y. Jin and A. Alvarado. 2011. Comparative evaluation of radiant and forced convection heaters in grow-finish swine rooms. Paper No.: CSBE 11-408. CSBE/SCGAB Annual Conference, Winnipeg, MB, Canada., 10-13 July 2011.

Dominguez, L. and **B. Predicala**. 2011. Evaluation of the use of heat recovery ventilator and geothermal heating in swine grow-finish rooms. Paper No.: CSBE 11-304. CSBE/SCGAB Annual Conference, Winnipeg, MB, Canada., 10-13 July 2011.

**Predicala, B.** 2011. Improving energy efficiency in swine barns to reduce cost of production. Project#P41-A. Final Report submitted to Advancing Canadian Agriculture and Agri-Food Saskatchewan (ACAAFS). 30 June 2011.

**Predicala, B.** and Y. Jin. 2011. Engineering and management measures to reduce environmental emissions and improve the work environment in swine barns (Proj. No. 07-02-051). Progress report submitted to Manitoba Livestock Manure Management Initiative. 01 May 2011.

**Predicala, B.**, A. Alvarado, and D. Asis. 2011. Novel application of nanoparticles for controlling odour and gaseous emissions from swine barns. Project#20060134. Final report submitted to Saskatchewan Agriculture Development Fund (ADF). April 2011. 76p.

**Predicala, B.** and L. Dominguez. 2011. Improving energy efficiency in swine barns to reduce cost of production. Project#20080161. Progress Report submitted to Saskatchewan Agriculture Development Fund (ADF). 15 March 2011.

**Predicala, B.**, A. Alvarado, L. Dominguez and Y. Jin. 2011. From Nanoparticles to Natural Gas: Keeping Barns Efficient and Healthy Places to Work. 2011 Spring Producers Meetings. Niverville, Manitoba - March 1. Portage La Prairie, Manitoba - March 2. Saskatoon, SK - March 4. Red Deer, Alberta - March 23. Lethbridge, Alberta - March 24.

Alvarado, A. and **B. Predicala**. 2011. Reducing gaseous emissions from swine barns using zinc oxide nanoparticles.

Presentation at the Banff Pork Seminar. Banff, Alberta, Canada, 18-21 January 2011.

Alvarado, A. and **B. Predicala**. 2011. Reducing gaseous emissions from swine barns using zinc oxide nanoparticles. Advances in Pork Production, Univ. of Alberta, Edmonton, AB. Vol. 22. Abstr. #2.

**Predicala, B.** and Y. Jin. 2011. Benchmarking water use and developing strategies for water conservation in swine production (Proj# 20090310). Progress Report submitted to Agriculture Development Fund. 01 January 2011.

**Predicala, B.** and A. Alvarado. 2011. Controlling environmental emissions from swine barns using zinc oxide nanoparticles. 2010 Annual Research Report. Prairie Swine Centre Inc., Saskatoon, SK. pp. 16-18.

Dominguez, L., **B. Predicala** and A. Alvarado. 2011. Comparative evaluation of the use of heat exchanger, ground source heat pump and conventional heating systems in grow-finish rooms. 2010 Annual Research Report. Prairie Swine Centre Inc. Saskatoon, SK. pp. 19-20.

**Predicala, B.**, Y. Jin and A. Alvarado. 2011. Evaluation of methods for controlling and monitoring occupational exposure of workers in swine facilities. 2010 Annual Research Report. Prairie Swine Centre Inc., Saskatoon, SK. pp.21-23.

**Predicala, B.**, Y. Jin, E. Richards and A. Alvarado. 2011. Evaluation of water use and potential water conservation strategies in swine barns. 2010 Annual Research Report. Prairie Swine Centre Inc., Saskatoon, SK. pp.24-25.

Alvarado, A., **B. Predicala** and D. Asis. 2010. Evaluation of the effectiveness of zinc oxide nanoparticles in reducing gas emissions from swine manure. Paper No. 561. Proc. of the International Conference on Nanotechnology: Fundamentals and Applications. Ottawa, Canada., 4-6 August 2010.





Alvarado, A. and **B. Predicala**. 2010. Room-scale study of the effectiveness of zinc oxide nanoparticles in reducing gas emissions from swine manure. Paper No.: MBSK10-201. ASABE/CSBE North Central Conference, Saskatoon, SK, Canada., 7-9 October 2010.

Dominguez, L. and **B. Predicala**. 2010. Evaluation of Energy Saving Measures in Swine Barns Using Numerical Simulation. Paper No.: MBSK 10-205A. ASABE/CSBE North Central Conference, Saskatoon, SK, Canada., 7-9 October 2010.

**Predicala, B.** and L. Dominguez. 2010. What you should know about decreasing heating and ventilation costs. Red Deer Swine Technology Workshop. Red Deer, Alberta. 3-4 November 2010.

Jin, Y., **B. Predicala**, A. Alvarado, L. Dominguez and L. Moreno. 2010. Effects of engineering control and management measures on reducing risks of worker exposure to dust and ammonia in swine barns. Paper No.: MBSK10-207. ASABE/CSBE North Central Conference, Saskatoon, SK, Canada., 7-9 October 2010.

Alvarado, A. and **B. Predicala**. 2010. Effectiveness of zinc oxide nanoparticles in reducing gaseous emissions from swine manure. Poster presented at the 2010 ASABE International Symposium on Air Quality and Manure Management for Agriculture, Dallas, Texas, 13-16 September 2010.

Alvarado, A. and **B. Predicala**. 2010. Effectiveness of zinc oxide nanoparticles in reducing gaseous emissions from swine manure. Poster presented at the 2010 Saskatchewan Pork Industry Symposium, Saskatoon, SK, Canada, 23-24 November 2010.

Dominguez, L. and **B. Predicala**. 2010. Evaluation of Swine Barn Energy Measures Using Numerical Simulation. Poster presented at the 2010 Saskatchewan Pork Industry Symposium, Saskatoon, SK, Canada, 23-24 November 2010.

Jin, Y. and **B. Predicala**. 2010. Effects of engineering control and management measures on reducing risk of worker exposure to dust and ammonia in swine barns. Poster presented at the 2010 Saskatchewan Pork Industry Symposium, Saskatoon, SK, Canada, 23-24 November 2010.

**Predicala, B.**, Y. Jin, and E.N. Richards. 2010. Do you know how much water you are using in your barn? Poster presented at the 2010 Saskatchewan Pork Industry Symposium, Saskatoon, SK, Canada, 23-24 November 2010.

Alvarado, A. and **B. Predicala**. 2010. Controlling environmental emissions from swine barns using nanoparticles. Prairie Swine Centre Inc. Research report submitted to Agriculture Development Fund (ADF).

Alvarado, A., L. Moreno, **B. Predicala**, E. Navia, L. Dominguez and J. Price. 2010. Comparative evaluation of infrared radiant and forced-air convection heating systems for hog barns. *Centered on Swine*. Vol. 15, No. 2, pp. 6-7. Prairie Swine Centre Inc., Saskatoon, SK.

**Predicala, B.**, A. Alvarado, L. Dominguez, Y. Jin, and E. Navia. 2010. Comparison of performance of radiant and forced-convection heating systems in swine grow-finish rooms. Final report submitted to Alberta Agriculture and Rural Development, Alberta.

**Predicala, B.** and L. Dominguez. 2010. Application of computer simulation to evaluate potential measures for improving energy efficiency in hog production. 2009 Annual Research Report. Prairie Swine Centre Inc., Saskatoon, SK.

Brown, J.A., T.S. Samarakone, T. Crowe, R. Bergeron, T. Widowski, J.A. Correa, L. Faucitano, S. Torrey, and **H.W. Gonyou**, 2011. Temperature and humidity conditions in trucks transporting pigs in two seasons in eastern and western Canada. *Trans. ASABE*, 54: 2311-2318.

Brown, J., T. Crowe, S. Torrey, R. Bergeron, T. Widowski, J. Correa, L. Faucitano and **H.W. Gonyou**, 2011. Assessing welfare during transport: relationships between transport temperatures, pig behaviour, blood stress indicators and meat quality. 5th International Workshop on the Welfare of Animals at Farm and Group Level (WAFL), Guelph, Ontario.

Brown, J.A., S.M. Hayne, T. Samarakone, B. Street and **H.W. Gonyou**, 2011. Evaluation of conventional and large group auto-sort systems for grow/finish pigs. Proceedings of the 45th International Congress of the International Society of Applied Ethology, Indianapolis, Indiana.

Rioja-Lang, F. C., S.M. Hayne, **H.W. Gonyou**, 2011. Determining the floor space requirement for group housed sows. Proceedings of the 45th International Congress of the International Society of Applied Ethology, Indianapolis, Indiana.

Bench, C. J., S.M. Hayne, F.C. Rioja-Lang, **H.W. Gonyou**, 2011. Group sow housing with individual feeding: Identifying research gaps. *Advances in Pork Production*, Vol 22, Abstract #1.

Hayne, S.M., F.C. Rioja-Lang, and **H.W. Gonyou**, 2011. Free space utilization by sows in gestation pens equipped with walk-in/lock-in stalls. *Proceedings of the Canadian Society of Animal Science*.

Eastwood, L., P. Leterme and **A.D. Beaulieu**. 2012. Dietary n-6 to n-3 fatty ratio affects body fat mobilization during lactation in high producing sows. *ASAS Midwest meeting*. Abstr 284.

Shea, J., D.A. Gillis and **A.D. Beaulieu**. 2012. The effect of diet and creep feed on feed intake by weanling pigs. *J. Anim. Sci.* 89 e Suppl 1. 582.



Rioja-Lang F. C., S.M. Hayne, **H.W. Gonyou**, 2011. Free space utilisation of sows in free access stalls. *Pig Progress*. Net. Accessible online at: <http://www.pigprogress.net/background/free-space-utilisation-of-sows-in-free-access-stalls-7432.html>

Juárez, M., M.E.R. Dugan, N. Aldai, J.L. Aalhus, J.F. Patience, R.T. Zijlstra, and **A.D. Beaulieu**, 2011. Increasing omega-3 levels through dietary co-extruded flaxseed supplementation negatively affects pork palatability. *Food Chemistry*, 126(4), pp. 1716-1723.

Eastwood, L., **A.D. Beaulieu** and P. Leterme. 2011. Effect of altering the dietary omega-6 to omega-3 fatty acid profile of sow diets on the immune responses of their offspring when challenged with *E. coli* lipopolysaccharide. *J. Anim. Sci.* 89 e Suppl 1: 756.

Damdinsuren, U., L. Eastwood, and **A.D. Beaulieu**. 2012. Effect of altering the dietary n-6 to n-3 fatty acid ratio on the pro-inflammatory responses of newly weaned pigs when challenged with *E. coli* lipopolysaccharide. *ASAS Midwest meeting*. Abstr 278.

Eastwood, L., P. Leterme and **A.D. Beaulieu**. 2012. Dietary  $\omega$ -6 to  $\omega$ -3 fatty acid ratios affect body fat mobilization in high producing sows. *Adv Pork Prod.* 23: A-9.

Damdinsuren, U., L. Eastwood and **A.D. Beaulieu**. 2012. Dietary  $\omega$ -6 to  $\omega$ -3 fatty acid ratios affect the immune responses of newly weaned piglets challenged with *E. coli* lipopolysaccharides. *Adv Pork Prod.* 23: A-27

Eastwood, L., and **A.D. Beaulieu**. 2012. Can omega-3 fatty acids improve piglet health? *BC SPCA Farm Sense*. Feb 2012.

Eastwood L., and **A.D. Beaulieu**. 2012. Can Omega-3 Fatty Acids Modulate the Immune Response of Pigs? *Prairie Swine Centre, Centred on Swine*: 17(2)

Labas, M., J.D. Johnston, **A.D. Beaulieu** and S. Kontulainen. 2011. Effect of freezing on pQCT derived muscle size and density: A pilot study. *Life Health Sci Conf.* U of S.

Eastwood, L., P. Leterme and **A.D. Beaulieu**. 2011. Sow fatty acid profile may alter weaned pig immune response. *National Hog Farmer*. Dec .2011

# Financial Support

Prairie Swine Centre Inc. wants to recognize the many individuals and agencies that supported the research and technology transfer programs this year. Their support is essential to the ongoing developments that will keep Canadian pork producers at the forefront of applied technology.

In addition to the many industry and government funding agencies, the University of Saskatchewan contracts the facilities and services of PSCI for research and teaching.

The following organizations have provided funding or donations in kind to support public research at the Centre for the 2010/11 fiscal year.

## PROGRAM SPONSORS

- Agriculture Development Fund (ADF)
- Alberta Pork Producers Development Corporation
- Manitoba Pork Council
- Saskatchewan Pork Development Board

## MAJOR PROJECT SPONSORS

- Advancing Canadian Agriculture and Agri-Food (ACAAF)
- Agriculture and Agri-Food Canada
- Feed Opportunities from Biofuel Industries / Ag. Bioproducts Innovation Program (FOBI / ABIP)
- Natural Sciences and Engineering Research Council of Canada (NSERC)
- Canadian Swine Research and Development (Cluster)
- Manitoba Livestock and Manue Management Initiative
- Mathematics of Information Technology and Complex Systems (MITACS)

## PROJECT SPONSORS

- Agriculture Food Council
- Alberta Agriculture & Rural Development
- Alberta Farm Animal Care (AFAC)
- Alberta Livestock and Meat Agency (ALMA)
- Alberta Livestock Industry Development Fund Ltd.
- Canada Adaptation and Rural Development in Saskatchewan (CARDS)
- Cargill
- Degussa Canada Inc.
- Easyfix Rubber
- Elanco (Division of Eli Lilly Canada Ltd.)
- Maple Leaf Fresh Foods
- Masterfeeds
- National Pork Board
- Ontario Pork Producers Marketing Board
- Saskatchewan Pulse Crop Development Board
- Vandeputte





**PRAIRIE SWINE CENTRE INC.**  
*Box 21057, 2105 8TH STREET EAST*  
*SASKATOON, SASKATCHEWAN CANADA*  
*S7H 5N9*

***[www.prairieswine.ca](http://www.prairieswine.ca)***

Prairie Swine Centre is an affiliate of



**UNIVERSITY OF  
SASKATCHEWAN**